HOMING IN LEACH'S PETREL

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LEACH'S Petrel (*Oceanodroma leucorhoa*) is strictly a marine bird almost never sighted over land except when flying to its nesting burrow or when blown inland by gales (Boyd, 1954; Bagg and Eliot, 1937: 16). Griffin (1940) has suggested that these birds may be able to select a short overland route in preference to a much longer all-water route when they are released at a distance from their burrows. This implies that the birds have some means of orientation not dependent upon the familiarity of the territory over which they find themselves. The experiments described in this paper were an attempt to test the homing ability of Leach's Petrel over a wide range of distances, and especially under conditions in which the birds were presented a choice of flight paths. The petrels whose homing is described breed on Kent Island near Grand Manan, New Brunswick, Canada (44° 35′ N, 66° 45′ W).

METHODS

Leach's Petrels nest in burrows on offshore islands. While one of the pair feeds at sea the other incubates the single egg. Incubation spells last from 1 to 5 days; the change-over occurs only at night (Ainslie and Atkinson, 1937; Gross, 1935; C. E. Huntington, pers. comm.). The incubation drive should be strongest in birds that have recently returned from feeding at sea, and they would be expected to home more quickly than birds nearing the end of an incubation spell. To find and identify these recently-returned birds without upsetting them unnecessarily, lattices of sticks were placed across a number of burrow entrances so that a bird entering or leaving the burrow would be forced to knock the sticks aside (Lockley, 1932). Experimental birds were taken only from burrows whose lattices had been disturbed within the preceding 48 hours.

This method is not infallible as incubating birds do occasionally leave their burrows and return to them during the same night. Incubators lose an average of 2.2 g in a 24-hour period (C. E. Huntington, pers. comm.). The mean weight of all the birds used in experiments 1–11 was 48.9 g, which is not significantly different from the mean weight of birds on the first day of incubation (51.3 g as given by Huntington in Palmer, 1962: 226). Thus it is probably safe to assume that most of the homers were near the beginning of their incubation spells.

The experimental birds were removed from their burrows, banded, weighed, and placed in individual cloth bags inside a cardboard box for transportation to the release point. In most experiments the birds were released within 24 hours. Birds in the transatlantic experiment were held 64 hours before release. They were force fed cod liver oil and salt water several times.

The birds were released singly and were followed visually until out of sight. In experiments 2, 5, 6, 9, and 11, binoculars were used; in the remaining experiments birds were followed with the naked eye. The final direction taken by each bird was approximated within about 20 degrees.

The return of birds was detected by setting up lattices at all experimental burrows and checking them at 1-hour intervals throughout the night. When a lattice was down,

TABLE 1

RELEASE POINTS, HEADINGS, AND SPEEDS OF RETURN IN EXPERIMENTS 1–11

Expt. No.	*Release type* S = at sea, E = water's edge, I = inland	*Release date*	*Location*	*Distance (miles) and direction to Kent*			*Initial headings* f = fastest, s = slowest, o = no return	*Number returned/ released*	*Return*[1] *(mi/day)* Maximum	Mean	Median
		(1965)									
1	S	29 June	Bulkhead Rip		8	WNW	2S[f, s] 2E 1W	5/5	17	7	2
2	S	29 June	Murre Ledges		8	NE	2NNW[o] 2S[s] 1N[f]	4/5	21	7	4
3	E	30 June	Machias Seal Island		18	ENE	4SW[f, s, o] 1N	4/5	86	40	35
4	I	5 July	Halifax Airport	a) airline	170	W	4E[f, s, o] 1N	3/5	a) 54	43	–
				b) Fundy	204	N			b) 64	51	–
				c) Atlantic	302	SSE			c) 96	76	–
5	E	5 July	Cape Hopewell		143	WSW	3ESE[f] 2SSE 1SSW[s]	6/6	66	51	46
6	E	5 July	Smith's	a) airline	163	SW	2E[f] 1SE[o] 1S[s] 1SSW 1NE	5/6	a) 52	41	39
				b) via Gut of Canso	579	E			b) 185	147	137
				c) via Cape Breton I.	760	E			c) 243	192	180
7	E	a) 6 July b) 8 July c) 10 July	(controls) Kent Island		0.2		a) NW[s], E b) W[f] c) NW	a) 2/2 b) 1/1 c) 1/1	–	–	–
8	E	21 July	Stephenville	a) airline	505	SW	all SSW	12/15	a) 158	91	87
				b) Atlantic	666	SSW			b) 208	120	118
9	E	24 July	S. Harpswell		172	ENE	2SE[s] 2E[f, o] 1SSE 1WNW	5/6	149	70	41
		(1966)									
10	I	23 June	Magdalen Is.	a) airline	320	WSW	9E[f, s, o] 1ENE 1ESE 1S	9/12	a) 122	79	63
				b) via Gut of Canso	555	S			b) 212	137	109
				c) via Cape Breton I.	625	ESE			c) 237	154	123
11	E	14 July	Selsey Bill England		2,980	W	all S	4/7	217	131	202

[1] Birds returning 10 or more days after others in same group are omitted in calculation of mean speed of return.

the burrow was explored; if the homer was found, its weight and condition were recorded. Burrows were checked in this manner for 8 to 10 nights after a release, then daily for the following week. This schedule was not followed for the transatlantic experiment.

RESULTS AND DISCUSSION

In many respects the results (summarized in Table 1) seem to raise more questions than they answer. The mean homing speeds are almost double those reported by Griffin, and, unlike Griffin's results, the proportion returning appears almost independent of distance, although the latter varied from 0.2 to 2,980 miles. This does not fit the radial exploration hypothesis (Griffin, 1952) which predicts that the percentage of returns should decrease as the birds are sent farther and farther from familiar territory.

Dissimilarity in the procedures used in Griffin's study and in this one may provide partial explanation for the different results. Griffin's birds were subjected to longer periods of transportation before release. Also he did not select birds in the first day of incubation for his experiments. This factor appears to be related to the speed of homing, for I found that birds that were heaviest when removed from their burrows, and therefore presumably most recently returned from feeding at sea, homed the most quickly. In experiment 8, for example, birds were classified on the basis of their homing speeds as "fast" (96–158 miles per day) or "slow" (11–62 miles per day) and their initial weights compared. Weights of the "fast" birds averaged 50.2 g while the "slow" birds averaged 46.6 g at the time of removal from the burrow, a significant difference ($P = .05$). However, comparison of individual weights before release and after return showed no consistent pattern.

Griffin did not examine burrows for returned birds at regular intervals throughout the night until most of his experiments had been completed. Thus it is entirely possible that a bird's initial return went undetected. In several instances he was unable to check for returned birds until several days after the release. By that time birds could conceivably have arrived and departed again. Finally, most of Griffin's birds were released at sea, while most of the birds in this study were released at the water's edge.

Route selection.—To test the ability of petrels to select an overland shortcut when homing, birds were released simultaneously near Cape Hopewell (experiment 5) in the Bay of Fundy (45° 49′ N, 64° 34′ W) and at Smith's (experiment 6) in the Northumberland Straits (46° 14′ N, 64° 31′ W) (Figure 1). It is extremely doubtful that petrels from Kent Island feed to the northeast (Griffin, 1940: 71) and the territory including Cape Hopewell and Smith's is therefore probably unfamiliar to them.

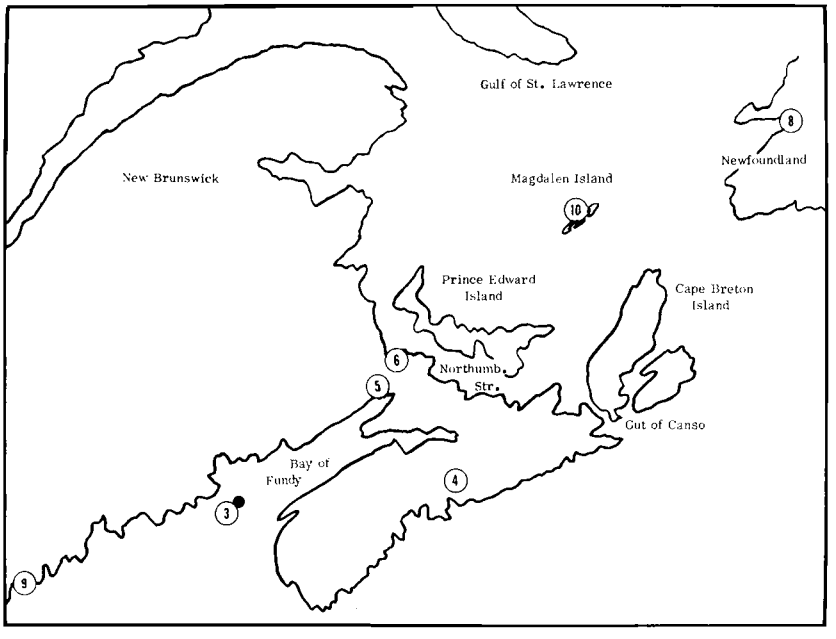

Figure 1. Release points for experiments with Leach's Petrels. Kent Island is indicated by the solid circle. Releases for experiments 1, 2, and 7 were close to Kent Island; releases for experiments 3 through 6 and 8 through 10 were made at the numbered points. Table 1 gives the distances involved.

If the Smith's birds flew around Cape Breton Island or through the Gut of Canso, a narrow strait crossed by a bridge connecting Cape Breton Island and Nova Scotia, they should take considerably longer to return than the Hopewell birds because of the greater distances involved (Table 1). On the other hand, if they chose a transisthmus route the difference in flight times should not be great, as Smith's is only 20 miles farther from Kent than Hopewell by this direct path. Birds from both groups returned at roughly the same time which seems to indicate that the Smith's petrels chose the overland route and flew at least 18 miles across the isthmus. The number of birds released was small, but the results agree with Griffin's findings.

Halifax (experiment 4) is about the same airline distance from Kent as Smith's and Hopewell. Birds in the three groups were released on the same day. All had similar homing speeds, averaging 41, 43, and 51 miles per day from Smith's, Halifax, and Hopewell respectively. This again suggests that the Smith's birds chose the overland route.

In further tests, two larger groups of birds were released at the Mag-

dalen Islands (experiment 10) and at the Stephenville, Newfoundland airport (experiment 8). Again the birds had the choice of a short overland route or several longer all-water routes. Although results from these two releases (Table 1) are not themselves evidence that petrels must fly the overland route, they do not contradict this suggestion. Caution should be used in interpreting such results, but it seems reasonable to conclude that the petrel can navigate well enough to choose a direct flight path over at least 18 miles of land if it lies in the direction of home.

Initial headings.—In this study the sun was clearly visible above the horizon in experiments 1, 2, 10, and 11; in experiments 3 through 9 it was obscured by clouds, or releases were carried out after sunset. Under both conditions the birds' final headings before they were lost from sight seem unrelated to true direction of home, speed of homing, or wind direction at the release point. The deviations of headings from the home direction fit a random distribution ($P = .05$). Matthews (1953) in his study of Manx Shearwaters (*Puffinus puffinus*) reported an association between good initial flight direction taken by birds released when the sun was visible and swift return. This relationship was not noted here, but conditions for observing the released petrels were by no means ideal.

Griffin and Goldsmith (1955) report no homeward orientation in the initial headings of petrels released inland. This is consistent with the lack of homeward initial headings observed in the Halifax birds.

The initial headings seem to reflect local conditions at the release point. Birds released at sea flew low over the water in apparently arbitrary directions. On the other hand, birds released on land but in sight of water almost always flew toward the water following the contours of the shore line, as did the Manx Shearwaters with which Lack and Lockley (1938) worked.

Nighttime homing.—Matthews (1953) suggests that Manx Shearwaters cannot orient at night, as in his experiments no birds released at 2330 hours returned that same night although they could easily have flown the required distance before sunrise. This, he concludes, shows that the shearwaters need to get their bearings by daylight. Petrels may be different. Two birds released after sunset, one at 2000 and the other at 2200 hours at a distance of 18 miles (experiment 3), returned the same night at 0345 and 0330 hours respectively through rain and fog. This raises the question of whether a petrel actually needs to see the sun or even landmarks in order to orient, at least in familiar waters. Additional nighttime releases of birds at short distances, preferably in the open sea or inland, would be necessary to substantiate this preliminary finding.

Transatlantic homing.—Seven petrels were flown to England and released in fair-to-good condition (weights 34–45 g) at Selsey Bill, Sussex

TABLE 2
WEIGHTS IN GRAMS OF PETRELS IN TRANSATLANTIC HOMING EXPERIMENT

Capture	*Release*	*Recapture*	*Return Sequence*
57	45	54	3
55	44		
51	40	43	1
51	40	46	4
49	39		
49	35	Not weighed	1
45	34		

(50° 44′ N, 0° 48′ W) at 0800 ADT on 14 July. At the time of release the sun was visible, although there were scattered clouds. All the birds headed approximately westward when released, but were carried downwind and disappeared to the southward.

At 0130 ADT on 28 July two petrels were back in their burrows, within the next 52 hours another bird returned, and on 8 August a fourth was caught. The great circle distance from Selsey Bill to Kent Island is 2,980 miles. This was covered in 13.7 days by the two fastest petrels—an average speed of at least 217 miles per day. The speeds of the other two birds were 187 and 121 miles per day. Unfortunately the burrows were not checked until 28 July; it is possible that the first petrels had already been there a day or more.

The weight of the birds when released seems to have little to do with whether or not they returned (Table 2). The bird that lost the most weight in transit looked weak when released, but was one of the first to return.

Faster returns over similar distances have been reported for other procellariiform birds. A Laysan Albatross (*Diomedea immutabilis*) returned 3,200 miles to Midway at an average speed of at least 317 miles per day (Kenyon and Rice, 1958). A Manx Shearwater flew 3,050 miles from Boston to Skokholm at a speed of 244 miles per day (Mazzeo, 1953).

As the average speed over the 2,980 mile distance was higher than those for shorter distances (see Table 1), the petrels apparently did not travel in random directions in the absence of familiar landmarks. The data reported here suggest instead that Leach's Petrels can determine the approximate direction of home when released in unfamiliar waters and can maintain a direct line of flight homeward over a distance of about 3,000 miles.

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SUMMARY

Homing experiments were carried out with Leach's Petrels breeding on Kent Island, New Brunswick, Canada. Birds were released from distances of 0.2 to 2,980 miles. A high proportion returned to their nest burrows at speeds of about 40 to a maximum of 217 miles per day.

Under conditions where there was a choice of flight paths between a short overland route and a longer all-water route, the petrels apparently chose the overland route. As petrels are strictly marine birds, this suggests that they may have some means of orientation by which they can home even when it necessitates their flying over totally unfamiliar territory.

No relationship between birds' final headings and true direction of home, speed of homing, or wind direction could be shown.

It is suggested that petrels do not require daylight to navigate, at least when released in what is presumably familiar territory.

Two birds released 2,980 miles from home at Selsey Bill, England, returned in 13.7 days—an average speed of 217 miles per day. Two other birds also returned from this point at speeds of 187 and 121 miles per day.

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