

Adult Mortality and Fidelity to Mate and Nest-site in a Group of Marked Fulmars

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Evidence is presented to show that divorce and nest-site change do occur in the Fulmar; such changes can be associated with failure to rear a chick the previous year. A particularly low adult mortality was found.

IT IS WIDELY BELIEVED THAT PETRELS AND THEIR RELATIVES show a low adult mortality and a high degree of fidelity to their mates and nest-sites between breeding seasons (Warham 1964). Several studies on various species have confirmed these general conclusions, but have suggested that some of the claims may have been overstated (see Richdale 1965, Beck and Brown 1971). For the Fulmar *Fulmarus glacialis*, Carrick and Dunnet (1954) found complete constancy of nest-site and (except in cases of bereavement) mate among a small number of marked birds on Eynhallow in Orkney, but described one case which could be interpreted as a divorce. The adult mortality of Fulmars on Eynhallow has been estimated at about 6% *per annum* (Dunnet, Anderson and Cormack 1963, Cormack 1973, Dunnet 1975).

In the course of a study on the Fulmar at Sands of Forvie National Nature Reserve, Aberdeenshire, Scotland, between 1972-75 a number of breeding adults were individually marked and were observed intensively over three breeding seasons. This allowed estimation of the adult mortality, the rate of breakage of the pair bond, and the degree of fidelity to the nest-site.

Eighty-three adult Fulmars were caught in 1973 on sites containing eggs or chicks. Each was given a unique combination of three coloured rings, duplicated on each leg. In 1974 a further 13 known breeders were treated similarly. Their nest-sites were photographed and allocated individual numbers. During the winters of 1973/74 and 1974/75 the colony was visited regularly and the positions and associates of the marked birds were recorded. In the breeding seasons the mates and nest-sites of all marked birds were determined. It is unlikely that any marked birds were overlooked during the breeding seasons, and it has been assumed that efficiency in detecting them was total. Movements within the colony were extremely limited, even in winter, and disappearance of marked individuals is very unlikely to have been due to emigration.

For the estimation of mortality all the marked birds were included. In order that changes of mate could be identified without doubt the estimation of fidelity to the mate was based only on 'marked pairs' (those pairs where both members were colour-ringed). To eliminate the effect of change of mate on the fidelity to the nest-site, calculation of the latter was based on marked pairs which remained intact for two consecutive years.

Adult mortality

An accumulated total of 96 birds was available for this analysis, all of which had bred at least once in the study area. Table I shows the calculation of the

TABLE I. CALCULATION OF MEAN ANNUAL ADULT MORTALITY OF FULMARS, SANDS OF FORVIE
 Part (a) estimates the probability that a bird will die within one or two years of marking. Part (b) shows the observed mortality from May to May in the appropriate years.

Year	No. ringed	No. survived for		Accum. total
		1 year	2 years	
1973-74	83	82	80	83
1974-75	13	13	—	96
Totals	96	95	80	
	proportion survived	0.9895	0.9638	
	" died	0.0105(m)	0.0362(m ²)	
	mortality (m)	0.0105	0.0183	
	geometric mean	0.0139		

Year	No. alive at start	No. died	m
1973-74	83	1	0.0120
1974-75	95	2	0.0211
		geometric mean =	0.0159

annual adult mortality, m , by two different methods. In Table Ia it is estimated by the probability that an individual will die within one or two years of marking. In Table Ib the observed mortality figures between May 1973 and May 1974, and between May 1974 and May 1975 are shown. The methods give, respectively, geometric means for m of 1.39% and 1.59%.

Fidelity to mate

Twenty-seven marked pairs bred on the study area in 1973 and the same number (but not all the same pairs) in 1974.

All but one of the 1973 pairs (96.3%) remained intact until 1974. The members of the broken pair were both alive in 1974. The male did not breed in that year, but the female bred at a new site with an unringed bird. This, therefore, constituted a divorce.

All but two of the marked pairs (92.5%) which bred together in 1974 were intact in 1975. The female of one of the broken pairs was not identified after May 1974, and was assumed to have died before the 1975 breeding season. The second pair was split by divorce, and while the male failed to breed in 1975 his former mate bred with an unringed bird at a new site.

The mean annual rate of dissolution of established pair bonds during the study was approximately 6%, with a divorce rate of about 4% *per annum*.

Fidelity to nest-site

Twenty-three out of 26 marked pairs (88.5%) held the same nest-sites in 1973 and 1974. Twenty-one out of 25 (84%) remained on the same sites in 1974 and 1975. In no case was a shift necessary because the earlier site had been destroyed. The mean rate of change of nest-sites among intact pairs was about 14% *per annum*. The distance moved to the new sites varied between 2 and 30 m (mean 7.9 m), but in only one instance did the distance exceed 6 m.

There was an association between the tendency to change sites and the breeding success in the earlier year. Six of the seven pairs (86%) which changed sites had failed to raise a chick to fledging in the previous breeding season, compared with 18 out of 44 pairs (41%) which did not change. The difference was significant ($P = 0.03$).

DISCUSSION

The generality of the estimates given here may be limited, for a number of reasons. The study extended over only two years, larger examples would have been desirable, and the inevitable disturbance caused during the study (although kept to a minimum) may have increased the incidence of site-changes indirectly through affecting the breeding performance. In addition the rate of adult mortality would have influenced the overall rate of dissolution of marked pairs. As there are few such estimates published for marked populations of fulmarine petrels, however, they provide useful comparative data.

In comparison with the estimates obtained on Eynhallow the adult mortality was extremely low. The figures for Forvie were lower than for any two consecutive years on Eynhallow and much lower than the mean of 6%. In view of the short period for which estimates are available from Forvie it is not justifiable to describe this difference as real, but since the estimate for the overall rate of dissolution of pairs depends directly on adult mortality it is important to recognise the difference. The adult mortality for two other fulmarine petrels, the Cape Pigeon *Daption capensis* and the Snow Petrel *Pagodroma nivea* has been estimated at between 4% and 7% *per annum* (Hudson 1966).

No comparative data are yet available for the fidelity of the Fulmar to its mate and site. For other fulmarines Conroy (1972) found no cases of divorce among 150 pairs of Giant Petrels *Macronectes giganteus*, and Brown (1966) had no proof of divorce in the Snow Petrel. Pinder (1966) did not quote any instance of divorce in the Cape Pigeon. All three authors describe a high degree of fidelity to the nest-site (93% *per annum* in the Giant Petrel).

The two instances of divorce described here are, therefore, the only published cases in the sub-family Fulmarinae. They allow the Fulmar to be placed in that category of birds in which the pair-bond is maintained for a relatively high number of breeding seasons, but in which there appears to be a definite element of divorce. This category was first proposed by Richdale (1947) to contain four species of penguin and four species of burrowing petrel (*Pelecanoides urinatrix*, *Pachyptila turtur*, *Pelagodroma marina* and *Puffinus griseus*) for which divorce had been described. Since then representatives of other groups of petrels have been shown to undergo periodic divorce (*Oceanites oceanicus*, Beck and Brown 1971; *Procellaria aequinoctialis*, Mougin 1970; *Diomedea immutabilis*, Rice and Kenyon 1962). It seems probable that divorce is a regular event for many Procellariiformes, although in some like the Royal Albatross *D. epomophora* it may be exceptional (Richdale 1957).

The mechanism which brings about the phenomenon of fidelity to the mate in birds has been the subject of debate. Do the individuals recognise and remember each other from year to year, or do they join together passively as a result of attraction to the old nest-site? Penney (1964) indicates that in penguins the attraction to the territory is an important, but not the only, part of the process. No firm conclusions could be drawn about the method applying to the Fulmar, but a few casual observations did suggest that birds could identify their mates both in flight and on land away from the regularly held territory. In a small group individual Fulmars can be recognised fairly easily by the pattern of dark marks on the generally pale bill. The variation in these marks is such that in some birds they

are almost absent, while in others the pale ground colour on the nasal tube and the sides of the bill is almost totally obscured. Marked individuals retained the same pattern for at least three years. This variation may provide a system of individual recognition which could be used alone or in conjunction with an attraction to a specific area of a colony to re-establish pair bonds from year to year.

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SUMMARY

Observations on an accumulated total of 96 individually colour-ringed adult Fulmars at Sands of Forvie NNR, Aberdeenshire, between 1972-75 allowed estimation of the adult mortality, rate of breakage of established pair bonds, and the degree of fidelity to the nest-site. The adult mortality was low at under 2% *per annum*. The population showed a divorce rate of 4% *per annum*. Fidelity to the nest-site was high at over 80% *per annum*. When a change occurred the new site was generally close to the old one. Changes were associated with failure to raise a chick in the previous year. The results are compared with the situation in other petrels, and the mechanism bringing about maintenance of the pair bond is discussed.

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