Waders of the Manukau Harbour and Firth of Thames

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ABSTRACT

Thirty-one species of wader have been counted on the Manukau Harbour and Firth of Thames in summer and winter censuses since the winter of 1960. Data are presented on total numbers of waders, the numbers of selected wader species and the numbers of observers involved in the counts. The numbers of many native waders have increased during the last 39 years, especially Pied Oystercatchers (*Haematopus ostralegus*), which have increased 8-fold from the 1960s to 1990s; however, Pied Stilts have been stable and Wrybills (*Anarhynchus frontalis*) may be declining. Numbers of many Arctic wader species have increased on one or both harbours, but of the two main species, Bar-tailed Godwits (*Limosa lapponica*) have remained constant over both harbours and Lesser Knots (*Calidris canutus*) have declined slightly on the Firth of Thames but increased greatly on the Manukau Harbour.

Notable changes of habitat are noted and possible reasons for changes in abundance of some species are discussed. Likely seasonal maxima of wader numbers are considered and the implications of these are discussed.

KEYWORDS: Waders, Charadrii, Manukau Harbour, Firth of Thames, population, census.

INTRODUCTION

New Zealand harbours and estuaries support more than 250 000 waders (birds of the Order Charadriiformes, suborder Charadrii) (Sagar *et al.* 1999). Twenty-four species are regularly counted (Sagar 1993). The Manukau Harbour and Firth of Thames are among the richest areas for waders, and due to the enthusiasm in the 1950s and 1960s of a few dedicated ornithologists, they have had the longest period of documentation of wader numbers.

Annually large numbers of three species of wader breeding in New Zealand (Pied Oystercatcher (*Haematopus ostralegus*), Wrybill (*Anarhynchus frontalis*) and Banded Dotterel (*Charadrius bicinctus*)) migrate northward, mainly from the South Island, to winter on northern harbours, although many Banded Dotterel also migrate to Australia (Pierce 1999). Native Pied Stilts (*Himantopus himantopus*) also migrate northwards to northern harbours, but many also come from nearby inland areas. Small numbers of these four species remain behind in summer and are joined by thousands of Arctic-breeding waders, "wintering" here during our summer. Some non-breeding Arctic birds remain here during our winter (over-winter). Small numbers of resident waders (Variable Oystercatcher (*Haematopus unicolor*) and New Zealand Dotterel (*Charadrius obscurus*)) are present throughout the year.

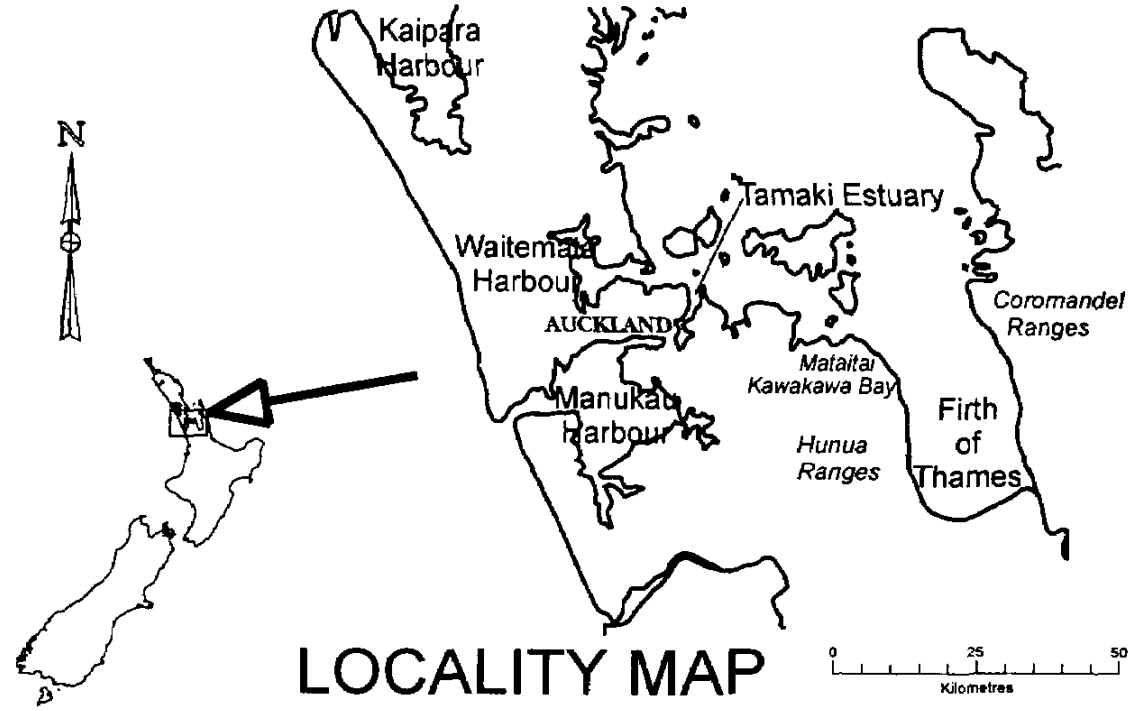

FIGURE 1 - Locality of the Manukau Harbour and Firth of Thames and other locations mentioned in the text.

This paper summarises the results of summer and winter censuses undertaken by members of the Ornithological Society of New Zealand since 1960. Some information from earlier publications (Veitch 1978) is repeated in the interest of providing complete information in this paper. Nomenclature follows Turbott (1990).

HABITAT DESCRIPTION

Manukau Harbour

Low water spring tide exposes approximately 18 000 ha of inter-tidal area in the Manukau Harbour, on the west coast of the Auckland isthmus (Fig. 1 & 2). This is presumed to be suitable for waders to forage on except for a relatively small portion that seems too sandy, a small portion that is rocky and the upper reaches of most of the tidal arms, where there are mangroves (*Avicennia marina* var. *australasica*). Pollok Spit, Seagrove, Karaka, Wiroa Island (Airport), Puketutu and Onehunga (Fig. 2) are the principal high tide roosts. Other areas included in the censuses, also shown in Fig. 2, may sometimes have high numbers of birds. Land use around the harbour includes urban housing and forest in the north, city and industrial in the north-east, urban housing in the south-east, and mainly mixed farming in the south and west.

Major modifications to the Manukau Harbour and its environs, with emphasis on the period covered by this paper, have been:

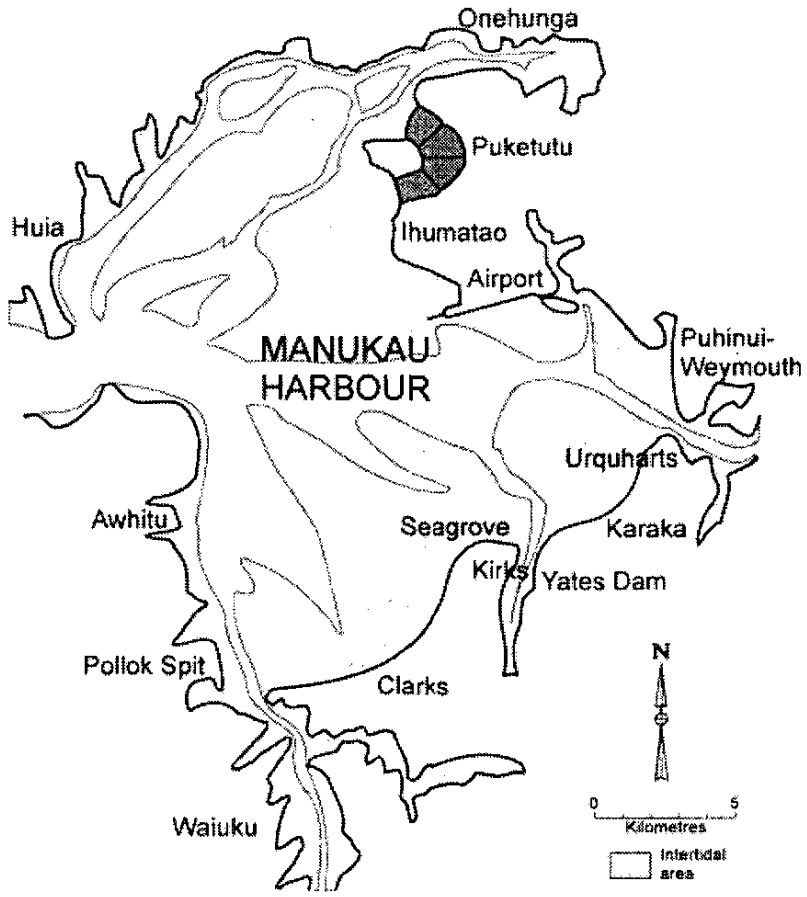

FIGURE 2 - Inter-tidal area and major census counting areas of the Manukau Harbour.

1. Conversion of nearby forest and scrub to farmland during the latter part of the 19th century. Between 1943 and 1978 there was an average annual increase of 10% in the rate of fertiliser application (Agricultural Statistics) with an assumed increase in nutrient runoff.
2. An increase in farm stocking rates, particularly up to 1978, is presumed to have resulted in an increase of effluent from stock, stock sheds and silage pits.
3. Since about 1980, large areas have been changed from pastoral farming to horticulture, with a presumed increase in use of pesticides and herbicides.
4. Increasing urban development and associated runoff of pollutants into the harbour.
5. Direct discharge of sewage and industrial effluent from the greater Auckland area. Since 1960 this has been treated in the sewage ponds (Fig. 2), which cover some 400 ha of former mudflat. From here some 300 million litres of treated effluent are discharged per day into the Manukau Harbour.
6. In the course of constructing Auckland International Airport some 100 ha of mudflat were covered in solid fill. This reclamation protrudes from the former shore in a way that has changed the inter-tidal area immediately to the south from soft mud to firm sand.

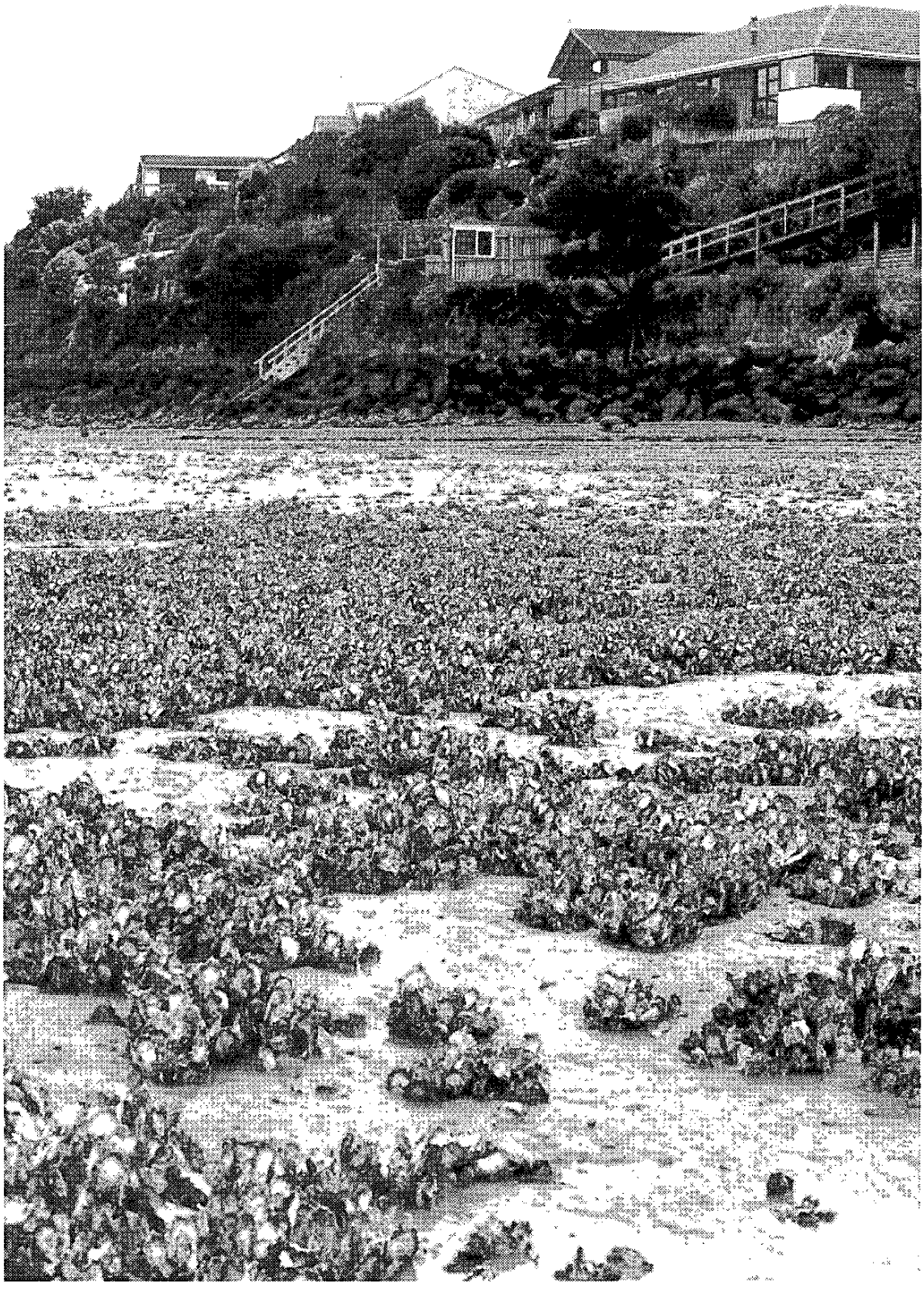

FIGURE 3 – Pacific oysters, shoreline modification and human occupation on the Manukau Harbour.

7. Large beds of the marine grasses *Zostera muelleri* and *Z. capricorni* have disappeared. This is presumed to be due to a fungal disease (M. Larcombe, pers. comm.).
8. The grasses *Spartina alterniflora* and *S. townsendii*, which grow in the inter-tidal zone, were introduced to the Manukau Harbour between 1965 and 1978. In 1984 they were estimated to cover about 13 ha of mudflat and were spreading. A 1994 survey recorded the area covered as just under 12 ha (Jamieson 1994).
9. The pacific oyster (*Crassostrea gigas*) arrived in New Zealand in about 1964 and was common in the Manukau Harbour in the late 1970s (Bioresearches 1992). This shellfish now covers large, but unmeasured, areas of the inter-tidal zone (Fig. 3). At present, distribution appears to be limited to sheltered arms and bays and slopes of channel sides that are sheltered from wave action.
10. There is a continually increasing level of human activity in the harbour. Speed boats, small hovercraft, people shellfishing, people setting fish nets, and other activities are becoming more frequent.
11. Stopbanks, particularly along the southern shoreline, reclamations in the north-eastern area and causeways for bridge approaches, have changed water flows and reduced water and bird access to areas that were saltmarsh. Mangrove areas diminished by c. 130 ha between 1955 and 1981 due to reclamation or destruction (Crisp *et al.* 1990).
12. Removal of shell, particularly at Clarks Bay, may have altered mid-tide roosts during the early years of this study.

Firth of Thames

The Firth of Thames is east of Auckland and lies between the Hunua and Coromandel Ranges (Fig. 1). Mudflat areas extend along all of the southern and south-western sides. At low water spring tides there are approximately 8500 ha of exposed inter-tidal area, most of which appears suitable for waders to forage on, although more than 800 ha are covered by mangroves. There are no tidal arms but two major rivers, other streams and man-made canals, draining an area of approximately 360 000 ha, flow into the Firth. The main high tide roosts are shown in Fig. 4. The counts given in this paper include observations at Mataitai and Kawakawa Bay, which lie further north on the western side of the Firth of Thames. Use of individual roosts has not been consistent over the study period, due mainly to environmental changes, but this is not considered to impact on the data in this paper. The land surrounding the mudflat area is all farmed.

Major modifications to the Firth of Thames and its environs have been:

1. The clearing of forest and drainage of swamps within the Hauraki Catchment, which began in the early 19th century, is continuing today. An assumed consequence is a change of river flows and silt loads being carried into the Firth. The advance of the mangrove fringe by c. 200 m near the Piako River mouth

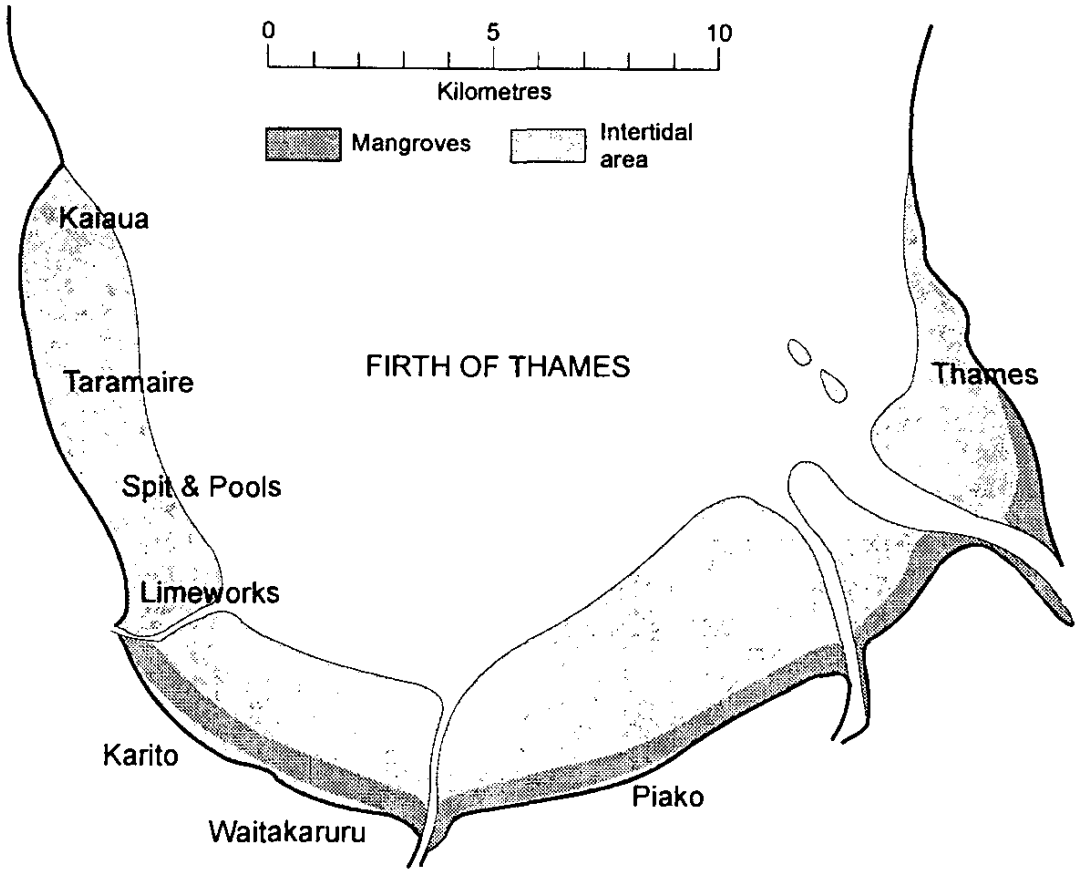

FIGURE 4 – Inter-tidal area and major census counting areas of the Firth of Thames.

between 1944 and 1993, is attributed to the vertical accretion of the mudflats adjacent to the mangroves (Young & Harvey 1996).

2. Since 1940-1945 there has been an increased rate of fertiliser application and a presumed increase in nutrient runoff from the land.
3. A continual increase in farm stocking rates. This has resulted in an increase of effluent from stock, stock sheds and silage pits.
4. Some treated and untreated sewage is discharged into the Firth of Thames and its catchment.
5. The area of mangroves has increased from less than 50 ha in 1952 to more than 800 ha in 1973 (Fig. 5).
6. The grasses *Spartina alterniflora* and *S. townsendii*, which grow in the inter-tidal zone, were introduced to the Firth of Thames during the 1960s. In 1978 these two grasses occupied less than 2 ha of mudflat.
7. The pacific oyster (*Crassostrea gigas*) arrived in New Zealand in about 1964 and is now present in the Firth of Thames.
8. In selected locations, particularly the coastline between Miranda and Kaiaua, human activity has increased significantly in recent years. Elsewhere human activity has increased slowly and remains less than on the Manukau Harbour.

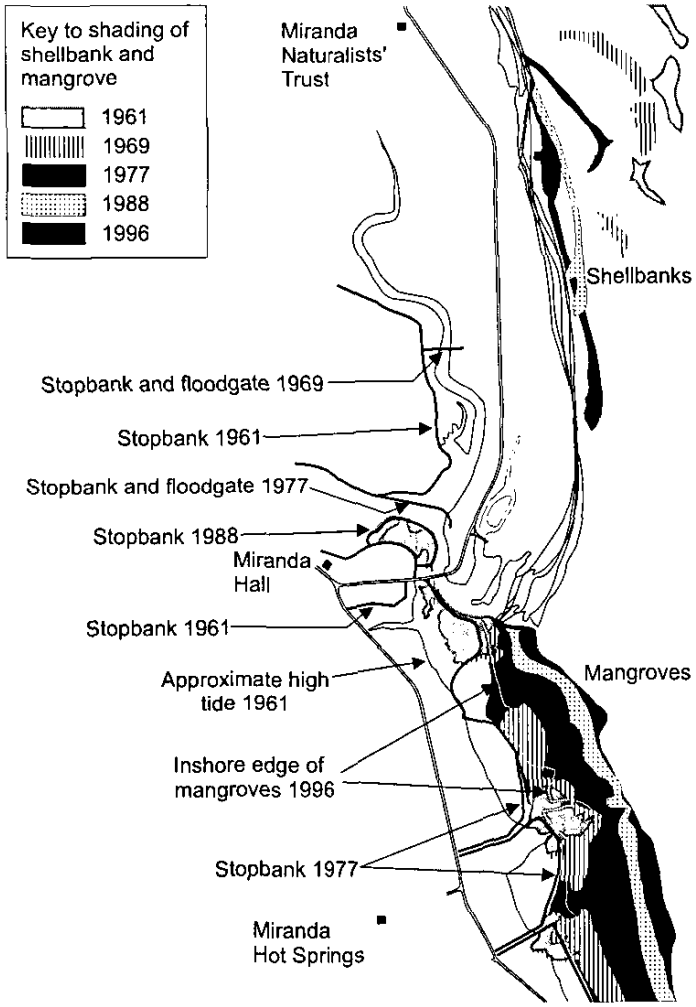

FIGURE 5 – Changes to the shoreline of part of the Firth of Thames. Traced from air photos (Aerial Mapping Ltd.).

9. Stopbanks have been constructed around most of the shoreline. The location of many of these in relation to high water spring tide is now difficult to determine due to changes on the seaward side of the bank since construction. In some areas (Fig. 5) the stopbanks have altered the normal ebb and flow of the tide.

METHODS

Census

The Manukau Harbour and Firth of Thames wader censuses have been done twice yearly, usually on a Sunday with a suitable spring tide. Summer censuses have been between 18 October and 22 December and winter censuses between 17 May and 1 August. Observers watched each known high tide roost and patrolled other areas where birds roost occasionally. The birds were counted at the predicted time of high tide. As some census areas are long shallow stretches of water or beach, which take a long time for an observer to cover and count, it was necessary for all observers to note arrival and departure of birds at the roosts for a period before and after census time so that, if necessary, corrections could be made.

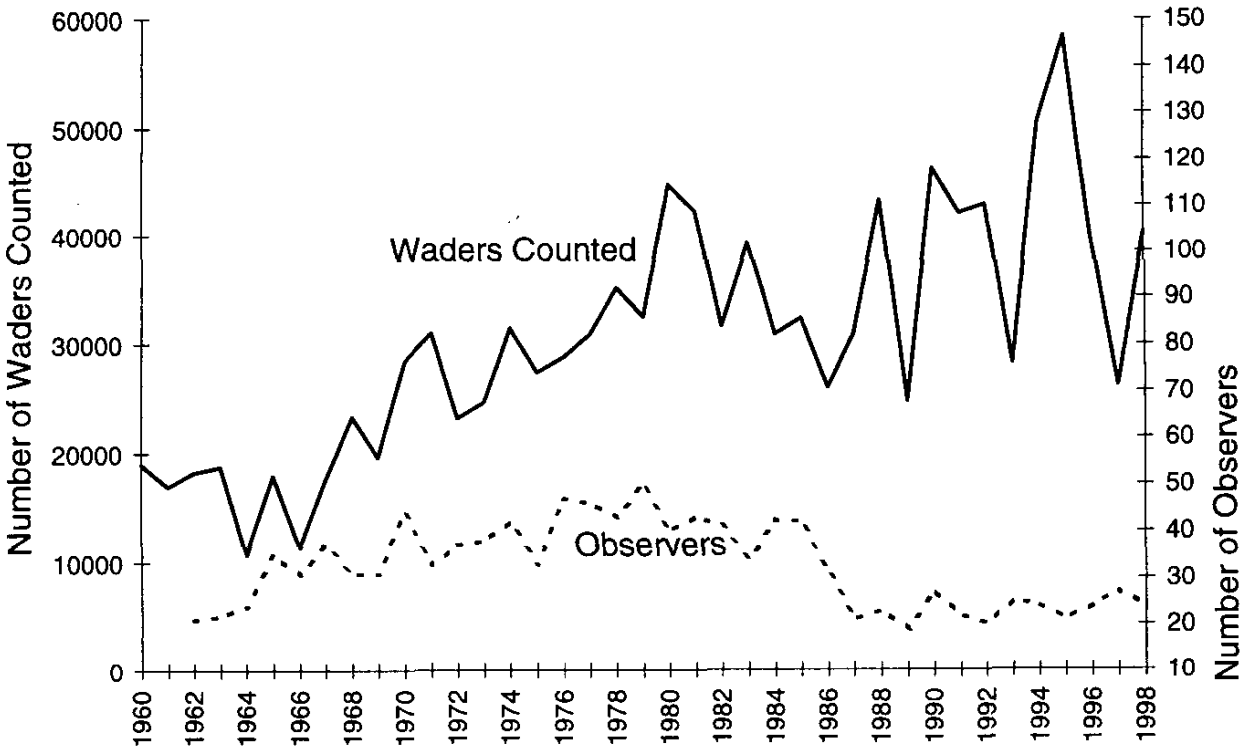

FIGURE 6 – Total numbers of waders counted, and observers present, on the Manukau Harbour during summer censuses.

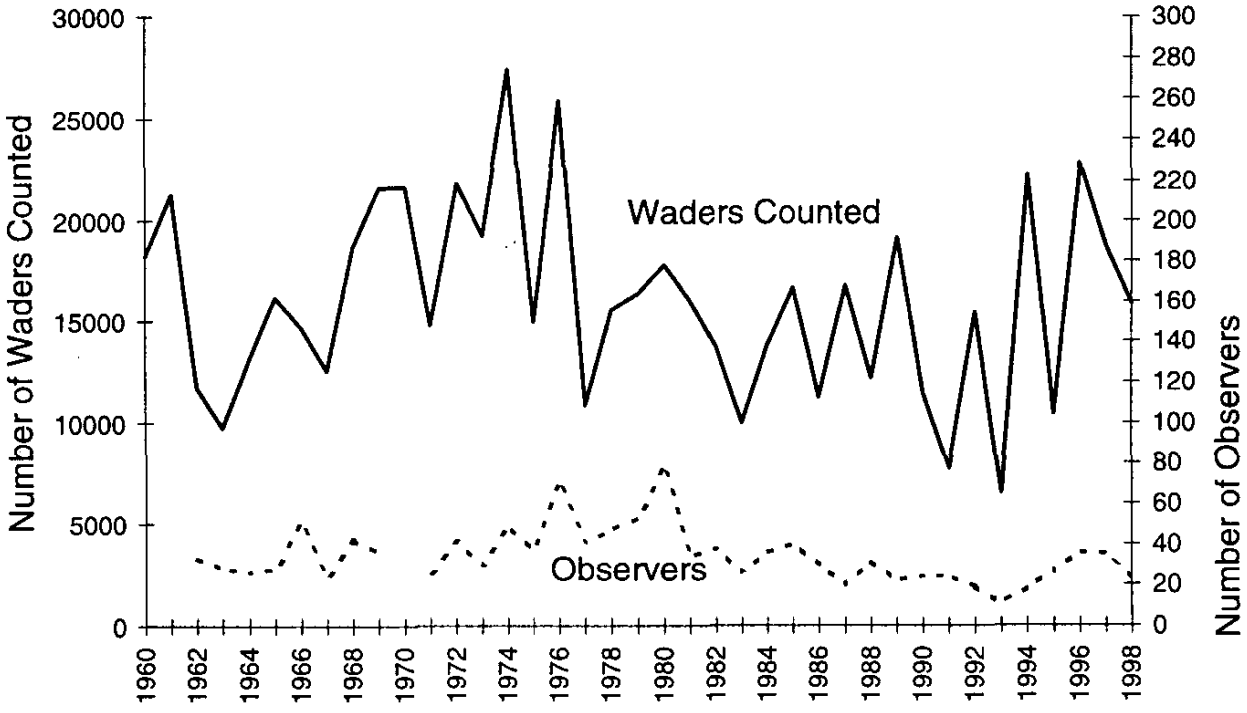

FIGURE 7 – Total numbers of waders counted, and observers present, on the Firth of Thames during summer censuses.

Censuses, principally as described, have been made on the Manukau Harbour and Firth of Thames since 1951. In the period between 1951 and 1959, counts were irregular and on some occasions not all species were counted or not all areas were covered. Data from winter 1960 on the Manukau Harbour and summer 1960 on the Firth of Thames to summer 1998 have been regular and are believed to be complete. They form the basis of this paper.

Analysis

Long-term trends in wader numbers over the 39 years of summer counts and winter counts for the Manukau Harbour (38 years for winter counts of the Firth of Thames or combined estuaries) have been analysed with Spearman Rank Order Correlation tests. Where particular periods (usually decades) have been compared, we used either the Mann-Whitney U test or Kruskal-Wallis one-way analysis of variance test, followed, where appropriate, by Dunn's method of multiple comparison between decades. We present data as the mean ± standard deviation.

RESULTS

The annual totals for summer and winter censuses in each harbour and the number of observers participating are shown in Fig. 6 to 9.

Pied Oystercatcher (*Haematopus ostralegus*)

Over the 38 years of complete winter counts, the number of Pied Oystercatchers present in winter has increased remarkably ($r = 0.96$, $P<0.001$) on both estuaries (Table 1, Fig. 10). When the winter counts are calculated on a per hectare basis (Fig. 11) the Manukau Harbour appears to have been favoured in the early years but now the Firth of Thames appears to be favoured. Pied Oystercatchers using the Manukau Harbour and Firth of Thames in winter comprised approximately 47% of the New Zealand population between 1984 and 1993 (Table 2).

The proportion of the population that remains on the Firth of Thames in summer has been steady at 17.3 ± 7.2% each year, but the proportion remaining on the Manukau Harbour in summer has declined ($U = 271$, $P=0.02$) from 22.7 ± 10.1% in 1960-79 to 16.4 ± 6.0 % in 1980-88.

Variable Oystercatcher (*Haematopus unicolor*)

This non-migratory species was not known to nest within the census area until recently, but a few may have done so. They are now known to nest nearby on the Awhitu Peninsula and northern Firth of Thames. Small numbers of birds are present on both harbours during winter and summer censuses (Table 1) and they have increased over the census period ($r = 0.71$, $P<0.001$), especially in the last six years (Fig. 12). Average counts on the Manukau Harbour in winter have increased ($U = 37.0$, $P=0.01$) from 2.79 ± 2.67 in 1960-92, to 8.0 ± 5.51 in 1993-98; the increase in the Firth of Thames is even greater, from 2.44 ± 3.52 to 33.67 ± 22.55 ($U = 3.5$, $P<0.001$) over the comparable periods.

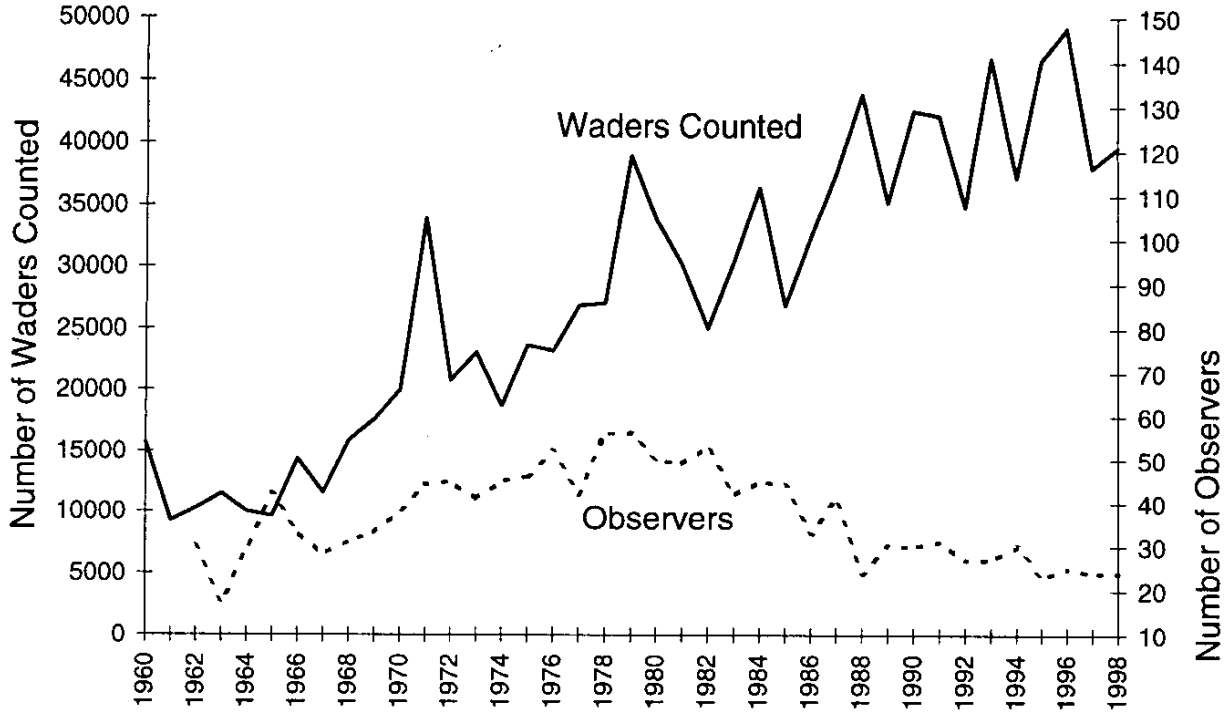

FIGURE 8 – Total numbers of waders counted, and observers present, on the Manukau Harbour during winter censuses.

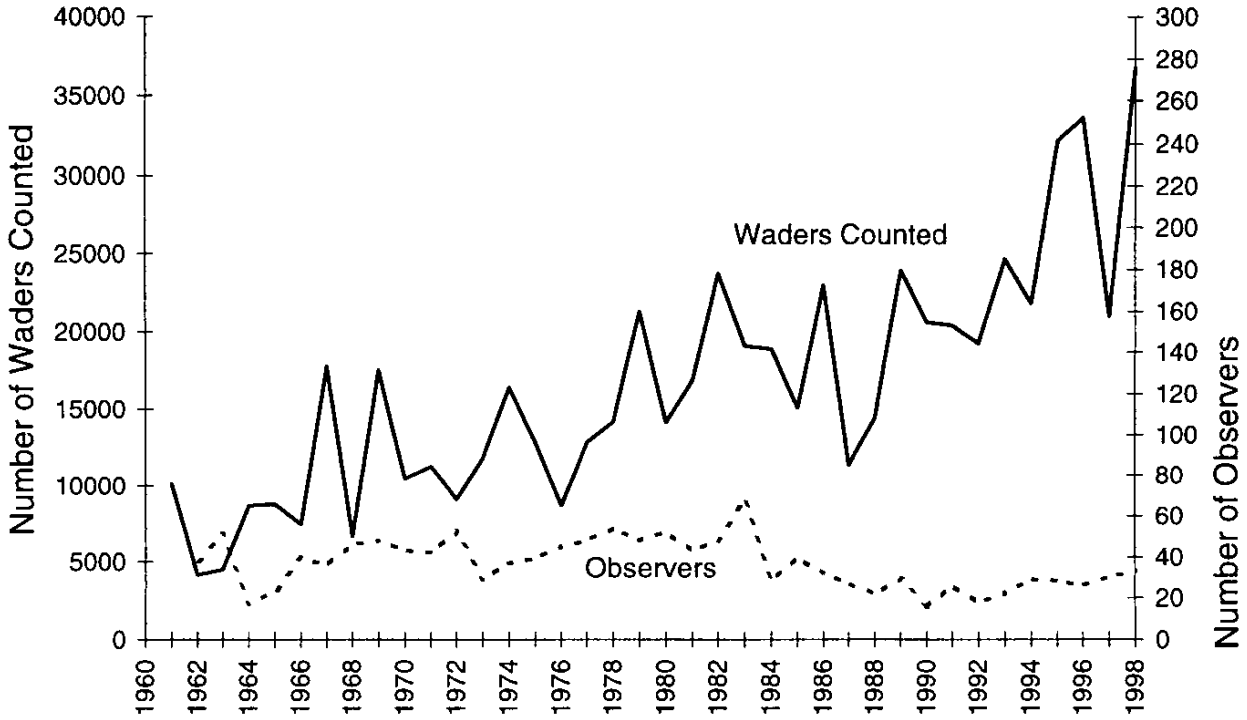

FIGURE 9 – Total numbers of waders counted, and observers present, on the Firth of Thames during winter censuses.

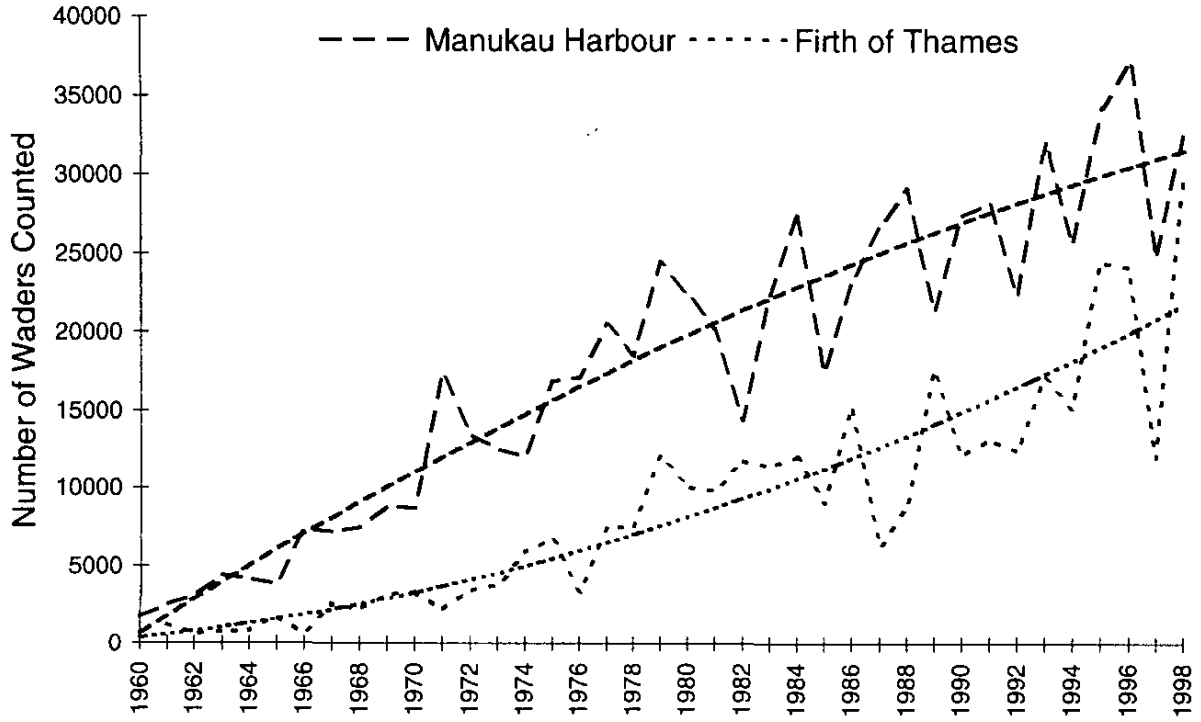

FIGURE 10 – Total numbers of Pied Oystercatchers counted on the Firth of Thames ($r = 0.936$, $P<0.001$) and Manukau Harbour ($r = 0.933$, $P<0.001$) during winter censuses. The trend lines are binomial lines fitted automatically by MS Excel.

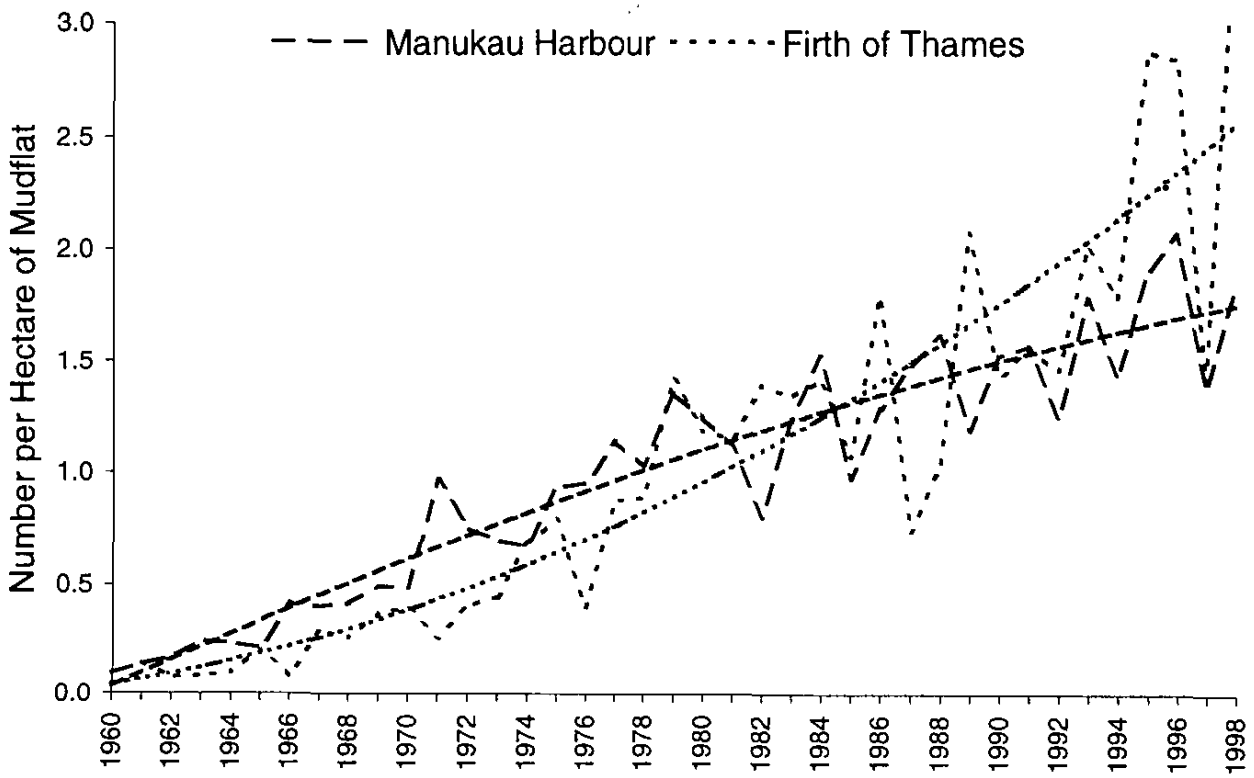

FIGURE 11 – Numbers of Pied Oystercatchers per hectare of mudflat on the Manukau Harbour ($r = 0.94$, $P<0.001$) and Firth of Thames ($r = 0.94$, $P<0.001$) in winter. The trend lines are binomial lines fitted automatically by MS Excel.

TABLE 1 - Mean numbers (with standard deviations) of the more common native waders on the Manukau Harbour and Firth of Thames (FOT).

		1960-69	1970-79	1980-89	1990-98
Pied Oystercatcher	Manukau summer	1091 ± 543	3544 ± 1543	3542 ± 1083	4617 ± 1267
	FOT summer	244 ± 147	916 ± 537	1688 ± 295	3027 ± 1309
	Manukau winter	5045 ± 2472	16160 ± 4571	22475 ± 4510	29447 ± 4943
	FOT winter	1523 ± 927	5573 ± 2985	11229 ± 3276	17834 ± 6610
Variable Oystercatcher	Manukau summer	1 ± 1.5	2 ± 1.8	2 ± 1.8	8 ± 6.4
	FOT summer	2 ± 2.4	2 ± 1.7	4 ± 4.8	21 ± 14
	Manukau winter	2 ± 2.0	3 ± 1.8	4 ± 3.7	6 ± 5.2
	FOT winter	1 ± 1.5	1 ± 0.9	3 ± 4.3	26 ± 22
Pied Stilt	Manukau summer	1088 ± 462	1017 ± 389	903 ± 391	801 ± 304
	FOT summer	888 ± 688	1126 ± 777	891 ± 301	629 ± 453
	Manukau winter	3261 ± 783	3879 ± 974	3654 ± 650	3772 ± 889
	FOT winter	3605 ± 2824	2837 ± 1242	2939 ± 1168	4134 ± 1326
Black Stilt	Manukau summer	0.1 ± 0.3	0.1 ± 0.3	0.4 ± 0.7	0.4 ± 0.7
	FOT summer	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.3	0.3 ± 0.7
	Manukau winter	1.7 ± 2.4	1.8 ± 1.5	0.3 ± 0.7	5.0 ± 2.8
	FOT winter	0.3 ± 0.7	0.8 ± 1.0	0.9 ± 1.4	1.3 ± 1.2
New Zealand Dotterel	Manukau summer	8 ± 5.8	19 ± 4.5	16 ± 5.6	18 ± 8.3
	FOT summer	8 ± 5.1	9 ± 4.1	9 ± 5.5	10 ± 6.6
	Manukau winter	13 ± 5.6	25 ± 8.7	25 ± 7.8	25 ± 10
	FOT winter	9 ± 5.5	11 ± 5.4	13 ± 4.3	21 ± 12
Banded Dotterel	Manukau summer	14 ± 10.7	7 ± 13	3 ± 2.7	5 ± 6.9
	FOT summer	9 ± 7.3	7 ± 6.9	6 ± 11.0	2 ± 2.1
	Manukau winter	337 ± 223	435 ± 233	733 ± 207	633 ± 267
	FOT winter	44 ± 32	43 ± 43	111 ± 94	89 ± 66
Wrybill	Manukau summer	13 ± 18	34 ± 37	18 ± 14	30 ± 40
	FOT summer	97 ± 68	142 ± 69	82 ± 91	48 ± 26
	Manukau winter	1108 ± 782	860 ± 420	1102 ± 296	1301 ± 231
	FOT winter	3342 ± 1705	2749 ± 791	2475 ± 675	2230 ± 519

TABLE 2 - Average numbers of the common New Zealand migrants during the period from winter census 1984 to summer census 1993, with the percentage of the New Zealand population that is at each location in winter (Rest of North Island, South Island and New Zealand data from Sagar *et al.* 1999).

	Manukau		Firth of Thames		Rest of North Island		South Island	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Pied Oystercatcher Average	3673	25 562	1880	12 660	3132	9147	6362	23251
% of N.Z. in winter		31.7		15.7		23.8		28.8
Wrybill Average	28	1171	54	2140	28	483	49	23
% of N.Z. in winter		32.0		58.5		8.9		0.6

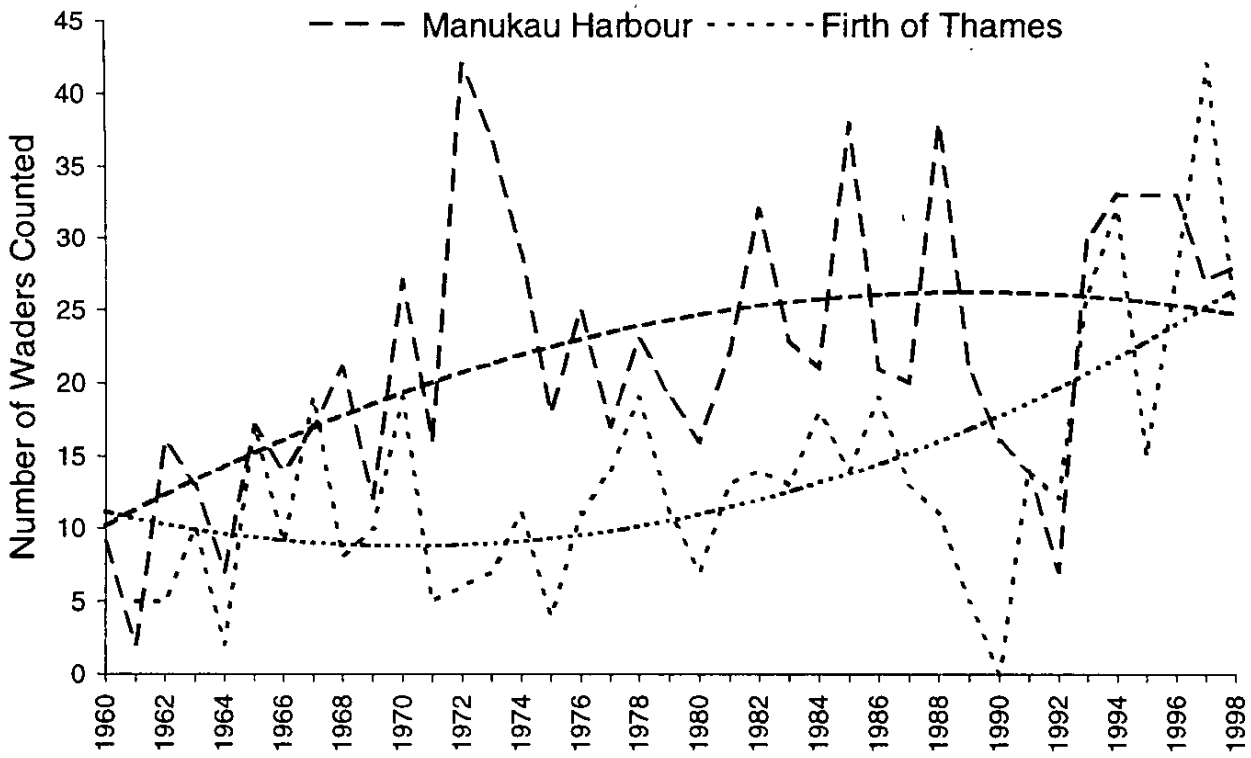

FIGURE 12 – Total numbers of Variable Oystercatchers counted on the Firth of Thames and Manukau Harbour during winter censuses.

Pied Stilt (*Himantopus himantopus*)

The numbers of Pied Stilts present on high tide roosts in winter has changed little ($r = 0.25$, $P=0.132$) during the period of study (Table 1, Fig. 13). As this species is not dependent on the estuarine habitat for feeding or roosting, the count data may not show any trends that are occurring.

Black Stilt (*Himantopus novaezealandiae*)

Few Black or "smudgy" stilts have been recorded during Firth of Thames censuses but there are usually some on the Manukau Harbour (Table 1); however, their numbers have increased significantly on both estuaries during the census period ($r = 0.34$, $P=0.040$, and $r = 0.32$, $P=0.049$ respectively).

New Zealand Dotterel (*Charadrius obscurus*)

New Zealand Dotterels nest along the shores of both harbours, so the summer census figures are likely to be an accurate assessment of the local breeding population. Numbers present in summer have increased over the study period ($r = 0.39$, $P=0.015$), especially on the Manukau Harbour ($r = 0.44$, $P=0.006$) (Table 1), mainly due to an increase there during the 1960s and a sudden increase in the last two years of the study when a record 42 birds were noted on the two harbours each year (Table 1). The winter population on the Manukau Harbour has also increased over the study period ($r = 0.50$, $P=0.001$), but has remained reasonably stable ($r = 0.08$, $P=0.685$) at an average of 25.0 ± 8.4 since 1970 (Table 1).

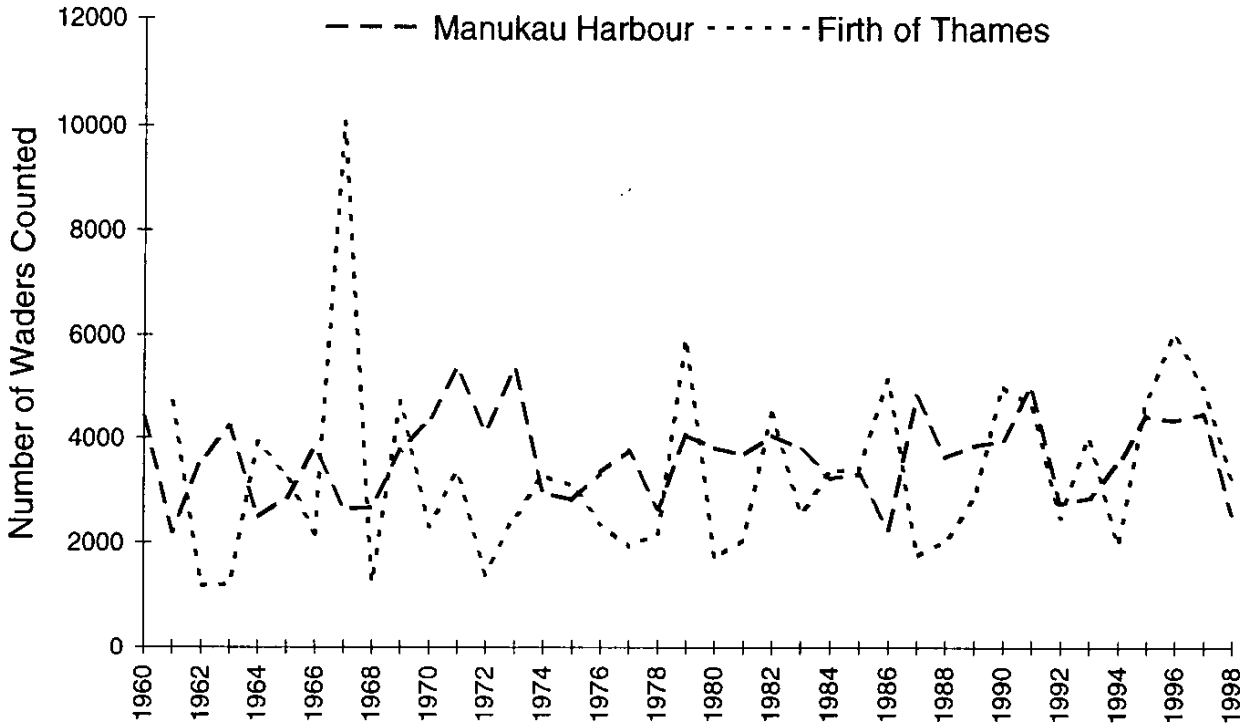

FIGURE 13 – Total numbers of Pied Stilts counted on the Firth of Thames and Manukau Harbour during winter censuses.

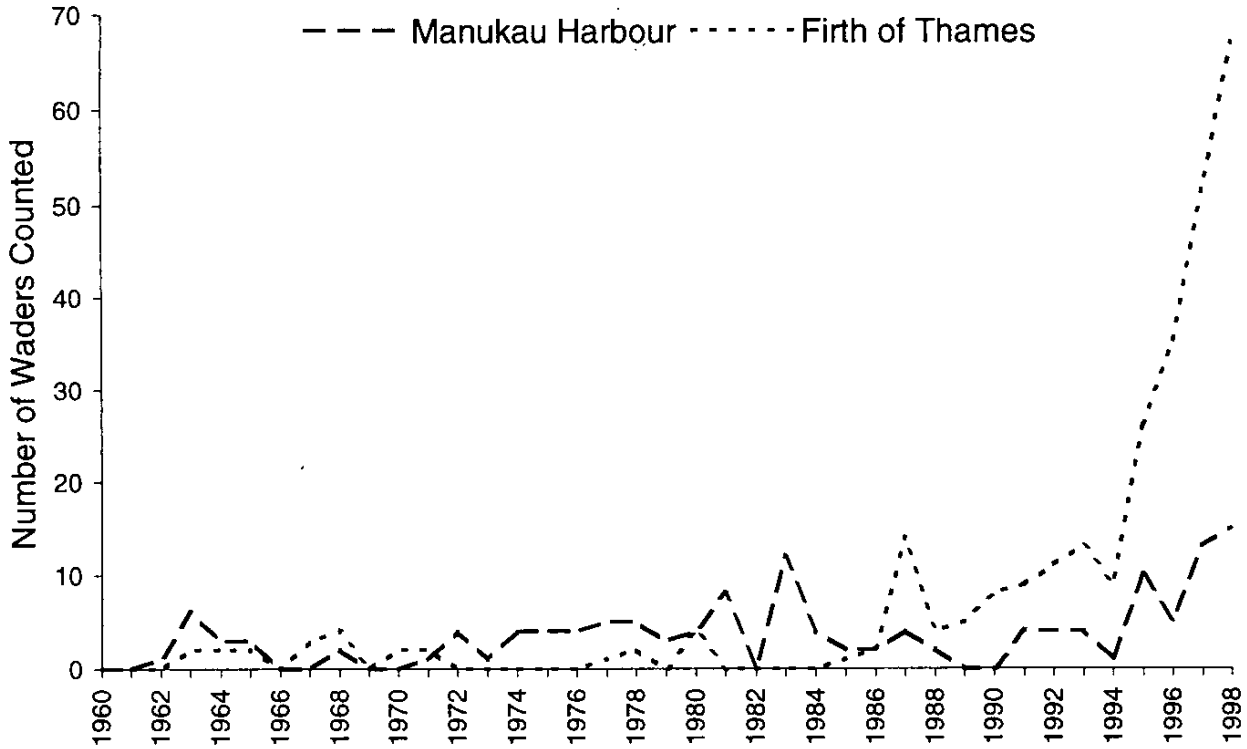

FIGURE 14 – Total numbers of New Zealand Dotterels counted on the Firth of Thames ($r = 0.53$, $P<0.001$) and Manukau Harbour ($r = 0.50$, $P=0.001$) during winter censuses. The trend lines are binomial lines fitted automatically by MS Excel.

On the Firth of Thames, however, New Zealand Dotterel numbers in winter have increased ($r = 0.53$, $P<0.001$) throughout the study period (Table 1, Fig. 14) with the most noticeable increase being during the last six years. From 1960-92 the winter count was 10.8 ± 5.3, but this increased to 27.8 ± 8.9 in 1993-98 ($U = 6.0$, $P<0.001$).

Banded Dotterel (*Charadrius bicinctus*)

Although their numbers were highly variable, the census results indicate that this species has increased greatly in winter ($r = 0.59$, $P<0.001$). They have a marked preference for the Manukau Harbour, where they have increased greatly ($r = 0.53$, $P<0.001$), but on the Firth of Thames there has not been a parallel increase ($r = 0.27$, $P=0.102$) (Table 1). This species is, however, not entirely dependent on the estuarine ecosystem and the changing numbers counted at high tide roosts in winter may not reflect a true change in the population.

Black-fronted Dotterel (*Charadrius melanops*)

A single bird was seen on the Manukau Harbour during the 1970 winter census and there are two other records of single birds there during the winters of 1971 (Sibson 1972) and 1972 (Ross McKenzie, pers. comm.). Two birds were present during the winter of 1996 but were not seen at census time.

Wrybill (*Anarhynchus frontalis*)

During the 38 years of winter counts covered by this paper the combined number of Wrybill on the Manukau Harbour and Firth of Thames in winter has declined from nearly 4500 to about 3500 individuals (Table 1, Fig. 15), but this was not statistically significant ($r = -0.15$, $P=0.36$). On the Firth of Thames, numbers have apparently declined ($r = -0.31$, $P=0.058$) over the study period, while on the Manukau Harbour their numbers have been more stable and may have even increased in recent years ($r = 0.27$, $P=0.101$; Table 1). Although neither trend, individually, is significantly different from a stable population, the trends of the populations on the two harbours are significantly different from one another ($z = 2.40$, $P<0.02$). Between 1984 and 1993 the Manukau Harbour and Firth of Thames winter population comprised approximately 90% of the New Zealand population (Table 2).

Few Wrybill (average 3.3 ± 2.6 % of the winter population) remain on these harbours over summer. Between 1960 and 1979, 4.03 ± 2.84 % of the winter population remained in summer, but this declined to 2.49 ± 2.11 % in 1980-98 ($U = 299.0$, $P=0.038$).

Pacific Golden Plover (*Pluvialis fulva*)

Numbers of this species in summer are highly variable (Table 3). Although there has been no consistent trend in overall numbers ($r = -0.27$, $P=0.092$), there were substantial differences in the numbers recorded between decades ($H = 8.9$,

P= 0.031), especially between the 1970s and 1990s (Q = 2.76, P<0.05), when overall numbers dropped from 113.0 ± 80.6 to 33.0 ± 24.6. In the four year period, 1995-98, the annual summer total has not exceeded 25 birds over the two harbours combined. This species is rarely present (total of eight birds recorded) during winter censuses and these were always on the Manukau Harbour.

Turnstone (*Arenaria interpres*)

Moderate numbers of Turnstone are present on both harbours at the time of summer censuses and they have increased over the study period (r = 0.38, P= 0.017) (Table 3). In the early years of this study, numbers increased on the Firth of Thames from 41 ± 22 in the 1960s to 131 ± 85 in the 1980s (Q = 3.13, P<0.05), but they have since returned towards earlier levels. On the Manukau Harbour over the same period average numbers have doubled from about 200 to 400 (r = 0.34, P=0.036), but there are indications of fewer birds since 1994. The winter population there shows a similar, but non-significant, pattern (r = 0.22, P= 0.184). The Firth of Thames winter population was about 9% of the summer population and the Manukau winter population was about 27% of the summer population during the 1983-1993 period (Table 4).

Lesser Knot (*Calidris canutus*)

Average numbers have changed greatly during summer census on both harbours during the study period (Table 3, Fig. 16). Numbers present on the Firth of Thames have declined (r = -0.40, P= 0.013) throughout the study period, from 5748 ±2355 in 1960-69 to 3737 ±1818 in 1990-98 (U = 71.0, P=0.03). However, on the Manukau Harbour there has been a significant increase (r = 0.82, P<0.001), with the numbers building from 1724 ±1644 in 1960-69 to 18 703 ± 7185 in 1990-98 (U = 135.0, P<0.001).

The average proportion of the summer population over-wintering at the Firth of Thames (17.9 ± 31.7 %) was less than that in the Manukau Harbour (21.3 ± 13.6 %) during the period 1980-98 (U = 91.0, P=0.009).

Curlew Sandpiper (*Calidris ferruginea*)

Although few in number, Curlew Sandpipers are a regular component of the Firth of Thames summer census (Table 3) and their numbers have remained moderately stable there (r = 0.14, P=0.383). In contrast, they have increased on the Manukau Harbour (r = 0.56, P<0.001), but this is mainly because they were rarely seen until 1992, but have since become a regular, but small, component of the summer census (Table 3).

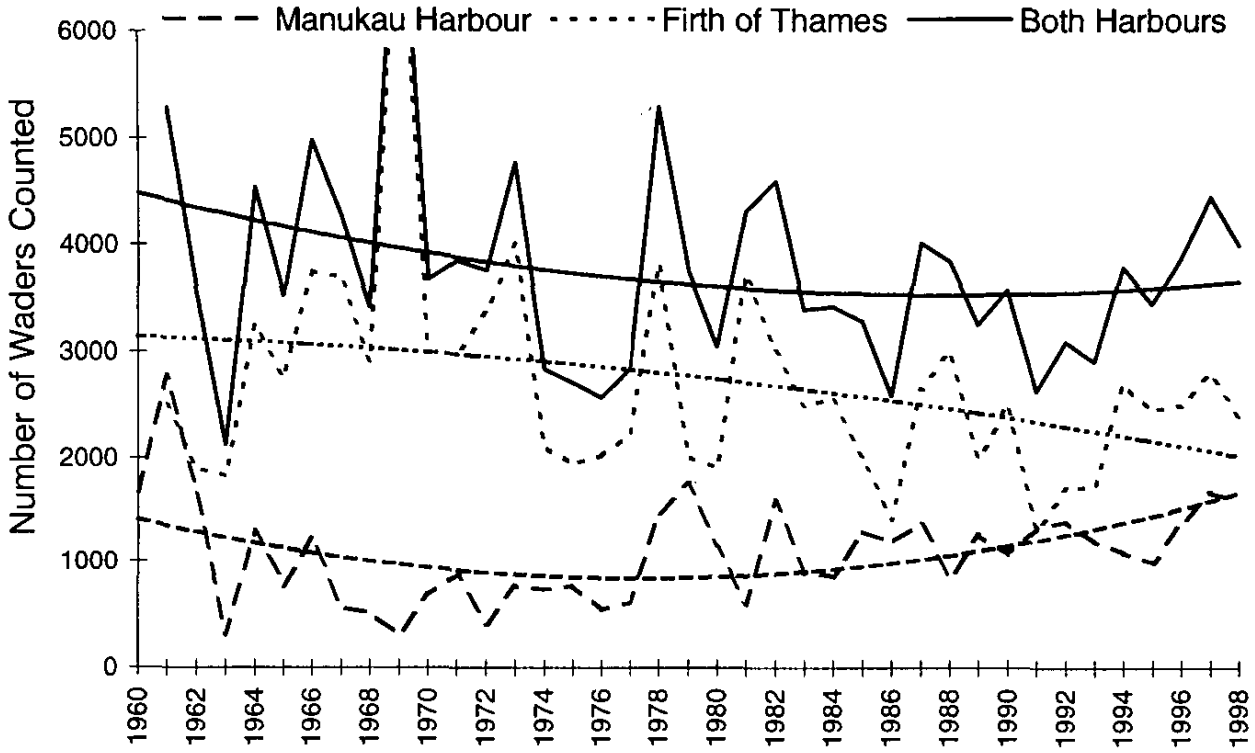

FIGURE 15 – Total Wrybills counted (r = -0.15, P=0.360) and numbers on the Firth of Thames (r = -0.31, P=0.058) and Manukau Harbour (r = 0.27, P=0.101) during winter censuses. The trend lines are binomial lines fitted automatically by MS Excel.

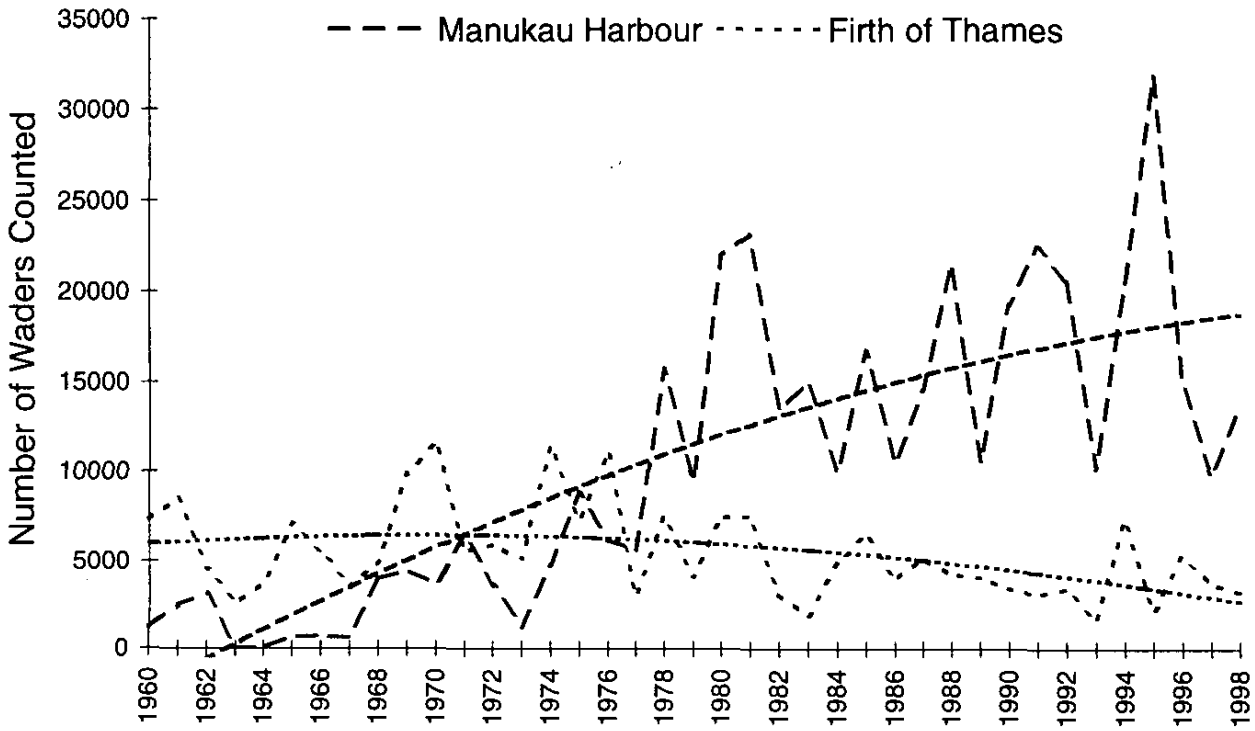

FIGURE 16 - Total numbers of Lesser Knots counted on the Firth of Thames (r = -0.40, P=0.013) and Manukau Harbour (r = 0.82, P<0.001) during summer censuses. The trend lines are binomial lines fitted automatically by MS Excel.

TABLE 3 - Mean numbers (with standard deviations) of the more common Arctic waders on the Manukau Harbour and Firth of Thames (FOT).

		1960-69	1970-79	1980-89	1990-98
Pacific Golden Plover	Manukau summer	28 ± 31	44 ± 33	42 ± 28	30 ± 26
	FOT summer	46 ± 45	69 ± 82	49 ± 58	3 ± 4.7
	Manukau winter	0.2 ± 0.4	0.3 ± 0.9	0.3 ± 0.5	0.0 ± 0.0
	FOT winter	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Turnstone	Manukau summer	176 ± 94	355 ± 145	409 ± 197	342 ± 180
	FOT summer	41± 22	107 ± 70	131 ± 85	64 ± 45
	Manukau winter	30 ± 34	100 ± 100	106 ± 34	54 ± 59
	FOT winter	12 ± 13	39 ± 35	27 ± 22	3 ± 4.8
Lesser Knot	Manukau summer	1724 ± 1644	6540 ± 4045	15755 ± 4989	18131 ± 6937
	FOT summer	5758 ± 2355	7244 ±3138	4862 ± 1828	3672 ± 1712
	Manukau winter	1037 ± 1257	1944 ± 2298	3037 ± 1311	3365 ± 1260
	FOT winter	314 ± 307	854 ± 1254	681± 1159	447 ± 592
Curlew Sandpiper	Manukau summer	1 ± 2.5	2 ± 2.8	2 ± 2.1	8 ± 5.2
	FOT summer	6 ± 5.6	15 ± 10	16 ± 10	12 ± 13
	Manukau winter	0 ± 0.0	0 ± 0.3	1 ± 1.4	4 ± 8.2
	FOT winter	1 ± 3.0	3 ± 6.0	3 ± 10	2 ±5.0
Red-necked Stint	Manukau summer	9 ± 5.8	8 ± 5.6	18 ±9.9	11 ± 7.3
	FOT summer	9 ± 5.9	7 ± 3.1	6 ±5.5	3 ±2.0
	Manukau winter	0 ± 0.7	3 ± 4.5	8 ± 7.1	3 ± 2.6
	FOT winter	2 ± 3.8	1 ± 1.2	2 ± 4.0	1 ± 1.0
Eastern Curlew	Manukau summer	0 ± 0.0	2 ± 1.9	6 ± 3.5	8 ± 5.6
	FOT summer	15 ± 8.8	10 ± 5.4	5 ±2.3	4 ± 4.0
	Manukau winter	0 ± 0.3	1 ± 1.3	2 ±2.3	2 ± 3.7
	FOT winter	4 ± 3.2	1 ± 2	2 ± 1.9	1 ± 2.0
Whimbrel	Manukau summer	1 ± 1.0	1 ± 1.7	5 ± 3.6	9 ± 9.2
	FOT summer	1 ± 1.7	7 ± 10.3	17 ± 15.7	14 ± 10.2
	Manukau winter	0 ± 0.3	0± 0.5	3 ± 4.5	2 ± 2.4
	FOT winter	0 ± 0.3	2± 2.0	4 ± 5.8	1 ± 1.3
Bar-tailed Godwit	Manukau summer	13199 ± 2838	17778 ± 3553	13860 ± 2828	17639±5212
	FOT summer	8657 ± 2094	9201 ± 3408	6950 ± 2351	7078 ± 3415
	Manukau winter	1722 ± 956	2208 ±969	2044 ±1275	3247 ± 1619
	FOT winter	636 ± 375	761±419	559 ± 326	797 ± 248

Red-necked Stint (*Calidris ruficollis*)

This species has been a regular, but infrequent part of the summer census on both harbours (Table 3). Numbers present on the Manukau Harbour increased between 1975 and 1985 but have since declined. On the Firth of Thames there has been a continual decline ($r = -0.43$, $P = 0.007$) throughout the study period with few or none being present in recent years (Table 3).

Eastern Curlew (*Numenius madagascariensis*)

Although total numbers counted during summer censuses have always been low, they have been present in most years (Table 3). The total population on these harbours has not changed ($r = -0.16$, $P=0.343$), but their distribution has. Initially

TABLE 4 - Average numbers of the three more common Palearctic migrants during the period from summer census 1983 to winter census 1993 with the average percentage of the summer population that is present in winter (Rest of North Island and South Island data after Higgins & Davies 1996).

	Manukau		Firth of Thames		Rest of North Island		South Island	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Turnstone Average	410	89	124	18	1658	194	2200	294
Average % in winter		27		9		14		15
Lesser Knot Average	15572	3186	3822	437	15875	931	16953	518
Average % in winter		22		9		6		4
Bar-tailed Godwit Average	14594	3168	6130	735	36009	3722	26992	4167
Ave % in winter		24		13		10		15

they were more common in the Firth of Thames, but during the study (especially in the last ten years) numbers have increased in the Manukau Harbour ($r = 0.81$, $P<0.001$) and decreased in the Firth of Thames ($r = -0.51$, $P<0.001$). The few that remain in winter have shown a similar change in location in recent years.

Whimbrel (*Numenius phaeopus*)

They are an uncommon and irregular component of census counts; for a number of years none may be present then the next year there may be more than 20. The Firth of Thames appears to be the preferred estuary. Numbers have increased in both the Firth of Thames ($r = 0.54$, $P<0.001$) and the Manukau Harbour ($r = 0.50$, $P=0.001$) (Table 3). Of all the birds recorded, 42% have been identified to sub-specific level and of these 90% were Asiatic Whimbrel (*N. p. variegatus*) and 10% American Whimbrel (*N. p. hudsonicus*).

Bar-tailed Godwit (*Limosa lapponica*)

This is by far the most abundant Palearctic wader to visit New Zealand. At the time of the summer census, the Firth of Thames and Manukau Harbour support an average of 23 562 ± 5325 Bar-tailed Godwit, or about 23% of the national total of 102 000 birds (Sagar 1999). There was no clear long-term trend in numbers (Fig.17) on either the Firth of Thames ($r = -0.19$, $P=0.241$) or Manukau Harbour ($r = 0.17$, $P=0.310$); however, they were more common in the Manukau Harbour in the 1970s and 1990s that in the 1960s ($Q = 3.92$, $P<0.05$ and $Q = 3.71$, $P<0.05$ respectively). Numbers present in winter have remained similar in the Firth of Thames at about 700 (Table 3), but on the Manukau Harbour, winter numbers have apparently increased from less than 2000 to more than 3000 (Table 3), but this was not statistically significant ($r = 0.28$, $P=0.086$).

Over the study period, a smaller proportion of the previous summer total over-wintered at the Firth of Thames (10.58 ± 9.93 %) than in the Manukau Harbour (15.09 ± 8.31%) ($U=396.0$, $P<0.001$).

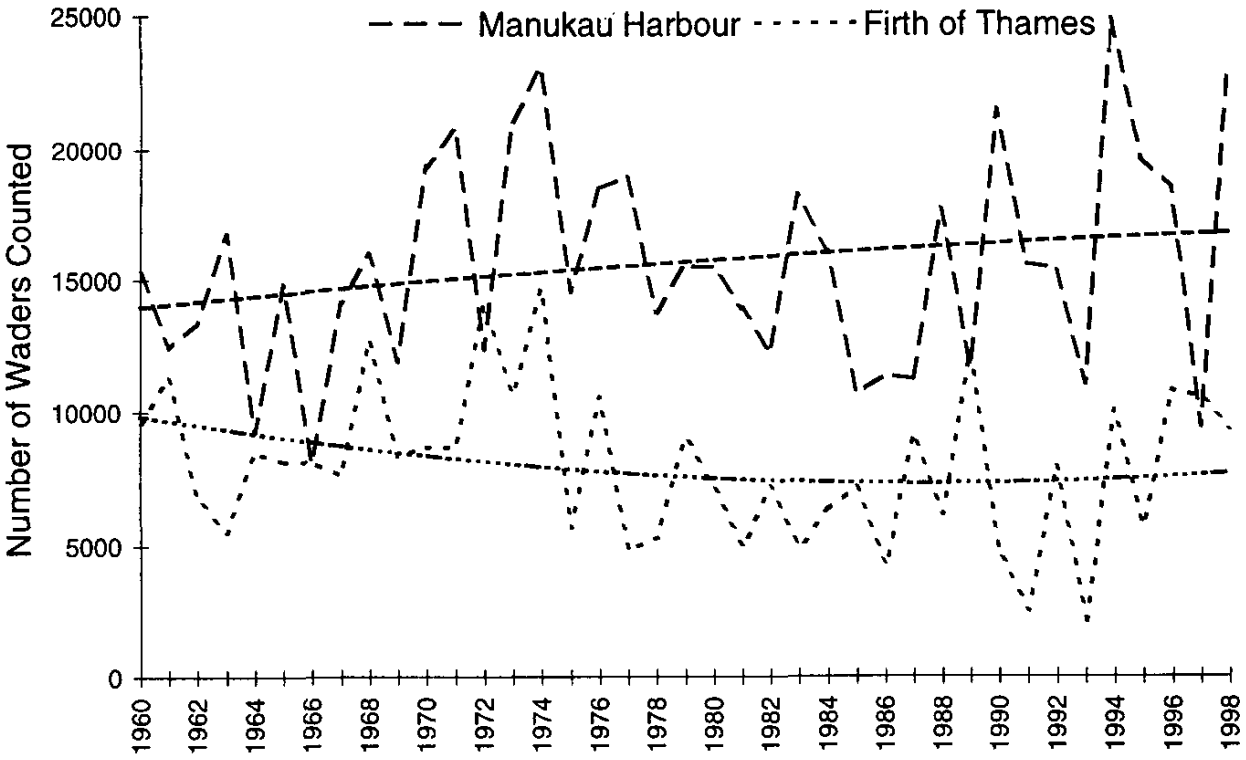

FIGURE 17 – Total numbers of Bar-tailed Godwits counted on the Firth of Thames (r = -0.19, P=0.241) and Manukau Harbour (r = 0.17, P=0.310) during summer censuses. The trend lines are binomial lines fitted automatically by MS Excel.

Other Migrants

There are 23 species of migratory waders which reach New Zealand irregularly and have been seen during the 155 census counts on the Manukau Harbour and Firth of Thames (Table 5).

A further eight species of migratory wader have been recorded on the Manukau Harbour and Firth of Thames but have not been seen during censuses: Oriental Dotterel (*Charadrius veredus*)(McKenzie 1956), Japanese Snipe (*Gallinago hardwickii*) (Baker *et al.* 1986), White-rumped Sandpiper (*Calidris fusicollis*) (McKenzie 1970), Ruff (*Philomachus pugnax*) – probable sighting only (McKenzie & McKenzie 1965), Asiatic Dowitcher (*Limnodromus semipalmatus*) (Keeley 1988), Upland Sandpiper (*Bartramia longicauda*) (McKenzie 1968), Wandering Tattler (*Tringa incana*) (McKenzie 1949), Red-necked Phalarope (*Phalaropus lobatus*) (Jenkins *et al.* 1986). These birds account for 0.06% of the total waders using the Firth of Thames and Manukau Harbour, but they attract a disproportionate amount of attention.

To complete the list of migratory waders, the following species have been recorded in the New Zealand region but not yet on the Firth of Thames or Manukau Harbour: Australian Red-necked Avocet (*Recurvirostra novaehollandiae*) (Buller 1888, Kaigler 1968), Oriental Pratincole (*Glareola maldivarum*) (Falla 1959), Red-kneed Dotterel (*Erythrogonys cinctus*) (Robertson & Dennison 1977), Little Stint (*C. minutus*) (O'Donnell & West 1995), Bristle-thighed Curlew (*Numenius tahitiensis*)

TABLE 5 - Frequency of presence and highest counts of the less abundant Palearctic migrants on the Manukau Harbour (Man) and Firth of Thames (FOT) during 155 census counts.

	Number of counts				Highest count			
	Man Summer	FOT Summer	Man Winter	FOT Winter	Man Summer	FOT Summer	Man Winter	FOT Winter
Red-capped Dotterel (*Charadrius ruficapillus*)	1	0	1	0	1	0	1	0
Ringed Plover (*C. hiaticula*)	0	1	0	1	0	1	0	1
Large Sand Dotterel (*C. leschenaultii*)	15	10	3	1	4	3	1	1
Mongolian Dotterel (*C. mongolus*)	3	1	0	0	1	1	0	0
Grey Plover (*Pluvialis squatarola*)	3	1	0	0	1	1	0	0
Great Knot (*Calidris tenuirostris*)	0	0	1	0	0	0	1	0
Sanderling (*C. alba*)	0	0	1	0	0	0	1	0
Dunlin (*C. alpina*)	0	1	1	0	0	1	1	0
Sharp-tailed Sandpiper (*C. acuminata*)	29	33	4	2	18	40	7	12
Pectoral Sandpiper (*C. melanotos*)	4	5	0	0	5	1	0	0
Baird's Sandpiper (*C. bairdii*)	0	1	0	0	0	1	0	0
Western Sandpiper (*C. mauri*)	0	1	0	0	0	1	0	0
Broad-billed Sandpiper (*Limicola falcinellus*)	0	3	0	2	0	1	0	1
Little Whimbrel (*Numenius minutus*)	1	0	0	0	1	0	0	0
Asiatic Black-tailed Godwit (*Limosa limosa*)	7	6	6	2	3	11	1	2
Hudsonian Godwit (*L. haemastica*)	0	0	1	1	0	0	1	1
Siberian Tattler (*Tringa brevipes*)	2	4	1	2	1	1	1	1
Common Sandpiper (*T. hypoleucos*)	1	0	0	0	1	0	0	0
Greenshank (*T. nebularia*)	1	0	2	0	1	0	1	0
Marsh Sandpiper (*T. stagnatilis*)	1	5	2	6	2	3	2	4
Lesser Yellowlegs (*T. flavipes*)	2	0	0	0	1	0	0	0
Terek Sandpiper (*T. terek*)	9	25	3	6	2	3	3	2
Grey Phalarope (*Phalaropus fulicarius*)	0	0	1	0	0	0	1	0

(Veitch 1974), Wilson's Phalarope (*Phalaropus tricolor*) (Moore & Moore 1984, Sagar & Harrison 1984).

DISCUSSION

The data presented for many species indicate that either the populations, or their use of these two harbours, has changed during the period of this study.

The changing number of observers and factors that effect their ability to count need to be considered as a cause in the changing number of birds counted. Observer numbers have changed during the censuses, with a peak of observer numbers in the late 1970s and consistently fewer for the last ten years (Fig. 6 to 9). Weather patterns and tidal cycles, which might limit or enhance counter ability, will have been random events affecting both censuses and both harbours. Over the study period, counts of some species have increased and others have decreased, indicating that there is no consistent change in relationship between observer numbers or counting ability and the number of birds counted.

Wader flocks moving from the Manukau Harbour to the Tamaki Estuary or Waitemata Harbour (Fig. 1) when the tide is high on the Manukau in February and March, are now a recognised regular occurrence. When on the Tamaki Estuary

they do not feed but instead loaf for the duration of the Manukau Harbour high tide period and then return to the Manukau Harbour (T.G. Lovegrove, pers. comm., C.R. Veitch, pers. obs.); however, birds which fly to the Waitemata Harbour have been observed to feed there (A.C. Riegen, pers. comm.).

In recent years a similar pattern of flights, but of fewer birds, has been observed during the winter census (T.G. Lovegrove, pers. comm.). The total number of birds involved, whether this is a significant portion of the birds which might normally roost at a Manukau location, and whether this is a new or previously unobserved activity is not known.

Native waders

Numbers of Pied Oystercatchers have increased significantly. Soon after this species was protected by law in 1940, Sibson (1966) noted total winter numbers on the Manukau Harbour and Firth of Thames to be less than 300. He then recorded a steady increase in numbers on both harbours between 1941 and 1965. Examination of his data suggests that before about 1960, he may have been recording only half the birds that were present on the Manukau Harbour, but was recording all the birds on the Firth of Thames. His early counts, at least, were of maximum numbers seen, generally in April (Sibson 1945). Since 1960 counts have been later in the year (17 May to 1 August), when total numbers of Pied Oystercatchers on the Firth of Thames are known to be below the peak (Veitch 1999). Baker (1973) estimated that the total New Zealand population of Pied Oystercatchers was 59 000 in 1972. During winter of that year the Manukau and Firth of Thames total was 16 900 or 29% of the total. Twenty years later, during the National Wader Count of June 1992, 80 911 individuals were recorded (Sagar 1993), of which 34 765 (43%) were at the Manukau or Firth of Thames. If the data relating to the annual cycle of waders in the Firth of Thames (Veitch 1999) is applicable to the waders of the Manukau Harbour, then we can calculate the likely maximum numbers of Pied Oystercatchers on both harbours. The numbers in May, at the peak, can be 40% greater than in June and July, although 30% higher appears to be a more likely average. Hence, during the last five years, when the average combined winter census has been 49 416 Pied Oystercatchers, the maximum number present during May would have been more than 64 000 birds.

Sibson (1963) counted Wrybills on the Manukau Harbour and Firth of Thames from as early as 1940, and recorded a marked increase in numbers between the first counts of about 1000 birds to more than 4000 on these two harbours in 1960. It is clear that early counts on the Manukau Harbour did not include all Wrybill roosts, but counts on the Firth of Thames may have done so. In winter census counts since 1960, the numbers of Wrybill increased on the Firth of Thames and decreased on the Manukau Harbour until about 1970 (Fig. 15), then the trends reversed and numbers declined on the Firth of Thames while increasing on the Manukau Harbour. The combined Manukau Harbour and Firth of Thames population has remained approximately stable since 1960. There are no comparable data from other northern estuaries to indicate how the remainder of the Wrybill popu

lation has fared. Data from the Firth of Thames (Veitch 1999) suggest that the maximum Wrybill population supported by these two harbours, in April, is about 20% higher than the average census count. This worked out to be about 4200 birds between 1988 and 1997, and is supported by a count of 4261 birds on 29 May 1994 during a special National Wrybill Census (Riegen 1994). We have no exact knowledge of the food items taken or roosting spaces desired by Wrybill. The fact that numbers are declining on the Firth of Thames while increasing on the Manukau Harbour suggests that one or both of these habitats are changing.

Winter counts of both Variable Oystercatchers and New Zealand Dotterels have increased sharply during the past six years. It is possible that this change results from increased protection of breeding locations in Northland and the Coromandel Peninsula. Colour-banded birds from locations in Auckland, Northland and on the Coromandel Peninsula have been seen on the Manukau Harbour and Firth of Thames.

The greater number of sightings of Black Stilts in recent years may be because the "smudgy" stilts are now recognised as immatures or hybrids of Black Stilt and Pied Stilt (Pierce 1984). Management of the breeding population may have also contributed to the greater number of sightings.

Arctic migrants

We know of no evidence from elsewhere in the world that indicates overall long-term changes in numbers of the more abundant Palearctic migrant waders which visit New Zealand. There is no indication in our counts of Bar-tailed Godwit and Lesser Knot of any cyclical change of abundance similar to that observed for waders breeding further to the west in Siberia, and attributed to a three-year lemming cycle and associated prey switching by foxes (Underhill 1987). Our waders breed in far-eastern Siberia and Alaska (Higgins & Davies 1996) and it is not known whether the lemming populations there follow the three- year cycle observed on the Taimyr Peninsula (P. Tomkovich, pers. comm.). Additionally, a cycle may not be visible from counts alone, as even wintering flocks contain birds from a number of year classes. To determine the percentage of juveniles present each winter, samples would have to be caught and aged in the hand.

Total numbers of Bar-tailed Godwits have remained more-or-less constant throughout the study period, but the possible drift from the Firth of Thames to the Manukau Harbour may suggest changes in habitat quality. Total numbers of Lesser Knot have increased during the study period. There is no comparable census data from other harbours, and so it is not possible to determine whether this change in total numbers is a result of an overall increase in the Lesser Knot population in New Zealand or a reduction in numbers of Lesser Knot wintering at other locations. There is, however, a clear indication that the Firth of Thames has become a less favoured habitat and the Manukau Harbour more favoured during our study.

A greater percentage of the three most common Palearctic migrants (Bar-tailed Godwit, Lesser Knot and Turnstone) over-winter on the Manukau Harbour than on the Firth of Thames, or elsewhere in New Zealand (Table 4).

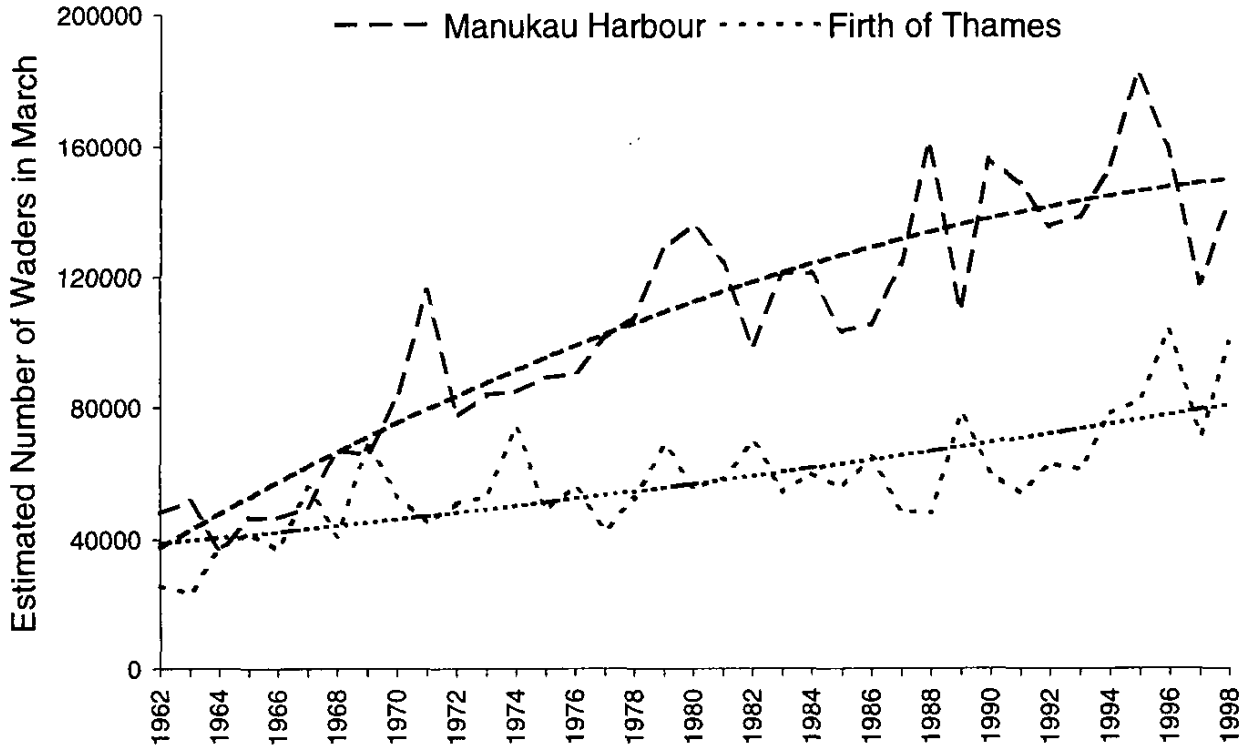

FIGURE 18 – Possible maximum numbers of waders present on the Manukau Harbour and Firth of Thames in March (after Veitch 1999).

Over the last 40 years, there has been an increase in the total number of waders using both the Manukau Harbour and Firth of Thames. This is evident in winter censuses on both harbours and summer censuses on the Manukau Harbour. If the annual cycle of wader numbers observed on the Firth of Thames (Veitch 1999) is equally true for the Manukau Harbour, the estimated maximum numbers of waders present in March can be calculated (Fig. 18). On the Manukau Harbour the recent average has been about 140 000 birds and the Firth of Thames about 65 000. The trend lines in Fig. 18 indicate that further increases in waders can be expected.

It is not known how, or by how much, the habitat changes noted in this paper have affected the food or roost sites for waders. It is also not known how much competition there is between different wader species. We are therefore unable to predict whether these changes to the habitat will cause further changes in bird numbers, or whether the species that are increasing in number will eventually have a detrimental impact on other species. Monitoring of these important, and relatively easily counted, wader populations should continue.

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LITERATURE CITED

AGRICULTURAL STATISTICS. Annual publication by Statistics Department, Government Printer, Wellington.

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

BAKER, D.G.; CHILD, R.J.; TAYLOR, M.J. 1986. A Japanese Snipe at Mangere. Notornis 33: 149-150.

BIORESEARCHES. 1992. Inter-tidal seafood resources of the Manukau Harbour. Unpublished report to the Auckland Regional Council, Environment and Planning Division

BULLER, W.L. 1888. A history of the birds of New Zealand, 2nd ed. Buller, London.

CRISP, P.; DANIEL, L.; TORTELL, P. 1990. Mangroves in New Zealand, trees in the tide. GP Books, Wellington.

FALLA, R.A. 1959. Pratincole records in New Zealand. Notornis 8:126-127.

HIGGINS, P.J.; DAVIES, S.J.J.F. (Eds). 1996. Handbook of Australian, New Zealand & Antarctic Birds. Vol. 3. Oxford University Press, Melbourne.

JAMIESON, A. 1994. Survey of Spartina in the Auckland Region. Unpublished report for the Coastal Resources Section, ARC Environment.

JENKINS, J.A.F.; LOVEGROVE, T.G.; SIBSON, R.B. 1986. Red-necked Phalarope at Mangere, Manukau Harbour. Notornis 33: 191-192.

KAIGLER, C.G. 1968. Red-necked Avocet in Westland. Notornis 15: 123.

KEELEY, B.R. 1988. Classified Summarised Notes, North Island: 1 July 1986 to 30 June 1987. Notornis 35: 285-310.

McKENZIE, H.R. 1949. A Wandering Tattler. N.Z. Bird Notes 3: 178-180.

McKENZIE, H.R. 1956. Probable recent occurrences of Oriental Dotterel in New Zealand. Notornis 6: 25-26.

McKENZIE, H.R. 1968. Suspected Upland Plover (*Bartramia longicauda*) in Manukau Harbour. Notornis 15: 216-218.

McKENZIE, H.R. 1970. A new Arctic wader for New Zealand: two White-rumped (Bonaparte's) Sandpipers at Karaka. Notornis 17: 236-237.

McKENZIE, N.B.; MCKENZIE, H.R. 1965. Probable sighting of a Ruff. Notornis 12: 108-109.

MOORE, J.L.; MOORE, M. 1984. Wilson's Phalarope at Manawatu River estuary - a new bird for New Zealand. Notornis 31: 330-333.

O'DONNELL, C.F.J.; WEST, J.A. 1995 Classified Summarised Notes: South Island 1 July 1992 - 30 June 1993. Notornis 42: 53-77.

PIERCE, R.J. 1984. Plumage, morphology and hybridisation of New Zealand Stilts *Himantopus* spp. Notornis 31: 106-130.

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

RIEGEN, A. 1994. National Wrybill census. OSNZ News 72: 2-3.

ROBERTSON, H.A.; DENNISON, M.D. 1977. Red-kneed Dotterel (*Charadrius cinctus*) - first record for New Zealand. Notornis 24: 193-194.

SAGAR, P.M.; HARRISON, K.C. 1984. Wilson's Phalaropes at Lake Ellesmere. Notornis 31: 333-334.

SAGAR, P.M.; SHANKAR, U.; BROWN, S. 1999. Distribution and numbers of waders in New Zealand, 1983-1994. Notornis 46: 1-43.

SIBSON, R.B. 1945. Some observations on South Island Pied Oystercatchers in Auckland. N.Z. Bird Notes 1: 107-109.

SIBSON, R.B. 1963. A population study of the Wry-billed Plover (*Anarhynchus frontalis*). Notornis 10: 146-152.

SIBSON, R.B. 1966. Increasing numbers of South Island Pied Oystercatchers visiting northern New Zealand. Notornis 13: 94-97.

SIBSON, R.B. 1972. The spread of the Black-fronted Dotterel. (a) Manukau Harbour. Notornis 19: 83-91.

TURBOTT, E.G. 1990. Checklist of the Birds of New Zealand. Random Century, Auckland.
UNDERHILL, L.G. 1987. Changes in the age structure of Curlew Sandpiper populations at Langbaan Lagoon, South Africa, in relation to lemming cycles in Siberia. Trans. Roy. Soc. S. Afr. 46: 209-214.
VEITCH, C.R. 1974. Bristle-thighed Curlew records from the Kermadec Islands. Notornis 21: 83-84.
VEITCH, C.R. 1978. Waders of the Manukau Harbour and Firth of Thames. Notornis 25: 1-24.
VEITCH, C.R. 1999. Annual cycle of waders at the Firth of Thames. Notornis 46: 71-78.
YOUNG, B.M.; HARVEY, E.H. 1996. A spatial analysis of the relationship between mangrove (*Avicennia marina* var. *australasica*) physiognomy and sediment accretion in the Hauraki Plains, New Zealand. Estuarine, Coastal and Shelf Science 42: 231-246.