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Changes in the numbers and distribution of waders in an archipelago off the southern coast of Finland in 1914-1981

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This study is based on censuses carried out in an archipelago off the southern coast of Finland in 1914-1981. The most extensive censuses were made in 1921-22, 1936-37, 1974-75, and 1978-81. Most censuses are not directly comparable, as the censused areas and census methods have not been the same. Of the four wader species breeding mainly in woodless skerries, the Oystercatcher *Haematopus ostralegus* has increased and is now the most abundant wader species. The Turnstone *Arenaria interpres* and the Redshank *Tringa totanus* may have increased. The Ringed Plover *Charadrius hiaticula* has decreased. The distribution of the waders has changed within the archipelago. The Oystercatcher has spread both out- and inwards, the Turnstone inwards. The Redshank has decreased in the outer parts, but increased in the inner parts of the archipelago. The changes are probably mainly due to an increase and spreading inwards of the Arctic Tern *Sterna paradisaea* and the Common Gull *Larus canus* colonies and to human activity.

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1. Introduction

Bird species and communities breeding on islands and in archipelagoes have been intensively studied all over the world. One of the best known areas is the Baltic Sea and its archipelagoes. The marine bird populations of Finnish coasts have been amply documented (e.g. Sundström 1927, Nordberg 1932, 1950, Ahlqvist & Fabricius 1938, Bergman 1939, 1946, von Haartman 1945, Paavolainen 1957, Hildén 1964, 1966, Grenquist 1965, Tenovuo 1966, Väisänen & Järvinen 1977 a, 1977 b, Kilpi et al. 1980).

We have studied breeding birds in the Tvärminne, Ekenäs, and Snappertuna archipelagoes off the southern coast of Finland since 1974. Published records on the bird communities of this area exist since 1915 (Nyberg 1915, 1916, Öhman 1918, Sundström 1927, Ahlqvist & Fabricius 1938, Lampio 1946, Koistinen & Palmgren 1976, Palmgren & Valste 1983), as well as unpublished census data (1955-1974) from the Tvärminne Zoological Station and from Koistinen & Palmgren.

The aim of this paper is to elucidate numerical and spatial trends in wader populations of unforested skerries and islets in these archipelagoes during the last 60 years.

2. Study area: a general description

The study area is located off the southern coast of Finland at the entrance of the Gulf of Finland (Fig. 1) and measures about 500 km^2. The land area is split into more than 1300 islands and skerries and comprises about 36 km^2 (Tab. 1).

On the basis of biogeographic characteristics the archipelago is divided into distinctive parallel zones (Fig. 1), which are: 1) the marine or outmost zone, 2) the outer zone, 3) the inner zone, and 4) the mainland or inmost zone (Häyrén 1900, Luther 1961). As earlier censuses have excluded zone 4, we have excluded it also here.

In zone 1 the skerries are in general small and separated from each other by large open water areas. The shores are mostly bare, steep rock and offer few foraging areas for waders. Sometimes islets form groups or there may be bays with sheltered shingle or pebble shores. Some larger skerries may have small meadow or heath areas.

In zone 2 the skerries are closer to each other and are often protected by larger forested islands. The shores are also here mostly bare rock surfaces, but they are not as steep as in zone 1. There are more stone and pebble shores,

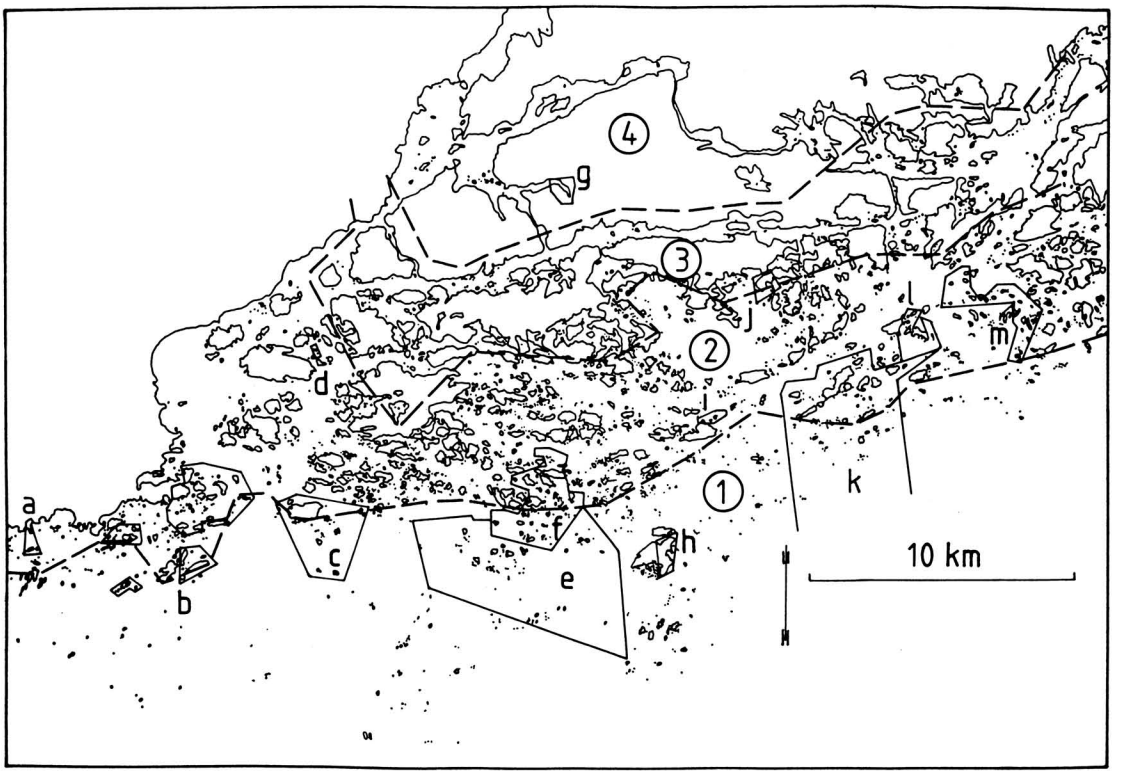

Fig. 1. The study area. Archipelago zones are separated by dashed lines: 1 = marine zone, 2 = outer zone, 3 = inner zone, and 4 = mainland zone. Protected and military areas are indicated by continous lines: a) Högholmen nature reserve, land area 8 ha, founded in 1982; b) Tvärminne nature reserve (somewhat simplified in the map), land area 142 ha, major parts protected in practice since 1902; c) Hästö-Busö military area, land area 90 ha, military area since 1912; d) Enören nature reserve, land area 1 ha, founded in 1983; e) Jussarö strict nature reserve, land area 37 ha, founded in 1956; f) Alglo bird sanctuary, land area 70 ha, founded in 1925; g) Näsebyfladan nature reserve, land area 47 ha, founded in 1981; h) Jussarö military area, land area 60 ha, military area since 1967; i) Busö nature reserve, land area 5 ha, founded in 1969; j) Dalkarö nature reserve, land area 27 ha, founded in 1969; k) Nothamn bird sanctuary, land area 192 ha (Lill-Själö included), founded in 1926; l) Gästans nature reserve, land area 13 ha, founded in 1978; m) Strömsö nature reserve, land area 46 ha, founded in 1981. Bird sanctuaries formed by one skerry have been omitted here.

more protected bays and lagoons, and in particular much more shoreline available for waders. Small patches of meadow, heath, and peat-bog are common on skerries. Some large forested islands have farms with fields and pastures.

Zone 3 is characterized by large islands and the land area exceeds the water area. Shores of the skerries are more gently sloping than in the outer zones. The shores of islands are usually forested and the shore line is rock or stones, but shore meadows are not uncommon. Larger islands are inhabited and there are large cultivated areas.

During this century the foraging and breeding habitats available for waders in zone 1 have not appreciably changed. The almost total disappearance of fishermen-farmers in zone 2 has ended the grazing of cattle and sheep and the cutting of grass. Former pastures and meadows have been invaded by bushes. In zone 3 the eutrophication of coastal waters combined to the ending of grazing and grasscutting has favored the spreading of the reed *Phragmites australis* in the shore meadows and sheltered shallow waters.

Seawater is brackish and the salinity of surface water ranges from 5.5 ‰ (inner zone) to 7 ‰ (marine zone). The sea freezes almost every winter for a period of 1-4 months. Shores of the skerries become ice free usually in the latter half of April. There is no tide, but changes in atmospheric pressure and winds change the water level: e.g. in 1975-83 the maximum in May-June was +23 cm and the minimum -63 cm. Water level is typically below average during May-June.

Considerable parts of the study area are protected in some way (Fig. 1). Several skerries are inside military areas. In practice this means that they are protected.

3. Material and methods

This paper is based on bird censuses carried out in the Tvärminne, Ekenäs, and Snappertuna archipelages by different people during the last 65 years (Tab. 1). The census areas, census times, and censusing methods have not been identical in the different censuses. Some of them differ so

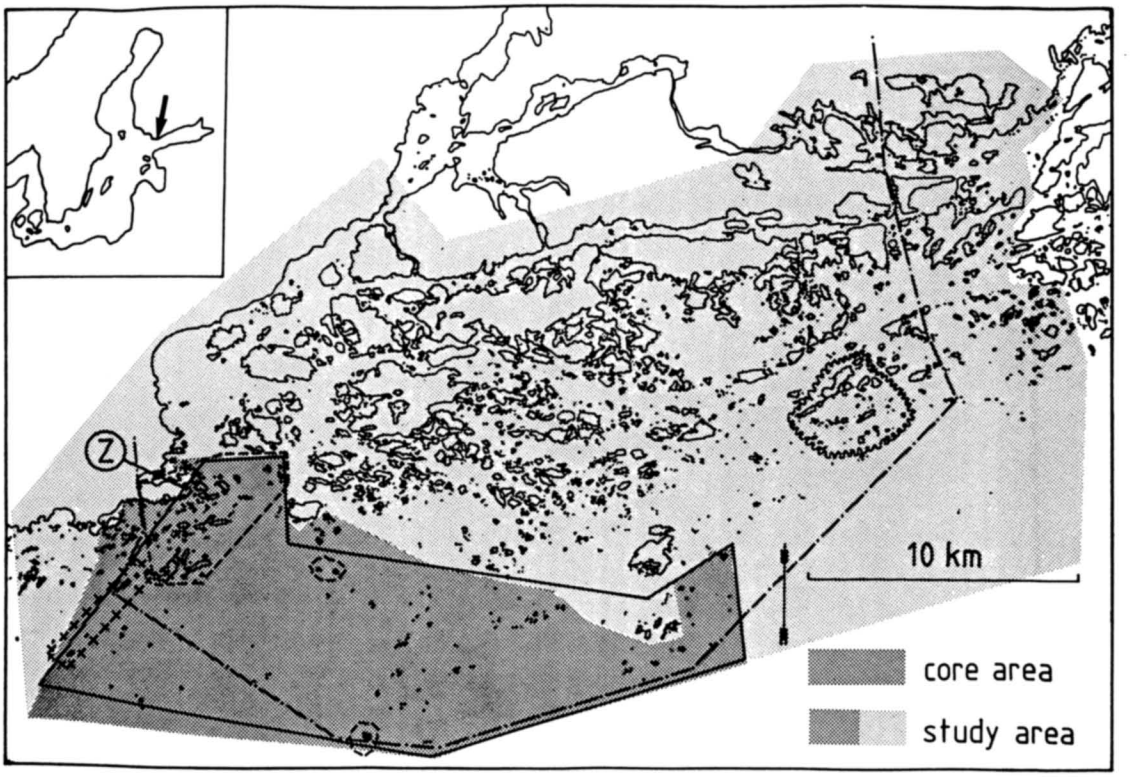

Fig. 2. Map of census areas. Wavy line shows the census area of Nyberg (1915). Dots and dashes show the excursion area of Sundström (1927). Continuous line indicates the census area of Ahlqvist & Fabricius (1938). Dashed line shows the census area of Lampio (1946). The field courses of vertebrate ecology made censuses in Lampio's area and the area marked with crosses. Z = Tvärminne Zoological Station.

much that they cannot be used for this study. The most important censuses for this study are shortly covered below. We emphasize aspects affecting wader numbers (cf. also Fig. 2 and Table 1).

3.1. Censuses 1974–81

Koistinen & Palmgren (1976, partly unpubl.) censused the whole study area in 1974–75 (Fig. 2), which comprises more than 1300 islands. The size distribution of islands in the marine, outer, and inner zones is given in Table 2. Koistinen & Palmgren (1976) slowly circled every island and counted all seabirds including waders from the boat. Nests of all birds were counted only on islands with gull or tern colonies. Presumably all wader pairs were found on such islands. The censuses were conducted between 23 May and 9 June in 1974 and 24 May and 17 June in 1975, i.e. both during incubation and nestling stages. In the boat counts all breeding pairs were apparently not observed, as their behaviour especially during incubation period is stealthy. The error is probably greater in the Redshank, Ringed Plover, and Turnstone numbers than in the Oystercatcher numbers, as the last mentioned species is by far the easiest to observe.

In 1978–81 we censused each single land area within our so-called "core area" comprising about 150 km², out of which about 2.2 km² is land split into 272 islands, islets, and skerries (Tab. 3). The core area is predominantly located in the marine zone (Fig. 2), but 47 % of the islands are in the outer zone. When forested islands and birdless rocks are excluded, the number of censused skerries was 171, out of which 63 were in the marine and 108 in the outer zone. Censuses were conducted between 13 May - 30 June in 1978, 13 May - 15 July in 1979, and 23 May - 15 July in 1981. Most islands were visited only once, but skerries with gull or tern colonies were censused twice or three times during each season. These "lariform-islands" include most islands with breeding waders. Each skerry was first inspected from the boat with binoculars at approaching. After landing the islet was thoroughly criss-crossed by 2–4 observers. Accordingly, all waders should have been detected. Censuses carried out in mid-May may have overlooked some waders that had not yeat commenced breeding.

Waders were considered to be breeding, if either (1) a nest or chicks were found, (2) two adults were seen during the breeding season on a suitable islet, or (3) one or two adults were seen during the breeding season behaving in a way that indicated breeding. In uncertain cases waders were considered to be not breeding.

Table 1. Censuses and counts used in this study. a = land census, b = boat census

Year	Census time	Censusers	Census method	Number of censused islands	Distribution of islands into archipelago zones		
					Marine	Outer	Inner
1914	18-23 June	Nyberg (1915)	a	25	10	15	0
1921-22	20 May - 10 July	Sundström (1927)	a, b	48	42	6	0
1936-37	6 June - 29 July	Ahlqvist & Fabricius (1938)	a	75	40	35	0
1945	8-29 July	Lampio (1946)	a, b	53	7	46	0
1955	8 June	Vert. Ecol. Course (unpubl.)	a	20	16	4	0
1958	3-10 June	— " —	a	39	20	19	0
1959	25 May - 11 June	— " —	a	39	25	14	0
1960	23 May - 10 June	— " —	a	23	9	14	0
1962	25 May	— " —	a	26	3	23	0
1963	25 May - 4 June	— " —	a	36	9	27	0
1964	1-4 June	— " —	a	14	0	14	0
1965	25 May - 2 June	— " —	a	36	3	33	0
1966	26 May - 3 June	— " —	a	41	9	32	0
1969	23 May - 4 June	— " —	a	43	8	35	0
1971	28 May - 1 June	— " —	a	23	8	15	0
1972	17 May - 2 June	— " —	a	20	8	12	0
1973	22-29 May	— " —	a	24	10	14	0
1974	17-24 May	— " —	a	13	4	9	0
1974	23 May - 9 June	Koistinen & Palmgren (unpubl.)	b, a	1320	203	799	318
1975	24 May - 17 June	Koistinen & Palmgren (1976)					
1978	13 May - 30 June	Valste (unpubl.)	a	131	26	105	0
1979	13 May - 15 July	Palmgren & Valste (unpubl.)	a	148	40	108	0
1981	23 May - 15 July	— " —	a	23	23	0	0

3.2. Earlier censuses

Nyberg (1915, 1916) visited the Nothamn Bird Sanctuary 18-23 May 1914 and in June 1915. In 1914 he counted birds on 25 skerries and islets, in 1915 he ringed birds in the same area (Fig. 2). Nyberg concentrated in the Eider, but apparently he recorded all the waders, as well. 15 of Nybergs's islets were in the outer and 10 in the marine zones. The time of the census was a little too early in 1914 and a little late in 1915. As he counted the nests and adult birds at least in most cases by landing on the skerries, his results are presumably reliable. The number of censused skerries is, however, very low.

Sundström (1927) made boat excursions through almost the entire study area in 1921-22 (Fig. 2). He visited 42 skerries in the marine zone, out of which he censused thoroughly 7. In the outer zone Sundström visited 6 skerries, 2 of which he censused. Sundström's excursions and censuses were conducted mainly in late May and in June, but some visits were made in July and in the beginning of August, as well. Sundström presents estimates for the numbers of breeding pairs for each archipelago zone separately. His estimates are based on the numbers of birds observed during excursions. In spite of the fairly extensive excursions and Sundström's thorough knowledge of his study area, he probably did not notice all wader pairs as part of his boat counts were made during the incubation period. Sundström's data are, however, invaluable in considering the relative abundances of the waders and their distribution within the archipelago zones 60 years ago.

The thorough censuses of Ahlqvist & Fabricius (1938) in June and July 1936-37 covered an area almost identical with our core area (Fig. 2). Their censuses were made with the same method as we used in 1978-81 (Ahlqvist, pers. comm.), i.e. by searching thoroughly the nests of all seabirds including waders. They did not, however, census all the islands, but 75 skerries and islets rich in seabirds. 35 of these were in the marine and 40 in the outer zones. On these skerries they presumably found almost all breeding wader pairs, though missing those with breeding failures. Their figures cannot, however, be regarded as representative for the whole core area, as they did not census all islands.

Lampio (1946) censused 7 skerries in the marine zone and 46 in the outer archipelago zone off the Tvärminne Zoological Station in July 1945. His census area covered a part of our core area (Fig. 2). His numbers are apparently based on observed adults, which, considering the season, weakens their comparability to other censuses. He mentions, however, that observations from the beginning of the breeding season also were obtained. Lampio's figures cannot be considered as representative for his whole area, neither for our core area, as he did not census all islands and his census season was too late.

Field courses of vertebrate ecology held at the Tvärminne Zoological Station 1955-74 mainly in May and June (Table 1) censused seabirds including waders with the same method we used in 1978-81: waders were recorded when seabirds were censused by nest counting mainly during the waders' incubation stage. Sometimes the work was done in a hurry and sometimes by inexperienced census takers. The censused area was approximately the same during the different censuses (Fig. 2), but the number of censused skerries inside this area varied greatly from year to year (Table 1). The data are heterogeneous.

Table 2. Numbers of islands and wader pairs in different archipelago zones in the study area in 1974-1975 according to Koistinen & Palmgren (1976, partly unpubl.). Area of each zone and number of islands are indicated (percentage of totals in brackets). The distributions of the different species (Ringed Plover excluded due to lack of data) in the archipelago zones differs significantly from each other ($\chi^2 = 41.9$, $df = 4$).

	Marine zone	Outer zone	Inner zone	Total
Area (km²)	180 (36)	210 (42)	110 (22)	500
Islands				
<0.1 ha	39 (10)	232 (60)	117 (30)	388
0.1 - 1.0 ha	112 (20)	334 (59)	117 (21)	563
1.0 - 10.0 ha	52 (17)	195 (63)	62 (20)	309
>10.0 ha	0	38 (63)	22 (37)	60
Total	203	799	318	1320
Wader pairs				
Haematopus ostralegus	27 (14)	155 (79)	14 (7)	196
Charadrius hiaticula	1 (17)	4 (67)	1 (17)	6
Tringa totanus	19 (24)	45 (58)	14 (18)	78
Arenaria interpres	36 (40)	54 (60)	0	90

3.3. Comparability of censuses

It is, of course, hazardous to try to compare results obtained by different observers during 60 years. The census methods, seasons, and workers have not been the same. In most cases it is impossible to evaluate the changes in the exact numbers of breeding pairs. The boat counts, early or late censuses, and such censuses where the methods are unknown, must not be used for comparing the changes in numbers. With some caution, they can be used for comparing the relative abundances of waders in different decades and, in some cases, for pointing out major changes in numbers.

However, treeless skerries are easier to census than perhaps any other habitat. Most of them are small or very small and the vegetation offers very little protection. Waders included in this study are easy to observe and easy to recognize. We consider the censuses of Ahlqvist & Fabricius (1938) in 1936-37 and those made by ourselves in 1978-81 to be directly comparable, as the methods and seasons are compatible. Consequently, these censuses can be used for estimating numerical changes.

Since the aim of this study is to show the trends rather than exact changes in the wader numbers and the changes in their distribution, we use the different census results for assessing these changes. In most cases the evaluations are based on the studies of Sundström (1927), Ahlqvist & Fabricius (1938), Koistinen & Palmgren (1976, partly unpubl.), and ourselves (1978, 1979 and 1981, unpublished).

4. Results

The estimates given by Sundström (1927) are presented in Table 4 side by side with Koistinen & Palmgren's (1976, partly unpubl.) census results. The numbers are not directly comparable, as Sundström's method for obtaining the numbers of breeding pairs was not the same and his study area was somewhat smaller. Table 5 shows the census results of Ahlqvist & Fabricius (1938) compared to our results from the same 75 skerries more than 40 years later. Table 6 presents the numbers of breeding pairs in the whole core area in 1979, partly in 1981.

Table 3. Total area (ha) and numbers (N) of islands of different size classes in the core area.

Size class (ha)	Marine zone N	Marine zone Area	Outer zone N	Outer zone Area	Total N	Total Area
<0.2	76	8.9	67	5.9	143	14.8
0.2-0.5	32	11.7	26	8.3	58	20.0
0.6-1.0	15	11.4	14	11.3	29	22.7
≥1.1	21	36.8	21	130.0	42	166.8
Total	144	68.8	128	155.5	272	224.3

4.1. The Oystercatcher

The total population of Oystercatcher has grown in the study area. The estimate in 1921-22 was 20 pairs, while the number of counted pairs in 1974-75 in the somewhat larger census area was 196 pairs (Table 4). The same trend is shown in the 75 core area skerries: from 1936-37 to 1979-81 the number of pairs rose from 3 to 16 (Table 5). In the Nothamn Bird Sanctuary the numbers have risen, also: in 1914 there were 2 pairs (Nyberg 1915), in 1974 on the same islands 6 pairs (Koistinen & Palmgren, unpubl.).

The spatial distribution of the Oystercatcher has changed, as well. In the study area all the pairs bred in the outer zone in 1921-22, but in 1974-75 21% of them were in the marine or

Table 4. Results of two censuses of the study area (Fig. 2)

	1921-22 (Sundström 1927)[1]				1974-75 (Koistinen & Palmgren 1976)[2]			
	Marine	Outer	Inner	Total	Marine	Outer	Inner	Total
No of islands	160	640	260	1060	203	799	318	1320
Haematopus ostralegus	0	20	0	20	27	155	14	196
Charadrius hiaticula	4	4	8	16	1	4	1	6
Tringa totanus	33	17	0	50	19	45	14	78
Arenaria interpres	44	6	0	50	36	54	0	90

[1] numbers are estimates based on the number of observed birds during boat excursions through the archipelago; note the somewhat smaller census area
[2] exact numbers of censused pairs; the census area is somewhat larger than Sundström's

inner zones (Table 4). In the core area the Oystercatcher has increased more in the marine than in the outer zone (Table 5).

The changes in the numbers and distribution of the Oystercatcher are so extensive and so uniform in all the studies that they really show a steady increase. It is harder to estimate the exact scope of the change. We suggest that the number of breeding Oystercatcher pairs in the study area in the late 1970's was at least five times as great as their number in the early 1920's.

Table 6 presents the situation in the core area partly in 1979 and partly in 1981. The Oystercatcher was then breeding on about 16 % of the skerries both in the outer and in the marine zones. As the number of skerries in the outer zone of the whole study area is much greater (799) than in the marine zone (203), it seems that the distribution Koistinen & Palmgren (1976, partly unpubl.) found in their censuses was unchanged 5-6 years later. The numbers had, however, grown. Koistinen & Palmgren (1976) found 18 Oystercatcher pairs in the core area, while the number was 29 in our censuses.

4.2. The Ringed Plover

The total population of the Ringed Plover has decreased in the study area. Sundström (1927) estimated that there were 16 pairs in his study area, but Koistinen & Palmgren (1976, partly unpubl.) found only 6 pairs in their somewhat larger study area (Table 4). The species was completely absent from the 75 skerries in the core area, where 3 pairs were breeding in 1936-37 (Table 5). There were 3 pairs left on the other skerries of the core area in 1979-81, however (Table 6). The situation has remained stable since the beginning of 1970s in the Tvärminne area, but during the preceding decades more than 50 % of the Ringed Plover islands were abandoned (Ahlqvist & Fabricius 1938, Lampio 1946, Vertebrate Ecology Courses unpubl., Palmgren & Valste 1983).

The distribution may have also changed, though the numbers are too small to allow any definite conclusions. Sundström (1927) estimated that 50 % of the population was breeding in the marine zone and 25 % in the outer and inner zones respectively. Koistinen & Palmgren (1976, partly unpubl.) censused 67 % of their Ringed Plovers in the outer zone and 17 % in the inner and marine zones respectively.

4.3. The Redshank

The numbers of the Redshank seem to have changed little in the whole study area from 1921-22 to 1974-75 (Table 4). On the same 75 skerries in the core area there has been a clear decrease from 1936-37 to 1979-81, however (Tab. 5).

The results agree with changes in the distribution. The Redshank bred earlier mainly in the marine zone and in the marine parts of the outer zone, but nowadays most of the pairs are in the outer zone and the species is common on the mainland and in the inner zone (Table 4, 5, and 6). The numbers in the marine core area are lower now than in the 1920s and 1930s, but the number of breeding pairs in the whole study area may have grown a little.

4.4. The Turnstone

The number of Turnstones seems to have grown somewhat in the whole study area from

Table 5. Results of comparable censuses on 75 skerries in the core area (Fig. 2)

	1936-37 (Ahlqvist & Fabricius 1938)			1978-81 (Valste & Palmgren, unpubl.)		
	Marine	Outer	Total	Marine	Outer	Total
No of islands	35	40	75	35	40	75
Haematopus ostralegus	1	2	3	10	6	16
Charadrius hiaticula	1	2	3	0	0	0
Tringa totanus	9	6	15	2	3	5
Arenaria interpres	18	4	22	17	2	19

1921-22 to 1974-75 (Table 4). On the 75 core area skerries the numbers have remained practically constant from 1936-37 to 1979-81 (Table 5).

The distribution of the Turnstone has clearly changed. Earlier it bred mainly in the marine zone, only few pairs inhabiting the outer zone, but today the majority of the pairs in the study area breed in the outer zone (Table 4).

In the outer parts of the archipelago the number of Turnstones is very stable. Koistinen & Palmgren censused 40 pairs in the whole core area in 1974-75 while our own censuses in 1979-81 showed 41 breeding pairs in the same area (Table 6).

4.5. Relation to larid colonies

In the core area the four wader species seem to favor tern *Sterna* sp. and/or Common Gull *Larus canus* colonies (Table 7; for the sociability of waders see also e.g. von Haartman 1937, Bergman 1939, Nordberg 1950). This is supported also by the disappearance of waders from such skerries from which the larid colony has disappeared (in the core area 2 cases).

5. Discussion

5.1. Are the changes real?

The reliability of bird censuses is a matter of great controversy. In particular different methods for censusing land birds have been discussed (e.g. Berthold 1976, Ralph & Scott 1981). As a rule bird censuses on treeless skerries are easier to carry out and give more reliable results with much less work than land bird censuses (Hildén 1966). In the Baltic skerries are usually separated entities or

Table 6. Breeding pairs of four wader species on 171 unforested skerries in the core area (Fig. 2) censused partly in 1979 (148 skerries) and partly in 1981 (23 skerries).

	Marine zone	Outer zone	Total
No of islands	63	108	171
Haematopus ostralegus	12	17	29
Charadrius hiaticula	1	2	3
Arenaria interpres	26	15	41
Tringa totanus	8	12	20

Table 7. Wader breedings in the core area in 1978-81 in relation to Common Gull and/or tern colonies (5 pairs or more). Total of censused skerries = 302, skerries with colonies = 63 (20 % out of total).

	Breedings (total)	Breedings in colonies	%
Haematopus ostralegus	49	28	57.1
Charadrius hiaticula	7	5	71.4
Tringa totanus	30	20	66.7
Arenaria interpres	63	42	66.7

groups. Birds are easily observed when they fly to adjacent islets. For waders, the behavior in general suffices to ascertain the breeding. Accordingly, wader censuses carried out between 20 May and 20 June by landing on the skerries and counting the nests and adult birds, as well as recording their behavior, produce according to our experience reliable results on the numbers of breeding pairs.

Small changes in numbers may be caused by annual variations in breeding populations. The extent of annual fluctuations for three wader species in two different archipelago areas is shown in Table 8, which is based on the studies of Hildén (1966) and Lemmetyinen (1980). The annual fluctuations are very small in the Oystercatcher numbers, but the yearly changes in the Turnstone and Redshank numbers are also small compared to most passeri-

Table 8. Coefficient of variation (*CV*) for annual number of breeding pairs in three wader species in two Finnish archipelagos. Calculated from Lemmetyinen 1980 (Trollö in the Archipelago Sea) and Hildén 1966 (Valassaaret in the Quark).

	Trollö			Valassaaret		
	CV	Period	*N*	*CV*	Period	*N*
Haematopus ostralegus	0.24	16	161	0.11	8	62
Tringa totanus	0.34	16	60	0.15	6	525
Arenaria interpres	0.30	16	163	0.16	6	864

Table 9. Census results of 1936 and 1937, 1955, 1958 and 1959, 1965 and 1966, and 1975 (first number) compared to the results of censuses carried out in 1979 and 1981 (second number). Marine and outer zones are separated. The number for the Oystercatcher in the marine zone in 1936–37 compared to the number in 1979 and 1981 is the only one, which significantly differs from the expectation of a stable population ($\chi^2 = 8.1$, $df = 1$). In other cases the material is too small to give statistical significance. Numbers of different columns are not comparable with each other.

	Zone	1936–1957	1955	1958–1959	1965–1966	1975
Haematopus ostralegus	Marine	3/6		2/3	1/4	9/8
	Outer	0/10**		1/7		4/10
Tringa totanus	Marine	7/2		2/3		4/5
	Outer	8/2		3/5		4/7
Arenaria interpres	Marine	5/3.5		5/4		9/6.5
	Outer	17/17.5	7/11.5	11/19		13/24

nes in a corresponding period of time (Solonen 1981). Consequently, we assume that the census results from different years represent the status of these waders at each specific period of time in the study area or in parts of it.

Boat counts tend to underestimate the breeding population. In particular during incubation the waders slip away from their breeding skerries stealthily, but in the open landscape they are in general observed. In our own censuses 1978–81 we first scanned the skerries from the boat upon approaching and waders were apparent on their breeding islets in most cases before our landing. The four species behave, however, differently. The Oystercatcher usually silently flies to some skerry near the breeding site, while the Turnstone and the Ringed Plover run to the farthest point of the breeding skerry, sometimes silent and sometimes calling. The Redshank remains incubating or shies away as long as the boat is near the skerry. Behavioral patterns change completely after hatching, and all waders become conspicious.

Accordingly, the boat counts miss some breeding pairs and their accuracy is not equal for each species. It must be emphasized that in all four wader species a majority of the breeding pairs can be observed from the boat. Koistinen & Palmgren (pers. comm.) suggest that the censused number of Oystercatcher should be multiplied by 1.1 and those of the other waders by 1.3 to get a more accurate estimate of the real numbers. These coefficients are based on observations on boat counts vs. census results obtained by landing and counting the nests or adults.

A major problem arises when the results obtained from some restricted areas or from a small number of skerries are generalized. How do we know, whether the results were representative or not? Sundström's (1927) estimates are generalizations based on data collected during both boat excursions and censuses on a limited number of skerries. Sundström's excursion map shows that he visited the "best" bird areas during his boat trips and most of his censuses were made on "good" skerries. This could easily have led to overestimates on the numbers. Sundström was apparently so familiar with his study area that he was, however, able to avoid this. His estimates appear to be little overcautious. Sundström did not intend to present exact numbers of breeding pairs, but rather a general idea of the numbers of each species. We rely upon his success in this.

Special problem are the relatively low numbers of breeding wader pairs. As the censused areas have usually been fairly small and the skerries not the same from year to year, comparable numbers of pairs become very low (Table 9). A statistical analysis is in most cases unpracticable.

There is no doubt about the reality of increased Oystercatcher or decreased Ringed Plover numbers. We believe also that the increase in the number of Turnstones is real. The Redshank is more problematic, as it is perhaps the most difficult species to census during incubation period and as the possible increase is slight. We hold that the species is at least as numerous in the study area as it used to be, and perhaps even a little more abundant. Koistinen & Palmgren (1976, partly unpubl.) *censused* over 50% more pairs in their study

area than Sundström (1927) estimated to breed in his study area.

Changes in the distribution are easier to deduce from the available data than changes in the numbers. Complete or nearly complete absence of a species from some archipelago zone is highly significant, as well as regular and numerous appearance. It is our opinion that the distribution changes given in the previous chapter are real.

5.2. Changes in other areas

The Oystercatcher has increased elsewhere in Finland, too. In the Trollö archipelago to the west of the study area the numbers were doubled in 1960–1977 (Lemmetyinen 1980). In the Kirkkonummi (Kyrkslätt) archipelago to the east of our study area the number of Oystercatcher pairs rose from 3 to about 10 in 40 years (Bergman 1939, Kilpi et al. 1980). Hildén & Hyytiä (1981) mention a "slight or somewhat stronger increase in certain areas since the 1950's" and consider it probable that the total population of Finland has grown. On the coasts of the North Sea the Oystercatcher declined in the second half of the 19th century, increased slightly during the first half of this century, and started a rapid rise in 1950 (Glutz von Blotzheim 1975).

The archipelago population of the Ringed Plover has decreased in Finland since 1950's (e.g. Grenquist 1965, Hildén 1966, Hildén & Hyytiä 1981). In the study area the decrease has apparently not been as drastic as elsewhere. The Ringed Plover has decreased also in the German Baltic Sea coasts and in the British Isles, but it has increased in the Dutch and German North Sea coasts since 1940's (Glutz von Boltzheim 1975).

The Redshank has increased in the inner parts of the archipelago everywhere in the Finnish coasts (Hildén & Hyytiä 1981). In central Europe the changes in Redshank numbers have in general been short-term fluctuations caused by man-induced habitat changes (Glutz von Blotzheim 1977).

The increase in Turnstone numbers and the spreading inwards of the species have been observed also elsewhere in Finnish archipelagoes (Kilpi et al. 1980, Rauhala 1980, Hildén & Hyytiä 1981).

5.3. What causes the changes?

Changes in bird numbers may result from e.g. changes in reproductive success, adult mortality, immigration and emigration, or the availability of suitable habitats.

The four species included in present study feed on different invertebrates and some plant material. In addition, the Turnstone preys on birds' eggs during breeding season (Vuolanto 1968). Both the primary and secondary production of the Baltic Sea have increased during this century (Melvasalo et al. 1981), and so an increase in the amount of food during the breeding season may have affected wader numbers.

Competition between the wader species studied during breeding season seems to be negligible. They are morphologically different and they have somewhat different habitat preferences. Intraspecific competition is not strong either. Only some of the total island number each species has inhabited in recent years are occupied in a single year, i.e., there are suitable but vacant breeding habitats for each of the four species every year.

Competition during wintertime is hard both intra- and interspecifically, and winter mortality is an important factor in the population changes of these long-living species (Glutz von Blotzheim 1975, 1977). Finnish Oystercatchers migrate mainly to the North Sea coasts and to France, Ringed Plovers mainly to SW-European coasts, Turnstones mainly to the coasts of West Africa, and Redshanks mainly to SW-European and W-African coasts (Finnish ringing scheme, unpubl.).

Predators of waders have increased strongly in the study area (Palmgren & Valste 1983). Large gulls, the Hooded Crow *Corvus corone cornix*, and the Mink *Mustela vison* are either much more common today than earlier or completely new species to the archipelago animal community. The predation pressure towards waders has not grown in line with predator numbers, as the numbers of other prey species have also risen considerably (Palmgren & Valste 1983). The decrease in Redshank numbers in the marine zone and Ringed Plover numbers in all zones might have some connection with the increase in the Herring Gull *L. argentatus* and Greater Black-backed

Table 10. Common Gull and/or tern colonies (5 pairs or more) in the same 75 skerries in 1936-37 (Ahlqvist & Fabricius 1938) and 1979-81 (Valste & Palmgren, unpubl.).

	Marine zone (35 skerries)	Outer zone (40 skerries)	Total (75 skerries)
1936-37	7	1	8
1979-81	10	10	20

Gull *L. marinus* numbers. An increase in the numbers of Turnstone may also have had some effect, as they feed on the eggs of other waders.

The distributions and numbers of the four studied waders have changed. We maintain that at least one important reason for this has been the spread and increase of Common Gull and Arctic Tern colonies, which has taken place during the last 40 years (Table 10). As stated above, the waders prefer terneries or Common Gull colonies as breeding habitat. Thus the increase of Turnstones, Redshanks, and Oystecatchers in the outer zone, and Redshanks and Oystercatchers in the inner zone agrees very well with the changes in the distributions and numbers of these larids.

Human activities and inactivities have both direct and indirect effects on bird populations. Hunting, pollution, and oil spills have affected many marine birds. The breeding populations of Oystercatcher, Redshank and Turnstone in the study area, at least, have not been diminished by these factors.

The almost total disappearance of permanent human settlement in the archipelago during this century has caused many changes. Open meadows and pastures have been invaded by reed and bushes and wader habitats have been limited. This change has, however, affected only restricted parts of the archipelago.

Disturbance in the archipelago is increasing together with the increasing number of summer cottages and boats. Many areas are protected, but most skerries and islands are not. Late breeders, among them waders, suffer as the disturbance suddenly grows in June. The Ringed Plover seems to be particularly vulnerable, as it prefers the flat skerries with bare patches and little vegetation also favored by sun-bathers. During our study period we have twice documented the deaths of complete Ringed Plover broods caused by people staying too long on breeding skerries. Considering the small number of pairs breeding in the study area, disturbance may have been an important factor in the decline of the species.

Direct persecution and vandalism are not common nowadays, but sometimes people destroy gull colonies to "protect" nature and the difference between gull and Oystercatcher eggs is not very conspicuous. In the beginning of this century Oystercatchers were persecuted because they disturbed the summer fishing with their calls and flying (Öhman 1918). Together with egg-collecting, persecution may have been one reason for its low numbers at that time.

6. Conclusions

Changes in the numbers and/or distribution of the four waders in the study area have evidently taken place in this century. The reasons are not clear, but the Oystercatcher has increased extensively and spread out-and inwards, the Turnstone has increased and spread inwards, the Redshank has decreased in the marine zone and increased in the inner archipelago, and the Ringed Plover has decreased.

Results obtained from single areas or parts of them must not be generalized too easily because we do not know the true geographical scale of the population processes involved (e.g. Wiens 1981). Our initial study concentrated on the marine and outer zones. The comparision of censuses carried out in 1936-37 and 1978-81 seemed to indicate some evident changes and some fairly stable situations (Palmgren & Valste 1983). However, when the inner archipelago as well as much larger areas were included, the overall view was in some cases radically changed. In particular, the estimated changes in total population numbers of archipelago birds are not reliable when they are based on censuses of limited areas only.

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