Population trends among archipelago birds in the Krunnit sanctuary, northern Gulf of Bothnia, in 1939–85

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Helle, E., Helle, P. & Väisänen, R. A. 1988: Population trends among archipelago birds in the Krunnit sanctuary, northern Gulf of Bothnia, in 1939–85. — Ornis Fennica 65:1–12.

Breeding pairs of ducks, alcids, waders, gulls and terns were censused on the Krunnit Islands, northern Gulf of Bothnia, in 24 summers between 1939–85. The data for ducks, gulls and terns are mainly based on nest finds, those for waders and alcids on the numbers of adult birds.

The sanctuary was founded in 1936 and effective guarding started in the late 1940s. In 1939 the number of regularly nesting species was 28 and these were joined by *Scolopax rusticola*, *Tringa glareola* and *Larus argentatus* in the 1940s, and by *Anas penelope*, *L. marinus* and *L. ridibundus* in the 1950s. On the other hand, *Cepphus grylle* has almost disappeared. From the 1930s to the 1950s, the total bird numbers remained at the level of about 650 pairs, but by the 1980s they had increased to over 2000 pairs, chiefly due to the rapid growth of gull and tern numbers.

The populations of *Anas* species varied irregularly, except for that of *A. penelope*, which clearly increased. Most waterfowl species (8 out of 12) showed an increase from the 1970s to the 1980s. Of the waders, *Arenaria interpres* and *Actitis hypoleucos* have increased, whereas *Charadrius hiaticula*, *Calidris temminckii*, *Numenius arquata* and *Phalaropus lobatus* have decreased. In 1939 only 30 pairs of gulls were breeding on the Krunnit Islands. *Larus fuscus* showed a rapid increase in the 1950s, *L. canus* in the early 1960s, *L. argentatus* in the late 1960s and *L. ridibundus* from the early 1970s onwards. *Sterna caspia*, *S. hirundo* and *S. paradisaea* also increased.

The role of this sanctuary in monitoring bird populations is discussed. Information about the feeding ecology of gulls is needed to elucidate the effect of increasing predation by *L. argentatus* and *L. marinus* in the coming years and the significance of the large *L. ridibundus* population in competition for food among gull and tern species. The bird populations of the Krunnit Islands are threatened by possible immigration of the mink, raccoon dog and Arctic fox.

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Introduction

Several long-term studies have dealt with the numbers of breeding sea birds in Finnish archipelagoes. Coastwide population trends have been reported (Grenquist 1965, Kilpi 1985), and also changes in more restricted areas (e.g. Bergman 1982, Palmgren & Valste 1983, Siira & Eskelinen 1983, Hario et al. 1986). Our study area, the Krunnit Islands in the northern Gulf of Bothnia, has been included in the general surveys of bird populations in Finnish archipelagoes (Grenquist 1965, Kilpi 1985), and the structure and dynamics of the archipelago bird communities breeding on the Krunnit Islands have been described by Merikallio (1950), Salkio (1952), Grenquist (1965), Väisänen (1972) and Väisänen & Järvinen (1977a, b).

The factors causing changes in the populations of archipelago birds vary with the locality and species (e.g. Lemmetyinen 1980, Siira & Eskelinen 1983, Hario et al. 1986). They include changes in the environment in the breeding area (e.g. building-up of shores, increasing disturbance by boating, eutrophication, changes in the intensity of cattle grazing on shores), or wintering grounds, climatic changes, changes in food resources, predation, hunting, and interspecific competition.

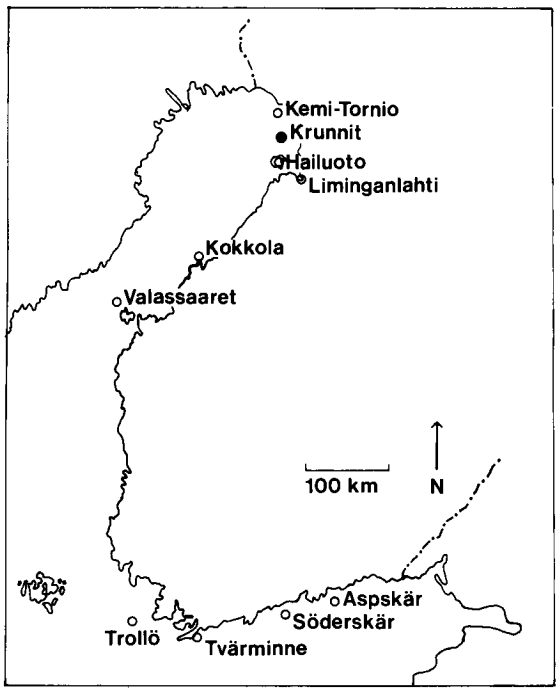

Fig. 1. Location of the Krunnit Islands and some other areas where archipelago birds are studied on the coast of Finland.

Here we describe changes in sea bird populations on the Krunnit Islands in the period 1939–85 and compare the trends with those observed in other Finnish archipelagoes. By the term 'sea bird' or 'archipelago bird' we mean all species of waterfowl, waders, larids and alcids; thus the term includes a large variety of species living close to the shoreline and even those breeding in wet areas. The data from Krunnit cover nearly five decades, dating back to the 1930s, when these islands became protected (censuses from 24 separate years) and may be assumed to reflect the general development in the northern Gulf of Bothnia.

Study area and bird censuses

The Krunnit Islands (65°20'N, 25°00'E) are situated in the northern Gulf of Bothnia 10–20 km from the Finnish coast (Fig. 1; for a detailed map of the Krunnit, see Väisänen & Järvinen 1977a). The three largest islands are forested; in addition, the archipelago includes some 20 smaller islands and islets which lack woody vegetation. The islands can be divided into four successional types according to their vegetation (Vartiainen 1967, 1980) and breeding bird communities (Väisänen & Järvinen 1977a). The succession is mainly caused by the strong land uplift (75 cm/100 years) resulting from the latest glaciation:

A. "Boulder skerries", average elevation 1.25 m, 6 islands, total area 1.6 ha in 1957;

B. "Grassy skerries", average elevation 2.12 m, 4 islands, 6.2 ha;

C. "Grassy islands", average elevation 2.38 m, 6 islands, 17.8 ha;

D. "Wooded islands", elevation up to 12 m (the oldest parts being about 900 years old), 4 islands, 330 ha.

The category C/D was also used for two intermediate islands (total area 4.5 ha; see Väisänen & Järvinen 1977a). We determined the habitat range used by each species in the successional island gradient by calculating the mean occurrence on different island types. The following numerical values were used in the calculation: A=1, B=2, C=3, C/D=3.5 and D=4. The area of the wooded islands (D) includes the whole land area, although the main part of it is covered by deciduous forest. The area used by sea birds is substantially smaller but is difficult to delimit exactly, because several species breed in the forest as well.

Merikallio (1930) presented some semi-quantitative data from the Krunnit in the beginning of this century. True breeding bird censuses were made in 24 years: in 1939, 1948–49, in eight years in the 1950s, six years in the 1960s, six years in the 1970s and finally in 1985. Väisänen & Järvinen (1977a, b) have presented details of the censuses (census years, dates and observers) up to 1972. Later data are from censuses carried out by EH and PH on 16–28 June 1973, 10–24 June 1975, 18–29 June 1977, and 14–20 June and 7–10 July 1985. Breeding gulls were censused by EH in 1978 as well.

The numbers of gulls, terns and waterfowl are mainly based on nests found, those of waders on the numbers of pairs observed. In years in which the census was carried out later in the breeding season, the broods were used to determine the numbers of early nesting dabbling ducks. These species present problems for two reasons: 1) dabbling ducks breed early in the season (see Väisänen 1974 for data), and they should be censused in late May when the males are still on the breeding grounds; 2) many species of dabbling ducks nest abundantly on the main islands, in forested parts, where the nests are difficult to find.

The numbers of *Sterna hirundo* and *S. paradisaea* have not been reported separately for some study years. In these cases the total number is divided between *hirundo* and *paradisaea* using the ratio between

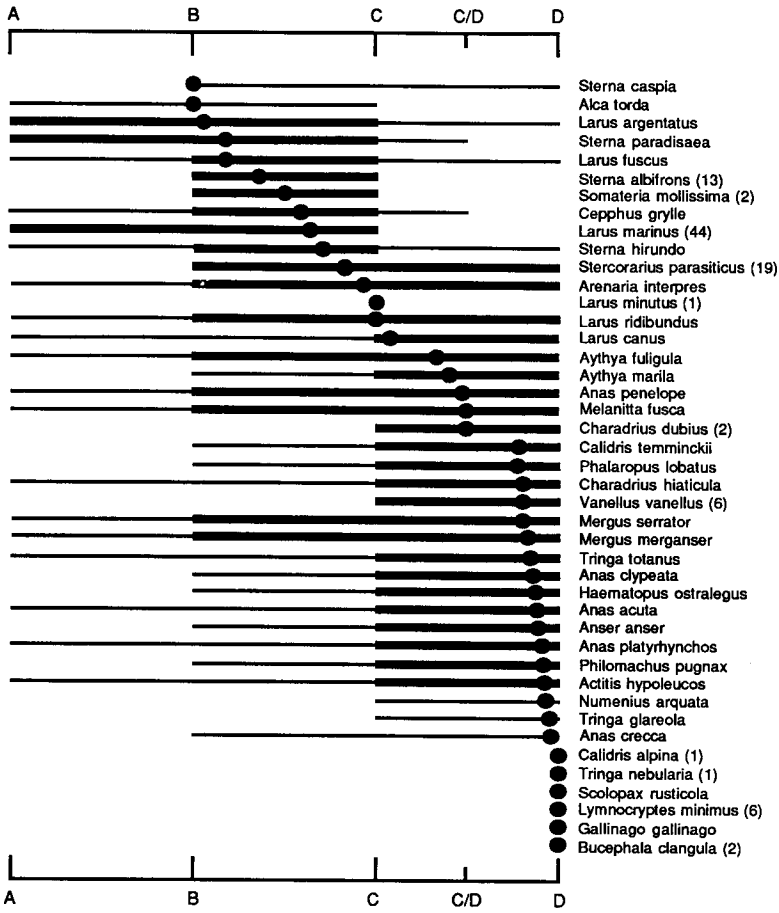

Fig. 2. Distribution of species by island types arranged from the youngest to the oldest in 1939–85 (A = boulder skerry, B = grassy skerry, C = grassy island, D = wooded island). A dot indicates the median, a thin line all island types inhabited by the species and a thick line those types on which at least 90% of the total population was nesting. The total number of nestings is given in parentheses, if it is less than 50.

the species on that island in the previous or following census year. For a more detailed description of the census methods and a discussion of the reliability of the results, see Väisänen & Järvinen (1977a).

The numbers of each archipelago bird species breeding on the 22 islands studied in 1939, 1949, 1959 and 1970 are presented in Väisänen & Järvinen (1977b); data for 1985 are given in the Appendix.

Results and discussion

Nesting habitats

The distribution of the archipelago bird species on the different island types on the Krunnit Islands is shown in Fig. 2. It should be noted that the results are means for pooled data covering several decades. Altogether 43 waterfowl, larid, alcid and wader species have bred on the Krunnit in 1939–85. Sixteen of these have bred on all the four island types, but none is abundant on all the island types; this can be seen from the range of islands on which 90 % of the population are nesting.

The first 15 species breed on small, young islands (from *Sterna caspia* to *Larus canus*); the last 23 have their main populations on the large wooded islands (from *Calidris temminckii* to *Bucephala clangula*). Between these groups are a few intermediate cases. There are no distinct groups of species in the habitat selection pattern in Fig. 2; the species are fairly regularly distributed along the succession gradient.

Detailed descriptions of the bird communities in the different island types can be found in Väisänen & Järvinen (1977a).

Number of species and pairs

In 1939 Merikallio (1950) found 28 species of archipelago birds (waterfowl, waders, larids and alcids) breeding on the Krunnit Islands. New, regularly breeding species arrived in the following sequence: *Scolopax rusticola* and *Tringa glareola* in 1948 (it is also possible that these escaped notice in 1939), *Larus argentatus* in 1948, *L. ridibundus* in 1952, *L. marinus* in 1954 and *Anas penelope* in 1957. No regular species has disappeared during the study period, although two are now near local extinction: about 30 pairs of *Aythya marila* were breeding in the late 1940s, but only seven in 1985, and *Cepphus grylle* was represented by at least one hundred pairs in the beginning of this century (Merikallio 1930), but only one pair was present in 1985. Besides the 34 regular species (Appendix; note that *Tringa glareola* was not present in 1985), the following irregular breeders have been recorded: *Lymnocryptes minimus* (1948–49), *Vanellus vanellus* (in 6 years between 1954–85), *Bucephala clangula* (1959), *Charadrius dubius* (1972 and 1977), *Sterna albifrons* (1973–83; 1–5 pairs found in eight years during annual ringing visits by Unto Järvinen), *Tringa nebularia* (1975), *Somateria mollissima* (present in the beginning of the century, 2 pairs in 1977 and 1 in 1978), *Calidris alpina* (1985) and *Larus minutus* (present in the beginning of the century, one pair in 1985).

The total number of breeding pairs remained fairly stable, around 650, from the late 1930s to the early 1950s, but started to increase rapidly thereafter. In the 1970s the average number of pairs exceeded 1500 and the highest figure during the study period, 2125 pairs, was recorded in 1985.

The population trends were fairly similar for dabbling ducks, diving ducks and waders: the numbers of pairs in the 1980s were equal to those in the 1930s and 1940s, whereas in the 1950s–70s the numbers were slightly lower (Fig. 3). In contrast, the number of gulls increased from 30 pairs in 1939 to over 600 pairs in the 1970s and to about 1100 pairs in 1985. The number of nesting terns increased from about 50 pairs to about 500 pairs in the 1970s, but decreased thereafter to 350 pairs in 1985. The highest figure was recorded in 1973 (525 pairs).

Ducks

Anas penelope is the only *Anas* species which has clearly increased in numbers (Table 1). *A. platyrhynchos* has decreased on the Krunnit Islands, but the 1985 census suggests that the population may have recovered. *A. crecca* shows a somewhat similar trend. Its population was seemingly very low in 1939, but this can be an artefact due to late censusing. The early fluctuations of *A. acuta* resembled those of the two previous ducks. From the 1950s onwards this species has remained stable (10–15 pairs/average year; Table 1).

Aythya marila has decreased slightly to about 7 pairs a year in 1970–85. *A. fuligula* declined from 65 pairs in 1939 to about 20–30 pairs in the 1950s, but by 1985 had increased to 95 pairs (Table 1). *Mergus serrator* shows a similar pattern. The population of *M. merganser* was fairly stable from 1939 to the 1970s (13 pairs on average); the number in 1985 (27 pairs) suggests a recent increase. The population trends of *Melanitta fusca* and *Anser anser* resemble those of *M. serrator*. Both species were numerous in 1985.

Some of these changes may be artefacts due to differences in census dates between study years. As the methods and dates were the same in the 1970s and 1980s, this period provides data for the most reliable comparisons. The general result is that most waterfowl species have increased in numbers from the 1970s to 1985.

In the 1930s–1940s, all Finnish ducks, in particular *Anas platyrhynchos*, were exposed to uncontrolled shooting, frequent collecting of eggs, and severe winters (v. Haartman et al. 1963–72, Hildén 1966). They have recovered since then and the numbers have fluctuated irregularly during recent decades, possibly due to varying hunting pressure.

Anas acuta has increased in Finland in general since the 1940s, whereas the numbers of *A. clypeata* have remained fairly constant (Linkola 1961, v. Haartman et al. 1963–72). These species have been scarce on the Krunnit Islands since the population peak in 1939 and 1948–49. *A. acuta* in particular reached a peak at the end of the 1940s, most probably due to the optimal nesting habitats created by cattle grazing, which had ceased only recently. At Liminganlahti, 60 km south of the Krunnit, both species decreased during the period 1954–81 (Siira & Eskelinen 1983). *A. crecca* is also among the species which have become more frequent since the 1940s. On the other hand, the census methods used are least satisfactory as regards *A. crecca* (see Methods) and hence the data may not be

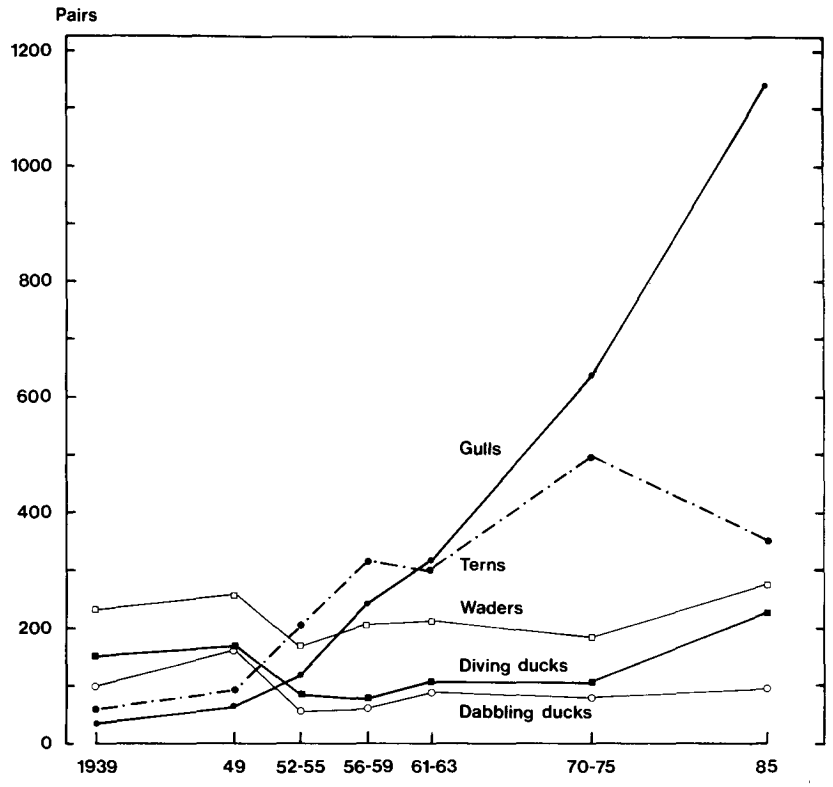

Fig. 3. Trends of pair numbers in different groups of species on the Krunnit Islands. The data are from the 17 most complete censuses made in the following years or periods: 1939; 1949; 1952–55 = mean of 1952, 1954 and 1955; 1956–59; 1961–63; 1970–75 = mean of 1970, 1972–73 and 1975; 1985.

Table 1. Number of waterfowl pairs breeding on the Krunnit Islands in 1939–85. Means and ranges are given for periods of several years (note that data are missing for 1953 and 1974). Rough estimates in brackets.

	1939	1949	1952–55		1956–59		1961–63		1970–75		1985
Anser anser	11	11	3.3	3–4	3.3	0–7	10	0–21	7.0	2–10	21
Anas penelope	0	0	0	0–0	7.3	0–16	24	22–28	27	21–30	37
A. crecca	(2)	35	10	9–12	10	8–13	17	14–22	13	10–17	24
A. platyrhynchos	(46)	28	21	12–33	16	14–19	24	22–29	11	5–16	17
A. acuta	26	76	14	12–15	15	11–17	12	9–15	12	7–16	12
A. clypeata	12	13	3.0	2–4	5.0	2–7	7.7	2–13	4.3	1–8	8
Aythya fuligula	(65)	45	28	21–34	27	15–37	34	30–39	44	33–57	95
A. marila	14	32	14	12–17	10	4–20	11	7–15	7.8	5–10	7
Melanitta fusca	14	23	5.3	3–10	7.5	7–8	6.0	5–7	13	5–19	38
Bucephala clangula	0	0	0	0–0	0.5	0–2	0	0–0	0	0–0	0
Mergus serrator	45	59	33	22–43	20	11–33	40	36–41	28	19–37	60
M. merganser	15	11	5.0	4–6	17	11–22	15	11–18	14	8–22	27

sufficiently accurate. The population of *A. penelope* increased throughout the study period, as elsewhere in Finland (v. Haartman et al. 1963–72, Hildén et al. 1978, Hario et al. 1986; cf. Siira & Eskelinen 1983, however).

The numbers of *Aythya fuligula* crashed in Finland after the severe winters of 1939–42 and 1946–47 (v. Haartman 1957, Hildén 1966). The population began to increase on the Valassaaret Islands at the end of the 1940s, and the maximum was reached in 1962 (Hildén et al. 1978). The populations recovered even more rapidly in the southern archipelago, where the maximum was observed in 1955 (Grenquist 1965). The development has been somewhat different on the Krunnit Islands. The population was smaller in the 1950s and 1960s than in the 1930s or 1970s, but no severe losses seem to have occurred during 1939–49 (see Table 1). The numbers of *A. fuligula* increased rapidly at Liminganlahti in the late 1970s (Siira & Eskelinen 1983) and in the archipelago of Kokkola in the early 1980s (Hongell 1986); the same trend on the Krunnit Islands is indicated by the high population in 1985.

The population of *Aythya marila* was weak in Finland in the beginning of the 1940s, but then increased rapidly. A downward trend occurred in Valassaaret after 1962 (Hildén et al. 1978, Stara & Taxell 1987). On the Krunnit Islands *A. marila* has decreased continuously since the end of the 1940s. *Melanitta fusca* has increased in the southern Finnish archipelago since the 1940s due to establishment of bird sanctuaries and stricter control of hunting (v. Haartman et al. 1963–72), but the population has decreased during the last 20 years in the Gulf of Finland (Kilpi et al. 1985, Hario et al. 1986) due to human disturbance and predation by large gulls (Hario et al. 1986). A decreasing trend is also apparent in the Bothnian Bay (Rauhala 1980, our data from 1939–77). A notable increase in numbers took place, however, in the population of the Krunnit Islands between 1977 and 1985.

The breeding population of *Anser anser* decreased generally in the Bothnian Bay area until the early 1960s (v. Haartman et al. 1963–72). On the Krunnit Islands it has been fairly steady for long periods, and shows a slight but clear increase from the 1970s to the 1980s (see also Pulliainen & Tynjälä 1984). The most recent increase matches the trend observed at Liminganlahti (see Siira & Eskelinen 1983; cf., however, Lampio 1982). The nesting of *Somateria mollissima* in the Bothnian Bay after an interval of 65 years (two nests found on the Krunnit Islands in 1977,

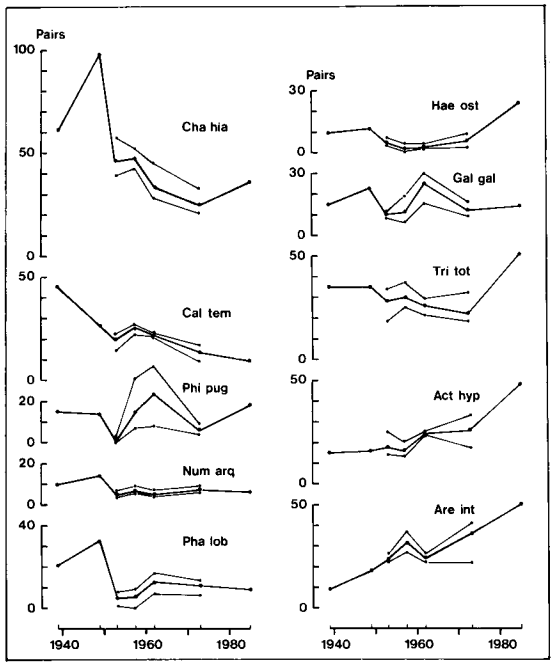

Fig. 4. Population trends among waders on the Krunnit Islands. When several censuses were made in a period (cf. Fig. 3), the range is given around the mean: *Charadrius hiaticula, Calidris temminckii, Philomachus pugnax, Numenius arquata, Phalaropus lobatus, Haematopus ostralegus, Gallinago gallinago, Tringa totanus, Actitis hypoleucos* and *Arenaria interpres*.

Pulliainen et al. 1979; one nest in 1978, U. Järvinen, unpubl.) reflects the huge increase that has taken place in more southern archipelagoes in Finland (e.g. Stjernberg 1982, Hario & Selin 1986). In the Gulf of Bothnia, the population of Valassaaret has increased continuously in 1970–85, from 200 to 430 pairs (Hildén 1986).

Mergus serrator and *M. merganser* have apparently increased slightly in our study area in recent times, as in the archipelago of Kokkola (Hongell 1986). The trends in more southern areas are less clear, however (Hildén et al. 1978, Hario et al. 1986, Stara & Taxell 1987); the reasons for these changes are poorly known.

Waders

Two species have increased fairly regularly on the Krunnit Islands during the study period: *Actitis hypoleucos* and *Arenaria interpres* (Fig. 4). Three wader species have clearly declined. *Charadrius hiaticula*

decreased from about 100 pairs in 1949 to about 25 pairs in the 1970s; the figure for 1985, 36 pairs, suggests that the population low has now been passed. *Calidris temminckii* has decreased from 46 pairs to about 10 pairs and *Phalaropus lobatus* from 21–33 pairs to about 10 pairs during the study period. *Numenius arquata* also shows a declining trend, from 10–14 pairs in 1939–49 to about 6 pairs in later years. The population size of *Philomachus pugnax* has varied erratically between 0 and 31 pairs in the 1950s, and 8 and 37 pairs in the 1960s. The numbers of *Gallinago gallinago* have varied widely, too. *Tringa totanus* decreased steadily from the 1930s to the 1970s, but the highest number was recorded in 1985 (51 pairs, Fig. 4). *Haematopus ostralegus* shows a similar U-shaped trend: the 24 pairs recorded in 1985 indicate a clear recent increase.

Among the less common wader species, the numbers of *Scolopax rusticola* and *Tringa glareola* have been relatively stable throughout the study period (5–8 pairs in an average year).

Actitis hypoleucos and *Arenaria interpres* decreased in the archipelago of Kokkola in 1971–86 (Hongell 1986), which disagrees with the trends in our study area. The population of *A. interpres* has remained fairly stable since the beginning of the 1960s in Valassaaret (Hildén et al. 1978, Stara & Taxell 1987) and Söderskär (Hario et al. 1986). However, in the northernmost archipelagoes of the Bothnian Bay there has been an increasing trend (Rauhala 1980), as also earlier in Hailuoto (Helle & Mikkola 1969). The reasons for the changes in the population of *A. interpres* are not known. *Actitis hypoleucos* favours forested shorelines and thus may have benefited from the cessation of cattle grazing on the Krunnit. The declines in the numbers of *Charadrius hiaticula* and *Calidris temminckii* are general trends observed along the Finnish coasts (Hildén & Hyytiä 1981). The decrease of *C. temminckii* is linked with the shrinkage of suitable habitats, due to termination of pasturing and shore meadow cultivation.

Tringa totanus has become more abundant along the Finnish coast during recent decades, penetrating not only to the inner archipelago but also inland (Hildén & Hyytiä 1981, Valste & Palmgren 1984). On the Krunnit Islands *T. totanus* decreased until the 1970s, but has increased clearly from 1977 to 1985. In the 1960s 2–4 pairs of *Haematopus ostralegus* bred on the Krunnit, but 24 pairs in 1985. The species has increased markedly along the Finnish coast (Lemmetyinen 1980, Valste & Palmgren 1984, Hario et al. 1986, Hildén 1986).

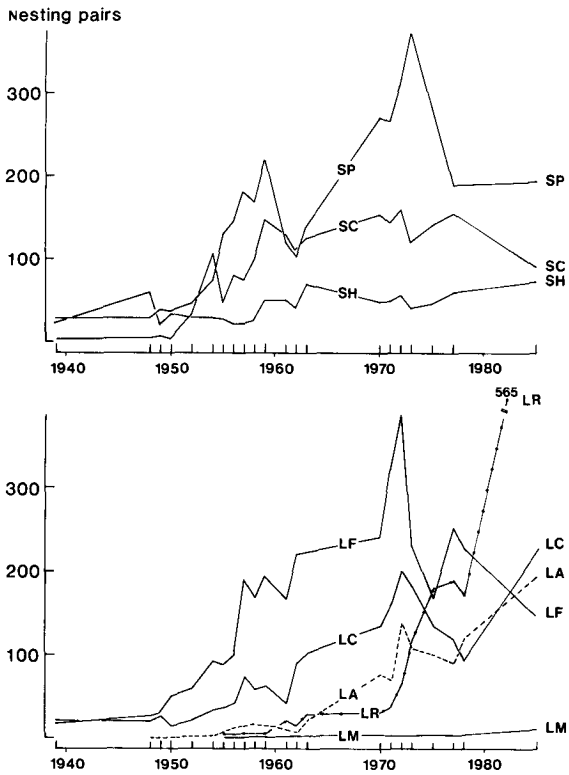

Fig. 5. Population changes in gull and tern species on the Krunnit Islands. LR = *Larus ridibundus*, LC = *L. canus*, LF = *L. fuscus*, LA = *L. argentatus*, LM = *L. marinus*, SC = *Sterna caspia*, SH = *S. hirundo* and SP = *S. paradisaea*. The census years are marked on the abscissa.

Gulls

In 1939 only *Larus fuscus* and *L. canus* bred on the Krunnit Islands, both with fewer than 20 pairs (Fig. 5). *L. argentatus* and *L. ridibundus* colonized the archipelago in 1948 and *L. marinus* in 1954. The first breeding of *L. minutus* after Merikallio's (1930) observation in the first decade of this century was noted in 1985. There has been one breeding pair of *Stercorarius parasiticus* in nearly every study year. Each of the abundant gull species has had a phase of rapid population growth during the study period: *L. fuscus* in the 1950s, *L. canus* in the 1960s, *L. argentatus* in the late 1960s, and *L. ridibundus* from the early 1970s onwards (Fig. 5). *L. marinus* has also increased, but its numbers are still low, the highest figure so far reached being 11 pairs (1985).

The rapid increase of gulls has taken place at roughly the same time as on Valassaaret (Hildén et al.

1978) and in the western Gulf of Finland and the Archipelago Sea (see Grenquist 1965, Kilpi 1985). The growth of the *L. canus* population in the Bothnian Bay was also observed in Hailuoto from the 1940s to 1960s (Helle & Mikkola 1969) and in the Kemi-Tornio archipelago (Rauhala 1980).

The dramatic growth of gull populations in the northern Baltic Sea and in the whole of NW Europe is well known (e.g. Bergman 1939, 1965, Grenquist 1965, Kilpi et al. 1984, Kilpi 1985). The most important reason has been the huge increase of food resources accompanied by changes in the feeding habits of gulls. The growth of the populations has strengthened interspecific competition, leading to a decline in the populations of *L. fuscus*, e.g. in the Gulf of Finland (Bergman 1982, Kilpi 1983; see, however, Lemmetyinen 1980). The weakness of *L. fuscus* in competition with *L. argentatus* is probably due to its smaller body size, which makes competition for food and nest places more difficult, to its later breeding time, which occurs when the best places are already occupied by *L. argentatus* and when human disturbance is stronger, and to its lower productivity (Kilpi 1983). Hario (1985) reported that the reason for starvation of *L. fuscus* chicks is inefficient parental care (due to shortage in food intake); further, the best growing chicks are frequently taken by *L. argentatus*.

On the Krunnit Islands *L. fuscus* was more numerous than *L. argentatus* until at least 1978, but by 1985 the ratio was reversed. The *L. fuscus* population on the Krunnit was highest in 1972. In more southern Finnish archipelagoes, on Valassaaret, Gullkrona and Aspskär, the maxima occurred earlier, in 1956–64, after which the numbers decreased (Kilpi 1983). In the northern Gulf of Bothnia *L. fuscus* has not suffered greatly so far from competition with *L. argentatus*. *L. fuscus* has decreased in the archipelagoes of Tornio, Kemi and Simo, but this has been caused by human persecution — *L. argentatus* is still uncommon. On Krunnit the numbers of *L. fuscus* are now the lowest since 1957, which is alarming; however, *L. canus* has not yet decreased (cf. with Söderskär, where *argentatus* also preys heavily on *canus*; Hario et al. 1986). On the islands of Kokkola and Valassaaret *L. argentatus* is increasing strongly, but the population of *L. fuscus* has remained stable or even increased slightly in recent years (Hildén 1986, Hongell 1986).

L. ridibundus settled on the Krunnit Islands in the 1940s and 1950s, choosing the wooded islands, which with their sheltered bays correspond to the typical habitats in the inner archipelago. When the population continued to increase in the 1970s, *L. ridibundus* spread to the smallest outer skerries, breeding in the company of *Sterna paradisaea* and *Arenaria interpres*.

Terns and alcids

The most numerous tern species on the Krunnit Islands is *Sterna paradisaea*. It increased strongly from 30 pairs in the 1930s–40s to over 200 pairs in the 1950s. The population reached its peak in 1973 (350 pairs); in 1977 and 1985 about 200 pairs were recorded (Fig. 5). *Sterna caspia* has shown a pronounced increase, too, but the number in 1985, 90 pairs, suggests a recent decrease. *S. hirundo* has increased only slightly during the study period.

After a decline in the 1940s, *Alca torda* regained the population level of 1939 (about 20 pairs) in the 1970s. The increasing trend has continued since then: in 1985 about 40 pairs were recorded. *Cepphus grylle* has shown an alarming decrease from 33 pairs in 1939 to only one pair in 1985.

A clear increase in the numbers of *Sterna paradisaea* prevailed on the Finnish coasts until the beginning of the 1970s. Since then the populations have continued to increase (Lemmetyinen 1980), decreased (Hario et al. 1986, Hongell 1986, our data), or fluctuated (Hildén 1986). The irregular movements and changes of breeding places typical of *S. paradisaea* probably explain these trends (see Hario et al. 1986:84). The slight increase of *S. hirundo* on the Krunnit Islands — and in the nearby Kemi-Tornio archipelago — differs somewhat from the declining or stable trends generally found along the Finnish coast (e.g. Hildén et al. 1978). The factors regulating tern populations are not known. Predation by *Arenaria interpres* may cause considerable losses of eggs (Bergman 1946, Brearey & Hildén 1985), but according to G. Bergman (pers. comm.), predation by the mink *Mustela vison* may nowadays be more important in general (this predator does not occur on the Krunnit, however).

The first colony of *Sterna caspia* on the Krunnit Islands appeared in the late 1940s and the population increased strongly in 1954 (for details of the immigration history, see Väisänen 1973); another colony was established in a similar way on Valassaaret in 1969–70 (Hildén et al. 1978). In recent times the Finnish population seems to have diminished by one third, for unknown reasons (Kilpi et al. 1986, Hario et al. 1987), although the populations of Valassaaret (stable until 1985, when the mink disturbed the colo-

ny; Hildén 1986) and Kokkola (increasing colony; Hongell 1986) deviate from this trend. The start of regular breeding by *S. albifrons* in the Bothnian Bay (Helle & Mikkola 1969, Helle & Merilä 1976) gave rise to a small population on the Krunnit Islands in 1973–83, but the species was not found in 1985.

Cepphus grylle has almost disappeared from the northern Gulf of Bothnia. The large potential recruit population of Valassaaret suffered losses of about 30% due to an oil spill in 1984. The decrease of *C. grylle* has not been studied in detail.

Future research in the sanctuary

The observations in previous papers (Väisänen 1973, 1974, Väisänen & Järvinen 1977a, b) and the present study suggest two promising aspects of the population ecology of archipelago birds to be studied in the Krunnit sanctuary.

The first is connected with conservation ecology and the purposes for which the sanctuary was originally founded, namely the population changes and the ecology of species listed as vulnerable in Finland, for example *Aythya marila, Melanitta fusca, Charadrius hiaticula, Calidris temminckii, Sterna caspia* and *Cepphus grylle*.

The second comprises the feeding ecology of large gulls and the effects of competition from and predation by these birds. The gull and tern fauna of the Krunnit Islands is one of the most diversified in the Finnish archipelagoes, including all the species breeding regularly in the country (excluding *Chlidonias niger*). The Krunnit sanctuary is now at an interesting stage of development: one large predator, *Larus argentatus*, is increasing and the number of *L. marinus* will probably start to grow exponentially, as on Söderskär in the 1980s (Hario et al. 1986: Fig. 1). How will these two species affect other larids and the avifauna in general on the Krunnit Islands? In addition, continuous increase in the population of *L. ridibundus* will apparently intensify the competition for food among tern and gull species of medium or smaller size.

A threat is posed by newly distributed species of medium-sized mammalian predators. Invasions by the mink, the raccoon dog *Nyctereutes procyonoides* or the Arctic fox *Alopex lagopus* (runaways from fur farms) may easily mask future ("natural") population trends in the birds of the Krunnit Islands. Three Arctic foxes immigrated in 1981. One of them lived on the islands Kraasukka and Hietakraasukka (cf. Appendix), and in the beginning of July no other ground-nesting birds remained but one pair of *Oenanthe oenanthe*. Although the Arctic fox was caught then, its visit had long-lasting effects: it took six years for the numbers of *Mergus serrator* breeding in juniper bushes of Hietakraasukka to return to their normal level (U. Järvinen, unpubl.). In 1987, three Arctic foxes immigrated again and one of them caused great disturbance on the islands Isonkivenletto and Tyni in early summer by repelling the colonies of *L. ridibundus* and *Sterna caspia* and by eating most of the eggs of other birds (E. Reinilä, pers. comm.).

Acknowledgements. We owe sincere thanks to Unto Järvinen for unpublished observations, to Erkki Reinilä, the guard of the sanctuary, for kind hospitality and help in the field, to Göran Bergman, Martti Hario, Antero Järvinen, Olli Järvinen and an anonymous referee for comments on the manuscript, and to Anna Damström for checking the language.

Selostus: **Iin Krunnien merilinnuston kannanmuutokset 1939–85**

Maakrunnisäätiö rauhoitti Iin Krunnien saariston (kuva 1) v. 1936 erityisesti merihanhikannan säilyttämiseksi. Krunnien ennen runsas merilinnusto oli tuolloin hävitetty vähiin. Saariston tehokas vartiointi alkoi 1940-luvun lopulla Veikko Salkion ja 1950-luvulla Erkki Reinilän toimesta, ja linnusto toipui nopeasti. Esittelemme tässä lintukantojen muutosten pääpiirteet 1939–85 24 kesänä suoritettujen laskentojen perusteella. Vesilintujen, lokkien ja tiirojen kannanarviot perustuvat pääosin pesälöytöihin, kahlaajien ja ruokkilintujen pariarviot emolintujen määriin. Krunnien 22 saaren lajikohtaiset pesivät parimäärät vuosilta 1939, 1949, 1959 ja 1970 esittävät Väisänen & Järvinen (1977b); v. 1985 parimäärät ovat liitteenä.

Linnusto esitellään lyhyesti käyttäen Perämeren maankohoamisrannikon saarityyppejä: A = luoto, B = luotoletto, C = letto ja D = metsäsaari (tarkemmin Väisänen & Järvinen 1977a). Kuvassa 2 lajit on asetettu ylhäältä alas "mereisyysjärjestykseen" sen perusteella, miten ne valitsevat eri tyyppisiä saaria pesimäpaikoikseen.

Vuonna 1939 pesiviä merilintulajeja (mukaan on luettu vesilinnut, kahlaajat, ruokki- ja lokkilinnut) oli 28; uusina vakituisina pesimälajeina Krunneille asettuivat 1940-luvulta lehtokurppa, liro ja harmaalokki ja 1950-luvulla merilokki, haapana ja naurulokki. Yhtään vakituista lajia ei ole kadonnut vuoteen 1985 mennessä, mutta kaksi lajia on vakavasti uhattuina. Krunnien vuosisadan alussa vähintään toistasatainen riskiläkanta on vähentynyt yhteen pariin 1985. Lapasotkia oli noin 30 paria 1940-luvun lopulla, mutta vain seitsemän paria 1985. Vuoden 1985 lajistosta voidaan satunnaisiksi pesijöiksi lukea töyhtöhyyppä, suosirri ja pikkulokki; 1970-luvun tavanomaisista lajeista jäivät havaitsematta liro ja pikkutiira.

Kokonaiskanta pysyi noin 650 parin tasolla 1930-luvulta 1950-luvulle, mutta kasvoi sitten noin 2000 pariin, mikä pääosin

johtui lokkien ja tiirojen runsastumisesta (kuva 3). Kullakin valkosiipislajilla oli oma voimakkaan kasvun kautensa. Selkälokki, räyskä ja lapintiira runsastuivat 1950-luvulla, kalalokki 1960-luvun alussa, harmaalokki 1960-luvun lopulta lähtien ja naurulokki 1970-luvulla siten, että se on nyt Krunnien selvästi runsain merilintulaji (kuva 5 ja liite).

Vesilintulajeista on lapasotka vähentynyt ja haapana runsastunut (taulukko 1); lisäksi vuoden 1985 tukkasotka- ja pilkkasiipimäärät olivat suuremmat kuin aikaisemmin. Laskentamenetelmällisesti luotettavimmat vertailut voitiin tehdä jakson 1970–77 ja vuoden 1985 välillä: kahdeksan vesilintulajia 12:sta runsastui tällöin. Muiden kannat pysyivät suunnilleen ennallaan, paitsi vuosien 1977–78 tilapäistulokas haahka (1–2 paria) puuttui 1985.

Kahlaajista vähenivät tutkimusvuosien 1939 ja 1948–49 huippukannoistaan tylli, lapinsirri, isokuovi ja vesipääsky (kuva 4). Karikukko ja rantasipi ovat jatkuvasti runsastuneet ja meriharakka sekä punajalkaviklo saavuttivat suurimmat parimääränsä 1985. Ruokkilinnuista väheni riskilä, mutta ruokkikanta on tuntuvasti kasvanut.

Krunneilla on jatkossa erityistä merkitystä lintukantojen yleisessä seurannassa, koska alueen saaribiotoopit ovat monipuolisia ja monien taantuvienkin lajien kannat vielä runsaita. Jotta paremmin ymmärtäisimme kannanvaihtelujen taustalla olevia tekijöitä, kaivataan erityisesti tietoa lokkilintujen ruokailuekologiasta. Krunnien poikkeuksellisen monipuolinen lokki- ja tiiralajisto on nyt kiintoisassa kehitysvaiheessa: harmaalokki runsastuu ja merilokin kanta alkaa mahdollisesti kasvaa nopeasti. Nämä kaksi suurta petoa aiheuttanevat lähivuosina huomattavia muutoksia muiden lokkilintujen kannoissa ja koko saaristolinnustossa. Krunnien vankka naurulokkikanta vaikuttanee tähän osaltaan kiihdyttämällä pienten ja keskikokoisten valkosiipislajien ravintokilpailua.

Minkeistä ja supikoirista ei Krunneilta vielä ole havaintoja, mutta sekä talvella 1981 että 1987 saapui sinne kolme turkistarhoista karannutta naalia. Parhaille lintusaarille oleilemaan jääneet yksilöt aiheuttivat tavatonta tuhoa pesimäaikaan.

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Received 7 September 1987, accepted 23 November 1987

Appendix. Numbers of breeding pairs of archipelago bird species on the Krunnit Islands in 1985. The islands are numbered as in Väisänen & Järvinen (1977a, p. 50): 1 = Pohjankarit, 2 = Maakrunni, 3 = Länsiletto, 4 = Tiirakari, 5 = Majankari, 6 = Ristikari, 7 = Ristikarinletto, 8 = Pohjanletto, 9 = Pohjanleton karvot, 11 = Ulkokrunni, 13 = Vatunginnokka, 14 = Vatunginletto, 15 = Isonkivenletto, 16 = Tyni, 17 = Raiska, 18 = Törö, 20 = Kraasukka, 21 = Hietakraasukka, 22 = Tasasenletto and 23 = Pesäkari (a recently elevated boulder skerry 200 m west of Maakrunni, not presented in previous reports; area 0.1 ha). The data for islands nos. 10 (Luusiletto) and 12 (Pihlajakari) were combined with those for Ulkokrunni. No birds on island no. 19 (Pookikraasukka).

	1	2	3	4	5	6	7	8	9	11	13	14	15	16	17	18	20	21	22	23	Totals
Anser anser	–	5	–	–	–	–	–	1	–	8	–	–	2	1	2	1	–	1	–	–	21
Anas penelope	–	11	–	–	–	4	–	–	–	21	–	–	–	–	–	–	–	–	1	–	37
A. crecca	–	10	–	–	–	1	–	–	–	11	–	–	1	–	–	–	1	–	–	–	24
A. platyrhynchos	–	9	–	–	–	1	–	–	–	4	–	–	1	1	–	–	–	1	–	–	17
A. acuta	–	3	–	–	–	–	–	–	–	5	–	–	2	–	1	–	–	–	1	–	12
A. clypeata	–	1	–	–	–	–	–	–	–	5	–	–	2	–	–	–	–	–	–	–	8
Aythya fuligula	–	20	–	–	–	2	2	–	–	23	3	3	19	5	1	4	–	3	9	1	95
A. marila	–	–	–	–	–	–	–	–	–	4	–	–	2	–	–	1	–	–	–	–	7
Melanitta fusca	–	9	–	–	–	1	–	2	–	6	–	–	7	3	1	4	–	2	3	–	38
Mergus serrator	–	10	–	–	–	8	–	5	–	17	–	–	5	4	1	1	2	4	3	–	60
M. merganser	–	5	–	–	–	8	–	–	–	12	–	–	–	–	–	–	–	–	2	–	27
Haematopus ostralegus	–	9	1	–	–	2	–	–	–	5	–	–	3	2	–	–	–	1	1	–	24
Charadrius hiaticula	–	6	–	–	–	1	–	–	–	18	2	–	3	2	–	–	–	3	1	–	36
Vanellus vanellus	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Calidris temminckii	–	–	–	–	–	–	–	–	–	7	–	–	1	1	–	–	–	1	–	–	10
C. alpina	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
Philomachus pugnax	–	2	–	–	–	–	–	–	–	13	–	–	3	–	–	–	–	–	–	–	18
Gallinago gallinago	–	6	–	–	–	2	–	–	–	6	–	–	–	–	–	–	–	–	–	–	14
Scolopax rusticola	–	2	–	–	–	1	–	–	–	3	–	–	–	–	–	–	–	–	–	–	6
Numenius arquata	–	2	–	–	–	–	–	–	–	3	–	–	1	–	–	–	–	–	–	–	6
Tringa totanus	–	12	–	–	–	2	1	–	–	27	–	–	4	1	1	1	–	1	1	–	51
Actitis hypoleucos	–	13	–	–	–	5	–	–	–	27	–	–	–	1	–	–	1	1	–	–	48
Arenaria interpres	1	7	1	1	1	2	1	1	1	14	1	2	4	5	1	1	–	3	3	–	50
Phalaropus lobatus	–	–	–	–	–	–	–	–	–	7	–	–	2	–	–	–	–	–	–	–	9
Stercorarius parasiticus	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
Larus minutus	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
L. ridibundus	–	–	–	–	–	–	93	–	–	12	–	17	283	–	62	–	–	–	68	30	565
L. canus	1	4	–	–	1	–	–	–	1	22	–	3	128	13	1	1	–	34	15	3	227
L. fuscus	–	–	–	–	–	–	–	24	–	–	–	1	–	24	36	36	–	17	10	–	148
L. argentatus	–	–	–	–	–	–	–	22	2	–	–	1	–	44	20	37	–	33	34	–	193
L. marinus	1	–	–	–	–	–	–	–	1	–	–	1	2	4	1	–	–	1	–	–	11
Sterna caspia	–	–	–	–	–	–	–	–	–	–	–	–	–	19	–	70	–	–	1	–	90
S. hirundo	–	–	–	1	1	–	6	–	–	8	–	3	14	5	7	–	–	6	14	6	71
S. paradisaea	3	3	1	1	2	–	5	25	12	11	16	33	9	6	5	–	–	20	35	6	193
Alca torda	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8	32	–	–	–	–	40
Cepphus grylle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1