HOMING EXPERIMENTS WITH ARCTIC TERNS RELEASED OVER LAND AND SEA

By Jeremy J. Hatch

After release in unfamiliar territory, some birds take up consistent departure directions that have no apparent relationship to home direction (e.g., nest-site or other point of capture). Such behavior was reported by Griffin and Goldsmith (1955) and Goldsmith and Griffin (1956) for Common Terns (*Sterna hirundo*) from New England and the Great Lakes, and by Southern (1969) for Ring-billed Gulls (*Larus delawarensis*) from Michigan. Several species of ducks in North America and Europe show similar unexplained tendencies for consistent directional preferences, which have been labelled "nonsense" orientation, although the coiner of this phrase has since ascribed less importance to it (Matthews, 1968).

The releases of Common Terns by Griffin and Goldsmith showed that this species has a tendency to fly SE when released inland in New England, and that this directional preference is only evident when the sun is visible. This is true both for terns from the population breeding along the coast of New England and for those from the Great Lakes. Such a heading would bring the terns to the coast, but it seems that this would be inappropriate for homing by those nesting inland (on the Great Lakes).

Recoveries of banded birds show (Austin, 1953) that the Common Terns migrating from the Great Lakes initially fly SE to reach the coast; thereafter part of the migration routes of both populations is approximately SW at sea and along the east coast of North America. The winter distribution of both populations includes the Caribbean area and coastal waters of northern South America. Likewise, Southern (1969) showed for banded Ring-billed Gulls that the first part of the fall migration is SE, and he subsequently interprets his orientation experiments with gull chicks on this basis.

In eastern North America the Arctic Tern (*S. paradisaea*) breeds from Cape Cod, Mass. northwards, often in mixed colonies with Common Terns. The postbreeding migration is thought to be initially eastward across the North Atlantic and then south in the eastern Atlantic to "winter" quarters in the Southern oceans (Hawksley, 1949; Salomonsen, 1967). Thus, the Arctic Tern migrates further than the Common Tern, and in a different direction. It has long been cited as an outstanding example of a long-distance oceanic migrant (Bellrose, 1972; Dorst, 1962).

Two general kinds of explanations are possible for the directional tendencies of terns released inland: (1) it is a "coast-finding" strategy for individuals accidentally brought to unfamiliar territory, or (2) it reflects the direction taken during the initial stages of fall migration. These two explanations are not mutually exclusive. The purposes of the present experiments were to determine the directional preferences of Arctic Terns for comparison with those of Common Terns and to learn if these preferences are similarly dependent on the sun's visibility, and what directions are selected at sea. If the preferred direction reflects the migration route, then the two species may differ. If coast-finding is the predominant consideration when released inland, then releases at sea may reveal other preferred directions (homeward, for example, or none at all). Some observations were also made of homing performance.

METHODS

All Arctic Terns for these releases were caught in drop-traps on their nests on Petit Manan Island, Me. (Fig. 1) and transported

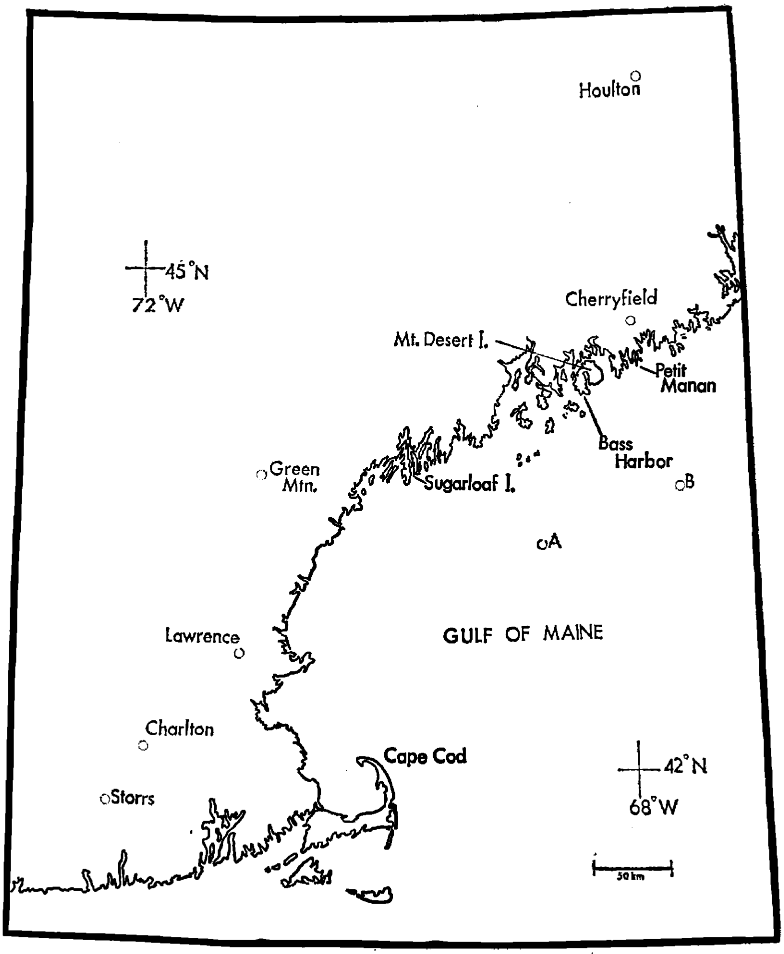

FIGURE 1. Map of release sites and breeding colonies from which terns were taken. A and B are release sites at sea.

to release sites in ventilated cardboard boxes. Water was provided at least once before release. Each bird was released singly and followed through binoculars until lost to sight. The vanishing bearings so obtained were used in subsequent analyses if the bird was followed in free flight for at least 100 sec preceding vanishing. Release sites were selected for wide visibility, and, as far as possible, absence of nearby lakes or streams. A total of 71 terns was released at 11 sites. The location of nine release sites are shown on Fig. 1; the other two were near Durham, N. C. (36°00′N, 78° 49′W) and at sea in Onslow Bay, off the coast of N. C. (34° 10′N, 77° 01′W). The release in Onslow Bay, N. C. was made from R. V. *Eastward* (Duke University Marine Program), and the two releases in the Gulf of Maine from a 35 ft sloop. All three releases at sea were at sufficient distances from the mainland (or large islands) that the terns could not see this land if they did not climb substantially higher than usual cruising height for such birds. Most of the releases were in 1968, but two were released in the Gulf of Maine in 1969.

When a watcher was present in a blind near the marked nests, checking for homing birds, the terns were colored on tail and wing with dyes for identification. Nests were watched for six or more hours each day for at least two days, or (in a few cases) checked at least six times daily.

RESULTS

The results of the 12 releases at 11 sites are summarized in Table 1. Releases are divided into three groups: (1) over land (sun visible), (2) over land (sun's disc obscured), and (3) at sea (sun visible).

Behavior on Release

In general the terns first flew in an irregular pattern, but eventually took up a consistent (straight) course that seemed to be little affected by the wind (thus, the vanishing bearings were not greatly different from the terns' headings). The chief exceptions to this were the terns released at sea (or on the coast); their courses were much more variable, and some terns were not tracked successfully because they settled on the water and were lost to view. The courses followed by terns released inland under clouds were intermediate in variability.

Some of the terns circled and climbed high (above approximately 30 m); this was true for all of the terns (8/8) released inland with sun invisible, some (12/39) of the inland releases with sun visible, but none (0/24) of the releases at sea or by the coast. The terns released at sea did not climb to more than 10 m above the sea and probably could not see land.

Initial Headings

Terns that could see the sun when released inland showed nonrandom vanishing bearings in most cases (the exception being two releases with small sample sizes of 4). On the other hand, the inland releases with sun hidden, the coastal release, and the three releases at sea with the sun visible revealed no such directional

TABLE 1.
Vanishing bearings of Arctic Terns.

Date	Release	N	n[1]	Homeward Dist. km	Homeward Bearing degrees	Downwind degrees	Downwind vel.[2]	Observed Flights Mean bearing	Observed Flights Mean vector	P[3]	Homed
LAND RELEASES											
—sun's disc not visible											
21 June	Houlton, Me. 1	5	(5)	193	182	135	6	31	.514	n.s.	4/5
27 June	Bass Harbor, Me. (coastal)	5	(6)	40	68	270	10	159	.501	n.s.	4/6
30 June	Lawrence, Mass.	3	(3)	328	54	—	0	357			2/3
—sun visible											
22 June	Houlton 2.	5	(5)	193	182	—	0	185	.967	< .01	3/5
24 June	Durham, N.C.	5	(7)	1,340	43	45	8	97	.957	< .01	0/7
26 June	Cherryfield, Me.	10	(10)	34	169	135	3	140	.969	< .01	5/10
7 July	Storrs, Conn.	6	(8)	456	50	90	15	113	.712	< .05	1/8
7 July	Charlton, Mass.	4	(4)	414	52	101	15	125	.483	n.s.	0/4
13 July	Green Mtn., N.H.	4	(5)	262	74	342	10	90	.816	n.s.	—
RELEASES AT SEA											
—sun visible											
24 June	Onslow Bay, N.C.	2	(6)	1,390	33	45	20	29,58			1/6
7 July	Gulf of Maine A	4	(6)	112	30	225	8	355	.495	n.s.	—
7 July	Gulf of Maine B	6	(6)	70	347	90	15	6	.135	n.s.	—

[1]N = Number of bearings; n = total birds released, including those for which satisfactory bearings were not obtained.
[2]Mean wind velocity estimated for release (km/hr).
[3]Rayleigh test (for random heading).

tendencies. The terns released at sea did not head towards the nearest land, nor to the parts that would first become visible to a climbing bird. The mean vanishing bearings (of the inland sunny releases) lay approximately between E and S (90° to 185°), and were not apparently related to home direction (Table 1).

Homing Performance

The number of terns observed to have homed from each release is shown in the last column of Table 1. Some birds that did return remained near their nests for only a short time (possibly as little as two minutes), so others could easily have been missed because each nest was not watched continuously. These numbers may be considerably less than those that actually did home. Of somewhat greater interest are the fastest homing performances, shown in Table 2. These homing speeds of 7 to 10 km/hr can be compared

TABLE 2.
Selected homing speeds of Arctic Terns.

Release site	Distance km	Time elapsed hours	Velocity km/hr
Cherryfield	34	4.28	7.9
Houlton	193	18.2 (overnight)	10.6
Lawrence	328	35.42	9.3
Onslow Bay	1390	198 (8.25d)	7.0 (168 km/day)

to the velocity of 36 km/hr characteristic of Common Terns flying from feeding areas back to their nests (speeds of Arctic Terns are similar). In addition to the one tern that homed in 8 days from Onslow Bay, N. C., one of the Durham birds was trapped at its nest in 1970. (In 1969 and 1970, 220 Arctic and 102 Common terns were trapped.) These two returns from 1,390 and 1,340 km, respectively, are the longest yet reported for this species.

DISCUSSION

Releases at sea

The failure to detect any directional preferences in the releases at sea suggests that in an unfamiliar environment (over land), the terns employ a sun-compass to select an initial SE heading, but they do not do this in a familiar one (ocean). It seems likely that the selection of a direction appropriate for *homing,* if it occurs, takes longer than the period for which the terns can be kept in view. Williams et al. (1974) released Herring Gulls (*Larus argentatus*) under clear skies in the Gulf of Maine but closer to land than the terns of the present experiments, and reported that they all flew directly to the mainland and showed no homeward orientation.

Comparison with Common Terns

At the inland releases the Arctic Terns behaved similarly to the Common Terns studied by Griffin and Goldsmith: they headed approximately SE after release if the sun was visible. However, the mean vanishing bearings of Arctic Terns varied more than those of the Common Terns. Table 3 compares the initial headings of two groups of terns from Maine, released at Storrs, Conn. and at Houlton, Me. These two groups were Common Terns from Sugarloaf Island (Griffin and Goldsmith, 1955) and Arctic Terns from Petit Manan (this study). The mean bearing for Common Terns at each site is very similar, but the two releases of Arctic Terns differ ($P = 0.05$, Mardia, Watson, and Wheeler test, after Batschelet, 1972).

TABLE 3.
Vanishing bearings of Arctic and Common terns released at same sites with sun visible.

	Storrs, Conn.				Houlton, Maine			
	n	Home Bearing	Mean Bearing	Mean Vector	n	Home Bearing	Mean Bearing	Mean Vector
Arctic Terns[1]	6	50°	113°	.712	5	182°	185°	.967
Common Terns[2]	11	44°	142°	.924	15	211°	149°	.951

[1]This study. Terns from Petit Manan Island, Maine.
[2]After Griffin and Goldsmith (1955). Terns from North Sugarloaf Island, Maine. Vanishing bearings of the 2 species do not differ significantly; $0.1 > P > .05$ in each case: Mardia, Watson and Wheeler test, after Batschelet (1972).

Homing performance was similar to that reported for Common Terns by Griffin (1943): of 80 released, he observed 34 (42.5%) at their nests on Penikese Island, Mass. within the next few days, compared to 37% in this study (Table 1). In comparing homing speeds it is necessary to bear in mind that the speeds are always minimal estimates for the particular individual bird, which might have arrived substantially earlier than when it was observed. The fastest homing speeds of Griffin's Common Terns were somewhat higher: 23 km/hr for a coastal release at 164 km, and 16 km/hr for an inland release at 618 km. Dircksen (1932) reported homing by an Arctic Tern from a coastal release site at 110 km at 15.7 km/hr. For both studies watching at nests was concentrated during times when early terns were most likely to return so that the recordings of maximum homing speeds were probably equally accurate. The nests in Griffin's study were watched for rather longer periods (8-10 hrs/day), but the percentage of birds that homed differed little.

Migration routes

The directions of the first stages of migration of the two species differ. Banded Arctic Terns from Maine, New Brunswick, Labrador, and Devon Island have been found in Europe and Africa (Hawksley, 1949, with two subsequent records from the Bird Banding Laboratory files). Common Terns have been found over a wide area of the Caribbean and the Atlantic, with largest numbers around Trinidad (Austin, 1953). The initial headings for direct courses to these places from Petit Manan are shown in Table 4:

TABLE 4.
Great Circle courses from Petit Manan, Maine.

Destination	Heading
Brittany, France	62
Dakar, Senegal	108
Cape of Good Hope, South Africa	118
Recife, Brazil	140
Trinidad	167
Cape Hatteras, North Carolina	210

great circle courses to the Arctic Tern's initial wintering areas could span 62-118°, for the Common Tern's, 140-210°. However, some of the Common Terns from the Great Lakes and hence other inland areas, may initially migrate SE (Austin, 1953), and the Great Circle heading from there to Trinidad is 141°, although the major wintering area for this population is to the west, around the Gulf of Mexico (Austin, 1953). The vanishing bearings at inland releases do not correspond with the initial directions of oversea migration of the two species, but may be consistent with the initial overland directions, although little is known of these. It would be instructive to determine the directional preferences of terns (both Arctic and Common) from populations that have migration routes different from those followed by the New England terns.

SUMMARY

Arctic Terns from nests in coastal Maine, when released over land with the sun visible, departed approximately SE. When the sun was not visible and at a coastal release, and three releases at sea with sun visible, the terns showed no such directional preference. The directional preference is similar to that of Common Terns and is not consistent with the probable directions of oversea migration.

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