The effect of egg harvesting on the growth of chicks and breeding success of the Shag *Phalacrocorax aristotelis* and the Kittiwake *Rissa tridactyla* on Bleiksøy, North Norway

Robert T. Barrett

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Eggs of Shags *Phalacrocorax aristotelis* and Kittiwakes *Rissa tridactyla* are harvested annually for human consumption on Bleiksøy, North Norway until 1 June. The continual experimental removal of 19 Shag and 30 Kittiwake clutches until the same date in 1986 had little effect on the growth of chicks and the breeding success of the pairs involved. The size of the Kittiwake replacement clutches was smaller than the first clutches, and the Shag replacement eggs were smaller than the first eggs. There was no difference in the hatching success (no. eggs hatched/clutch laid) of the control and replacement clutches of either species. The growth rates of chicks hatched from control and replacement clutches were similar for both species, as was the overall fledging success of both categories of Kittiwake chick. Egg harvesting did not seem to have any short-term effect on either species, probably because it was limited to the first half of the laying season.

R. T. Barrett, Norwegian Institute for Nature Research, University of Tromsø, Tromsø Museum, N-9000 Tromsø, Norway.

Introduction

The harvesting of seabird eggs has a long tradition in North Norway. Eggs were an important and welcome supplement to the local diet after a hard and long winter. The sale or trading of eggs was also a significant source of income for the small coastal communities during the 18th and 19th centuries (Soot-Ryen 1941, Munck 1975, Wold 1981, Bratrein 1982). All the commonest species were harvested, including the Shag *Phalacrocorax aristotelis*, Puffin *Fratercula arctica*, Common Guillemot *Uria aalge*, Brunnich's Guillemot *U. lomvia* (on Bear Island), Kittiwake *Rissa tridactyla*, Herring Gull *Larus argentatus*, Great Black-backed Gull *L. marinus* and Eider *Somateria mollissima*. Seabird eggs are still popular today and although recent conservation laws have effectively restricted the commercial market to gulls' eggs (Herring Gull and Great Black-backed Gull), Kittiwake and Shag eggs are still harvested at a few colonies for local consumption. Although there have never been recorded negative effects of egg harvesting on any of the populations in Norway, no direct studies have been made on the short-term effect it may have on their breeding success. In 1986, the opportunity arose to study such an effect on the Shags and Kittiwakes on Bleiksøy (69°17′N, 15°53′E) where their eggs, plus those of Herring and Great Black-backed Gulls are traditionally harvested every year (Wold 1981).

Material and methods

About 200 pairs of Shags and 4100 pairs of Kittiwakes bred on Bleiksøy in 1986 (pers. obs.). Weather permitting, the contents of 43 marked Shag nests and 82 marked Kittiwake nests were recorded almost every other day after 15 May as were the laying date, number and size (length l and breadth b measured using vernier calipers to the nearest 0.1 cm) of all eggs laid. The internal volume (V in ml) of the eggs was determined using the equations V (Shag) = $0.51 \times l \times b^2$ (Coulson et al. 1969) and V (Kittiwake) = $0.4861 \times l \times b^2$ (Runde & Barrett 1981). To imitate the local harvesting practices, all eggs laid in 19 Shag and 30 Kittiwake "experimental" nests were removed on or before 1 June, the date at which egg harvesting ceases on the island. Eggs were laid in all the experimental nests before 1 June, but the first clutches in

Table 1. Mean date of clutch initiation in control, experimental and replacement clutches, and interval (in days) between removal of last egg of experimental clutch and initiation of replacement clutch of Shags and Kittiwakes on Bleiksøy, 1986 (n = no. of clutches).

	Shag				Kittiwake			
	Mean	SD	n	Range	Mean	SD	n	Range
Date of 1st egg								
Control	24/5	4.9	19	17/5–2/6	25/5	4.9	52	16/5–11/6
Experimental	22/5	3.2	15	16/5–7/6	24/5	3.3	30	17/5–3/6
Replacement	6/6	5.6	15	27/5–19/6	6/6	3.0	28	1/6–14/6
Interval								
	8.9	7.8	15	1.5–34.0	10.7	1.7	28	7.5–13.5

one Shag and one Kittiwake nest were not completed until 7 and 3 June resp. (Table 1). These eggs were not removed from the nests. Eggs are normally harvested every three days, but in this experiment most were removed every two days and within a mean 1.7 d, range 0.5–5.5 d (for Shag) and 1.3 d, range 1–7 d (for Kittiwake). All data concerning any eggs of which the laying or hatching dates were known within 1.5 d are included in the analyses. In three of the Shag experimental nests (in which 6–8 eggs were laid), there was no apparent pause between the laying of replacement eggs and eggs of first clutches such that it was difficult to distinguish between the two egg categories. However, because the normal maximum Shag clutch size is 4 (Snow 1960, Barrett et al. 1986), it was assumed that all eggs from number 5 onwards were replacement eggs.

Chicks were weighed using Pesola spring balances and their wing and culmen length measured using a wing rule and vernier calipers every 3 days after hatching until near fledging.

Results

Shags and Kittiwakes showed similar patterns of laying of the first clutches in the experimental and control nests, and the mean dates of first clutch initiation were 22–25 May (Table 1). The initial clutch sizes were ca. 3 and 2 for the Shag and Kittiwake, respectively (Table 1). The mean dates on which both species initiated their replacement clutches were the same, 6 June (Table 1). 15 (83%) of the 18 clutches removed from the Shag nests and 28 (97%) of the 29 removed from the Kittiwake nests were replaced, the first replacement egg being laid on average 8.9 and 10.7 d respectively, after the removal of the last egg of the first clutch (Table 1). None of the clutches (4 Shag and 3 Kittiwake) lost before hatching in any of the control nests was replaced. These were lost 4–12 d (Shag) and 12–22 d (Kittiwake) after the clutches were initiated.

There were no differences between the clutch sizes (Mann-Whitney test, $P>0.05$) or egg volumes (t-test, $P>0.05$) of the control and the first clutches in the experimental nests. The numbers of eggs in the Kittiwake replacement clutches were significantly lower than in the first clutches (Table 2). The Shag replacement eggs were ca. 1.8 ml (4%) smaller than in their respective first clutches while there was no significant difference in the size of the two categories of Kittiwake eggs (Table 2). Nor were there any differences in the incubation period of eggs in the control and replacement clutches in either species (Table 2).

Although the Kittiwake replacement clutch size was smaller than that of the control clutches, there were no differences in the hatching success of the control and the replacement clutches of either species (Table 3). This is accounted for by the higher egg survival in the replacement clutches (42 of 44 (95%) replacement eggs hatched vs. 79 of 100 (79%) control eggs, $\chi^2=6.2$, $P<0.01$). The survival of Shag eggs was the same for the two clutch categories (17 of 32 (53%) replacement, 35 of 71 control (49%) eggs, $\chi^2=0.13$, $P>0.05$).

Although Kittiwake chicks hatched from replacement eggs were lighter than control chicks for all age groups (t-test, $P\leq0.01$) until they were 27 days old, the actual weight gains were similar for both groups

Table 2. Mean number of eggs, their volume (ml) and incubation period (d) in control, experimental and replacement clutches of the Shag and Kittiwake on Bleiksøy, 1986 (n = no. of clutches (clutch size) or eggs (vol. & inc. per.) [1,2]Mann-Whitney, P<0.05, [3]t=2.6, P<0.01

	Shag				Kittiwake			
	Mean	SD	n	Range	Mean	SD	n	Range
No. of eggs/clutch								
Control	3.0	0.6	24	1–4	1.9[1]	0.4	52	1-3
Experimental	3.1	0.9	18	1–4	2.0[2]	0.5	30	1-3
Replacement	2.4	1.0	15	1–4	1.6[1,2]	0.5	28	1-3
Egg volume								
Control	48.0	4.3	70	39.2–56.2	44.5	3.0	99	34.0–51.0
Experimental	48.3[3]	3.3	55	42.6–55.5	45.3	3.2	60	39.0–52.2
Replacement	46.5[3]	3.3	37	38.9–52.9	44.4	3.2	45	35.7–50.2
Incubation period								
Control	32.1	2.2	15	28.5–36.5	27.1	1.6	52	24.5–29.0
Replacements	31.0	1.3	12	28.5–33.5	26.6	0.9	34	24.4–28.5

Table 3. The hatching and fledging success of control and replacement clutches of the Shag and Kittiwake on Bleiksøy, 1986 (n = no. of clutches). [1]Mann-Whitney, P<0.05

	Shag	n	Kittiwake	n
No. eggs hatched/clutch				
Control	1.46	24	1.52	52
Replacement	1.13	15	1.50	28
No. chicks fledged/clutch hatched				
Control	No data		1.36[1]	44
Replacement	No data		1.00[1]	27
No. chicks fledged/clutch				
Control	No data		1.15	52
Replacement	No data		0.93	29

after day 5 (Fig. 1A). Shag replacement chicks tended to be heavier than control chicks during the period of maximum growth (Fig. 1), but weight differences were only significant at ages 14, 17, 20 and 26 days (t-test, P<0.05).

Although the fledging success of the Kittiwake replacement clutches which actually hatched from the replacement eggs was lower than that of the controls (Table 3), the success as calculated in relation to the number of experimental nests in which eggs were laid was similar to the controls. There was no difference

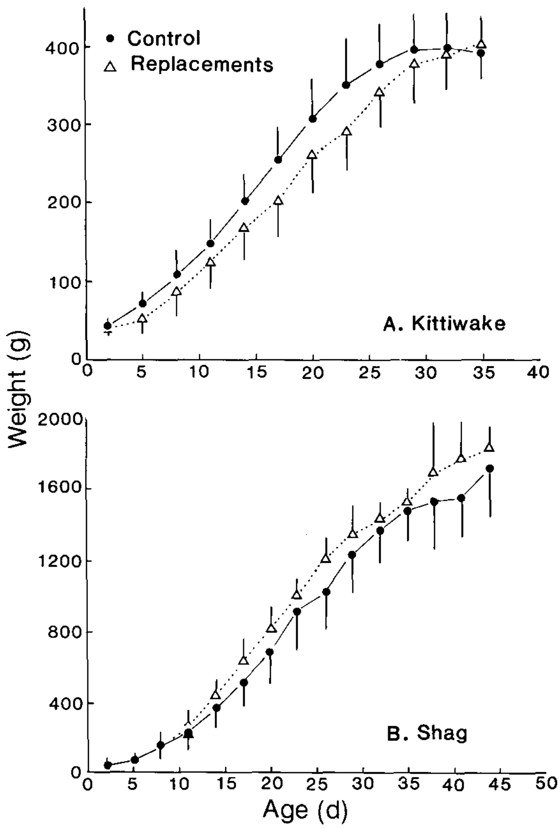

Fig 1. The growth of Kittiwake(A) and Shag(B) chicks hatched from control and replacement eggs on Bleiksøy, North Norway (vertical bars = 1 SD, N = 10–60).

between the survival of individual chicks in control nests (60 of 79, 76%) and that of chicks hatched in the experimental nests (27 of 42, 64%) (χ^2=1.85, P>0.05). Due to our excess disturbance of the Shag nests which resulted in the loss of several chicks, it was not possible to measure the fledging success of either group of nests in 1986.

Discussion

The 1986 breeding season

Although the laying season of Shags on Bleiksøy was 1–3 weeks later than on Hornøy (70°22'N, 31°10'E), East Finnmark in 1980–1981 (Barrett et al. 1986), it was well within the variation expected of the species. Similarly the clutch and egg sizes in the first clutches were within the range previously documented for the species in Britain (Snow 1960, Potts et al. 1980), France (Debout 1985), and at several colonies in North Norway (Barrett et al. 1986).

For the Kittiwakes, the progression and mean date of egg laying during this study was very similar to that recorded on Hekkingen and Runneskholmen, two small (and now extinct) colonies ca. 80 km northeast of Bleiksøy in 1974–1976, but ca. 1 week later than on Hornøy in 1980 (Barrett 1978, 1983). In 1981, a late breeding season for all species due to bad weather (Barrett 1983, 1984, Barrett et al. 1986), Kittiwakes on Hornøy laid at about the same time as they did in this study. The clutch sizes of first clutches were similar on all three colonies (1.8–2.1 eggs/clutch), with the exception of Hekkingen and Runneskholmen in 1975, a year of reduced breeding effort due to food shortages, when the mean clutch size was 1.6 (Barrett 1978).

The relatively early laying season on Hornøy was probably a result of a superabundance of food in the region (Furness & Barrett 1985), and the timing of the 1986 breeding season was in no way exceptional for either the Shags or the Kittiwakes on Bleiksøy (pers. obs. 1986–1988).

Replacement clutches

There is little published data concerning Shag clutch replacement rates although both Snow (1960) and Potts et al. (1980) document their existence. The replacement rate in this study (83%) was higher than that on Hornøy (50%, n=12, Barrett et al. 1986) and lost clutches were replaced faster on Bleiksøy (after 9 d) than on either Lundy (mean=17 d, Snow 1960) or Hornøy (mean=15 d, Barrett et al. 1986). This is undoubtedly due to all the eggs being removed from the nest during the laying period or very early in the incubation period, as the interval between egg loss and relaying is known to increase as the incubation progresses (Potts et al. 1980).

The rate of Kittiwake clutch replacement on Bleiksøy (97%) was much higher than has been recorded elsewhere. Only 6 (32%) of 19 lost on Gull Island, Newfoundland were replaced (Maunder & Threlfall 1972), 49 (36%) of 136 (incl. one clutch lost twice) on Hekkingen and Runneskholmen in 1974 and 1976 (only 6% in 1975 — see above; Barrett 1978), and 49 (60%) of 81 removed clutches at North Shields, England (Wooller 1980). This again is probably partly due to the fact that all eggs in this study were removed early in the breeding season, thereby increasing their chances of being replaced (Maunder & Threlfall 1972, Wooller 1980). Indicative of this is the fact that all the control clutches which were lost and not replaced (4 Shag and 3 Kittiwake) were lost >3 days (Shag) and >5 days (Kittiwake) after clutch completion. On Hekkingen, Kittiwake replacement eggs were rarely laid if the clutch was more than 5 days old, i.e. within the approximate laying period, when lost, and never if more than 10 days old (Barrett 1978). Although the size of the replacement clutches on Hekkingen and Runneskholmen tended to be lower (1.4 eggs/clutch) than that of this study (1.6 eggs/clutch), possibly as a result of the first clutches being lost later in the season, the difference was not significant (Mann-Whitney, P>0.05).

Furthermore, the experimental eggs were removed during the early stages of the laying season when the more experienced and hence more successful breeding birds tend to lay (Coulson & White 1961, Coulson & Thomas 1985) thereby increasing the chances of clutch replacement after loss. A lower replacement rate could be expected if eggs were removed later in the season when the less experienced and first time breeders start laying.

While Kittiwakes laid fewer eggs in their replacement clutches, Shags laid smaller eggs. Although the number and size of eggs in first clutches of both species decrease during the season, the differences are not normally marked for at least 2 weeks (Snow 1960, Potts et al. 1980, Runde & Barrett 1981, Coulson & Thomas 1985). Although the decreases found in this study may reflect this seasonal decline, it may also be the result of the initially high energy resource investment in the first clutch and the subsequent inability of the adults to build up sufficient reserves to relay a full clutch.

Breeding success and chick growth

The hatching success of Shag eggs was the same in the control and replacement clutches, 49–53%, clearly lower than Snow's (1960) figure of 69–73%. The growth rate of chicks was also unaffected by egg harvesting, and equalled that of chicks raised on Hornøy (Barrett 1983). Although no fledging success data were collected, the mean numbers of chicks counted in July 1987 and 1988 in nests from which the majority of eggs had been harvested were 1.2 and 0.7 respectively. This is lower than the ca. 2 chicks/nest recorded on Hornøy in 1983, and the 2–3 chicks/nest on Bleiksøy and neighbouring islands in 1980 and 1981 (Barrett et al. 1986, Rikardsen & Strann 1983).

The hatching success and egg survival of Kittiwake eggs varies from locality to locality and year to year but lies generally in the region of 1–1.5 eggs/clutch or 60–80% respectively (Maunder & Threlfall 1972, Johansen 1977, Barrett 1978, Poluszynski 1979, Thomas 1983). Never have I seen egg survival figures as high as 95% for first clutches, let alone replacement eggs as recorded in this study. On the contrary, in my study on Hekkingen, only 26% of 74 replacement eggs hatched (Barrett 1978). The survival of the control eggs was also high (79%) despite the regular disturbance of the nests. All nests were near the bottom of the main breeding cliff, and all predation of nests by gulls *Larus* spp., Sea Eagles *Haliaeetus albicilla* or Peregrine Falcons *Falco peregrinus* which was seen almost daily, occurred higher up the cliff face. Never was a nest in either the control or the experimental group seen being robbed during the incubation period, a situation which is unusual at most Kittiwake colonies, including Bleiksøy.

Although there was a slight difference in growth rates between the two groups of Kittiwake chicks, their growth curves were very similar to those of chicks raised on Hornøy in conditions of abundant food (Barrett 1983) and they both reached the same asymptote. In other words there was no evidence that the "replacement" chicks were at any disadvantage at fledging. The survival rates and fledging success of chicks were also independent of whether chicks had hatched from first clutches or relaid clutches.

Conclusion

The only direct, short-term effects egg harvesting in 1986 seemed to have on the Shags and Kittiwakes on Bleiksøy were a 9–11 day delay in breeding, and a significant reduction in the Kittiwake clutch size. There was however a higher survival of replacement eggs, and the overall breeding success was the same for both categories of nests. 1986 was a normal breeding season for both species in the region and it seems that under such conditions they were relatively tolerant to the present levels of exploitation.

This tolerance is almost certainly a reflection of the eggers' practice of limiting the harvest to the first half of the the laying season, a period when the highest quality birds tend to lay (Coulson & Thomas 1985). If egging continued into the period when the first-time breeders could be expected to enter the colony, then one might expect a decrease in the overall breeding success in the nests harvested. What is not known is how they would respond to an egg harvest during a season with a shortage of food. Such seasons are not uncommon in the region (Barrett 1978, Barrett et al. 1987, pers. obs.).

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Selostus: **Munien keruun vaikutus karimetson ja pikkukajavan poikasten kasvuun ja pesimämenestykseen Pohjois-Norjassa**

Karimetson ja pikkukajavan munia kerätään ihmisravinnoksi Pohjois-Norjassa kesäkuun ensimmäiseen päivään asti. Kun 19 karimetson ja 30 pikkukajavan pesästä poistettiin kaikki munat yksitellen kesäkuun alkuun mennessä, vaikutukset uusintapesyeiden poikasten kasvuun ja parien pesintämenestykseen olivat pieniä. Pikkukajavan uusintapesyeissä oli vähemmän munia kuin ensimmäisissä pesyeissä, mutta karimetson uusintapesyeiden munat olivat kooltaan ensimmäisen pesyeen munia pienempiä. Kummallakaan lajilla ei havaittu eroja kontrollien ja uusintapesyeiden kuoriutuvuudessa eikä poikasten kasvussa. Pikkukajavan poikasten selviytyminen lentokykyisiksi oli samanlaista kummassakin ryhmässä. Munien keruulla ei näyttänyt olevan mitään lyhytaikaista vaikutusta kumpaankaan lajiin. Syynä on mahdollisesti se, että munien keruu rajoittui munintakauden alkupuoliskoon.

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