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Wader (Charadriiformes) and royal spoonbill (*Platalea regia*) use of roosts in Whangarei Harbour and Ruakaka Estuary, Northland, 1973-2000

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Abstract Roost sites in Whangarei Harbour and Ruakaka Estuary were used regularly by 12 wader species and 6 other species were present occasionally between 1974 and 2000. Counts at 7 roost sites in Nov, Jun/Jul, and Mar showed that 4 species, eastern bar-tailed godwit (*Limosa lapponica*), lesser knot (*Calidris canutus*), pied stilt (*Himantopus leucocephalus*), and South Island pied oystercatcher (*Haematopus ostralegus finschi*) contributed 70-99% (median 94%) of the waders. Most of the common waders used several roosts at each tide, but numbers and species richness of resident and vagrant species were greatest along the southern margin of the harbour. Changes in roost structure and proximity to feeding areas, and differences in migration patterns affected counts at individual roosts and the overall totals of wading birds counted in the harbour and its environs.

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Keywords Whangarei Harbour; Northland; waders; Charadriiformes; royal spoonbill; counts; roost sites

INTRODUCTION

Whangarei Harbour is 24 km long and extends southeast from Whangarei City to Bream Bay on the east coast of the far northern North Island (Fig. 1). The 140 km of shoreline and 12,315 ha of its 4 major catchments drain urban areas and pastoral farmland. At low tide 5200 ha are open water, 50 ha are rocky shore, 189 ha are salt marsh, 1496 ha are mangroves, and 5380 ha are sand and mud flats. The hydrology of the harbour is influenced by the relatively small freshwater input for its length, which results in the entire harbour not flushing each tide. These factors result in higher deposition of silt, sand, and mud, in the upper harbour west of Limestone Island (Miller 1980).

Whangarei Harbour and the associated Ruakaka Estuary together constitute the 10th most important harbour system, in terms of the number of resident waders, in New Zealand, but provides habitat for less than 0.5% of the overseas migrant waders (Sagar *et al.* 1999). The harbour can be visited by 10-20% of the national totals of Asiatic whimbrels (*Numenius phaeopus variegatus*), 2% of wrybills (*Anarhynchus frontalis*), 1-10% of variable oystercatchers (*Haematopus unicolor*), and 10% of the royal spoonbills (*Platalea regia*; Heather & Robertson 1996).

Since the 1920s, major areas of wader habitat have been developed along the shores of Whangarei Harbour, which has indirectly or directly affected the numbers and distribution of migrant and resident waders (Munro 1971). Roosting habitat has been created, using sediment pumped from channels, at Port Whangarei, on the margin of the Portland channel south of Limestone Island, and on Snake Bank (Fig. 1; Table 1).

A roost was also created from the annual average discharge of 106,000 tonnes of sediment into the harbour by the Portland cement works for 70 years until 1983 (Miller 1980; Parrish 1984; Northland Harbour Board 1988). However, this activity also damaged the habitats for waders and other biota as the discharge spread fine material throughout the middle and upper harbour. During this time *Zostera* spp. and scallop (*Pecten novaezelandiae*) beds were destroyed, and black swan (*Cygnus atratus*) ceased to use the harbour (B. Dickie, *pers. comm.*).

The development of the Marsden Point oil refinery in 1964, and extensions in 1987, also destroyed a roost site, but some roosts remained

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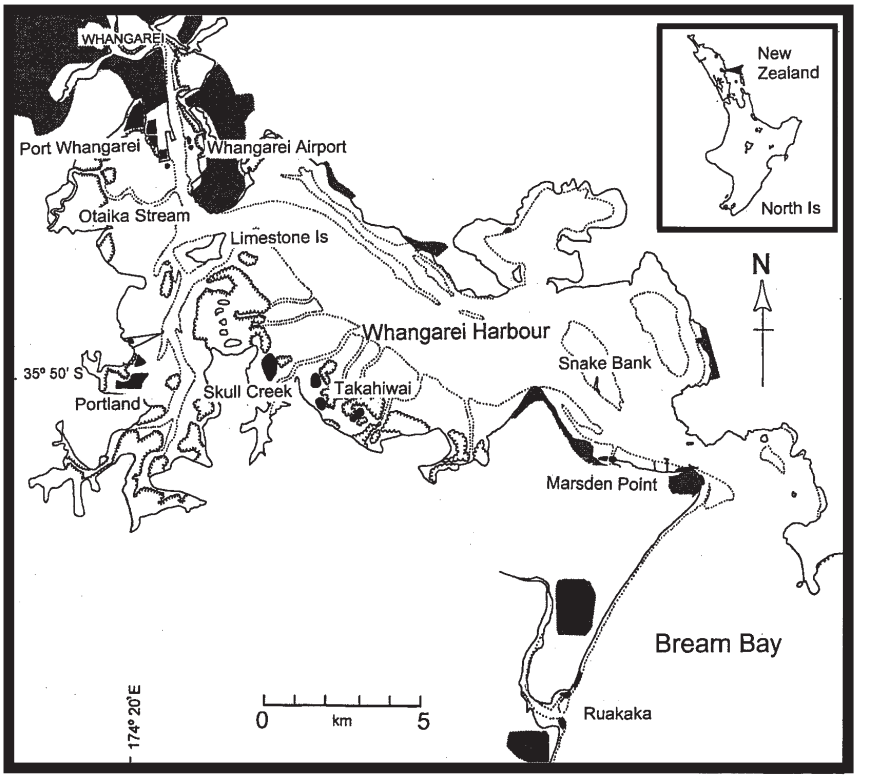

Fig. 1 Distribution of wading bird roosts in Whangarei Harbour and Ruakaka Estuary, Northland, New Zealand.

nearby. Despite ongoing erosion they were partly restored in the later 1990s. Development of a logging port near Marsden Point has since removed *c*.5 ha of feeding habitat.

Wader roost counts done by Northland Region of the Ornithological Society of New Zealand (OSNZ) were used to assess the importance of the various roost sites to waders, in relation to protection status (B. Dickie, *pers. comm.*). Roosts at Portland and Skull Creek were very important for many species, but lay outside the designated wildlife refuge. Subsequently, the Golden Bay Cement Company established a predator control programme and erected a walkway and observation hide beside the Portland roost. The fields neighbouring the Skull Creek roost have been fenced off by Mr J. Hewlett, the land owner.

Data collected by OSNZ Northland were also used in an assessment of national wader number over a 10-year period (Sagar *et al.* 1999), and in an analysis of roost use in Port Whangarei (Parrish 1984; Beauchamp & Parrish 1999). Many species' totals for Whangarei Harbour have been published in Classified Summarised Notes (*Notornis*, various issues to 2006). However, to provide OSNZ Northland Region with a focus for further research and to indicate the areas where immediate response would be required if there was a major oil spill in the harbour. This paper seeks to assess the number of waders using the harbour; the patterns of preferences for roost sites by each species between 1975 and 2000; the representation of wader species at roosts, the predominant species using each roost in 1990-2000; and the areas where regular surveys would be most productive, and the areas where research is needed.

METHODS

Data collection

Waders were counted at roost sites in Whangarei Harbour and at Ruakaka during Mar (1974-2000), Jul (1975-1983), Jun (1984-2000), and Nov (1974-2000; Table 2). North shore sites were not counted regularly until 1986, and the Portland and Skull Creek sites sometimes were not counted. Counts were timed to assess numbers in the the period just before Palaearctic waders left on northward migration, to determine the winter distribution, and to assess numbers of returning migrants within 6 weeks of the return of Palaearctic waders (Veitch 1999).

Thirty-two experienced observers were paired with at least 14 other observers during the 25 years of the counts. All counts were made at the same time during a high tide, on a single day at a weekend, by 7-18 people on foot. Routes to access sites, and the

Table 1 Location and changes in status of wading bird roost sites in and around Whangarei Harbour, Northland, New Zealand, 1973-2000.

			Period		
Roost site	Area	NZMS 260 Q07	1973-1980	1981-1990	1991-2000
Port Whangarei	50 ha (ponds)	325040	Wall with spill areas onto mud flats of the harbour. Rough reclaimed land with weeds and ponds	Settlement ponds and reclaimed land with 5 ha of mud and shell used as a roost site	Reclaimed land with logs and port buildings. Settlement ponds with 1 ha of mud in original roost being filled by mangroves. Filled and mud ponds provide dry and shallow water roost areas during spring tides.
Portland	20 ha (mudflat)	308978	Limestone slack muddy spring tide roost. Muddy area forms a neap roost	One spring tide roost area progressively grown over by mangroves.	One spring tide roost overgrown, leaving muddy neap tide roost as only roost site. Site covered by largest spring tides.
Skull Creek	20 ha	346979	*Sarcicornia* and mud roost site	Unchanged	Unchanged
Takahiwai	20 ha	373960	*Sarcicornia*, mangrove and mud roost sites	Unchanged	Unchanged
Marsden Bay	2 ha	440951 463945	Long narrow tidal spit gradually eroding.	Eroding and shortening spit.	Tidal spit shortened before being eliminated in southeasterly gale in 1998. Replaced man-made island. Spring tide roost unchanged
Northern Harbour and Airport	30 ha	338023; 355037; 383014; 448020; 464985 493943.	Large grassed areas near runway.	Playing fields added in 2 areas providng more short grass, and closer access to roosting birds near the runway.	Area surrounding the airport occasionally used for hay production obscuring roosting birds. Full area available all tides.
Ruakaka	5 ha	425875	Estuary margin and sand bars	Unchanged	Unchanged and available in spring tides

surrounding vegetation changed, but access routes and the bird locations at a site and tidal coverage of each roost were not recorded (Table 1). Birds were counted using binoculars and 15-45× telescopes. Bird movements to or from sites were noted and the time, direction of flight, and numbers were estimated. The count co-ordinator adjusted totals in light of the observations of movements, to reduce the chance of multiple counts. Any unusual records were checked to ensure correct identifications. Weather conditions and tide height above chart datum were recorded by the co-ordinator.

During most censuses the data were grouped by roost site, but in Jun 1986 and 1988, and Nov 1986 and 1987, all data for the harbour were pooled (Table 2). Before 1982 and until 1984 not all sites were surveyed. Total harbour counts were therefore used when all sites were covered. In addition, the 1991-2000 records showed that lesser knots (*Calidris canutus)* did not use the airport and north shore as day roosts, and only 0.4-2.6% (n = 29) of the godwits (*Limosa lapponica*) used these sites. Overall, the airport and north shore contributed only an average 0.66% (SE_{mean} 0.31, range 0.03-3.66%) and 3.4% (SE_{mean} 1.03, range 0.1-10.7%) of all waders in Nov and Mar, respectively. Harbour counts lacking totals for these 2 areas were therefore considered to be adequate estimates of total wader numbers, and are included as such in analyses.

The dispersion of waders and their preferred roost sites in Mar, Jun/Jul, and Nov were assessed using the 1991-2000 data. The presence of species at a roost site, and the importance of those sites to the less common species, were assessed from all individual roost records. Changes in roost site presence was assessed using data from all sites in the 3 periods; 1974-1980, 1981-1990, and 1991-2000.

RESULTS

Numbers of waders

Twenty species of wading birds were recorded in Whangarei Harbour and Ruakaka Estuary between 1973 and 2000. Four species (eastern bar-tailed godwit; lesser knot; South Island pied oystercatcher *Haematopus ostralegus finschi*; pied stilt *Himantopus leucocephalus*) were common and always comprised over 80% of the waders counted (Table 3). Eight species (variable oystercatcher; northern New

Table 2 Count periods at each roost. M, Mar; J, Jun or Jul count; N, Nov; X, no count; *Station counted Jun/Jul and Nov but roost totals not separated.

Roost site	1973	1974	1975	1976	1977	1978	1979	1980
Port Whangarei	MXX	MN	MJN	MJN	MJN	MXN	MJN	MJN
Portland	MXX	MN	MJN	MJN	MJN	MXN	MJN	MJN
Skull Creek	MXX	MN	MJX	MJN	MJN	MXN	MJN	MJN
Takahiwai	MXX	MN	MJN	MJN	MJN	MXN	MJN	MJN
Marsden Bay	MXX	MN	MJN	MJN	MXN	MXN	XJN	MJN
Northern shore	XXX	XXX	XXX	XXX	XJX	MXX	XXX	XJX
Ruakaka	MXX	MXN	MJN	MJN	MJN	XXX	XJN	MJN

Roost site	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Port Whangarei	MJN	MJN	MJN	MXN	MJN	M**	MJ*	M*N	MXX	XJN
Portland	MJN	MJN	MJX	MXN	MXN	M**	MJ*	M*N	MXX	XJN
Skull Creek	MJX	MJN	MJN	MXN	MJN	M**	MJ*	M*N	XXX	XJN
Takahiwai	MJN	MJN	MJN	MXN	MJN	M**	MJ*	M*N	MXX	XJN
Marsden Bay	MJN	MJN	MJN	MXN	MJN	M**	MJ*	M*N	MXX	XJN
Northern shore	XXX	XXN	XJN	MXX	MJN	MJN	MJ*	M*N	MXX	XJN
Ruakaka	MJN	MJN	MJN	MXN	MJN	M**	MJN	MJN	MXX	XJN

Roost site	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Port Whangarei	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN
Portland	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN
Skull Creek	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN
Takahiwai	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN
Marsden Bay	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN
Northern shore	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN
Ruakaka	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN	MJN

Table 3 Overall representation (% , mean ± SD, range) of the 4 commonest waders at Whangarei Harbour and Ruakaka Estuary. SIPO, South Island pied oystercatcher.

	Taxon				
	SIPO	Pied stilt	Lesser knot	Eastern bar-tailed godwit	Total
Mar (*n*=25)	27.9±13.1	9.6±5.0	18.2±11.1	36.9±12.8	92.8±4.2
	6.7-65.0	2.1-21.6	0-38.8	9.6-61.4	80.9-97.8
Jun/Jul (*n*=18)	58.8±8.3	15.5±5.8	0.8±1.3	9.1±4.9	84.2±6.8
	39.0-73.7	6.4-26.8	0-4.3	2.1-18.9	69.5-93.6
Nov (*n*=20)	6.3±4.5	7.2±6.0	32.3±14.8	51.5±10.0	97.2±1.
	0.2-16.4	1-19.4	4.2-58.7	36.1-70.5	94.5-99.2

Zealand dotterel *Charadrius obscurus aquilonius*; banded dotterel *C. bicinctus*; wrybill; spur-winged plover *Vanellus miles novaehollandiae*; Pacific golden plover *Pluvialis fulva*; turnstone *Arenaria interpres*; Asiatic whimbrel) were encountered frequently (Table 4). Others, including the sharp-tailed sandpiper (*Calidris acuminata*) and curlew sandpiper (*C. ferruginea*) were recorded only in the late 1970s, and the eastern curlew (*Numenius madagascariensis*) and the red-necked stint (*Calidris ruficollis*) were seen frequently in the early 1980s and only twice in the 1990s. Single black-tailed godwit (*Limosa limosa*), oriental dotterel (*Charadrius veredus*), and grey plover (*Pluvialis squatarola*) were seen in Mar 1978, Jun 1993, and Nov 1983, respectively.

The total number of birds of all Palaearctic and New Zealand migratory species varied greatly and regression models explained little of the variance in the 1983 to 2000 data during Mar (y = -121.16x + 249806, r^2 = 0.044), Jun/Jul (y = 28.936x – 54423, r^2 = 0.0657), or Nov (y = -64.656x + 135511, r^2 = 0.043) (Fig.2). The number of waders was generally both higher and more variable during Mar (mean = 8432, SE_{mean} = 745, range = 2582-13230, n =16), and Nov (mean = 6703, SE_{mean} = 457, range = 2340-10286, n =15) than during Jun (mean = 3233, SE_{mean} = 179, range = 2282-4784, n =14). The peak Mar 1984 count included high numbers of South Island pied oystercatchers and peak pre-migration populations of lesser knots and bar-tailed godwits, whereas peaks in 1995 and

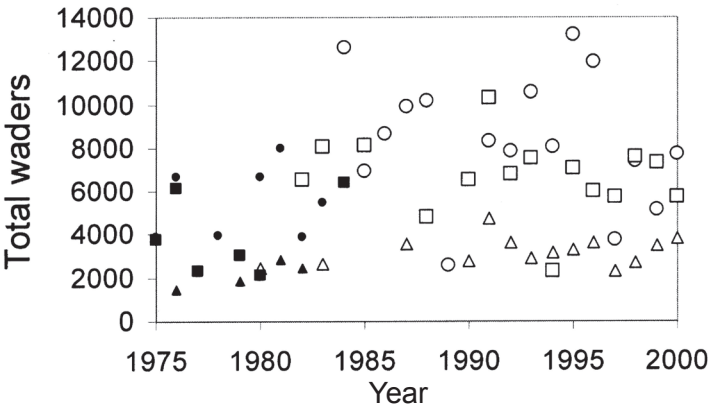

Fig. 2 Total numbers of wading birds on Whangarei Harbour and Ruakaka Estuary roost sites 1974-2000. Solid symbols are estimates because Whangarei Airport and northern shore sites not counted.

Table 4 Numbers (median, min, max) of royal spoonbill (*Platalea regia*) and charadriiform waders in Whangarei Harbour and in Ruakaka Estuary, 1991-2000.

	Mar	Jun	Nov	*H* value	P value
Royal spoonbill	0, 0-9	28, 12-84	0, 0-10	28.563	<0.001
South Island pied oystercatcher	2235, 1119-2994	1871, 887-3048	262, 16-798	19.613	<0.001
Variable oystercatcher	174, 55-272	114, 49-209	90, 56-254	5.499	0.064
Pied Stilt	705, 401-1195	437, 265-829	321, 113-611	14.063	0.001
New Zealand dotterel	30, 6-57	24, 10-51	12, 4-37	7.795	0.020
Banded dotterel	175, 22-322	346, 33-429	0, 0-9	21.132	<0.001
Wrybill	96, 2-160	109, 2-154	0, 0-1	19.733	<0.001
Pacific golden plover	34, 0-79	0, 0-4	0, 0-41	12.461	<0.001
Spur-winged plover	8, 0-40	22, 0-75	10, 0-29	2.616	0.270
Turnstone	0, 0-10	0, 0-3	0, 0-10	0.012	0.994
Lesser knot	1245, 16-4100	7, 0-150	2097, 1294-4010	19.626	<0.001
Asiatic whimbrel	14, 0-31	0, 0-22	10, 0-41	4.280	0.118
Eastern bar-tailed godwit	2738, 365-6943	351, 217-709	3222, 2488-7253	18.490	<0.001

Table 5 Dispersion (mean ± SD number of roosts used; minimum and maximum number of roosts used during any tide) of each species over the 7 Whangarei Harbour roosts and at Ruakaka Estuary at each high tide. Data are. a, Northern shore and airport; m, Marsden Bay; p, Portland; r, Ruakaka; s, Skull Creek, t, Takahiwai; w, Port Whangarei. Bold capitals indicate that the roost contained >75% of the total number of that species present at that site during at least 1 count at some time between 1991 and 2000.

	Mar		Jun		Nov	
	Sites	Dispersion	Sites	Dispersion	Sites	Dispersion
Royal spoonbill	**W**	0.3±0.0, 0, 1	pt**W**	1.1±0.31, 1, 2	s**W**	0.3±0.68, 0, 2
South Island pied oystercatcher	amprstw	5.9±0.99, 4, 7	a**M**p**R**stw	6.2±1.03, 4, 7	a**M**prstw	3.6±1.35, 1, 5
Variable oystercatcher	amp**R**stw	3.3±0.82, 2, 5	amrstw	3.4±0.97, 2, 5	amp**R**stw	3.9±0.99, 3, 6
Pied Stilt	amprstw	6.7±0.67, 5, 7	amprstw	6.4±0.97, 4, 7	am**P**rst**W**	5.9±0.99, 4, 7
New Zealand dotterel	amp**R**s**T**w	3.1±1.10, 2, 5	amprs	2.4±0.70, 1, 3	**A**mp**R**stw	2.4±0.97, 1, 4
Banded dotterel	ar**ST**	2.6±0.84, 2, 4	**A**mprst	3.0±0.81, 2, 4	**ART**	0.6±0.97, 0, 3
Wrybill	pr**S**t**W**	2.6±1.07, 1, 4	apr**S**t**W**	2.4±0.70, 2, 4	**PTW**	0.2±0.42, 0, 1
Pacific golden plover	**A**s**T**w	1.3±0.95, 0, 3	**A**	0.1±0.32, 0, 1	**T**w	0.5±0.70, 0, 2
Spur-winged plover	a**M**ps**TW**	1.4±1.43, 0, 4	amprst**W**	2.9±1.91, 0, 5	amprstw	2.4±1.26, 0, 4
Turnstone	**R**w	0.3±0.67, 0, 2	**PR**	0.2±0.42, 0, 1	**RW**	0.2±0.42, 0, 1
Lesser knot	m**P**rstw	3.6±1.07, 1, 5	**A**m**S**	0.7±0.67, 0, 2	amprs**TW**	4.0±1.56, 2, 6
Asiatic whimbrel	**ST**	0.8±0.79, 0, 2	**ST**	0.3±0.48, 0, 3	**ST**	0.7±0.48, 1, 1
Eastern bar-tailed godwit	amprstw	5.5±1.08, 3, 7	**A**mpr**S**tw	3.8±1.32, 2, 6	amprstw	5.0±0.94, 3, 6

1996 resulted from higher than usual counts of lesser knots and bar-tailed godwits.

Numbers of the most common species differed significantly ($P < 0.001$) between the 3 count periods during 1991-2000 (Table 4). The only species with less significant or non-significant changes in numbers were the resident breeding variable oystercatcher and New Zealand dotterel, the resident spur-winged

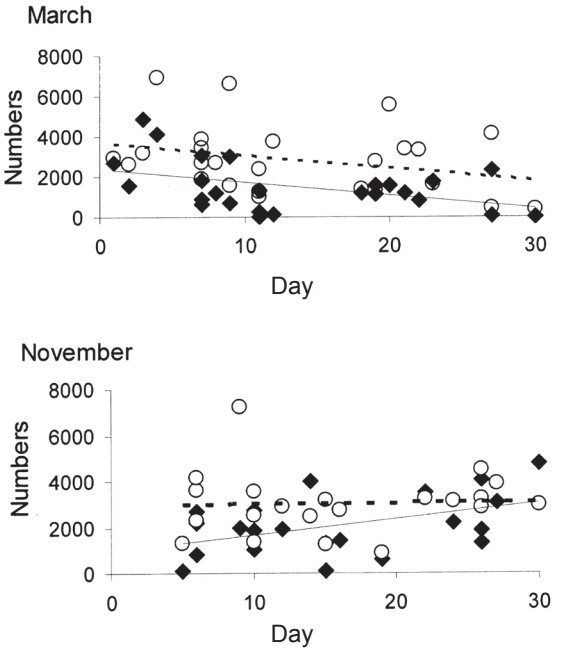

Fig. 3 Numbers of eastern bar-tailed godwits (*Limosa lapponica*) (○) and lesser knots (*Calidris canutus*) (♦) during Mar and Nov (1974 – 2000).

plover (which rarely congregates on roosts), and uncommon Palaearctic migratory species, including turnstones and Asiatic whimbrels.

Patterns within (count periods) months

Eastern bar-tailed godwits and lesser knots were expected to leave for the northern hemisphere breeding grounds during Mar (Battley & Piersma 1997, Veitch 1999). Counts during Mar showed substantial variability in numbers (Fig. 3). They indicated a pronounced decline in lesser knots (y = -64.255x + 2366.2, $F_{1,23}$ = 5.328, P<0.03, r^2 = 0.188), but not bar-tailed godwits (y = -60.868x + 3655.6, $F_{1,23}$ = 2.324, P<0.14, r^2 = 0.092) as the month progressed. New Zealand resident waders became dominant in late Mar (Fig. 4) as a result of the departure of most Palaearctic waders, as there was no evidence for an increase in the numbers of South Island pied oystercatchers at that time (y = 6.02x + 1833.5, $F_{1,23}$ = 0.79, P<0.78, r^2 = 0.003) or pied stilt (y = -8.018x + 733.9, $F_{1,23}$ = 1.66, P<0.21, r^2 = 0.07).

There were also substantial differences in the numbers of waders counted during Nov (Fig. 3). The number of lesser knots increased as the month progressed (y = 71.206x + 2880.2, $F_{1,11}$=10.989, P<0.04, r^2= 0.203), but bar-tailed godwits numbers remained unchanged (y = 8.5729x + 2880.2, $F_{1,11}$ = 6.147, P<0.82, r^2 = 0.003).

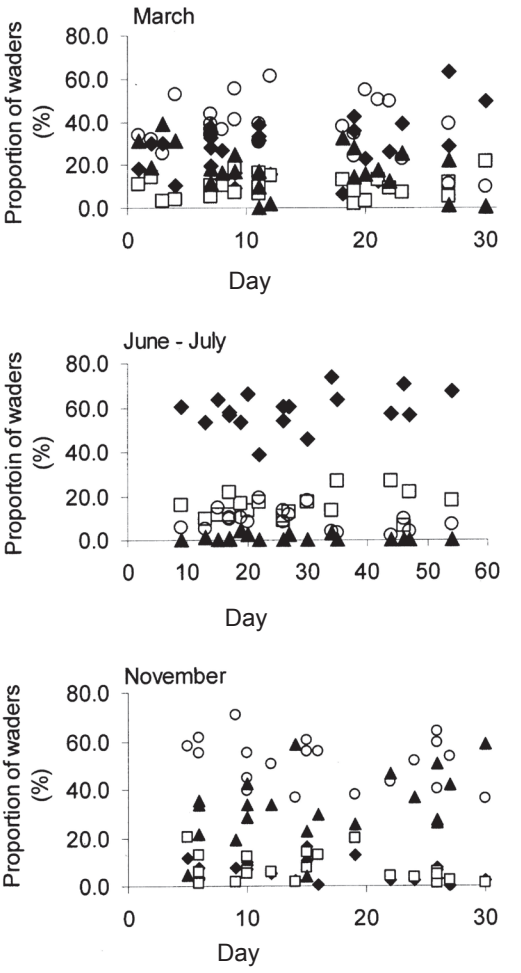

Fig. 4 Changes in composition (%) of the 4 most common wading birds in Whangarei Harbour and at Ruakaka Estuary during Mar, Jun/Jul, and Nov (1974-2000). Multiple plots on the same day indicate that a census was conducted on that day in different years, at some time between 1974 and 2000. ♦, South Island pied oystercatcher; ▲, lesser knot; ○, eastern bar-tailed godwit; □, pied stilt.

Wader distribution between, and preference for, roost sites

Concurrent counts at all roost sites in 1991-2000 showed that the most numerous waders (bar-tailed godwit, lesser knot, pied stilt, South Island pied oystercatcher, New Zealand dotterel, variable oystercatcher) used many roosts each tide (Tables 5, 6), and that the populations were well dispersed, with few species having >75% of their total at 1 location during any high tide. The outer harbour sites, Marsden Point and Ruakaka Estuary, were the only locations to have had >75% of the total South

Table 6 Percentage of total recoveries (Mar; Jun; Nov) of 13 species of wading bird at each roost site in Whangarei Harbour and Ruakaka Estuary, 1991-2000 (n = 30 counts).

	North Shore and airport	Port Whangarei	Portland	Skull Creek	Takahiwai	Marsden Point	Ruakaka Estuary
Royal spoonbill	0	94	1	1	4	0	0
South Is oystercatcher	6	5	28	20	12	24	5
Variable oystercatcher	9	0	2	3	1	32	53
Pied stilt	6	44	25	9	9	5	2
New Zealand dotterel	29	3	1	18	12	6	33
Banded dotterel	52	0	1	16	26	5	1
Wrybill	3	23	11	53	8	0	2
Pacific golden plover	23	4	0	5	68	0	0
Spur-wing plover	23	10	5	17	15	28	2
Turnstone	0	7	4	0	0	0	89
Lesser knot	0	27	21	20	19	1	11
Asiatic whimbrel	0	0	0	32	68	0	0
Eastern bar-tailed godwit	1	20	29	22	19	6	4

Island pied oystercatcher population, and these were the closest roosts to major feeding grounds. Other New Zealand residents, including wrybill, banded dotterel, and spur-winged plover, and some less common migrants such as Pacific golden plover and Asiatic whimbrel used fewer roost sites but generally more than 1 at each high tide.

There were changes in roost site preference by some species during the three periods (1974-1980; 1981-1990; 1991-2000; Table 5). In the 1970s and 1980s, South Island pied oystercatcher were most numerous at Marsden Point, but in the 1990s they were distributed widely amongst the inner southern harbour sites. New Zealand dotterel favoured Ruakaka Estuary all year until the late 1980s, and then were found over most sites. This species also stopped using the Port Whangarei roost in summer during the mid-1980s, but birds were seen at Skull Creek, Takahiwai, and Whangarei Airport. New Zealand dotterel roosted at Whangarei Airport and at Ruakaka Estuary in winter.

In winter, most of the banded dotterel were counted at Whangarei Airport, but in summer they were more widely distributed between the airport, Skull Creek, and Takahiwai. Wrybills were found always within inner harbour southern roosts, but appeared to change their sites to those closest to the deposition of new dredgings. From Mar 1991 to Jun 1996, they frequented the Port Whangarei and Skull Creek roosts, and in 1997-2000 they used the Portland roost. Pacific golden plover frequented Takahiwai and the airport, and occasionally used Skull Creek. Turnstones stopped using Takahiwai in the 1980s and after that were restricted to the Ruakaka Estuary. Spur-winged plovers first appeared in the Whangarei area in 1979 (Parrish 1984; Bull *et al.* 1985), but started to use harbour roosts only in 1992. Thereafter they used most roost sites.

The numbers of royal spoonbills increased in Jun counts, from 13 in 1990 to 84 in 2000. Until 1999 they roosted almost always at Port Whangarei (Table 5). The 1st birds to remain in summer were recorded in 1996. The Port Whangarei roost became less suitable in 2000 as the dredge ponds were filled and then overgrown by weeds, and the spoonbills began to use other roost sites (Table 6).

DISCUSSION

Trends in numbers

OSNZ counts of waders at harbour roosts have been used before to assess the progress of wildlife management in Whangarei Harbour (Parrish 1984, B. Dickie, *pers. comm.*) and as part of the national survey of wader populations (Sagar *et al.* 1999). Previous studies of waders in the northern New Zealand harbours have shown that numbers varied significantly within and between months (Veitch 1999). These studies included sufficient counts to enable standardisation, so that long-term trends could be explored. The counts in the present study also showed a high annual variability, even when counts took place on the same date in different years; they also showed that there were seasonal differences in bird numbers or presence and absence. However, there were not sufficient data to allow corrections for missed sites nor to assess possible trends, because until 1990 collection and compilation of data were not standardised sufficiently (Table 2).

If single annual counts are to be continued then the results suggest that the timing of counts needs to be more consistent to reduce the variation resulting from temporal changes in numbers associated with migration, especially in spring and late summer. Mar (summer) counts need to be restricted to the 1st week of the month, when lesser knots and bar-tailed godwits are unlikely to have migrated. Nov counts need to be done during the same week each year to minimize the variation resulting from changes in the composition of the wader flocks. Rigid timing is less important in mid-winter because of the relative

stability of local wader populations at that time, but it would be best to restrict counting to the last week in Jun to be consistent with surveys in other areas (Veitch 1999). If changes in numbers and species composition over time need to be known in more detail, then more counts will be required throughout the year.

Importance of roost sites

Even with the limitations imposed by irregular coverage and count dates, there were still sufficient data on which to assess the relative importance of roost sites to different species, and to indicate the types of changes that could be expected if roosting sites were lost. Counts since the 1970s indicated that the loss of a roost site was not critical to South Island pied oystercatchers, variable oystercatchers, pied stilts, lesser knots, or bar-tailed godwits, because they were well distributed amongst the roosts at each high tide. However, for some species, such as royal spoonbill, wrybill, banded dotterel, and Pacific golden plover, that use only a few sites, the loss of a single site may be more problematic. It is, therefore, important that these species are monitored to see if existing or new sites are used.

The next roost to be lost will be that at Port Whangarei (Beauchamp & Parrish 1999). Its loss will leave only the airport and Ruakaka Estuary as known highest spring-tide safe roosts. In 2002, the Whangarei Airport authorities increased their activities to discourage roosting waders, and it may be that waders from the airport will roost at Ruakaka Estuary, as they did Mar 2001 (AJB, pers. obs.).

The absence of some species from some counts, and substantial changes in numbers of other species, indicate some roost sites were being missed, or the potential for some species to alter their behaviour if a roost was lost was not appreciated. Counts suggested that Pacific golden plovers were restricted to the Takahiwai and the airport roost sites. However, this species roosts also on fields: its absence from the records in some years may result from their using such alternative roosting sites. Previous work has also indicated that pied stilts are more likely to be present at roosts during drier periods, when they are more likely to use the settlement ponds and harbour rather than damp fields for feeding (Beauchamp & Parrish 1999). Future work should include investigation of wader use of the fields surrounding the harbour for roosting and feeding.

Further work is also required to determine the use of roost sites by waders in relation to the location of feeding areas. For example, since 1974 wrybills have changed roost sites often, and have roosted at the site nearest to newly-disturbed mud from dredging operations. Other species, such as Asiatic whimbrel, were found generally at Takahiwai and Skull Creek roosts. They may have restricted foraging regions within the harbour.

The counts discussed here were all done in daylight and at high tide. Studies in northern New South Wales indicate that waders can change their use of foraging areas between day and night (Rohweder & Baverstock 1996), and this may well apply to roost sites as well. Although it might be difficult, the full pattern of roost use should include surveys of how the sites are used during the changing tide in daylight, and how the same areas are used at night.

Whangarei Harbour: trends in wader numbers and national importance

We found that partial counts can seriously affect count statistics, especially when one or more of the southern roost sites was missed. For example, the Mar 1989 total did not include the waders at Skull Creek, and the Jan 1985 total did not include the waders at Portland, consequently the species totals included in national analyses (Sagar *et al.* 1999) were underestimates. Full counts in Mar of godwits and knots in Whangarei Harbour were poorly correlated (r=0.275) with the mean totals for these species in New Zealand in 1983-94 (Sagar *et al.* 1999). The low correlation reflects the dynamics of the temporal distributions of these species within and between harbour systems in northern New Zealand (Veitch 1999).

Nationally, the population of South Island pied oystercatchers has increased by 75% since 1971 (Heather & Robertson 1996). In the early 1970s, Munro (1971) reported typical numbers of 350-540 at Whangarei in Jul, 115 in Nov, and 450 in Mar. The Whangarei Harbour counts indicate an increase during the 1980s, when counts included both full and partial coverage of the harbour. In the 1990s, the wintering population stabilised and this oystercatcher has become the most common wader in the harbour in Jun/Jul. The recent history of the South Island pied oystercatcher at Whangarei is similar to that in the Manukau Harbour (Veitch & Habraken 1999).

Variable oystercatchers have increased in Whangarei Harbour, from *c*.2000 in the 1970s to *c*.4000 in the 1990s (Heather & Robertson 1996). Much of this local increase can be attributed to protection of breeding areas, including those at Mangawhai, Ruakaka, and Waipu sand spits. An apparent decline in the 1980s has been halted and numbers in Whangarei Harbour have rebounded. Towards the end of the count period, rats were removed from Limestone Island and the 12 pairs of variable oystercatcheres there each now annually produce up to 2 clutches of 2 young (C. Bishop, *pers. comm.*).

In the count period there have been few effects of development of land behind the key southern

foraging areas and roost sites (Parrish 1984). The stability in the number and species of waders and high annual variability in numbers seen during the past 15 years in Whangarei Harbour and at Ruakaka Estuary, suggest that food resources are not limiting. However, further work is needed on the current relationships between foraging and roosting sites, and on food availability, to ensure we are able to assess and mitigate the effects of future development.

Risks to wading birds in Whangarei Harbour

The populations of wading birds in Whangarei Harbour are at significant risk from habitat destruction or direct damage during a storm or other incident such as a major oil spill. Winds associated with a major tropical depression in Jun 1996 destroyed the remnants of the islands south of Port Whangarei, which eventually led to the royal spoonbills abandoning this area as a roost site (Beauchamp & Parrish 1999). The same storm reduced the available roost site at Marsden Point, before the roost area was restored to protect nearby houses.

There have been significant oil spills in the lower harbour associated with oil tanker discharge and refilling operations (R. Elliott, *pers. comm.*), but such spills could take place anywhere within the harbour. Since 1990 there have been at least 2 small oil spills at night. Wading bird use of the harbour at night is not well known and there are no recent data on seasonal or daily use patterns (Parrish 1984). Patterns of use such as those demonstrated by this study need to be integrated into the bird response parts of the Whangarei Harbour and environs oil spill contingency plan. Wader use of each roost should continue to be monitored, so that trends and potential problems can be identified and groups of species such as wrybill, variable oystercatcher, New Zealand dotterel, and royal spoonbill which are threatened, or for which Whangarei Harbour holds more than 1% of the national total, can be located.

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