



## Ages of Storm Petrels *Hydrobates pelagicus* prospecting potential breeding colonies

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Each year, ringers using sound lures mark and recapture immature Storm Petrels *Hydrobates pelagicus* prospecting potential breeding colonies. Attempts have been made to estimate the size of this population, but a full demographic model has not been possible since the age structure of this population has not been determined. To address this, between 1990 and 2004, 799 Storm Petrel chicks were ringed at the breeding colony on the Island of Mousa, Shetland, to establish a sample of marked known-age birds. There were 39 subsequent recaptures of these individuals, mainly by using sound lures at sites away from breeding colonies. Only one recapture related to a first-year bird: the largest cohort was of second-year birds and the relative frequencies of third-year and fourth-year cohorts progressively diminished as birds entered the breeding population and ceased responding to sound lures. These data provide demographic information to facilitate the construction of population models. Given the difficulty in determining the size of breeding populations of Storm Petrels and in long-term annual monitoring of breeding productivity, there may be considerable conservation benefit from ringing and recapture of Storm Petrels each year to monitor the size of the pre-breeding population.

The ringing of adult Storm Petrels *Hydrobates pelagicus* at colonies has been undertaken since the 1950s at many sites throughout northern Britain (Mainwood 1976). From the mid-1970s increasing numbers of full-grown birds have been trapped, away from colonies, attracted to mist nets using sound lures of the nest song. Most have been caught between late June and mid September at many sites around Britain, Ireland, Iceland, the Faeroes, Norway, France and Portugal. It has become apparent that these sound-lured birds are part of a sub-population of wandering birds that roam widely, visiting potential breeding colonies for several seasons before they settle into a colony and begin breeding. Breeders generally are not attracted to sound lures (Fowler *et al* 1982). Both males and females are attracted to the sound lures in approximately equal proportions and these wandering birds are attracted to the song playback in the way they would be to a colony (Fowler *et al* 1986).

Fowler *et al* (1982) attempted to estimate the number of wandering birds in the Shetland population, but recognized that a full demographic model was not possible, due to a lack of quantitative information regarding the age structure of the population of prospecting non-breeders. In particular, it was not

known at what age immature birds first returned to northern waters. A long-term programme of ringing nestlings at one of the principle breeding colonies in Shetland has established a sample of marked known-age birds. The aim of this study was to estimate the age-specific recapture rate of these individuals as wandering immatures.

### METHODS

#### Study site

The island of Mousa, Shetland UK (60° 00'N 1° 10'W) is believed to hold the largest breeding colony of Storm Petrels in Britain, supporting around 6,800 pairs (Mitchell *et al* 2004). In 1990, the RSPB initiated a study of Storm Petrels at this site, which resulted in small numbers of chicks being ringed in 1990 and 1991. In 1992, MB began a detailed investigation that required the establishment of a population of birds breeding in nest boxes located in dry stone walls and the boulder beach (Bolton 1996); these, together with the many natural nest sites that were also located, facilitated the annual ringing of relatively large numbers of nestlings. Prior to that time, only a handful of Storm Petrel chicks had been ringed in Britain in any year, as the nests are both difficult to locate and to access.

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From 1994, ringing at all of these sites, together with newly found ones, was carried out by JDO and members of the Shetland Ringing Group; the sites in the boulder beach were eventually abandoned due to movements of the boulders and inundation of the sites by sand during winter storms. The numbers of chicks available for ringing varied from year to year: very wet seasons caused some flooding of the nest sites and in other seasons success was low, perhaps due to food shortages. The annual ringing totals are given in Table 1. The earliest chicks normally fledge from this colony about the middle of September but the fledging period is very extended and the last chicks do not usually leave their nests until the end of November. The aim has been to visit the site before the first chicks fledge thereby maximising the numbers of chicks available for ringing whilst minimising disturbance. Data on all subsequent recoveries of the nestlings ringed on Mousa were obtained from information reported to the British Trust for Ornithology up to May 2005.

### Statistical analysis

The number of recaptures of individuals of each age class is dependent not only on the number of individuals of that age class in the population of prospecting birds, but also on the number of individuals of each cohort that were ringed as fledglings, their subsequent survival rates and the effort expended by ringers in trapping Storm Petrels in each subsequent year. Large inter-

annual variations in these parameters could bias the proportions of each age class recaptured annually. We examined the need to account for recapture effort and fledging cohort using a Generalised Linear Model (McCullagh & Nelder 1989). A measure of recapture effort was taken as the total number of full-grown Storm Petrels ringed in Britain and Ireland each year from 1991 to 2003 (the most recent year for which data are available). The model employed a binomial error structure and logit link function, with the number of individuals of each age class retrapped each year as the response variable and the number of nestlings of the corresponding cohort that were originally ringed, as the binomial denominator. Hence the model considered the age-specific recapture rate (number of recaptures per nestling ringed), controlling for any potential bias introduced by large annual variation in recapture effort. Additionally, we examined a further source of bias: differential post-fledging survival among cohorts, by incorporating year of fledging in the model. We included all chicks ringed up to 2002 in the analyses. The procedure was implemented in SAS v 8.2.

## RESULTS

### Recaptures

Of the 799 ringed nestlings, 34 (4.3%) were recaptured in subsequent years at sound-lure sites on both sides of

**Table 1.** Numbers of Storm Petrel chicks ringed on Mousa, Shetland (1990 - 2004) and number recaptured in each subsequent year. Multiple recaptures of the same individual in different years are included.

Year	No Ringed	Age of Chicks Recaptured (Number of years)										
		1	2	3	4	5	6	7	8	9	10	11
1990	9	0	0	0	0	0	0	0	0	0	0	0
1991	35	0	0	0	0	0	0	0	0	0	0	0
1992	70	0	7	1	0	0	0	0	1	0	0	0
1993	79	0	4	2	0	0	0	0	1	1	0	1
1994	127	0	2	0	2	0	0	0	0	0	0	
1995	85	0	1	2	1	0	0	0	0	0		
1996	62	0	1	1	0	0	0	0	0			
1997	50	0	2	0	0	0	0	0				
1998	29	0	1	0	0	0	0					
1999	38	1	2	1	0	0						
2000	49	0	2	1	0							
2001	35	0	0	1								
2002	47	0	0									
2003	50	0										
2004	34											
Total	799	1	22	9	3	0	0	0	2	1	0	1

the North Sea: all of these were caught between one and four years after ringing and one individual was retrapped on two occasions in different years. Three individuals (including one previously retrapped elsewhere as a three-year old) were controlled between eight and 11 years old but these older birds were all caught on islands where there are colonies and presumably were breeding adults. One individual was caught in two successive years (eight and nine years after fledging) at the same colony (Table 1). A single chick, ringed in 2000, was recovered in the regurgitated pellet of a Great Skua *Stercorarius skua* on Mousa in July 2004 but this has not been included in this analysis.

#### Effect of recapture effort, year of fledging and age on recapture rate.

Recapture rates (number of recaptures per nestling ringed) of Storm Petrels up to five years old in each year from 1991 to 2003 were significantly related to age at recapture (Fig 1,  $\chi^2_4 = 43.05$   $P = 0.0001$ ), but were not dependent on either the level of annual recapture effort or year of fledging ( $\chi^2_1 = 0.16$   $P = 0.69$  and  $\chi^2_{12} = 15.43$   $P = 0.22$  respectively). Recapture rates were extremely low for first-year birds, were substantially higher for second-years and then fell progressively for third and fourth-year individuals. No five-year old birds were retrapped. Assuming first-year birds in the population of wandering immatures were equally responsive to sound lures and therefore equally likely to be trapped at mist net sites compared with their older conspecifics, their scarcity in the recaptured sample suggests that few individuals prospect potential

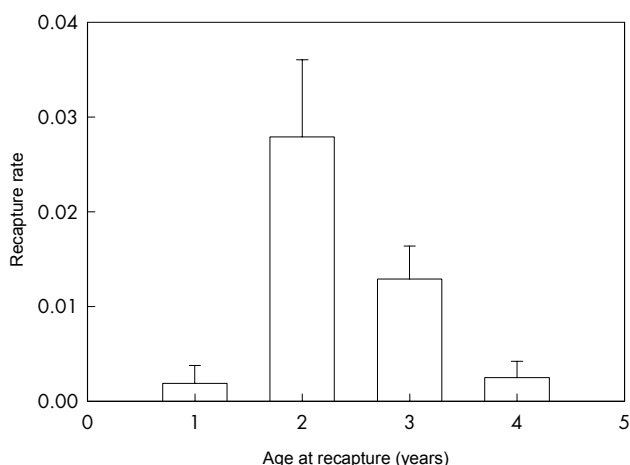
colonies in their first year after fledging. If the age structure of the sample of known-age birds reflects that of the population of prospecting immatures as a whole, and the capture probabilities of all known-age individuals are equal, then the age-specific recapture rates may reflect the age structure of this population. It is perhaps surprising that the recapture rate was not dependent on recapture effort, but this may be due to the relatively small inter-annual variation in the number of full-grown Storm Petrels mist-netted between 1991 and 2003.

#### DISCUSSION

Prior to this study there was little information regarding the age at which Storm Petrels first return to northern colonies to prospect for a breeding site (but see Scott 1970). The data presented here indicate that approximately 3% of the population of wandering pre-breeders are in their first year, and the majority of birds do not visit land until two years after fledging. Over the course of the next two seasons most birds recruit into a breeding colony, such that by five years of age, few, if any Storm Petrels remain in the pool of prospecting birds. It is probable that most first-year birds remain in their normal wintering range in the southern oceans, although some may travel part of the way north. It is known that the immatures of various other migrant seabird species eg Gannet *Morus bassanus*, Fulmar *Fulmarus glacialis*, Guillemot *Uria aalge*, do not normally visit their natal area in their first year, or do so only in small numbers (Wernham *et al* 2002).

It is possible to sound-lure the wandering immature Storm Petrels in Portugal as they migrate north towards their natal areas in the late spring (Harris *et al* 1993). Bolton & Thomas (2001) were able to differentiate between first-year birds which showed uniform primary wear having grown these feathers simultaneously in the nest and older individuals that showed a graded pattern of primary wear having moulted their feathers sequentially over a long period. Using this criterion they found that 3.4% of those caught were first-year birds, similar to the value found here.

It is also possible that chicks do return in the year after fledging, but do not visit colonies or react to sound lures. This would seem doubtful, since the purpose of spending a number of seasons wandering, before breeding, is probably to enable the immature birds to familiarise themselves with the location of existing breeding colonies, feeding areas, seasonal changes etc. For birds to visit their natal areas and not to undertake



**Figure 1.** Recapture rates of Storm Petrels ringed as nestlings on Mousa, Shetland in relation to age at recapture. Recapture rate = number of recaptures per nestling ringed, bars show one standard error.

this visiting process by reacting to sound lures seems unlikely.

Most British Storm Petrels are ringed as sound-lured, wandering, immature birds. The contrast between the recapture rate of the birds ringed as chicks and the national recovery rate of birds ringed as immatures (2.7%; Clark *et al* 2004) is notable. However, birds ringed as chicks are available to be sound-lured throughout their wandering immature period, potentially over the next four years; the multiple recapture of a single wandering immature known-age individual, among a sample of 34, is wholly consistent with this. Conversely, many sound-lured birds captured for ringing will be close to finishing their wandering period and will disappear from this population soon after being ringed as they become breeding adults and unresponsive to sound lures. The decline in recapture rate from two to five years of age reflects losses from the wandering population due to both mortality and recruitment as breeding adults. Scott (1970) suggested that annual mortality between the period of first return to the colony and recruitment into the breeding population might be around 10-15%. Assuming all individuals begin to prospect by their second year, the 55% reduction in recapture rate between the second and third year would be consistent with 40-45% of second-years recruiting into the breeding population in their third year. A nestling ringed in 1992 was found on a nest on Mousa in 1995. There are other reported instances of Storm Petrel and Leach's Storm-petrel *Oceanodroma leucorhoa* breeding at three years of age (Scott 1970, Gross 1947).

Data presented here permit an assessment of the age structure of the population of prospecting Storm Petrels, which are the target of a great deal of voluntary ringing effort in Britain. Given a knowledge of the frequency distribution of ages in this population, there may now be scope for analysis of annual Storm Petrel ringing totals in relation to data on productivity of individual colonies, to determine whether any relationship exists between the numbers of Storm Petrels sound-lured each year and the breeding performance of major colonies in the preceding years. Given the logistic complexities of monitoring the population size of Storm Petrel colonies regularly, a simple method of monitoring the combined productivity of Storm Petrel colonies in Britain would be of considerable conservation benefit.

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