

# SEABIRD 11



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# SEABIRD 11

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Cover vignette of Manx Shearwater by B. Zonfrillo

## Timing of breeding of Kittiwakes *Rissa tridactyla* and growth and diet of the chicks at Hantzsch Island, N.W.T., Canada.

A. J. Gaston

The timing of breeding of Kittiwakes *Rissa tridactyla* and the growth and diet of chicks have been described from several parts of the species' extensive holarctic range (USSR, Belopol'skii 1961; Norway, Barrett & Runde 1980; U.K., Coulson & White 1958, Galbraith 1983, Coulson & Porter 1985; Greenland, Salomonsen 1967; Newfoundland, Maunder & Threlfall 1972; Alaska, Schneider & Hunt 1984, Hunt *et al.* 1986). However, no information has hitherto been available for colonies in the eastern Canadian arctic, except for notes on timing of breeding at Prince Leopold Island (Nettleship 1977).

During 1982 I visited Hantzsch Island, a small islet off southeastern Baffin Island (Figure 1), which supports 50 000 pairs of Brunnich's Guillemots *Uria lomvia* and 5 000 pairs of Kittiwakes (A.J.Gaston and D.N.Nettleship unpublished). I estimated dates of laying, measured the growth of a sample of chicks and collected any regurgitations of food which occurred during handling of the birds. The data are presented here to provide baseline information on the Kittiwakes of the eastern Canadian arctic, and because they differ in some respects from information published previously.

### METHODS

Measurements were begun on 29 July, by which time most chicks had hatched. Six were weighed while still wet, but for the rest age was determined from wing-length, using a calibration curve constructed from successive measurements of a sample of 49 chicks (Figure 2), using the method of Ricklefs and White (1975). Chick ages were used to extrapolate hatching dates. Laying dates were then estimated assuming an incubation period of 27 days (Coulson & White 1958, Maunder & Threlfall 1972).

Chicks were weighed to the nearest 1 g using a Persola spring balance and wing-length was measured to the nearest 1 mm by flattening and straightening the feathers to give a maximum value. Measurements were carried out three times, initially on 29 or 30 July, and again on 5 and 10 August. The long intervals between successive weighings were chosen to minimise the effect of my disturbance on the growth of the chicks. Seven adults, caught at the nest on 30 July, were also weighed. Weights are given  $\pm 1$  standard deviation.

Regurgitations were preserved in 10% formalin. No attempt was made to encourage regurgitation. In addition to those collected, seven regurgitations were examined on the spot and the relative volumes of fish and crustacea were estimated. Those regurgitations preserved were sorted in the laboratory into major taxonomic groups (fish, crustacea, molluscs, annelids, plant material) and the volume of each component estimated. Individual organisms, or parts, were then separated, counted and identified to the lowest possible taxonomic level. Identifications of fish were made mainly on the basis of otoliths, by comparison with a reference collection maintained at Canadian Wildlife Service. All identifications of invertebrates were performed by the staff of the National Museum of Natural Sciences, Ottawa. Nomenclature of fishes follows Hunter *et al.* (1984).

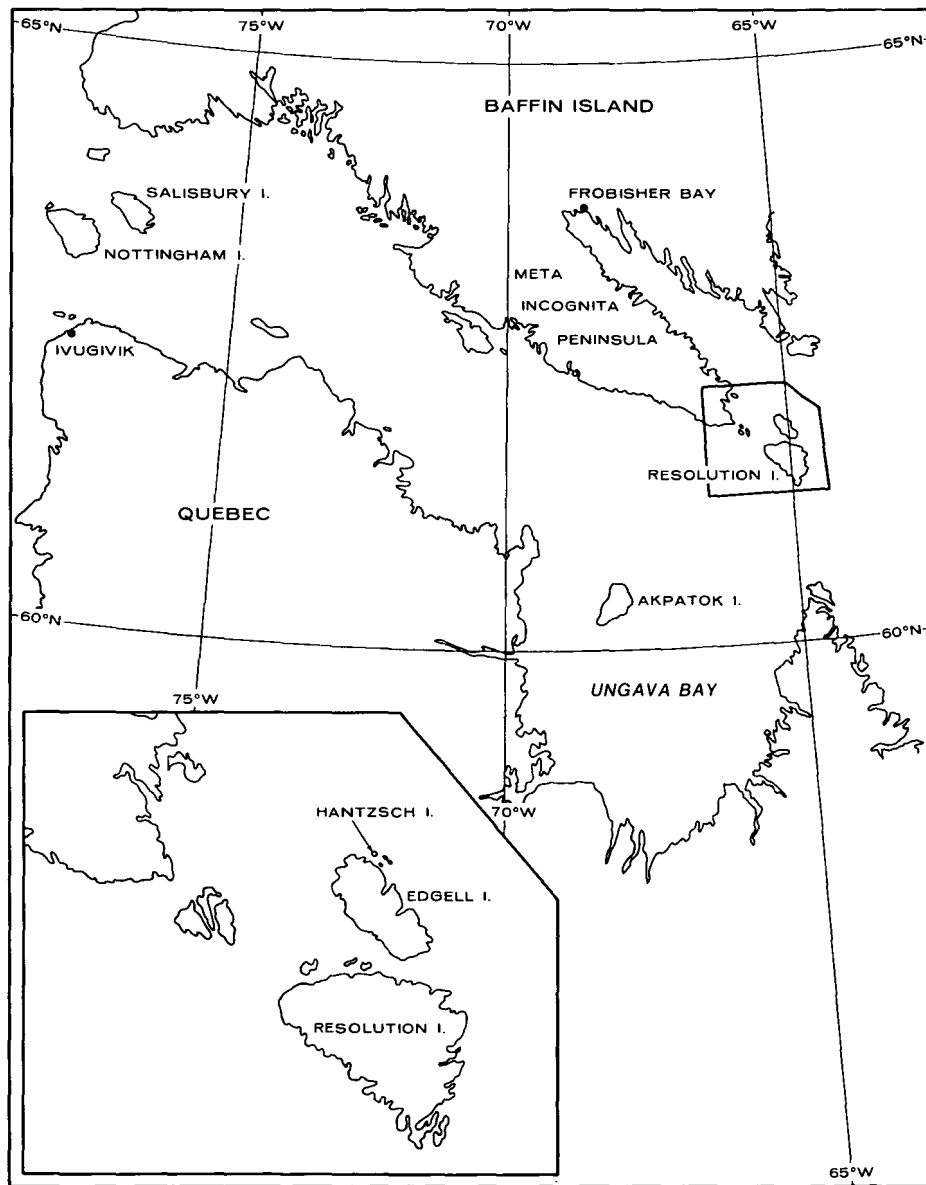


Figure 1. Map showing the position of Hantzsch Island.

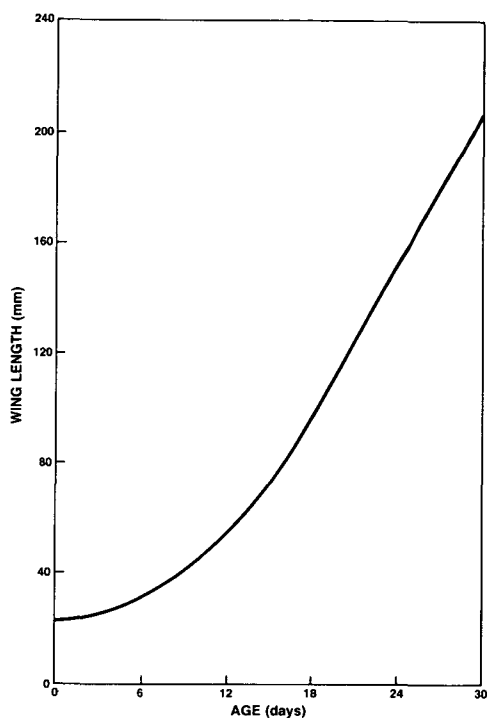


Figure 2. Wing-length in relation to age for Kittiwakes measured at Hantzsch Island in 1982.

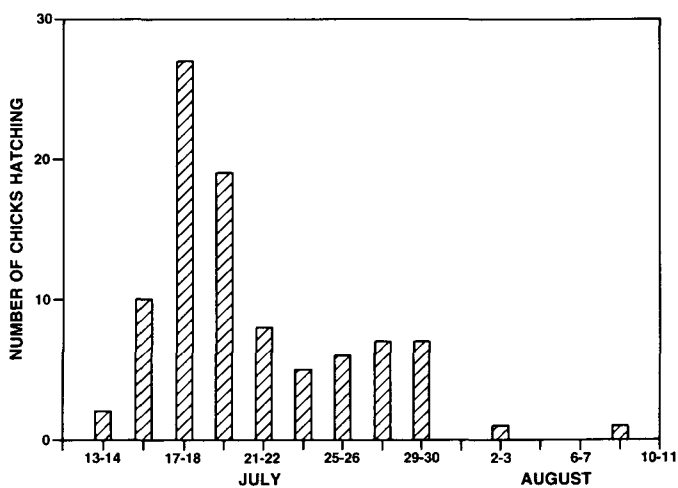


Figure 3. Estimated dates of hatching of Kittiwake chicks measured on Hantzsch Island in 1982.

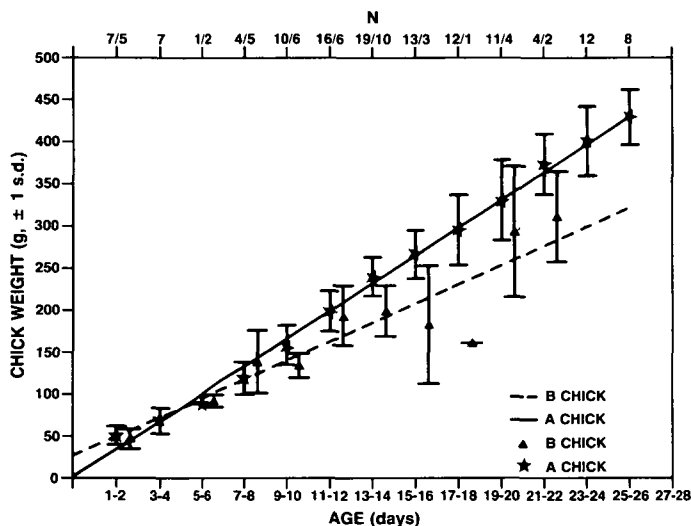


Figure 4. Chick weights in relation to age.

## RESULTS

### Growth

The ages of chicks at first examination suggested that the earliest hatching had occurred on 13 July and the latest on 9 August. The peak occurred between 17 and 20 July (Figure 3). Laying therefore extended from about 16 June to about 12 July, with more than 50% taking place during 20 to 23 June. The first flying juveniles were seen on 19 August, indicating a minimum nestling period of 37 days.

Weight increments of chicks 5 to 25 days old were practically linear (Figure 4). Consequently it was not possible to estimate the asymptotic or maximum weights that might have been achieved. Chicks weighed at 25 and 26 days old (all single or eldest chicks) had an average weight of  $425.9 \pm 10.7$  g ( $N=9$ ), which exceeded the mean of adult weights recorded on 29 July ( $393.9 \pm 13.8$  g,  $N=7$ ).

No clutches or broods of three were seen in 100 nests inspected on 29 July. In broods of two chicks the elder grew faster than the younger. Regression of weight on age for chicks more than 5 days old showed the rate of increase of elder (A) chicks averaged 17.0g/day ( $N=109$ ), whereas B chicks averaged only 12.8g/day ( $N=39$ ). Mean weights of B chicks were much lower than those of A chicks at ages 13 to 18 days (Figure 4).

There is some indication of a convergence of weights thereafter and this could reflect the fact that most of the lightest chicks disappeared before 18 days. However, the effect is not statistically significant.

Among 17 broods of two chicks measured more than once, the lighter chick disappeared in 10 cases and the heavier in only one ( $P=0.006$ , binomial test). Eight of 18 chicks that disappeared from the entire sample did so at more than 13 days old. In a sample of 38 undisturbed nests (viewed only from a distance) the proportion of 1-chick broods fell from 39% on 30 July to 10% on 21 August, when chicks began to fledge. The mean brood size of this sample at fledging was 0.84 chicks/pair.

TABLE 1. PROPORTION BY VOLUME OF MAJOR CONSTITUENTS IN REGURGITATIONS COLLECTED FROM KITTIWAKE NESTLINGS AT HANTZSCH ISLAND IN 1982.

		<i>Proportion (%) by volume</i>				
	<i>Date</i>	<i>Fish</i>	<i>Crustacea</i>	<i>Molluscs</i>	<i>Annelids</i>	<i>Vegetation</i>
1	28 July	100				
2	"	100				
3	"	100				
4	"	99			1	
5	29 July	70	1			29
6	"	73	1		1	25
7	30 July	85	5			10
8	"	99	1			
9	"	100				
10	"	100				
*	"	100				
*	"	100				
*	"	100				
*	"	100				
11	4 August	100				
12	"	99	1			
13	"	45	15	40		
14	"	30	50			20
15	"	69	30		1	
16	5 August	94	5		1	
17	10 August	50	40			10
18	"	100				
19	"	99			1	
20	12 August	98	1		1	
21	"	70	25			5
22	"	70	5	20	5	
23	"	100				
24	"	100				
*	"	95	5			
*	"	95	5			
*	"	95	5			
25	14 August	45	50			5
26	"	40				60
27	"	70	30			
28	"		90			10

\* Examined in the field, but not preserved.

### Food

Twenty-eight regurgitations were collected for subsequent analysis and seven were examined only in the field. Fish material occurred in all but one sample and comprised more than 50% by volume in all but six (Table 1). In most cases the fish involved could not be identified, but the arctic cod *Boreogadus saida* was present in eight samples, snailfishes *Liparis* sp. in two, and an eelpout *Lycodes* sp. and a sculpin, probably *Triglops* sp., in one each (Appendix 1).

Crustacea were present in 19 samples, but comprised 5% or more by volume in only 11. The hyperiid amphipods *Themisto gaudichaudi* and *T. libellula*, the mysid *Boreomysis nobilis*, the euphausiid *Meganicthiphanes norvegica* and the copepod *Calanus hyperboreus* all



occurred in more than one sample. The most common was *C. hyperboreus* which was found in nine samples, being the major constituent of three (Appendix 1). Most samples obtained in July comprised almost entirely fish. Only 29% (N=14) contained crustacea. In contrast, 71% of August samples (N=21) contained crustacea and many also contained a smaller proportion of fish material than earlier samples (Table 2).

TABLE 2. PROPORTION OF FISH MATERIAL AND PRESENCE OF CRUSTACEA IN REGURGITATIONS IN RELATION TO DATE.

Month	Proportion of fish		Crustacea	
	<99%	≥99%	Present	Absent
July	3	11	4	10
August	15	6	15	6
Totals	18	17	19	16
Chi Square (with Yates' corr)	6.52		4.61	
P	<0.02		<0.05	

TABLE 3. DIET OF KITTIWAKE CHICKS AT VARIOUS COLONIES, IN TERMS OF % OCCURRENCE IN STOMACHS OR REGURGITATIONS.

Locality	Fish	Crust.	Moll.	Ann.	Insect	Refs.
Newfoundland	About 100* ( <i>Mallotus</i> )		"5 nests"			Maunder & Threlfall 1972
Farne Is., U.K.	About 100 ( <i>Ammodytes</i> )					Pearson 1968
Isle of May, U.K.	98 ( <i>Ammodytes</i> )†	0.4	0.4			Galbraith 1983
E. Murman, USSR	71 ( <i>Clupea</i> , <i>Ammodytes</i> , <i>Mallotus</i> )	2	7	1	2	Belopol'skii 1961
C. Thompson, Alaska	81	16			2	Swartz 1966
Pribilof Islands	95 ( <i>Theragra</i> , <i>Ammodytes</i> )§	5				Hunt <i>et al.</i> 1981
Hantzsch Island	97 ( <i>Boreogadus</i> , <i>Liparis</i> )	54	6	17		This study
Spitzbergen	100 ( <i>Boreogadus</i> )	71		7		Mehlum & Giertz 1984

\* no numerical data given

† % of total items recorded

§ August samples, apparently some adult stomachs contents included

Annelid jaws were present in seven samples. These chitinous parts were probably very persistent in seabird stomachs (Gaston *et al.* 1985) and no other evidence of these organisms was found. Hence they are probably less important in the diet of the Hantzsch Island Kittiwakes than their occurrence suggests. A small, sub-tidal limpet *Capulacmaea commodum* was present in two samples. Vegetable material comprised from 5-60% by volume of nine samples, although some of this may have found its way into them by contamination during collection.

## DISCUSSION

The difference in growth rate between A and B chicks has been described for Kittiwakes at North Shields, U.K. by Coulson & Porter (1985). The disappearance of the smaller chick from 2-chick broods was almost certainly linked to their lower weights, as suggested by the possible convergence of weights after the age by which most B chicks had disappeared. A similar situation was observed at Runde, Norway in 1974, when heavy mortality of chicks occurred, although in that case the majority of chicks disappeared at younger ages than at Hantzsch Island (Barrett & Runde 1980). Those that died were practically all lighter at their last weighing than the same age that survived.

The degree of brood-reduction observed at Hantzsch Island is somewhat surprising, because the weights of the surviving chicks were relatively high. They reached adult weight by 25 days old, and the oldest chicks averaged 109% of adult weight, heavier relative to adults than any recorded elsewhere, except at Hekkingen, Norway, where maximum weights reached 116% of adult weight (Barrett & Runde 1980) (cf. Coulson & White 1958, Galbraith 1983, Hunt *et al.* 1980, Maunder & Threlfall 1972, Pearson 1968). It is possible that the strategy of arctic-breeding Kittiwakes differs from that of those breeding at temperate latitudes, requiring that chicks reach a higher asymptotic weight and hence increasing selection for brood reduction to occur in order to ensure a high fledging weight for the survivor. Only further studies of growth at arctic colonies can answer this question.

The diet of Kittiwake chicks recorded on Hantzsch Island is similar to that recorded elsewhere. Fish appears to predominate in chick diets throughout the species range (Table 3). The proportion of crustacea recorded at Hantzsch Island is higher than seen elsewhere, except at Spitzbergen (Mehlum & Giertz 1984). This evidence, and examination of adult diets in summer in arctic waters (Belopol'skii 1961, Hartley & Fisher 1936, Mehlum & Giertz 1984) support the suggestion that invertebrates, particularly crustacea, probably form a more important component of Kittiwake diets in the arctic than in boreal waters.

The high frequency of arctic cod among fish identified in Kittiwake diets at Hantzsch Island is a little surprising. This fish is the most important component of Brunnich's Guillemot chick diets throughout the eastern Canadian arctic (Gaston 1985), but it was found to be less common in the diet of chicks at Hantzsch Island than at any other Brunnich's Guillemot colony. The most common fish fed to murre chicks at Hantzsch Island were various species of sculpins, with arctic cod comprising only 14% of items collected. However sculpins, being benthic fishes, are presumably not available to the surface-feeding Kittiwakes.

## ACKNOWLEDGEMENTS

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## SUMMARY

Kittiwakes initiated laying at Hantzsch Island about 16 June in 1982 and laying peaked between 20 and 23 June. Many younger chicks in 2-chick broods disappeared before half grown, after putting on weight more slowly than their elder siblings. However, mean weights of surviving chicks at 25-26 days were high relative to adult weight. Chick diets comprised mainly fish, with arctic cod being the commonest species identified. The proportion of crustacea increased in August. Crustacea may form a more important component of Kittiwake diets in arctic than in boreal waters.

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## APPENDIX 1. NUMBERS OF INDIVIDUAL ORGANISMS IDENTIFIED IN REGURGITATIONS.

	Bs	Ly	Tr	Li	Am	Hm	Tl	Tg	My	Bn	Eu	Mn	Ta	Th	Ca	Ch	Cc	Ne
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
6	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	3
7	0	0	0	1	0	0	0	14	0	0	0	0	0	0	0	0	0	0
8	0	0	0	1	0	0	0	7	0	0	0	0	0	0	0	0	0	0
9	unidentified fish material only																	
10	unidentified fish material only																	
11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
13	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0	3	2	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	362	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	134	0	1
16	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	72	0	10
17	0	0	3	0	0	0	1	0	5	5	6	1	1	0	0	0	0	0
18	unidentified fish material only																	
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
20	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	43
23	unidentified fish material only																	
24	unidentified fish material only																	
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	283	0	0
26	0	0	0	0	0	0	1	0	0	1	0	0	0	32	0	96	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	442	0	0
28	unidentified fish material only																	

## Key:

Fish; Bs = *Boreogadus saida*, Ly = *Lycodes* sp., Tr = *Triglops* sp., Li = *Liparis* sp., Am = *Ammodytes* sp.; Crustacea, Amphipoda, Hm = *Hyperoche medusarum*, Tl = *Themisto libellula*, Tg = *T. gaudichaudi*; Mysidacea, My = unident., Bn = *Boreomysis nobilis*; Euphausiacea, Eu = unident., Mn = *Meganctiphanes norvegica*, Ta = *Thysanopoda acutifrons*, Th = *Thysanoessa* sp.; Decapoda, Ca = unident. Caridea; Copepoda, Ch = *Calanus hyperboreus*; Mollusca, Cc = *Capulacmaea commodum*; Annelida, Ne = *Nereis* sp.

# Seasonal changes of erythrocyte numbers and haemoglobin content in the blood of Herring Gulls *Larus argentatus*

O. Hüppop

## INTRODUCTION

Seasonal differences in blood cell numbers, packed cell volume (haematocrit), haemoglobin concentration, blood-serum chemistry and other haematological values are known from a variety of vertebrate species, including birds as for example penguins (Groscolas 1975), wildfowl (e.g. Perry *et al.* 1986), raptors (Rehder & Bird 1983 and others), pigeons (Riddle & Braucher 1934) and passerines (Trost 1968, deGraw *et al.* 1979, Carey & Morton 1976). Of all birds studied only captive Red-winged Blackbirds *Agelaius phoeniceus* did not show seasonal variation (Ronald *et al.* 1968).

Blood parameters were investigated in a number of seabirds also (Groebbs 1932, Christoph & Traue 1961, Lenfant *et al.* 1969, Clausen *et al.* 1971, Kostelecka-Myrcha & Myrcha 1980, Myrcha & Kostelecka-Myrcha 1980, Leighton *et al.* 1983, Viscor *et al.* 1984, Kostelecka-Myrcha 1987), but nothing is known about seasonal differences in this bird group. Generally, such investigations are important, because conclusions can be drawn concerning how far haematological changes may be involved in other seasonally varying physiological parameters and thus in how far they are an adaptation to environmental alterations. Therefore, changes of erythrocyte number and haemoglobin concentration are presented here for the Herring Gull *Larus argentatus*. Possible physiological implications are discussed.

## METHODS

The Herring Gulls were obtained as eggs or chicks from a mixed colony of Herring and Common Gulls *Larus canus* near the island of Lühesand (9° 36' E 53° 35' N) in the lower River Elbe (West Germany) in 1983 and 1984, respectively. They were handreared to make them accustomed to handling and transferred to a 25m<sup>2</sup> aviary at sea level with natural conditions of photoperiod and weather at the Zoological Institute and Zoological Museum of the University of Hamburg. Food (mainly fish, molluscs and crustaceans) and fresh water were provided *ad libitum*. The food was first deep-frozen to reduce the risk of infection by parasites. All gulls were healthy throughout the whole study period. Blood samples were taken from three gulls at intervals of about four months (28 February, 30 May, 29 August and 13 November 1986) from 0800 to 1300 hours. Last feeding was on the day prior to the sampling, respectively. To minimize stressful effects, always the same person handled the gulls. After weighing the birds on an electronic balance to the nearest gram, about 1cm<sup>3</sup> blood was withdrawn from the *Vena cutanea ulnaris* (usually right wing) with a heparinized syringe. Standard methods were used to count red blood cells (erythrocytes) and to measure haemoglobin content of the blood: erythrocytes were diluted with sodium citrate solution (1:100) and counted in a Thoma's Chamber (50 0.0025mm<sup>2</sup> squares in two samples each). Haemoglobin concentrations were measured photometrically in four samples each by the cyanmethaemoglobin method with a clinical test-combination (Boehringer, Mannheim).

Mean cell haemoglobin concentration (MCHC) was calculated by  
 haemoglobin concentration

$$\text{MCHC} = \frac{\text{haemoglobin concentration}}{\text{erythrocyte number}}$$

Measurements of ambient temperatures were obtained from the Meteorological Institute of the University of Hamburg.

## RESULTS

Although there is some individual variation, the mean numbers of red blood cells and mean haemoglobin concentrations were both found to exhibit seasonal differences (Figure 1): a mean decrease of 17% in red blood cells and 16% in haemoglobin content from winter to summer. For erythrocytes highest counts were found in November (mean  $\pm$  SE =  $3.31 \pm 0.20 \times 10^6 / \text{mm}^3$ ), lowest in August ( $2.74 \pm 0.16 \times 10^6 / \text{mm}^3$ ). The haemoglobin concentrations fell from  $13.3 \pm 1.1 \text{ g}/100\text{cm}^3$  in February to  $11.2 \pm 0.2 \text{ g}/100\text{cm}^3$  in August. Due to the low sample number a statistical treatment of the data was not reasonable. However, the tendency towards higher values during the winter is obvious.

In mean cell haemoglobin concentration a drop of 8% was observed: from summer to winter it was highest in August (mean  $\pm$  SE =  $41.2 \pm 2.1 \times 10^{-12} \text{ g}$ ) and lowest in November ( $37.7 \pm 1.3 \times 10^{-12} \text{ g}$ ), while the mean body mass decreased from  $1216 \pm 51 \text{ g}$  in February to  $1094 \pm 50 \text{ g}$  in May.

Both red blood cell numbers and haemoglobin level are inversely correlated with the mean ambient temperature of the day prior to the sampling (Spearman's  $r_s = -0.68$  and  $r_s = -0.61$ ,  $P < 0.05$ ,  $n = 12$ ), but they are not correlated with mean cell haemoglobin content, body mass and photoperiod.

## DISCUSSION

The numbers of erythrocytes and consequently of haematocrit values, as well as the haemoglobin concentrations, in the blood of birds and mammals are known to depend on species, habits, altitude, age, sex, diet, hormones, health, seasonal (e.g. temperature, moult, migration, pregnancy) and other factors (Jones & Johansen 1972, Seal & Mech 1983, Keys *et al.* 1986, Perry *et al.* 1986, Sturkie 1986 and others). Generally, elevated erythrocyte numbers, haematocrit values and haemoglobin concentrations are correlated with a high oxygen demand.

The haematological data of Herring Gulls presented here fall within the range reported for other birds (Groebbs 1932, Jones & Johansen 1972, Sturkie 1986). In general, they further agree with those found earlier in gulls: Clausen *et al.* (1971) measured 2.16 to 3.08 (mean = 2.55) million erythrocytes per  $\text{mm}^3$  blood and 11.6 to 15.5 g (mean = 12.9 g) haemoglobin per 100  $\text{cm}^3$  blood in six Herring Gulls shot in flight (season not given). Christoph & Traue (1961) counted  $2.14 \times 10^6$  red blood cells per  $\text{mm}^3$  in the Herring Gull,  $2.55 \times 10^6 / \text{mm}^3$  in the Common Gull and  $2.67 \times 10^6 / \text{mm}^3$  in the Black-headed Gull *Larus ridibundus*. They found 14.4, 14.7 and 13.8 g haemoglobin per 100  $\text{cm}^3$  in these species, respectively. Groebbs (1932) reported red blood cell counts of  $3.36 \times 10^6 / \text{mm}^3$  in the Great Black-backed Gull *Larus marinus*,  $2.16 \times 10^6 / \text{mm}^3$  in the Southern Black-backed Gull *Larus dominicanus* and  $3.285 \times 10^6 / \text{mm}^3$  in the Black-headed Gull. Viscor *et al.* (1984) found in the last species  $3.86 \times 10^6$  red blood cells /  $\text{mm}^3$  and a mean haemoglobin content of  $12.87 \text{ g}/100\text{cm}^3$ , while Myrcha & Kostelecka-Myrcha (1980) measured  $3.640 \times 10^6$  red blood cells /  $\text{mm}^3$  and  $12.6 \text{ g}/100\text{cm}^3$  haemoglobin in the Southern Black-backed Gull.

In contrast, Leighton *et al.* (1983) measured mean haemoglobin contents in two groups of Herring Gull nestlings of 9.2 and 8.7 g/100 cm<sup>3</sup> only. However, haemoglobin concentrations are known to increase with age in the chicks of e.g. penguins (Kostecka-Myrcha & Myrcha 1980) and of the Little Auk *Plautus alle*, another charadriiform species (Kostecka-Myrcha 1987).

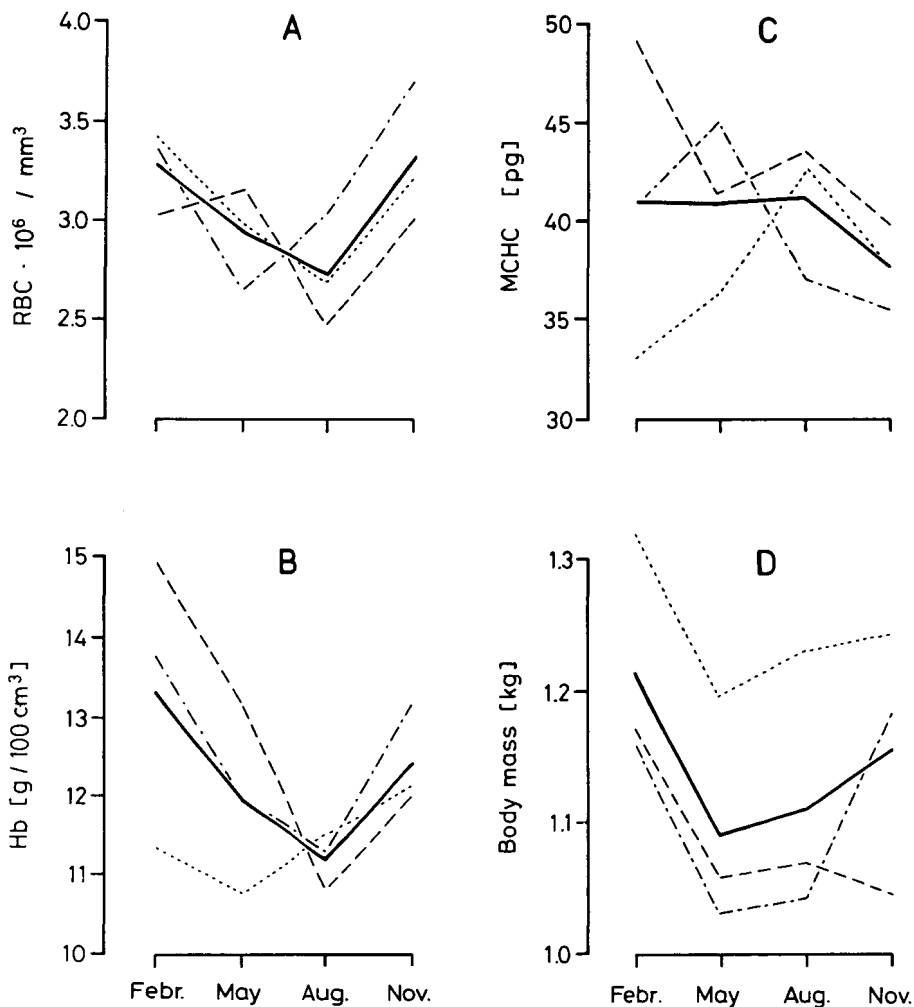


Figure 1. Red blood cell numbers (A), haemoglobin levels (B), mean cell haemoglobin concentrations (C) and body mass (D) in three captive subadult Herring Gulls *Larus argentatus* during February to November. The solid lines connect mean values.

The observed seasonal changes of body mass showed almost the same periodicity as in free-living Herring Gulls in Britain (Coulson *et al.* 1983), the body mass itself being higher in the captive birds. This might be due to the fact that all three birds investigated were probably males.

Elevated erythrocyte numbers, haemoglobin concentrations and haematocrit levels were recorded in birds and mammals under hypoxic conditions, such as high altitude (Carey & Morton 1976, Sturkie 1986 and others) or during periods of high oxygen demand, for example when the temperature is low (e.g. Riddle & Braucher 1934, Sealander 1960, Trost 1968, Maclean & Lee 1973, Carey & Morton 1976, Rehder & Bird 1983, Seal & Mech 1983) or during migration (deGraw *et al.* 1979).

The Herring Gull is a lowland species and a resident or low-distance migrant (Goethe in Glutz von Blotzheim & Bauer 1982), which moults over long periods without pronounced peaks (Coulson *et al.* 1983). Furthermore, in the case of this study the birds were non-reproductive and were furnished with a similar diet all year round and samples were always taken in the same manner on non-fed birds. Therefore it is very likely that ambient temperature is the most effective factor on erythrocyte numbers and haemoglobin level. This assumption is supported by the fact that both erythrocyte counts and haemoglobin concentrations were inversely correlated with ambient temperature as is also haematocrit in the American Kestrel *Falco sparverius* (Rehder & Bird 1983). It is also supported by the study of Trost (1968), who found elevated haemoglobin concentrations (but no higher haematocrit) in Horned Larks *Eremophila alpestris*, which were maintained at +10°C for a month, compared with larks kept at +25°C. Moreover, Groscolas (1975) induced short-time reductions of haematocrit in winter adapted Emperor Penguins *Aptenodytes forsteri* during heat exposure. The effect was reversed, when the birds returned to cold conditions. Finally, Sealander (1960) found increases in both haemoglobin levels and haematocrit in mice exposed to 5 to 6°C for 23 to 46 days.

Assuming the same or even a higher blood volume in cold adapted birds and mammals (Maclean & Lee 1973), a higher haemoglobin concentration increases the overall oxygen carrying capacity of the blood and the oxygen extraction efficiency from the air inhaled. Thus, the actual respiratory volume can be reduced, resulting in an advantage in thermoregulation, i.e. heat losses in the respiratory tract due to convection and evaporation are lowered. Moreover, the energy consumption for breathing itself is also reduced.

#### SUMMARY

Mean red blood cell numbers and mean haemoglobin concentrations of three captive Herring Gulls varied seasonally. Erythrocytes increased from  $2.74 \times 10^6/\text{mm}^3$  blood in August to  $3.31 \times 10^6/\text{mm}^3$  in November. Haemoglobin level was lowest in August (11.2g/100 cm<sup>3</sup> blood) and highest in February (13.3 g/100cm<sup>3</sup>). Red blood cell counts and haemoglobin concentrations were inversely correlated with ambient temperature. High levels of erythrocytes and haemoglobin thus mainly appear to be an adaptation to cold: With increased oxygen carrying capacity of the blood the actual respiratory volume and thus heat loss during breathing may be reduced.

#### ACKNOWLEDGEMENTS

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## The feather louse *Halipeurus gravis gravis*, Timmermann, 1961 (Mallophaga: Philopteridae) from a Sooty Shearwater *Puffinus griseus* in Scotland.

B. Zonfrillo

Sooty Shearwaters *Puffinus griseus* (Gmelin, 1789) are regular migrants to British seas, arriving in late July and departing by late October. Outside of this period they are uncommon, presumably having returned to their breeding colonies in the southern hemisphere. A freshly dead Sooty Shearwater found at Elliot, near Arbroath, Scotland on 7 February 1987 was therefore of considerable interest being in the wrong hemisphere in the wrong season. The bird was prepared as a cabinet skin for Montrose Museum, Angus, Scotland.

Feather lice (Mallophaga) were removed from the plumage and were identified by R. L. Palma (National Museum of New Zealand).

Four species of feather lice were present, three of which are previously known from Sooty Shearwaters, and a variety of other shearwater species, (Pilgrim & Palma 1982). The lice are *Trabeculus hexakon* (Waterston, 1914), *Austromenopon paululum* (Kellogg & Chapman, 1899) and *Halipeurus diversus* (Kellogg, 1896). The fourth species present was the subspecies *Halipeurus gravis gravis* Timmermann, 1961, whose only known host is the Great Shearwater *Puffinus gravis* (O'Reilly, 1818). One male and one female of this louse were found on the Sooty Shearwater. The *Halipeurus* louse, normally found on Sooty Shearwaters, *H. diversus*, was present in good numbers and various instars. The occurrence of *H. g. gravis* must, in such circumstances, be regarded as a straggler to the host species.

How the lice were transferred from one shearwater species to another remains uncertain but human interference can be ruled out. Both shearwaters may come into contact briefly at sea, perhaps while engaged in feeding on a common food source. Transfer of lice, which must be by physical contact, under such circumstances would have to be rapid and would be extremely hazardous for the insects. Transfer is more likely at a breeding colony, where casual contact would be frequent both above and below ground for fledglings and adults respectively, particularly where burrow density is high. Away from the vast numbers on the Tristan da Cunha Islands (where Sooty Shearwaters are not known to breed), the only other place where Great Shearwaters have been found breeding is in the Falkland Islands, at Kidney Island and Sea Lion Island (Woods, 1982). At Kidney Island there is also a large colony of Sooty Shearwaters, the only place where both species are known to breed sympatrically. It seems likely that the Sooty Shearwater washed up dead on the east coast of Scotland may have originated from Kidney Island, or that general area of the Falklands. Well over 100 Sooty Shearwaters from the New Zealand islands have been systematically deloused and none was parasitised by *H. g. gravis* (R. L. Palma pers. comm.)

A large scale programme of ringing and wing-tagging of Sooty Shearwaters in the Falkland Islands might reveal the truth of the origins of this species in British seas, and confirm the circumstantial evidence here presented.

## ACKNOWLEDGEMENTS

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# The European cline in wing-length of Guillemots *Uria aalge*

*P. Hope Jones*

The naming and rejection of Guillemot *Uria aalge* subspecies has proved a popular pastime amongst ornithologists, and this short paper will refrain from adding to the confusion. However, there is now general agreement that there is a genuine northward cline of increasing body size and wing-length (Cramp 1985).

In some past studies, mean wing-length for any one locality might have been based on a short series of specimens of doubtful provenance, of unknown age, and of fresh corpses and of skins whose wings had suffered varying degrees of post-mortem shrinkage. As attention to auks has increased (as a result, especially, of actual and potential damage from oil pollution), people have now measured several series of birds in some of the more accessible colonies in

TABLE 1. WING-LENGTH MEASUREMENTS OF FULL GROWN GUILLEMOTS IN BREEDING COLONIES, 1975-1983

	country	colony	degrees north	sample size	mean (mm)	standard deviation	range	authority
1.	Norway	Vardø	70	95	210.5	5.50	199-223	R.T. Barrett
2.	Norway	Røst	68	63	209.6	5.20	*202-223	T. Anker-Nilssen & O.W. Røstad
3.	Iceland	Grimsey	67	60	207.2	3.49	199-216	P.H.J.
4.	Faroe	Esturoy	62	19	207.0	3.03	200-212	S. Prendergast & P.H.J.
5.	Scotland	Noss, Shetland	60	65	207.3	4.71	196-217	B.F. Blake & T.J. Dixon
6.	Scotland	Foula, Shetland	60	38	207.3	3.96	198-214	M.L. Tasker
7.	Scotland	Fair Isle, Shetland	59	252	206.6	4.30	196-219	P.H.J. §
8.	Scotland	Canna	57	91	203.8	4.81	193-215	R.L. Swann & A.D.K. Ramsay
9.	Scotland	Troup Hd.	57	39	203.6	3.64	195-210	J. Hardey & R. Rae
10.	Denmark	Graesholm	55	46	201.2	4.43	193-210	P. Lyngs
11.	Scotland	Isle of May	56	351	200.9	4.83	192-212¶	M.P. Harris & S. Wanless
12.	Ireland	Gt. Saltee	52	35	199.5	3.67	194-209	P.H.J.
13.	Wales	Skomer	52	84	197.6	4.75	185-210	T.R. Birkhead

\* outlier of 196; ¶ outlier of 217; § courtesy of Fair Isle Bird Observatory.

western Europe. Consequently, reasonably long series of measurements are available for known localities in the breeding season.

For all data reported here, wing-length was measured as the distance between carpal joint and the tip of the longest primary with the wing straightened and flattened; wings with badly abraded primary tips were not included. Birds were measured at breeding colonies, but it is possible that a small proportion of the birds measured will not actually have been breeders; this is unlikely to have affected the mean values (Harris & Wanless in press). Basic results are given in Table 1.

In order to characterise the cline more precisely, the mean wing-length measurements were plotted against latitude (Figure 1). Although a linear regression is significant ( $r^2 = 0.84$ , 11 df,  $p < 0.001$ ), visual inspection suggests a curvilinear relationship. A curve was therefore fitted, and the equation wing length =  $46.4 + 38.8 \log(\text{latitude})$  was found to explain slightly more of the variance ( $r^2 = 0.86$ , 11 df,  $p < 0.001$ ). Winglength is also negatively correlated ( $r = -0.92$ ) with mean June air temperatures (US Navy 1956) and with mean June sea temperatures ( $r = -0.84$ ; US Hydrographic Office 1944). But neither of these independent variables is a more powerful predictor of wing-length than is latitude.

I have no data on live Guillemot wing-lengths from colonies south of Britain, but a series of 12 dried skins from the Berlengas colony in Portugal ( $39^\circ 23' \text{N}$ ) gave a mean value of 195.5mm, probably indicating a mean value of some 2mm longer for live birds (P.H.Jones,

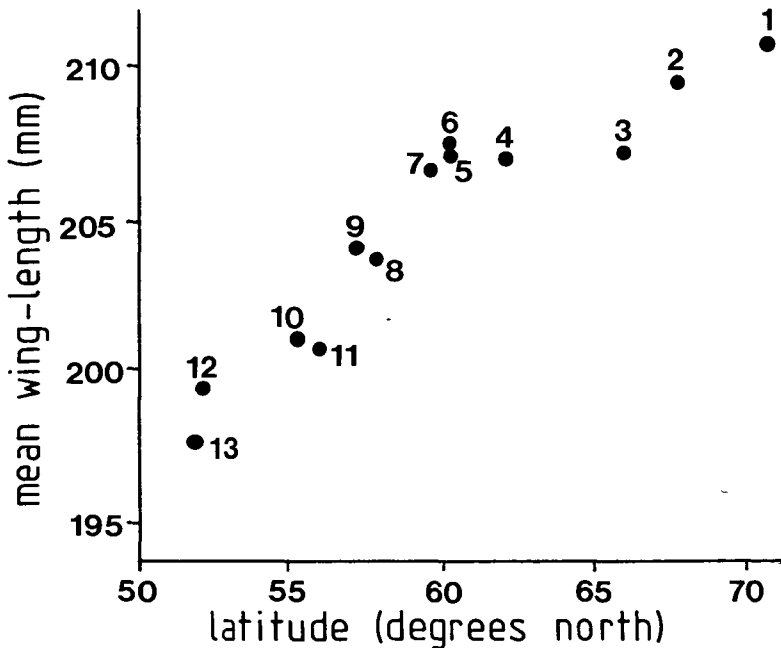


Figure 1. Mean wing length of 13 samples of Guillemots at different latitudes in N.W. Europe. Data from Table 1. Sites numbered as in Table 1.

in Morgan 1980). This might indicate a clinal break or pivot in N.W. France or southern Britain, although at present this suggestion must remain conjectural.

Thus, from data currently available, Guillemot wing-length increases northwards with increasing latitude through N.W. Europe, though the *rate* of change decreases northwards along the cline.

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# Post-chick-leaving behaviour of the Razorbill *Alca torda* as shown by radio-telemetry

S. Wanless, J.A. Morris and M.P. Harris

## INTRODUCTION

Most aspects of the chick-rearing period of many seabirds are well documented but the post-fledging or post-chick-leaving period is poorly understood. The Razorbill *Alca torda* chick leaves the nest site when only partly grown and still flightless (Perry 1940, Brun 1958). The chick jumps and/or scrambles from the breeding site to the sea at dusk and is led away from the colony by the male whilst the female remains behind and occupies the breeding site intermittently for the next few days (Perry 1940, Greenwood 1964, Bédard 1969, Lawman 1975, Lloyd 1976, Wanless & Harris 1986). By morning the males and chicks are out of sight of the colony.

The development of light, waterproof, powerful radio transmitters has increased our understanding of the foraging behaviour of several species of seabird (e.g. Trivelpiece *et al.* 1986, Anderson & Ricklefs 1987, Wanless *et al.* 1988) and the same technique should be appropriate for studying post-fledging behaviour. This paper reports on the feasibility of using radio-telemetry to study the behaviour of the Razorbill prior to and immediately after the chick leaves the breeding site.

## METHODS

Three Razorbills with chicks about 7 d old were caught on the Isle of May, Firth of Forth, Scotland in June 1987. They were sexed by their behaviour after their chick had left; two birds remained at the site (normal female behaviour) while one accompanied the chick to sea (male behaviour) (Harris & Birkhead 1985).

Single-stage, purpose-built radio transmitters operating on the 173 MHz telemetry band were attached (under licence) to the middle of each bird's back using 'superglue'. The total weight of the transmitters, waterproofed and potted in fibreglass resin, was approximately 7.4g, about 1.2% of the weight of the birds. Signals were detected with an AVM (LA12) or an RX-81 receiver using a vertically polarised 5 or 12 element yagi aerial mounted on the roof of a hut 73m above sea level from where all three breeding sites were visible. During the days preceeding the departure of the young, the birds' attendance patterns were recorded by an observer in the hut from 0330 to 1800 hrs GMT. At other times attendance was logged automatically on a chart recorder as was attendance of the two females for eight and one day respectively, after their young had left. Both females were then recaptured and their transmitters removed. We distinguished four different behaviour patterns, either directly from the signal or from the chart recorder trace, a) on site (strong, steady signal), b) on the sea under the cliffs (moderate, variable signal), c) away (no signal; range of transmitters was c. 10km (manual tracking) or c. 1km (automatic), and d) rapid alternation between cliff and the sea (very variable signal). Our interpretations of the radio signals as different behaviour patterns were confirmed periodically by direct observations of the birds. In addition, during manual tracking we could also identify when a bird dived, since on the 173MHz frequency no receivable signal is detected when the transmitter is in salt water. Such breaks in transmission were always abrupt and of short duration (Wanless *et al.* 1988). They were

distinguished easily from when birds went out of range because in this case the signal became fainter gradually and the loss of signal lasted for many minutes.

When the male took his chick to sea the direction in which the signal was strongest and changes in signal strength were noted every 10-20 min until the signal disappeared completely. It was not possible to determine the bird's position by triangulation, because it departed more or less in line with the orientation of the island, so its position was estimated by changes in signal strength which were calibrated by tests with an identical transmitter mounted on a boat. Water movements in the Firth of Forth are well documented and details of the tidal flow experienced by the male along his estimated route were obtained from the Admiralty Chart no. 175. Times are GMT and directions are true bearings.

## RESULTS

### *Female behaviour*

Prior to the departure of their young the two females showed very similar attendance patterns; they spent 64-69% of the time on the site, 28-30% away from the colony (presumably feeding as they frequently brought back fish for the young) and relatively little time on the sea under the cliffs (Table 1). Both females remained on the cliff overnight following the departure of their young at dusk. Female 1 subsequently spent a similar proportion of time out of range (27% compared to 30% prior to chick-leaving) but whilst at the colony she was almost constantly on the move, alternating between the breeding site, the sea and other ledges near the site. This is normal Razorbill behaviour before laying and after the chick has left (pers. obs.). Female 2 was followed for just one day after her chick had left; she too was either absent or alternated between the cliff and sea.

Before chick-leaving the mean lengths of time at the site, out of range, on the sea and alternating between site and sea for the two females combined were 496 min ( $\pm 408$  min s.d.,  $n=44$ ), 299 ( $\pm 173$  min s.d.,  $n=32$ ), 23 ( $\pm 29$  min s.d.,  $n=16$ ) and 287 ( $\pm 44$  min s.d.,  $n=3$ ) respectively. There was no obvious pattern of attendance in relation to daylight or tidal cycle (Fig. 1). In contrast, after chick-leaving Female 1 spent long, continuous spells either away (mean = 441,  $\pm 95$  min s.d.,  $n=7$ ) or in the vicinity of the site (mean = 1074,  $\pm 183$  min s.d.,  $n=7$ ). There was a strong diurnal pattern with the bird absent at night (after the first night) and present by day. Time of return in the morning appeared to be influenced by the state of the tide as the bird returned at or just after high tide on seven successive mornings (Fig. 1). Thus there was a significant positive correlation between time of return

TABLE 1. PROPORTIONS OF TIME SPENT SITTING QUIETLY ON THE SITE, ON THE SEA UNDER THE COLONY, ALTERNATING BETWEEN THE CLIFF AND SEA, AND OUT OF RANGE FOR TWO FEMALE RAZORBILLS (F) BEFORE AND AFTER THEIR YOUNG LEFT AND ONE MALE (M) BEFORE CHICK-LEAVING.

	Sex	Hours followed	At site	% Time		
				On sea	Site/ sea	Out of range
Before chick-leaving	F	218	64	2	4	30
	F	339	69	1	2	28
	M	287	54	8	7	31
After chick-leaving	F	190	0	0	73	27
	F	25	0	0	59	41



and time of high water ( $r=0.85$ ,  $df=5$ ,  $P<0.05$ ). We detected no short breaks in transmission such as would be expected if the bird was diving so feeding presumably occurred between about 2000-0500 hrs at a distance of more than 10km from the colony.

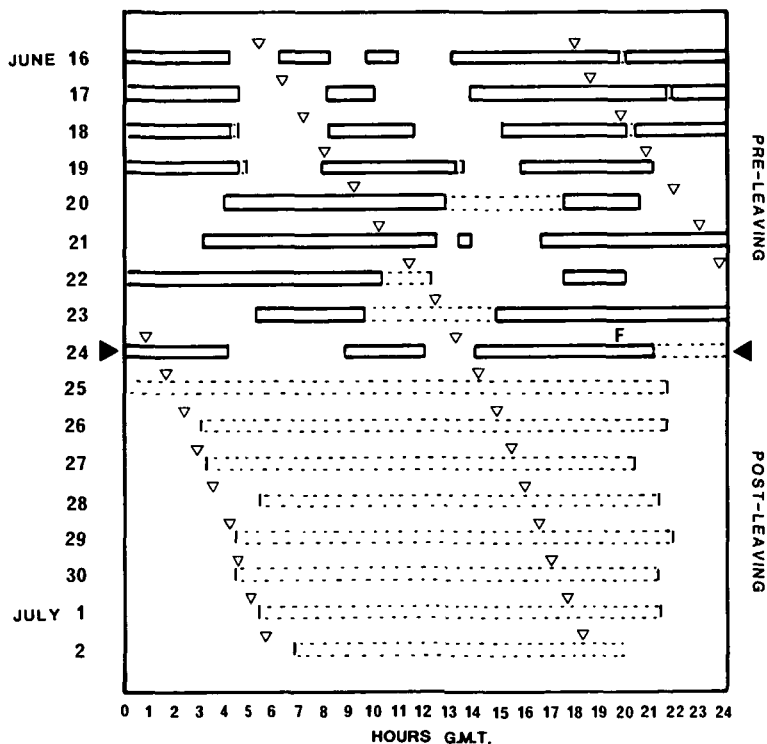


Figure 1. Time budget of Female 1 during the chick-rearing and post-chick-leaving period. Solid lines indicate time on the site, dotted lines time on the sea or alternating between the cliff and sea and a space indicates the time out of range. The solid arrows separate the pre- and post- chick-leaving periods, F indicates when the young left the breeding site and the open arrows show the time of high water each day.

#### *Male behaviour*

During chick-rearing the male showed a similar pattern of attendance to the two females except that he spent more time on the sea (Table 1). We did not see the male's chick leave but by 2030 hrs on 2 July it had left the ledge and we were receiving a very strong signal from the male indicating that he was on the sea under the cliffs (presumably with the chick). During the next 30 min the signal indicated that the bird moved down the west cliffs, the bearing gradually changed from  $180^\circ$  to  $150^\circ$  and became weaker due to the signal being masked by the cliffs (Fig. 2). The signal became markedly stronger at 2100 hrs as the bird rounded the sound end of the island and was again in line of sight. During the subsequent

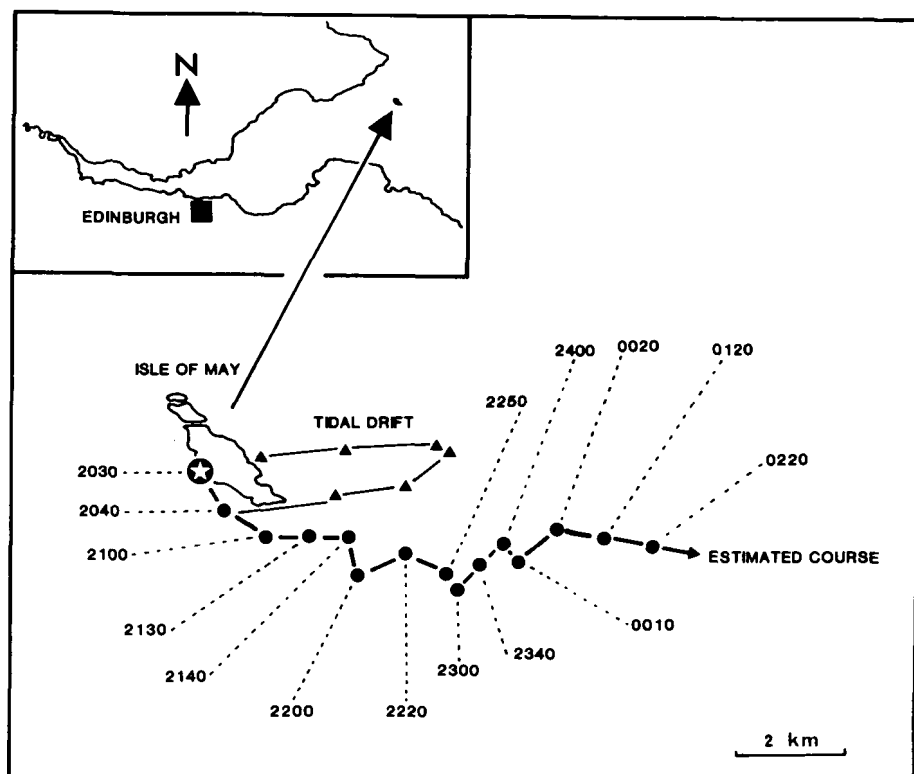


Figure 2. The course taken by the male Razorbill as he led his chick away from the colony. The star indicates the cliff from which the chick fledged at about 2030 hrs GMT. If the bird had been carried passively in the tide its course would have been that shown by the triangles. Each triangle marks the bird's predicted position at hourly intervals.

three hours the bearing varied between  $100^{\circ}$ - $130^{\circ}$  and the signal became progressively fainter as the bird moved gradually away from the island. From 0021 to 0220 hrs the bearing was steady at  $100^{\circ}$  but the signal weakened gradually until by 0220 hours only an occasional weak pulse was heard. Despite repeated searches from the tracking station during the next two days we never detected a signal again. We estimated that the male, and presumably the chick, covered about 8-9 km in the 5.8 hrs after the chick left the breeding site, i.e. an average speed of approximately  $1.5 \text{ km hr}^{-1}$ . During the whole time we never recorded an abrupt break in signal and we concluded that the adult never dived.

The male encountered considerable variation in the direction and rate of tidal flow. At first his course could be explained largely by him drifting passively with the tide which was flowing in a direction somewhere between  $87^{\circ}$ - $98^{\circ}$  at  $0.6$ - $1.3 \text{ km hr}^{-1}$ . However he also appeared to be actively pursuing a more southerly course so that by 2340 hrs we estimated that he was about 1.5 km south-east of where the current would have taken him. After 0042 hr the tide started to flow in a direction somewhere between  $274^{\circ}$ - $279^{\circ}$  at  $1.1$ - $1.3 \text{ km hr}^{-1}$  but the bird continued to move away from the island.

## DISCUSSION

Interpretation of data from instruments attached to animals assumes that the devices do not substantially alter the animals' behaviour. As part of the present study we compared the attendance and foraging behaviour of the three Razorbills carrying transmitters with that of five untagged controls. We failed to detect any significant differences (Wanless *et al.* in press) and thus we were reasonably confident that our results reflected normal Razorbill behaviour. Our observations on those aspects of fledging and post-chick-leaving behaviour which are easily visible were consistent with those reported previously (Greenwood 1964, Bédard 1969, Lawman 1975, Wanless & Harris 1986). However, the strong diurnal rhythm of attendance shown by the female after her chick had gone would have been difficult to establish by direct observations because the bird was highly mobile, visiting other ledges and also spending some time sitting on the water under the cliffs. We never recorded it diving close the the colony. The progressive delay in the time of return each day coincided with the advancement of the time of high water which suggests that feeding may have been influenced by the tidal cycle. Although more data are needed to establish if this is a consistent characteristic of Razorbill foraging at this time, a tidal rhythm has been demonstrated at one Guillemot *Uria aalge* colony during the pre-laying but not the chick-rearing period (Slater 1976). Slater found that the greatest numbers of birds returned to the cliff when the tide was flowing and that numbers of birds on the ledges were highest around high tide.

Greenwood (1964) concluded that fledging at dusk was a compromise between the risk of predation if the chick left during the day and the risk of injury if the young left in the dark. Once united on the sea the male and chick would be expected to move as far away from the colony as possible so as to be out of range of gulls *Larus* spp., the main potential predators, by daylight. The fact that the male, and we presume the chick, were well out into the open sea by dawn agrees with this hypothesis. The general impression was of a bird swimming towards a well-defined goal. Over the 16 days prior to the young fledging, we recorded 32 stable bearings for the three Razorbills as they flew out of range, presumably to feed, 10 (31%) were between 80°-115°. Thus the direction in which the male swam away was consistent with a known favoured feeding area.

Although our results are based on only three birds, they indicate that radio-tracking is a useful tool for studying post-chick-leaving behaviour of those auks with an 'intermediate' or 'precocial' fledging strategy (Gaston 1985). If aerial and/or ship-based support were available it would be possible to continue observations during the post-chick-leaving period. Individually identifiable birds could add much to surveys of migrating flightless auks such as those carried out on Brunnich's Guillemot *Uria lomvia* (Gaston 1982) and Guillemot (Tasker *et al.* 1987). Ideally transmitters should also be attached to the young, but the transmitters in current use would be about 4% of chick weight at fledging which might adversely affect a chick's behaviour. However, the speed of development of new devices is such that a suitable transmitter should become available in the next few years.

## ACKNOWLEDGEMENTS

Jimmy Smith and the Isle of May lighthouse keepers helped test the range of the transmitters and H.M. Coastguard, Firth of Forth provided information on the tidal stream. We thank Mark Tasker for commenting on the manuscript and NCC for permission to work on the Isle of May. This work was funded partly by the commissioned research programme of the Nature Conservancy Council.

## SUMMARY

Three Razorbills were equipped with radio transmitters and their attendance behaviour recorded prior to and after their young left. After chick-leaving females showed a strong diurnal pattern being away from the colony at night (after the first night) and in the vicinity of the breeding site by day. For one female

time of arrival in the morning was apparently influenced by the state of the tide. One male was tracked as he led his chick to sea. We estimated that he swam 8.9 km during the first 6 hrs after leaving the colony. Initially his course could be explained mainly by the tidal flow but when the tide turned he maintained the same bearing until he went out of range of our receivers. Our preliminary results suggest that radio-tracking is a useful tool for studying post-chick-leaving behaviour of auks.

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# Age, sex and origins of auks (*Alcidae*) killed in the Skagerrak oiling incident of January 1981

*Tycho Anker-Nilssen, Peter Hope Jones and Ole Wiggo Røstad*

## INTRODUCTION

In January 1981 an estimated 100 000 seabirds were oiled in S E Norway and S W Sweden; details of the incident are given in Anker-Nilssen & Røstad (1981) and Uddén & Åhlund (1984). Of this total, about 60% were Guillemots *Uria aalge*, 12.5% Little Auks *Alle alle* and 9.5% Razorbills *Alca torda*.

This provided an opportunity to examine the corpses for age and sex proportions, and to try to ascribe an origin for the auks involved. This paper reports the major conclusions from analyses of morphometric data collected from auks killed in this incident.

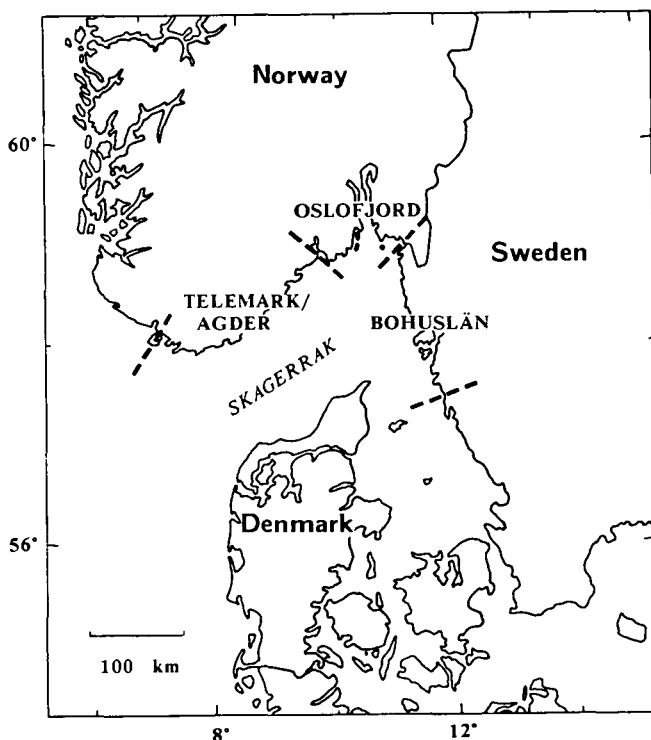


Figure 1. Map of the Skagerrak area, showing the three main sampling regions.

## METHODS

Corpses were examined using the procedure developed by Jones *et al.* (1982a). The variables recorded were as follows:

*External:* proportion of plumage covered by oil; whether the specimen was in winter, summer, or intermediate head plumage; for Guillemots, whether or not the bird was bridled; for Razorbills, the number of white and dark bill grooves on the upper mandible (00=no bill grooves, W0=one white bill groove only, W1=one white and one dark bill groove, etc.); winglength (maximum flattened chord); culmen length (tip to proximal end of sheath); bill depth at gonys; and body weight.

*Internal:* sex, from gonadal inspection; for males, length and breadth of left testis; for females, diameter of the largest follicle; thickness of subcutaneous fat (four rankings: 0 (no fat) to 3 (thick fat)); amount of visceral fat (four rankings); presence or absence of cloacal bursa and, if present, its length and breadth.

To reduce the bias due to differences in measuring techniques, individual comparisons and corrections between observers were made prior to the examination.

One wing was taken from each Guillemot where at least one wing was unoiled, and labelled with the individual's reference number. These wings were then compared individually with a series of specimen wings taken from birds at a variety of European Guillemot mortality incidents. They were ranked in shade of colour from 1 (very pale brown, with over 6% reflectance of white light) to 9 (almost black, with about 2% reflectance). Analyses of stomach content are reported in Blake (1983), and will not be discussed further in this paper.

Bird samples were collected from several coastal localities, but the corpses have been ascribed to three main regions: Oslofjord – north of 59°N (from the Norway/Sweden border round to the Vestfold/Telemark border, Norway); Telemark/Agder (from the Vestfold/Telemark border southwest to Farsund in Vest-Agder); and Bohuslän (from the Norway/Sweden border down as far as Göteborg) (Figure 1).

Yates' correction for continuity was used in calculating  $\chi^2$  when the number of degrees of freedom was one.

## RESULTS

*Razorbills*

Sample sizes were 98 from Oslofjord, 31 from Telemark/Agder and 179 from Bohuslän. Most birds were relatively lightly oiled: 78% of 308 corpses had 30% or less oil cover on the plumage. All birds in the sample were in full winter plumage.

Petersen (1976) established that, in Puffins *Fratercula arctica*, the proportion of birds with a cloacal bursa diminished with age until only very few breeders possessed a bursa. This feature, therefore, could perhaps provide a useful (though not necessarily infallible) criterion for separating auks into adult and immature age-classes. The opportunity arose in the present data to compare bursa details with bill configuration in Razorbills, where the number of bill grooves increases with age to a certain point: first-year birds have smooth-sided bills without any grooves; second-year birds have a white groove; and three-year and older birds have one white and one to three black grooves on the bill (Salomonsen 1944). In the Skagerrak sample a very few adult birds still had a small bursa, whereas the great majority of first and second winter birds possessed a sizeable bursa; the intermediate bill stage was similarly intermediate in the proportions of birds with and without bursa (Table 1).

TABLE 1. BILL MORPHOLOGY AND DETAILS OF CLOACAL BURSA IN RAZORBILLS, SKAGERRAK, JANUARY 1981. ONLY BIRDS WHICH POSSESSED A BURSA WERE USED TO CALCULATE THE MEAN BURSA INDEX (LENGTH  $\times$  BREADTH).

<i>Bill type</i>	<i>Putative age</i>	<i>Sample size</i>	<i>Numbers with bursa</i>	<i>Mean bursal index (SE) (mm<sup>2</sup>)</i>
No grooves (00)	1st winter	26	24 (92%)	200 (26.5)
One white groove only (W0)	2nd winter	29	26 (90%)	143 (87.3)
One white groove, one black (W1)	? mainly immature	47	23 (49%)	107 (79.0)
One white groove, two or three black (W2/W3)	adult	196	9 (5%)	63 (70.4)

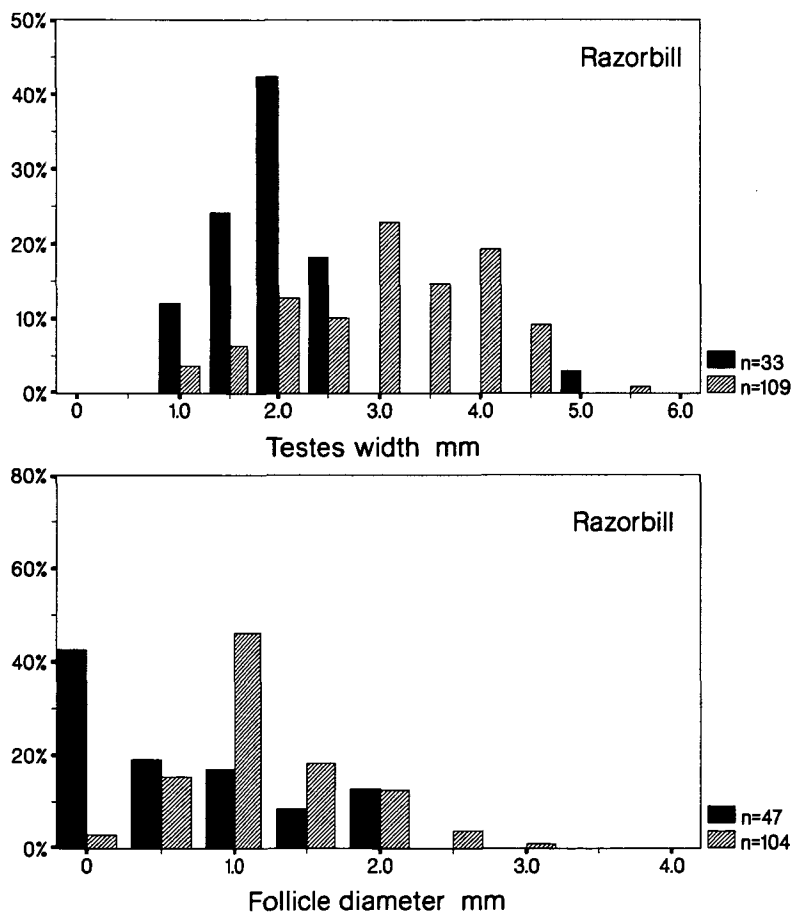


Figure 2. Frequency distribution of testis width in male and diameter of largest follicle in female Razorbills from Skagerrak, January 1981. Black bars represent birds with bursa, hatched bars birds without bursa.

As a further indication, gonad size varied in accordance with the presence or absence of the cloacal bursa. Testis width in males with bursa present was significantly smaller (median: 2.0mm) than in birds without bursa (median: 3.1mm) (Mann-Whitney U-test,  $U=618$ ,  $n_1=109$ ,  $n_2=33$ ,  $p<0.001$ ) (Figure 2). Furthermore, the maximum follicle diameter in females which possessed a bursa was smaller (median:  $<0.5$ mm) than in birds without bursa (median: 1.1mm) (Mann-Whitney U-test,  $U=1291$ ,  $n_1=104$ ,  $n_2=47$ ,  $p<0.001$ ).

These results indicate that the state of the cloacal bursa is a useful ageing criterion in Razorbills. In this study the presence or absence of the cloacal bursa is therefore assumed to distinguish juveniles from adults in other auk species as well.

Proportions of adults and immatures did not differ significantly between the regions ( $X^2=2.31$ ,  $df=2$ ,  $p>0.1$ ), the overall proportion of adults was 66% (Table 2). The sex ratios did not differ significantly from equality neither in adults ( $X^2=0.05$ ,  $df=1$ ,  $p>0.5$ ), nor in immatures ( $X^2=1.21$ ,  $df=1$ ,  $p>0.1$ ).

TABLE 2. AGE AND SEX RATIOS OF RAZORBILLS FROM DIFFERENT LOCALITIES AROUND THE SKAGERRAK, JANUARY 1981. THE AGE GROUP IMMATURE CONSISTS OF BIRDS WITH BILL GROOVE CODES 00/W0/W1, WHILE ADULTS ARE BIRDS WITH W2/W3. BILL GROOVE CODES ARE EXPLAINED IN "METHODS".

Region	Age group	Male	Female	Total
Oslofjord	adult	28	34	62 (66%)
	immature	18	14	32 (34%)
Telemark/Agder	adult	7	10	17 (55%)
	immature	3	11	14 (45%)
Bohuslän	adult	66	53	119 (69%)
	immature	23	31	54 (31%)
Total	adult	101	97	198 (66%)
	immature	44	56	100 (34%)

TABLE 3. MORPHOMETRY OF ADULT RAZORBILLS FROM SKAGERRAK, JANUARY 1981. THE TWO SUBSPECIES WERE SEPARATED USING A NONLINEAR REGRESSION ANALYSIS, WHICH GAVE ESTIMATES OF THE PARAMETERS  $k$ ,  $\mu$  AND  $\sigma$  IN A BINORMAL DISTRIBUTION MODEL (SEE TEXT). ALSO THE STANDARD ERRORS OF THESE ESTIMATES ARE GIVEN.

	$k$ Proportion (SE)	$\mu$ Mean (SE)	$\sigma$ Standard deviation (SE)	Discr. value	Overlap (%)
WINGLENGTH (n = 198)					
<i>A.t.islandica</i>	0.529 (0.0077)	197.39 (0.101)	3.48 (0.078)	204.10	2.70
<i>A.t.torda</i>	0.471 (0.0077)	213.70 (0.169)	4.98 (0.182)		
HEAD + BILL (n = 111)					
<i>A.t.islandica</i>	0.613 (0.1456)	91.06 (0.691)	2.18 (0.421)	93.79	10.52
<i>A.t.torda</i>	0.387 (0.1456)	95.87 (0.673)	1.66 (0.416)		
CULMEN LENGTH (n = 192)					
<i>A.t.islandica</i>	0.326 (0.0393)	31.29 (0.166)	1.11 (0.124)	32.84	7.97
<i>A.t.torda</i>	0.674 (0.0393)	34.98 (0.129)	1.52 (0.092)		
GONYS DEPTH (n = 195)					
<i>A.t.islandica</i>	0.573 (0.0086)	19.69 (0.019)	0.80 (0.018)	21.01	4.11
<i>A.t.torda</i>	0.427 (0.0086)	22.10 (0.021)	0.63 (0.020)		



The taxonomy of Razorbills is still not clarified, but according to the nomenclature of Vaurie (1965) and Cramp (1985), the two subspecies *A.t.torda* and *A.t.islandica* were probably involved in this incident. The two subspecies are recognized through differences in winglength and bill depth, with *islandica* generally being the smaller.

The frequency distributions of the four measurements collected from the Skagerrak birds (only adult birds with bill grooves W2/W3) are all assumed to be the simultaneous distribution of two independent normal distributions, one from each of the two subspecies (Figure 3). In order to obtain values of the relevant parameters of such a binormal distribution, a nonlinear regression assuming a binormal function was performed. See appendix for more details.

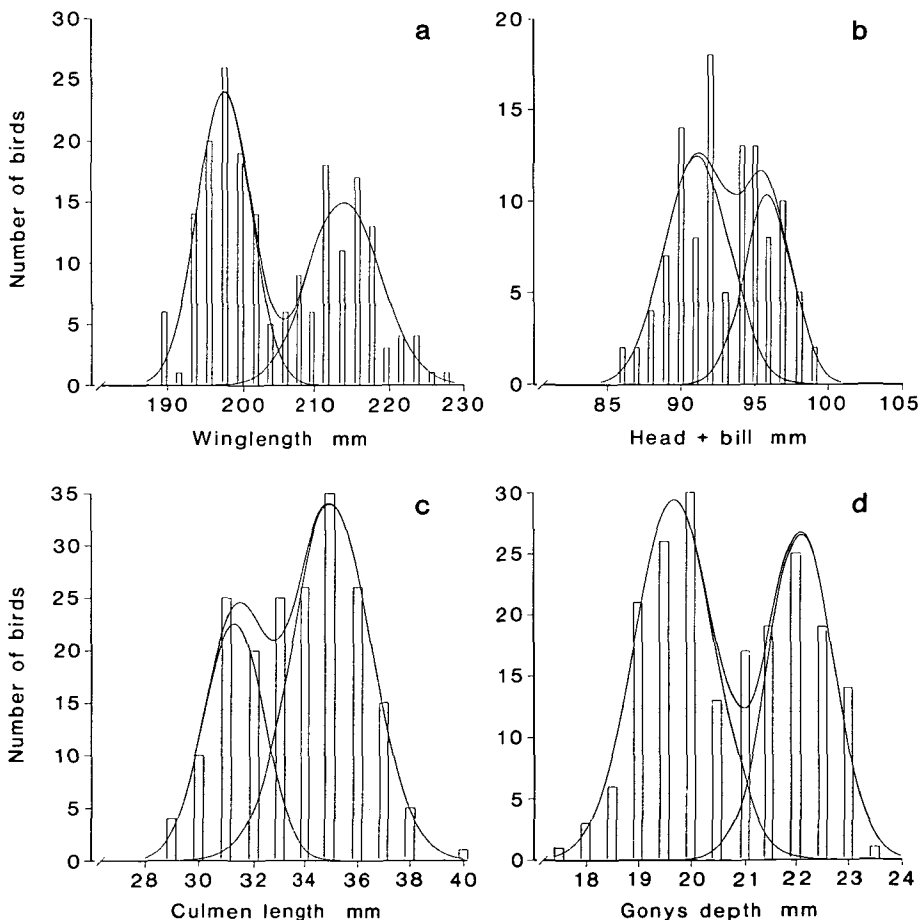


Figure 3. Frequency distribution of winglength(a), head + bill(b), culmen length(c), and gony's depth(d) of adult Razorbills from Skagerrak, January 1981. The best fitted binormal distributions are also drawn.

The results of these analyses are shown in Table 3, and the binormal curves obtained are drawn in Figure 3. None of the four distributions deviated significantly from the assumed binormality (Kolmogorov-Smirnov test,  $p > 0.2$  in all cases).

In the Skagerrak birds the best parameters for separating the two subspecies were winglength (2.7% overlap), and gonys depth (4.1% overlap) (Table 3).

In order to detect any biometrical differences between sexes, the nonlinear regression analyses described above were repeated separately for males and females. Only winglength and gonys depth were examined. There were no significant sexual differences in winglength in either subspecies, but in both cases males had deeper bills (Table 4). The assumption of two normal distributions used in the regression analysis of the total sample of adult birds therefore should not be severely biased by combining the two sexes.

TABLE 4. MORPHOMETRY AND STATISTICAL TEST RESULTS OF ADULT RAZORBILLS FROM SKAGERRAK, JANUARY 1981. THE CALCULATIONS WERE DONE FOR EACH SEX SEPARATELY. SEE LEGEND OF TABLE 3.

		$\mu$	$\sigma$		
	Sex	Mean (SE)	Standard deviation (SE)	t-value	t-test p-level
WINGLENGTH (n = 100 males, 93 females)					
<i>A.t.islandica</i>	males	197.24 (0.198)	4.29 (0.204)	0.28	>0.5
	females	197.43 (0.131)	2.82 (0.153)		
<i>A.t.torda</i>	males	213.70 (0.251)	4.78 (0.259)	0.07	>0.9
	females	213.78 (0.282)	5.60 (0.306)		
GONYS DEPTH (n = 99 males, 91 females)					
<i>A.t.islandica</i>	males	20.00 (0.036)	0.76 (0.033)	4.32	<0.001
	females	19.40 (0.019)	0.66 (0.020)		
<i>A.t.torda</i>	males	22.27 (0.034)	0.58 (0.032)	2.59	<0.05
	females	21.93 (0.026)	0.63 (0.029)		

In a scattergram of winglength against gonys depth of adult Razorbills the two subspecies clearly form one cluster of points each, although it is impossible to allocate all the individuals to a given group (Figure 4). However, by assuming the covariance within each cluster to be zero (no correlation between the variables within the subspecies as can be seen in Figure 4), it is possible to draw the 95% confidence ellipses for the two clusters (Figure 4).

Similar nonlinear regression analyses were also performed for the other age groups (according to bill grooves) of Razorbills. Only winglength and gonys depth were examined (Table 5). Again Kolmogorov-Smirnov tests revealed no significant deviation from the assumed binormality. The results show how both winglength and gonys depth generally increase with age.

The obtained estimates of the standard deviations (Table 5) seem to be more unreliable than for adult birds. The SD values were expected to be more or less similar, or to vary in a systematic way, within each subspecies. This was not the result in this case, probably because of small sample sizes. Therefore the pooled standard deviation for each group was calculated, assuming equal proportions of the subspecies within each group. The values obtained were for winglength: *islandica* 3.84, *torda* 4.65; for gonys depth: *islandica* 0.801, and *torda* 0.551. Using these values, the 95% confidence ellipses for all groups were constructed (Figure 5).

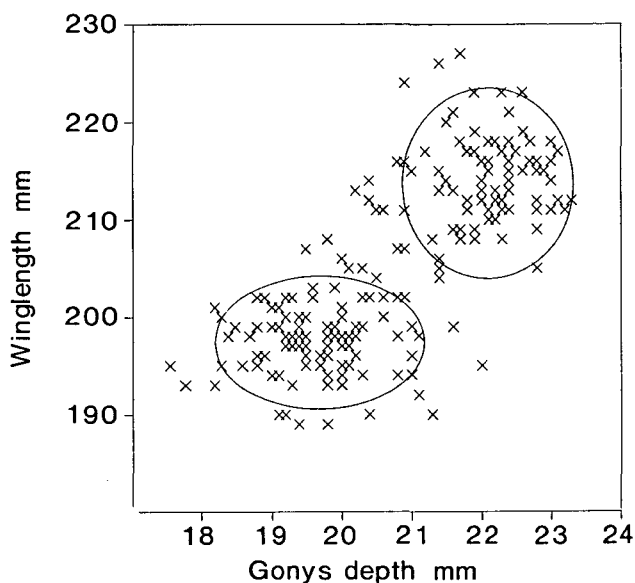


Figure 4. Winglength plotted against gonys depth of 195 adult Razorbills killed in Skagerrak, January 1981. The 95% confidence ellipses for the two assumed subspecies *A. t. islandica* and *A. t. torda* are drawn.

TABLE 5. MORPHOMETRY OF DIFFERENT AGE GROUPS OF ADULT RAZORBILLS FROM SKAGERRAK, JANUARY 1981. SEE LENDGEND OF TABLE 3. BILL GROOVE CODES ARE EXPLAINED IN "METHODS".

	Bill groove code	$\mu$ Mean (SE)	$\sigma$ Standard deviation (SE)
WINGLENGTH (n=198 (W2/W3), 47 (W1), 30 (W0), 27 (00))			
<i>A. t. islandica</i>	W2/W3	197.39 (0.101)	3.48 (0.078)
	W1	198.86 (0.579)	5.68 (0.526)
	W0	193.38 (0.180)	2.07 (0.244)
	00	188.59 (0.305)	4.13 (0.339)
<i>A. t. torda</i>	W2/W3	213.70 (0.169)	4.98 (0.182)
	W1	212.71 (0.576)	3.13 (0.581)
	W0	211.31 (0.196)	3.65 (0.262)
	00	206.41 (0.497)	5.22 (0.539)
GONYS DEPTH (n=195 (W2/W3), 46 (W1), 30 (W0), 27 (00))			
<i>A. t. islandica</i>	W2/W3	19.69 (0.019)	0.80 (0.018)
	W1	19.19 (0.004)	0.89 (0.004)
	W0	18.13 (0.110)	0.88 (0.089)
	00	14.73 (0.036)	0.86 (0.038)
<i>A. t. torda</i>	W2/W3	22.10 (0.021)	0.63 (0.020)
	W1	21.11 (0.004)	0.02 (0.001)
	W0	20.34 (0.104)	0.62 (0.088)
	00	16.92 (0.033)	0.24 (0.041)

The geographical breeding distribution of the two forms is as follows: *torda* in Norway, Sweden and the Baltic, and N W Russia, with *islandica* in Iceland, Faroe, British Isles, Helgoland, Channel Islands and Brittany – though nowadays scarce in the last three areas (Vaurie 1965, Cramp 1985). At the time of oiling, the two forms were evidently present in Skagerrak in considerable numbers, both as adults and immatures. The estimates of the proportion of birds in each subspecies (*k* in Table 3) seem to be quite unreliable, as the values obtained varied considerably with the morphometric parameter analysed, and especially culmen length gave a markedly different distribution to the other three measurements. However, by using the most consistent results, i.e. winglength and gony's depth, ca 55% of the adult birds were of the form *islandica*, while ca 45% were of *torda*.

In attempting to ascribe origins for the Skagerrak samples, measurements are compared to other samples of live or freshly dead adult Razorbills (Table 6). This procedure is considered preferable to a comparison with museum skins, since the latter may shrink by varying amounts – a median value of 2mm, though with a range of up to 6mm, was found in a sample of 58 Razorbills from Wales (Jones, in Morgan 1980). Morphometrics alone cannot help in deciding between Iceland, Faroe and the British Isles as the origin of the *islandica* complement, but two birds (adults when they died in the Skagerrak in 1981) had been ringed

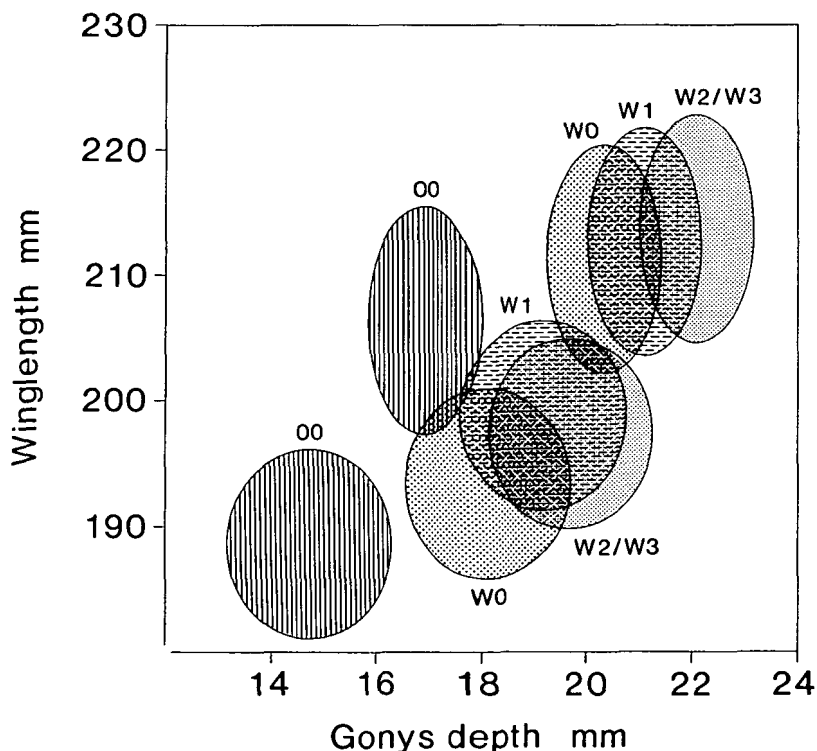


Figure 5. The 95% confidence ellipses of winglength and gony's depth of Razorbills of different age groups from the Skagerrak incident, January 1981. Bill groove codes are explained in "Methods".

TABLE 6. WINGLENGTH MEASUREMENTS FOR ADULT RAZORBILLS (LIVE OR FRESHLY DEAD, EXCEPT WHERE STATED).

Locality	Sample size	Mean (mm)	Standard deviation	Data collection
<i>A.t. islandica</i>				
Shetland, U.K.	62	197.8	4.0	M.L. Tasker
Grimsey, Iceland	36	196.1	4.0	PHJ
Great Saltee, Ireland	34	198.3	4.2	PHJ
Skagerrak <i>islandica</i>	105*	197.4	3.5	<i>This paper</i>
<i>A.t. torda</i>				
Vardø, NE Norway	73	211.6	5.9	R. Barrett
Røst, N Norway	41	208.5	5.8	TAN & OWR
Sweden (dried skins)	25	207.2	4.7	Salomonsen (1944)
Sweden (dried skins)	22	210.0	?	Vaurie (1965)
Skagerrak <i>torda</i>	93*	213.7	5.0	<i>This paper</i>

\* Estimated value.

in Scotland in 1973 and 1974, so evidently some northern British birds were involved. In fact, Mead (1974) had indicated that adult Razorbills from that region may well be found in the Skagerrak in mid-winter, even though the majority were more likely to be in the southern and eastern North Sea. Origins for the *torda* complement involved in the incident were north or north-east from the oiling. The Skagerrak sample of adults showed a mean winglength well above that for Vardø ( $t=2.25$ ,  $p<0.05$ ) and probably above that for Sweden (Table 6). So as well as birds from northern Norway and the Baltic, there may also be several from the Barents Sea coasts of Russia, an idea strengthened by the several recoveries in the Skagerrak of Razorbills winged at White Sea colonies (Bianki 1967) and on south coasts of the Barents Sea (Norderhaug *et al.* 1977).

### Little Auks

Sample sizes were: Oslofjord 45, Telemark/Agder 32 and Bohuslän 125. Most birds were relatively lightly oiled: 87% of 202 corpses had only 10-30% oil cover on the plumage, and only 2% of the sample were more than 50% oil-covered. Practically all birds were in full winter plumage (97.5% of 200) with the remainder intermediate between winter and summer plumage.

Very few corpses of this species have been examined previously, but if the cloacal bursa is an age indicator as is assumed in the larger auks, then just over three-quarters of the birds were adults, with an equal ratio of sexes in both age groups (Table 7). Testis width in males with bursa present was significantly smaller (median: 1.5 mm) than in birds without bursa (median: 2.5mm) (Mann-Whitney U-test,  $U=90.5$ ,  $n_1=66$ ,  $n_2=20$ ,  $p<0.001$ ) (Figure 6).

TABLE 7. AGE AND SEX RATIOS IN LITTLE AUKS (ALL SAMPLES COMBINED) FROM SKAGERRAK, JANUARY 1981.

Cloacal bursa	Putative age	Males	Females	Total
No bursa	adult	66	66	132 (77%)
With bursa	immature	20	20	40 (23%)

The maximum follicle diameter in females which possessed a bursa was smaller (median: <0.5mm) than in birds without bursa (median: 1.0mm) (Mann-Whitney U-test,  $U=176$ ,  $n_1=65$ ,  $n_2=21$ ,  $p<0.001$ ).

For winglength measurement, there was no significant difference between males and females in either age group, but adult wings (both in males and females) were significantly longer than those of immatures (Table 8). With bill depth at gonys, however, bills of adult males were significantly deeper than those of adult females (no difference between juvenile males and females), whilst adults had bills significantly deeper than those of immatures of both sexes.

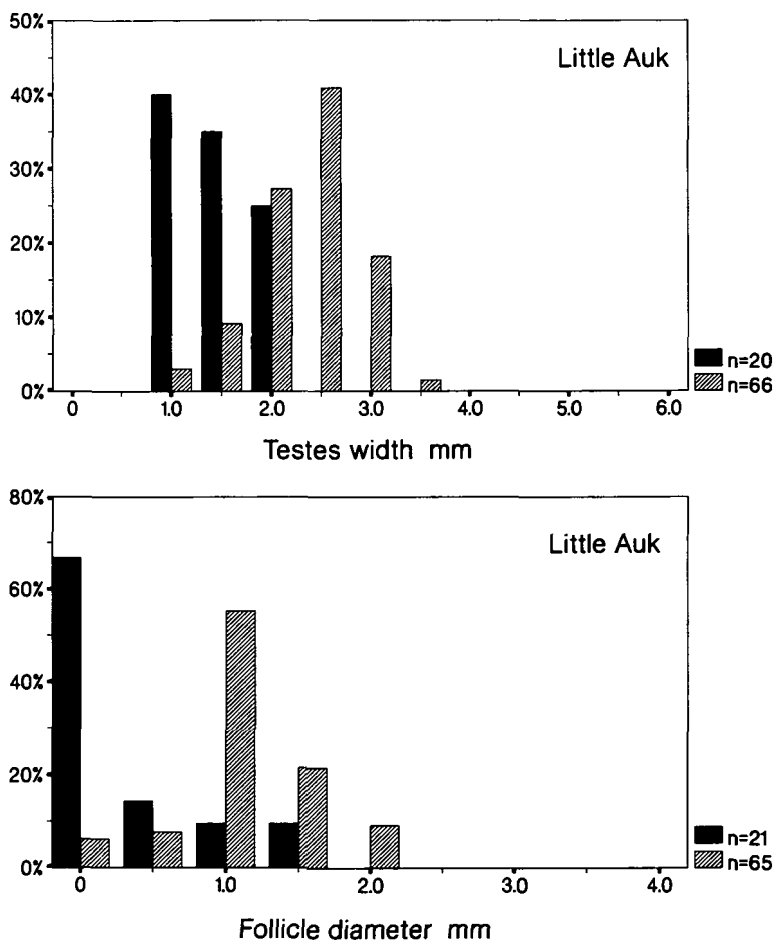


Figure 6. Frequency distribution of testis width in male and diameter of largest follicle in female Little Auks from Skagerrak, January 1981. Black bars represent birds with bursa, hatched bars birds without bursa.

TABLE 8. MEASUREMENTS AND STATISTICAL TEST RESULTS OF WINGLENGTH AND BILL DEPTH AT GONYNS FOR LITTLE AUKS, SKAGERRAK, JANUARY 1981.

	MALE		FEMALE		<i>t</i> -value	<i>t</i> -test <i>p</i> -level
	<i>Sample size</i>	<i>Mean (SD)</i> (mm)	<i>Sample size</i>	<i>Mean (SD)</i> (mm)		
WINGLENGTH						
Adult	65	126.4 (3.4)	66	125.9 (3.5)	0.83	>0.1
Immature	20	123.1 (4.4)	20	123.1 (4.3)	0.00	>0.9
( <i>t</i> -test ad-imm)	(t=3.08, p<0.01)		(t=2.66, p<0.01)			
GONYNS DEPTH						
Adult	58	8.61 (0.45)	58	8.22 (0.52)	4.32	<0.001
Immature	19	7.99 (0.40)	19	7.74 (0.59)	1.53	>0.1
( <i>t</i> -test ad-imm)	(t=5.68, p<0.001)		(t=3.17, p<0.01)			

Two subspecies of Little Auk were recognized by Salomonsen (1944) and Vaurie (1965): *polaris* from Franz Josef Land and possibly Severnaya Zemlya, with nominate *alle* through the remainder of the range of the species. The main distinguishing feature is the size, as indicated by winglength. With the large difference between sample means given in the literature (Table 9), the most which can be said is that the Skagerrak birds were representative of the larger end of the range of winglength measurements of the form *alle*, but without further series of measurements from various colonies, the area of origin of the Skagerrak birds cannot be precisely delimited.

TABLE 9. WINGLENGTH MEASUREMENTS FOR ADULT LITTLE AUKS.

<i>Locality</i> ( <i>Authority</i> )	MALE			FEMALE		
	<i>Sample size</i>	<i>Mean (mm)</i>	<i>Range (mm)</i>	<i>Sample size</i>	<i>Mean (mm)</i>	<i>Range (mm)</i>
<i>A. a. polaris</i>						
? Franz Josef Land (Vaurie 1965)	27	131.9	124-138	7	131.6	129-137
<i>A. a. alle</i>						
Svalbard (Vaurie 1965)	32	124.6	118-138	33	124.8	120-132
Greenland (Vaurie 1965)	20	120.2	116-124	20	120.1	114-125
Svalbard (Norderhaug 1980)	(185)	118.5	106-129	live birds, not sexed)		•
NW Greenland (Roby <i>et al.</i> 1981)	117	123.1	?	92	122.4	? *
Skagerrak ( <i>This paper</i> )	65	126.4	117-135	66	125.9	120-132 •

• Fresh specimens (all other dried skins).

*Guillemots*

Sample sizes were: Oslofjord 285 (with another 147 examined, but without bursa details); Telemark/Agder 113, and Bohuslän 428. Most birds were relatively lightly oiled: 72% of 802 corpses had only 10-30% oil cover on the plumage, and only 15% of the sample were more than 50% oil-covered. Most birds were in full winter plumage (92.9% of 497), 3.4% were in a transitional stage, and 3.7% were in summer plumage (part of the Bohuslän sample has been omitted from these calculations because unoiled birds were selectively collected).

In Razorbills the state of the cloacal bursa seemed to be a useful ageing criterion. Assuming this is also valid for Guillemots, 18% of the birds ( $n=802$ ) were adults (without

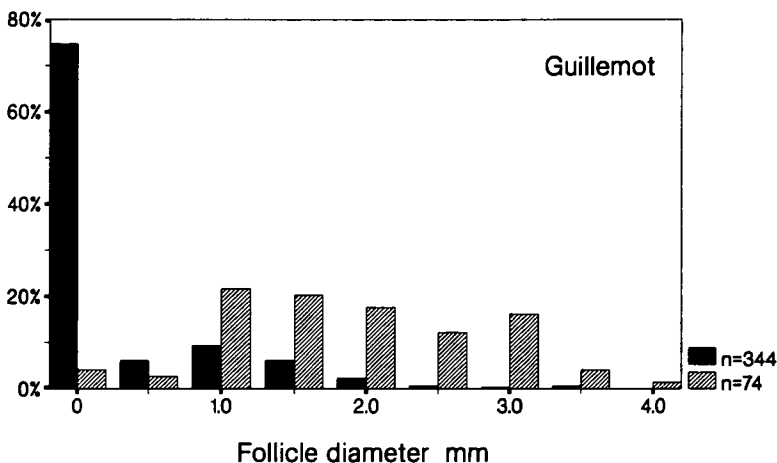
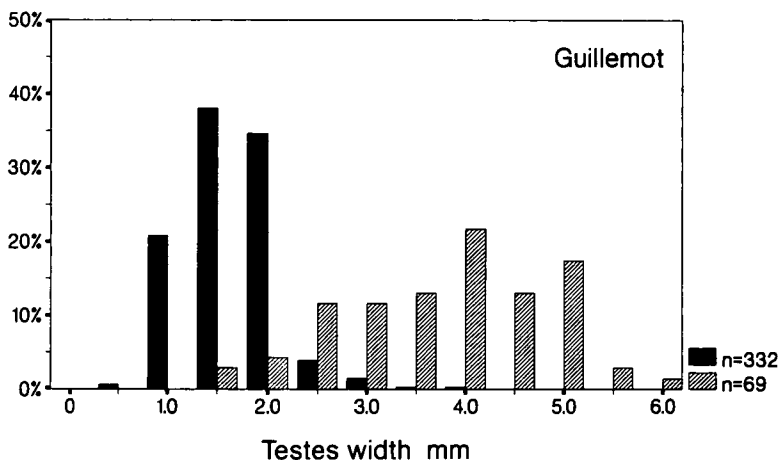


Figure 7. Frequency distribution of testis width in male and diameter of largest follicle in female Guillemots from Skagerrak, January 1981. Black bars represent birds with bursa, hatched bars birds without bursa.



TABLE 10. AGE AND SEX RATIOS AND STATISTICAL TEST RESULTS OF GUILLEMOTS FROM THREE LOCALITIES AROUND THE SKAGERRAK, JANUARY 1981.

Region	Age from bursa	Males	Females	Total	$\chi^2$ -test	
					$\chi^2$ -value	p-level
Oslofjord	adult	23	27	50 (18%)	0.18	>0.5
	immature	90	135	225 (82%)	8.60	<0.01
Telemark/ Agder	adult	9	12	21 (19%)	0.19	>0.5
	immature	44	43	87 (81%)	0.00	>0.9
Bohuslän	adult	36	34	70 (17%)	0.18	>0.5
	immature	190	159	349 (83%)	2.58	>0.1

bursa) and 82% immatures (with bursa), with no difference between regions ( $\chi^2=0.55$ ,  $df=2$ ,  $p>0.5$ ). The sex ratio in adults did not differ from 1:1 in either of the three regions, though in immatures there was a preponderance of females in Oslofjord, but no significant skewness in Telemark/Agder or in Bohuslän (Table 10). Testis width in males with bursa present was significantly smaller (median: 1.6mm) than in birds without bursa (median: 3.9mm) (Mann-Whitney U-test,  $U=674.5$ ,  $n_1=333$ ,  $n_2=69$ ,  $p<0.001$ ) (Figure 7). Also the maximum follicle diameter in females which possessed a bursa was smaller (median: <0.5mm) than in birds without bursa (median: 1.9mm) (Mann-Whitney U-test,  $U=2074.5$ ,  $n_1=346$ ,  $n_2=74$ ,  $p<0.001$ ).

Immatures were significantly smaller than adults in all measurements taken (winglength, length of head plus bill, culmen length and bill depth at gonys; Table 11). Females had generally longer wings, but smaller bills than males. The winglengths did not differ from a normal distribution within any of the four sex-age groups (Kolmogorov-Smirnov-test,  $p>0.05$  in all cases).

TABLE 11. MORPHOMETRY AND STATISTICAL TEST RESULTS FOR GUILLEMOTS, SKAGERRAK, JANUARY 1981.

	MALE		FEMALE		t-value	t-test p-level
	n	Mean (SD) (mm)	n	Mean (SD) (mm)		
WINGLENGTH						
Adult	68	206.4 (4.0)	73	208.4 (5.3)	2.50	<0.05
Immature	323	200.1 (4.8)	334	200.4 (4.5)	0.71	>0.1
(t-test ad-imm)	(t=10.17, $p<0.001$ )		(t=13.42, $p<0.001$ )			
HEAD + BILL						
Adult	34	114.9 (2.6)	32	112.1 (3.2)	3.97	<0.001
Immature	170	112.8 (3.7)	141	110.2 (3.1)	7.06	<0.001
(t-test ad-imm)	(t=3.58, $p<0.001$ )		(t=3.03, $p<0.01$ )			
CULMEN LENGTH						
Adult	61	49.6 (2.1)	68	47.6 (2.4)	5.15	<0.001
Immature	296	48.0 (2.6)	306	46.1 (2.4)	9.50	<0.001
(t-test ad-imm)	(t=4.51, $p<0.001$ )		(t=4.62, $p<0.001$ )			
GONYS DEPTH						
Adult	65	12.82 (0.66)	71	12.66 (0.64)	1.37	>0.1
Immature	305	11.86 (0.61)	319	11.54 (0.58)	6.85	<0.001
(t-test ad-imm)	(t=11.35, $p<0.001$ )		(t=14.64, $p<0.001$ )			

The taxonomy of Guillemots in N W Europe is complicated but, as a general rule, three clinal characters increase with higher latitudes (though showing occasional local variations): winglength, the proportion of bridled birds, and colour saturation in the plumage of the upperparts. The current nomenclature, following Vaurie (1965) and Pethon (1967), recognizes three subspecies in the region: *albionis* in Iberia, France, Helgoland, England, Wales and Ireland; *hyperborea* on the Murmansk coast and eastwards; and nominate *aalge* from the remaining areas – Iceland, Faroe, Scotland, Denmark, Norway and Sweden. As already mentioned, the shrinkage of dried study skins probably invalidates a direct comparison of the Skagerrak measurements with those of museum skins. However, in recent years a series of measurements has been made at a variety of breeding colonies (Table 12). Different workers were involved, but all used the maximum chord wing measurement method. Proportions of bridled birds increase from nearly zero in Iberia to over 30% in parts of northern Europe (Birkhead 1984). Back colour in *albionis* is pale greyish-brown, but the shade deepens through a dark grey-brown in the *albionis/aalge* intergrade one to almost black in the far-north populations of *aalge* and *hyperborea*. Efforts to refer samples of Guillemots to their natal origins must consider at least one of these three factors and preferably all three.

The overall proportion of bridled birds in the sample was 6.8% (of 950 examined). However, this feature can be difficult to detect in winter-plumaged birds, and the proportion bridled in those specimens with complete or almost-complete summer plumage was 13% (of 62 examined). Therefore, in a sample comprising 93% winter-plumaged birds – many with soiled head plumage – the parameter may not be completely reliable, and thus it will not be considered further in detail.

A wide range of back colour and of winglength measurements amongst adults indicated that more than one regional population was involved in the incident. Mean winglength increased with deepening wingcolour saturation (Table 13). For the adults it is likely that the three wings at the paler end of the colour spectrum represent the *albionis* type: colour types 3 and 4, comprising only 3% of the wing sample; the origin indicated is England or Helgoland. Three very long-winged birds of 221 and 222 mm – outliers of the distribution – are probably referable to the form *hyperborea*, with origins for 3% of the sample in N W Russia. The bulk of the sample comprises wings of colour and length representative of

TABLE 12. GUILLEMOTS: WINGLENGTH MEASUREMENTS FROM LIVE (OR IN SOME CASES FRESHLY DEAD) BIRDS FROM EUROPEAN BREEDING COLONIES.

Sample Locality	Mean size	Standard (mm)	deviation	Data collection
Vardø, NE Norway	256	213.0	5.7	R.T. Barrett & R.W. Furness
Røst, N Norway	63	209.6	5.2	TAN & OWR
Grimsey, N Iceland	93	207.1	3.5	PHJ
Ellidaey, SW Iceland	150	198.5	4.9	Grandjean (1972)
Foula, N Scotland	38	207.3	3.7	M.L. Tasker
Noss, N Scotland	65	207.3	3.7	B.F. Blake & T.J. Dixon
Fair Isle, N Scotland	91	206.3	4.0	PHJ
Canna, NW Scotland	91	203.9	4.8	R.F. Swann
Troup Head, NE Scotland	27	203.3	3.8	J. Hardey
Isle of May, NE Scotland	83	200.0	4.8	M.P. Harris
Great Saltee, SE Ireland	35	199.5	3.7	PHJ
Skomer, SW Wales	84	197.6	4.7	T.R. Birkhead
Skagerrak (adults only)	141	207.4	4.9	<i>This paper</i>

TABLE 13. WINGLENGTH MEASUREMENTS FOR EACH COLOUR TYPE OF GUILLEMOT, SKAGERRAK, JANUARY 1981.

Colour code	ADULT			IMMATURE		
	Sample size	Mean (mm)	Standard deviation	Sample size	Mean (mm)	Standard deviation
8 + 9 (dark)	31	210.1	5.7	50	200.8	4.1
7	31	207.1	4.3	121	200.6	4.6
6	25	205.4	5.1	79	200.4	4.7
5	0			41	199.2	4.7
3 + 4 (pale)	3	205.3	3.1	7	198.7	4.0

nominate *aalge*; the longest blackest wings (mainly Type 8 comprising 32% of the sample) may be birds from N Norway, whereas the remaining birds (mainly Types 6 and 7 comprising 61% of the sample) probably came from N Scotland, Faroe and S Norway. Ringing returns from Sweden and Denmark indicate that Baltic Guillemots rarely move westwards beyond the Kattegat (Baillie 1982), and so they were unlikely to have been involved in the present oiling incident in any numbers, but they cannot be excluded on purely morphometric evidence. Differences between winglength mean measurements for adults and immatures indicate that the winglength parameter (at this stage of our knowledge) cannot be used to fit the latter into an area of origin: information is lacking on growth rates over the period of immaturity in Guillemots, and this can only be resolved by a study of birds of known age and origin.

Rings found on oiled Guillemots proved the presence of one adult from Faroe, one bird from Helgoland, and one adult and 18 immatures from northern Scotland.

## DISCUSSION

The Skagerrak morphometric data would indicate that populations of Guillemots and Razorbills from Norway and Scotland might be affected, but the wide scatter of origins will spread the load of increased mortality over a wide range of breeding areas so that the impact may be scarcely noticed (even if monitoring procedures were able to detect them). A very tentative attempt to assign origins and ages is made below.

Using the minimum estimate of 100 000 birds oiled (Anker-Nilssen & Røstad 1981), approximately 9500 Razorbills were affected. The results from the morphometric analysis would indicate about 3750 adults and 1550 immatures of *A.t.islandica* (probably from Scotland and possible Faroe), and about 3100 adults and 1100 immatures of *A.t.torda* (probably from the Baltic and the Barents Sea). Using an estimate of 60 000 Guillemots oiled, perhaps 3500 adults and 15 500 immatures would have originated in N Norway, and 6700 adults and 30 000 immatures in Scotland (and probably S Norway and possibly Faroe), with small numbers from England and Helgoland, and Russia.

The impact of the Skagerrak oiling on breeding populations of auks at localities ranging from Russia and the British Isles is difficult to gauge. Razorbills will be more immediately affected because of the greater proportions of adults killed, whereas the effect on Guillemots will not be evident until the immatures would have recruited into the breeding stock. Oiling during the winter of 1980-81 was particularly severe on British auks in the North Sea and English Channel, and Baillie & Mead (1982) considered that this might result in a decline of up to 6% in Razorbill breeders and up to 9% in Guillemots over a number of years. However, there are few data on the compensatory density dependent mechanisms – such as earlier breeding – which are likely to occur in affected auk populations.

The morphometric details currently used in determining auk subspecies (or identifiable sectors of the cline) are in general not fine enough to identify the specific breeding colonies a sample of birds belong to. Not only is the comparison of measurements taken from live birds with those from dried museum skins of limited value (e.g. Jones, in Morgan 1980). The measuring techniques have changed through time as well, and such techniques usually differ between persons using the same method. This makes the data in the literature difficult to interpret. Two sets of data may help clarify the situation: details from auks at numerous breeding colonies throughout the European range of each species (to establish the fundamental characteristics for each locality and region) and equally detailed data for birds of known age and origin at various ages and seasons (to show, for example, how winglength may change with increasing age). This last could easily be achieved by encouraging the collection, examination and museum curation of carcasses of ringed auks.

An additional approach has been successfully used in fisheries research: stocks within species have been separated on, for example, blood group antigens (Cushing 1964) where differences can be detected at a finer level than by the traditional meristic and morphological methodology. Certainly in Guillemots, some of the clines in morphological characters are sufficiently steep to suggest very little interchange between adjacent populations (that is, most birds probably return to breed in regions, if not the exact colonies, where they were born), so with a presumed small gene flow, an approach involving genetic characters might enhance the detection of origins of birds involved in incidents away from their breeding colonies.

Increased ringing is critical to obtain a good understanding of auk movements, and needs to be concentrated in those areas where little ringing has been done to date. It is essential to make available data on numbers ringed at each colony as well as the recovery information. Coupled with the methods discussed above, increased ringing effort could further elucidate the dispersion patterns through the year of regional auk stocks throughout western Europe.

In many oilspill incidents, ornithologists have tended to concentrate effort on a wide geographical coverage of affected coasts (to count the total numbers of beached birds) rather than on making careful examination of the birds affected. Consequently, data on age and sex composition have usually not been obtained, even though the total numbers, and the species composition, of the kill may have been well known. However, efforts to improve this situation, especially with regard to Guillemots and Razorbills, were made by, for example, Bourne *et al.* (1967) for birds from the Torrey Canyon incident, and by Jones *et al.* (1982b) in the Amoco Cadiz incident, but the principle of more intensive data collection is still not well established for birds involved in European oilspills. Such procedures, when carried out over a period of years, could produce valuable information for auks – often at seasons and localities for which few data would otherwise have been available. The Skagerrak results, reported here, show how the sex and age proportions present in the three main auk species were affected. This is an important finding since, at present, practically nothing is known about the dispersion of sexes, and knowledge about the dispersion of different age groups is limited to well-studied colonies, in European auks outside the breeding season.

In Europe, some auk populations are increasing and others declining. Reasons for these changes are usually unknown, even if a variety of plausible factors has been invoked in explanation. Victims of the Skagerrak oilspill showed once again the great vulnerability of concentrated numbers of auks, and they indicated that populations from many widespread localities could be affected by such an incident. The true impact of these catastrophic oilspills on breeding populations is still unknown, but the opportunities must be taken to learn more about the ages, sex and origins of the birds involved in them, as a contribution to greater knowledge (and hence better-informed conservation) of auks in Europe.

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## SUMMARY

Sample corpses of auks killed in a Skagerrak oilspill were examined. These comprised 308 Razorbills *Alca torda*, 202 Little Auks *Alle alle* and 826 Guillemots *Uria aalge*. Presence and size of cloacal bursa was linked to age (as indicated by bill grooves) in Razorbills. The sex ratio did not differ from 1:1 either in adults or in immatures in any of the species. In Razorbills, adults comprised 66% of the kill. About 55% were of the form *islandica* (probably from Scotland, possibly Faroe), 45% *torda* (probably from the Baltic and the Barents Sea). In Little Auks, 77% were adults, and all birds were of the nominate form *alle*. In Guillemots 18% were adults. A very few birds were of the forms *albionis* and *hyperborea*, the great majority being nominate *aalge* (probably mainly from Norway and Scotland).

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TAN: Norwegian Institute of Nature Research, Tungasletta 2, N-7004 Trondheim, Norway.

PHJ: c/o Marine Science Laboratories, Menai Bridge, Gwynedd, United Kingdom.

OWR: Zoological Museum, Sarsgt. 1, N-0562 Oslo 5, Norway.

## APPENDIX

*Ole Wiggo Røstad*

In many biological treatments the distribution of a sampled variable is assumed to be normal, and the mean ( $\mu$ ) and the standard deviation ( $\sigma$ ) can easily be calculated analytically. However, sometimes the population from which the variable is sampled consists of a mixture of two subpopulations, each of them normally distributed with independent (and different) means and standard deviations, but an individual sample can not be allocated to the correct subpopulation. Picturing such a distribution in a histogram will typically show two tops, one for each subpopulation. The analytically evaluated mean and standard deviation for the whole population have no biological relevance.

Problems arise when the two subpopulations have more similar mean values, and thereby overlap to a greater extent. In a histogram such a distribution will look like a "broad" normal distribution.

The parameters describing the simultaneous distribution of two independent normal distributions, the binormal distribution, are not possible to calculate analytically. They can be estimated using graphical methods (Harding 1949, Bhattacharya 1967), but it is a tedious procedure, and is not very reliable because it includes fitting lines through points by eye. Fortunately, it is possible to estimate the parameters of a binormal distribution numerically using a computer. The idea is to perform a nonlinear regression. The normal distribution can be represented as:

$$y = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

where  $\mu$  denoted the mean and  $\sigma$  the standard deviation (Sokal and Rohlf 1981). If the population consists of a mixture of two normally distributed subpopulations (1 and 2) having independent means ( $\mu_1$  and  $\mu_2$ ) and standard deviations ( $\sigma_1$  and  $\sigma_2$ ), the function describing the distribution will be:

$$y = \frac{k}{\sigma_1\sqrt{2\pi}} e^{-\frac{(x-\mu_1)^2}{2\sigma_1^2}} + \frac{1-k}{\sigma_2\sqrt{2\pi}} e^{-\frac{(x-\mu_2)^2}{2\sigma_2^2}}$$

where  $k$  denotes the proportion of the population belonging to subpopulation 1 (and thereby  $1-k$  the proportion belonging to subpopulation 2),  $0 < k < 1$ . This function could be used for the nonlinear regression, but better estimates are obtained if the cumulative form of the function is used. Additionally, necessary input for the Kolmogorov-Smirnov-test, used for testing the fit of the data to the binormal distribution, is achieved when using the cumulative form:

$$y = \int_{-\infty}^x \frac{k}{\sigma_1\sqrt{2\pi}} e^{-\frac{(x-\mu_1)^2}{2\sigma_1^2}} + \frac{1-k}{\sigma_2\sqrt{2\pi}} e^{-\frac{(x-\mu_2)^2}{2\sigma_2^2}} dx$$

Different computer software can be used for the calculations. We have used the *BMDP* statistical computer software (Dixon 1983) to perform the regression analysis, and the *IMSL* mathematical computer library (IMSL 1987) to estimate the integral.

The output from the *BMDP* programme consists of the best estimates of the five parameters, as well as the standard error of these estimates. Also necessary input for the Kolmogorov-Smirnov-test is supplied.

In a binormal distribution there will always (at least theoretically) be an overlap between the two subpopulations. The 'best' discriminating value, i.e. where the same proportions of the two subpopulations are extended into each other, is given by:

$$d = \frac{\mu_1\sigma_2 + \mu_2\sigma_1}{\sigma_1 + \sigma_2}$$

The numeric amount of this overlap, i.e. the proportion of individuals allocated to the 'wrong' subpopulation when using  $d$  as the discriminating value, can be found using standard area considerations under the normal curve, see e.g. Sokal & Rohlf (1981). The actual values are tabulated by Rohlf & Sokal (1981), or they can be calculated numerically by integrating the normal distribution function using e.g. the computer subroutine *DCADRE* (IMSL 1987).

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# The Mallophaga of Leach's Petrels *Oceanodroma leucorhoa* from North Rona, Scotland.

*J. A. Fowler and D. Hodson*

The frequency distributions and population structures of Mallophaga infesting a number of procellariiform species have been described. Frequency distributions conform with a negative binomial distribution which suggests a "fundamental model" upon which, for example, more accurate statistical analyses (by means of precise data transformations) may be contemplated. Examination of Mallophagan population structures – especially those obtained from a series of consecutive samples – is a means of investigating population dynamics and may even provide an insight into the relationship between the ectoparasite and the host itself (see, for example, Fowler & Price, 1987, for a review of recent work in this field).

The Mallophagan populations of British breeding procellariiform species were described by Fowler & Miller (1984). However, only 7 Leach's Petrels *Oceanodroma leucorhoa* were deloused in that study. This paper describes the frequency distribution and population structure of Mallophaga collected from a much larger sample.

## METHODS

Leach's Petrels were mist netted in the vicinity of the old village on North Rona, Western Isles (59° 10'N, 05° 48'W) between 3-17 July 1987. Catches were sometimes augmented by the use of a tape lure. It was not possible to assign individuals to age, sex or breeding class categories. Birds were deloused in glass vessels saturated with ethyl acetate vapour, exactly as described by Fowler & Cohen (1983). Ectoparasites thus removed were stored in 70% ethanol.

## RESULTS

One hundred Leach's Petrels were deloused, yielding 149 Mallophaga. All but nine of these were *Halipeurus pelagicus* Denny 1842, for which the mean ( $\bar{x}$ ) was 1.4 per bird, the variance ( $s^2$ ) 3.04 and the median 1.7. The remaining Mallophaga comprised *Saemundssonina incisa* (8) and *Austromenopon* sp.(1) These lice are found on a number of small petrel species (R.L. Palma pers. comm.) The frequency distribution of *Halipeurus pelagicus* is shown in Figure 1A, together with the expected frequencies (closed circles) of a negative binomial distribution based on the exponent  $k=1.121 \pm 0.397$  estimated from the sample data. The observed distribution is clearly in excellent agreement with that predicted by the negative binomial model ( $X^2=1.55$ , 3.d.f., NS).

Individuals of *Halipeurus pelagicus* were readily sorted into size classes corresponding to 1st, 2nd, 3rd instar nymphs, adult males and adult females. The population structure is depicted in Figure 1B, and reveals a structure dominated by older age-classes.

## DISCUSSION

It is of interest that the dominant louse on the Leach's Petrel is the "elongate" *Halipeurus pelagicus* – the same species as the dominant louse on the Storm Petrel *Hydrobates pelagicus*.



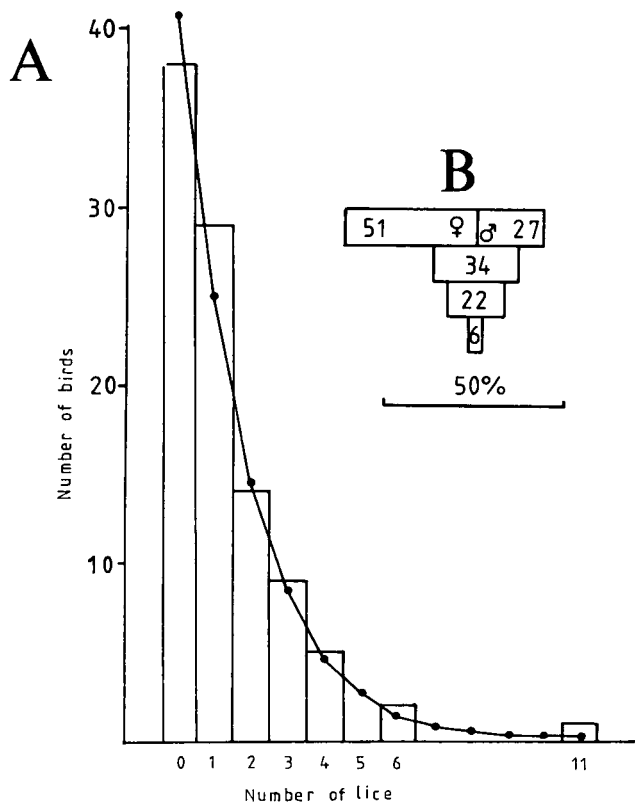


Fig. 1 A: Frequency distribution of *Halipeurus pelagicus* on Leach's Petrels. Joined closed circles are the expected frequencies of a negative binomial distribution; B (inset) : Population structure of *H. pelagicus* on Leach's Petrels in July 1987; each "tier" in the structure represents, in ascending order, 1st, 2nd, 3rd instar nymphs, adults. Numbers within the structures are the numbers of lice obtained.

The close agreement of the frequency distribution of the louse on Leach's Petrels with a negative binomial model comes as no surprise (e.g. Fowler & Price, 1987). However, the values of the mean and binomial exponent,  $k$ , are considerably lower than for similar Mallophaga on Storm Petrels and Wilson's Petrels *Oceanites oceanicus*, and result in a very much more positively skewed distribution, in which most individuals have zero or few lice, but in which most lice are found on a few birds.

The population structure of *Halipeurus pelagicus* is clearly dominated by adult classes. The proportion of nymphs in a louse population peaks when the population is in a vigorously reproducing phase (Marshall, 1981). When reproduction rates decline, so too does the proportion of nymphs, as their more ephemeral instars moult into the longer-lived adults. The structure observed therefore suggests that, at the time of sampling, breeding activity was waning, corresponding to the observations of *Philoceanus robertsi* on Wilson's Petrels *Oceanites oceanicus* in January and *Halipeurus pelagicus* on Storm Petrels in September (Fowler & Price, 1987).

## ACKNOWLEDGEMENTS

This study was conducted as part of the Rutland VI Form College Expedition to North Rona. We are grateful to several members, especially Jacqueline Vincent, for help with the fieldwork. We are grateful to R. L. Palma for confirming the identification of the lice.

## SUMMARY

The frequency distribution of an elongate feather louse *Halipeurus pelagicus* infesting Leach's Petrels conforms well with a negative binomial model. Its population structure suggests that, in July, the louse is in a declining state of breeding activity.

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# The distribution of Shetland Black Guillemots *Cephus grylle* outside the breeding season.

Peter J. Ewins and David A. Kirk

## INTRODUCTION

Although the main breeding concentrations of Black Guillemots *Cephus grylle* occur in the high Arctic (Nettleship & Evans 1985), the restricted light conditions and increased ice cover in winter forces many birds from these northern populations to move south. The general pattern appears to be of greater dispersal in higher latitudes (Cramp 1985). Very little information exists on *Cephus* distribution or ecology outside the breeding season. The limited accounts of winter distribution further south in the range suggest a regular dispersion in shallow inshore waters (Andersen-Harild 1969, Haftorn 1971, Nilsson 1982, Lack 1986), with some immatures wintering well away from the natal colony (Salomonsen 1967, Myrberget 1973, Petersen 1981, Brown 1985). Within the British Isles, Witherby *et al.* (1941) considered that some individuals from northern areas moved south in winter, "though not as a rule to any great distance beyond the normal breeding range", and the BTO Winter Atlas project has recently confirmed these views (Lack 1986).

The *Esso Bernicia* oil incident in December 1979 highlighted the vulnerability of seabirds in Shetland to oil pollution outside the breeding season: Black Guillemots were badly affected, with 633 oiled corpses found in the vicinity of the oil terminal and in Yell Sound (Heubeck & Richardson 1980). It was known from a few accounts that following breeding, adult Black Guillemots congregate in moult flocks (Bianki 1967, Heubeck 1981, Petersen 1981), where they shed all their flight feathers simultaneously and remain flightless for a few weeks (Salomonsen 1944, Storer 1952). In the event of an oil spill, such large concentrations of flightless adults would be unable to fly away. Since Black Guillemots were thought to be comparatively sedentary in Shetland they would be vulnerable to oil pollution throughout the winter months too.

As part of ecological studies of Black Guillemots in relation to the North Sea oil industry in Shetland (Ewins 1986), this paper reports on surveys of autumn and winter distributions and investigates various determining factors. Breeding distributions for Shetland and Orkney are presented in Ewins & Tasker (1985).

## METHODS

### *Autumn moult surveys*

Much of the Shetland coastline was covered between mid August and late September 1982-84 in searches for moult concentrations, but a few counts from 1980-81 have also been used (supplied by M Heubeck). More detailed studies of moult timing had found this to be the optimum period for surveying moult flocks (Ewins 1988). Foula was not surveyed and coverage was poor in parts of northwest Shetland. Since Black Guillemots only rarely occurred in water deeper than 40m outside the breeding season (Ewins 1986), surveys were restricted to areas of water up to this depth only. White and grey birds were often difficult to detect on the water, so counts were not attempted when winds exceeded force 4, or sea states rose above 2 (International Sea State Code), and lee shores were selected whenever possible.

Shallow water areas amongst offshore islands were surveyed from a slow-moving boat: at large concentrations of birds the engines were stopped and a number of 360° scans were made. Counts from land were made by walking the coastline and making repeated, slow scans from vantage points at c.200m intervals. A telescope with a 20× wide angle lens, mounted on a tripod, proved invaluable for this work. Attention was focussed on bays, mouths of voes (long, fjord-like inlets) and offshore island groups, since it quickly became apparent that moult flocks favoured such areas.

Since regular counts at some sites, both within and between autumns, found numbers to be fairly stable during the optimum period [eg. Ewins (1988)], data used in these analyses are gathered from the 5-year period 1980-84. For moult flocks counted on more than one occasion the maximum count has been used. Raw data are presented by Ewins & Kirk (1985).

#### *Winter surveys*

Between late October and mid February there is a daily movement of birds from communal overnight roosts on the sea, usually in the lee of islands or large cliffs affording some protection from heavy seas, to the foraging grounds. These may be anything from 0.5 to 8km apart. Thus in the 1982-83 and 1983-84 winters counts in this period were made of birds on the foraging areas, between 1 hour after sunrise and 1 hour before sunset. After mid February morning attendance and the level of heterosexual activity at breeding colonies increased sharply (Ewins 1985). Counts were made in those 10-km, squares for which coverage of water less than 40m deep could be completed (usually within a day), usually by combining boat and land-based counts. Survey methods were similar to those used for the autumn moult work, but with the exception of the 10-km squares near to the Sullom Voe oil terminal (for which maximum counts have been used) each square was only counted once. More detailed observations in Lerwick and Scalloway harbours showed that numbers on the feeding grounds varied very little from week to week in winter (pers.obs.).

#### *Sample coastal stretches*

From May 1982 to June 1984 monthly counts were made of birds on foraging areas along 6 sample stretches of coast of different exposures. Counts were made in winds not exceeding force 4, in good light conditions, between 1000 and 1600 GMT, and as near to the middle of the month as possible. Coastal exposure ranged from 1 (very sheltered) to 8 (fully exposed to heavy seas) (ITE 1975). 'Exposed' coasts refer to those with values from 6-8, and 'sheltered' those from 1-5. Count methods were similar to those used for land-based counts during autumn and winter surveys. Birds clearly associated with breeding areas (ie. incubating birds flushed off the nest) were omitted.

In all surveys age determination was attempted only for birds seen clearly within 200m and in good light and weather conditions.

## RESULTS

#### *Autumn moult distribution*

Concentrations of moulting adults occurred throughout Shetland, but were dispersed rather irregularly (Figure 1). Since the moult areas appeared to be traditional, with a significant correlation between years for moult counts at 10 sample sites ( $r=0.98$ ,  $P<0.001$ ), pooling the data from a number of years was probably justified. Although some areas were poorly covered, the sum of maximum counts for each moult area was 9609 birds, mostly adults. This figure represents 81% of the pre-breeding adult number, and suggests that few major moult

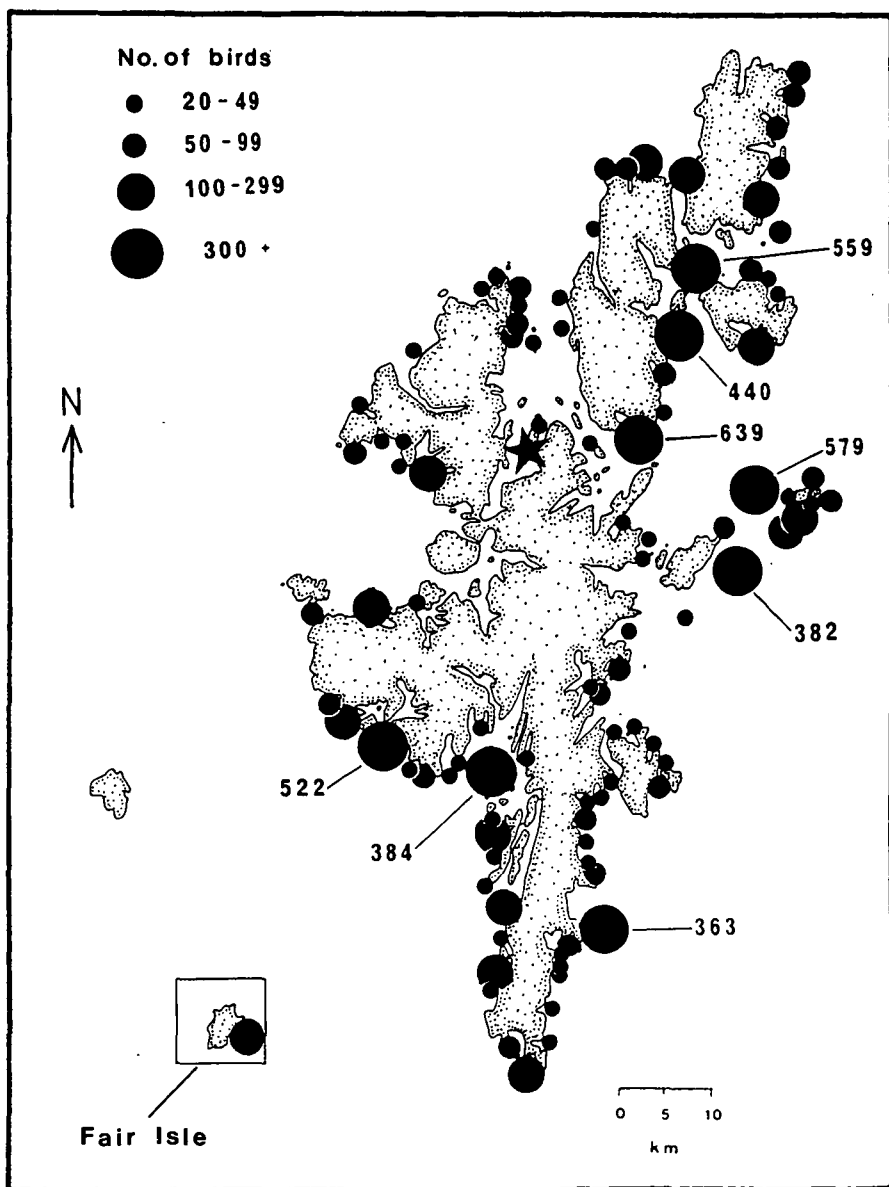


Figure 1. The size and distribution of autumn moult concentrations in Shetland. Only the maximum count for each site has been used. Sullom Voe Oil Terminal (★).

concentrations were overlooked. Flocks occurred in water less than 40m deep in bays, at the mouth of voes, and amongst offshore island groups – sites which afforded suitable feeding conditions as well as some protection from heavy seas. The cohesiveness of the moult flocks changed according to the birds' activities – compact when roosting but more dispersed when feeding. In general, densities were often similar to those seen off the colonies in the pre-breeding period. Most adults were observed in moult flocks of more than 20 birds. For 97 separate flocks, 52% contained 20-49 birds, 27% had 50-99, 13% had 100-299, and 8% contained more than 300 birds.

Juveniles were much more evenly dispersed than adults at this time and the proportion of juveniles was significantly lower in moult flocks than in other areas during the autumn moult period (4.1% vs. 11.9%,  $G=17.5$ , 1 d.f.,  $P<0.001$ ), although there was considerable variation in the proportion of juveniles in areas away from moult flocks, possibly due to small sample sizes.

A comparison between autumn moult flock and pre-breeding numbers in parts of 11 distinct regions [locations shown in Ewins & Tasker (1985)] for which coverage was complete, revealed no significant correlation ( $r=0.26$ ,  $P>0.1$ ), emphasizing the lack of any general tendency to moult near breeding sites. The extent of shallow water areas did not appear to influence moult distribution, since there was no significant correlation between area of water less than 40m deep and adult moult totals in the 11 regions ( $r=0.39$ ,  $P>0.1$ ). Some regions supported relatively few moult flocks despite having some large areas of shallow water; this was because the shallow areas were very exposed to the open sea. In contrast, the four regions supporting more adults during the autumn moult period than in the breeding season all had groups of small islands, amongst which shelter could be found during rough autumn weather, from any direction.

#### *Winter distribution*

Complete coverage was achieved for nineteen of the 10-km squares. Marked differences were found in total numbers among squares (Figure 2). Combining results for all squares surveyed, the average density of birds on foraging areas in winter was 13.1 birds per km<sup>2</sup> of water not greater than 40 m deep. The sheltered shallows between Fetlar, Unst and Yell (ie. squares D & E) were very important foraging areas in winter. There was a highly significant positive relationship between winter totals and the area of water (km<sup>2</sup>) not deeper than 40m within the square:

$$\text{Total no. birds} = 12.1 \times (\text{Shallow water area}) + 12.7; r=0.8, 17df, P<0.001.$$

The total number of birds recorded during pre-breeding surveys in each square (ie. adults associated with breeding areas, plus immatures and other adults away from the colonies) was also significantly correlated with winter numbers ( $r=0.71$ ,  $P<0.001$ ) and the slope of the regression line differed significantly from that of  $y=x$  ( $t=2.93$ , 17 d.f.,  $P<0.01$ ) (Figure 3). The total number of birds recorded in the squares in winter (3308) was only 74% of the pre-breeding total (4478), but some squares contained more birds in winter (eg. D,F,G,K,L etc.).

To investigate the importance of shelter in winter, we used the results of surveys conducted by the Institute of Terrestrial Ecology (ITE 1975), in which coastal exposure was scored at each point along the coast intersected by the 1-km Ordnance Survey grid. We calculated the percentage of intersections within each 10-km square for which the exposure rating was 6 or above, to give an index of coastal exposure for the square. The ratio of winter : pre-breeding numbers was negatively correlated with this exposure index ( $r=-0.53$ , 17 df,  $P<0.05$ ), indicating that the more exposed coastlines supported fewer Black Guillemots in winter.

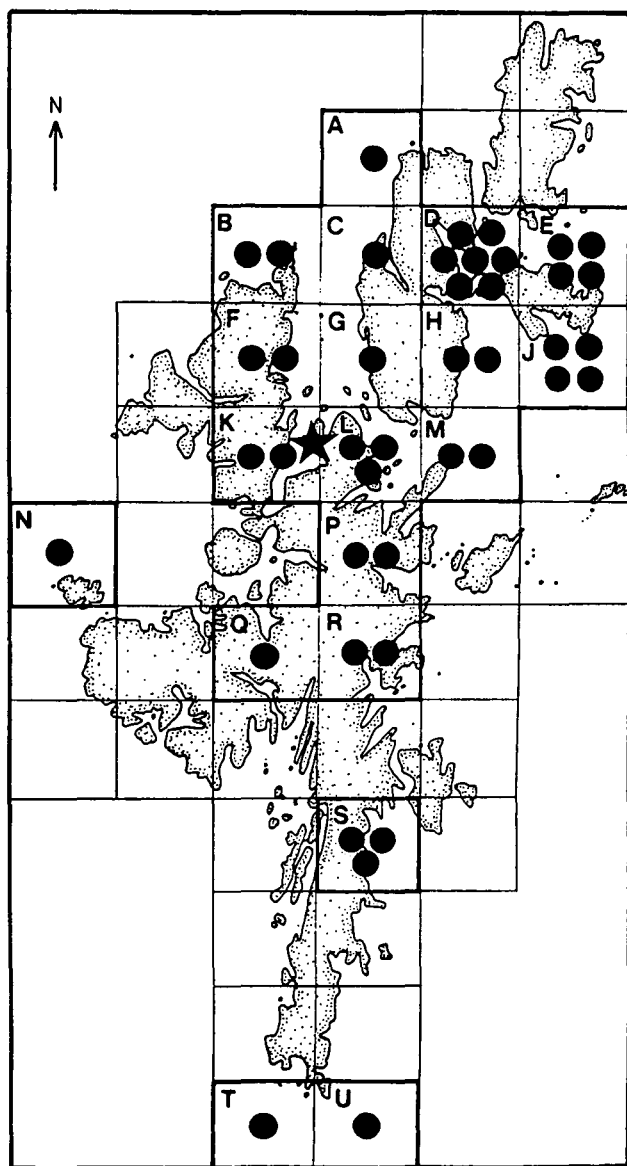


Figure 2. Winter numbers in selected 10-km squares. Each filled circle represents up to 100 birds. Sullom Voe Oil Terminal (★).

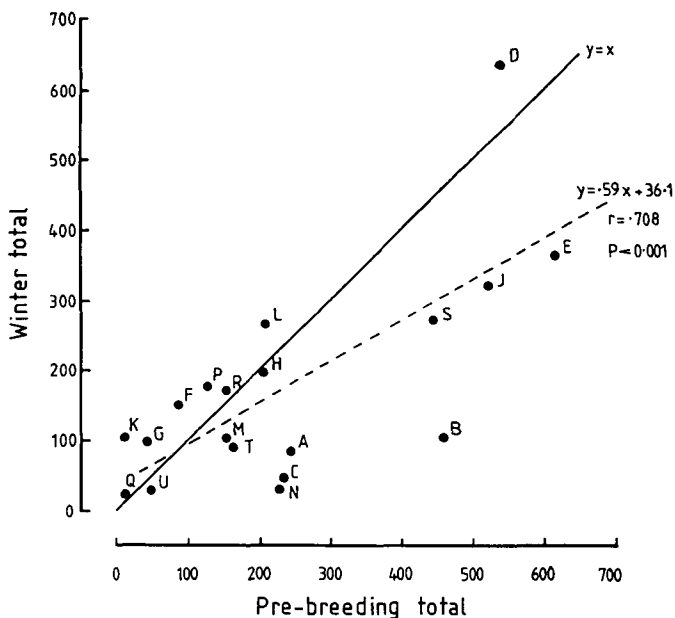


Figure 3. The relationship between winter numbers and total numbers recorded in the pre-breeding surveys for the nineteen 10-km squares shown in Figure 2.

Examination of Figure 3 bears this out: squares D, F, G, K, L and P have large areas of sheltered inshore waters, and support more birds in winter than in summer.

The mean ( $\pm$ se) percentage of immatures in winter (excluding the central Yell Sound islands area – square L and southern part of G), based on ageing of a random sample of at least 10 birds in each of 12 squares, was  $13.1 \pm 2.8\%$ . The % immatures in winter in the central Yell Sound islands area (42.6%) was significantly greater than elsewhere in Shetland ( $G=125.7$ , 1 df,  $P<0.001$ ). When this sample was included, the overall winter figure rose to 18.2% immatures. That the age composition in winter in the vicinity of the Sullom Voe oil terminal was somewhat unusual, and not just a result of immatures congregating in sheltered inshore waters, was supported by the significantly lower percentage of immatures in the superficially similar inshore area between Fetlar, Unst and NE Yell (11.6% immatures;  $G=73.0$ , 1 df,  $P<0.001$ ). Although after 6 years Black Guillemot numbers in Sullom Voe itself had nearly returned to pre-*Esso Bernicia* levels, the percentage of immatures in the area prior to the oil spill was not known. However, in a sample of 91 corpses collected in January and February 1979 following the *Esso Bernicia* incident, 21% were immatures – significantly lower than the 43% recorded during the 1983-84 winter in the same area ( $G=5.89$ , 1 df,  $P<0.05$ ).

#### *Seasonal changes in numbers at sample coastal stretches*

Monthly counts at sample foraging areas revealed fundamental differences in the pattern of usage through the year between exposed and sheltered coasts. The three sample stretches of exposed coastline each supported breeding concentrations, the birds feeding in the relatively



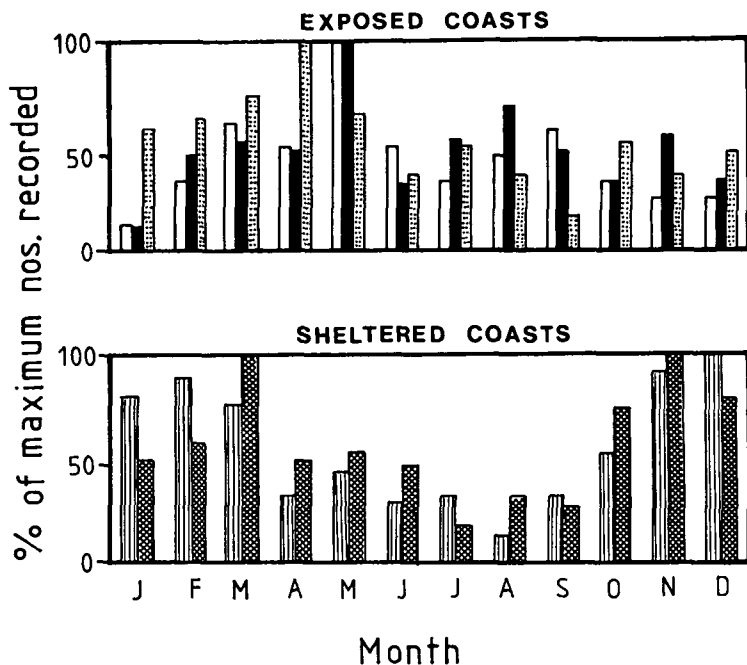


Figure 4. Monthly variation in numbers of birds foraging along sample stretches of exposed and sheltered coasts. Maximum counts, and total lengths of coastline (in brackets) were, for exposed coasts: 24 (2.5km), 50 (4.5km), 44 (5km); and for sheltered coasts: 26 (4km) and 87 (8km).

narrow belt of shallow water adjacent to the coast. The two stretches of sheltered coastline lacked suitable breeding habitat and both contained large expanses of shallow water.

Along exposed coasts numbers increased from January to April-May, then declined from June onwards. In contrast numbers in sheltered inshore waters were highest through the winter, declined steadily until July-August, then rose steeply in the late autumn (Figure 4). The actual number of individuals foraging along the exposed coasts during the breeding season would have been much higher than suggested by the histogram because birds associated with breeding sites were omitted from these counts, an unknown number sat tight on eggs, and others may have foraged outside the census area. Thus, the highest numbers occurred along exposed coasts in summer, and along sheltered coasts in winter.

The mean proportion of immatures present at the 5 sample sites, and in a total of 15 other areas, was significantly higher along sheltered (range 10-50%) than along exposed coasts (range 2-19%) at all times of year (Two-way ANOVA,  $F=14.0$ ,  $P=0.014$ ).

#### *Movements away from Shetland*

Analysis of ringing recoveries reported to the BTO up to November 1987 revealed that both immatures (<2 years old) and adults (>2 years old) from Foula and Fair Isle were recovered at much greater distances from the breeding colony than those elsewhere in Shetland. There was no obvious seasonal pattern to the dispersion of Foula and Fair Isle birds, with recoveries

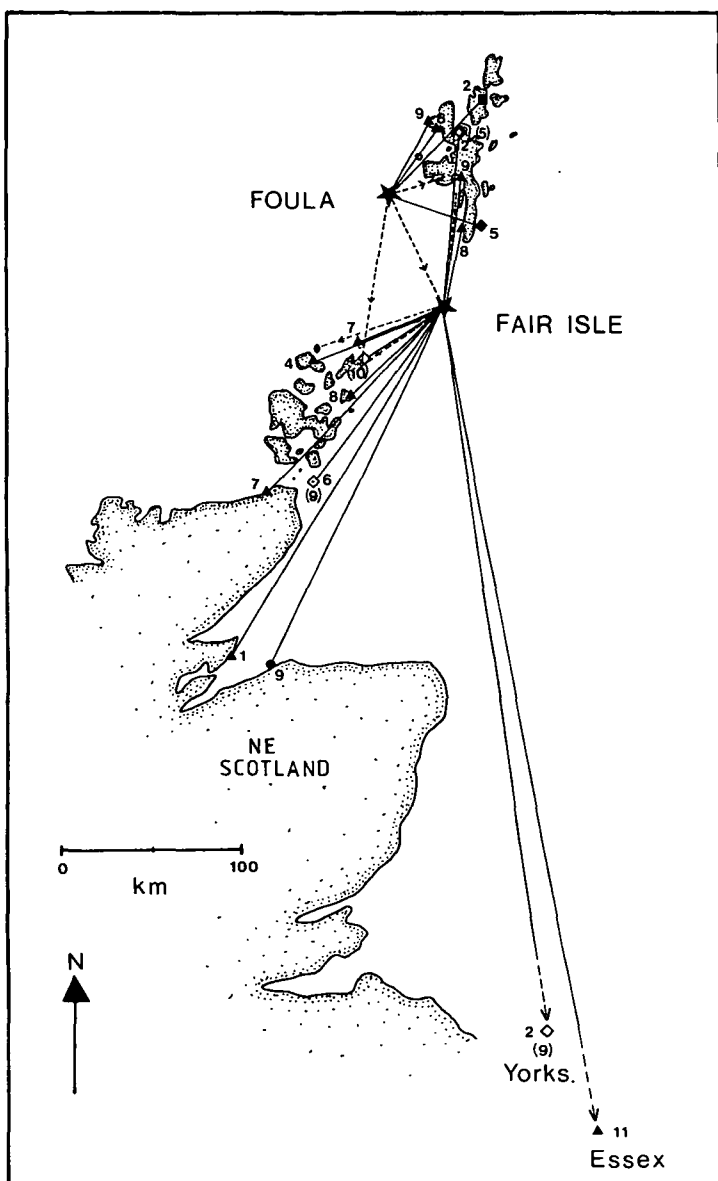


Figure 5. Recoveries of Black Guillemots ringed as adults (dashed line) and chicks (solid line) on Foula and Fair Isle. The symbol at each recovery site for birds ringed as chicks represents the age at death: ▲ 1st year; ● 2nd year; ■ 3rd year; ● 4th yr; ◇ (n) nth year. The month of recovery is given next to each symbol.

occurring both during and outside the breeding season, mostly in the Shetland and Orkney archipelagos (Figure 5). From over 1000 birds ringed in the main group of Shetland islands there have been no recoveries further than 14 km from the breeding colony; median recovery distance for immatures was 5 km ( $n=6$ ), and 6 km ( $n=5$ ) for adults. The corresponding figure for Foula/Fair Isle immatures was 64 km ( $n=16$ ) and 53.5 km ( $n=20$ ) for adults. To date there have been no recoveries in Shetland of birds ringed elsewhere.

During numerous boat journeys in Shetland outside the breeding season Black Guillemots were hardly ever noted in water more than 40 m deep or further than 2 km from land. However, on Fair Isle there was a "spectacular influx" on 20-21 October 1981, including a flock of 119 (F.I.B.O. 1982), and small numbers were seen flying south during autumn seawatches (A del-Nevo pers. comm.). Recent extensive surveys of seabirds from ships recorded no Black Guillemots outside the breeding season in deeper waters off NE Scotland (Tasker *et al.* 1987).

## DISCUSSION

### *Autumn distribution*

This appears to be the first detailed study of moult flocking in Black Guillemots. The majority of adults congregated in moult flocks after breeding, whereas juveniles dispersed more evenly around the coastline.

A few adults were found during the autumn moult period in groups of fewer than 20 birds, but most occurred in larger flocks, which were dispersed more irregularly around the coast than were adults in the pre-breeding period (see Ewins & Tasker 1985). The largest moult concentrations occurred amongst groups of small islands or in sounds between larger islands – areas which were sheltered from heavy seas and autumn gales from any direction. Flightlessness imposes several restrictions, perhaps the most important being the inability to move quickly to alternative feeding areas and sheltered roost sites. It prevents birds from feeding in strong tidal currents (which are often favoured foraging areas) because they would be unable to fly back up-current to resume the diving sequence. Diving capabilities are probably little affected by lack of flight feathers; however, since observations in winter showed that birds propelled themselves underwater with half-closed wings, with the primaries folded back beneath the secondaries. Moult flocks occurred in areas of water less than 40 m deep, away from strong tidal currents, and in situations providing shelter from heavy seas. The low reported numbers of moulting birds in parts of northwest Shetland partly reflects poor coverage, but suitable sheltered shallows are scarcer here than in other parts of Shetland.

The reason why adults undergo the autumn moult in flocks is unclear. Flocking behaviour is often considered to be a response to predation pressure, minimizing the risk to an individual of predation (Perrins & Birkhead 1983), but as far as we are aware Otters *Lutra lutra*, Great Skuas *Catharacta skua* and man are the only recorded predators of fully-grown Black Guillemots in Shetland. In many hundreds of hours observing birds on the water (both in flocks and as scattered individuals) we never witnessed any attempted predation. Although Grey Seals *Halichoerus grypus* will attempt to take auks and other seabirds on the water (Corbet & Southern 1977, del-Nevo 1986), and frequently occur along with the more numerous Common Seal *Phoca vitulina* in the vicinity of Black Guillemot moult flocks, we never saw any attempted predation (by either species), and seals were tolerated at very close quarters. We think it unlikely that predation constitutes a sufficiently strong selective pressure to be a major factor accounting for widespread flocking behaviour during the

autumn moult period. It is possible that adults simply congregate to moult at rich feeding areas in suitable sheltered conditions. The regular use of similar environments in different areas lends support to this as the main reason for autumn moult flocking.

#### *Winter distribution*

Interpretation of the finding that numbers in winter in the areas sampled were only 74% of those in the pre-breeding season is complicated by various sources of bias. We tended to concentrate winter survey work on 10-km squares with more sheltered, inshore waters since coverage could usually be achieved in one day. However, suitable breeding habitat was often scarce in such areas and although total numbers were compared, pre-breeding surveys were not of birds on the foraging areas. Poor light conditions and the problems of detecting winter-plumage birds on the sea may have led to under-estimation of numbers then. In the pre-breeding surveys, most birds occurred within 300 m of the shore, whereas in winter birds were scattered throughout shallow areas, and some were undoubtedly overlooked even on the calmest days. However, bearing in mind that winter numbers were actually somewhat higher than recorded, the overall density of birds in water not deeper than 40 m was c.13 per km<sup>2</sup>, compared with c.17 per km<sup>2</sup> in spring/summer (Ewins 1986). Although allowance should be made for some over-winter mortality, the overall impression is that numbers in winter were only slightly lower than in the pre-breeding period.

Late winter surveys in the Canadian arctic found densities of only 0.17 birds per km<sup>2</sup> along offshore pack ice edges (Renaud & Bradstreet 1980), and along the Baltic coasts of south and east Sweden, Nilsson (1982) recorded similar low densities of between 0.01 – 0.2 birds per km<sup>2</sup>. The high winter densities in Shetland probably reflect the relatively sedentary habits of Black Guillemots there (ultimately related to the warming influence of the Gulf Stream, and food availability), compared with more northerly populations which show greater dispersal in winter, often in response to ice conditions (Brown 1985, Cramp 1985).

The most important winter concentration in Shetland occurs in the Fetlar-Unst-NE Yell area, but some birds are found along all coasts. In winter, sheltered inshore areas support greater numbers than during the pre-breeding period, and exposed coastlines open to heavy seas are frequented by relatively few birds. Immatures in particular tend to avoid exposed coastlines, where their lack of foraging experience would be a severe handicap. Although only a few Black Guillemots were found dead on Shetland beaches following severe gales (pers. obs.), Formosov (1946) has recorded large numbers perishing in winter storms. Movement to sheltered inshore waters in winter has not previously been documented for this species, but some Pigeon Guillemots *Cephus columba* breeding along 'open' Pacific coasts migrate to inshore wintering grounds, protected from heavy seas (Scott 1973, Oakley 1981). Prey availability may be reduced along exposed coasts in winter since some inshore fish and invertebrates migrate to deeper water and crevices then, possibly due to increased water turbulence (Sverdrup *et al.* 1942, Gibson 1969), and lower temperatures and light intensity lead to reduced activity of sandeels (Woodhead 1966).

Foula and Fair Isle are small isolated islands with little sheltered water during winter gales and heavy seas. Birds roost ashore more regularly there than elsewhere outside the breeding season (R A Broad pers. comm.; pers. obs.), and we suspect that both islands are inhospitable to Black Guillemots in winter. Accordingly, post-fledging and post-breeding dispersal is greater than for the main group of Shetland islands: some birds disperse to the main Shetland and Orkney archipelagos, and a few Fair Isle birds have ventured down the east coast of Scotland, and once to Essex. Thus, excepting Foula and Fair Isle birds, most Shetland Black Guillemots probably never stray further than 10-15km from their natal colony.

## ACKNOWLEDGEMENTS

This work was carried out via the Edward Grey Institute of Field Ornithology, contracted to the Shetland Oil Terminal Environmental Advisory Group. We thank both organisations for their support, and the British Trust for Ornithology for permission to use ringing recovery data. Considerable help with the surveys was provided by Nick Dymond, Paul Fisher, Billy Fox, Martin Heubeck, Mike Richardson, Bobby Tulloch and Robin Wynde. David Cairns, Mike Harris, Chris Perrins and Mark Tasker kindly improved earlier manuscripts.

## SUMMARY

In Shetland adult Black Guillemots undergo the autumn moult in flocks of between 20 and 600 birds, in areas of shallow water which afford protection from heavy seas. Juveniles disperse more evenly around the coastline initially, but many move to more sheltered, inshore waters in winter. Adults also tend to avoid exposed coasts in winter. Some Foula and Fair Isle birds move considerable distances outside the breeding season, but elsewhere in Shetland most birds probably never stray further than 10-15 km from the natal colony. The mild winters and large areas of sheltered inshore waters in Shetland provide relatively good conditions for overwintering Black Guillemots, and densities in winter are much higher than those recorded elsewhere.

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## BOOK REVIEWS

HARRISON, P. 1987. *Seabirds of the World: A photographic guide*. Pp. 317 incl. 152 of colour plates and 24 of line drawings, numerous maps. Christopher Helm, London. £15.95. ISBN No. 0-7470-1401-9.

Peter Harrison's earlier (1983) *Seabirds: An identification guide* was extremely well received and the revised edition (1985) is now an essential part of every birdwatcher's library. The present book is truly pocket-sized but contains 741 colour photographs illustrating the vast majority of the world's seabirds. It also includes divers and marine grebes.

The book's reputation and sales will be made on the photographs. These were chosen to show identification features and are mostly of birds in flight or on the sea. "Some reviewers would no doubt have preferred portraits but this is a book intended for the field guide fraternity". The author quite rightly makes no apologies for this. The selection of photographs is awe-inspiring and the species covered are the stuff of twitcher's fantasies. Some photos are just magnificent (e.g. Great Shearwater, some Storm petrels), others show field characters to great advantage or morphological features that may convince doubters that some taxonomic decisions are soundly based (e.g. Chilean Skua). Many are intriguing. Why should a Craveri's Murrelet look so like a Dipper? Why does the Tahiti Petrel have such long wings and a small head? The production of the plates (and indeed of the whole book) is excellent. A few of the photos are, as the author admits, disappointing. Some groups of seabirds are just not photogenic. I cannot remember seeing a decent photo of any diving petrel, let alone one in flight. Other species are extremely rare. The challenge is given – get a better photo and send it in for the next edition. Surely you can get a better shearing Manxie but it might be more fun to venture to the Pacific for swimming or flying auklets.

The text consists of very short species accounts and useful distribution maps. There is also a 24 page section of good pen drawings for flight identification of tubenoses. No series of photographs can ever take the place of good field guide drawings but these do give a new and often extremely useful perspective of even quite familiar species. Every ship's bridge will doubtless soon have a copy of this book. Anyone likely to read *Seabird* will probably have a copy of *Seabirds: An identification guide*. They should get the photographic guide too. Doubtless there are a few minor errors to be found in it, but I can't bring myself to worry about them. The book is extremely good value.

M.P. Harris.

FREETHY, R. 1987. *Auks: an ornithologists' guide*. Pp. 208. Blandford, Poole. £14.95. ISBN 0713715979.

Of all the seabird families the auks stand out as the most diverse, the most beautiful and the most interesting. They also include some of the seabird species most under threat from Man's activities. The last ten to fifteen years have seen an enormous expansion in our knowledge of auks, and the appearance of Ron Freethy's book is particularly timely: this is the first popular account of the biology of auks. The book starts off with a general, introductory chapter, followed by eight chapters dealing with natural taxonomic groupings, e.g. guillemots *Uria* spp., auklets, and puffins etc., in turn. The final chapter considers auks in the modern world and deals with factors affecting populations such as predators, commercial fishing and pollution.

Ron Freethy has reviewed the alcid literature, particularly the more historical material, very thoroughly. His writing style is good, clear and straightforward, and each chapter is packed with information. I found Chapter 3 on the Great Auk particularly interesting, especially some of the quotes from the older literature, for example that of Fleming (1822) on moulting. This chapter would have been even more interesting if Freethy could have referred to Bengtson's (1984, Auk 101:1-12) classic paper on this species and if he had ignored the idea that the Great Auk might still (1986) exist in the Hebrides!

The chapters on the extant species cover the following aspects: habitat, morphology, distribution and status, behaviour and breeding, and food and feeding. The distribution of each species is indicated by a map, but these unfortunately provide only a rough indication of where each species breeds and winters, and in my copy it appears that 13 species all breed in South America as well as in the northern hemisphere. The text is broken up by numerous black and white sketches of auks which some readers may find attractive, by some good black and white photographs, and some excellent colour plates.

It would be surprising if in a book of this size and scope, there were not some omissions and short-comings. The most misleading short-comings are his insouciant interpretation of the facts and

indiscriminant use of reliable and unreliable sources. For example on p.80 the north-south cline of bridled Guillemots is interpreted thus. It will be advantageous for a Guillemot to know where its partner's eyes are during bill-fencing in the darker northern spring. Therefore a feature, like the bridle, which makes the eyes more obvious will be of selective value. On p. 89 we learn that Guillemots stick their eggs on to the ledge with guano to prevent them blowing away. On p. 104 referring to Brunnich's Guillemot; "as with other species of auk, its diet is exclusively fish". Interestingly, on p. 95 we also discover that Brunnich's Guillemot is "restricted to the North Atlantic and is not found in the North Pacific". On p. 68 we learn that Razorbills sometimes lay a clutch of two eggs. Freethy also tends to assume that all information is equally reliable, whether it is anecdotal or based on a scientific study, whether the sample size is three or three hundred. For example he cites Witherby's *Handbook of British Birds* for the incubation and 'fledging' periods of the Guillemot and Razorbill. A further problem concerns the references. Any ornithologist wishing to use this book to get into the primary literature is likely to encounter difficulties. The names of several authors are incorrectly spelt in the text, are not cited in the Bibliography, or are cited incompletely, in an annotated form, or incorrectly.

Notwithstanding these reservations, this is a very readable account of auk biology for anyone interested in the early history of the subject.

T. R. Birkhead

FURNESS, R.W. 1987. The Skuas. Pp.368, 30 black and white plates. Illustrated by J. Busby. T. and A.D. Poyser, Staffordshire. £18.00. ISBN 0-85661-046-1.

Poysers strike again with another fine book on seabirds. Following Bryan Nelson's and Mike Harris' Gannet and Puffin books, Bob Furness has written about the seabirds which have occupied much of his time in the past 15 years. The book starts with a review of skua systematics and the history of the Great Skua in the North Atlantic. Furness concludes, on the basis of naturally fragmentary evidence, that Great Skuas did not breed in northern latitudes much before the 16th century. Evidence indicates that the North Atlantic bird is most closely related to the very sedentary Falkland Skua. These two suggestions make me wonder if man had any sort of hand in introducing the species to the North Atlantic.

The breeding distribution and population sizes of the various skuas are reviewed, followed by a chapter on migration patterns. One criticism here is the rather odd choice of examples of the distribution of skuas at sea: Long-tailed Skuas off southern Africa and Argentina. Rather too much emphasis is placed on results of ringing to extrapolate other distributions of birds at sea. Various larger scale surveys of birds at sea are not mentioned. Chapter 5 reviews the various theories on causes of reverse sexual dimorphism in skuas and concludes that the female's large size is caused by her role in defending the young against predation.

Skua behaviour is discussed next, followed by chapters on food and feeding and kleptoparasitism. Much of this is based on observations in the breeding season, with only four short paragraphs on the non-breeding period. This is not surprising, but there is a choice area for study here. The thorny subject of plumage polymorphism is reviewed, with a variety of conclusions on the causes behind such polymorphism. Furness suggests that the various colour phases may be only a secondary effect of the actions of some genes. No doubt this subject will continue to be an area of further research.

Chapters 10 to 12 cover the breeding biology of the birds, with Chapter 13 being on population dynamics. The final three chapters cover various aspects of the interaction between man and skuas. Much of these three chapters is based on the work of the author on pollutants of seabirds, and on a variety of "problems" with skuas in Shetland. The chapters make some predictions on the future fortunes of skuas in Shetland and some well-reasoned discussion about ways in which skua conservation might be advanced.

I enjoyed this book and, as with many books, was pleased to see a lot of extra detail often not present in scientific papers. I felt that the book tends to over-emphasise the author's own research; it is certainly not comprehensive on Long-tailed Skuas. The book will sit in a prominent place on my shelves, and I suggest that all Seabird Group members should own a copy.

Mark L. Tasker



MEDMARAVIS & X. MONBAILLIU (Eds.) 1986. Mediterranean Marine Avifauna: Population Studies and Conservation. Paris, France (NATO ASI Series, Series G: Ecological Sciences, Vol 12) XX, 535 pp. Hard cover DM248, -. ISBN 3-540-16092-2.

Although the Mediterranean Sea has, for centuries, provided an attractive focus for leisurely birdwatching, scientific research on its avifauna has been sporadic and very localised. The availability of what data have been collected has perhaps been restricted by the diversity of languages and apparent lack of communication between those involved in field research. This volume represents an important reassessment of the situation, the techniques employed, the emphasis for future research and the value of cooperation.

In March 1986, an international group of ornithologists met at Alghero, Sardinia, to attend the NATO Advanced Workshop on Population Dynamics and Conservation of the Mediterranean Marine Avifauna. Participants were invited on the basis of either their experience of field research on Mediterranean seabirds or their expertise in the areas of population dynamics and impact assessment. Papers presented during the workshop, and published in this volume, fall within the following categories: national census surveys; data banks and census techniques; population control of invading species; demography and population fluctuations; impact assessment; and conservation and wildlife management.

The proceedings of this first Mediterranean seabird symposium represent a valuable source of information regarding the distribution and population sizes of many species within the Mediterranean. They provide an indication of ongoing changes within the Sea with regard to population levels, the interactions between species and the threats facing the rarer species. Inevitably, Audouin's Gull enjoyed attention disproportionate to its population size. However, far from being repetitious, the reports from widely separated study sites provided an interesting opportunity to compare the birds' nesting conditions, biologists' techniques and the species' future prospects.

These proceedings were published within ten months of the workshop for which the editors and publisher must be commended. In the haste, however, the overall standard of translation of papers into English has suffered. Although the desire to retain a flavour of the 'Latin style' is appreciated, incorrect English surely makes its contents less accessible to the international public. The papers were not refereed and therefore of variable scientific standard. Northern European readers may be confused by the editors' decision to refer to the Herring Gull *Larus argentatus michahelles* as the Yellow-legged Gull *Larus cachinnans*. At £60 a copy this book is unlikely to find its way into many personal libraries but is certainly worth consulting for those with an interest in the distribution of seabirds within the western Mediterranean, in particular, and for those conservationists and wildlife managers concerned with marine avifauna.

This book is also important for what it represents – a minor revolution in field research and conservation within the Mediterranean. Decisions were taken during this meeting which may help to rationalise future research. Agreements were reached on ringing protocol, census techniques and cooperative ventures to maximise effectiveness and coverage.

This spirit of cooperation is embodied within this volume in the important Alghero Declaration 1986. The participants felt the need to express their concern for the well-being of the avifauna of the Mediterranean. In the Declaration they emphasised the urgent need for further scientific research and drew international attention to the many Mediterranean seabird colonies and roosts threatened with extinction. In particular special protection was sought for ten internationally important breeding and wintering sites which are currently unprotected.

Tricia Bradley

## THE SEABIRD GROUP 1988

*The Seabird Group* was founded in 1966 to circulate news of work in progress on seabirds and to promote cooperative research. It is run by an Executive Committee composed of nine elected members and maintains close links with the three major British national ornithological bodies – the British Ornithologists' Union, the British Trust for Ornithology, and the Royal Society for the Protection of Birds. Membership (£5 per annum, £2.50 for students and pensioners) is open to all with an interest in seabirds; for details please contact the Secretary (address below) – payment by banker's order and deed of covenant helps the Group.

*Current Executive Committee.* The present committee comprises: Chairman T.R. Birkhead, Secretary P.J. Ewins, Treasurer R.W. Furness, I. Hepburn, M. de L. Brooke (Editor of *Seabird*), also D. Budworth, C.S. Lloyd, P. Monaghan and B. Zonfrillo. K. Taylor is a co-opted member, representing the interests of the former Gull Study Group which has now merged with the Seabird Group. M.L. Tasker is the Newsletter Editor.

*Newsletter and Meetings.* Three duplicated newsletters are circulated every year to members. They contain all sorts of news including reports on research projects (particularly those with a grant input from the Group – see below), seabird conservation issues, book reviews, details of meetings etc. The Newsletter Editor welcomes contributions from members. The usual venue for the Group's annual meeting is the BTO Ringing & Migration Conference at Swanwick, except when the Group holds its own conference (as in 1988), in which case the meeting is combined with that. Our conferences draw on seabird workers from home and abroad to join in a forum of topical interest: at the February 1988 Conference for example, the theme was 'Seabird Food and Feeding Ecology'. In keeping with our desire to promote work in the field, practical manuals and guidelines evolve from the workshop sessions which cater for specialist topics within the conference theme.

*Seabird Group Grants.* Each year the Group has some money available to help fund research conducted by members. All grant applications should be submitted to the Secretary by the end of February annually, and will be considered by the executive Committee by the end of March for distribution. Certain areas of research may be favoured for grant support from time to time and from 1986 to 1988 the allocation has reflected our commitment to the Seabird Colony Register (see below). Successful applicants are required to submit a typed report, not exceeding 500 words, by the end of October of the same year for inclusion in the Newsletter. A full typed report (in triplicate) must be submitted by the end of the year.

*Seabird Colony Register.* The Seabird Group has always sought to organise and implement national schemes to promote the participation of and harness the energies of its membership, now standing at some 420 members. The Group membership played a major role in the national Operation Seafarer survey whose results were published in 'The Seabirds of Britain and Ireland' (1974). The Group has this year completed its Seabird Colony Register, in conjunction with the Nature Conservancy Council. This register was begun in 1985 to gather together all existing data on breeding seabird numbers in the British Isles, to bring our knowledge of their status up to date by detailed field surveys and to establish a computerised database which can easily be updated in the future. Clare Lloyd is currently carrying out the final analyses and we hope to see the publication of the Seabird Colony Register book in 1989. Although this round of survey work is now completed it is important to continue monitoring of seabird breeding numbers: anyone eager to conduct counts on a regular basis should contact Mark Tasker, NCC, 17 Rubislaw Terrace, Aberdeen AB1 1XE, Scotland.

*Seabird Journal and previous reports.* In November 1984 the Group launched its new-look journal *Seabird*, numbered 7 in deference to its pedigree of Seabird Group Reports 1-6. After the production of *Seabird* 8 in 1985, a new format was settled for Number 9 and subsequent issues to guarantee a viable annual production schedule for the future, at a time of rising costs. Our priority is to maintain a high volume and quality of content at stable cost to the membership, and we trust that the recipients of *Seabird* welcome the modest change of format in pursuit of these standards. The current editor, M. de L. Brooke, welcomes offers of papers (see Notice to Contributors, and address below). Members of the Seabird Group receive *Seabird* free of charge; additional copies to members, and any copies to non-members are £5 + 50p postage within the British Isles, £5 + £1 postage overseas. Postage overseas must, regrettably, be by surface mail, unless the recipient can make prior provision for air mail. The subscription to Libraries is £7.50 per copy. To help reduce costs, overseas subscribers are kindly asked to make payment by international money order rather than by cheque. At intervals in the past, the Group published Reports, to which *Seabird* is the successor. Copies of 3 of the earlier Reports are available from the Secretary as follows: issues for 1969 at 50p, 1975-6 (Number 5) at £1, 1977-81 (6) at £2. *Seabird* 7 (1984) is also available, at £2, *Seabird* 8 (1985) at £2, and *Seabird* 9 (1986) and *Seabird* 10 (1987) at £5. For all these back issues postage costs are as given above. There are no cost concessions for multiple orders of *Seabird* or previous reports, and postal charges are additive. Copies of the Proceedings of the 1982 Seabird Group Conference are available on receipt of 50p postage, as are copies of the Auk Censusing Manual (1980), though it should be borne in mind that censusing techniques are still advancing.

*Who to write to.* As appropriate, contact the Secretary (for general enquiries about the Group, seabird conservation matters, grants etc.), the Membership Secretary (for membership renewals, applications and enquiries), the Treasurer (for subscriptions, donations, etc.), Newsletter Editor, or Editor of *Seabird*. All may be contacted through the following address: Seabird Group, c/o RSPB, The Lodge, Sandy, Beds, SG19 2DL, England, UK. Please help the Group by enclosing a stamped envelope for reply.

## NOTICE TO CONTRIBUTORS

*Seabird* publishes original contributions relating to any aspect of seabird ornithology as full-length papers (preferably not exceeding thirty manuscript double-spaced pages) or short notes. Although a portion of the journal will be of particular interest to UK members, contributions are welcomed on aspects of seabird ornithology from any part of the world so long as they are likely to be of general interest.

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*Seabird* contributions should be submitted in the same format as used by *Ibis*, and this is outlined (with slight modifications) below:

All submissions, of which *three* copies are required, must be typewritten, on one side of the paper, with double spacing and adequate margins. The approximate position of figures and tables should be indicated in the margin. Authors must consult recent copies of *Ibis* and *Seabird* and follow the conventions for section headings, tables, captions, references, quotation marks, abbreviations etc. The Editor may return without consideration any submission that departs from the *Ibis* form of presentation. Spelling should conform with the preferred, i.e. first-cited spelling of the *Shorter Oxford English dictionary*. Hyphenated terms commonly used include: body-weight, breast-band, cross-section, eye-ring, tarsus-length, wing-length, wing-moult, tail-coverts. Details of experimental technique, extensive tabulations of results of computation procedures, etc. are best presented as appendices. A full-length paper must include a summary not exceeding 5% of the total length.

On first mention a bird species should be designated by an English vernacular name drawn from *The status of birds in Britain and Ireland*, or from an authoritative faunistic work treating the appropriate region, followed by the systematic binomial; author and date need be cited only in taxonomic papers. Thereafter only one name should be used, preferably the English one. Capitals should be used for the initial letters of all single words or hyphenated vernacular names (e.g. Great Black-backed Gull, White-eyed Gull) but not in a group name (e.g. gulls, terns). Trinomials should be used only if the identity of specimens has been verified by critical comparison and if the subspecific nomenclature is relevant to the topic under discussion.

Underlining is used for all words of foreign languages, including Latin, other than those which have been adopted into English. Underlining should also be used for phonetic renderings of bird vocalizations. Underlining is not needed for emphasis.

Measurements should be given in SI (International system of units), but if the original measurements were made in non-SI units, the actual values and units should be given, with SI equivalents inserted in parentheses at appropriate points. Measurements may be given in cm.

Figures and diagrams should be drawn in black ink on white board, paper or tracing material, with scales (for maps), and lettering given in Letraset. In designing drawings, authors are asked to note the page-size and shape of *Seabird*; originals should be 1½-2 times final size. Tables should be typewritten and spaced appropriately.

References should be quoted in the text in the format indicated by the following examples: Harris 1980, Cramp & Simmons 1980, Monaghan *et al.* 1980. References at the end of the paper (following acknowledgements) should be given in the following format:

COULSON, J.C. and WOOLER, R.D. 1976. Differential survival rates among breeding Kittiwake Gulls *Rissa tridactyla* (L.). *J. Anim. Ecol.* 45: 205-213.

The author's name should be placed beneath the title of the paper and again at the end, together with the address, after the references.

Twenty-five offprints (40 if more than one author) of each original contribution will be supplied free. Additional copies can be supplied on payment; orders will be required at the time of proof-correction. Reprints of book reviews will only be supplied if a request is submitted with the original copy; in this case the full number will be charged at cost.