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Movements of bar-tailed godwits and red knots within New Zealand

P.F. Battley, R. Schuckard and D.S. Melville



Cover: Colour-banded bar-tailed godwit, code 4YWWY, taking off. This bird was caught as an adult male in February 2006 at the Manawatu River Estuary. *Photo: Phil Battley.*

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Abstract

This study of the movements of two Arctic-breeding waders (bar-tailed godwit, *Limosa lapponica baueri*, and red knot, *Calidris canutus rogersi*) was commissioned in response to (A) a lack of knowledge of how individual birds use networks of sites around New Zealand, and (B) the threat of avian influenza viruses, as migrating waders are potential vectors of these pathogens. The Ornithological Society of New Zealand (OSNZ) ran a colour-banding programme to study the movements of these waders in New Zealand from 2004 to 2008. A total of 770 bar-tailed godwits and 345 red knots were colour-banded around the country, and OSNZ members and other observers made over 9500 sightings of 721 godwits and over 1500 sightings of 275 knots during the project. Most resightings were from the capture site, but movements of up to 1185 km (one way) were documented. On average, young birds of both species were more mobile than adults; knots were generally more mobile than godwits. Some juvenile or immature godwits wandered widely around New Zealand and apparently settled at long-term 'wintering' locations during these explorations. Small numbers of godwits were recorded making stopovers at northern sites upon arrival from migration before moving on to their eventual destination. Overall, it is clear that non-breeding knots use an extensive network of sites around New Zealand and probably move frequently between them. Knots banded in the Firth of Thames were recorded from Parengarenga Harbour in the north of the North Island down to Tasman Bay in the northern South Island, but it is not clear how regular these long-distance movements are. Godwits, in contrast, are much more likely to remain at one site or intertidal system and not venture far away when present in New Zealand during their non-breeding season.

Keywords: New Zealand, shorebirds, waders, migration, movements, arctic, bar-tailed godwit, *Limosa lapponica baueri*, red knot, *Calidris canutus rogersi*, *Calidris canutus piersmai*, non-breeding, wintering sites

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1. Introduction

New Zealand's intertidal shores are host to over 100 000 international migratory waders (also known as 'shorebirds') annually. Breeding in the Arctic and Subarctic regions of Russia, northern China and Alaska, they migrate 12 000–17 000 km in each direction between their breeding and non-breeding grounds. Two species dominate numerically in New Zealand—bar-tailed godwits (*Limosa lapponica baueri*) from western Alaska, with a global population of around 120 000 birds (McCaffery & Gill 2001), and red knots (mostly *Calidris canutus rogersi* from the Chukotka Peninsula and a smaller proportion of *C. c. piersmai* from the New Siberian Islands, Russia), with a total flyway population of perhaps 105 000 birds (Rogers et al. 2010). Both are widespread around New Zealand, occurring in sandy and muddy habitats from the Far North to Southland, with some birds also reaching the Chatham Islands regularly and subantarctic islands irregularly.

For both species, New Zealand holds internationally important numbers. Most of the *baueri* subspecies of the bar-tailed godwit occurs there, and New Zealand holds potentially 40% of the combined global population of *rogersi* and *piersmai* knots (Ornithological Society of New Zealand (OSNZ), unpubl. data; Rogers et al. 2010). From a conservation perspective, New Zealand is critical to the future of these species in the East Asian-Australasian Flyway (which encompasses breeding grounds from central Siberia to Alaska, and non-breeding or migration grounds through eastern and Southeast Asia, to Australia and New Zealand), and both have declined in recent years (Southey 2009). Shorebirds that migrate along the East Asian-Australasian Flyway pass through or skirt some of the most densely populated areas of the world. Tidal flats in those regions are threatened by massive land-claim schemes such as the 40 000 ha Saemangeum reclamation in South Korea, the seawall of which was completed in April 2006 (Moores et al. 2008), and ongoing reclamation in Bohai Bay, China, which has reclaimed an estimated 218 km² of tidal flat since 1994 (Yang et al. 2011). New Zealand's harbours and estuaries have not recently been subject to large reclamation schemes, though there is ongoing pressure for the development of new marine farms and for shellfish harvesting, and catchment land-use issues have the potential to be detrimental to shorebirds indirectly.

From a management viewpoint, understanding the linkages between populations of a species using different sites is important, as the effects of a localised impact could be much greater than expected from counts alone if birds move between sites. Additionally, with rising concern about the possible spread of pathogens such as avian influenza A viruses by wild birds, it is important to have an understanding of possible routes of introduction and dispersal (Melville & Shortridge 2006). While information is available on the non-breeding distribution of most shorebirds in New Zealand (Sagar et al. 1999; Dowding & Moore 2006; Southey 2009), no studies have been made on the movements of Arctic-breeding waders within New Zealand. The New Zealand Wader Study Group has been banding godwits and knots around Auckland since the mid-1980s, and leg-flagging them with a country-specific (in this case white) Darvic leg-'flag' since the early 1990s, and the OSNZ started banding godwits and marking them with white over green leg flags in the northern South Island in 2000. The main aim of that work was to detect international movements of birds from New Zealand. Sightings of these birds in New Zealand away from the banding sites provided the only evidence for movements within the country, but with birds lacking individual markers, the sightings typically provided no specific details on individual movements.

Accordingly, and in response to a need identified by the Department of Conservation (DOC), OSNZ embarked on a study of the movements of Arctic-breeding waders in New Zealand in 2004. Attention focussed on bar-tailed godwits and red knots. The other species found in significant numbers in New Zealand, ruddy turnstone (*Arenaria interpres*), has a patchy distribution and proved difficult to catch anywhere in sufficient numbers to contribute meaningfully to the project. All birds were individually identified with a combination of four colour bands and a white leg flag, and OSNZ members were encouraged to search among flocks of waders for these birds. With

regular searches for colour-banded birds around the country, it has proven possible to describe the scale and nature of a range of movements of these Arctic-breeding waders while they are in New Zealand. Additionally, any international sightings of these birds confirmed them as active migrants in a given year. This report summarises the local and long-distance movements within New Zealand recorded through this study. Such information will clarify the degree to which individual shorebirds use networks of sites around New Zealand's coasts.

2. Methods

Bar-tailed godwits and red knots were caught and colour-banded at 17 sites around New Zealand from February 2004 to March 2008 (Fig. 1; details are given in Table 1 and Table 7 in section 3.2). Catching was led by Rob Schuckard, David Melville, Phil Battley and Adrian Riegen in the Far North; Phil Battley, Adrian Riegen and Tony Habraken in the Auckland/South Auckland regions; Phil Battley, Hugh Robertson, Ralph Powlesland, David Melville and Rob Schuckard in the Manawatu; and Rob Schuckard and David Melville in the South Island. The OSNZ project overlapped a 3-year study by Phil Battley on the survival rates of bar-tailed godwits and red knots in the Firth of Thames; catching for that study began before the start of the OSNZ project, but the two were treated as one thereafter.

Birds were caught by cannon-net during the day or by mist-net at night, at or near high-tide roosts or the adjacent tidal flats. After capture, birds were metal-banded, measured and weighed,

and aged on plumage characteristics; in particular, the stage of primary moult and the degree of wear of the primary feathers, the presence of breeding plumage and, for godwits, the distinctive 'notched' tertials and scapulars, buffy breast and neck of juveniles (Higgins & Davies 1996). Age codes referred to in this report are: 1 = 1st-year, a bird within its first year of life; 2 = 2nd-year, a bird within its second year of life; 3+ = 3rd-year or older, a bird within its third year of life or older (Melville 2011). As the birds are northern hemisphere breeders, their breeding seasons start in May–June and run until July. The birth date for such birds is given as 1 August. In general, adults are 3+, but at some times of year, age-classes 2 and 3+ cannot be distinguished, in which case a 2+ code (2nd-year or older) was used. At other times of the year, it was possible to age some birds as 3 (rather than 3+). Retrapped individuals that had previously been metal-banded were given a new metal band on a tibia (thus allowing the colour bands to be placed on the tarsi) and were included in this study. The minimum age was higher for those birds than for newly trapped birds, as the period between their initial capture and colour-banding can be added to their initial age estimate. For instance, a bird aged as 3+ in 2000 would be classified as 8+ in 2005. For analysis, we typically combined juvenile and immature categories (the latter comprising ages 2, 2?, 2/3 and 3), and compared them with adults.



Figure 1. Locations around New Zealand where bar-tailed godwits, *Limosa lapponica*, and red knots, *Calidris canutus*, were caught and colour-banded. Note: formal name of the Avon–Heathcote Estuary is Estuary of the Heathcote and Avon Rivers/Ihutai.

Table 1. Capture locations of bar-tailed godwits, *Limosa lapponica*. Sites are listed from north to south.

SITE	REGION	LAT (S)	LONG (E)	NZ GRID (N)	NZ GRID (E)
North Island					
Parengarenga Harbour	Far North	34 32 17	172 56 57	6740593	2506371
Kaipara Harbour: Jordan's Farm	North Auckland	36 34 53	174 26 15	6512565	2639118
Manukau Harbour: Clarks Bay South	Auckland	37 06 39	174 45 56	6453270	2667270
Manukau Harbour: Karaka	South Auckland	37 04 47	174 49 28	6456613	2672576
Firth of Thames, Miranda coast: Taramaire	South Auckland	37 09 20	175 18 38	6447176	2715567
Firth of Thames, Miranda coast: shellbanks and stilt ponds	South Auckland	37 10 46	175 19 15	6444502	2716409
Manawatu River Estuary	Manawatu	40 28 02	175 13 33	6079908	2698743
South Island					
Farewell Spit: Lighthouse to Tip	Golden Bay	40 32 58	173 01 14	6073185	2511744
Pakawau	Golden Bay	40 35 30	172 41 15	6068452	2483546
Totara Avenue	Golden Bay	40 37 37	172 40 46	6064531	2482878
Motueka Sandspit	Tasman Bay	41 07 45	173 01 05	6008805	2511516
Waimea Inlet: Bell Island	Tasman Bay	41 17 32	173 10 56	5990682	2525264
Waimea Inlet: Rabbit Island	Tasman Bay	41 16 58	173 11 22	5991729	2525871
Avon-Heathcote Estuary*	Canterbury	43 33 27	172 45 08	5739039	2490002
Warrington	Otago	45 43 51	170 35 56	5494874	2322995
Awarua Bay	Southland	46 35 35	168 31 28	5392480	2166881

* Formal name: Estuary of the Heathcote and Avon Rivers/Ihutai.

Godwits were sexed primarily on bill length, on the assumption that birds with bill length ≥ 97 mm were female and those with bill length < 97 mm were male (Battley & Piersma 2005; OSNZ, unpubl. data). It has since been determined that there is some overlap within Alaskan godwits between large males and small females (Conklin et al. 2011). Another way to sex godwits is by the breeding plumage (only males develop the complete red plumage commonly associated with the species) and this was used in a few cases to clarify the sex of an individual. Knots cannot be sexed reliably on morphometrics or plumage; sexes were determined by genetic testing (Baker et al. 1999) for 157 birds as part of Phil Battley's project.

Birds were colour-banded with a combination of four Darvic colour bands (two on each tarsus; these were white, yellow, blue or red) and a single white Darvic flag. The position of the flag was part of the combination and there were six positions, designated by a prefix in the band combination: 1 = left tibia, 2 = right tibia, 3 = left tarsus above bands, 4 = right tarsus above bands, 5 = left tarsus between bands, and 6 = right tarsus between bands. The combination 4YWWY (see cover), therefore, has a flag on the right tarsus above the bands, with the bands yellow over white on the left tarsus and white over yellow on the right tarsus. In the South Island, flags were used on only the left leg (odd combinations); in the North Island, combinations had the flag on only the right leg (even combinations). Twenty-eight colour combinations were unintentionally used twice on godwits in the northern South Island. These birds could only be included in the analysis of movements if the same combination had been used on different sexes. Sighting reports (including of sessions where no colour-banded birds were seen) were e-mailed to Phil Battley or Rob Schuckard, who entered the data into a Microsoft Access database. Records that were obviously in error (e.g. non-existent combinations, a sex incompatible with the combination claimed, or simultaneous records of the

same bird at different places) were not entered into the database. It is likely, however, that there are some errors in the data, i.e. incorrect but plausible records that cannot be detected. Band discolouration, particularly of white bands, did occur, and can lead to incorrect band readings.

The study relied on observers using high-powered spotting scopes looking for colour-banded waders. Shorebird-watching is popular in New Zealand, and a dedicated band of observers put great effort into searching for marked birds. However, because of the geographic distribution of observers (clumped around major centres), the distances between sites and the varying conditions under which birds could be viewed at different sites, coverage around New Zealand varied (see Figs 2 & 3). Most resighting effort was put into summer (September–March), when adult migrants are resident in New Zealand; fewer checks were made in winter (April–August), when most birds present are juvenile or immature. It is now known that some adults occasionally overwinter here.

There is undoubtedly a bias in the reported survey effort towards occasions when colour bands were seen. We expected that whenever a colour-banded bird was seen (especially away from the banding site where banded birds are numerous) it was reported to us. The same is not necessarily true for nil returns (such as OSNZ wader censuses, when counting takes priority or is done at sites well away from banding regions, so the chance of banded birds being present is low). Some census nil results have been included in the study but we did not enter all census counts in which no colour-banded birds were reported, as it was not clear whether or not observers had actually looked for colour bands. In terms of detecting movements, this is not an issue, but our data underestimated the likelihood of sighting colour-banded birds at some sites. More detail

on resighting effort is given in the species accounts. The project formally ran from June 2004 to June 2007, though some records, where provided, were included up to autumn 2008.

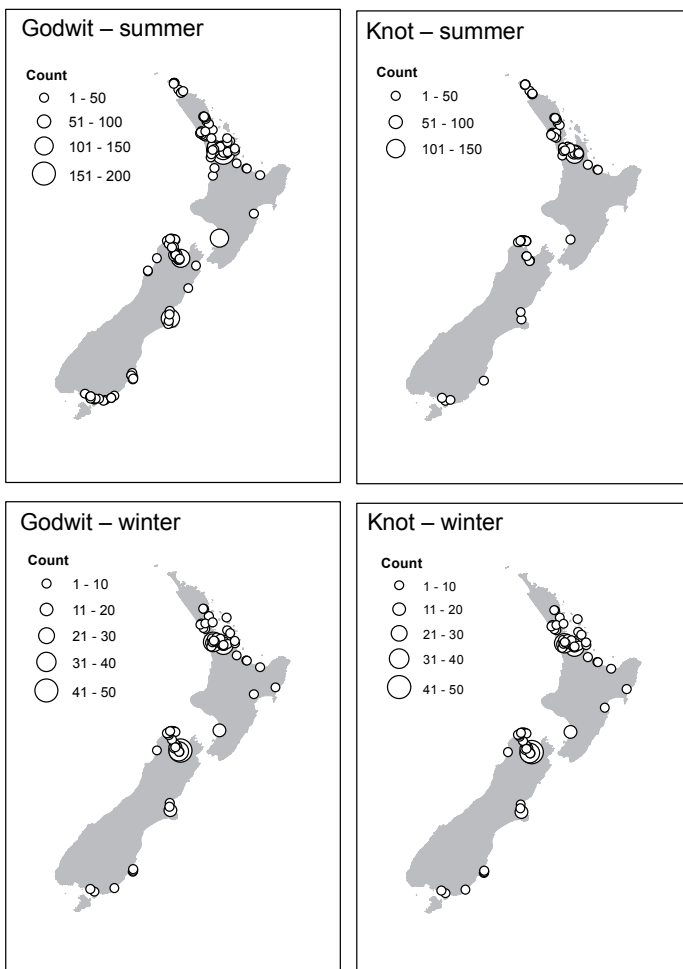


Figure 2. Resighting effort (numbers of reported checks for bands) for bar-tailed godwits, *Limosa lapponica*, and red knots, *Calidris canutus*, in New Zealand in summer (September–March) and winter (April–August).

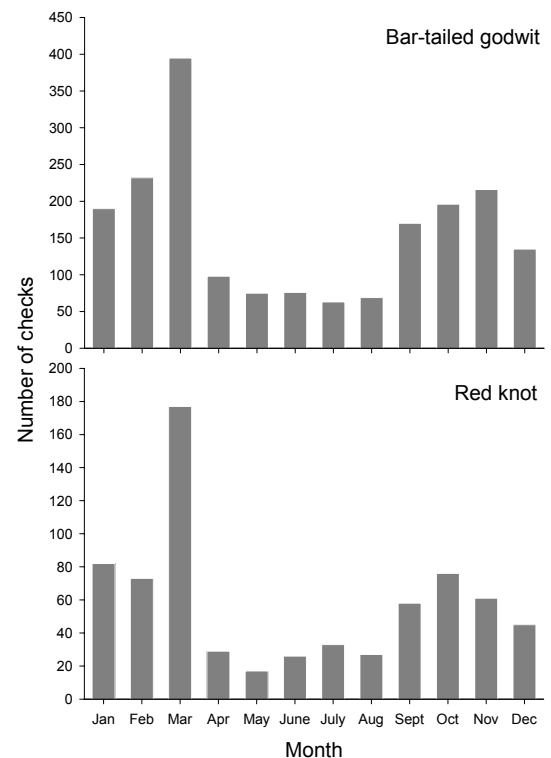


Figure 3. Number of reported checks for bar-tailed godwits, *Limosa lapponica*, and red knots, *Calidris canutus*, made per month around New Zealand, 2004–08.

2.1 Regions and sites

In analyses of bird movements within New Zealand, we distinguished between three levels of movement—interisland, regional and local. Resighting locations were grouped into general geographical regions (e.g. South Auckland, Tasman Bay) while local movements were analysed at a finer scale (e.g. Manukau Harbour south v. Manukau Harbour east, Miranda (west coast of the Firth of Thames) separate from sites in the south and east of the Firth of Thames (Piako, Waihou River mouth and Thames)). The smaller areas are referred to as ‘districts’. Resighting locations where checks were made for colour-banded birds, and their regional and district grouping codes, are given in Appendix 1.

3. Results

3.1 Bar-tailed godwits

Godwits were caught and colour-banded at 16 sites in 14 locations around New Zealand (Table 2), from Parengarenga Harbour in the Far North to Awarua Bay in Southland. Most birds were caught on the Miranda coast, Firth of Thames (218 birds), in Golden Bay (northwest Nelson, including Farewell Spit, 155 birds) and in Tasman Bay (189 birds). There was a slight bias towards males in the sample (55% male, 45% female), but there was no correlation of sex ratio to latitude ($F = 0.187$, $df = 1,12$, $P = 0.67$), indicating that differential migration was unlikely. Substantial variation existed between sites (e.g. Miranda, 55.5% females in 218 birds; Rabbit Island/Bell Island, Tasman Bay, 35.3% females in 119 birds: this difference is significant—Fisher’s exact test, $P = 0.0004$). These differences may have arisen through using different capture methods at different locations. Females, the heavier sex, may be less able to avoid mist-nets (which were mostly used at Miranda); the sex ratio of birds cannon-netted could be more representative of that of the population, but only if there was no segregation within flocks (which might not be true). We do not have independent sex ratio estimates (e.g. visual scans) to assess these possibilities, but further investigation is warranted.

Most birds caught (78.5%) were aged as adult (3+ years old), with some retrapped birds from previous banding sessions being up to 15+ years old when colour-banded. Only 9% of birds caught were confirmed juveniles, yet this figure is higher than the typical age ratio observed in the field in New Zealand during the October–December period when juveniles can be readily aged (PFB, unpubl. data). It is likely that some young godwits move through Australia to New Zealand at that time (Minton et al. 2010), therefore being absent for some of the New Zealand banding period. On the other hand, the higher proportion for this study may indicate that juveniles are caught more readily than adults (and mist-nets are known to catch more juvenile waders; Pienkowski & Dick 1976).

Because of the accidental duplication of 28 colour combinations, the pool of individually colour-banded birds for which movements could be unequivocally detected was 795.

3.1.1 Resightings

Of the 770 bar-tailed godwits banded, 721 (93.6%) were resighted in the field in New Zealand during the study, 1–66 times per individual (Table 3). Birds from intensively monitored sites with good resighting opportunities (Miranda coast, Manawatu River Estuary, Avon–Heathcote Estuary (formal name: Estuary of the Heathcote and Avon Rivers/Ihutai)) were recorded the most frequently.

Most birds (81.3%) were seen only in the region in which they were banded, with a further 17.4% seen in just one other region. Only ten godwits were seen in three or four regions around New Zealand. The regional breakdown of numbers of sightings of birds is given in Table 4.

Table 2. Sex, capture location and age of colour-banded bar-tailed godwits, *Limosa lapponica*. 'Older' refers to retrapped birds from 4+ to 15+ years old at the time of colour-banding. Unk = unknown. Ages refer to the age relative to a birthday of 1 August rather than a calendar year.

REGION	SITES	AGE													TOTAL			
		1	1?	1+	2	2?	2/3	2+	3	3?	3+	3+?	OLDER	UNK		2*	2/3*	3+*
Female																		
Far North	Parengarenga Harbour																	4
Nth Auckland	Kaipara Harbour,	3		2			1											10
	Jordan's Farm																	
Sth Auckland	Manukau Harbour,																	6
	Clarks Bay																	
Sth Auckland	Manukau Harbour,																	5
	Karaka																	
Sth Auckland	Firth of Thames,	6	2	12	1	10	3	3	1	73	7	1	1	1	1	1		121
	Taramaire and Miranda																	
Manawatu	Manawatu River Estuary				1	2				38	1							42
	Farewell Spit	1								19					1			21
Golden Bay	Pakawau	2			4					7	1							15
	Totara Avenue	11								11								22
Tasman Bay	Motueka Sandspit	1				1				31								33
	Waimea Inlet, Rabbit Island and Bell Island	4			3					34					1			42
Canterbury	Avon-Heathcote Estuary†	3								22								25
Otago	Warrington	1	1							14								16
Southland	Awarua Bay	2		1			1			8								12
	Total	34	3	14	9	13	5	3	1	275	1	8	1	1	1	4		374
Male																		
Far North	Parengarenga Harbour									5								8
Nth Auckland	Kaipara Harbour,	2								2								4
	Jordan's Farm																	
Sth Auckland	Manukau Harbour, Clarks Bay									3								3
Sth Auckland	Manukau Harbour, Karaka							1		12								13
	Firth of Thames,	7		7	8	5	3	2	2	47	13				3			97
Manawatu	Taramaire and Miranda																	
	Manawatu River Estuary					1				36								38
Golden Bay	Farewell Spit	9			1					46								56
	Pakawau	1			2		1			5								14
Golden Bay	Totara Avenue	10								13					1			27
	Motueka Sandspit	2								36								40
Tasman Bay	Waimea Inlet, Rabbit Island and Bell Island	2					2			72								77
	Avon-Heathcote Estuary†	4			5	1				32								42
Otago	Warrington	2								21								23
Southland	Awarua Bay	4		1						5								10
	Total	43	1	1	15	12	6	3	2	337	8	13	3	4				452

* Birds whose sex could not be confirmed (Female? and Male? categories).

† Formal name: Estuary of the Heathcote and Avon Rivers/Ihutai.

Table 3. Number of resightings of individual bar-tailed godwits, *Limosa lapponica* within New Zealand from each banding site (or district, for nearby sites). Data exclude birds that were never seen again.

BANDING SITE	MEAN	MAX	MIN	SD	<i>n</i>
Parengarenga Harbour, Far North	1.7	4	1	1.1	7
Jordan's Farm, Kaipara Harbour, North Auckland	5.2	19	2	4.4	13
Clarks Bay and Karaka, Manukau Harbour, South Auckland	6.2	16	1	4.2	23
Miranda coast, Firth of Thames, South Auckland	18.0	66	1	14.1	208
Manawatu River Estuary, Manawatu	25.6	54	2	14.8	77
Farewell Spit, Golden Bay	4.8	12	1	2.9	66
Golden Bay, western shores (Pakawau and Totara Avenue)	8.1	24	1	6.2	75
Motueka Sandspit, Tasman Bay	8.3	29	2	5.8	46
Waimea Inlet, Nelson	10.7	56	1	11.2	86
Avon-Heathcote Estuary*, Canterbury	19.1	34	1	9.2	66
Warrington, Otago	5.3	12	1	3.3	33
Awarua Bay, Southland	5.0	14	1	4.5	21
Total	13.5			12.6	721

* Formal name: Estuary of the Heathcote and Avon Rivers/Ihutai.

3.1.2 Long-distance movements

Movements between North and South Islands

Thirty godwits banded in the North or South Island were recorded making movements to or through the other island. Of these, ten birds were juvenile or immature birds 'wandering' the country, in some cases settling at a location other than where they were banded. The movements of 16 of the 30 birds were clearly or probably related to migration, mostly South Island birds seen in the North Island when godwits were arriving in New Zealand.

Movements of juveniles and immatures

A summary of interisland movements by juvenile and immature godwits is shown in Table 5. Full resighting histories for these birds are given in Appendix 2.

Two birds are known to have moved widely as juveniles. 1RWYR was caught in October 2004 at the Avon-Heathcote Estuary, was seen at Lake Ellesmere (Te Waihora), Canterbury, 3 weeks later and, by January 2005, had relocated to the Manukau Harbour, South Auckland. All nine subsequent sightings of this bird in New Zealand have been at Clarks Bay, Manukau Harbour, or Turanga Creek, Whitford (Waitemata Harbour), the latter being a site that godwits from the southern side of the Manukau Harbour are known to visit. 2RWWY was banded at Miranda in October 2005. It was seen at Kaiua in the Firth of Thames in March 2006, but 2 weeks later was at Motueka Sandspit, Tasman Bay. All seven subsequent sightings have been from Motueka Sandspit, apart from one sighting midway along Farewell Spit, in Golden Bay. Both these birds appear to have selected their preferred non-breeding site during their first year in New Zealand.

Eight godwits are known to have moved between islands as immatures (ages 2-4; Table 5). Of the five birds with reasonable numbers of resightings (i.e. more than ten), four moved between islands and subsequently returned to their banding location or nearby. One bird (1YWWY) relocated as a 2-year-old from the South Island to Manukau Harbour, South Auckland. The longest movement recorded was 1185 km, from Miranda to the New River Estuary, Invercargill, Southland, by 2WWYR, which then returned to the Firth of Thames.

Movements of adults

Seventeen adult godwits were recorded in both islands (Table 6). Most of these sightings could be attributed to birds arriving after their southward migration at a site further north than their eventual destination. Despite intense efforts to resight birds during the premigratory period in the Auckland and South Auckland regions (216 checks in February and March resulting in

Table 4. Number of regional resightings (and percentage of total) of bar-tailed godwits, *Limosa lapponica*, by banding site, including multiple records of individuals.

BANDING SITE	RESIGHTING LOCATION												TOTAL			
	FAR NORTH	NORTH AUCK- LAND	NORTH AUCK- LAND	AUCK- LAND	SOUTH AUCK- LAND	CORO- MANDEL	BAY OF PLENTY	WAI- KATO	MANA- WATU	GOLDEN BAY	NORTH- WEST NELSON	TASMAN BAY		CANTER- BURY	OTAGO	SOUTH- LAND
Parengarenga Harbour, Far North	7 (0.07)				5 (0.05)											12 (0.12)
Jordan's Farm, Kaipara Harbour, North Auckland		34 (0.35)			34 (0.35)											68 (0.70)
Clarks Bay and Karaka, Manukau Harbour, South Auckland		1 (0.09)		3 (0.15)	138 (1.42)											142 (1.47)
Miranda coast, Firth of Thames, South Auckland		9 (0.07)		15 (0.15)	3695 (38.12)	5 (0.05)	18 (0.19)	1 (0.01)		1 (0.01)					1 (0.01)	3752 (38.71)
Manawatu River Estuary, Manawatu				2 (0.02)	8 (0.08)				1952 (19.99)	2 (0.02)						1971 (20.18)
Farewell Spit, Golden Bay				1 (0.01)	3 (0.03)					299 (3.09)						317 (3.27)
Golden Bay, western shores (Pakawau and Totara Avenue)			1 (0.01)	1 (0.01)	19 (0.20)				5 (0.05)	499 (5.15)	1 (0.01)	76 (0.78)	5 (0.05)	1 (0.01)		608 (6.27)
Motueka Sandspit, Tasman Bay		2 (0.02)			18 (0.19)					2 (0.02)						380 (3.92)
Waimea Inlet, Nelson					4 (0.04)					11 (0.11)						918 (9.47)
Avon-Heathcote Estuary*, Canterbury					11 (0.11)					4 (0.04)						1259 (12.99)
Warrington, Otago					1 (0.01)					1 (0.01)				173 (1.79)		17 (1.82)
Awarua Bay, Southland										3 (0.03)						104 (1.07)
Total	7 (0.07)	47 (0.48)	22 (0.23)	3936 (40.61)	5 (0.05)	18 (0.19)	1 (0.01)	1957 (20.04)	822 (8.48)	1 (0.01)	1332 (13.74)	1282 (13.23)	202 (2.08)	75 (0.77)	9707 (100)	

* Formal name: Estuary of the Heathcote and Avon Rivers/hutai.

Table 5. Interisland movements by juvenile and immature bar-tailed godwits, *Limosa lapponica*. Birds are listed by the age category they were in when known to have moved within New Zealand (juvenile, immature), then age at which movements are known to have occurred. Sighting locations in the opposite island to the banding site are shown in bold. 'Birthday' of birds is 1 August.

BAND	BANDING SITE	DATE BANDED	AGE AT BANDING	AGE WHEN MOVED	SEQUENCE OF SIGHTINGS (SITE, DATE(S), NUMBER OF SIGHTINGS)	NUMBER OF RECORDS		COMMENT
						TOTAL	OTHER ISLAND	
2RWVY	Miranda	22 Oct 05	1	1	Firth of Thames (15 Mar 06), Motueka Sandspit (31 Mar 06 – 22 Mar 07; 4 records), Farewell Spit (23 May 07), Motueka Sandspit (27 Nov 07, 25 Feb 08). Avon-Heathcote Estuary (29 Oct 04), Lake Ellesmere (Te Waihora) (17 Nov 04), Manukau Harbour/Whitford (10 Jan 05 – 27 Oct 07; 9 records).	8	7	Relocated as 1st-year to Tasman Bay.
1RWYR	Avon-Heathcote Estuary*	22 Oct 04	1	1	Golden Bay (10 Feb 05 – 25 June 05), Manukau Harbour (2 Oct 05); 11 records), Golden Bay (2 Dec 05 – 26 Dec 07; 8 records).	11	9	Relocated as 1st-year to Manukau Harbour.
1YRYR	Totara Avenue	13 Dec 04	1	2	Waiamea Inlet, Nelson (2 Mar 05), Farewell Spit (12 Mar 05 – 21 Sept 5; 3 records), Manukau Harbour (5 Feb 06 – 27 Oct 07; 11 records).	20	1	Wandered and returned.
1YWWY	Totara Avenue	13 Dec 04	1	2	Avon-Heathcote Estuary (4 Mar 05), Golden Bay (4 Oct 05 – 15 Feb 06; 3 records), Kaipara Harbour (15 July 2006), Farewell Spit (20 Mar 07), Golden Bay (27 Nov 07, 25 Feb 08).	15	11	Relocated as a 2nd-year to the Manukau Harbour.
1YYYW	Totara Avenue	13 Dec 04	1	2	Manukau Harbour (19 Jan 06). Farewell Spit (12 Feb 05 – 31 Jan 06; 11 records), Manawatu River Estuary (18 Apr 06 – 8 Sept 06; 5 records), Warrington, Otago (19 Sept 06), Miranda (1 Oct 06 – 27 Dec 06; 3 records), Miranda (4 Nov 07), Farewell Spit (10 Feb 08).	8	1	Wandered and returned.
1YBWB	Pakawau	04 Dec 05	2?	2?		1	1	One record only.
1YWBB	Totara Avenue	13 Dec 04	1	2,3		22	9	Wandered widely and returned to near banding site. This bird was not present at the Manawatu River Estuary constantly throughout winter 2006—it was seen on just 5 of 15 checks from 2 April to 8 Sept 06. It migrated north in 2007 (seen three times in South Korea).
3WBBY	Motueka Sandspit	16 Jan 06	1	2,3	Motueka Sandspit, Tasman Bay (29 Mar 06 – 21 Feb 07; 8 records), Firth of Thames (29 Apr 07, 7 Sept 07), Motueka Sandspit (23 Nov 07, 27 Nov 07).	12	2	Wandered and returned to banding site.
3YBBY	Pakawau	04 Dec 05	2?	3?	Farewell Spit (18 Mar 06), Manukau Harbour (3 Feb 07), Firth of Thames (31 Mar 07).	3	2	
2WWYR	Miranda	19 Oct 04	3?	3?,4?	Firth of Thames (26 Oct 04 – 20 Nov 04; 5 records), Invercargill Estuary (4 Feb 05), Firth of Thames (3 Mar 05), Avon-Heathcote Estuary (17 Sept 05).	8	2	Fate and whereabouts unknown after Sept 05.

* Formal name: Estuary of the Heathcote and Avon Rivers/Ihutai.

Table 6. Interisland movements by adult bar-tailed godwits, *Limosa lapponica*. Birds are listed by probable explanation (northward or southward migration where evident), then banding site (north to south). Sighting locations in the opposite island to the banding site are shown in bold.

BAND	BANDING SITE	DATE Banded	AGE AT BANDING	AGE WHEN MOVED	SEQUENCE OF SIGHTINGS (SITE, DATE(S), NUMBER OF SIGHTINGS)	NUMBER OF RECORDS		COMMENT
						TOTAL	OTHER ISLAND	
Northward migration								
3WWRR	Avon-Heathcote Estuary* or Waimea Inlet, Tasman Bay	9 Feb 05 16 Nov 05	1 1	3 2	Avon-Heathcote Estuary (5 Mar 05 – 7 Jan 07; 17 records, 26 Jan 08). Tasman Bay (Waimea Inlet, Nelson Haven; 21 Nov 05–24 Mar 07; 29 records), (Nelson Haven, Tahunanui: 14 Sept 05–7 Feb 08; 16 records).	18 45	1 1	This combination was inadvertently used twice, so the Manukau Harbour record could refer to either of two birds. The Tasman Bay bird would be on its first migration north.
6YYBR	Manawatu River Estuary	19 Feb 07	3+	3+	Karaka, Manukau Harbour (1 Apr 07). Manawatu River Estuary (7 Mar 07), Farewell Spit (21 Mar 07), Manawatu River Estuary (14 Sept 07 – 13 Mar 08; 27 records).	29	1	Moved 187 km to the west to Farewell Spit when embarking on migration.
Southward migration								
4YRRB	Manawatu River Estuary	18 Feb 07	3+	3+	Manawatu River Estuary (19 Feb 07 – 23 Mar 07; 3 records), Farewell Spit (26 Nov 07), Manawatu River Estuary 11 Dec 07 – 25 Mar 08; 30 records).	33	1	Probable returning migrant to non-breeding ground when seen on Farewell Spit.
4YRRR	Manawatu River Estuary	21 Sept 06	3+	3+	Manawatu River Estuary (22 Sept 06, 28 Sept 06), Tasman Bay (Motueka Sandspit, Marahau, Nelson Haven: 6 Oct 06 – 27 Feb 07; 3 records), Manawatu River Estuary (9 Nov 07), Marahau, Tasman Bay (28 Feb 08).	8	5	Caught and banded during southward migration 2006 en route to Tasman Bay wintering ground. Record in Nov 2007 for Manawatu River Estuary could also indicate a late arrival and return from migration.
3YWBY	Farewell Spit	02 Feb 06	3+	3+	Farewell Spit (15 Dec 05 – 18 Mar 06; 3 records), Turanga Creek, Whitford (8 Sept 06), Farewell Spit (7 Oct 07 – 10 Feb 08; 4 records).	9	1	Stopoff in South Auckland region on return from migration; back in South Island within a month.
3YYBY	Farewell Spit	02 Feb 06	2?	2?	Nelson Haven, Tasman Bay (22 Mar 06), Mangere Sewage Ponds, Manukau Harbour (2 Sept 06), Golden Bay (Pakawau, Farewell Spit: 9 Oct 06 – 10 Feb 08).	10	1	Early southward migration stopoff in South Auckland region.
5WYBY	Farewell Spit	02 Feb 06	3+	3+	Farewell Spit (16 Feb 06, 18 Mar 06), Miranda, Firth of Thames (23 Sept 06), Farewell Spit (4 Feb 07).	4	1	Southward migration stopoff in South Auckland region.

* Formal name: Estuary of the Heathcote and Avon Rivers/Ihutai.

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Table 6 continued

BAND	BANDING SITE	DATE BANDED	AGE AT BANDING	AGE WHEN MOVED	SEQUENCE OF SIGHTINGS (SITE, DATE(S), NUMBER OF SIGHTINGS)	NUMBER OF RECORDS		COMMENT
						TOTAL	OTHER ISLAND	
1YWB	Totara Avenue	13 Dec 04	1	3	Farewell Spit, Manawatu River Estuary , Warrington, Otago, Miranda, Firth of Thames (12 Feb 05 – 27 Dec 06; 20 records), Miranda (4 Nov 07), Farewell Spit (10 Feb 08).	22	9	Wandered widely when immature (Table 5). Migrated north in 2007 (seen three times in South Korea), so the Nov 07 record at Miranda probably represents a stopoff on southward migration. Timing of North Island record matches a southward migration but there are only two records in total.
1WYBY	Motueka Sandspit	09 Mar 05	3+	3+	Jordan's Farm, Kaipara Harbour (24 Sept 05), Nelson (15 Oct 07).	2	1	Seen in South Korea Apr 05. Stopoff in North Auckland on southward migration that year; back in Motueka 11 days later. Did not migrate 2006.
1WYWB	Motueka Sandspit	09 Mar 05	3+	3+	Motueka Sandspit (10 Mar 05), Jordan's Farm, Kaipara Harbour (24 Sept 05), Tasman Bay (Motueka Sandspit, Waimea Inlet, Nelson Haven: 5 Oct 05 – 10 Feb 06), Farewell Spit (16 July 06).	6	1	Timing of North Island record matches a southward migration but there are only two records in total.
1WBBY	Rabbit Island, Waimea Inlet	15 Dec 04	3+	3+	Motueka Sandspit (10 Mar 05), Miranda, Firth of Thames (8 Sept 07).	2	1	Southward migration stopoff in South Auckland region; back in Nelson district 15 days later. Seen in Tasman Bay, back from migration on 20 Oct 06 and 11 Oct 07.
1WRRW	Rabbit Island, Waimea Inlet	15 Dec 04	3+	3+	Tasman Bay (Nelson Haven & Waimea Inlet: 31 Dec 04 – 22 Mar 05; 15 records), Karaka, Manukau Harbour (16 Oct 05), Tasman Bay (31 Oct 05 – 16 Dec 05; 6 records), Avon-Heathcote Estuary (2 Jan 06), Tasman Bay (12 Jan 06 – 9 Feb 08; 15 records).	38	1	Timing of North Island record matches a southward migration but there are only four records in total.
1WRRW	Rabbit Island, Waimea Inlet	15 Dec 04	3+	3+	Tasman Bay (Motueka Sandspit, Nelson Haven: 17 Feb 06 – 18 Mar 07; 3 records), Miranda, Firth of Thames (15 Sept 07).	4	1	Timing of North Island record matches a southward migration but there are only three records in total.
3WYWY	Rabbit Island, Waimea Inlet	16 Nov 05	3+	3+	Waimea Inlet, Tasman Bay (10 Feb 06), Miranda, Firth of Thames (28 Oct 06), Waimea Inlet (29 Jan 08).	3	1	Timing of North Island record matches a southward migration but there are only four records in total.
1RYR	Avon-Heathcote Estuary	22 Oct 04	3+	3+	Avon-Heathcote Estuary (17 Nov 04 – 3 Jan 05), Karaka, Manukau Harbour (2 Oct 05).	4	1	Timing of North Island record matches a southward migration but there are only four records in total.
1BRRW	Warrington	28 Feb 06	3+	3+	Karaka, Manukau Harbour (24 Sept 06), Otago (Karitane, Warrington: 1 Nov 06 – 24 Feb 08; 6 records).	7	1	Southward migration stopoff.

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Table 6 continued

BAND	BANDING SITE	DATE BANDED	AGE AT BANDING	AGE WHEN MOVED	SEQUENCE OF SIGHTINGS (SITE, DATE(S), NUMBER OF SIGHTINGS)	NUMBER OF RECORDS		COMMENT
						TOTAL	OTHER ISLAND	
Non-migratory								
4YYBB	Manawatu River Estuary	01 Feb 06	3+	3+	Manawatu River Estuary (2 Feb 06 – 13 Oct 07; 15 records), Avon-Heathcote Estuary (29 Oct 07), Manawatu River Estuary (11 Dec 07 – 10 Mar 08; 14 records).	30	1	Side-trip to South Island.
3YWWY	Farewell Spit	02 Feb 06	3+	3+	Karaka, Manukau Harbour (11 June 06), Motueka Sandspit, Tasman Bay (21 Feb 07).	2	1	Possible immature; only two records, one in winter.
3WBYR	Motueka Sandspit	18 Nov 05	3+	3+	Miranda, Firth of Thames (7 Sept 06 – 16 Oct 06; 3 records), Waimea Inlet, Tasman Bay (11 Aug 07, 13 Aug 07), Miranda, Firth of Thames (13 Feb 08, 14 Feb 08), Tasman Bay (Motueka Sandspit, Waimea Inlet: 25 Feb 08, 27 Feb 08).	9	5	Possible arrival at Miranda in 2006 but did not migrate in 2007 so may be a wandering immature; summer visit to Miranda 2008 but returned to Tasman Bay within 11 days.
5WYWY	Motueka Sandspit	18 Nov 05	3+	3+	Motueka Sandspit (18 Nov 05), Miranda and Kaiaua, Firth of Thames (14 Feb 06 – 3 Mar 07; 13 records).	14	13	Relocation by seemingly adult bird; could be a bird banded during exploratory trip.

1992 resightings) and in the northern South Island (Tasman and Golden Bays: 180 checks and 1139 resightings), only two sightings were made of birds apparently on a northward migration. 3WVRR was seen in the Manukau Harbour on 1 April 2007 (the end of the northward departure period), and 6YYBR was seen on Farewell Spit on 21 March 2007. Interpretation of the first record is difficult, as the band combination had inadvertently been used twice. In any event, it was a bird from either Tasman Bay or the Avon–Heathcote Estuary, Canterbury, possibly on its first migration north. The second bird, 6YYBR, had been seen on 7 March 2007 at the Manawatu River Estuary and had moved to Farewell Spit (a distance of 187 km) by 21 March before embarking on a flight to Asia (unless this was just a side-trip). Records from daily band checks at the Manawatu River Estuary in March 2008 (by Jesse Conklin, PhD student, Ecology Group, Massey University) reveal that 6YYBR was present there up to 13 March 2008. If its migration schedule was similar to that of 2007 (see Battley (2006) and Conklin & Battley (2011) for evidence of annual consistency in migration timing of individuals), then a stopover of around a week on Farewell Spit is possible.

In contrast, there were 14 records of godwits on (or probably on) their southward migration recorded in both islands (Table 6). Most of these were birds that had been banded in the South Island and had been seen in the Auckland region during the September–October arrival period. Two birds were seen back on the South Island non-breeding grounds soon after being seen around Auckland: 1WYWB from Motueka Sandspit was seen in the Kaipara Harbour on 24 September 2005 and then again, 11 days later, in Tasman Bay on 5 October 2005; 1WRRW from Rabbit Island, Tasman Bay, was seen in the Manukau Harbour on 16 October 2005 and then again, 15 days later, in Tasman Bay on 31 October 2005. For most birds, however, there were too few records from the non-breeding grounds for any indication of a minimum period between being recorded in the North Island and being confirmed back in the South Island.

The number of South Island adult birds stopping off in the North Island appears to be low, given the fairly large pool of individuals banded in the South Island (157 adults banded by 2005, 373 by 2006 and 391 by 2007).

There was an uneven distribution of South Island godwits between the west and east coasts of the Auckland region during southward migration. Sites in the Kaipara Harbour, Manukau Harbour and Whitford can be grouped together (given that Manukau Harbour birds commute regularly to Whitford) as ‘west coast’ sites and the Mataitai (Clevedon) site can be grouped with those at the Firth of Thames (‘east coast’ sites). Much greater resighting effort was made over the September–November period in 2005–07 on the east coast than on the west coast (133 sessions compared with 79 sessions) and far more band combinations were recorded (which was expected, given the larger pool of locally marked birds: 1214 records compared with 133 records). Despite this difference in resighting effort, fewer South Island birds were seen at east coast sites (five) than west coast sites (seven), suggesting that godwits arriving in New Zealand may sometimes make landfall in the large harbours of the west coast.

3.1.3 Movements within islands

Movements away from the local banding site and nearby sites (i.e. from districts) were recorded for 315 godwits, totalling 941 sightings. These represent records of 38% of all godwits banded or 44% of those seen in the field after banding, and 10% of all resightings. Many movements were fairly short in distance within a larger coastal system (e.g. within Golden Bay), but some longer-distance movements were also recorded. These movements are analysed below by banding district, from north to south.

FAR NORTH: PARENGARENGA HARBOUR

Of the 12 godwits banded in Parengarenga Harbour, only seven birds were resighted, a total of 12 times. Seven of these records, involving three birds, were of resightings away from Parengarenga Harbour. One adult and one immature banded in January 2007 were seen at East Beach, Rangaunu Harbour (Far North, 49 km south) in November 2007; the adult was seen at Miranda, Firth of

Thames (South Auckland, 363 km away), a month later in December 2007. The third Parengarenga bird, an immature also banded in January 2007, was seen four times in the southern Firth of Thames (Miranda and the Waihou River mouth) in November and December 2007.

NORTH AUCKLAND: KAIPARA HARBOUR

All 14 godwits banded in the Kaipara Harbour were caught at Jordan's Farm on the southeast shore of the harbour. Thirteen of these were resighted a total of 68 times, but only 20 of these records were from the eastern shores of the Kaipara Harbour (17 at Jordan's Farm; 3 at Tapora, 25 km north; Fig. 4). Seven birds were seen a total of 14 times on the western Kaipara: two birds

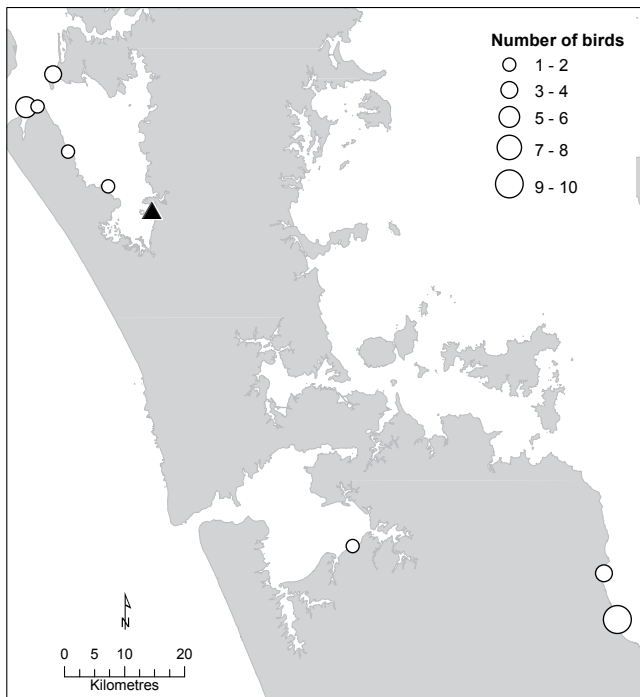


Figure 4. Sightings away from the banding district of colour-banded bar-tailed godwits, *Limosa lapponica*, banded at the Kaipara Harbour site, in North Auckland. Triangle symbol shows the banding site.

at Mairerahi (7 km from Jordan's), one at McLeods Bay (17 km away), and four more at or near Papakanui Spit on the South Head of the entrance to the Kaipara Harbour (25 km away), where two of the first three birds were also seen.

Eleven birds were seen 34 times elsewhere in the South Auckland region: two at Karaka in the Manukau Harbour (65 km away), and ten (including one of the Karaka birds) at Miranda and Kaiarau in the Firth of Thames (103 km away). Over half of the resightings were of a single juvenile that settled at Karaka in the Manukau Harbour (15 records) but was periodically seen (a total of four times) on the western shores of the Firth of Thames.

Four of the birds recorded in the South Auckland region were banded as juveniles, two as 2nd-years, and five as adults. The records of adults included four seen at Miranda and Kaiarau in the Firth of Thames in mid- to late March (including one bird in successive years), suggesting that birds may move around the Auckland region before migrating northward. However, resighting effort was also more intensive in the Firth at that time of year, giving greater opportunities to detect such movements.

SOUTH AUCKLAND: MANUKAU HARBOUR

Twenty-seven godwits (all adults) were banded in the southern Manukau Harbour district—nine at Clarks Bay and 18 at Karaka (also known as Kidd's Shellbanks, 6 km to the east). Twenty-three of these were seen 142 times; only 17 of those resighting records were not from the southern Manukau Harbour (Fig. 5). Three records of two birds were from elsewhere in the Manukau Harbour (Mangere Sewage Ponds and Kiwi Esplanade, 15–18 km away), and there was one record from Jordan's Farm in the Kaipara Harbour (mid-July) of a bird that had earlier been seen at Kaiarau in the Firth of Thames (mid-March). Three birds were seen at Turanga Creek, Whitford, 22 km northeast of Karaka. There are often highly visible movements of birds from the Manukau Harbour to Whitford, the birds presumably taking advantage of the fact that high tide is 3 hours later

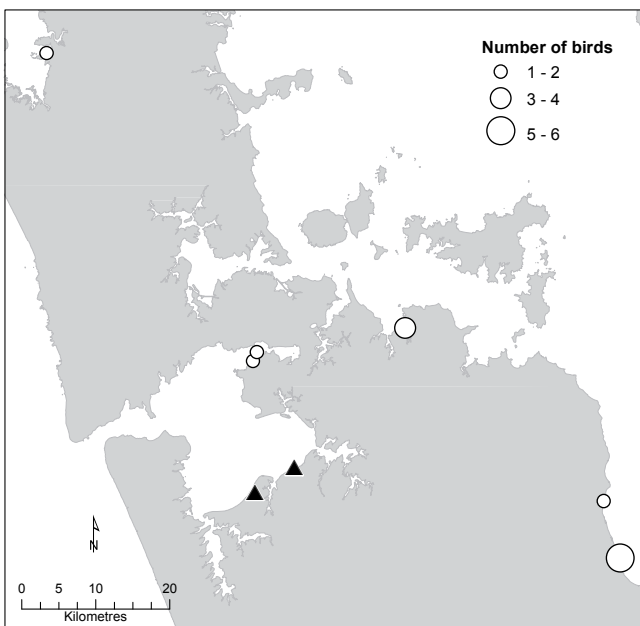


Figure 5. Sightings away from the banding district of colour-banded bar-tailed godwits, *Limosa lapponica*, banded at the Manukau Harbour sites, in South Auckland. Triangle symbols show the banding sites.

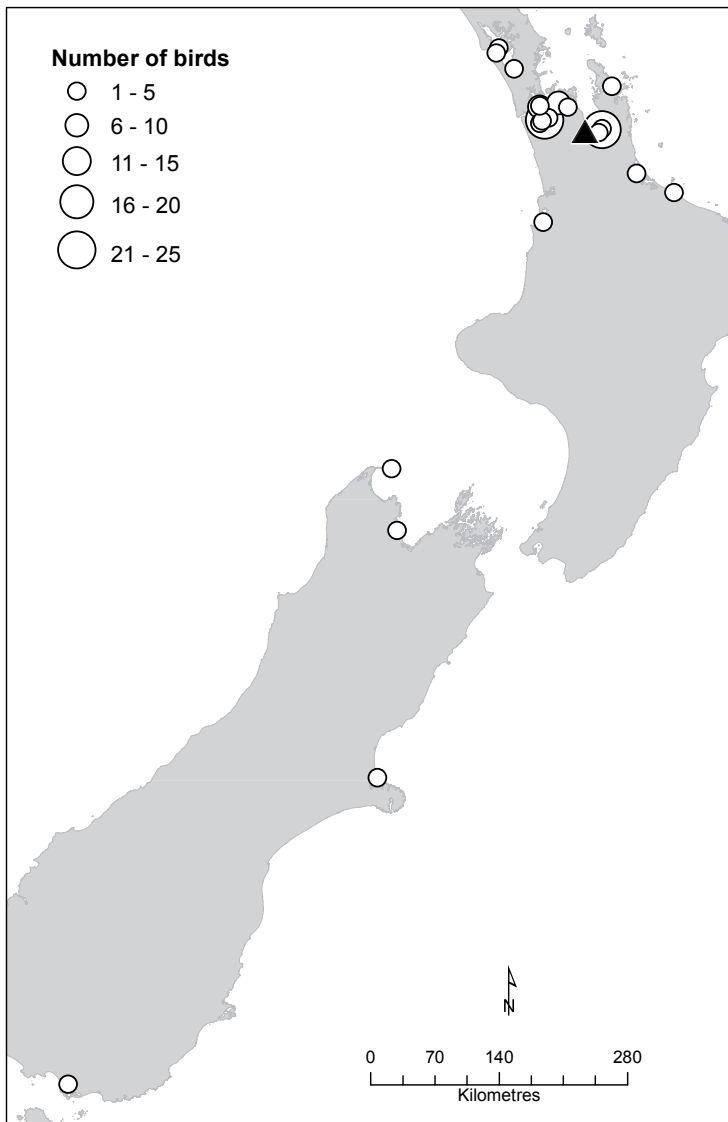


Figure 6. Sightings away from the banding district of colour-banded bar-tailed godwits, *Limosa lapponica*, banded at the Firth of Thames sites, in South Auckland. Triangle symbol shows the banding sites.

on the west coast and can be avoided by flying to the east coast, where the tide will already be receding (A.M. Habraken, OSNZ, pers. comm. 2006; PFB, pers. obs.). The remaining ten records of eight birds were from Kaiawa and Miranda, Firth of Thames (45–66 km east of the southern Manukau Harbour), spread mostly across summer (nine records in November–March; one mid-September record coincided with the arrival of migrating birds).

SOUTH AUCKLAND: FIRTH OF THAMES

The Firth of Thames had the most intensively studied sites, partly through being the study area for mark-resighting studies of shorebirds coinciding with this project (PFB, unpubl. data). Of 218 godwits banded, 208 were resighted a total of 3752 times. Seventy of these birds were recorded 177 times elsewhere in the North Island away from the western shores of the Firth (Fig. 6). About 75% of those resightings were from the Auckland region (sites in Manukau Harbour, Whitford, Clevedon, and southeastern Firth of Thames), with almost 25% (40) from 25 birds seen further south or east within the Firth (Piako River mouth, Waihou River mouth and Thames, 15–19 km away). Sightings away from the Firth are discussed by region below.

NORTH AUCKLAND

Three immatures were seen in the Kaipara Harbour, 103–130 km away, during excursions away from the Firth that may have lasted up to 5.5 months, 7 months and even, possibly,

1.5 years before returning to the Firth. One record on 17 March 2007 could represent a migrant relocating before departure (banded as an immature in March 2004, this bird would have been adult in 2007). Three adults were also recorded in the Kaipara Harbour district. One made a summer visit of unknown duration (but less than 1.5 months: seen on 19 January 2005, 5 days after banding in the Firth, and then seen again in the Firth in March), one was a confirmed migrant (resighted in China and Alaska in different years) probably relocating before departure (20 March 2007) and one record was uninterpretable, the bird having been seen once in August after not having been recorded for 1.5 years.

AUCKLAND

Nineteen adults were recorded in eastern or southern Manukau Harbour or Turanga Creek, Whitford. Eight were migrants completing their southward migration in September or October; five of these were later confirmed to be back in the Firth of Thames during that same season, being seen there 9, 12, 15, 19 and 29 days after their Manukau Harbour sightings. There were two records of birds in the Manukau Harbour on their northward migration. One was seen on 5 April 2006, a year when bad weather at the end of March delayed departures (PFB, unpubl. data). The other was seen on 25 March 2006.

Other birds made short-term return visits to the Manukau Harbour sites or Whitford, being seen in October, December, January, February (two birds), March and July (a bird aged as adult but not actively putting on weight for migration when caught in March). One of these sighting records had a definitive, 1-day duration associated with it: a bird seen at Kaiarau, Firth of Thames, on 17 March, Karaka, Manukau Harbour, on 18 March and Kaiarau again on 19 March. Another two birds were seen at the Manukau Harbour sites or Whitford in mid-March, but it is not clear whether these birds made return trips or carried on with migration from Auckland.

Eleven birds banded as immatures were seen in the Auckland region. Eight of these made short-to medium-duration excursions away from the Firth of Thames to the Manukau Harbour and Mataitai, Clevedon. It was impossible to estimate the durations of most of these trips with any accuracy, but one lasted at least 4 months, one up to 3 months, and another at least 1 month. One bird banded at Miranda was probably a bird from the Manukau Harbour making a visit to the Firth of Thames—it was seen subsequently 14 times in the Manukau Harbour but only four times in the Firth, each record representing a separate visit. One immature relocated to the Manukau Harbour permanently (banded November 2004; seen at Clarks Bay, Karaka and the Mangere Sewage Ponds, Manukau Harbour, December 2005 – October 2007); another appeared to have done so (banded February 2006; seen at the Firth of Thames March–June 2006, and in Manukau Harbour September–December 2006 and again in 2008) but subsequently returned to the Firth. Finally, a bird banded at Miranda as a possible 2-year-old in October 2004, and seen 37 times in the Firth of Thames, was recorded in the Manukau Harbour (Karaka and Mangere Sewage Ponds, respectively) in December 2005 and September 2006. In both years, it had been previously resighted in March, so it may have been a migrant returning from the breeding grounds.

COROMANDEL

Two adults were seen at Matarangi (58 km from the Firth), on the northeast side of Coromandel Peninsula. One may be resident there but moves through the Firth of Thames before and after migration to the breeding grounds (all Firth records were dated November or March; Matarangi records were for January, when birdwatchers were holidaying there). The other was an old bird (a previously-banded bird aged 15+ when colour-banded in 2004) seen just once at Matarangi, in late October, and may have been returning to the Firth (where it has been seen 31 times) after migration.

BAY OF PLENTY

Three birds caught during the arrival period after the southward migration (21 September 2004) were subsequently seen at Maketu Estuary (118 km away). Two of these were adult females that had apparently stopped at Miranda after arriving in New Zealand. One of them was seen at Maketu Estuary in October and December 2004 and in February 2007. Later that year, in November, it was seen three times at Miranda, probably en route to the Bay of Plenty. The second adult was seen only once again in New Zealand, at Maketu Estuary on 4 February 2006 (though it was seen in South Korea in April 2006 and 2007). Presumably, this bird usually lives elsewhere in the Bay of Plenty or further east. Both birds were extremely light when caught (they were large females yet weighed 264 g and 247 g, rather than 300–350 g), indicating that they had just arrived from migration in poor condition. The final bird was an immature that had been present on the Miranda coast from September 2004 to at least the end of November 2004 and was subsequently seen 11 times at Maketu Estuary. It migrated north in 2006 (seen in Alaska in August), returned to Maketu Estuary (1 January 2007) and made a return visit to Miranda in January–February (seen at Miranda 8 February, and at Maketu Estuary 27 February). The only other Bay of Plenty records were for a juvenile that visited Tauranga Harbour (Matahui Point, 72 km away) in February and August (confirmed to be back in the Firth of Thames after both sightings) and a possible juvenile that was seen at Matahui Point in August 2005 but was back in the Firth by November that year.

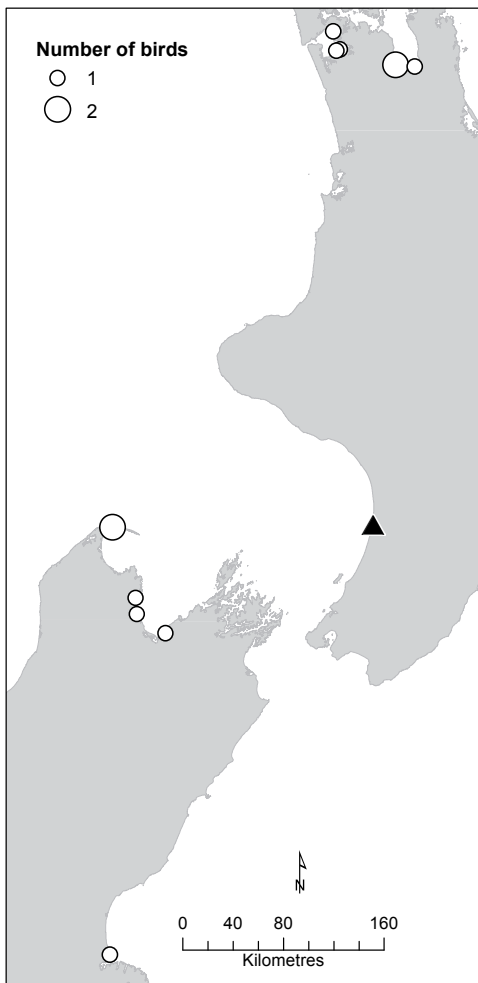


Figure 7. Sightings away from the banding district of colour-banded bar-tailed godwits, *Limosa lapponica*, banded at the Manawatu River Estuary, Manawatu. Triangle symbol shows the banding site.

WAIKATO

The sole record from the Waikato (in which there had been very few intensive searches for banded birds) was of an adult seen on 24 February 2005 at the entrance to Raglan Harbour. It had been seen in the Firth 18 days earlier and had returned by 28 April, so was away for at most 2.5 months. It did not migrate that year.

MANAWATU: MANAWATU RIVER ESTUARY

The Manawatu River Estuary is geographically isolated compared with most other banding sites, being 187–216 km from sites in Golden and Tasman Bays, 365 km from sites at Miranda and 400 km from the Avon–Heathcote Estuary, Canterbury. Eighty godwits were banded at the Estuary, 77 of which were resighted after banding. Of the three that were not, one was a fuelling (feeding and laying down body reserves) adult female caught in mid-February, one was an adult caught on 21 September that was potentially moving through the estuary to another wintering site, and one was immature.

The estuary affords excellent resighting opportunities, and the intensive resighting efforts of Jesse Conklin have helped generate a huge number of resightings of locally-banded birds (1952 records). Only six birds have been seen elsewhere in the North Island (Fig. 7). Three of these were adults, on their southward migration, seen in the Auckland region (at sites in the Manukau Harbour and the Firth of Thames) in September and October 2007, and were back in the Manawatu the same season. A fourth adult, banded in February 2006, was recorded the next summer only from sites at the Firth of Thames (four times). This bird apparently changed its wintering site or was originally caught and banded during an exploratory movement within New Zealand. The two remaining birds were recorded near Auckland during the southern winter: one adult in the

Manukau Harbour in mid-April 2006 and one immature at Miranda in late August 2007. The latter bird seemingly left the Manawatu for the winter (last seen 15 April 2007 before returning in spring (seen 9 September 2007).

GOLDEN BAY: FAREWELL SPIT

Seventy-seven godwits were banded at the eastern tip of Farewell Spit in February 2006, of which 66 were subsequently seen. Of the 313 records for all of New Zealand, 299 were from Golden Bay, mostly from Farewell Spit (see Fig. 8 for all resightings). Most of the resightings were from near the end of the spit (Lighthouse to Tip section, 216 records of 61 birds) with decreasing numbers further west (Lagoon to Lighthouse, 38 records of 30 birds; Mullet to Lagoon, 11 records of 9 birds; Stockyard Point to Mullet, 11 records of 8 birds). These observations suggest that godwits are faithful to particular parts of Farewell Spit. Furthermore, there was a divide of sorts between Stockyard Point (8 km from the base of the spit) and the Gobi Desert (3 km from the base). Stockyard Point birds left the roost heading southeast to the large central tidal flats of Farewell Spit, whereas birds from Gobi Desert headed southwest to the shores around Puponga at the base of the spit (RS & DSM, unpubl. data; this appears to be a frequent movement). Birds colour-flagged in earlier work in Golden Bay were seldom recorded beyond Gobi Desert (RS & DSM, unpubl. data). There was a small amount of movement to the base section of the spit: eight godwits banded at the tip of the spit were seen in the Puponga–Gobi Desert section 13 times, and seven of these were subsequently recorded on the outer half of the spit. Eight birds were seen ten times in Golden Bay itself, mostly at Pakawau (28 km away); five of these returned to the outer spit.

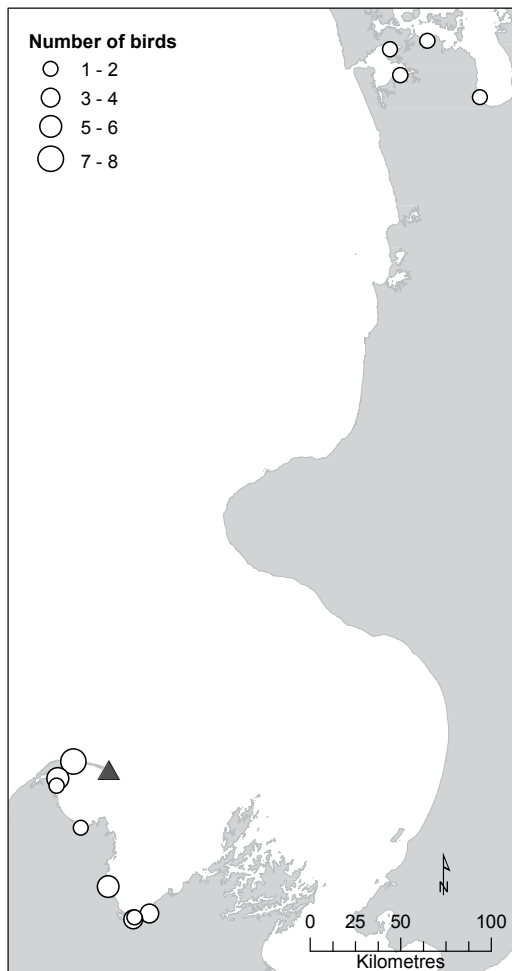


Figure 8. Sightings away from the banding district of colour-banded bar-tailed godwits, *Limosa lapponica*, banded on Farewell Spit, Golden Bay. Triangle symbol shows the banding site.

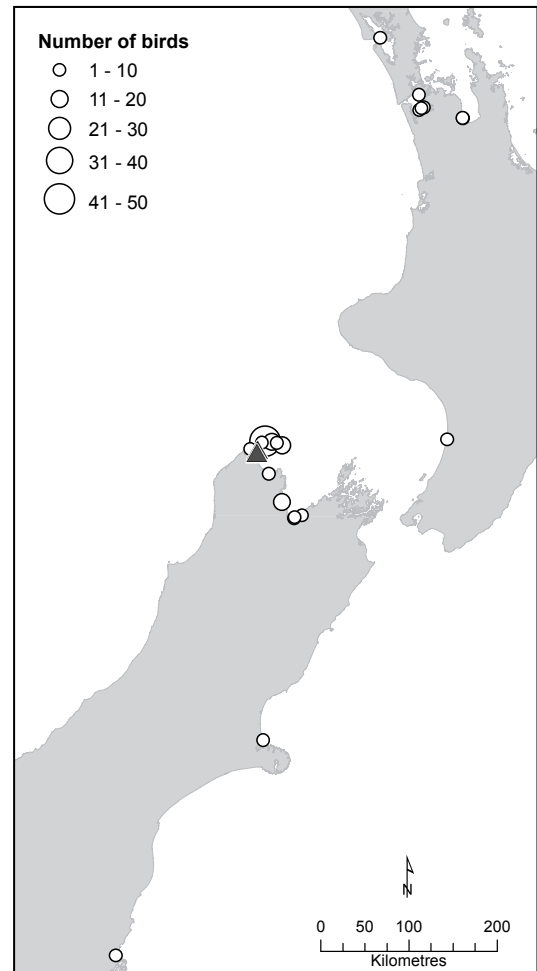


Figure 9. Sightings away from the banding district of colour-banded bar-tailed godwits, *Limosa lapponica*, banded on the western shores of Golden Bay. Triangle symbol shows the banding sites.

Longer-distance movements were made by nine birds that were seen in Tasman Bay (Motueka Sandspit, 64 km away, two records; Waimea Inlet, 84 km, four records; Nelson Haven, 82 km, four records). The dates of two of these records could indicate that the birds had arrived from migration (October), but other records clearly did not. These included birds seen at Motueka Sandspit and Waimea Inlet in November that were seen on Farewell Spit the previous October and the following February. Two adult birds were seen at Waimea Inlet in mid-late March and were probably making premigratory movements. One of these was seen in Waimea Inlet in October 2006, then Gobi Desert, Farewell Spit, on 18 February 2007, Nelson on 18 March 2007, tip of Farewell Spit on 21 March 2007, and Gobi Desert, Farewell Spit on 22 March 2007, confirming two ‘commutes’ between Tasman Bay and Farewell Spit within a single season.

GOLDEN BAY: WESTERN SHORES

Seventy-six godwits were banded at Pakawau and Totara Avenue. All but one of these were subsequently resighted, 608 times in total. Of these resightings, 345 were South Island records away from the banding district, predominantly from Farewell Spit (Fig. 9). There, 50 birds were seen 198 times in the Puponga-Gobi Desert section; 14 birds, 17 times in Stockyard Point-Mullet; four birds, four times in Mullet-Lagoon; and 13 birds, 31 times in the Lighthouse-Tip section. It seems that birds banded in Golden Bay are far more likely to be seen at Farewell Spit than the reverse. This is likely due to disturbance factors along the Golden Bay coast where both human disturbance and very high tides usually result in birds moving northeastwards to the Gobi Desert area at the base of Farewell Spit (RS & DSM, unpubl. data).

At Westhaven Inlet, only two banded birds were resighted (from five checks totalling 2920 scanned birds), each a single time. They were seen c. 10 km from the banding site, over a range of hills. Elsewhere around Golden Bay away from the banding sites, there were eight records of three birds at Rototai (24 km) and five records of four birds at Taupata Creek, just south of Puponga. In Tasman Bay, 22 birds were seen, including one seen 21 times at Nelson Haven. This was an immature that had apparently settled in Nelson within 4 months of being banded in December 2005. Most other birds were seen just a few times in Tasman Bay. Another exception, however, was 1YYYYB, which made several movements between Golden Bay and Tasman Bay. Banded in December 2004 at Totara Avenue, Golden Bay, it was seen four times on Farewell Spit and at Pakawau before apparently migrating in March 2005. It was seen four times in Nelson Haven from 15 November 2005 to 16 January 2006, but the next day was back at Pakawau, where it was also seen

on 3 February. By 13 February it was at Nelson Haven again, was seen at Farewell Spit from 15 February to 17 March, yet on 19 March was back at Nelson Haven. It was seen in China in April that year. Another bird, 5YWYY, was banded on 3 February 2007 at Totara Avenue, but was thereafter seen only at Motueka Sandspit (six times), suggesting that it had been caught during a local movement.

The only long-distance movement within the South Island of a Golden Bay godwit was by 1YWBB, banded as a juvenile in December 2004. This bird wandered widely, being seen at Farewell Spit during February 2005 - January 2006, at the Manawatu River Estuary in April, August and September 2006, and at Warrington, Otago, on 19 September 2006, before heading north to Miranda by 1 October 2006. It was seen there twice in December, and migrated north in 2007 (seen in South Korea in April). It returned to Miranda by 3 November 2007 and was at Farewell Spit on 10 February 2008.

TASMAN BAY: MOTUEKA SANDSPIT

All 46 godwits banded at Motueka Sandspit were resighted, a total of 380 times. Away from the banding site, 33 birds were resighted 115 times (Fig. 10). Most were seen at Waimea Inlet (particularly Bell Island) and Nelson Haven (22-25 km away; 78 records) or Marahau (13 km to the north; eight records). Only two birds from Motueka Sandspit were seen in Golden Bay, one of which was an adult that had migrated in 2005 (seen in South Korea on its northward migration and at the Kaipara Harbour on the southward migration), had returned to Tasman Bay, but was seen at Farewell Spit the following winter (July 2006).

To the south, a single bird (3WWRY) banded as an adult at Motueka on 18 November 2005 was subsequently seen 24 times in Canterbury (Ashley Estuary and Avon-Heathcote Estuary, 271 km away) and just three times in Tasman Bay. It overwintered in New Zealand in 2006, migrated in 2007 (it was seen in China), and returned to Canterbury after the breeding season. This bird was probably still migrating when caught, possibly arriving in New Zealand too late to enable it to migrate north the following year (as is known from satellite-tagged birds; PFB & Pacific Shorebird Migration

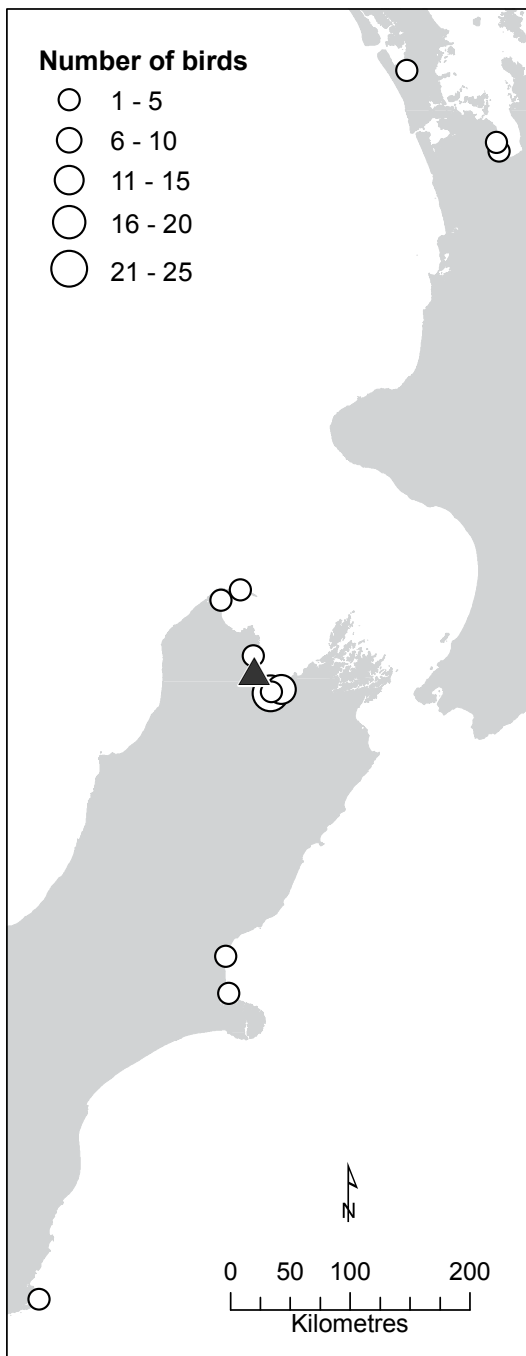


Figure 10. Sightings away from the banding district of colour-banded bar-tailed godwits, *Limosa lapponica*, banded at Motueka Sandspit, Tasman Bay. Triangle symbol shows the banding site.

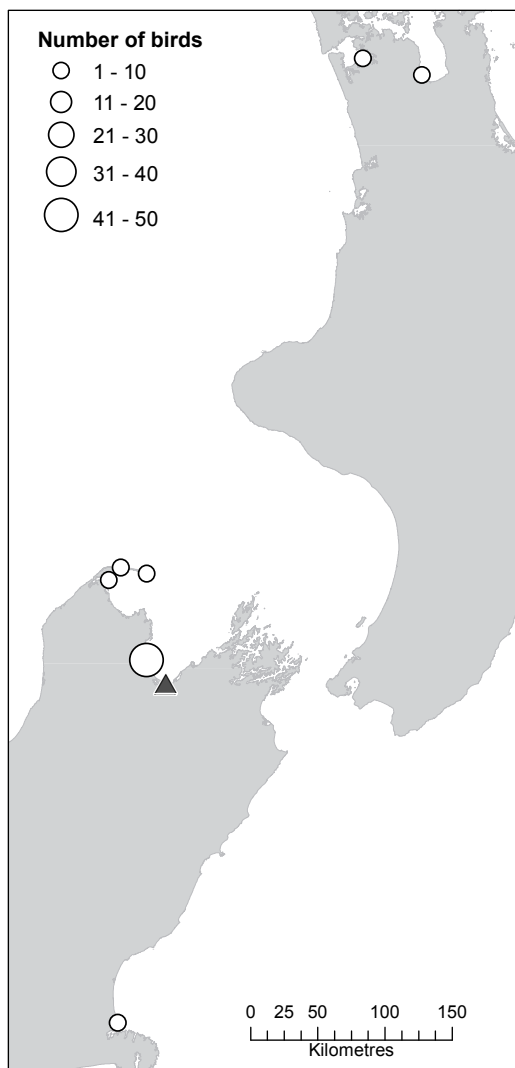


Figure 11. Sightings away from the banding district of colour-banded bar-tailed godwits, *Limosa lapponica*, banded at the Waimea Inlet sites, in Tasman Bay. Triangle symbol shows the banding sites.

Project., unpubl. data). The three records for Tasman Bay—20 March 2006 (the year 3WRRY did not migrate; 6 days later, it was back in Canterbury), 21 February and 23 March 2007—suggest that it may move to the Nelson region before migrating north.

TASMAN BAY: WAIMEA INLET

Ninety-two godwits were banded around the Waimea Inlet, Nelson (Rabbit Island and Bell Island sites). Of these, 86 were seen again, 918 times. Of these birds, 50 were resighted 93 times away from the banding district (Fig. 11). The majority of the resightings were from Motueka Sandspit (81 records of 44 birds), indicating frequent interchange between these flocks. Higher spring tides usually result in godwits from Nelson Haven moving to eastern Rabbit Island to roost with birds from east Waimea Inlet; however, if this site is disturbed or the roosting area reduced by 'king' tides, the birds move to Motueka Sandspit (OSNZ, unpubl. data). As with godwits from the Motueka district, there were very few resightings in Golden Bay, with three birds seen once each. Two of these were confirmed as making within-season 'return visits' to Golden Bay and back to Tasman Bay.

There were records of six birds (all adults) at the Avon-Heathcote Estuary in Canterbury (255 km away), with various probable explanations for their movements:

- 3WRRY was seen at the Avon-Heathcote Estuary on 8 September 2006, apparently after migration; it was back in Nelson by 7 October that year.
- 1WRRW made a mid-summer (January 2006) visit and was back in Nelson 10 days later.
- 3WBYY was recorded just once during the 2 years after banding, then it was seen at the Avon-Heathcote Estuary in October 2007 before turning up in Tasman Bay 8 days later, and was resighted there five times until late November 2007.
- 3WRRR was seen at the Avon-Heathcote Estuary on 8 November 2006 and at Nelson Haven 2 days later; in 2007, it was at Nelson Haven on 11 and 15 October, at the Avon-Heathcote Estuary on 29 October, but back at Nelson Haven by the following January.
- 3WWRB, banded in November 2005, was seen in Tasman Bay in February, March and April, and on 2 November 2006, but was at the Avon-Heathcote Estuary on 9 November 2006. The next March, it was back in Tasman Bay, and the following season after migrating (it was seen in China), it was resighted regularly around Tasman Bay (January 2008). There is the possibility that this bird lived at a site south of Tasman Bay during the non-breeding season and passed through the northern South Island on its northward and southward migrations, but changed its wintering site in 2007/08.
- 1WRRR was seen only twice ever (Avon-Heathcote Estuary in March 2005, Nelson Haven in October 2007), and was probably a resident at a site away from observers.

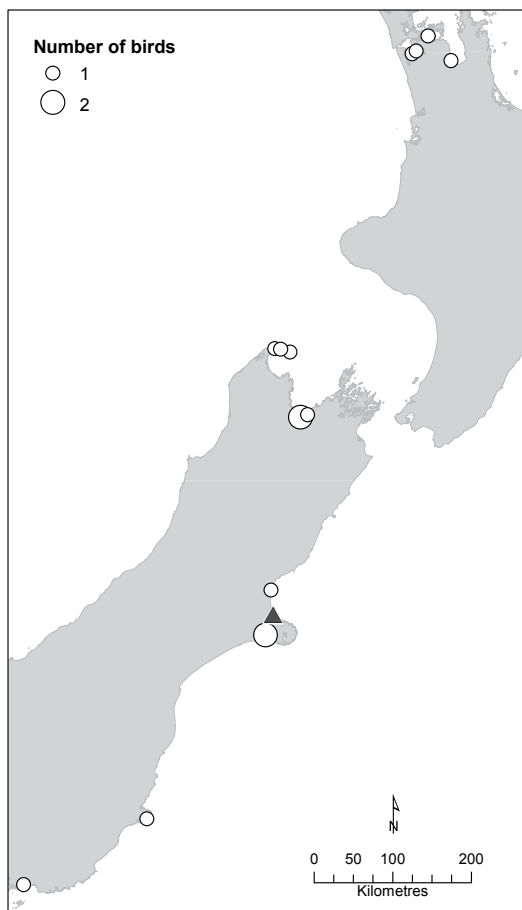


Figure 12. Sightings away from the banding district of colour-banded bar-tailed godwits, *Limosa lapponica*, banded at the Avon-Heathcote Estuary (formal name: Estuary of the Heathcote and Avon Rivers/Ihutai), Canterbury. Triangle symbol shows the banding site.

CANTERBURY: AVON-HEATHCOTE ESTUARY

Of the 67 godwits banded at the Avon-Heathcote Estuary (formal name: Estuary of the Heathcote and Avon Rivers/Ihutai), all but one have been seen again. Of the 1259 records in total, only 13 (involving ten birds) are from elsewhere in the South Island (Fig. 12). Three were from nearby, in Canterbury (Ashley Estuary and Lake Ellesmere (Te Waihora), 25-30 km away), one was from Hoopers Inlet in Otago (300 km southwest; this record, in October 2006, was the only sighting of the bird, which had been banded in February 2005) and one was from Waituna Lagoon, Southland (475 km southwest; the record is of an immature seen in Canterbury on 2 October 2005, Southland on 16 October, and back in Canterbury on 13 November).

Six birds were seen in the northern South Island. Resightings of two of the birds were attributable to migration. One (1RRBB) was a bird seen on Farewell Spit on 20 March 2007, presumably about to embark on its migration to Asia. The other (1RBWR) was seen at Nelson Haven on the morning of 2 October 2005, and by the next morning it was at the Avon-Heathcote Estuary. The number of godwits roosting at Nelson Haven dropped at the same time, from 561 (1 October) to 509 (3 October), suggesting that a group of up to 50 or so godwits could have been involved in the flight to Christchurch (previously, the Nelson Haven flock had increased from 330 on 23 September to 372 on 26 September).

Two birds were recorded making 'unseasonal' visits to Tasman or Golden Bays. One (1RYWW) was seen at the Avon-Heathcote Estuary on 15 March 2005, was absent over the winter, seen at the Avon-Heathcote Estuary on 1 and 13 October, but was recorded at Nelson Haven on 3 November 2005. It was 2 years

before it was seen again at the Avon-Heathcote Estuary, so it may have temporarily shifted its non-breeding site. The other bird (3YRRR) was seen during two visits to Golden Bay in February 2007 and November 2008. In both cases, it had been seen in Canterbury 1-2 months before or after the Golden Bay records.

Lastly, one adult spent the summers of 2004/05, 2005/06 and 2006/07 at the Avon-Heathcote Estuary but was recorded on Farewell Spit on 26 November 2007, and a 3rd-year overwintered at the Avon-Heathcote Estuary in 2005 (it was seen there 11 times to 20 August), was seen at Waimea Inlet on 9 September 2005, then was back at the Avon-Heathcote on 30 September and was seen there 14 times thereafter.

OTAGO: WARRINGTON

Thirty-nine godwits banded in Otago generated 176 sightings of 33 birds. Over 30% of those records are for birds that moved short distances to the Otago Peninsula (Fig. 13): 44 records of 16 birds at Aramoana (10 km away), nine records of nine birds at Hoopers Inlet (15 km) and single records of two birds at the adjacent Papanui Inlet. The other local records are from a similar distance northwards (four records of one bird at Karitane, 10 km away).

There were just two records of Otago-banded godwits elsewhere in the South Island. One was an adult banded in February 2006 that was seen on Farewell Spit (605 km away) on 31 March 2006. The dates are consistent with the bird being a late migrant stopping off at the spit before embarking on a transoceanic flight, but the bird was back in Otago in July that year. It may have attempted to migrate but returned rather than carrying on. The other record was of a possible juvenile banded in February 2006 that was seen at the Avon-Heathcote Estuary, Christchurch, on 26 September 2008. That summer it was back in Otago, so could have been returning from migration.

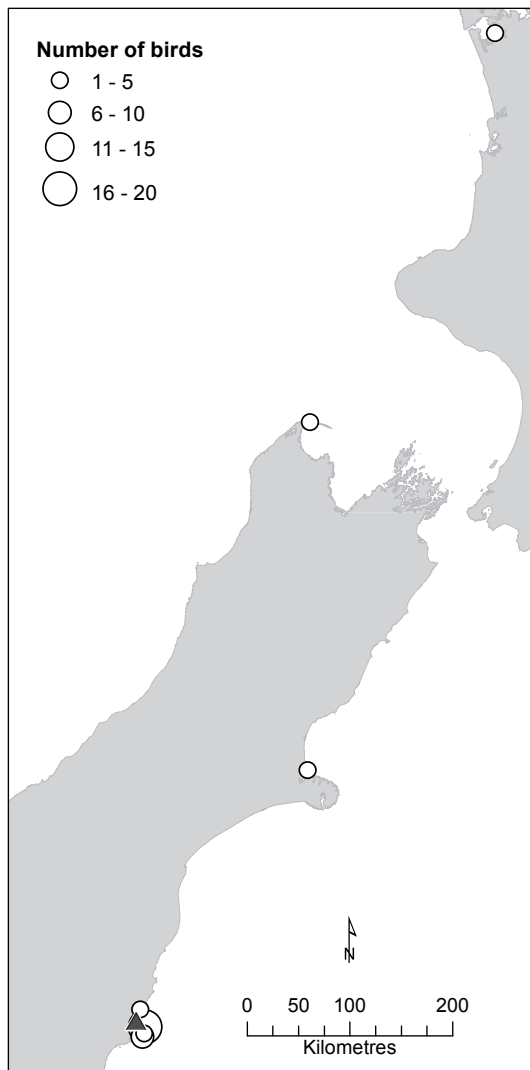


Figure 13. Sightings away from the banding district of colour-banded bar-tailed godwits, *Limosa lapponica*, banded at Warrington, Otago. Triangle symbol shows the banding site.

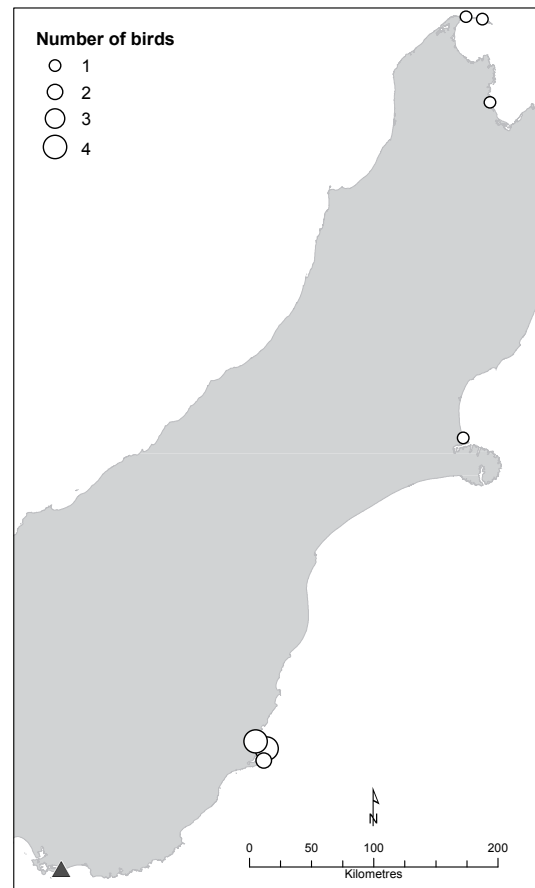


Figure 14. Sightings away from the banding district of colour-banded bar-tailed godwits, *Limosa lapponica*, banded at Awarua Bay, Southland. Triangle symbol shows the banding site.

SOUTHLAND: AWARUA BAY

Awarua Bay, the southernmost banding site, had the fewest godwits banded (22) and is the least populated site in terms of birdwatchers. Accordingly, it generated the smallest numbers of resightings (104 records of 21 birds). Nevertheless, nine birds were seen 31 times away from Awarua Bay (Fig. 14).

Six birds (four banded as juveniles, two as adults) were seen in Otago (185–191 km away). One juvenile (1BBBW) settled in Otago, being seen 13 times at Aramoana, Blueskin Bay and Hoopers Inlet in July 2005 – February 2008. Another (1BBYY) was banded in October 2004, was seen at Hoopers Inlet in October 2005, but was back in Awarua Bay by 3 and 4 March 2006. On 16 March 2006, it was in Otago again (Aramoana), and migrated north that year, being seen in Alaska in August 2006. The next season (later in 2006) it was seen back in Otago; and again in November 2006. It was seen in Otago in February 2007 and 2 March 2007, but two days later (4 March) was in Southland, at Awarua Bay. By 8 March 2007, it was back in Otago. The following February (2008) it was seen in Awarua Bay. While the records are patchy, they suggest that movements between Southland and Otago may be frequent, though resighting coverage is insufficient to determine whether these movements are more frequent in the premigratory period. The other two juveniles were seen only three times (Otago, in February–March 2007 after being banded in October 2004) or just once (also in Otago).

Of the two adults seen in Otago, one was seen at Aramoana on 7 March 2007, 3 days after having been seen in Awarua Bay. This is consistent with a movement northward before embarking on migration. The other has been recorded only once in New Zealand, at Blueskin Bay in November 2006, 11 days after banding.

A single adult was seen at the Avon–Heathcote Estuary, Canterbury (473 km away), on 17 September 2005, presumably making a stopover en route to its wintering grounds where it was seen in the following March. Two birds were seen in the northern South Island: a 2nd-year bird (banded as a juvenile in October 2004) was at Motueka Sandspit in October 2005, and an immature of uncertain age (caught in November 2006) was seen on Farewell Spit in March and May 2007 (but was back at Awarua Bay in December 2007 and February 2008).

3.2 Red knots

Knots were caught at substantially fewer locations and in smaller numbers than godwits (Tables 7 and 8). This was especially true for the South Island, where only 30 knots were caught, mostly in a single catch at Rabbit Island, Tasman Bay, on 16 November 2005. Of the 345 knots caught,

203 (58.9%) were caught at the Firth of Thames. Knots from only the Firth of Thames were sexed genetically; there was a male bias in the sample (61.8% male, $n = 157$). This is a significantly different sex ratio to that found in godwits at the same site (Fisher's exact test, $P = 0.0011$). Observations of knot plumages indicate that very few arrive in New Zealand as juveniles during the southern spring (PFB, pers. obs.), which is supported by the small numbers of juveniles (i.e. first austral summer birds) caught in this study (20, or 5.8% of the total). However, quite large numbers of often difficult-to-age immatures (2- or 3-year-old birds) were caught (96, or 27.8%). The explanation for the disparity is that many young knots spend some time in eastern Australia before coming to New Zealand (Riegen et al. 2005), and the immature population includes up to three age cohorts.

Table 7. Capture locations of red knots, *Calidris canutus*. Sites are arranged from north to south. For latitudes, longitudes and New Zealand Grid references see Table 1 and/or Appendix 1.

SITE	REGION
North Island	
Parengarenga Harbour	Far North
Kaipara Harbour, Jordan's Farm	North Auckland
Manukau Harbour, Clarks Bay	South Auckland
Manukau Harbour, Karaka	South Auckland
Firth of Thames, Kaihua*	South Auckland
Firth of Thames, Taramaire	South Auckland
Firth of Thames, Miranda (Shellbanks and Stilt Ponds)	South Auckland
Manawatu River Estuary	Manawatu
South Island	
Motueka Sandspit	Tasman Bay
Waimea Inlet, Rabbit Island	Tasman Bay
Awarua Bay	Southland

* A single bird from the Manukau Harbour, rehabilitated after a bout of possible botulism.

3.2.1 Resightings

In total, 1579 resightings were made of 275 knots (79.7% of the banded birds), individual birds being resighted 1–20 times (Table 9). The only knot banded in Southland was not seen again, but birds from all other banding regions were resighted. As with godwits, birds banded in well-watched

areas such as Miranda and the Manawatu River Estuary were seen most frequently, though in contrast to godwits, many sightings were away from the banding site or region. Of all knots that were seen again after banding, almost 25% were seen in a different region to that in which they were banded. This is evident in Table 10, which shows the distribution across New Zealand of resightings of birds banded at different sites. For the Manawatu River Estuary, for instance, almost 25% of the sightings were at other sites, mostly around Auckland. There is a strong bias in the resightings, however, towards the Auckland region, where knots are both numerous and able to be observed closely. In contrast, although knots are also common in the Far North, for example, conditions are more challenging for checking for bands, few observers are able to visit, and so fewer resightings were made there. Hence, while the data suggest that few knots from Parengarenga Harbour stay there (only 11% of the resightings are in the Far North, compared with 70% around Auckland), little resighting effort was made there after banding and the Auckland records represent just 21 sightings of 11 birds, out of 37 banded. This is discussed further below.

Table 8. Sex, capture locations and age of colour-banded red knots, *Calidris canutus*. Unk = unknown. Ages refer to the age relative to a birthday of 1 August rather than a calendar year.

REGION	SITE	AGE (year)														TOTAL				
		1	1?	1/2	1-2?	2	2?	2/3	2/3?	2?/3	2+	3	3?	3+	7+		8+	9+	17	UNK
Female																				
South Auckland	Firth of Thames, Taramaire and Miranda	3			14	2	1			5	4		30			1				60
Male																				
South Auckland	Firth of Thames, Taramaire and Miranda	8	1	1	18		4	1	3	3	4	51	1	1						97
Unknown sex																				
Far North	Parengarenga Harbour								5			32								37
North Auckland	Kaipara Harbour, Jordan's Farm	1							5			25								31
South Auckland	Manukau Harbour, Karaka				1				4			1								6
South Auckland	Manukau Harbour, Clarks Bay						1					4								5
South Auckland	Firth of Thames, Taramaire, Miranda and Kaihua	6		1	12	6	7	1	1	1	1	9				1				46
Manawatu	Manawatu River Estuary	2	3		7	1			1			19								33
Tasman Bay	Motueka Sandspit											5								6
Tasman Bay	Rabbit Island, Waimea Inlet				1	1			1			18							2	23
Southland	Awarua Bay											1								1
Total		20	4	2	1	53	10	13	1	24	9	6	195	1	2	1	2	345		

Table 9. Number of resightings of individual red knots, *Calidris canutus*, within New Zealand from different banding sites or districts (excluding birds that were never seen again).

BANDING SITE(S)	MEAN	MAX	MIN	SD	n
Parengarenga Harbour, Far North	1.9	6	1	1.4	13
Jordan's Farm, Kaipara Harbour, North Auckland	2.9	10	1	2.6	17
Manukau Harbour (Clarks Bay and Karaka), South Auckland	1.8	3	1	1.0	6
Miranda coast, Firth of Thames, South Auckland	6.5	20	1	4.3	192
Manawatu River Estuary, Manawatu	6.7	19	1	4.1	31
Motueka Sandspit, Tasman Bay	1.3	2	1	0.5	4
Waimea Inlet, Nelson	2.1	5	1	1.2	12
Awarua Bay, Southland	0.0	-	-	-	0
Total	5.7			4.3	275

Table 10. Number of regional resightings (and percentage of total) of red knots, *Calidris canutus*, by banding site, including multiple records of individuals.

BANDING SITE	RESIGHTING LOCATION									TOTAL
	FAR NORTH	NORTH-LAND	NORTH-AUCKLAND	AUCKLAND	SOUTH-AUCKLAND	BAY OF PLENTY	MANAWATU	GOLDEN BAY	TASMAN BAY	
Parengarenga Harbour, Far North	3 (0.19)		3 (0.19)	2 (0.13)	19 (1.20)					27 (1.71)
Jordan's Farm, Kaipara Harbour North Auckland			11 (0.70)		34 (2.15)			5 (0.32)		50 (3.17)
Clark's Bay and Karaka, Manukau Harbour, South Auckland					11 (0.70)					11 (0.70)
Miranda coast, Firth of Thames, South Auckland	6 (0.38)	1 (0.06)	22 (1.39)	11 (0.70)	1194 (75.62)	1 (0.13)		7 (0.44)	10 (0.63)	1253 (79.35)
Manawatu River Estuary, Manawatu			7 (0.44)	1 (0.06)	47 (2.98)		152 (9.63)	1 (0.06)		208 (13.17)
Motueka Sandspit, Tasman Bay									5 (0.32)	5 (0.32)
Waimea Inlet, Nelson									25 (1.58)	25 (1.58)
Awarua Bay, Southland										0
Total	9 (0.57)	1 (0.06)	43 (2.72)	14 (0.89)	1305 (82.65)	1 (0.13)	152 (9.63)	13 (0.82)	40 (2.53)	1579 (100)

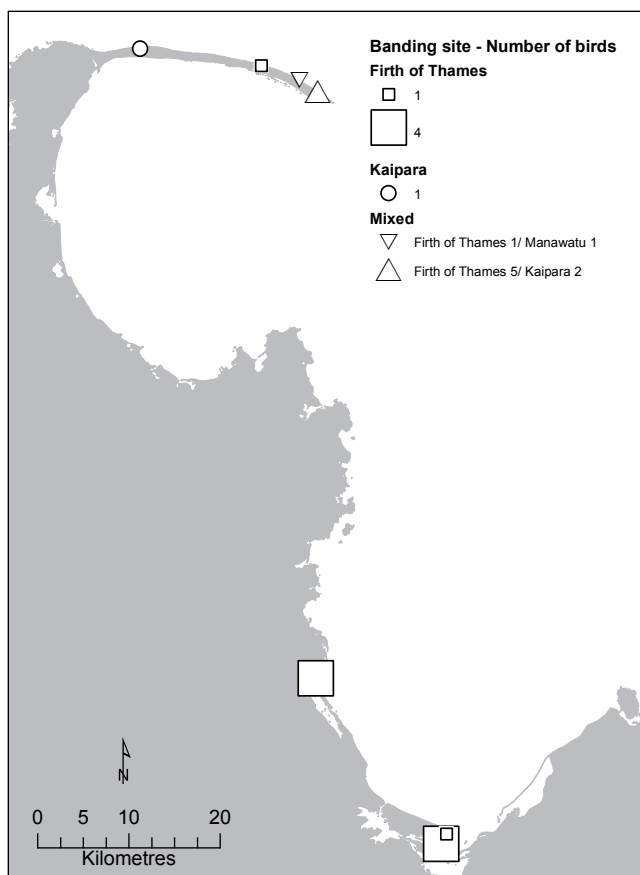


Figure 15. Sightings in the South Island of red knots, *Calidris canutus*, colour-banded in the North Island.

3.2.2 Long-distance movements

Movements between North and South Islands

Eighteen knots banded in the North Island were seen in the South Island, with 25 sightings in total (Table 11, Fig. 15; see Appendix 3 for full sighting lists of these birds). Most (15) birds were seen at just a single location in the northern South Island (mostly Farewell Spit); one was seen on Farewell Spit and at Waimea Inlet, Tasman Bay, and two were seen at both Motueka Sandspit and Waimea Inlet in Tasman Bay. The sightings were all during the spring or summer (October to March), though this is also when most checks of knots were made. There is a suggestion of higher reporting rates of North Island knots in January–March (20 sightings from 74 sessions) than in October–December (three sightings from 36 sessions: Chi-squared test, $P = 0.045$). Five of the North Island knots were immatures when seen in the South Island; the other 11 were adults. No South Island bird was definitively seen in the North Island.

Movements within the North Island

As it is evident that substantial movements occur within the greater Auckland area (i.e. between Kaipara and Manukau Harbours, and the Firth of Thames) (see section 3.2.3), only movements outside that area are detailed here.

Table 11. Interisland movements by red knots, *Calidris canutus*.

BAND	BANDING DETAILS				GOLDEN BAY: FAREWELL SPIT						TASMAN BAY			TOTAL
	BANDING SITE	DATE BANDED	AGE AT BANDING	AGE WHEN MOVED	Base to Gobi Desert	Stocky-yard Point to Mullet	Mullet to Lagoon	Lagoon to Light-house	Motueka Sandspit	Bell Island, Waimea Inlet	Rabbit Island, Waimea Inlet			
2RRWW	Kaipara Harbour, Jordan's Farm	13 Feb 05	2+	2+	3			1					4	
2RRYB	Kaipara Harbour, Jordan's Farm	13 Feb 05	3+	3+			1						1	
2RWYW	Miranda coast	26 Sep 05	3+	3+			1						1	
2RYWW	Miranda coast	17 Feb 05	3+	3+			1						1	
2WBWR	Miranda coast	06 Oct 04	3+	3+					2	1			3	
2WBWW	Miranda coast	06 Oct 04	3+	3+					1				1	
2WRBW	Miranda coast	06 Oct 04	3+	3+				1					1	
2WWBB	Miranda coast	02 Oct 04	3+	3+						1			1	
2WWWRR	Miranda coast	12 Jun 04	2-3	3-4								1	2	
2WWYR	Miranda coast	12 Jun 04	2	2									1	
2WYYR	Miranda coast	17 Nov 04	3+	3+				1					1	
2YBBW	Miranda coast	12 Jun 04	1	2-4		1							1	
2YBWW	Miranda coast	12 Jun 04	1	4					1				1	
2YBWY	Miranda coast	12 Jun 04	2+	3+					1	1			2	
2YBY	Miranda coast									1			1	
4YYBB	Manawatu River Estuary	01 Feb 06	2	3				1					1	
<i>Partials</i>														
4??WR	Parengarenga Harbour or Manawatu River Estuary					1							1	
?YBYR	Miranda coast	12 Jun 04	2	5					1				1	
Total					3	1	1	2	7	6	4	1	25	



Figure 16. Sightings away from the banding district of colour-banded red knots, *Calidris canutus*, banded at Parengarenga Harbour, in the Far North. Triangle symbol shows the banding site.

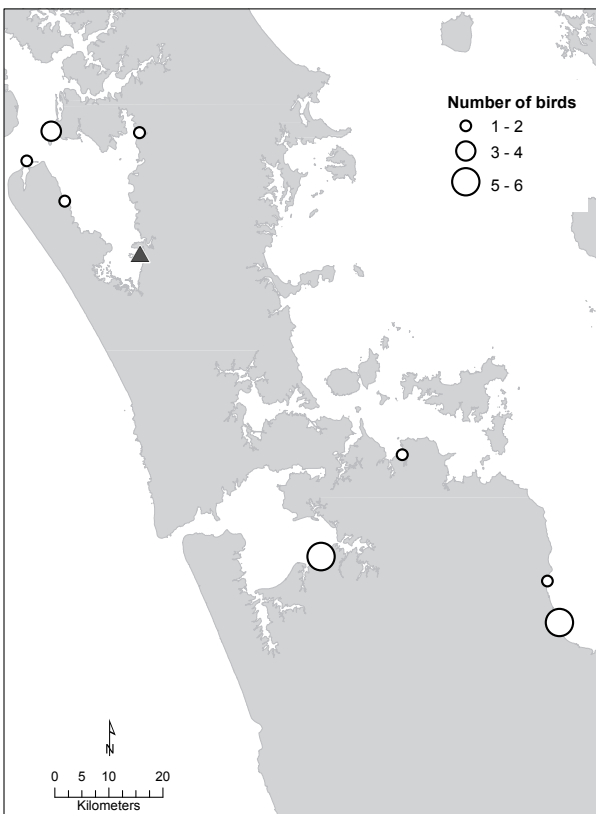


Figure 17. Sightings away from the banding district of colour-banded red knots, *Calidris canutus*, banded at the Kaipara Harbour, in North Auckland. This does not show birds seen on Farewell Spit, Golden Bay. Triangle symbol shows the banding site.

FAR NORTH: PARENGARENGA HARBOUR

Of the 37 knots banded in Parengarenga Harbour (one in September 2006, 36 in January 2007), only 11 were seen again, and only three of these at Parengarenga (Fig. 16). This is almost certainly due to poor coverage of the area by observers in 2007 (one session 9–11 November) and difficulty in tracking down roosting birds on the large Kokota Spit. Proof of considerable movement of knots between Parengarenga Harbour and the greater Auckland area (260–360 km away) comes from 24 sightings of 11 Parengarenga birds in the Kaipara Harbour (three records of two birds), Manukau Harbour (17 records of eight birds) and Whitford (four records of two birds), as well as six records of five birds banded on the Miranda coast seen later at Parengarenga Harbour (see below).

NORTH AUCKLAND: KAIPARA HARBOUR

Thirty-one knots (all but one of which were adult) were banded at Jordan's Farm in the Kaipara Harbour. Of these, 17 were seen again, but only five of the 50 resightings were away from the Auckland regions (see Fig. 17; South Island records are not shown). These were of two birds seen on Farewell Spit. One may have been resident there now (seen in March 2005, January 2006, March 2006 and March 2007); the other was seen at Miranda a month before being seen in the South Island, and again after the following breeding season.

SOUTH AUCKLAND: MANUKAU HARBOUR

No knots banded at the Manukau Harbour sites were seen at other sites; three individuals banded at each site were later seen at the same location.

SOUTH AUCKLAND: FIRTH OF THAMES

A total of 133 knots banded on the Miranda coast were seen away from the western shores of the Firth of Thames. Most resightings were in the Auckland regions (sites at Kaipara Harbour, Manukau Harbour, Waitemata Harbour, eastern Firth of Thames), but there were nine confirmed sightings of Miranda birds further afield in the North Island (Fig. 18). Five birds (three adults and two immatures) were seen six times in the Far North (mostly at Parengarenga Harbour, but a single bird was seen at Rangaunu Harbour). Three birds were later seen again in the Auckland area, one a bird probably stopping off during migration (Parengarenga Harbour, 19 October 2005; Miranda, 1 November 2005).

One adult was seen at Mataitai, Clevedon (South Auckland), 15 days before being resighted at Parengarenga Harbour; another was caught and banded on 17 February 2005 and seen in the Far North (Rangaunu Harbour) on 27 March that year.

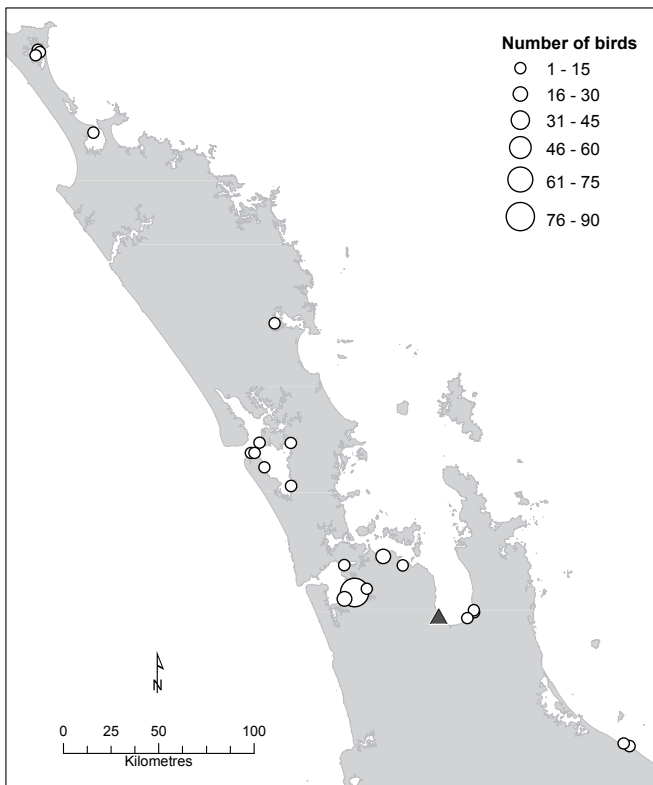


Figure 18. Sightings away from the banding district of colour-banded red knots, *Calidris canutus*, banded at the Firth of Thames sites, in South Auckland. This does not show knots seen on Farewell Spit, Golden Bay, and in Tasman Bay. Triangle symbol shows the banding sites.

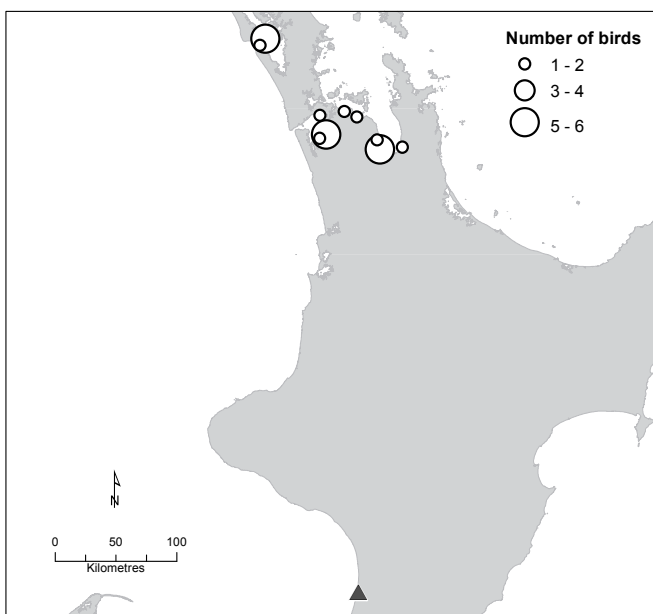


Figure 19. Sightings away from the banding district of colour-banded red knots, *Calidris canutus*, banded at the Manawatu River Estuary, Manawatu. This does not show a single knot seen on Farewell Spit, Golden Bay. Triangle symbol shows the banding site.

A single bird was seen once at Takahiwai, Whangarei Harbour (March 2006, when aged 4; it was seen in the South Island a year later, as a 5-year-old, and then returned to the Manukau Harbour sites). To the east, two adults were seen at neighbouring Maketu Estuary and Little Waihi (Bay of Plenty). One of these was seen in the Bay of Plenty on 20 February 2005 and was back in the Manukau Harbour 3 weeks later; the other was seen a year later at Turanga Creek, Whitford.

MANAWATU: MANAWATU ESTUARY

Of the 33 knots banded at the Manawatu Estuary, 14 were seen in the Auckland area, a total of 55 times (Table 12, Fig. 19). Eleven of the 14 juvenile/immature birds originally banded were recorded in the Auckland area, but only three of the 19 banded adults were (Fisher's exact test, $P = 0.0005$). This implies that young knots from the Manawatu River Estuary were much more likely than adults to be seen at other sites. The three adults were all seen around Auckland at dates when birds may have still been on their southward migration (7 October – 11 November), and all were seen back in the Manawatu in December–January (one bird was recorded for 2 years in both Auckland and the Manawatu region). A 3-year-old was also resighted on dates consistent with a southward migration (7 October – 12 December). Of the immature birds, six were seen in the Manawatu region again after having been recorded in Auckland; five were not.

3.2.3 Local movements around the Auckland regions

By far the greatest number of knot resightings (1283) were of birds banded and resighted in the Auckland regions, particularly at the Firth of Thames, where 203 were banded (Fig. 18). Of the 1253 sightings of knots banded at Firth of Thames sites, 1194 were from the South Auckland region. These were not just resightings of birds at the Firth, however. Ninety-eight knots were seen 264 times in the Manukau Harbour; 19 birds 27 times at Turanga Creek, Whitford; nine birds 21 times at Mataitai, Clevedon; and 16 birds 18 times at sites in the southeast Firth of Thames. Overall, 125 knots from Miranda (60.1% of those banded) were seen 330 times at sites away from

the western shores of the Firth, from the Manukau Harbour to Thames. Additionally, 21 birds were seen 22 times further afield, in the Kaipara Harbour.

The age composition at banding of those knots that were recorded making local movements was 41.6% adult (52 birds) and 58.4% immature/juvenile (58 immatures and 15 juveniles). This is slightly biased towards young birds compared with the age ratio of all knots banded in the Firth:

Table 12. Resightings in the Auckland regions of red knots, *Calidris canutus*, banded at the Manawatu River Estuary.

BAND	BANDING DETAILS		KAIPARA HARBOUR SITES			MANUKAU HARBOUR SITES			EAST COAST SITES			FIRTH OF THAMES SITES			TOTAL
	DATE BANDED	AGE AT BANDING	AGE WHEN MOVED	Tapora	Papa-kanui Spit	Kiwi Esplanade, Mangere	Clarks Bay	Karaka	Turanga Creek, Whitford	Mataitai, Clevedon	Kaiaua	Miranda coast mouth	Waihou River		
4YRRY	18 Feb 07	2?	2?					3				1		4	
4YRYB	18 Feb 07	2?	3?										1	1	
4YWYB	2 Feb 06	3	3	1										1	
4YWYR	2 Feb 06	2?	2?							2	11	6		19	
4WYWV	1 Feb 06	3+	3+	1			1							2	
4YBR	1 Feb 06	1	1	1				7				2		10	
4YBW	1 Feb 06	2	2					5	2					7	
4YBY	1 Feb 06	2	3					1						1	
4YRR	1 Feb 06	1?	2?					2						3	
4YWB	1 Feb 06	3+	3+									1		1	
4YWR	1 Feb 06	2	3		1									1	
4YWWW	1 Feb 06	1	2	1										1	
4YYB	1 Feb 06	3+	3+	1								1		2	
4YYW	1 Feb 06	2	2	1				1						2	
Total				6	1	1	1	19	2	2	11	1		111	

50.7% adult and 49.3% immature/juvenile. Expressed another way, movements around the greater Auckland region were recorded in 50.5% of knots banded as adults at the Firth of Thames sites, in 70.7% of immatures banded there and in 83.3% of juveniles banded there. Statistically, juvenile and immature birds (combined) were more likely to be recorded having moved than were adults (Fisher's exact test, $P = 0.0014$).

The resighting histories for knots (Table 9) are generally much less detailed than they are for godwits (Table 3), so it is less easy to determine the frequency of movements between sites. Nevertheless, there are some striking examples of the itinerant habits of knots. 2WYYY was banded in June 2004 in the Firth of Thames and seen there three times that month. On the afternoon of 7 July, it was resighted at Taporā, Kaipara Harbour, but by the next morning was back in the Firth (130 km away). It was seen in the Manukau Harbour, at Karaka, in late July and late August, and in January of the following year was in the Far North. On a smaller scale, 2WYYR was seen at Miranda late in the afternoon on 19 March 2007, at Turanga Creek, Whitford, the next morning (43 km away in a straight line or 55 km along the coast), but was back at Miranda that afternoon, having made a round trip of c. 85–110 km in 24 hours. Across all knots, 15 movements between the Kaipara Harbour, Manukau Harbour, Whitford, Clevedon and the western Firth of Thames were recorded 5 days or less apart.

Some birds were not seen especially frequently, but evidently moved around widely. 2WRBW

was seen seven times since being banded; only twice was it at the same location (in order)—Miranda, Farewell Spit, Taporā (Kaipara), Whitford, Mataitai, Karaka, Mataitai. Similarly, 2WYYR was seen six times at five locations—Maketu, Karaka, Miranda, Whitford, Miranda, and Farewell Spit.

For 49 movements within New Zealand, the date could be confirmed to a month, and to a period of 2–3 months for another 30 movements. Adults were recorded moving between sites in most months, particularly late summer (Fig. 20); immatures were recorded moving most in late winter (though most of those movements relate to the same catch of overwintering birds at Miranda).

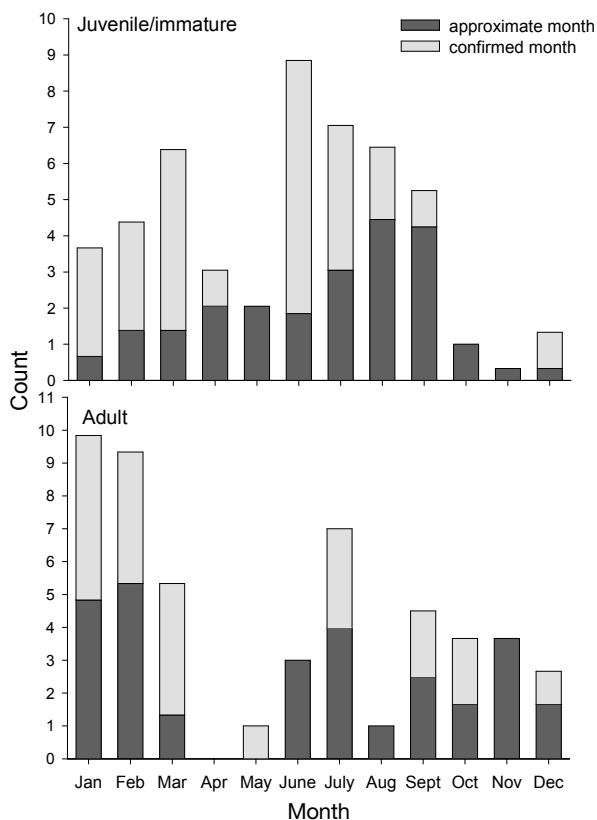


Figure 20. Timing of movements of red knots, *Calidris canutus*, between sites in the North Island, 2004–08. 'Approximate months' refers to intervals between sightings that spanned more than 1 calendar month; these have been weighted to reflect this (e.g. a 2-month possible span would be scored as 0.5 movements in each month).

3.2.4 Local movements in the South Island

TASMAN BAY

There were no long-distance movements of any of the 29 knots banded in Tasman Bay (Motueka Sandspit and Rabbit Island). Sixteen were seen during the study, at Motueka Sandspit (ten records of seven birds) and at Waimea Inlet (20 records of 12 birds). One knot banded at Motueka Sandspit was seen at Bell Island, while three birds banded at Rabbit Island were seen at Motueka Sandspit. This lack of movement contrasts with the higher movement rates of knots from the Manawatu Estuary, and may reflect the age structure of the banded birds—of 27 birds aged at capture in Tasman Bay, only two were recorded as immature or possibly immature.

4. Discussion

Colour-banding proved to be a highly effective means of clarifying the movement patterns of bar-tailed godwits and red knots within New Zealand. Although the recorded movements are only a subset of total movements, and the data are better for godwits than for knots (the former were caught more widely around New Zealand and, being larger birds with longer legs and larger bands, were typically easier to resight), numerous short-distance and long-distance movements were documented for both species. Some of these movements were attributable to birds stopping briefly while on migration, but most were not. For both godwits and knots, the proportions of birds recorded away from the banding site decreased with age (young birds moved more) and, overall, knots were much more mobile than godwits. The general patterns of movements of the two species are explored below.

4.1 Bar-tailed godwits

4.1.1 Migratory stopovers

The perception in New Zealand has traditionally been that because bar-tailed godwits arrive from their southward migration at virtually the same date throughout New Zealand, most travel directly to their destination. This would be a remarkable feat in view of the birds having just completed an 11 000+ km flight from Alaska (Gill et al. 2009) and would require superb navigational skills (though their finding New Zealand is evidence of these). However, the resighting data of individually-marked godwits revealed that at least a small number of southbound birds made stopovers before arriving at their eventual destination (28 birds confirmed or highly likely to have done so, another four may have). These data included long-distance movements of:

- Twelve birds banded in the South Island seen around Auckland/South Auckland
- One bird from Canterbury that made an overnight flight from Nelson to Christchurch, probably as part of a flock of around 50 birds
- Two Southland birds seen in the northern South Island
- One Southland bird seen in Canterbury

Additionally, resightings that indicated shorter-distance stopovers were recorded for:

- Eight birds from the Firth of Thames seen in the greater Auckland region
- Two birds from the Bay of Plenty region caught and banded in the Firth of Thames during the arrival period
- One bird probably from Tasman Bay caught at the Manawatu River Estuary one year and seen there the next
- One bird from the Manawatu River Estuary seen on Farewell Spit

The data do not allow us to determine how long these birds stayed at the stopover sites before moving on. Likewise, it is impossible to know what proportion of birds made such stopovers. However, overall, few godwits were detected making stopovers relative to the numbers banded. The fortuitous sightings of an Avon-Heathcote bird that made an overnight flight from Nelson to Canterbury coincided with a drop of the Nelson Haven flock of around 50 birds, suggesting that a flock may have been moving through. Despite intensive resighting efforts around Auckland, only four, three and five South Island birds were recorded in the years 2005, 2006 and 2007, respectively, out of potential respective pools of 157, 373 and 391 birds banded as adults in the South Island. It therefore seems probable that most godwits do indeed return fairly directly to their southern hemisphere summer location.

Recent evidence from satellite-tracking of godwits shows that some birds on southward migration turned westwards in the South Pacific and made landfall, apparently due to adverse weather conditions, but subsequently returned to New Zealand (Gill et al. 2009). Colour-band resightings also confirm that some adult godwits occur in eastern Australia during their southward migration (OSNZ, unpubl. data). How frequent these movements are is unknown. Flag sightings and recaptures of banded birds also show that some godwits (principally juvenile and immature birds) pass through southeastern and southern Australia and then settle in New Zealand (Minton et al. 2010; A.C. Riegen, New Zealand Wader Study Group, pers. comm. 2011).

Ornithological folklore in New Zealand held that, as part of their northward migration, godwits moved north within New Zealand and left in huge flocks from the Far North, or from Farewell Spit (e.g. Gordon 1938; Riley 2001). Hawkins (1980) suggested that dramatic increases in numbers of godwits at Nelson Haven in February and early March resulted from the arrival of birds from further south moving north before embarking on migration *per se*. Owen & Sell (1985) claimed likewise for godwit numbers around the same time at Waimea Inlet. In contrast, despite substantial resighting efforts in the premigratory and migratory periods, only eight northward movements within New Zealand were recorded:

- Birds from the Firth of Thames were seen at the Manukau Harbour (two) and the Kaipara Harbour (one)
- One bird from Coromandel possibly moved through the Firth of Thames
- One bird from the Manawatu River Estuary was seen on Farewell Spit
- One bird from Tasman Bay or Canterbury was seen in the Manukau Harbour
- One bird banded in Tasman Bay but apparently resident in Canterbury was seen in Tasman Bay in the premigratory period only
- One bird from Canterbury was seen on Farewell Spit
- One bird from Otago was seen on Farewell Spit (but it did not complete migration)
- One bird from Southland was seen in Otago

More than 100 adult godwits were banded in the eastern and southern South Island, and checks in the northern South Island were frequent in the February–March period (Tasman Bay, 41 checks in February, and 70 in March; Golden Bay, 33 and 35, respectively). Only two southern birds were seen a total of three times over 3 years of the study, so it is unlikely that substantial numbers of godwits from the southern and eastern South Island stop in the Tasman Bay/Golden Bay regions before flying to Asia. The benefit of moving to the northern South Island before leaving for Asia would be a small reduction in the flight distance to eastern Asia. The great circle distance between Golden Bay and the southern coast of South Korea is around 9480 km. Equivalent distances from Canterbury, Otago and Southland are 9750–9850 km. Godwits have been satellite-tracked flying just over 10000 km from Golden Bay and Miranda to the Yellow Sea region of China and South Korea (Battley et al. in press), and the sole godwit that has been tracked flying direct from Alaska to New Zealand flew approximately 11700 km (Gill et al. 2009). Whether it is beneficial to fly 500–750 km from the eastern or southern South Island to the northern shores in order to save 270–370 km in a transoceanic flight is debatable. In theory, different sites along the length of New Zealand might experience different weather systems (and waders are known to be sensitive to local and large-scale weather conditions when embarking on migration—Battley 1997; Gill et al. 2008; Conklin & Battley 2011), and therefore justify birds moving within the country before migrating internationally; no one has yet studied this. All observed migratory departures of godwits from Farewell Spit have been of birds flying more-or-less due north, towards Asia rather than towards the North Island, a route confirmed by satellite-telemetry (Battley 1997; Battley et al. in press; RS & DSM, unpubl. data).

An alternative explanation for the increases in godwit numbers recorded by Hawkins (1980) is that the birds made different roost choices as they became heavier when fuelling, leading to changes in their roost sites. This is evident in the Firth of Thames, where, in late summer, up to a couple of

thousand godwits may roost at Kaiuaa rather than their ‘usual’ sites at Miranda, 7 km south, during daytime high tides (PFB, unpubl. data). This explanation for the Nelson birds is strengthened by Hawkins’ record of 100 knots, suggesting a movement from Waimea Inlet or Motueka Sandspit (where knots occur) to Nelson Haven. It should be noted that, as a result of reclamation of the Wakapuaka area in Nelson, opportunities for roosting near Nelson during higher tides have been reduced since Hawkins’ observations, so direct comparisons are not possible.

Some short-term movements were recorded in the premigratory period (e.g. Firth of Thames to Manukau Harbour, Golden Bay to Tasman Bay), and it is possible that some individuals are more mobile before migration, perhaps as a form of physiological preparation for long-distance flight. Godwits are clearly capable of extremely long flights, and a satellite-tagged bird in Alaska was recorded making repeated journeys between the Yukon-Kuskokwim Delta and the Alaska Peninsula, an 800-km round-trip, while fuelling for a trans-Pacific migration (R.E. Gill, Jr., US Geological Survey & Pacific Shorebird Migration Project, pers. comm., 2011).

4.1.2 Non-migratory movements

On the whole, most godwits seemed highly sedentary, being recorded in just a single region. At the finer scale, however, movements were not infrequent. Forty-four percent of the godwits that were resighted were seen away from their banding site or district (which, as defined here, usually comprised up to 10–20 km of coastline), though these records constitute less than 10% of the total resightings. These results reflect the overall high site-faithfulness evident in godwits—even

those birds sighted elsewhere tended to return to their banding site and be seen multiple times there.

Medium-distance and long-distance movements (e.g. between regions or islands) were recorded in birds from all banding sites. The longest movement was from Miranda, South Auckland to the New River Estuary, Southland (1185 km). Long, wandering journeys were predominantly made by juvenile or immature birds; adults tended to move shorter distances (almost 73% of recorded movements by adults were less than 10 km from the banding site: see Figs 21 & 22 and Battley et al. in press).

For some young birds, these journeys resulted in a bird settling at a different location from where it had been banded. For adults with good resighting coverage, the

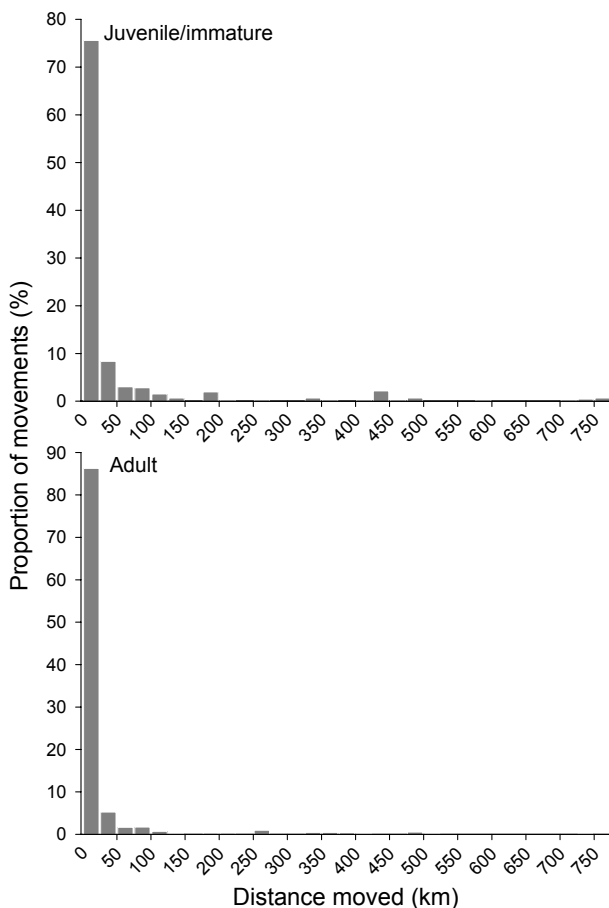


Figure 21. Distances moved within New Zealand by bar-tailed godwits, *Limosa lapponica*, banded as juvenile/immature ($n = 464$ distances) and adult ($n = 1163$ distances) birds. Distance was calculated from the banding site to where an individual bird was seen; multiple sightings at the same location were not included. Distances are summarised in 25-km bands; movements of 758 km, 762 km, 1183 km (juvenile/immature birds) and 1023 km (adult) are imperceptible on this scale and are not shown.

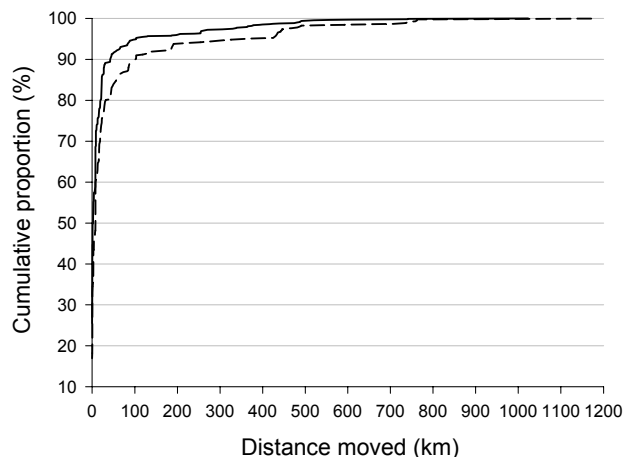


Figure 22. Cumulative frequency distribution of distances from the banding site at which immature (dashed line) and adult (solid line) bar-tailed godwits, *Limosa lapponica*, were seen.

evidence suggests visits were probably of quite short duration. One bird was confirmed making a single-day visit to the Manukau Harbour from the Firth of Thames. Generally, however, the data had insufficient detail to enable true durations of visits to be revealed.

Overall, adult godwits can be characterised as highly site-faithful birds that apparently only infrequently venture far from their 'usual' non-breeding site. They are highly likely to return to the same non-breeding site year after year; at those sites, they may show strong preferences for particular areas. As young birds, they may wander widely around New Zealand before settling on a non-breeding site (which may or may not be where the bird was caught and banded). Upon arriving in New Zealand after their southward migration, birds may stop first at sites north of their eventual destination, from some tens of kilometres away (e.g. Firth of Thames birds stopping in the Manukau Harbour) to some hundreds (e.g. South Island birds stopping in the Auckland region). How many birds make such stopovers, and how long they stay before moving onwards, may depend on the flight conditions experienced during migration.

4.2 Red knots

Knots are much more mobile than godwits in New Zealand. More birds of all ages made short-distance movements (e.g. around the Auckland region) than did godwits, and long-distance movements were recorded in similar proportions for adults and immatures (27 of 229 adults, or 11.8%, and 18 of 116 juvenile/immatures, or 15.5%; Chi-squared test, $P > 0.05$). Most knots that were recorded after banding were seen in many regions.

While many long-distance movements of godwits could be attributed to migratory stopovers, fewer could be so attributed for knots because smaller numbers of birds had been banded in the South Island (and only late in the study) or the southern North Island. There was little opportunity to test whether knots banded in the South Island occur in the northern North Island during their southward migration, but there were records of knots being seen around Auckland in October (four records) or November (one record) and subsequently carrying on to the Manawatu River Estuary that season. Additionally, one knot was seen in the Far North in mid-October and Miranda at the start of November. These findings suggest that some knots do indeed stop in northern New Zealand on their southward migration. Knots evidently continue to trickle into the South Island through spring and summer (Schuckard 2002) and this could include birds passing through the North Island as well as birds passing through Australia.

The long-distance movements recorded in knots involved a high proportion of adult birds from the Auckland region, but not from the Manawatu River Estuary (Tables 10 & 11). The fact that the Manawatu River Estuary birds that were seen around the Auckland regions were mostly young birds raises the possibility that the Manawatu River Estuary is a site that young knots pass through when exploring New Zealand; those that settle there may have higher site fidelity from then on. It is notable that knots rarely overwinter at the Manawatu River Estuary, despite the presence there of reasonable numbers of immatures in late summer (PFB, pers. obs.); these birds must move elsewhere around the time that adults migrate north.

Even adult knots were capable of making long-distance movements within the non-breeding season (Fig. 23). Of the North Island adults seen in the South Island (Table 11), six from Auckland were confirmed as having moved within a non-breeding season (South Island sightings were made 3, 5, 5, 5, 9 weeks and 5 months after their North Island sighting, and a Manawatu bird was seen on Farewell Spit 2 days after having been seen at the Manawatu River Estuary). Because the resighting histories are less detailed for knots than for godwits, it is not clear whether these knots returned to the North Island within the non-breeding season.

Shorter-distance movements were recorded in both summer and winter (Fig. 20). Immatures appeared to move more during winter than summer, though how much this pattern is an artefact of the behaviour of the population overwintering at the Firth of Thames in 2004 is not clear. In

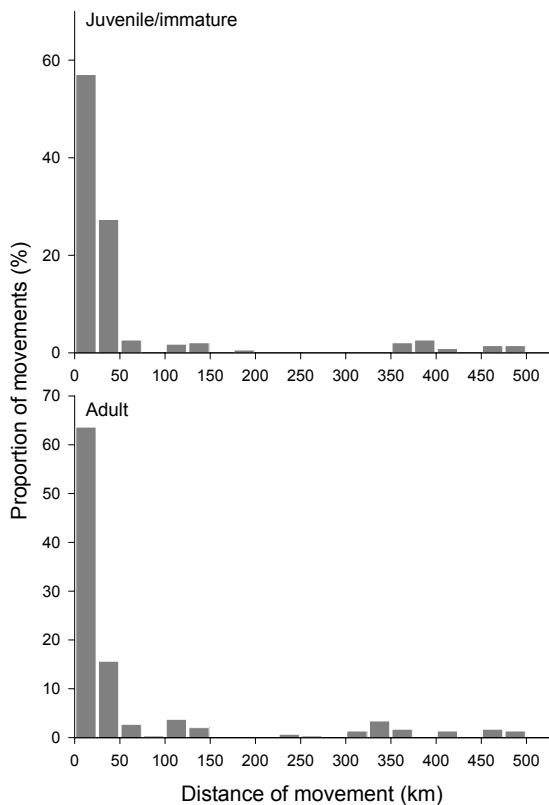


Figure 23. Distances moved within New Zealand by red knots, *Calidris canutus*, banded as juvenile/immature ($n = 339$ distances) and adult ($n = 294$ distances) birds. Distances were calculated from the banding site to where an individual bird was seen; multiple sightings at the same location were not included. Distances are summarised in 25-km bands. Note that movements by one or two birds occurred in some apparently empty distance categories but are not visible on the plots.

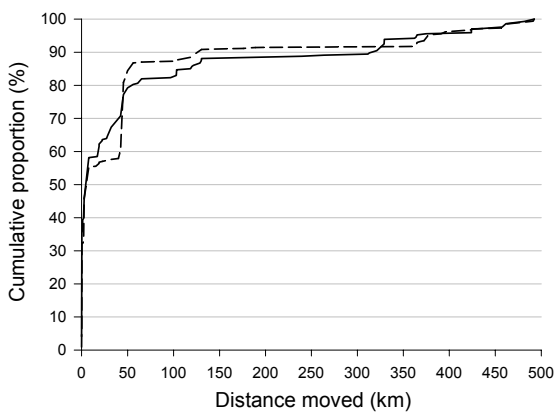


Figure 24. Cumulative frequency distribution of distances from the banding site at which immature (dashed line) and adult (solid line) red knots, *Calidris canutus*, were seen.

June of that year, a large catch of knots was made from which 40 birds were colour-banded. At the time, around 400 knots were present in the Firth. Through the winter, this number dwindled until by August only about 30 birds remained (PFB, unpubl. data). That winter, 35 of the 40 newly-banded Firth of Thames knots were seen in the Manukau Harbour, confirming that most of the overwintering flock had shifted harbours. This winter decline in numbers at the Firth of Thames has occurred more than once (PFB, unpubl. data). Adults (which include some older non-migrants) moved between sites throughout the year. Movements were most frequently recorded during summer months, which is to be expected as the pool of birds present is larger. Overall, knots can be expected to move locally or longer-distance throughout the year.

Both age classes were recorded similar distances from the banding sites (Fig. 23). Compared with those of godwits (Fig. 22), both red knot age classes had considerably shallower cumulative distributions of movements (Fig. 24). For godwits, less than 10% of movements were greater than about 50 km (adults) or 100 km (immatures) (Fig. 22), whereas for knots 15–20% of movements were greater than 50 km (Fig. 24).

4.3 Ages of godwits and knots moving within New Zealand

In both species, there was a tendency for younger birds to move more than adults. Excluding godwits making migratory movements, 35% of adult, 44% of immature and 73% of juvenile godwits were seen away from where they were banded. A lot of the shorter-distance movements in godwits were between Farewell Spit and other Golden Bay sites. If Golden Bay records are omitted from the calculations, the values become 30% adult, 37% immature and 44% juvenile. For knots, the best data were from the Firth of Thames, where 51% of adult, 71% of immature and 83% of juvenile knots were seen around the Auckland region away from the western shores of the Firth.

The much higher level of inter-site movement recorded in knots compared with godwits may be related to differences in diet and food availability. Knots typically feed on mollusc (especially bivalve) prey (Piersma 1994) and range widely during the non-breeding season (they have foraging ranges

of up to 800 km² in the Dutch Waddensea: van Gils & Piersma 1999; see also Leyrer et al. 2006). Spatial and temporal variability of their prey have been suggested as factors underlying differences in the ranging behaviour of knots. If so, one would predict that the availability of the polychaetes and crabs on which godwits predominantly feed would be comparatively more stable over time (see e.g. Roper et al. 1992; Thrush et al. 1994; Cole et al. 2000; Hewitt & Thrush 2007).

4.4 Isolation of areas

A question for managers is whether birds from different locations form different, isolated subpopulations. The evidence for knots indicates that their non-breeding range may encompass several major intertidal systems around the country. The resightings of colour-banded birds show that, in the Auckland region, individual birds may use all of the large local harbours (Kaipara Harbour, Manukau Harbour and Firth of Thames) and that some birds venture further afield at some times (e.g. to the Far North or the South Island). There are other major movements that have not been picked up in this study. Birdwatchers in Tauranga Harbour, for example, often recorded large groups of knots (e.g. 500 birds) in late summer but not at any other time of the year (the late B. Chudleigh, OSNZ, pers. comm. to PFB, 2004). These are most probably knots from the Auckland region ranging further afield than they had earlier in the season. Occasionally, small flocks of knots have been seen flying north or south along the coastline past Kaiaua in the Firth of Thames (PFB, unpubl. data). These movements are very different in character to migratory departures (which are noisy, ascending, gaining in formation and usually heading inland) and probably are by groups of birds commuting locally. The frequency of these and other non-migratory movements will become clearer with time if resighting and banding efforts continue.

For godwits, the situation is different. While some adults may pass through different sites before reaching their destination, they are, in general, highly site-faithful and are expected to return to the same non-breeding site year after year. Once there, adults only rarely venture any distance from their non-breeding site, and most local populations are probably fairly independent units. Isolated sites such as the Manawatu River Estuary and Avon-Heathcote Estuary probably have very little interchange of adults with other sites (though a few 'unseasonal' movements were recorded from the latter site). Regions with contiguous or nearby alternative intertidal habitats showed frequent movements of godwits over quite small scales, but not over large scales. Birds banded in the sites at the western Firth of Thames were regularly seen in the Firth's southeastern corner (Waihou River mouth, 19 km away), but generally in small numbers only. Birds from the tip of Farewell Spit were resighted in decreasing numbers from the tip towards Puponga. In Golden Bay itself, godwits from the western shores regularly ranged as far as the base of Farewell Spit but did not move in substantial numbers to the southeastern shores of the Bay. There was very little movement between Golden Bay and Tasman Bay, and in the latter, there was frequent movement between Motueka Sandspit and Waimea Inlet and Nelson Haven. In Otago, godwits banded at Warrington moved in large numbers to Aramoana (10 km; 16 of 33 banded birds) or Hoopers Inlet (15 km; 9 birds), but there were no non-migratory records away from the immediate region. The high between- and within-season site-fidelity of adult godwits means that for management purposes most regions or districts can be regarded as having independent local populations.

Immature godwits do not show the same site fidelity as adults do, and some birds probably move widely around New Zealand before settling on a non-breeding site. In that regard, New Zealand provides a network of linked sites even for this site-faithful species.

4.5 Implications for avian influenza transfer risk

In late 2003 to early 2004, an outbreak of highly pathogenic avian influenza A H5N1 occurred in both poultry and wild birds in Southeast Asia. The virus then spread across Eurasia to Western Europe and Africa, infecting wild birds, poultry and humans. New Zealand prepared contingency plans for both human and poultry outbreaks (Ministry of Health 2005; Biosecurity New Zealand 2006) and there remains concern that migratory birds might introduce H5N1 or another pathogen to the country (Williams et al. 2006). Whilst a pandemic (Guan et al. 2004) has not eventuated, human deaths continue; as of late November 2011, there have been 570 confirmed human cases of H5N1, including 335 deaths (Anon. 2011). Hundreds of millions of domestic poultry have been slaughtered in 'stamping out' programmes and wild birds continue to be infected (EMPRES/FAO-GLEWS 2011).

Waders have long been considered to be an important natural reservoir of avian influenza A virus (AIV) (Webster et al. 1992), this view being largely founded on research at Delaware Bay, USA, where high levels of infection were regularly reported (Krauss et al. 2004). Studies elsewhere, however, have shown much lower levels of infection in shorebirds (Hlinak et al. 2006; Olsen et al. 2006; Hanson et al. 2008; Iverson et al. 2008; Chin & Shortridge 2010). AIV has been isolated from a variety of shorebirds in the East Asian-Australasian Flyway (Hurt et al. 2006; Melville & Shortridge 2006) and has been detected by PCR in samples from bar-tailed godwits in Alaska (Ip et al. 2008), and both bar-tailed godwits and red knots in Australia (Hansbro et al. 2010). No AIV was isolated from red knots in New Zealand (Langstaff et al. 2009), although Stanislawek et al. (2009) reported influenza viral RNA detected by PCR.

The spread of H5N1 virus across Eurasia highlighted the potential of wild birds as vectors; however, their role in spreading highly pathogenic forms of AIV remains contentious, especially where long-distance migration is involved (Kilpatrick et al. 2006; Gauthier-Clerc et al. 2007; Feare 2010; Hall et al. in press).

There is limited evidence of cross-species infection of AIV between waders and waterfowl in Australia (Hansbro et al. 2010). Thus, although the likelihood of Arctic-breeding waders introducing novel AIV, particularly a highly pathogenic form, to New Zealand appears to be low, birds such as bar-tailed godwits and red knots could potentially move viruses around the country. Results from the present study indicate that red knots, being more mobile than bar-tailed godwits, have greater potential for the movement of AIV within New Zealand. They also have greater potential exposure to AIV outside New Zealand than godwits do, as knots pass through Asia on both northward and southward migrations (though specific details of both migrations are lacking), whereas godwits pass through Asia only on northward migration (Gill et al. 2009; Battley et al. in press). It should be noted that endemic migratory waders also have potential to transfer AIV between sites (Dowding & Moore 2006).

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Within this list, there are several observers who contributed a disproportionate number of checks and resightings. Tony Habraken roamed the South Auckland estuaries relentlessly, clocking up 379 checks and 990 resightings of godwits and knots; in the Nelson region, Peter Field made virtually daily checks of Nelson Haven at crucial times of the year (generating 162 checks and 643 godwit band combinations); in Canterbury, Jan Walker and Sheila Petch kept a sharp eye on the Avon-Heathcote Estuary godwits (53 checks resulting in an impressive 527 band records). Other notable contributors were Gwenda Pulham, who let her eyes stray from Fairy Terns often enough to make numerous checks around the Auckland region, most importantly in the Kaipara Harbour; Roger and Pam Slack at the Manawatu River Estuary; Willie Cook in the Nelson region; and Peter Schweigman in Otago. Having dedicated observers spread around the country made this project what it is.

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Appendix 1

Locations where searches were made for colour-banded shorebirds

PLACE NAME	REGION	DISTRICT	LAT (S)	LONG (E)	NZ GRID (N)	NZ GRID (E)
Parengarenga Harbour, Te Pua Point	Far North	Parengarenga	34 31 48	172 56 53	6741487	2506271
Parengarenga Harbour, Paua Peninsula	Far North	Parengarenga	34 31 59	172 56 25	6741149	2505556
Parengarenga Harbour, shell island	Far North	Parengarenga	34 32 17	172 56 57	6740593	2506371
Parengarenga, Kokota Spit	Far North	Parengarenga	34 32 24	172 57 30	6740375	2507212
Parengarenga, Raumanawa Point	Far North	Parengarenga	34 33 09	172 56 16	6738629	2505096
Houhora Harbour, Kowhai Beach	Far North	Houhora	34 46 59	173 09 01	6713348	2524712
Rangaunu Harbour, East Beach	Far North	Rangaunu	34 53 18	173 16 39	6701610	2536292
Rangaunu Harbour, Walker Island	Far North	Rangaunu	34 54 33	173 17 18	6699293	2537269
Rangaunu Harbour, Kaimaumau	Far North	Rangaunu	34 55 15	173 16 05	6698009	2535409
Karikari Peninsula, Waimango Swamp	Northland	Karikari	34 50 38	173 22 44	6705889	2544873
Whangarei Harbour, Portland/Titoki Creek	Northland	Whangarei	35 48 52	174 19 51	6597909	2630529
Whangarei Harbour, Aubrey Road	Northland	Whangarei	35 48 53	174 22 19	6597551	2634650
Whangarei Harbour, Skull Creek	Northland	Whangarei	35 48 48	174 22 19	6597551	2634650
Whangarei Harbour, Takahiwai	Northland	Whangarei	35 50 10	174 25 20	6595282	2639154
Ruakaka Estuary	Northland	Ruakaka	35 54 00	174 27 43	6587710	2642390
Waipu Estuary	Northland	Waipu	35 59 53	174 28 58	6577000	2644395
Mangawhai	North Auckland	Mangawhai	36 05 30	174 35 56	6566642	2654582
Omaha Sandspit	North Auckland	Omaha	36 19 15	174 46 47	6540895	2670341
Kaipara Harbour, Tapora	North Auckland	Kaipara E	36 22 47	174 15 00	6535213	2622677
Kaipara Harbour, Tauhoa (Walker I)	North Auckland	Kaipara E	36 22 00	174 26 00	6535000	2639000
Kaipara Harbour, Waiomu Inlet	North Auckland	Kaipara E	36 27 00	174 11 00	6526000	2617000
Kaipara Harbour, Jordan's Farm	North Auckland	Kaipara E	36 34 53	174 26 15	6512565	2639118
Kaipara Harbour, Waller Island, Papakanui Spit	North Auckland	Kaipara W	36 25 43	174 13 17	6529827	2620029
Kaipara Harbour, Papakanui Spit	North Auckland	Kaipara W	36 25 46	174 12 02	6529762	2618160
Kaipara Harbour, McLeods Bay	North Auckland	Kaipara W	36 29 00	174 16 00	6468010	2623130
Kaipara Harbour, Mairetahi	North Auckland	Kaipara W	36 32 47	174 21 20	6516571	2631848
Weiti River mouth	North Auckland	Auckland N	36 38 43	174 43 42	6504992	2665002
Whangapoua Harbour	Hauraki Gulf	Great Barrier I*	36 08 22	175 25 36	6559619	2728976
Colville Harbour	Coromandel	Colville	36 37 20	175 28 17	6505952	2731503
Matarangi	Coromandel	Matarangi	36 43 46	175 38 10	6493633	2745879
Coromandel Harbour	Coromandel	Coromandel	36 46 00	175 29 41	6489870	2733138
Opoutere	Coromandel	Opoutere	37 06 34	175 52 49	6450807	2766317
Pauanui	Coromandel	Pauanui	37 00 55	175 52 04	6461288	2765543
Manukau Harbour, Mangere, Kiwi Esplanade	Auckland	Manukau E	36 56 26	174 45 52	6472164	2667559
Manukau Harbour, Mangere Sewage Ponds	Auckland	Manukau E	36 57 05	174 45 33	6470972	2667064
Whitford, Turanga Creek	South Auckland	Whitford	36 54 26	174 59 18	6475430	2687583
Waitemata Harbour, Kawakawa Bay	South Auckland	Kawakawa	36 57 02	175 09 30	6470263	2702610
Manukau Harbour, Puhinui	South Auckland	Manukau S	37 01 51	174 51 12	6461982	2675261
Manukau Harbour, Conifer Grove	South Auckland	Manukau S	37 03 18	174 52 25	6459262	2677006
Manukau Harbour, Urquharts	South Auckland	Manukau S	37 03 43	174 53 43	6458450	2678916
Manukau Harbour, Karaka	South Auckland	Manukau S	37 04 47	174 49 28	6456613	2672576
Manukau Harbour, Seagrove	South Auckland	Manukau S	37 05 22	174 47 34	6455593	2669739
Manukau Harbour, Kirks	South Auckland	Manukau S	37 05 52	174 47 25	6454673	2669497
Manukau Harbour, Clarks Bay	South Auckland	Manukau S	37 06 39	174 45 56	6453270	2667270
Manukau Harbour, Waiuku	South Auckland	Manukau S	37 15 00	174 44 00	6437886	2664096
Mataitai, Clevedon	South Auckland	Mataitai	36 56 48	175 06 19	6470810	2697897
Firth of Thames, Kaiaua	South Auckland	Miranda coast	37 06 43	175 17 48	6452046	2714460
Miranda, Taramaire	South Auckland	Miranda coast	37 09 20	175 18 41	6447174	2715641
Miranda, Paddocks	South Auckland	Miranda coast	37 09 48	175 18 33	6446316	2715421
Miranda, Stilt Ponds	South Auckland	Miranda coast	37 10 46	175 19 15	6444502	2716409
Miranda, Shellbanks	South Auckland	Miranda coast	37 10 50	175 19 26	6444371	2716677

* Formal name: Great Barrier Island (Aotea Island).

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PLACE NAME	REGION	DISTRICT	LAT (S)	LONG (E)	NZ GRID (N)	NZ GRID (E)
Firth of Thames, Piako River mouth	South Auckland	Piako	37 11 19	174 29 34	6445100	2642878
Firth of Thames, Waihou River mouth	South Auckland	Waihou	37 09 37	175 31 58	6446110	2735283
Firth of Thames, Thames	South Auckland	Thames	37 08 59	175 31 53	6447285	2735194
Port Waikato	South Auckland	Port Waikato	37 23 00	174 43 05	6423119	2662446
Matahui Point	Bay of Plenty	Tauranga	37 34 48	175 58 30	6398339	2772989
Maketu Estuary	Bay of Plenty	Maketu	37 45 24	176 26 48	6377250	2813867
Little Waihi	Bay of Plenty	Maketu	37 46 01	176 28 51	6375994	2816831
Ohiwa Harbour	Bay of Plenty	Ohiwa	37 59 40	177 07 35	6348361	2872500
Raglan Harbour	Waikato	Raglan	37 47 08	174 54 23	6378142	2678142
Aotea Harbour	Waikato	Aotea	37 58 33	174 50 20	6357158	2671751
Kawhia Harbour	Waikato	Kawhia	38 04 54	174 50 03	6345423	2671089
Wherowhero Lagoon	Gisborne	Gisborne	38 43 58	177 55 54	6262968	2938669
Ahuriri	Hawke's Bay	Napier	39 20 06	176 53 03	6233920	2846241
Manawatu River Estuary	Manawatu	Manawatu	40 28 02	175 13 33	6079907	2698743
Farewell Spit	Golden Bay	Gold Spit	40 31 28	172 56 51	6109276	2505539
Farewell Spit, Lighthouse to Tip	Golden Bay	Gold Spit	40 32 58	173 01 14	6073185	2511744
Farewell Spit, Lagoon to Lighthouse	Golden Bay	Gold Spit	40 32 19	172 59 49	6074388	2509744
Farewell Spit, Mullet to Lagoon	Golden Bay	Gold Spit	40 31 28	172 56 51	6075961	2505554
Farewell Spit, Stockyard Point to Mullet	Golden Bay	Gold Spit	40 30 51	172 52 47	6077097	2499809
Farewell Spit, Base to Gobi Desert	Golden Bay	Gold Pup	40 30 28	172 47 29	6077793	2492320
Puponga	Golden Bay	Gold Pup	40 31 13	172 44 56	6076396	2488721
Taupata Creek	Golden Bay	Gold Pup	40 32 54	172 43 15	6073273	2486353
Ruataniwha Inlet	Golden Bay	Gold W	40 35 14	172 40 53	6068748	2483014
Pakawau	Golden Bay	Gold W	40 35 30	172 41 15	6068452	2483546
Totara Avenue	Golden Bay	Gold W	40 37 37	172 40 46	6064531	2482878
Totara Avenue, sandbar 500 m off coast	Golden Bay	Gold W	40 39 43	172 41 28	6060648	2483879
Collingwood	Golden Bay	Gold W	40 40 47	172 41 12	6058672	2483510
Parapara Inlet	Golden Bay	Gold W	40 43 09	172 41 01	6054291	2483267
Wainui Inlet	Golden Bay	Gold E	40 48 43	172 56 29	6044033	2505055
Golden Bay Pohara	Golden Bay	Gold E	40 49 49	172 51 00	6041988	2497347
Rototai, Takaka	Golden Bay	Gold E	40 50 12	172 50 16	6041276	2496317
Westhaven Inlet	NW Nelson	Westhaven	40 35 11	172 35 31	6069005	2475453
Marahau	Tasman Bay	Marahau	41 00 43	173 00 27	6021823	2510631
Riwaka	Tasman Bay	Motueka	41 03 48	173 00 07	6016117	2510163
Motueka Sandspit	Tasman Bay	Motueka	41 07 45	173 01 05	6008805	2511516
Motueka Quay	Tasman Bay	Motueka	41 07 59	173 02 01	6008373	2512822
Moutere Inlet	Tasman Bay	Motueka	41 08 36	173 00 38	6007232	2510886
Nelson Haven	Tasman Bay	Nelson	41 15 45	173 17 22	5993958	2534256
Tahunanui	Tasman Bay	Nelson	41 16 37	173 14 20	5992367	2530015
Waimea Estuary	Tasman Bay	Nelson	41 19 10	173 10 49	5987659	2525095
Waimea Inlet, Rabbit Island	Tasman Bay	Nelson	41 16 58	173 11 22	5991729	2525871
Waimea Estuary, Bell Island	Tasman Bay	Nelson	41 17 32	173 10 56	5990682	2525264
Monaco	Tasman Bay	Nelson	41 18 14	173 12 30	5989381	2527448
Wakatu Drive, Stoke	Tasman Bay	Nelson	41 18 38	173 12 60	5988639	2528144
Karamea	Westland	Westland	41 15 00	172 05 00	5994975	2433164
Wairau Lagoons	Marlborough	Wairau	41 31 44	174 04 52	5963856	2600226
Orowaiti Lagoon	Westland	Westland	41 43 00	171 37 00	5942616	2394885
Westport	Westland	Westland	41 44 52	171 37 10	5939164	2395172
Kaikoura	Marlborough	Kaikoura	42 24 34	173 41 17	5866389	2566653
Ashley Estuary	Canterbury	Ashley	43 16 30	172 43 27	5770419	2487631
Brooklands Lagoon	Canterbury	Brooklands	43 24 35	172 42 26	5755446	2486308
Avon–Heathcote Estuary†	Canterbury	Avon– Heathcote Estuary	43 33 27	172 45 08	5739039	2490002
Lyttelton Harbour	Canterbury	Lyttelton	43 39 03	172 40 01	5728645	2483152
Lake Ellesmere (Te Waihora)	Canterbury	Ellesmere	43 47 21	172 38 08	5713264	2480686
Karitane	Otago	Karitane	45 37 59	170 39 18	5505862	2327057
Blueskin Bay	Otago	Blueskin Bay	45 43 42	170 36 05	5495157	2323182

† Formal name: Estuary of the Heathcote and Avon Rivers/Ihutai

PLACE NAME	REGION	DISTRICT	LAT (S)	LONG (E)	NZ GRID (N)	NZ GRID (E)
Warrington	Otago	Blueskin Bay	45 43 51	170 35 56	5494874	2322995
Aramoana	Otago	Aramoana	45 47 00	170 42 46	5489288	2332016
Papanui Inlet	Otago	Papanui Inlet	45 50 34	170 41 51	5482650	2331010
Hoopers Inlet	Otago	Hooper's Inlet	45 52 15	170 40 31	5479480	2329620
Riverton Estuary	Southland	Riverton	46 20 46	168 00 52	5417629	2126196
Catlins Lake	Southland	Catlins Lake	46 28 43	169 38 16	5409234	2251591
New River Estuary	Southland	Invercargill	46 28 00	168 20 00	5405693	2151461
New River Estuary, west shores	Southland	Invercargill	46 27 00	168 19 00	5407470	2150078
New River Estuary, Daffodil Bay	Southland	Invercargill	46 28 17	168 17 44	5405004	2148595
New River Estuary, shellbanks	Southland	Invercargill	46 28 44	168 20 52	5404400	2152646
New River Estuary, Whalers Bay	Southland	Invercargill	46 28 56	168 18 06	5403828	2149132
Tahakopa Bay	Southland	Tahakopa	46 33 23	169 28 26	5400074	2239382
Papatowai River Mouth	Southland	Papatowai	46 33 23	169 28 26	5400074	2239383
Fortrose Estuary	Southland	Fortrose	46 34 06	168 47 13	5396285	2186829
Bluff Harbour, Colyers Island	Southland	Bluff	46 33 04	168 18 36	5396220	2150208
Waituna Lagoon	Southland	Waituna	46 33 59	168 36 12	5395766	2172760
Awarua Bay North	Southland	Awarua	46 34 28	168 30 13	5394459	2165174
Awarua Bay, Cow Island	Southland	Awarua	46 34 48	168 26 52	5393607	2160935
Awarua Bay	Southland	Awarua	46 35 35	168 31 28	5392480	2166881
Waikawa Estuary	Southland	Waikawa	46 37 32	169 08 41	5391270	2214522
Haldane Estuary	Southland	Haldane	46 39 38	169 01 56	5386976	2206102
Chatham Island	Chatham Is	Chatham	43 52 52	176 28 17	5697328	2789115

Appendix 2

Movements of bar-tailed godwits, *Limosa lapponica*, between the North and South Islands

Birds are listed in order of colour-band code. All sightings of birds recorded in both the North and South Islands are given.

1BWRW	banded 28 Feb 06, Warrington, Otago	age 3+	sex m
seen	24 Sep 06, Karaka, Manukau Harbour, South Auckland		
	01 Nov 06, Karitane, Otago		
	08 Nov 06, Karitane, Otago		
	09 Nov 06, Karitane, Otago		
	20 Nov 06, Karitane, Otago		
	01 Mar 07, Warrington, Otago		
	24 Feb 08, Warrington, Otago		
1RWYR	banded 22 Oct 04, Avon-Heathcote Estuary*, Canterbury	age 1	sex m
seen	29 Oct 04, Avon-Heathcote Estuary, Canterbury		
	17 Nov 04, Lake Ellesmere (Te Waihora), Canterbury		
	10 Jan 05, Clarks Bay, Manukau Harbour, South Auckland		
	27 Feb 05, Clarks Bay, Manukau Harbour, South Auckland		
	09 Mar 05, Turanga Creek, Whitford, South Auckland		
	30 Oct 05, Clarks Bay, Manukau Harbour, South Auckland		
	18 Mar 06, Clarks Bay, Manukau Harbour, South Auckland		
	19 Mar 06, Clarks Bay, Manukau Harbour, South Auckland		
	23 Sep 06, Clarks Bay, Manukau Harbour, South Auckland		
	22 Oct 06, Clarks Bay, Manukau Harbour, South Auckland		
	27 Oct 07, Clarks Bay, Manukau Harbour, South Auckland		
1RYYR	banded 22 Oct 04, Avon-Heathcote Estuary, Canterbury	age 3+	sex m
seen	17 Nov 04, Avon-Heathcote Estuary, Canterbury		
	15 Dec 04, Avon-Heathcote Estuary, Canterbury		
	03 Jan 05, Avon-Heathcote Estuary, Canterbury		
	02 Oct 05, Karaka, Manukau Harbour, South Auckland		
1WBBY	banded 15 Dec 04, Rabbit Island, Tasman Bay	age 3+	sex f
seen	10 Mar 05, Motueka Sandspit, Tasman Bay		
	08 Sep 07, Miranda, Shellbanks, South Auckland		
1WRRR	banded 15 Dec 04, Rabbit Island, Tasman Bay	age 3+	sex m
seen	06 Mar 05, Avon-Heathcote Estuary, Canterbury		
	27 Dec 06, Miranda, Shellbanks, South Auckland		
	11 Oct 07, Nelson Haven, Nelson, Tasman Bay		
1WRRW	banded 15 Dec 04, Rabbit Island, Tasman Bay	age 3+	sex m
seen	31 Dec 04, Nelson Haven, Nelson, Tasman Bay		
	01 Jan 05, Nelson Haven, Nelson, Tasman Bay		
	11 Jan 05, Nelson Haven, Nelson, Tasman Bay		
	15 Jan 05, Nelson Haven, Nelson, Tasman Bay		
	25 Jan 05, Nelson Haven, Nelson, Tasman Bay		
	28 Jan 05, Nelson Haven, Nelson, Tasman Bay		
	01 Feb 05, Nelson Haven, Nelson, Tasman Bay		

* Formal name: Estuary of the Heathcote and Avon Rivers/Ihutai.

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<i>1WRRW contd</i>	08 Feb 05,	Nelson Haven, Nelson, Tasman Bay					
	11 Feb 05,	Nelson Haven, Nelson, Tasman Bay					
	02 Mar 05,	Bell Island, Waimea Estuary, Tasman Bay					
	08 Mar 05,	Nelson Haven, Nelson, Tasman Bay					
	16 Mar 05,	Nelson Haven, Nelson, Tasman Bay					
	19 Mar 05,	Nelson Haven, Nelson, Tasman Bay					
	21 Mar 05,	Nelson Haven, Nelson, Tasman Bay					
	22 Mar 05,	Nelson Haven, Nelson, Tasman Bay					
	16 Oct 05,	Karaka, Manukau Harbour, South Auckland					
	31 Oct 05,	Nelson Haven, Nelson, Tasman Bay					
	01 Nov 05,	Nelson Haven, Nelson, Tasman Bay					
	07 Nov 05,	Nelson Haven, Nelson, Tasman Bay					
	11 Nov 05,	Nelson Haven, Nelson, Tasman Bay					
	15 Nov 05,	Nelson Haven, Nelson, Tasman Bay					
	16 Dec 05,	Nelson Haven, Nelson, Tasman Bay					
	02 Jan 06,	Avon-Heathcote Estuary, Canterbury					
	12 Jan 06,	Bell Island, Waimea Estuary, Tasman Bay					
	20 Mar 06,	Nelson Haven, Nelson, Tasman Bay					
	20 Oct 06,	Nelson Haven, Nelson, Tasman Bay					
	24 Nov 06,	Nelson Haven, Nelson, Tasman Bay					
	25 Jan 07,	Nelson Haven, Nelson, Tasman Bay					
	03 Mar 07,	Bell Island, Waimea Estuary, Tasman Bay					
	11 Oct 07,	Nelson Haven, Nelson, Tasman Bay					
	15 Oct 07,	Nelson Haven, Nelson, Tasman Bay					
	25 Oct 07,	Nelson Haven, Nelson, Tasman Bay					
	23 Nov 07,	Nelson Haven, Nelson, Tasman Bay					
	21 Dec 07,	Nelson Haven, Nelson, Tasman Bay					
	23 Jan 08,	Nelson Haven, Nelson, Tasman Bay					
	24 Jan 08,	Nelson Haven, Nelson, Tasman Bay					
	07 Feb 08,	Nelson Haven, Nelson, Tasman Bay					
	09 Feb 08,	Nelson Haven, Nelson, Tasman Bay					
1WWRW	banded	15 Dec 04,	Rabbit Island, Tasman Bay	age	3+	sex	m
	seen	17 Feb 06,	Nelson Haven, Nelson, Tasman Bay				
		16 Feb 07,	Motueka Sandspit, Tasman Bay				
		18 Mar 07,	Motueka Sandspit, Tasman Bay				
		15 Sep 07,	Miranda, Shellbanks, South Auckland				
1WYBY	banded	09 Mar 05,	Motueka Sandspit, Tasman Bay	age	3+	sex	m
	seen	24 Sep 05,	Jordan's Farm, Kaipara Harbour, North Auckland				
		15 Oct 07,	Nelson Haven, Nelson, Tasman Bay				
1WYWB	banded	09 Mar 05,	Motueka Sandspit, Tasman Bay	age	3+	sex	f
	seen	10 Mar 05,	Motueka Sandspit, Tasman Bay				
		24 Sep 05,	Jordan's Farm, Kaipara Harbour, North Auckland				
		05 Oct 05,	Motueka Sandspit, Tasman Bay				
		16 Dec 05,	Nelson Haven, Nelson, Tasman Bay				
		10 Feb 06,	Bell Island, Waimea Estuary, Tasman Bay				
		16 Jul 06,	Farewell Spit, Stockyard to Mullet, Golden Bay				
1YBWB	banded	04 Dec 05,	Pakawau, Golden Bay	age	2?	sex	f
	seen	29 Jan 06,	Karaka, Manukau Harbour, South Auckland				

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1YRY	banded	13 Dec 04,	Totara Avenue, Golden Bay	age	1	sex	f
seen	10 Feb 05,		Totara Avenue, Golden Bay				
	11 Mar 05,		Totara Avenue, Golden Bay				
	12 Mar 05,		Totara Avenue, Golden Bay				
	14 Mar 05,		Totara Avenue, Golden Bay				
	25 Apr 05,		Farewell Spit, Golden Bay				
	09 May 05,		Farewell Spit, Golden Bay				
	09 May 05,		Farewell Spit, base to Gobi Desert, Golden Bay				
	14 May 05,		Farewell Spit, Golden Bay				
	14 May 05,		Farewell Spit, base to Gobi Desert, Golden Bay				
	24 May 05,		Farewell Spit, base to Gobi Desert, Golden Bay				
	25 Jun 05,		Farewell Spit, base to Gobi Desert, Golden Bay				
	02 Oct 05,		Karaka, Manukau Harbour, South Auckland				
	02 Oct 05,		Karaka, Manukau Harbour, South Auckland				
	02 Dec 05,		Farewell Spit, base to Gobi Desert, Golden Bay				
	15 Feb 06,		Farewell Spit, base to Gobi Desert, Golden Bay				
	17 Mar 06,		Farewell Spit, base to Gobi Desert, Golden Bay				
	14 Jul 06,		Farewell Spit, base to Gobi Desert, Golden Bay				
	09 Oct 06,		Farewell Spit, base to Gobi Desert, Golden Bay				
	18 Feb 07,		Farewell Spit, base to Gobi Desert, Golden Bay				
	26 Nov 07,		Farewell Spit, base to Gobi Desert, Golden Bay				
	26 Dec 07		Farewell Spit, base to Gobi Desert, Golden Bay				
1YWBB	banded	13 Dec 04,	Totara Avenue, Golden Bay	age	1	sex	f
seen	12 Feb 05,		Farewell Spit, Golden Bay				
	12 Mar 05,		Farewell Spit, Golden Bay				
	19 Mar 05,		Farewell Spit, Golden Bay				
	02 Dec 05,		Farewell Spit, lighthouse to tip, Golden Bay				
	14 Dec 05,		Farewell Spit, lighthouse to tip, Golden Bay				
	15 Dec 05,		Farewell Spit, lighthouse to tip, Golden Bay				
	27 Jan 06,		Farewell Spit, lighthouse to tip, Golden Bay				
	27 Jan 06,		Farewell Spit, lighthouse to tip, Golden Bay				
	28 Jan 06,		Farewell Spit, lighthouse to tip, Golden Bay				
	30 Jan 06,		Farewell Spit, lighthouse to tip, Golden Bay				
	31 Jan 06,		Farewell Spit, lighthouse to tip, Golden Bay				
	18 Apr 06,		Manawatu River Estuary, Manawatu				
	23 Apr 06,		Manawatu River Estuary, Manawatu				
	10 Aug 06,		Manawatu River Estuary, Manawatu				
	07 Sep 06,		Manawatu River Estuary, Manawatu				
	08 Sep 06,		Manawatu River Estuary, Manawatu				
	19 Sep 06,		Warrington, Otago				
	01 Oct 06,		Miranda, Shellbanks, South Auckland				
	02 Dec 06,		Miranda, Shellbanks, South Auckland				
	27 Dec 06,		Miranda, Shellbanks, South Auckland				
	04 Nov 07,		Miranda, Stilt Ponds, South Auckland				
	10 Feb 08,		Farewell Spit, lighthouse to tip, Golden Bay				
1YWWY	banded	13 Dec 04,	Totara Avenue, Golden Bay	age	1	sex	m
seen	02 Mar 05,		Bell Island, Waimea Estuary, Tasman Bay				
	12 Mar 05,		Farewell Spit, Golden Bay				
	19 Mar 05,		Farewell Spit, Golden Bay				
	21 Sep 05,		Farewell Spit, lighthouse to tip, Golden Bay				

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<i>1YWWY contd</i>	05 Feb 06,	Clarks Bay, Manukau Harbour, South Auckland			
	18 Mar 06,	Clarks Bay, Manukau Harbour, South Auckland			
	19 Mar 06,	Clarks Bay, Manukau Harbour, South Auckland			
	18 Apr 06,	Seagrove, Manukau Harbour, South Auckland			
	30 Apr 06,	Karaka, Manukau Harbour, South Auckland			
	13 May 06,	Clarks Bay, Manukau Harbour, South Auckland			
	12 Aug 06,	Clarks Bay, Manukau Harbour, South Auckland			
	26 Aug 06,	Karaka, Manukau Harbour, South Auckland			
	09 Sep 06,	Karaka, Manukau Harbour, South Auckland			
	24 Sep 06,	Karaka, Manukau Harbour, South Auckland			
	27 Oct 07,	Clarks Bay, Manukau Harbour, South Auckland			
1YYYYW	banded 13 Dec 04,	Totara Avenue, Golden Bay	age 1	sex f	
seen	04 Mar 05,	Avon-Heathcote Estuary, Canterbury			
	04 Oct 05,	Totara Avenue, Golden Bay			
	06 Nov 05,	Totara Avenue, Golden Bay			
	15 Feb 06,	Totara Avenue, Golden Bay			
	15 Jul 06,	Tapora, Kaipara Harbour, North Auckland			
	20 Mar 07,	Farewell Spit, Stockyard to Mullet, Golden Bay			
	27 Dec 07,	Collingwood, Golden Bay			
	16 Jan 08,	Totara Avenue, sandbar 500 m out of Golden Bay			
2RWYW	banded 22 Oct 05,	Miranda, Firth of Thames	age 1	sex m	
seen	15 Mar 06,	Kaiaua, Firth of Thames, South Auckland			
	31 Mar 06,	Motueka Sandspit, Tasman Bay			
	08 Sep 06,	Motueka Sandspit, Tasman Bay			
	06 Oct 06,	Motueka Sandspit, Tasman Bay			
	22 Mar 07,	Motueka Sandspit, Tasman Bay			
	03 May 07,	Farewell Spit, Mullet to Lagoon, Golden Bay			
	27 Nov 07,	Motueka Sandspit, Tasman Bay			
	25 Feb 08,	Motueka Sandspit, Tasman Bay			
2WWYR	banded 19 Oct 04,	Miranda, Firth of Thames	age 3?	sex m	
seen	26 Oct 04,	Miranda, Shellbanks, South Auckland			
	28 Oct 04,	Miranda, Taramaire, South Auckland			
	11 Nov 04,	Miranda, Shellbanks, South Auckland			
	12 Nov 04,	Miranda, Shellbanks, South Auckland			
	20 Nov 04,	Miranda, Shellbanks, South Auckland			
	04 Feb 05,	Invercargill Estuary, shellbanks, Southland			
	03 Mar 05,	Miranda, Shellbanks, South Auckland			
	17 Sep 05,	Avon-Heathcote Estuary, Canterbury			
3WBBY	banded 16 Jan 06,	Motueka Sandspit, Tasman Bay	age 1	sex f	
seen	29 Mar 06,	Motueka Sandspit, Tasman Bay			
	30 Mar 06,	Motueka Sandspit, Tasman Bay			
	31 Mar 06,	Motueka Sandspit, Tasman Bay			
	16 Apr 06,	Motueka Sandspit, Tasman Bay			
	08 Sep 06,	Motueka Sandspit, Tasman Bay			
	06 Oct 06,	Motueka Sandspit, Tasman Bay			
	03 Jan 07,	Motueka Sandspit, Tasman Bay			
	21 Feb 07,	Motueka Sandspit, Tasman Bay			
	29 Apr 07,	Miranda, Shellbanks, South Auckland			
	07 Sep 07,	Miranda, Shellbanks, South Auckland			

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		23 Nov 07,	Motueka Sandspit, Tasman Bay		
		27 Nov 07,	Motueka Sandspit, Tasman Bay		
3WBYY	banded	18 Nov 05,	Motueka Sandspit, Tasman Bay	age 3+	sex m
	seen	07 Sep 06,	Miranda, Shellbanks, South Auckland		
		01 Oct 06,	Miranda, Shellbanks, South Auckland		
		16 Oct 06,	Miranda, Shellbanks, South Auckland		
		11 Aug 07,	Bell Island, Waimea Inlet, Tasman Bay		
		13 Aug 07,	Bell Island, Waimea Inlet, Tasman Bay		
		13 Feb 08,	Miranda, Shellbanks, South Auckland		
		14 Feb 08,	Miranda, Shellbanks, South Auckland		
		25 Feb 08,	Motueka Sandspit, Tasman Bay		
		27 Feb 08,	Bell Island, Waimea Inlet, Tasman Bay		
3WWRR	banded	09 Feb 05,	Avon-Heathcote Estuary, Canterbury	age 1	sex f
	seen	05 Mar 05,	Avon-Heathcote Estuary, Canterbury		
		09 Mar 05,	Avon-Heathcote Estuary, Canterbury		
		15 Mar 05,	Avon-Heathcote Estuary, Canterbury		
		24 Mar 05,	Avon-Heathcote Estuary, Canterbury		
		09 Apr 05,	Avon-Heathcote Estuary, Canterbury		
		27 May 05,	Avon-Heathcote Estuary, Canterbury		
		28 May 05,	Avon-Heathcote Estuary, Canterbury		
		29 May 05,	Avon-Heathcote Estuary, Canterbury		
		20 Aug 05,	Avon-Heathcote Estuary, Canterbury		
		17 Sep 05,	Avon-Heathcote Estuary, Canterbury		
		23 Sep 05,	Avon-Heathcote Estuary, Canterbury		
		14 Oct 05,	Avon-Heathcote Estuary, Canterbury		
		14 Oct 05,	Avon-Heathcote Estuary, Canterbury		
		21 Nov 05,	Nelson Haven, Nelson, Tasman Bay		
		01 Jan 06,	Nelson Haven, Nelson, Tasman Bay		
		02 Jan 06,	Avon-Heathcote Estuary, Canterbury		
		16 Jan 06,	Nelson Haven, Nelson, Tasman Bay		
		10 Feb 06,	Nelson Haven, Nelson, Tasman Bay		
		22 Mar 06,	Nelson Haven, Nelson, Tasman Bay		
		26 Mar 06,	Nelson Haven, Nelson, Tasman Bay		
		27 Mar 06,	Nelson Haven, Nelson, Tasman Bay		
		28 Mar 06,	Nelson Haven, Nelson, Tasman Bay		
		14 Apr 06,	Bell Island, Waimea Inlet, Tasman Bay		
		13 Jun 06,	Bell Island, Waimea Inlet, Tasman Bay		
		28 Jul 06,	Nelson Haven, Nelson, Tasman Bay		
		09 Aug 06,	Bell Island, Waimea Inlet, Tasman Bay		
		10 Aug 06,	Bell Island, Waimea Inlet, Tasman Bay		
		12 Aug 06,	Nelson Haven, Nelson, Tasman Bay		
		13 Aug 06,	Nelson Haven, Nelson, Tasman Bay		
		14 Aug 06,	Nelson Haven, Nelson, Tasman Bay		
		28 Aug 06,	Nelson Haven, Nelson, Tasman Bay		
		08 Sep 06,	Bell Island, Waimea Inlet, Tasman Bay		
		08 Sep 06,	Nelson Haven, Nelson, Tasman Bay		
		07 Nov 06,	Rabbit Island, Waimea Inlet, Tasman Bay		
		09 Nov 06,	Avon-Heathcote Estuary, Canterbury		
		10 Nov 06,	Nelson Haven, Nelson, Tasman Bay		
		12 Nov 06,	Avon-Heathcote Estuary, Canterbury		

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<i>3WVRR contd</i>	20 Nov 06,	Nelson Haven, Nelson, Tasman Bay					
	23 Nov 06,	Nelson Haven, Nelson, Tasman Bay					
	24 Nov 06,	Nelson Haven, Nelson, Tasman Bay					
	28 Nov 06,	Nelson Haven, Nelson, Tasman Bay					
	08 Dec 06,	Nelson Haven, Nelson, Tasman Bay					
	19 Dec 06,	Nelson Haven, Nelson, Tasman Bay					
	07 Jan 07,	Avon-Heathcote Estuary, Canterbury					
	02 Feb 07,	Nelson Haven, Nelson, Tasman Bay					
	24 Mar 07,	Bell Island, Waimea Inlet, Tasman Bay					
	01 Apr 07,	Karaka, Manukau Harbour, South Auckland					
	14 Sep 07,	Nelson Haven, Nelson, Tasman Bay					
	17 Sep 07,	Nelson Haven, Nelson, Tasman Bay					
	27 Sep 07,	Nelson Haven, Nelson, Tasman Bay					
	11 Oct 07,	Nelson Haven, Nelson, Tasman Bay					
	24 Oct 07,	Nelson Haven, Nelson, Tasman Bay					
	25 Oct 07,	Nelson Haven, Nelson, Tasman Bay					
	30 Oct 07,	Nelson Haven, Nelson, Tasman Bay					
	09 Nov 07,	Nelson Haven, Nelson, Tasman Bay					
	23 Nov 07,	Nelson Haven, Nelson, Tasman Bay					
	25 Nov 07,	Nelson Haven, Nelson, Tasman Bay					
	21 Dec 07,	Nelson Haven, Nelson, Tasman Bay					
	14 Jan 08,	Nelson Haven, Nelson, Tasman Bay					
	15 Jan 08,	Tahunanui, Nelson, Tasman Bay					
	23 Jan 08,	Nelson Haven, Nelson, Tasman Bay					
	24 Jan 08,	Nelson Haven, Nelson, Tasman Bay					
	26 Jan 08,	Avon-Heathcote Estuary, Canterbury					
	07 Feb 08,	Nelson Haven, Nelson, Tasman Bay					
3WYWY	banded	16 Nov 05,	Rabbit Island, Tasman Bay	age	3+	sex	m
	seen	10 Feb 06,	Bell Island, Waimea Inlet, Tasman Bay				
		28 Oct 06,	Miranda, Shellbanks, South Auckland				
		29 Jan 08,	Bell Island, Waimea Inlet, Tasman Bay				
3YBBY	banded	04 Dec 05,	Pakawau, Golden Bay	age	2?	sex	m
	seen	18 Mar 06,	Farewell Spit, lighthouse to tip, Golden Bay				
		03 Feb 07,	Mangere Sewage Ponds, Manukau, Auckland				
		31 Mar 07,	Miranda, Shellbanks, South Auckland				
3YWBY	banded	02 Feb 06,	Farewell Spit, Golden Bay	age	3+	sex	m
	seen	15 Dec 05,	Farewell Spit, lighthouse to tip, Golden Bay				
		16 Feb 06,	Farewell Spit, lighthouse to tip, Golden Bay				
		18 Mar 06,	Farewell Spit, lighthouse to tip, Golden Bay				
		08 Sep 06,	Turanga Creek, Whitford, South Auckland				
		07 Oct 06,	Farewell Spit, lighthouse to tip, Golden Bay				
		04 Feb 07,	Farewell Spit, lighthouse to tip, Golden Bay				
		17 Feb 07,	Farewell Spit, lighthouse to tip, Golden Bay				
		25 Nov 07,	Farewell Spit, Lagoon to lighthouse, Golden Bay				
		10 Feb 08,	Farewell Spit, lighthouse to tip, Golden Bay				
3YWWY	banded	02 Feb 06,	Farewell Spit, Golden Bay	age	3+	sex	m
	seen	11 Jun 06,	Karaka, Manukau Harbour, South Auckland				
		21 Feb 07,	Motueka Sandspit, Tasman Bay				

Continued on next page

3YYBY	banded	02 Feb 06,	Farewell Spit, Golden Bay	age	2?	sex	m
seen	22 Mar 06,	Nelson Haven, Nelson, Tasman Bay					
	02 Sep 06,	Mangere Sewage Ponds, Manukau, Auckland					
	09 Oct 06,	Pakawau, Golden Bay					
	18 Feb 07,	Farewell Spit, base to Gobi Desert, Golden Bay					
	21 Mar 07,	Farewell Spit, base to Gobi Desert, Golden Bay					
	24 Nov 07,	Farewell Spit, lighthouse to tip, Golden Bay					
	25 Nov 07,	Farewell Spit, lighthouse to tip, Golden Bay					
	04 Dec 07,	Pakawau, Golden Bay					
	17 Jan 08,	Pakawau, Golden Bay					
	10 Feb 08,	Farewell Spit, lighthouse to tip, Golden Bay					
4YRRB	banded	18 Feb 07,	Manawatu River Estuary, Manawatu	age	3+	sex	m
seen	19 Feb 07,	Manawatu River Estuary, Manawatu					
	07 Mar 07,	Manawatu River Estuary, Manawatu					
	23 Mar 07,	Manawatu River Estuary, Manawatu					
	26 Nov 07,	Farewell Spit, base to Gobi Desert, Golden Bay					
	11 Dec 07,	Manawatu River Estuary, Manawatu					
	11 Dec 07,	Manawatu River Estuary, Manawatu					
	30 Dec 07,	Manawatu River Estuary, Manawatu					
	05 Jan 08,	Manawatu River Estuary, Manawatu					
	12 Jan 08,	Manawatu River Estuary, Manawatu					
	16 Jan 08,	Manawatu River Estuary, Manawatu					
	23 Jan 08,	Manawatu River Estuary, Manawatu					
	26 Jan 08,	Manawatu River Estuary, Manawatu					
	30 Jan 08,	Manawatu River Estuary, Manawatu					
	05 Feb 08,	Manawatu River Estuary, Manawatu					
	09 Feb 08,	Manawatu River Estuary, Manawatu					
	17 Feb 08,	Manawatu River Estuary, Manawatu					
	20 Feb 08,	Manawatu River Estuary, Manawatu					
	26 Feb 08,	Manawatu River Estuary, Manawatu					
	04 Mar 08,	Manawatu River Estuary, Manawatu					
	05 Mar 08,	Manawatu River Estuary, Manawatu					
	08 Mar 08,	Manawatu River Estuary, Manawatu					
	10 Mar 08,	Manawatu River Estuary, Manawatu					
	11 Mar 08,	Manawatu River Estuary, Manawatu					
	13 Mar 08,	Manawatu River Estuary, Manawatu					
	14 Mar 08,	Manawatu River Estuary, Manawatu					
	17 Mar 08,	Manawatu River Estuary, Manawatu					
	18 Mar 08,	Manawatu River Estuary, Manawatu					
	19 Mar 08,	Manawatu River Estuary, Manawatu					
	20 Mar 08,	Manawatu River Estuary, Manawatu					
	21 Mar 08,	Manawatu River Estuary, Manawatu					
	22 Mar 08,	Manawatu River Estuary, Manawatu					
	23 Mar 08,	Manawatu River Estuary, Manawatu					
	24 Mar 08,	Manawatu River Estuary, Manawatu					
	25 Mar 08,	Manawatu River Estuary, Manawatu					
4YRRR	banded	21 Sep 06,	Manawatu River Estuary, Manawatu	age	3+	sex	f
seen	22 Sep 06,	Manawatu River Estuary, Manawatu					
	22 Sep 06,	Manawatu River Estuary, Manawatu					

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<i>4YRRR contd</i>		22 Sep 06,	Manawatu River Estuary, Manawatu		
		28 Sep 06,	Manawatu River Estuary, Manawatu		
		06 Oct 06,	Motueka Sandspit, Tasman Bay		
		03 Jan 07,	Marahau, Tasman Bay		
		27 Feb 07,	Marahau, Tasman Bay		
		27 Feb 07,	Nelson Haven, Nelson, Tasman Bay		
		09 Nov 07,	Manawatu River Estuary, Manawatu		
		28 Feb 08,	Marahau, Tasman Bay		
4YYBB	banded	01 Feb 06,	Manawatu River Estuary, Manawatu	age 3+	sex m
	seen	02 Feb 06,	Manawatu River Estuary, Manawatu		
		17 Feb 06,	Manawatu River Estuary, Manawatu		
		21 Sep 06,	Manawatu River Estuary, Manawatu		
		22 Sep 06,	Manawatu River Estuary, Manawatu		
		22 Sep 06,	Manawatu River Estuary, Manawatu		
		28 Sep 06,	Manawatu River Estuary, Manawatu		
		21 Nov 06,	Manawatu River Estuary, Manawatu		
		25 Nov 06,	Manawatu River Estuary, Manawatu		
		19 Dec 06,	Manawatu River Estuary, Manawatu		
		18 Jan 07,	Manawatu River Estuary, Manawatu		
		19 Jan 07,	Manawatu River Estuary, Manawatu		
		03 Feb 07,	Manawatu River Estuary, Manawatu		
		19 Feb 07,	Manawatu River Estuary, Manawatu		
		07 Mar 07,	Manawatu River Estuary, Manawatu		
		13 Oct 07,	Manawatu River Estuary, Manawatu		
		29 Oct 07,	Avon-Heathcote Estuary, Canterbury		
		29 Oct 07,	Avon-Heathcote Estuary, Canterbury		
		11 Dec 07,	Manawatu River Estuary, Manawatu		
		30 Dec 07,	Manawatu River Estuary, Manawatu		
		12 Jan 08,	Manawatu River Estuary, Manawatu		
		16 Jan 08,	Manawatu River Estuary, Manawatu		
		23 Jan 08,	Manawatu River Estuary, Manawatu		
		30 Jan 08,	Manawatu River Estuary, Manawatu		
		05 Feb 08,	Manawatu River Estuary, Manawatu		
		09 Feb 08,	Manawatu River Estuary, Manawatu		
		17 Feb 08,	Manawatu River Estuary, Manawatu		
		26 Feb 08,	Manawatu River Estuary, Manawatu		
		04 Mar 08,	Manawatu River Estuary, Manawatu		
		05 Mar 08,	Manawatu River Estuary, Manawatu		
		08 Mar 08,	Manawatu River Estuary, Manawatu		
		10 Mar 08,	Manawatu River Estuary, Manawatu		
5WYWY	banded	18 Nov 05,	Motueka Sandspit, Tasman Bay	age 3+	sex f
	seen	18 Nov 05	Motueka Sandspit, Tasman Bay		
		14 Feb 06	Miranda, Shellbanks, South Auckland		
		08 Mar 06	Miranda, Shellbanks, South Auckland		
		09 Mar 06	Miranda, Shellbanks, South Auckland		
		14 Mar 06	Miranda, Shellbanks, South Auckland		
		24 Mar 06	Miranda, Shellbanks, South Auckland		
		30 Mar 06	Miranda, Shellbanks, South Auckland		
		07 Sep 06	Miranda, Shellbanks, South Auckland		

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<i>5WYWY contd</i>	23 Sep 06	Miranda, Shellbanks, South Auckland			
	16 Oct 06	Miranda, Shellbanks, South Auckland			
	29 Oct 06,	Miranda, Shellbanks, South Auckland			
	30 Dec 06,	Miranda, Shellbanks, South Auckland			
	12 Feb 07,	Miranda, Shellbanks, South Auckland			
	03 Mar 07,	Kaiaua, Firth of Thames, South Auckland			
5YWYB	banded 02 Feb 06,	Farewell Spit, Golden Bay	age 3+	sex m	
seen	16 Feb 06,	Farewell Spit, lighthouse to tip, Golden Bay			
	18 Mar 06,	Farewell Spit, lighthouse to tip, Golden Bay			
	23 Sep 06,	Miranda, Shellbanks, South Auckland			
	04 Feb 07,	Farewell Spit, lighthouse to tip, Golden Bay			
6YYBR	banded 19 Feb 07,	Manawatu River Estuary, Manawatu	age 3+	sex m	
seen	07 Mar 07,	Manawatu River Estuary, Manawatu River Estuary, Manawatu			
	21 Mar 07,	Farewell Spit, base to Gobi Desert, Golden Bay			
	14 Sep 07,	Manawatu River Estuary, Manawatu			
	29 Sep 07,	Manawatu River Estuary, Manawatu			
	02 Oct 07,	Manawatu River Estuary, Manawatu			
	03 Nov 07,	Manawatu River Estuary, Manawatu			
	11 Nov 07,	Manawatu River Estuary, Manawatu			
	27 Dec 07,	Manawatu River Estuary, Manawatu			
	30 Dec 07,	Manawatu River Estuary, Manawatu			
	01 Jan 08,	Manawatu River Estuary, Manawatu			
	05 Jan 08,	Manawatu River Estuary, Manawatu			
	12 Jan 08,	Manawatu River Estuary, Manawatu			
	16 Jan 08,	Manawatu River Estuary, Manawatu			
	23 Jan 08,	Manawatu River Estuary, Manawatu			
	26 Jan 08,	Manawatu River Estuary, Manawatu			
	30 Jan 08,	Manawatu River Estuary, Manawatu			
	02 Feb 08,	Manawatu River Estuary, Manawatu			
	05 Feb 08,	Manawatu River Estuary, Manawatu			
	09 Feb 08,	Manawatu River Estuary, Manawatu			
	17 Feb 08,	Foxton, Manawatu Estuary, Manawatu			
	19 Feb 08,	Foxton, Manawatu River Estuary, Manawatu			
	20 Feb 08,	Foxton, Manawatu River Estuary, Manawatu			
	26 Feb 08,	Foxton, Manawatu River Estuary, Manawatu			
	05 Mar 08,	Foxton, Manawatu River Estuary, Manawatu			
	08 Mar 08,	Foxton, Manawatu River Estuary, Manawatu			
	10 Mar 08,	Foxton, Manawatu River Estuary, Manawatu			
	11 Mar 08,	Foxton, Manawatu River Estuary, Manawatu			
	12 Mar 08,	Foxton, Manawatu River Estuary, Manawatu			
	13 Mar 08,	Foxton, Manawatu River Estuary, Manawatu			

Appendix 3

Movements of red knots, *Calidris canutus*, between the North and South Islands

Birds are listed in order of colour-band code. All sightings of birds recorded in both the North and South Islands are given.

2RRWW	banded 13 Feb 05,	Jordan's Farm, Kaipara Harbour, North Auckland	age 2+
seen	11 Mar 05,	Farewell Spit, Base to Gobi Desert, Golden Bay	
	31 Jan 06,	Farewell Spit, Lighthouse to Tip, Golden Bay	
	17 Mar 06,	Farewell Spit, Base to Gobi Desert, Golden Bay	
	20 Mar 07,	Farewell Spit, Base to Gobi Desert, Golden Bay	
2RRYB	banded 13 Feb 05,	Jordan's Farm, Kaipara Harbour, North Auckland	age 3+
seen	01 Nov 05,	Miranda, Shellbanks, South Auckland	
	21 Dec 05,	Miranda, Shellbanks, South Auckland	
	27 Jan 06,	Farewell Spit, Lighthouse to Tip, Golden Bay	
	28 Oct 06,	Miranda, Shellbanks, South Auckland	
2RWYW	banded 26 Sep 05,	Miranda, Firth of Thames, South Auckland	age 3+
seen	28 Jan 06,	Farewell Spit, Lighthouse to Tip, Golden Bay	
	19 Mar 07,	Turanga Creek, Whitford, South Auckland	
2RYWW	banded 17 Feb 05,	Miranda, Firth of Thames, South Auckland	age 3+
seen	12 Mar 05,	Farewell Spit, Lighthouse to Tip, Golden Bay	
	01 Apr 07,	Karaka, Manukau Harbour, South Auckland	
2WBWR	banded 06 Oct 04,	Miranda, Firth of Thames, South Auckland	age 3+
seen	07 Nov 05,	Motueka Sandspit, Tasman Bay	
	10 Feb 06,	Bell Island, Waimea Inlet, Tasman Bay	
	21 Oct 06,	Motueka Sandspit, Tasman Bay	
2WBWW	banded 06 Oct 04,	Miranda, Firth of Thames, South Auckland	age 3+
seen	18 Mar 05,	Karaka, Manukau Harbour, South Auckland	
	22 Mar 07,	Motueka Sandspit, Tasman Bay	
2WRBW	banded 06 Oct 04,	Miranda, Firth of Thames, South Auckland	age 3+
seen	12 Mar 05,	Farewell Spit, Lighthouse to Tip, Golden Bay	
	02 Jan 06,	Tapora, Kaipara Harbour, North Auckland	
	13 Feb 06,	Turanga Creek, Whitford, South Auckland	
	01 Apr 06,	Mataitai, Clevedon, South Auckland	
	23 Oct 06,	Karaka, Manukau Harbour, South Auckland	
	22 Oct 07,	Mataitai, Clevedon, South Auckland	
2WWBB	banded 02 Oct 04,	Taramaire, Firth of Thames, South Auckland	age 3+
seen	10 Feb 06,	Bell Island, Waimea Inlet, Tasman Bay	
2WWWR	banded 12 Jun 04,	Taramaire, Firth of Thames, South Auckland	age 2/3
seen	13 Feb 05,	Rabbit Island, Waimea Inlet, Tasman Bay	
	27 Jan 06,	Farewell Spit, Lighthouse to Tip, Golden Bay	
2WWYR	banded 12 Jun 04,	Taramaire, Firth of Thames, South Auckland	age 2
seen	10 Jul 04,	Karaka, Manukau Harbour, South Auckland	
	25 Jul 04,	Karaka, Manukau Harbour, South Auckland	
	12 Mar 05,	Karaka, Manukau Harbour, South Auckland	
	28 Jan 06,	Farewell Spit, Lighthouse to Tip, Golden Bay	

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2WYYR	banded 17 Nov 04,	Miranda, Firth of Thames, South Auckland	age 3+
seen	20 Feb 05,	Maketu Estuary, Bay of Plenty	
	12 Mar 05,	Karaka, Manukau Harbour, South Auckland	
	19 Mar 07,	Turanga Creek, Whitford, South Auckland	
	10 Feb 08,	Farewell Spit, Lagoon to Lighthouse, Golden Bay	
2YBBW	banded 12 Jun 04,	Taramaire, Firth of Thames, South Auckland	age 1
seen	25 Jul 04,	Karaka, Manukau Harbour, South Auckland	
	29 Aug 04,	Karaka, Manukau Harbour, South Auckland	
	19 Mar 07,	Farewell Spit, Mullet to Lagoon, Golden Bay	
2YBWW	banded 12 Jun 04,	Taramaire, Firth of Thames, South Auckland	age 1
seen	10 Jul 04,	Karaka, Manukau Harbour, South Auckland	
	25 Aug 04,	Karaka, Manukau Harbour, South Auckland	
	29 Aug 04,	Karaka, Manukau Harbour, South Auckland	
	26 Sep 04,	Karaka, Manukau Harbour, South Auckland	
	22 Mar 07,	Motueka Sandspit, Tasman Bay	
2YBWW	banded 12 Jun 04,	Taramaire, Firth of Thames, South Auckland	age 2+
seen	14 Jul 04,	Karaka, Manukau Harbour, South Auckland	
	25 Jul 04,	Karaka, Manukau Harbour, South Auckland	
	29 Aug 04,	Karaka, Manukau Harbour, South Auckland	
	13 Mar 05,	Motueka Sandspit, Tasman Bay	
	13 Mar 05,	Bell Island, Waimea Inlet, Tasman Bay	
2YBYY	banded 12 Jun 04,	Taramaire, Firth of Thames, South Auckland	age 2
seen	10 Jul 04,	Karaka, Manukau Harbour, South Auckland	
	25 Jul 04,	Karaka, Manukau Harbour, South Auckland	
	25 Aug 04,	Karaka, Manukau Harbour, South Auckland	
	29 Aug 04,	Karaka, Manukau Harbour, South Auckland	
	30 Oct 04,	Karaka, Manukau Harbour, South Auckland	
	10 Jan 05,	Karaka, Manukau Harbour, South Auckland	
	13 Mar 05,	Bell Island, Waimea Inlet, Tasman Bay	
4YYBB	banded 01 Feb 06,	Manawatu River Estuary, Manawatu	age 2
seen	21 Dec 06,	Farewell Spit, Lagoon to Lighthouse, Golden Bay	