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Reduced availability of refuse and breeding output in a herring gull (*Larus argentatus*) colony

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We studied the reproductive performance of herring gulls (*Larus argentatus*) in an old stable colony in SW Finland. Over the period 1993–1997, the colony decreased, and the garbage dumps the birds may have utilised have all closed. This had an effect on the breeding performance of the colony when comparing the year prior to the closing of the last garbage dump available (1996), and the following season (1997). It is clear that the last-laid egg size decreased significantly between years, more eggs were lost due to predation, and fewer of the hatched young fledged. The quality (in terms of body weight) of hatching chicks (both first and last) was not reduced, but first chicks grew slower in 1997. These changes are in agreement with predictions from other studies, and are likely effects of diminishing food resources. However, overall production was still good, and the birds seem capable of successful breeding without the presence of nearby garbage dumps.

1. Introduction

The herring gull (*Larus argentatus*) has benefited greatly from a steady supply of man-made refuse both on land and at sea over large areas of its range (Lloyd *et al*. 1991). In the Baltic Sea, populations increased in particular from the 1950s to the early 1980s (Kilpi 1988), probably aided both in summer (Bergman 1982) and in winter (Kihlman & Larsson 1974) by a stable food supply on refuse dumps along the coast.

Herring gulls breeding in the Finnish archipelagoes have commonly been thought as more or less dependent on refuse dumps throughout the breeding period (Bergman 1982) over several decades of continuous population growth. This dependence is essentially based on common knowledge more than on facts as several recent studies (Hario & Selin 1989, Hillström *et al.* 1994, Kilpi & Byholm 1995a) have questioned it.

In recent years, there has been an improvement in refuse handling (Rainio 1997) so that the number of small dumps has been greatly reduced, and refuse at larger dumps has been made less available by improved handling of refuse and localising larger dumps further from the coastal archipelagoes.

If the gulls were dependent on foraging on refuse dumps, these changes in the environment would affect the herring gull populations off the southern coast of Finland. If the above is true, a decrease in the overall reproductive success and

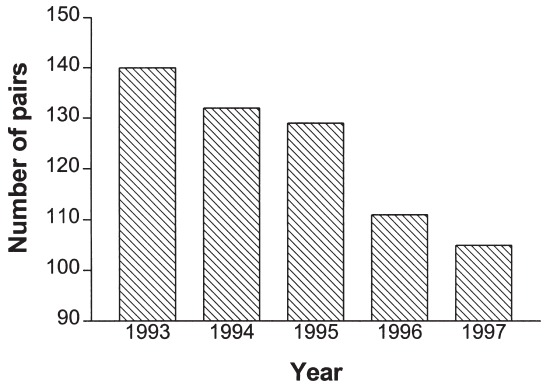

Fig. 1. The number of breeding pairs on Storsundsharun in 1993–1997 according to nest-counts each year. There is a decreasing trend (r_s = 1.0, n = 5, p = 0.05).

the size of a breeding population should occur, either as a direct response to lower fledging production, or due to emigration from old colonies. This paper is the first attempt to look at the effect of the changed refuse handling practices on herring gull breeding success in a well-studied herring gull colony on the southern coast of Finland (Hillström *et al.* 1994, Kilpi & Byholm 1995ab, Kilpi *et al*. 1996).

2. Material and methods

This study was performed in 1996–1997 off the Hanko peninsula (60°N, 23°E), southern Finland. The primary colony studied was located at Storsundsharun off Tvärminne. It has been described elsewhere (Kilpi *et al.* 1996). A long-term study of this colony, and another colony in the area (Tryskärsgund) has been running since the early 1980s (*see* Kilpi 1995). This background data is used here as reference (*see* Kilpi 1995, Kilpi *et al.*1996).

In 1996 and 1997, numbered and marked nest sites were checked at least once daily during egg-laying. Eggs were marked as they were laid, and measured with Vernier callipers (to the nearest 0.1 mm), and egg volume was calculated according to Harris (1965) as:

$$\text{length} \times \text{breadth}^2 \times 0.000476. \quad (1)$$

Chicks were marked with indelible marker ink on their down, and subsequently ringed to allow identification of individual chicks in the hatching sequence (A–B–C). The hatching span was monitored on a daily basis.

Upon hatching, chicks were weighed to the nearest 1 g. They were weighed a second time as the C-chick hatched. This gave a measure of size asymmetry for the chicks in a 3-chick brood, and indicated growth of the A-chicks during their first day(s) of life.

The survival of chicks was monitored as closely as possible, and the total number of chicks fledging from the entire colony was monitored by counts during successive days around the date when the median chick in the colony had reached an age of 60 days (Kilpi 1990).

Courtship-feeding pairs, and chick feeding pairs were observed in order to establish the frequency of garbage use among birds during breeding in 1993 and 1994 (Hillström *et al.* 1994, Kilpi & Byholm 1995).

In 1996, the nearest dump (Hanko, 14 km) was already transformed into a covered station for refuse container reloading. At this site no gulls fed. The only available dumps were in Ekenäs (22 km) and Karis (38 km). These dumps were closed in early August 1996. In 1997, no dump closer than 60 km from the colony was available. Foraging on dumps at distances in excess of 50 km is unlikely (Kilpi 1988).

3. Results

The study colony at Storsundsharun has decreased in size over the study period (Fig. 1). Of the 140 pairs breeding in 1993, 111 and 105 remained in 1996 and 1997, respectively.

There was a significant increase in the proportion of full clutches with 2 eggs from 1996 to 1997 (χ^2 = 9.15, df = 1, p = 0.002; Table 1). Herring gulls have a weak tendency for laying smaller clutches if the season is late (Kilpi 1990), and in 1996 spring was delayed as compared with 1997.

The laying span between the A- and C-eggs was similar in both years, as was the volume of A-eggs. C-egg volume was, however, significantly smaller in 1997 (Table 2), but the relative size of a C-egg as compared with an A-egg was not significantly smaller. C-eggs were, on the average 5.8% and 7.7% smaller than A-eggs in 1996 and 1997, respectively.

The hatching span was on the average similar in both years (Table 2), but C-chicks weighed significantly more at hatching in 1997. A-chicks had similar weights in 1996 and 1997. The relative

Table 1. Frequency of c3 and c2 on Storsundsharun in 1996 and 1997. These figures refer to clutches which most likely are full-laid clutches. In 1997, there were three one-egg clutches in addition to these.

Year	3-egg clutches	2-egg clutches
1996 (n = 111)	97 (87.4%)	14 (12.6%)
1997 (n = 102)	72 (70.5%)	30 (30.0%)

weight of the C-chick in comparison with the A-chick was significantly higher in 1997 (Table 2), and the weight of the A-chick at that time was significantly lower in 1997, indicating low early growth rates.

The survival of eggs until hatching was lower in 1997 ($\chi^2 = 4.0$, df = 1, $p = 0.04$), in terms of the proportion of nests with full or partial losses recorded. Of 67 monitored nests in 1997, 35.8% lost eggs due to predation, while in 1996, the loss in 97 monitored nests was 21.7%. Of those eggs that did survive, and the fate of which we were able to follow (for these nests we know only the final clutch size, not necessarily the initial clutch size), the proportion of hatched versus unhatched eggs were similar in both years ($\chi^2 = 0.0$, df =1, $p = 0.95$; Table 3).

Overall fledging success at the colony varied over all the years studied, but was remarkably low in 1997 (Fig. 2). In 1996, 261 chicks hatched, of which 162 fledged (62.0%). In 1997, 224 chicks in all hatched, of which 112 (50.0%) fledged. This difference is highly significant (χ^2 =7.1, df =1, $p = 0.007$); chick mortality was higher in 1997.

4. Discussion

The decline in numbers in the study colony is the first documented report on a decline in an old, stable colony within the area of former population growth on the coast of Finland (Kilpi 1987, 1988). Also other colonies in the Hanko area show the same trend (M. Kilpi unpubl.). This decline cannot stem from poor reproduction over a number of years, since the colonies studied in this area had high reproductive output during the years prior to this study (Kilpi 1989, 1995, Kilpi *et al.* 1996). Since herring gulls start breeding at the age of 4–5 years (Coulson *et al.* 1982), it is unlikely that the decline was caused by an insufficient production of new recruits during previous years. It seems more likely that it was due to either an increased adult mortality, or emigration. We cannot assess this, but emigration as a response to a decrease in availability of refuse is possible.

The evidence for use of a particular dump in these breeding birds is more or less indirect, since the adults were not marked. We know that a number of adult birds (maximum 200) occurred at the Ekenäs dump during the prebreeding phase when younger non-breeders had not arrived yet, and we know that marked fledged young from a few territories were found on the dump in the company of their parents that were in the late breeding stage (maximum flock size of 800 birds of all ages). Thus, at least some of the birds used the dump. We also know that a fraction of the breeders utilised garbage as food while feeding, both during courtship, and when feeding young (Hillström *et al.* 1994, Kilpi & Byholm 1995a). This fraction comprised about 15–20% of the pairs under observation.

The study year 1996 was characterised by a late onset of breeding, and by poor weather during breeding. On a qualitative basis, this year should be less successful than an average year in

Table 2. Laying-, egg-, hatching- and chick parameters in full clutches of three eggs in 1996 and 1997.

Parameter	1996		1997		*P*-value (*t*-tests)
	Value ± SD	*n*	Value ± SD	*n*	
Laydate[a)] (1 = 1 April)	31 ± 3.5	103	28 ± 6.0	102	< 0.001
A to C-egg laying interval (days)	3.7 ± 0.9	53	4.2 ± 0.7	45	= 0.19
A-egg volume (cm^3)	86.0 ± 6.5	67	84.7 ± 6.2	50	= 0.29
C-egg volume (cm^3)	81.0 ± 6.4	67	78.7 ± 5.2	44	= 0.05
C-egg volume as % of A	94.3 ± 5.5	67	92.9 ± 6.4	44	= 0.24
A to C-chick interval (days)	1.6 ± 1.1	58	1.7 ± 0.7	30	= 0.75
C-chick hatching weight (g)	59.6 ± 6.3	66	63.3 ± 7.5	32	= 0.01
A-chick hatching weight (g)	75.1 ± 8.4	10	74.6 ± 8.9	14	= 0.88
Relative C-chick weight[b)] (%)	66.9 ± 14.6	66	78.6 ± 13.5	29	= 0.0004
A-chick weight at C-chick hatching day (g)	93.2 ± 26.9	67	81.5 ± 12.8	29	= 0.005

[a)] The laydate for all clutches, not only c3.

[b)] The C-chick weight as a percentage of A-chick weight at the time of C-chick hatching.

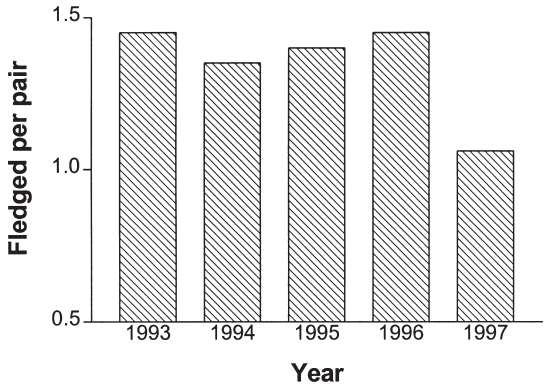

Fig. 2. The number of fledged chicks per nesting pairs at Storsundsharun in 1993–1997.

this colony (Kilpi 1990, 1995, Kilpi *et al.* 1996). There was no reason to expect 1997 to be a particularly poor year due to weather, since 1997 was an unusually warm and calm summer. We therefore assume, that the differences in breeding parameters we found, were due to changes in the food regime.

In large gulls in general, third-egg size is probably directly linked to pre-breeding food supply (Pierotti & Bellrose 1986, Salzer & Larkin 1990, Kilpi 1995, Kilpi *et al.* 1996). Therefore, we should expect a decline in both relative and absolute size of C-eggs. The size asymmetry measured in 1997 was the largest measured in this colony so far (Kilpi *et al.* 1996). The size-reduction of the A-egg is also in line with the prediction (Coulson *et al.* 1982, Kilpi 1985). A slight increase in laying interval length is perhaps indicative of pre-laying foraging difficulties (Saltzer & Larkin 1990), but in large gulls this issue is not well documented.

Table 3. The fate of eggs laid in c3 and c2 clutches up to hatching. Only nests with exactly known final clutch-size included, but some were subject to predation during incubation.

Egg fate	1996	1997
Laid	317	189
Hatched	261 (82.3%)	156 (82.5%)
Addled	21 (6.6%)	11 (5.8%)
Died at hatch	10 (3.1%)	4 (2.1%)
Lost	25 (7.9%)	18 (9.5%)

The increase in the proportion of clutches with only two eggs is a further indication of a decreased food supply (Hario 1990), and it is typical for declining colonies in spite of the fact that such colonies have few young breeders laying smaller clutches. In the Hanko area Kilpi (1990) previously documented two-egg clutch proportions of about 11%.

In both years, a fairly large proportion of all nests was subject to egg predation. In previous years, predation was seldom observed (Kilpi 1990, Kilpi & Byholm 1995b). The increase in predation rate from 1996 to 1997 also indicates a reduction in food supply, since increased predation rates point to long absence times from territories by foraging birds (Bukacińska *et al.* 1996).

The hatching success of eggs which did survive over the incubation period was as high as previously observed in the area (Kilpi 1990, 1995, Kilpi *et al.* 1996). Nothing in the present data directly indicates that factors related to egg quality affecting hatching would be exceptional for the eggs that survived the incubation period in 1996–1997. The proportions of eggs in clutches which were addled, lost or in which the chick died at hatching appeared normal as compared with the background data from the area (Kilpi 1990).

The weight of the hatching C-chick was not reduced from 1996 to 1997. In the previous study (Kilpi *et al.* 1996), we found that in 1993 the C-chicks hatching from eggs with an average volume of 83.2 cm^3 weighed on the average 66.2 g, so in both years studied here, there was a reduction compared with the weight of the C-chicks in 1993. In that year, C-eggs on average were 4.5% smaller than A-eggs by volume. This suggests that the egg-quality of surviving eggs was only slightly affecting chick quality at hatching, but the increase in hatching weight from 1996 to 1997 is difficult to explain. There was no difference in A-chick weight at hatching between the two years.

However, in 1997 the A-chicks weighed less at the time the C-chick hatched, although the hatching interval was similar. This again indicates a poorer feeding situation in 1997, since early growth of A-chicks was lower (*see* Parsons 1975).

However, from our previous studies we know that garbage is not used extensively when chicks are small, but instead the proportion of garbage in the diet increases as chicks grow older (Hillström

et al. 1994). We suggest that the effect might be more pronounced when chicks are large, when the birds probably have greater difficulties finding food. Annett and Pierotti (1989) found that western gulls (*L. occidentalis*) fed larger chicks with a higher proportion of garbage. Our results show that overall chick mortality was higher in 1997 than in 1996. We do not know when this mortality took place. Qualitative observations suggest, that larger chicks were encountered dead in the colony at a higher rate than usual — mortality usually takes place during the first 10 days of a chick's life in this colony (Kilpi *et al.* 1996). In 1997, we did not attempt to monitor chick mortality on a detailed basis, since our visits in the colony caused an unusually high incidence of aggressive encounters between birds, which may induce extra mortality among chicks. In 1996, the colony was monitored on a daily basis from blinds, and we know that most mortality took place early in life (M. Kilpi unpubl.).

There are few studies on larger gulls which describe the effect of refuse availability on the breeding of herring gulls. Sibly and McCleery (1983) found that herring gulls in a colony on the British Isles could not manage to breed without refuse availability. Pons (1992) studied changes in a colony in France, affected by a change in refuse handling at a major dump. He found that: (1) pair numbers immediately dropped by 11%, (2) the proportion of two-egg clutches increased to 28% from an average of 10%, (3) volumes of A-eggs and C-eggs were reduced, (4) hatching success dropped from 75% to 63%, and (5) fledging success dropped from an average 1.3/pair to 0.5/pair. In this colony, intraclutch egg-size asymmetry was initially larger than at our colony (11–12%) which is associated with low production (Kilpi *et al.* 1996). Belant *et al.* (1993) found that refuse dumps were of secondary importance for herring gulls breeding on Lake Erie.

Bukacińska *et al.* (1996) showed that herring gulls in the Netherlands which were subject to dwindling resources, were forced to spend much time feeding, and hence both eggs and chicks were more frequently preyed upon; a drop in overall breeding success followed.

We suggest that the closing of all dumps available to our gulls has had an effect on the colony. Firstly, there has been a reduction in the number of breeding birds, roughly corresponding to the number of pairs utilizing garbage to a large extent in previous years (15–20%, Hillström *et al.* 1994, Kilpi & Byholm 1995a). For the remaining pairs, we suggest that closing the dumps slightly affected all phases of breeding. The evidence suggests that the birds had to use more time off the territory which resulted in slightly smaller clutches, with slightly smaller eggs under circumstances of an elevated risk of egg predation. However, eggs surviving still had a high hatchability, and no drastic reduction in chick quality at hatching was evident. On the other hand, the fledging success of hatched chicks was further reduced.

The reduction in breeding success is, however, not yet remarkably low. Declining populations of herring gulls and related species of roughly the same size have typically an overall fledging success of about 0.5 fledged young/pair or less (Spaans *et al.* 1987, Bukacińska *et al.* 1996, Hario 1990, Kilpi *et al.* 1996). In the light of these results, it seems that herring gulls in the Gulf of Finland would be able to persist on natural foods at least throughout the breeding phase in the colonies. Thus it appears that garbage is not the key factor regulating reproductive performance, though refuse may become important for survival outside the breeding season.

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