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NORTHWARD FALL MIGRATION ON THE ATLANTIC COAST AND ITS RELATION TO OFFSHORE DRIFT

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ALTHOUGH the study of migration on islands has many advantages, interpretation of the results usually requires a detailed understanding of the way in which weather changes affect migrating birds. Such migration is often highly erratic, strongly correlated with the occurrence of winds blowing from the mainland, and characterized by a high incidence of species outside their normal range. These facts have been used at times to argue that the islands concerned lie off the main routes of migration, and that the birds reaching them should be classified as windblown vagrants. On the other hand, birds often reach outlying islands so regularly and in such large numbers that such an explanation is difficult to accept without more detailed investigation.

In describing investigations of migration on the island of Nantucket off southeast Massachusetts, Dennis and Whittles (1955, 1956) have called attention to a remarkably intense daytime migration that takes place there regularly each fall. The birds involved in this movement, consisting largely of species normally considered to be nocturnal migrants, pass rapidly through the island and leave in a northwest direction toward the mainland. Seventy-five miles to the west, on Block Island off the coast of Rhode Island, we encountered a closely similar northwestward migration in the falls of 1957 and 1958, and there is circumstantial evidence that analogous movements occur at many other places along the Atlantic coast of North America. This paper reviews the many scattered references to this singular phenomenon and discusses its significance in relation to studies of the migration along the Atlantic coast, which has received much attention in recent years (Baird, Robbins, Bagg, and Dennis, 1958; Baird, Bagg, Nisbet, and Robbins, 1959).

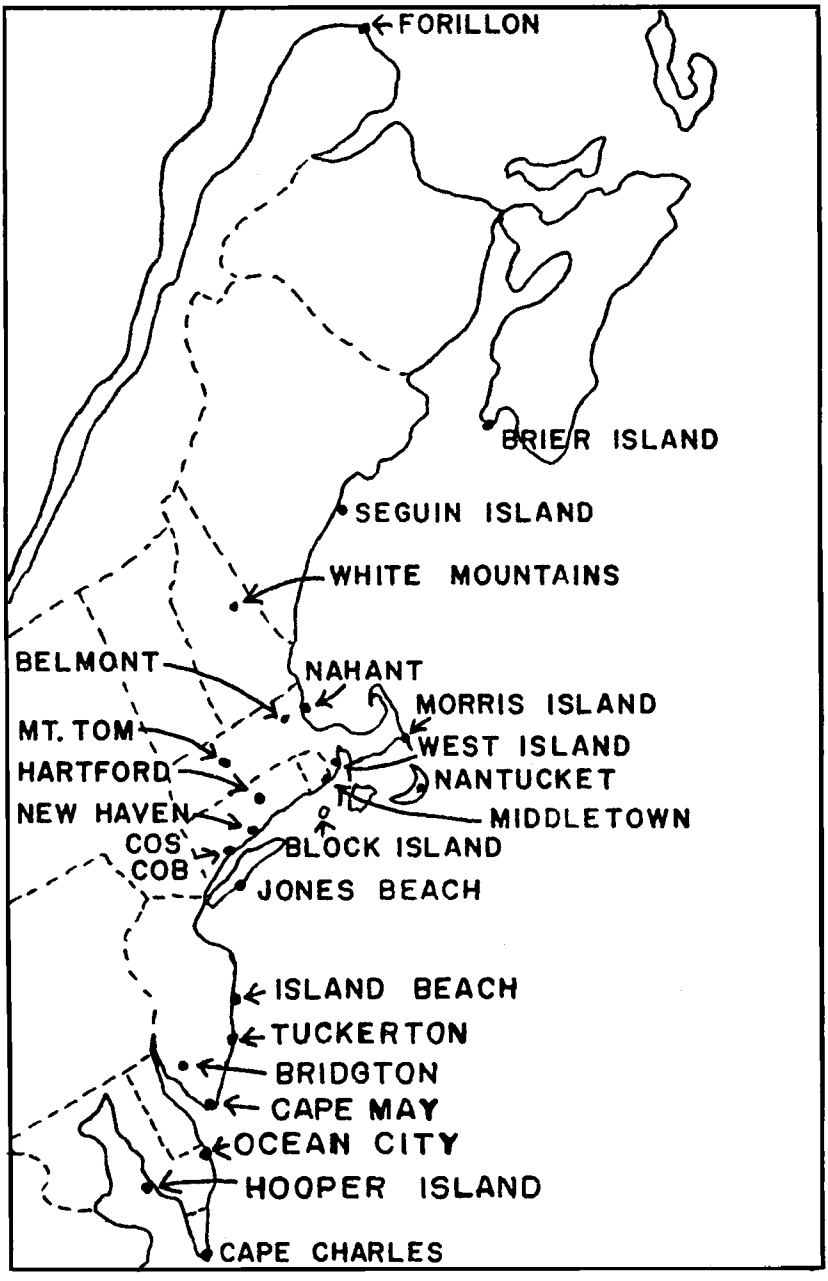

Figure 1. Places mentioned in the text.

It is necessary to distinguish between *diurnal migrants, i.e.,* species whose migration normally takes place largely in daylight hours, and *daytime migration,* the movement of any species in the daytime. In fact, this paper is concerned primarily with the unusual phenomenon of daytime migration of species that are primarily nocturnal migrants. Difficulties of interpretation arise over a few species whose migration may take place either by day or by night (*e.g.,* in our experience, the Robin, Bobolink, and Yellow-shafted Flicker); these species have usually been included in the descriptions of the observed movements, but little consideration has been given them in the discussion.

FIELD OBSERVATIONS

Nantucket, Massachusetts (Figure 2)

Daily observations (Dennis and Whittles, 1955, 1956) at the Mothball Pines, a small, planted grove close to the southern shore of the island, have shown that many flycatchers, vireos, warblers, sparrows, and certain other nocturnal migrants continually pass through in small groups, descending into the trees and stopping to rest and feed for periods of up to an hour before departing west-northwest. The same species also occur in thickets in the northern part of the island, but

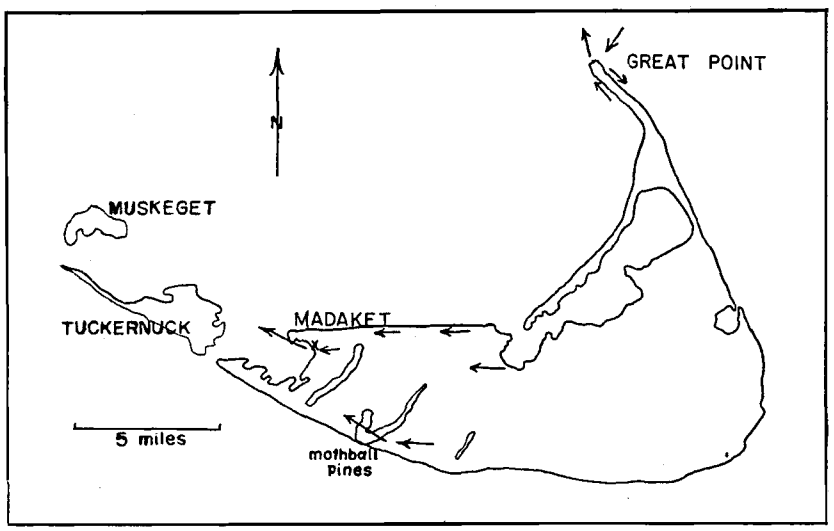

Figure 2. Map of Nantucket Island, Massachusetts. The arrows denote observed directions of migration (for details see the text, and Dennis and Whittles, 1955, 1956).

here other species, notably Catbird,[1] Brown Thrasher, Rufous-sided Towhee, etc., which rarely occur on the south coast, are also numerous. Both groups occur at Madaket, where also many birds descend for short periods before setting out to the northwest over the small islands of Tuckernuck and Muskeget. On the island, the birds characteristically ascend steeply on departure, and climb steadily until out of sight.

Warblers are also seen at Great Point, and Dennis and Whittles (1955) concluded that they arrived from the north (probably from Monomoy, the southern extremity of Cape Cod, 10 miles to the north), and drew hypothetical routes extending south and west through the island. A southerly route, close to the east and south shores, was thought to be used chiefly by warblers and sparrows (further details of the species found here may be found in the tables in Dennis and Whittles, 1955, 1956), and a northerly route through the northern part of the island was cited for other land birds. Subsequent observation, however (Dennis, pers. comm.), has suggested that these routes are not so well defined as was thought in 1955; many birds descend into the thickets from high altitudes, and it is now thought possible that many birds stop at only one place on the island. Recoveries of banded birds, however, show that at least some birds move west from place to place within the island (Baird *et al.*, 1958).

In addition to the movements of the nocturnal migrants, relatively small numbers of typical diurnal migrants (Eastern Kingbird, Tree and Barn swallows, Bobolink, and Redwinged Blackbird) also follow the southerly route and have often been seen flying west at the Mothballs. Large numbers of Pine Siskins also passed west and northwest through the island in October 1957 (Dennis, 1958). However, at Great Point, where the birds were thought to arrive (Dennis and Wittles, 1955), the only visible movement actually described was of flocks of Blue Jays on 30 September 1955; and these flew north toward the point and later returned, suggesting that they were not arriving but were attempting to leave the island (cf. Block Island records below). Meade (1944) had earlier described how large numbers of Tree Swallows flew north from Great Point towards Cape Cod on 6 October 1942 and 11 October 1943.

Migration often starts at dawn and frequently continues throughout the day. However, on some days, different species migrate at different times, and the behavior of the birds is doubtless also affected by the weather, although this is not discussed by Dennis and Whittles. A few individuals sometimes remain in the thickets all day, while others may

[1] Scientific names of species mentioned in the text are given in an Appendix.

linger "off-passage" in the same area for periods varying from a few days to several weeks (Baird *et al.*, 1958).

In discussing the species composition of the migrants at the Mothballs, Dennis and Whittles (1955) pointed out the relative scarcity of typical diurnal migrants, of species that prefer brushland and open-field habitats (which occur in numbers in other parts of the island), and of a few other nocturnal migrants, notably the Eastern Phoebe, House and Long-billed Marsh wrens, and Chipping and Field sparrows. Subsequent observation (Dennis, *in litt.*) has shown that all these species except the House Wren occur in numbers elsewhere on the island. With this one exception, the species recorded on Nantucket seem to be a fair sample of the nocturnal migrants that occur on the adjacent mainland, although a few species such as the Cape May and Bay-breasted warblers appear to be relatively more numerous on the island.

Block Island, Rhode Island (Figure 3)

Like Nantucket, Block Island has long been known for its remarkable concentrations of passerine migrants; during regular October visits made there in the last 10 years, members of the Audubon Society of Rhode Island have invariably encountered impressive numbers of birds. Baird first visited the island in 1956 with this group, and was immediately successful in netting over 200 birds, including 60 White-crowned Sparrows and nearly 100 Savannah Sparrows, in less than 50 net hours —a far larger number than could have been caught in the same netting period on the mainland. In October 1957, he again encountered a large "wave" of migrants, and noted that the main concentration of birds was at the north end of the island, and that some species departed in large numbers during the morning and flew off toward the mainland eight miles away. The northward movement was resumed after the wind dropped in the early evening, when Baird and others saw a few birds crossing the moon in a northerly direction; a similar casual watch during the previous evening had shown birds going south in strong northwest winds.

It was noted on this visit that the departing birds were concentrated over the northern tip of the island (A on Figure 3), and we were subsequently informed by some fishermen who regularly work this point that they had often seen small birds leaving in this way. This suggested that this northward movement is a frequent phenomenon at Block Island, and we made a special effort to study it during our most recent visit, from 11 to 13 October 1958. The details are given in full since

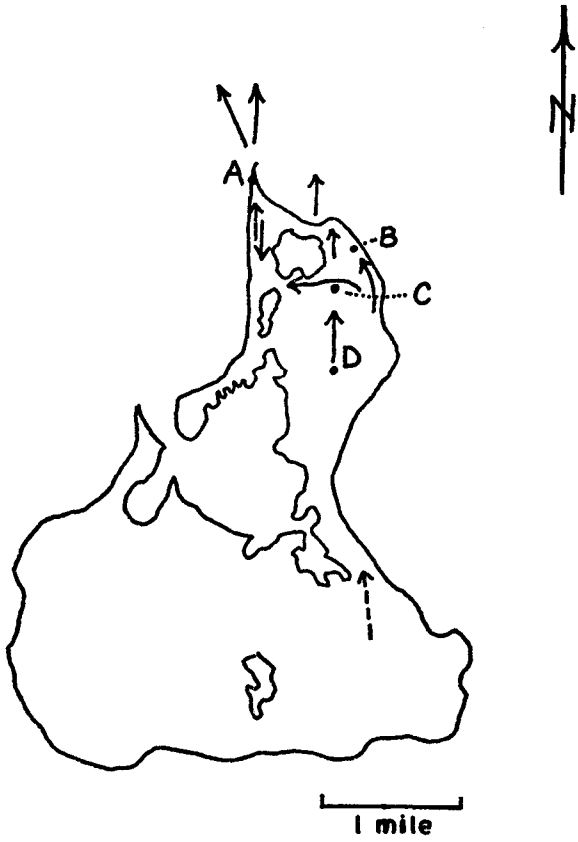

Figure 3. Map of Block Island, Rhode Island. The solid arrows indicate the directions in which night migrants were seen flying during the authors' visits in October 1957 and 1958. The dashed arrow denotes an observation of birds flying north across the face of the moon in 1957. A, B, C, D are the observation points mentioned in the text.

they illustrate points that were not covered in the accounts of the movements at other places (see points 7, 8, and 9 on page 133).

A cold front that passed during the night of 10/11 October was succeeded by an unusually strong flow of polar air, strong northwest winds persisting until the afternoon of the 13th. Perhaps for this reason (see Baird *et al.*, 1959), an exceptional wave of migrants reached the island, building up to a large peak on the morning of the 13th, when Myrtle Warblers, Slate-colored Juncos, and sparrows were present in hundreds or thousands wherever we went in the northern half of the

island. A much smaller, but still large, influx had occurred on the previous morning, but comparatively few migrants had arrived on the 11th. Because of this progressive build-up in the numbers of birds on the island, we can be sure that most of the birds seen migrating on the 12th and 13th had only just arrived.

The first sign of movement was seen on the morning of 12 October, in clear weather with the wind northwest at about 30 m.p.h. Watching at point A between 0700 and 0815, we saw only a single flock of eight Common Grackles, which flew north to the point six times, but returned on each occasion. A few birds were also noted working north to the cliffs at B, but were likewise forced to return by the strong headwinds. However, about 0830, the wind dropped slightly, and in the next 1½ hours, large numbers of birds (including Myrtle Warblers, Slate-colored Juncos, and Chipping Sparrows, in numbers between 100 and 300) were seen flying north from bush to bush through the gardens and brushy moorland around points C and D. By 1100, although none had been seen to return down the island, most of these birds had disappeared from the north end, and we believe that many had continued north to the mainland. However, substantial numbers of birds remained in other parts of the island throughout the day, and the only subsequent visible movement was that of a flock of 300 Tree Swallows, which passed north over C at 1600, and also appeared to continue northward over the sea.

Next morning (13 October), the wind was still blowing from the northwest at speeds varying between 15 and 25 m.p.h., the sky remaining clear until about 1030, when a heavy cloud bank began to build up over the mainland. Northward movement began soon after dawn, and until about midday, large numbers of birds were seen leaving the island at point A and flying north or northwest toward the mainland. Some birds turned on reaching the point and returned down the island, but most continued purposefully over the sea, and a small proportion was watched flying a steady northward course until out of sight. Table 1 summarizes counts made there between 0650 and 1135, and shows that only a few species departed in large numbers, the peak movements of each being at different times. In contrast to the observations reported from Nantucket, only a few species (*e.g.*, Myrtle Warbler and Savannah Sparrow) rose to a high altitude on departure: Eastern Meadowlarks and Yellow-shafted Flickers flew steadily at 100 to 300 feet, Slate-colored Juncos were flying at less than 100 feet, while Eastern Phoebes and Brown Creepers flew only a few feet above the waves.

The birds seen at A approached along both shores of the point, while early in the morning (0650–0730) another observer had seen many

TABLE 1

COUNTS OF BIRDS (GROUPED IN HALF-HOUR PERIODS) LEAVING THE NORTHWEST POINT OF BLOCK ISLAND, RHODE ISLAND, ON 13 OCTOBER 1958

	Time (E.S.T.)									
Species	0650 0730	0730 0800	0800 0830	0830 0900	0900 0930	0930 1000	1000 1030	1030 1100	1100 1130	*Total*
Yellow-shafted Flicker	34	2	88	24	46	197	119	105	48	600 (63)*
Brown Creeper	1	4	1	2	4	22	5	8	8	42 (13)
Water Pipit	22	27	—	3	—	—	3	1	—	20 (36)
Cedar Waxwing	—	—	—	—	2	—	24	27	—	51 (2)
Myrtle Warbler[1]	1	6	11	133	241	80	43	37	73	607 (8)
Blackbirds[2]	53	240	33	1	4	—	—	3	1	11 (324)
Eastern Meadowlark	17	—	24	—	8	6	3	—	—	28 (30)
Slate-colored Junco	1	9	61	63	117	283	361	485	311	1635 (56)
Savannah Sparrow[3]	8	35	149	180	143	67	83	53	6	721 (3)
Others (21 species)	1	3	8	9	26	14	2	5	10	48 (30)

* totals in parentheses are of birds that reached the point and returned southwards.
[1] Perhaps including a few other warbler species.
[2] Mainly Redwinged and Rusty Blackbirds.
[3] Possibly including a few other sparrow species.

Brown Creepers, Yellow-shafted Flickers, and other species migrating at point B, many arriving from the south and after some hesitation turning along the coast toward A. Later in the morning, however, large numbers of birds left northward from this point. Many birds of the same species were also seen flying north at C, while in addition, several other species were seen there in large numbers without appearing at A —*e.g.*, a flock of several hundred Tree Swallows, which turned west at B, and similar numbers of Robins, Eastern Meadowlarks, and Cedar Waxwings, which were first seen over the cliffs to the east and which flew west over C toward the west side of the island. Other species (notably White-throated and Chipping sparrows) steadily worked their way north through the bushes and accumulated in large numbers at C during the morning, while netting at C revealed several other species moving through at different times. Close examination of these captured birds showed that none had more than a little subcutaneous fat.

The numbers of birds that left the island were only a fraction of those present, and large numbers still remained on the island when the movement was over. Indeed, some species (Hermit Thrush, Rufous-sided Towhee, White-throated, White-crowned, and Chipping sparrows), although taking part in the northward migration through the island, were not seen to leave at all. It is possible that some of these species were deterred from leaving by the strong headwinds, as suggested by the observations on the previous day.

Other Places on the Atlantic Coast (Figure 1)

No systematic observations of migration have yet been made on Martha's Vineyard, Massachusetts, the only other island off the New England coast comparable in size to Block Island and Nantucket. However, the scattered observations summarized below on migration on smaller islands, and at places along the coast of the mainland, show that a northward or northwestward movement of nocturnal migrants during daylight hours is a common feature of autumn migration along the Atlantic seaboard from Virginia to the Gulf of St. Lawrence.

The following list summarizes the best-documented observations made of such movements. In addition to these, more or less casual observations of south or southwest movements in coastal districts have been given by Allen (1903), Anon. (1953a,b) and Brewster (1886), and at Belmont, Massachusetts, a short distance away from the coast (Robbins, *in litt.*). Northward movements have also been seen inland within 100 miles of the coast, in the White Mountains of New Hampshire (Allen, 1903), at Dover, Massachusetts (Bagg *in litt.*), and at Mt. Tom, Massachusetts, and Hartford, Connecticut (Bagg, 1950). However, at the last three places, southward movements have also been observed, and the situation is too complex to review without more observation.

Cape Charles, Virginia. The passerine migration here in the fall of 1936 was described briefly by Rusling (1937), and appears to be closely similar to that at Cape May, New Jersey, which has been studied in greater detail (see below). The largest numbers of birds were seen on days of north and northeast winds, when most flew south down the seaward side of the peninsula, turned on reaching the Cape and departed northward up the west shore. The numbers were often large, the highest day's counts being 3,155 Yellow-shafted Flickers, 5,000 Tree Swallows, 10,325 Robins, and 1,600 Myrtle Warblers. No flickers were ever seen to cross the mouth of Chesapeake Bay, but Robins, Eastern Bluebirds, swallows, and other diurnal migrants were often seen crossing the bay against southerly winds, and on one unusual occasion (3 November), some 200 Chipping Sparrows and 205 Myrtle Warblers were also seen in this southward movement.

Ocean City, Maryland. During observations in September 1957, Yellow-shafted Flickers, Tree Swallows, Bobolinks, and Baltimore Orioles, together with other diurnal migrants, were seen flying south along the barrier beach, while Tree Swallows tended to fly northward when the wind was blowing from a southerly quadrant (C. S. Robbins, quoted by Baird *et al.*, 1958). In September 1958, however, Yellow-shafted Flickers and warblers were seen flying north as well as south (Robbins, pers. comm.). The numbers involved were small, however, and we hope to investigate the significance of the movements in subsequent seasons.

Hooper Island, Maryland. Mr. C. S. Robbins informs us that this island is well known locally as the site of a pronounced autumn migration of hawks and Yellow-shafted Flickers, which fly northward up the east shore of Chesapeake

Bay. The birds were formerly hunted for food, and Tyrrell (1935) estimated that as many as 1,000 flickers were killed in the course of 29 September 1934. Rusling (1937) recorded flights of up to 700 Yellow-shafted Flickers per day in October 1936, and mentioned two occasions when large numbers of Tree Swallows and Eastern Meadowlarks were also seen flying north.

Cape May, New Jersey. The celebrated diurnal migration at Cape May has been described in great detail by Stone (1937). Diurnal migrants (*e.g.*, hawks, Nighthawks, Chimney Swifts, Eastern Kingbirds, and swallows) frequently pass down the coast in small numbers, and normally most cross the bay southward to the Delaware shore. However, in strong northwest winds, the numbers are vastly augmented, and almost all of the birds turn north on reaching Cape May Point and follow the shore of the bay north for as much as 20 miles. The large numbers appear to be due to the effect of the northwest winds in concentrating the birds against the coast (Allen and Peterson, 1936), while the birds' refusal to cross the bay in offshore winds is a typical example of the effect of wind on the response of migrants to lines of diversion[2] (Deelder, 1949; Tinbergen, 1949; van Dobben, 1953, 1955; Nisbet, 1957b).

Nocturnal migrants regularly take part in the northward movements in the early morning, but (unlike the diurnal migrants) in most cases described, they were seen flying in from the southeast over the sea in large numbers in the early mornings. The principal species involved are American Woodcock, Yellow-shafted Flicker, Robin, and Myrtle Warbler, all of which pass in thousands, but Stone (1937) also mentions that large numbers of Slate-colored Juncos, flycatchers, sparrows, and many other species are also involved at times.

Bridgeton area, New Jersey. Burns (1903) reported that in the region of the Upper Delaware Bay, Yellow-shafted Flickers were found flying north at some time in October of every year, just previous to and during northwest storms. "This peculiarity of flight affects a large territory extending inland from the east shore of the bay some 15 or 20 miles."

Tuckerton, New Jersey. This area of observation is a salt marsh extending for some four miles southeast from the mainland of New Jersey between Great Bay and Egg Harbor. A line of bushes along a road in the center of this marsh acts as an area of concentration for nocturnal migrants. On many visits in 1953 and 1954, Baird noted a general movement of these birds northwestward along these bushes toward the mainland, none leaving westward to make the shorter crossing to the wooded mainland, or southward to cross the narrow stretch of water to the islands of the Brigantine National Wildlife Refuge. A typical observation is that made by Mr. and Mrs. J. V. Moran *(in litt.)* on 27 September 1957, involving over 50 Yellow-shafted Flickers (many of which were seen crossing the open salt marsh), 24 Palm Warblers, 20 Cape May Warblers, and many other nocturnal migrants, all working northwest.

Barnegat Inlet, New Jersey. The south side of this break in the New Jersey barrier beach formerly contained a dune thicket (close to Barnegat Light), which harbored notable concentrations of migrants each autumn. On many occasions in 1953 and 1954, Baird saw small numbers of nocturnal migrants, notably warblers and Baltimore Orioles, depart from this thicket and fly off to the northwest towards the mainland more than five miles away. None was seen to cross the

[2] This term is used in preference to "guiding lines" or "leading lines"; see Lack and Williamson (1959), who define other terms used in this paper.

narrow inlet north to the southern tip of Island Beach, or to follow the beach southward.

Island Beach, New Jersey. During the extensive netting operations on this barrier beach in September 1957, casual observation of visible migration revealed Baltimore Orioles and Cedar Waxwings flying north in the early mornings, while Yellow-shafted Flickers flew south (Mrs. E. Dickerson, quoted by Baird *et al.*, 1958).

Jones Beach, New York. Elliott (1957) mentions frequent occasions when "in the early morning many land birds (up to the size of Flickers) may be seen . . . [over the ocean] flying towards land. This occurs most frequently during times of offshore winds." One such occurrence was seen by Nisbet on 18 October 1958, a steady trickle of Myrtle Warblers flying over the ocean from the southeast and settling in the bushes on the barrier beach. At the same time, larger numbers of Myrtle Warblers and Slate-colored Juncos (several hundred in all) were seen departing from these bushes and flying northwest over the marshes toward the main part of Long Island.

Nichols (1948), describing 50 years of observation in the same general area, referred to a diurnal movement of Yellow-shafted Flickers, Eastern Kingbirds, swallows, Robins, Cedar Waxwings, Bobolinks, and Eastern Meadowlarks westward along the outer beach. He added that at Garden City, 10 miles north of the coast, "one frequently observes . . . on mornings when there has evidently been a heavy night's migration, numbers of Robins or Myrtle Warblers flying north."

Cos Cob, Connecticut. Mrs. M. S. Roesler *(in litt.)* has described northward movements of night migrants seen 10 miles inland from Long Island Sound, along the crest of a ridge running parallel to the Mianus River. These movements are irregular and are not seen every autumn, but recur several times during favorable seasons; they always follow clear, cool nights with light, northwest winds. Most of the birds pass high above the tallest trees, a few stopping for very short periods before continuing north. The principal species involved are warblers and vireos, with smaller numbers of Robins, cuckoos, etc. Some diurnal migrants such as Nighthawks, Blue Jays, swallows, and Eastern Bluebirds are often noted also, their movements sometimes continuing in small numbers into the afternoon, whereas northward movement of night migrants is usually confined to the first four hours of the morning.

More frequently than the northward movement, south- or southwestward movements of nocturnal migrants (involving a similar range of species) are also observed in the same area, but even these occur only a few times each season. In contrast to the northward movements, these southerly movements frequently continue throughout the day, and sometimes occur in the afternoons of the days on which northward movement has been noted in the mornings.

New Haven, Connecticut. During regular observation in the autumns of 1902, 1903, and 1904 on a ridge east of the city, some two miles north of the head of New Haven harbor, Bishop (1905) regularly saw very large numbers of nocturnal migrants flying in directions between northwest and north-northeast during the first few hours of the morning. The species most regularly observed were Yellow-shafted Flicker and warblers (of many species), but Eastern Phoebe, kinglets, Bobolink, Rufous-sided Towhee, Slate-colored Junco, and sparrows were also seen in large numbers at times. Typical diurnal migrants (*e.g.*, hawks, Tree

Swallows, Blue Jays, Eastern Bluebirds, and blackbirds) seen at the same time usually flew west or southwest, but were rarely as numerous as the north-going night migrants. Bishop found that the movement was markedly concentrated at this one point, and suggested that the birds had arrived there by flying north along the eastern shore of the harbor; he was unable to detect any flying west across its mouth. He also described three occasions when large numbers of migrants were seen following the coast at Guilford, 16 miles to the east, but unfortunately does not mention the species.

Trowbridge (1902), describing observations of hawk migration in New Haven and elsewhere on the Connecticut coast, mentioned that "many other species of birds—woodpeckers, thrushes, blackbirds, etc.—make their appearance before sunrise near the Connecticut shore and are abundant for a few hours only, because they soon fly back into the country to feed."

Middletown, Rhode Island. During a special study of diurnal migration in this area in 1958, comparatively little movement of night migrants was observed, but up to 60 Robins and up to 71 Myrtle Warblers were seen on several days, usually following the shore of the Sakonnet River northward, but sometimes crossing in a westerly or northwesterly direction. Both species were seen flying northwest as much as 10 miles inland. Movements of diurnal migrants in this area are much affected by lines of diversion; many species fly between west-southwest and west-northwest when crossing the Sakonnet River and Narragansett Bay, but some—notably the Eastern Kingbird, Bobolink, and Redwinged Blackbird—habitually fly northwest (Baird and Nisbet, 1959).

An additional observation was made on 20 September 1958, when Baird saw large numbers of Savannah Sparrows flying north during the first hour after dawn from the coast in the southeastern corner of Aquidneck Island. No other large diurnal movements of night migrants have been seen in this part of the island, despite four seasons' observation at the Norman Bird Sanctuary, only half a mile inland. These observations suggest that such movements are relatively infrequent in this area, and that those occurring are most noticeable on the coast and the shores of Narragansett Bay.

West Island, Massachusetts. This small island, joined by a causeway to the west shore of Buzzards Bay, was visited by large numbers of warblers and other night migrants on 2, 3, and 5 September 1954, after the passage of a hurricane and a cold front on 31 August. All migrants seen each day flew off northwestward to the mainland in the first few hours each morning, their departure probably being hastened by the lack of food due to the killing of the vegetation by salt spray during the hurricane (Baird, 1955).

Nahant, Massachusetts. On 6 October 1958, Nisbet found a large number of newly arrived migrants, mainly Yellow-shafted Flickers, kinglets, Myrtle and Blackpoll warblers, Slate-colored Juncos and sparrows, in the wooded part of this island. But within two hours after dawn, small parties of juncos and flickers were flying north along the causeway connecting the island to the mainland.

Seguin Island, Maine. Spinney (1898, 1900, 1902, 1903, 1906a, 1906b), the keeper of the lighthouse on this small island, described numerous occasions when large numbers of birds were seen flying in from the east and southeast and continuing west and northwest toward the mainland. The most favorable conditions were "either very dark, moderate nights, or after a strong northwest wind during the night, when at daylight the birds can be seen by hundreds arriving

from seaward." The species most often mentioned were the Horned Lark, Snow Bunting, and (in two seasons) White-winged Crossbill, but sparrows and Slate-colored Junco were regularly present in thousands in late September and October. A still wider variety of birds occurred from time to time at the lantern during the night, often during overcast weather or rain with east or northeast winds.

Brier Island, Nova Scotia. Lewis (1956) described how numerous warblers and other species flew north through this island to the trees near its northernmost point in the early morning of 10 September 1955. On reaching the point, at least one warbler was seen to depart over the sea, but others returned southeastward down the shore of the island.

The Forillon, Gaspé Peninsula, Quebec. Ball (1947), reporting observations made between 1938 and 1946 on this narrow promontory, projecting for five miles southeast from the eastern end of the Gaspé Peninsula, described early-morning movements of large numbers of Red-breasted Nuthatches, which passed northwest out of the promontory, concentrated along the coast and other lines of diversion. The numbers seen varied greatly from year to year, but in good seasons (coinciding with "invasions" in New England), up to 1,188 birds were seen departing in a single morning. Few birds were ever seen entering the Forillon from the west, and Ball concluded that they arrived during the night, and that the fluctuations in the numbers of departing birds observed reflected fluctuations in the nocturnal immigration. The largest numbers occurred in cool, clear weather after the passage of depressions.

In a later paper, Ball (1952) has described in great detail observations of other species migrating in the same area. The observed movements were very confused; the birds showed a great attachment to diversion lines, and many were seen to enter the promontory from the northwest, as well as to depart in the same direction after having flown down to its tip. Ball concluded that many of the birds were engaged in a kind of "trial and error" dispersal along coastal diversion lines, as he later established for the nocturnally migrating thrushes that he specially studied. The behavior of these birds suggests that they were involved in a kind of premigratory dispersal rather than fully motivated migration, as Lowery and Newman (1955) have suggested. However, Ball added (p. 21) that far more birds were seen leaving the Forillon northwestward than were ever seen to enter it, and he concluded that many of the birds arrived at night, although his attempts to detect their arrival were unsuccessful. He gives few details of the species involved, but mentions a wide variety of warblers, thrushes, sparrows, etc., while the few actual counts that he gives suggest that on good days the numbers of birds to be seen migrating ran into hundreds.

Ball attempted to trace the subsequent course of the birds leaving the base of the Forillon, and found that a few turned southeastward to follow the north shore of Gaspé Bay. He gives no adequate counts, but it appears that the numbers of birds following this course were much smaller than those that left the promontory in a northwest direction.

Observations at sea. Although land birds are frequently seen at sea off the Atlantic coast (Scholander, 1955, and many references there and elsewhere), we have only found a few cases where their flight directions there have been recorded. Helmuth (1920), while at sea off the Maine coast, saw many large flocks of Pine Siskins flying north during 2 November 1917. Mr. P. W. Post *(in litt.)* saw one Yellow-bellied Flycatcher, six Tree Swallows, one Cedar Waxwing, and four

warblers during eight hours' observation on 24 August 1958, between 75 miles east-northeast and 40 miles west-southwest of Nantucket lightship; these remained on the ship for periods of up to half an hour, all eventually departing directly northwest. In the same area on 2 October 1956, McDade (1957) saw large numbers of birds (including 100 Yellow-shafted Flickers, 150 Cedar Waxwings, and 300 White-throated Sparrows), mainly flying west or west-southwest. The only record of more than odd birds flying south is that of Gordon (1954), who, in six days at sea, saw a total of 11 birds some 100 miles south of Nantucket and Block Island.

SUMMARY OF OBSERVATIONAL DATA

With the principal exception of those of Nantucket, where daily observation has now been maintained for a number of years, most of the observations described above have been more or less casual. But they are sufficient to show that a north- or northwestward diurnal movement of passerine night migrants is a common feature of fall migration along the Atlantic coast, and on islands and ships offshore. Southwestward movement of some of these species by day has been recorded inland, but so rarely on the coast that it seems probable that the northwestward flight is their normal behavior there, as it is definitely known to be at Nantucket and elsewhere. At some places, the northward movement could be attributed to the effect of lines of diversion on birds unwilling to make a water crossing; but this could not explain the direction of flight at other places, where fall migrants might be expected to fly southwest.

Before attempting to discuss the significance of this northwestward movement, it may be helpful to summarize the observational data and direct attention to its more salient features:

1. Most records have been made on islands and coastal barrier beaches, where the movement is most concentrated and conspicuous. But movement also takes place regularly a few miles inland in Connecticut, and there are several, possibly relevant records 50 to 100 miles inland.

2. At Nantucket all, or nearly all, the common migrants regularly take part in the northwestward flight. But at other places such flight usually involves only a proportion of the species present. Among the commoner species, the most conspicuous participants are usually the Yellow-shafted Flicker, Baltimore Oriole, Slate-colored Junco, and Savannah Sparrow; the least conspicuous are probably the Common Yellowthroat and the White-throated Sparrow.

3. Even though the migration waves on the islands and barrier beaches are often large, it is rare for all of the newly arrived migrants to leave immediately in the northward movement. Repeat records of

banded birds show that the proportion of birds staying for one or more days varies widely from place to place.

4. At some places, where lines of diversion have an important influence on their movements (*e.g.,* Nantucket and Cape May), typical diurnal migrants often take part in the northwestward movements. At other places, however, the directions of flight of diurnal and nocturnal migrants are widely different or even diametrically opposed. A few species (*e.g.,* Yellow-shafted Flicker, Robin, and Bobolink), which may migrate either by day or by night, have been seen taking part in both movements.

5. The observed directions of flight vary at different places between west-northwest and north-northeast, but this variation is probably due largely to local topographic influences. So far there is no evidence for species-specific differences in flight directions.

6. At most places, the birds are strongly influenced by lines of diversion, and at Block Island and Nantucket different species often follow different routes.

7. The movement may be inhibited altogether by unfavorable weather —as at Block Island, where departures were stopped by headwinds greater than 20–25 miles per hour.

8. In most places, migration takes place only during morning hours, with different species often migrating at different times. However, at Nantucket, where the most detailed observations have been made, the peak times of migration vary somewhat from day to day, and there is often heavy migration in the afternoon. It remains to be determined whether such variations are due to differences in the times of arrival of the birds, or to variations in the weather as it affects departures.

9. Sea-crossings may be undertaken by birds without fat reserves.

10. There is one observation of northward migration at night following a large wave of arrivals on the previous day.

DISCUSSION

Theories of Coastal Migration

Many writers, noting the correlation between large arrivals of nocturnal migrants on the coast and northwest winds, have surmised that the birds have been concentrated there by offshore winds, and some (Trowbridge, 1902; Allen and Peterson, 1936; Stone, 1937; Garrison, 1937; Griscom and Folger, 1948; Griscom, 1949) have suggested that the birds have been drifted eastward to the coast from an inland migration route. In the case of Nantucket, Dennis and Whittles (1955) point out that such drift during nocturnal flight could account for the

arrival of some of the migrants, but they suggest that the majority are in fact diurnal migrants, and arrive at Great Point from the north after a daylight crossing from Cape Cod. From analogies with migration as observed in Europe, they argue that the migration on Nantucket is the "final stage in a pronounced coasting movement which very well may have its origin several hundreds of miles to the north," and that the birds, normally nocturnal migrants, are forced to continue their flight during the day when over the inhospitable coastal habitats. Although such diurnal migration has not been recorded on Cape Cod, they point out that it could well occur unseen, and that the concentrations of birds observed there in northwest winds could arise from the precipitation of such diurnal migrants in danger of being blown out to sea. At Cape Cod, they argue, the effect of diversion lines would be to channel the birds into a narrow front, inducing them to cross to Nantucket, where the coast and other lines of diversion would lead them around to the western point and off to the northwest. The abundance of southern and western rarities in such a movement is explained by their staying "with the movement until the end, presumably because they are lost and are merely tagging along with the others."

Impressed by the arrival of different species at different times during a three-day period of maximum migration, they suggest that "an appreciable proportion of our birds reach us from Nova Scotia and other northerly points by an over-water route." Still more recently, Dennis (1957–1958) has mapped this hypothetical route from Nova Scotia and Maine to Cap Cod and Nantucket, and suggested that some of the birds arriving in this general area during the day had actually started the sea crossing at night.

While some of the arguments in these papers will need to be discussed later, it is sufficient at present to point out that none of them could explain the northward flight at Block Island or any of the places mentioned above. Other theories invoked to explain the reversed migration at specific places—*e.g.,* the following of lines of diversion (Bishop, 1905; Stone, 1937; Ball, 1947); following of tributary streams to reach a migration route in a large river valley (Allen, 1903); trial and error dispersal (Ball, 1952); downwind orientation (Devlin and Wykoff, 1958); dispersal to feed (Trowbridge, 1902); return to land after offshore drift (Spinney, 1898; Stone, 1937)—similarly cannot be extended to all the places where this northward flight has been observed. The northward movements usually coincide with north or northwest winds, so that in places where the birds are following well-marked topographical features (*e.g.,* Cape May, Hooper Island, or Nantucket), most of them could be dismissed as retromigration—the

well-known tendency for low-flying birds to follow lines of diversion into the wind (Vleugel, 1955; Lack and Williamson, 1959). There is much evidence, however, that this is not a complete explanation of the observed phenomena. In some places, the movements take place in areas without well-marked topographical features (*e.g.,* at Bridgton or at sea), or the birds cross prominent lines of diversion without change of direction (*e.g.,* at Jones Beach and New Haven). Moreover, in the places where the relation of the movements to weather has been reported in the greatest detail (New Haven and the Forillon), there is a poor correlation between the directions of the birds and the wind, while at Nantucket northwest movement regularly occurs in calm weather (Dennis, *in litt.*). Finally, coasting movements in the expected direction (south or southwest) are rarely observed, even in south or southwest winds, at least at low altitudes. We conclude that, while weather and topographical influences may at times help to concentrate the birds into spectacular numbers, they cannot account for all of the observed features of the northwest movements. In the remainder of this paper we will attempt to put forward an explanation of the widespread occurrence of this northward flight.

Importance of Wind Drift

Dennis *(in litt.)* informs us that observations on Nantucket subsequent to 1955 have suggested that Dennis and Whittles (1955) then underestimated the importance of wind drift. However, these authors present several important objections that must be considered before the drift theory can be applied to any major portion of the migrants there:

1. The birds arrive too regularly and in too large numbers for their occurrence to be regarded as accidental.
2. The birds are diurnal migrants, whereas drift should act primarily on nocturnal migrants.
3. The birds do not arrive only when the wind is offshore.

Let us consider these arguments in order:

1. The concentrating effect of islands is well known (Svärdson, 1953; Otterlind, 1955; Cornwallis, 1955). By such standards, the numbers of birds that reach Nantucket do not seem to be phenomenally large (see tables in Dennis and Whittles, 1955, 1956; cf. Gätke, 1891; Clarke, 1912; Baxter and Rintoul, 1918; Lowery, 1945; Bergman, 1951; Edelstam, 1951). The regular occurrence of drift migrants at Nantucket could be explained by the fact that the prevailing wind is offshore; it is well known that migration phenomena on the mainland

are associated with northwest winds (Trowbridge, 1902; Stone, 1937; Baird *et al.*, 1958, 1959). Moreover, as explained below, Nantucket is well placed to receive drift migrants from widely separate sources.

2. The daytime movements on the islands form the main topic of this paper and will be discussed later. The chief evidence for the contention that the birds arrive at Nantucket by day is the fairly frequent observation of arrivals at Great Point (Dennis, *in litt.*). But in the only such case that is described by Dennis and Whittles, the exhausted condition of the birds could hardly have been the result of the 10-mile crossing from Monomoy. Indirect evidence, such as the rarity with which nocturnal migrants were heard over Nantucket, and negative results from "moon-watching" there and on Cape Cod (Dennis and Whittles, 1955), have been contradicted in part by later, aural observations (Dennis, *in litt.*), while radar observations have recently shown that large-scale, nocturnal migration occurs regularly in this area (Richardson *et al.*, 1957, 1959). Migrants undoubtedly reach the other islands at night—at Block Island on 13 October 1958, for example, large numbers of birds were present before dawn. Finally, diurnal migration as seen on the adjacent mainland (Baird and Nisbet, 1959) involves just those species that are poorly represented on the islands, and the few nocturnal migrants seen moving on the mainland by day were in fact the species that showed the greatest reluctance to cross water.

3. Dennis and Whittles (1956), in describing an unusually large wave of arrivals at Nantucket on 12 October 1955, in west to southwest winds, asserted that this constituted "a final refutation of the concept that migration in the southeastern coastal regions is a product of northwesterly winds." However, it is well known that migration on Nantucket and the New England coast is usually associated with northwest winds (Dennis and Whittles, *op. cit.;* Baird *et al.*, 1958, 1959), and such anomalous cases therefore deserve special attention. The weather map for the previous night (Figure 4) shows a "low" receding northeastward over Newfoundland, and a flow of Polar air from the northwest over the Gulf of St. Lawrence and Nova Scotia, as a high-pressure ridge extended into Maine; the associated cold front moved slowly southward across the Gulf of Maine to reach Nantucket on the afternoon of the 12th. With clear skies and a sharp temperature drop in northern Maine and Nova Scotia, numbers of birds must have departed during the night, and doubtless many were drifted out to sea by the offshore winds. In the generally northerly winds prevailing over the Gulf of Maine, the most likely landfall for these birds, after flying through the front, would be Cape Cod and Nantucket. The continuance of migration through Nantucket until midafternoon on the 12th is incompatible with the hypothesis of a "deliberate" crossing from Nova Scotia, but can easily be explained in terms of offshore drift. Of course, other birds may have reached Nantucket at the same time by crossing directly from northern New England, but clearly the weather situation alone cannot be used as evidence for such a movement.

This case has been discussed in detail because the weather situation involved is typical of those that prevail when birds arrive at Nantucket in northeast, north, or southwest winds. Migration in northeast winds is usually associated with high-pressure centers or ridges in eastern Canada, which bring offshore winds to Maine, Nova Scotia, and Newfoundland. At least some of the birds arriving at Nantucket in these conditions must thus be the victims of drift from these more-northern areas. In some of these weather situations, where the wind is from the north over the Gulf of Maine, nocturnal migrants may reach Nantucket along

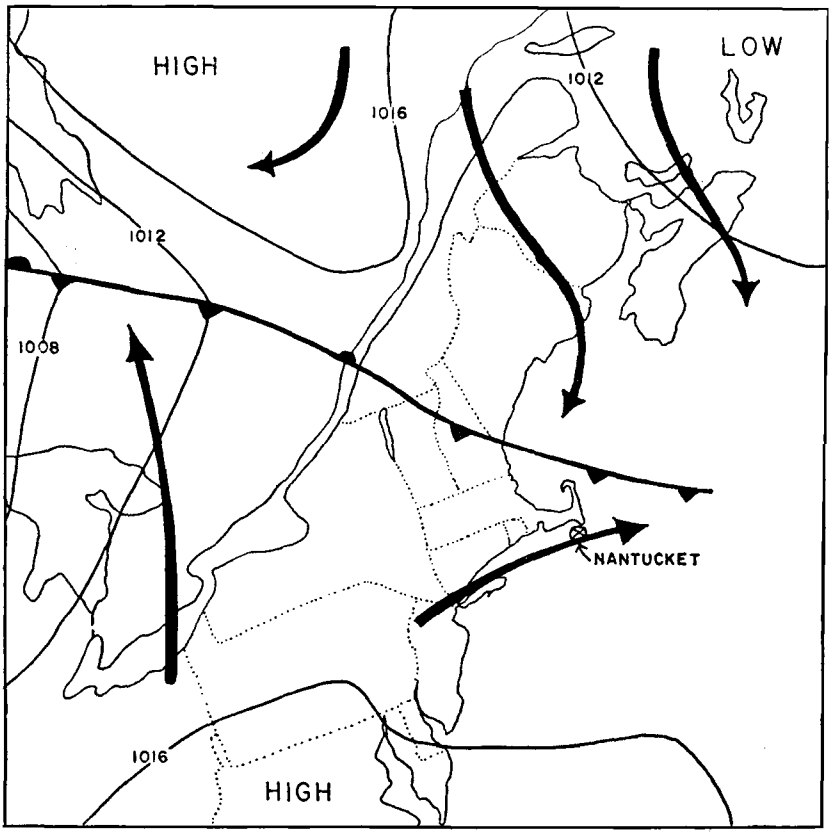

Figure 4. Simplified weather map for 0130 E.S.T. on 12 October 1955 (derived from the Daily Weather Map of the U.S. Weather Bureau). The heavy arrows denote the general direction of the airflow near the surface.

the exact routes postulated by Dennis (1957–1958), yet still be the victims of drift! Southwest winds at Nantucket are usually the return flow of tropical air on the west side of a high-pressure cell centered off the mid-Atlantic coast, and there is much circumstantial evidence that the birds reaching Nantucket under these conditions arrive, not from the north but from the *southwest* (Baird *et al.*, 1959). In cases such as that illustrated in Figure 4, when a front extends from east to west close to Nantucket, drift migrants from the northeast may fly through the front and arrive in southwest winds, while in analogous cases, migrants from the southwest may arrive in east or northeast winds. Indeed, in many of these cases, it is possible that birds may reach Nantucket from both sources simultaneously. It is a well-known feature of places where drift migration is important that birds may arrive from different sources in different weather conditions (Williamson, 1955; Cornwallis, 1955, 1956), and the position of Nantucket is indeed uniquely favorable to receive drift migrants from several different directions.

The best evidence against the hypothesis that the Nantucket birds are largely drift migrants derives from cases where large migration continued there in light winds or in calm weather, suggesting a well-oriented crossing of the Gulf of Maine from the north or northeast. A few such instances have been noted in recent years, mainly in October (Dennis and Whittles, 1956; Dennis, 1957–58; Baird *et al.*, 1959), but, pending more thorough investigation, they seem to be sufficiently rare to be regarded as exceptions.

Finally, there is now direct evidence that northwest winds do drift nocturnal migrants to Nantucket. A film made by Dr. R. E. Richardson of radar echoes of birds over Cape Cod on the night of 10–11 October 1957 shows large numbers of birds passing south-southeast on a broad front and continuing out to sea, with many reaching Nantucket. The weather was then cool (after cold-front passage), with variable cloudiness and north-northwest winds of 15–20 knots at the surface. Dennis *(in litt.)* reports that 11 October was one of the largest days of migration yet recorded at Nantucket. Another radar film made on the night of 19–20 September 1957 shows northeastward movement in tropical air of exactly the kind previously mentioned.

Determination of the origin of each migration wave at Nantucket or other offshore islands would require a much more detailed understanding of the dynamics of migration along the Atlantic coast than has yet been obtained. This will necessitate a detailed study extending over years of varying weather patterns—a study as yet only in its earliest stages (Baird *et al.*, 1958, 1959). However, there is already reason to suppose that most of the waves that reach these islands result from wind drift from the mainland, and there is as yet little evidence to indicate that significant numbers of birds arrive by any other process. In the case of Nantucket, in particular, the only alternative to thus classifying the birds as vagrants is to accept the fact that they could have evolved an unnecessary and hazardous nocturnal migration over a long stretch of water—despite an apparent preference for migrating when the wind is offshore!

Interpretation of the Northwest Flight

Perhaps the best argument for the importance of wind drift derives from the northwest flight described in this paper. The occurrence of this reversed migration in widely different geographical situations is easily understood when it is realized that most of the birds involved have been drifted southeast of their preferred routes: they are merely setting out to return to them. Such "redetermined passages" following migrational drift is now well established in Europe (Williamson, 1953; Jenkins, 1953; Cornwallis, 1955; Nisbet, 1957a, 1957b; Lack, 1959), and has even been demonstrated experimentally (Sauer, 1957). The same explanation can be advanced for the northwest movement of birds seen over the Atlantic far out of sight of land; for these birds, a northwestward flight is usually the quickest way to regain the mainland.

We now begin to see how the system may actually operate. Each cold-air mass that erupts southeastward over the Northeast tends to drift nocturnal migrants towards the coast. Some birds eventually drift

out to sea, even on clear nights when it might be expected that they could see the coast. At some stage—perhaps at first light—the birds detect their drift and attempt to correct for it. Those over the coast or near islands are able to stop, resulting in the transient concentrations that are observed there, but those over the sea must turn and fly back toward the mainland, presumably orienting by means of the sun (Kramer, 1952; Matthews, 1955) or the wind (Stone, 1937; Vleugel, 1954, 1955) if out of sight of land. These returning birds arrive during the course of the day, accounting both for fluctuations in numbers on islands and for occurrences on ships near land in late mornings or afternoons.

Meanwhile, those birds that have stopped on the islands also detect their drift—either by some process of navigation or merely from the proximity of the sea—and respond by setting out to fly north or northwest. "Diverted" by the shores of the islands and influenced by factors such as the strength of the wind, they become concentrated at the northernmost prominences and take off toward the mainland. Their behavior on arrival at the coast is not yet known, but it seems probable from the scattered observations there that at least some continue to fly inland.

In addition to these birds seen flying in from the sea, birds are already present in large numbers on the mainland coast before dawn, and it is evident that they have been concentrated there during the night. The mainland observations, *e.g.*, those made by Trowbridge (1902) at New Haven, show that many of these birds also depart northward, suggesting that they too have been drifted coastward from inland migration routes.

Within this generalized picture, there are many effects of local topography that remain to be worked out in detail. Although the observational data are still scanty, it is already clear that there are wide local variations in the frequency of this reversed migration and of the behavior of the birds, which can be resolved only by intensive local study. Moreover, the observed pattern is greatly complicated by interspecific differences in migration routes and in response to weather and topography. However, the north or northwest flight is common to so many different species, and occurs at so many different places, that it seems reasonable at present to regard it as a simple—perhaps automatic—reaction to lateral displacement; its function being correction of this displacement, regaining of the mainland (for those birds that have been drifted out to sea) and a return to the main migration route. Of course, this interpretation need not exclude the application of other theories to some species and some localities, but it seems to be the only one capable of explaining all the observed aspects of the phenomenon.

Three main problems are immediately raised by this interpretation, however:

A. It seems surprising at first sight that the birds should fly north or northwest, although a westward flight would have the advantage of returning them to a point farther south on their migration route. It seems likely that this preferred direction is in itself an adaptation to avoid drift, since a bird at sea heading west or southwest in a strong, northwest wind would continue to drift farther offshore. The northwestward flight is in fact the simplest reaction that would counter such drift and return the bird, whether over land or over water, to its preferred migration route, and it reveals the necessity for effecting this return as quickly as possible. Thus, the birds cannot be "voluntarily" drifting offshore, as part of a system of "pressure pattern flying" (McMillan, 1938; Landsberg, 1948; Lowery, 1951; Williamson, 1955), for any advantage they might have gained by deliberately drifting southward with the wind is immediately cancelled when they set out to return upwind.

B. It is still unknown what fraction of the wind-drifted birds fail to reorient their flight, but continue to drift out to sea. Records of birds on ships far out in the Atlantic (Scholander, 1955), at Bermuda (Bradles *et al.*, 1930; D. B. Wingate *in litt.*), and even in Europe (Alexander and Fitter, 1955) suggest that many must be lost in this way, but the northwestward orientation of the birds seen near the coast is so strong that it is hard to understand why the others do not also attempt to return. It is hoped that Wingate's current migration studies on Bermuda will shed some light on this problem.

C. It is difficult to explain why birds that have reached safe resting and feeding areas on the islands should leave them and return immediately to the mainland, rather than wait until their normal migration period the next evening (as drift migrants appear to do in Europe). Many of the birds have little fat remaining, yet they set out on a new sea crossing, often against a headwind so strong as to give them little chance of survival if it should increase even slightly. Since offshore winds may persist for 48 hours or more after cold-frontal passage, it is conceivable that it might be safer for some species to cross to the mainland in daylight, when they can orient visually, than at night when they may be unable to detect additional drift. Another possible advantage gained by leaving immediately might be that the limited food supply available on the islands and barrier beaches is inadequate for the large numbers of birds that sometimes occur there. Neither of these explanations is perhaps fully convincing, but the net advantage gained by this behavior may in any case be rather small, since some species do not share it.

In conclusion, it is interesting to note that some truly diurnal migrants that pass through southeastern New England have developed a similar adaptation to counter the danger of drift offshore. The main migration routes of most diurnal migrants in this area lie some distance inland, but some of these birds (the numbers varying from year to year) wander south to the coast, either by wind drift or through following lines of diversion. Many of these birds set out northwestward across the mouths of the bays, even though westward flight would be more in accordance with their standard direction and would in some cases result

in a shorter water crossing. Analysis of their behavior suggests that these birds are reacting primarily to the proximity of the sea (Baird and Nisbet, 1959).

The Importance of Drift in the Migration through the Northeast

The above arguments provide a plausible explanation of the observed movements, but they invite an important objection. If offshore drift is so important that the birds migrating through this area have evolved a special reaction to counter it, why have they not developed more efficient adaptations to the same end? Specifically, why do they not avoid the coast altogether and develop migration routes far inland? Why should they start their migration in northwest winds, and not develop a reaction to migrate in the calmer weather of the second or third nights following cold-frontal passage, as is found in Europe among hawks (Rudebeck, 1950) and some passerine night migrants (Nisbet, 1957b)?

There is, in fact, evidence that many of the birds that pass through the Northeast have developed such adaptations. For the reasons discussed elsewhere in this paper, the occurrence of large concentrations of birds along the coast is not evidence that significant numbers follow a coastal route (cf. Lowery, 1946). We have already shown that large numbers of migrants are drifted to the coast of the mainland, and the question naturally arises whether any significant numbers of birds arrive there by any other means. Observed migration on the coast, like that on the offshore islands, is in fact highly correlated with offshore winds (Baird *et al.*, 1958, 1959)—a conclusion that applies not only to areas such as southeastern New England (Garrison, 1937) and Cape May (Allen and Peterson, 1936), which are well to the southeast of the main trend of the Atlantic coast, but also to the coast of Maine and the New York City region, which must be part of any supposed system of coastal and river valley migration routes (Griscom, 1923, 1933, 1940, 1941, 1949; Bagg, 1923; Allen and Peterson, 1936; Lincoln, 1939, 1950; Nichols, 1948; Squires, 1952; Dennis, 1957–1958). A suggestive piece of evidence that concentrations of passerine night migrants on the coast are in fact dependent on drift due to offshore winds was obtained in September and October 1958, when a banding station 25 miles inland at Jamesburg, New Jersey, consistently reported peaks of migration in calm, high-pressure weather, one day later than the corresponding peaks (in northwest wind) at Island Beach, New Jersey, or coastal Long Island (Baird *et al.*, 1959, where other circumstantial evidence is quoted). If birds do follow the coast in any num-

bers, it is hard to explain why southward diurnal movements of night migrants are so rare there, although they are frequent enough 100 miles or more inland (Broun, 1945; Brooks, 1958; Eliot, 1935). The southwestward movements of nocturnal migrants occasionally seen in southern Connecticut, 40 miles from the Atlantic coast, may perhaps indicate a slight shifting of the southeastern fringe of the main body of transients, caused by northwest winds.

Conclusive proof of the existence of coastwise migration would admittedly be difficult to obtain, but almost all evidence available at present supports the hypothesis that most species of passerine night migrants reach the coast in numbers only as a result of wind drift (or other kinds of vagrancy) from their preferred migration routes inland. As exceptions, we might expect that populations that both breed and winter close to the coast might follow a genuinely coastal route; but if so they seem to be greatly outnumbered by drift migrants at the coastal observation stations.

Several anomalous features of the fall migration on the coast—*e.g.*, the high incidence of vagrant species (Dennis, 1957–1958); the high proportion of immature birds (Robbins, Bridge and Feller, 1959; Baird, unpublished); the absence of any regular concentration of diurnal migrants, at least in New England (Baird and Nisbet, 1959)—would find a ready explanation in this hypothesis. All these are characteristic features of migration at places where drift is important (Williamson, 1952; Jenkins, 1953; Svärdson, 1953). It is widely accepted that most long-distance migrants avoid the coast in spring (Griscom, 1933, 1941); the apparent difference in fall could be due largely to the presence of immature birds, which are well known to be less-successful navigators than adults (Drost, 1938; Rüppell and Schüz, 1948; Schüz, 1951; Perdeck, 1958) and to be more liable to be drifted off their course (Dwight, 1903).

In the same way, the occurrence of drift migrants along the coast is likely to exaggerate the extent to which birds migrate there after cold-front passage. Since drift is an important factor influencing their migration, those coastal breeding populations that have genuinely coastal migration routes should have developed some kind of adaptation to avoid migrating in northwest winds. The best-known example of this is the Catbird, which seldom figures prominently in the coastal waves that occur in northwest winds, but seems to migrate in largest numbers in the calmer weather two or three nights after a cold-front passage (Baird *et al.*, 1958, 1959). This species is thus well adapted to a coastal migration route, while the relative abundance of other species at coastal points may merely reflect the dangers of drift.

However, neither of these adaptations could preclude the danger of drift over the sea. The initiation of migration in passerines probably depends on a complex balance between the internal drive and external factors that act as inhibitors and releasers (Nisbet, 1957b). Thus, there are always weather situations that will defeat an adaptation to avoid migrating in northwest winds—*e.g.,* a long period of storms followed by a strong cold front, or an unusually prolonged period of northwest wind (such as that which led to the large wave on Block Island on 13 October 1958, described earlier in this paper). Even the special adaptation exhibited by the Catbird (see above) is not without its dangers, for migration peaks of Catbirds on outlying parts of the coast appear at times to be due to coastward drifting[3] in southwest winds (Baird *et al.,* 1959). Nor would adaptation to a migration route even 100 miles inland preclude drift to or beyond the coast for certain inexperienced or unlucky individuals.

The migratory behavior of many bird populations of northeastern North America may thus reflect a balance between the advantages gained by migrating close to the coast and by migrating in Polar air, and the danger thereby incurred of being blown offshore. For birds that "deliberately" migrate along the coast, the danger of drift is so serious that they seem to have evolved a special reaction to avoid migrating in offshore winds; those that migrate far inland, however, are able to exploit the advantage of migrating in northerly winds with little risk of drift to the coast. According to this hypothesis, the presence of birds on the coast would reflect not the well-adapted migratory behavior of these populations, but rather the active selection that is operating to maintain the adaptations. At any rate, it is clear that a reaction such as the redetermined migration to the northwest that is described in this paper will always be advantageous, however else the birds may be adapted to avoid drift.

Further progress in understanding the dynamics of the coastal migration will depend on more sophisticated methods of observation and analysis. Future research will be concerned with elucidation of interspecific differences in weather-migration pattern and behavior, attempts to determine more precisely the numbers involved in the migratory flights and their directions of movement, and more detailed examination of trapped migrants. We have attempted to demonstrate in this paper, however, that drift over the sea is common in migration in the coastal regions, and that detailed observation of birds subjected to it, whether

[3] In view of the earlier remarks on the preponderance of immature birds among drift migrants it is interesting to note that 95 per cent of the Catbirds trapped in the fall at Middletown, Rhode Island, are immature (Baird, unpublished).

at sea, on islands, or on the coast, is essential for solution of the problems involved.

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SUMMARY

Recent observations of fall migration at Nantucket Island, Massachusetts, and Block Island, Rhode Island, have shown that many nocturnal migrants pass rapidly through the islands and leave in a north or northwest direction during daylight hours.

Similar diurnal movements of night migrants to the north or northwest have frequently been observed at other places along the Atlantic coast from Virginia to the Gulf of St. Lawrence: they have also been noted at sea and at several places inland. Southwestward movements of these species by day have been noted inland, but are very rare on the coast. Published and unpublished observations of these movements are reviewed in detail.

We think that most of the birds that reach the outlying islands do so as a result of wind drift from migration routes over the mainland; there is as yet no convincing evidence for recent suggestions that the islands form part of the normal migration routes of these birds. The largest numbers of birds arrive after being drifted toward the coast by northwest winds, but northeastward movements also occur in southwest winds.

The northwestward flight is interpreted as "redetermined passage," *i.e.*, attempts by wind-drifted birds to regain their preferred migration routes. Some birds reorient northwestward while at sea out of sight

of land, while others start their northward flight from points on the mainland.

Drift over the sea appears to have been an important factor influencing migration close to the coast, and many of the nocturnal migrants that pass through the Northeast appear to have developed other ways of avoiding it. In particular, many species seem to have developed migration routes a little distance inland, and their occurrence on the coast is mainly a result of drift.

Some diurnal migrants appear to have similar adaptations.

APPENDIX

Scientific names of species mentioned in text

hawks (Falconiformes)
American Woodcock *(Philohela minor)*
cuckoos (*Coccyzus* spp.)
Common Nighthawk *(Chordeiles minor)*
Chimney Swift *(Chaetura pelagica)*
woodpeckers (Picidae)
Yellow-shafted Flicker *(Colaptes auratus)*
flycatchers (Tyrannidae)
Eastern Kingbird *(Tyrannus tyrannus)*
Eastern Phoebe *(Sayornis phoebe)*
Yellow-bellied Flycatcher *(Empidonax flaviventris)*
Horned Lark *(Eremophila alpestris)*
swallows (Hirundinidae)
Tree Swallow *(Iridoprocne bicolor)*
Barn Swallow *(Hirundo rustica)*
Blue Jay *(Cyanocitta cristata)*
Red-breasted Nuthatch *(Sitta canadensis)*
Brown Creeper *(Certhia familiaris)*
House Wren *(Troglodytes aëdon)*
Long-billed Marsh Wren *(Telmatodytes palustris)*
Catbird *(Dumetella carolinensis)*
Brown Thrasher *(Toxostoma rufum)*
thrushes (Turdidae)
Robin *(Turdus migratorius)*
Hermit Thrush *(Hylocichla guttata)*
Eastern Bluebird *(Sialia sialis)*
kinglets (*Regulus* spp.)
Water Pipit *(Anthus spinoletta)*
Cedar Waxwing *(Bombycilla cedrorum)*
vireos (*Vireo* spp.)
warblers (Parulidae)
Cape May Warbler *(Dendroica tigrina)*
Myrtle Warbler *(Dendroica coronata)*
Bay-breasted Warbler *(Dendroica castanea)*
Blackpoll Warbler *(Dendroica striata)*
Palm Warbler *(Dendroica palmarum)*
Common Yellowthroat *(Geothlypis trichas)*
blackbirds (Icteridae)
Bobolink *(Dolichonyx oryzivorus)*
Eastern Meadowlark *(Sturnella magna)*
Redwinged Blackbird *(Agelaius phoeniceus)*
Baltimore Oriole *(Icterus galbula)*
Rusty Blackbird *(Euphagus carolinus)*
Pine Siskin *(Spinus pinus)*
White-winged Crossbill *(Loxia leucoptera)*
Rufous-sided Towhee *(Pipilo erythrophthalmus)*
sparrows (Fringillidae)
Savannah Sparrow *(Passerculus sandwichensis)*
Slate-colored Junco *(Junco hyemalis)*
Chipping Sparrow *(Spizella passerina)*
Field Sparrow *(Spizella pusilla)*
White-crowned Sparrow *(Zonotrichia leucophrys)*
White-throated Sparrow *(Zonotrichia albicollis)*
Snow Bunting *(Plectrophenax nivalis)*

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