THE RETURN TO THE MAINLAND OF SOME NOCTURNAL PASSERINE MIGRANTS OVER THE SEA

By Bertram G. Murray, Jr.

During their southward migration large numbers of North American nocturnal passerines occur over the Atlantic Ocean (Baird and Nisbet, 1960; Drury, 1960; Drury and Keith, 1962; Nisbet et al., 1963; Drury and Nisbet, 1964; Richardson, 1972; Hilditch et al., 1973; Ireland and Williams, 1974; Williams et al., 1974). After the sun rises some of these birds head toward land, which lies to the north, northwest, or west (Baird and Nisbet, 1960; Drury, 1960). Indeed, the characteristic headings of day-flying, nocturnal passerine migrants along the coast are usually between north and west (see Baird and Nisbet, 1960, for a review of reports from Quebec to Virginia). Some birds, however, apparently do not fly toward the mainland because considerable numbers are found on ships at sea (Scholander, 1955), Bermuda (Bradlee et al., 1931), and even in Europe (Alexander and Fitter, 1955; see "Recent reports and news" sections in *British Birds* from 1958). So many birds are reported far at sea that Newman and Lancaster (1960: 6) suggested that there is a "point of no return," that is, "a point too far off track for their recovery mechanism to remain operative." Radar surveillance of trans-Atlantic passerine migration has not uncovered a point of no return; to the contrary, the interpretation is that many passerine migrants normally depart New England and eastern Canada for a long, over-water journey to the West Indies and South America (Drury and Keith, 1962; Nisbet et al., 1963; Drury and Nisbet, 1964; Richardson, 1972, 1976; Ireland and Williams, 1974; Williams et al., 1974).

Whether or not one believes that migrants usually depart the North American mainland north of Virginia for a long over-water crossing, and I have argued that they do not (Murray, 1965, 1966), there is no question that large numbers of migrants can be seen returning to the mainland in the morning (Baird and Nisbet, 1960). Evidently, not all birds over the sea complete the over-water crossing to the West Indies or South America.

The purpose of this paper is to present data on the timing of the return of migrants to the mainland, to suggest how these birds orient toward the mainland, and to evaluate the possibility of a point of no return for nocturnal passerine migrants over the sea.

METHODS

The data upon which this paper is based are the 1959 and 1960 banding records of the Island Beach Operation Recovery station, located at Island Beach State Park, Ocean County, New Jersey. Island Beach is a north-south barrier beach peninsula, about ¼ to ½ mile wide, 10 miles long, and bounded on the east by the Atlantic Ocean and on the west by Barnegat Bay. The banding station is located in the middle one third of the peninsula.

The vegetation at the banding station is generally less than 10 feet high, which facilitates the capture of large numbers of birds in mist nets. Nets were placed east-west along fishermen's paths on the bay side, across the path of northward-flying migrants, and were in operation 24 hours a day from 30 August to 26 September 1959 and from 26 August to 11 September and from 14 September to 1 October 1960. Nets were checked for birds between about 0700 and 2000 hours because pre-dawn and post-sunset net checks were unproductive. The number of nets varied from day to day, 31 to 103 in 1959 and 13 to 67 in 1960. The varying number of nets affects fluctuations between days but not fluctuations during the day.

Of the information recorded when a bird was captured, only the times of release (in 1959) and capture (in 1960) are considered in this paper. The time of release was usually within one hour of capture.

Five families accounted for about 85 percent of all passerines captured (Table 1). Of these the Turdidae, Vireonidae, and Parulidae are considered in this paper because Gray Catbirds (*Dumetella carolinensis*), Rufous-sided Towhees (*Pipilo erythrophthalmus*), and Song Sparrows (*Melospiza melodia*), which are common breeding species at Island Beach, make up a large porportion of the other two families. Casual examination of the data on the other migrant species suggests that the conclusions derived from analysis of data on the thrushes, vireos, and warblers are probably applicable to all nocturnal passerine migrant species captured at Island Beach.

TABLE 1

Number of passerines captured at Island Beach

	1959		1960	
	Number captured	% of total Passerines	Number captured	% of total Passerines
Mimidae	1,211	19.8	809	15.3
Turdidae	538	8.8	375	7.1
Vireonidae	416	6.8	492	9.3
Parulidae	2,282	37.4	1,707	32.4
Fringillidae	737	12.1	1,059	20.1
Other passerines (13 families)	921	15.1	832	15.8
Totals	6,105	100.0	5,274	100.0

The species and numbers of thrushes, vireos, and warblers captured during the banding periods are listed in Table 2.

RESULTS

During the banding periods many more individuals of all species were captured during the five morning hours than during the nine afternoon hours (Table 2). The hourly distribution of captures of all thrushes, vireos, and warblers captured on each day is shown in Tables 3 and 4. In general, the number of birds caught per hour declines from an early morning peak until about noon, after which few birds are caught. This pattern is particularly evident on migration days when large numbers of birds are caught.

I have applied a statistical test, the Friedman two-way analysis of variance by ranks (Siegel, 1956), to the data on all species of which over 50 individuals were captured. The results (Tables 5 and 6) indicate a significant difference between columns (hourly periods), except for the Cape May Warbler in 1960 (note that in 1959 the Cape May Warbler data showed a highly significant difference). Again, the general trend is for the greatest number of birds being captured in the first hour of the day, followed by a decline until about noon. It should be emphasized that the large number of birds caught in the first hour is not the result of a predawn buildup of migrants in the nets. Banders who check their nets before 0700 find few birds.

The Friedman two-way analysis of variance by ranks test was also applied to the data on non-same-day-repeat warblers, that is, those warblers that were recaptured on days subsequent to banding. The species are listed in Table 2. In the case of non-same-day-repeats, differences between columns (hourly periods) were statistically insignificant (Table 5 and 6), which means that non-same-day-repeats have no peak hour of activity during the day. Because the non-same-day-repeats reflect the activity of birds present one or more days prior to capture, and because this activity shows no peak during the day, the conclusion must be that the morning peak and activity of new captures reflects the activity of migrants that have arrived since the preceding day.

DISCUSSION

The pattern of captures of birds in mist-nets at Island Beach is striking, even more striking for those that have been there day after day and fall migration after fall migration. A burst of feverish activity in the morning gives way to greatly reduced activity in the afternoon. The birds that are captured in the morning are part of a northward movement of migrants flying rapidly through and above the shrubby growth and departing Island Beach, as indicated by the extremely low recapture rates (Table 2). Recapture rates at inland stations are considerably higher. At Drumlin Hill, Massachusetts, 9.2 percent of 2,301 Blackpoll Warblers was recaptured on a day after original capture (Nisbet et al., 1963), and at Cedar Grove, Wisconsin, 12.6 percent of 4,328 Swainson's Thrushes was recaptured on a day after original banding (Mueller and Berger, 1966). These data compare with 2.6 percent of 914 thrushes, 3.8 percent of 908 vireos, and 4.8 percent of 3,989 warblers captured at Island Beach (Table 2).

TABLE 2

The number of thrushes, vireos, and warblers captured and recaptured at Island Beach

	1959				1960			
	Number caught[1]	Number caught before noon	Number non-same-day repeat individuals	Total number non-same-day repeats[2]	Number caught[3]	Number caught before noon	Number non-same-day repeat individuals	Total number non-same-day repeats[4]
American Robin (*Turdus migratorius*)	6	4	0	0	37	32	3	3
Wood Thrush (*Hylocichla mustelina*)	4	4	0	0	10	9	0	0
Hermit Thrush (*Catharus guttatus*)	1	1	0	0	0	0	0	0
Swainson's Thrush (*Catharus ustulatus*)	386	289	11	11	229	184	2	3
Gray-cheeked Thrush (*Catharus minimus*)	73	66	4	5	34	26	1	1
Veery (*Catharus fuscescens*)	63	51	0	0	61	51	0	0
White-eyed Vireo (*Vireo griseus*)	24	15	10	14	5	4	2	3
Yellow-throated Vireo (*Vireo flavifrons*)	4	3	0	0	1	1	0	0
Solitary Vireo (*Vireo solitarius*)	9	7	0	0	28	19	2	2
Red-eyed Vireo (*Vireo olivaceus*)	336	248	4	4	412	292	3	4
Philadelphia Vireo (*Vireo philadelphicus*)	37	19	5	5	35	19	1	1
Warbling Vireo (*Vireo gilvus*)	1	1	0	0	3	2	0	0
Black-and-white Warbler (*Mniotilta varia*)	89	68	3	4	68	57	2	3
Prothonotary Warbler (*Protonotaria citrea*)	1	0	1	1	0	0	0	0
Worm-eating Warbler (*Helmitheros vermivorus*)	0	0	0	0	2	2	1	1
Blue-winged Warbler (*Vermivora pinus*)	3	2	0	0	2	2	0	0
Tennessee Warbler (*Vermivora peregrina*)	24	18	3	3	21	17	0	0
Nashville Warbler (*Vermivora ruficapilla*)	32	29	1	1	41	33	0	0

Northern Parula Warbler (*Parula americana*)	25	23	2	2	31	26	1	1
Yellow Warbler (*Dendroica petechia*)	55	48	4	4	31	23	1	1
Magnolia Warbler (*Dendroica magnolia*)	109	91	3	3	46	40	0	0
Cape May Warbler (*Dendroica tigrina*)	122	85	4	4	102	58	4	4
Black-throated Blue Warbler (*Dendroica caerulescens*)	96	72	2	2	92	81	1	1
Yellow-rumped Warbler (*Dendroica c. coronata*)	31	23	0	0	39	22	0	0
Black-throated Green Warbler (*Dendroica virens*)	45	38	0	0	23	19	1	1
Blackburnian Warbler (*Dendroica fusca*)	13	12	0	0	7	6	0	0
Chestnut-sided Warbler (*Dendroica pensylvanica*)	19	16	0	0	10	10	1	1
Bay-breasted Warbler (*Dendroica castanea*)	26	19	2	3	15	7	0	0
Blackpoll Warbler (*Dendroica striata*)	142	129	2	3	204	173	4	4
Prairie Warbler (*Dendroica discolor*)	30	19	1	1	20	16	0	0
Palm Warbler (*Dendroica palmarum*)	100	76	1	1	89	61	1	1
Ovenbird (*Seiurus aurocapillus*)	70	61	0	0	60	49	1	1
Northern Waterthrush (*Seiurus noveboracensis*)	205	176	12	14	90	69	4	8
Louisiana Waterthrush (*Seiurus motacilla*)	0	0	0	0	1	0	0	0
Kentucky Warbler (*Oporornis formosus*)	0	0	0	0	1	1	0	0
Connecticut Warbler (*Oporornis agilis*)	60	52	2	2	27	26	1	1
Mourning Warbler (*Oporornis philadelphia*)	8	8	0	0	7	5	0	0
Common Yellowthroat (*Geothlypis trichas*)	267	203	13	14	226	186	20	22
Yellow-breasted Chat (*Icteria virens*)	121	78	0	0	93	67	1	1
Hooded Warbler (*Wilsonia citrina*)	1	1	0	0	1	0	0	0
Wilson's Warbler (*Wilsonia pusilla*)	20	14	2	3	16	12	0	0
Canada Warbler (*Wilsonia canadensis*)	38	30	0	0	20	14	0	0
American Redstart (*Setophaga ruticilla*)	492	399	22	25	286	235	5	5

[1]An additional 6 thrushes, 5 vireos, and 38 warblers were captured but were untimed.
[2]An additional 1 vireo and 24 warbler non-same-day repeats were captured but were untimed.
[3]An additional 4 thrushes, 8 vireos, and 36 warblers were captured but were untimed.
[4]An additional 1 thrush, 1 vireo, and 20 warbler non-same-day repeats were captured but were untimed.

TABLE 3

Daily and hourly captures of thrushes, vireos, and warblers, in 1959

	Time (hours)														Total	Species
	0700	8	9	10	11	12	13	14	15	16	17	18	19	20		
Aug. 30	0	2	7	1	3	0	0	3	4	2	0	0	2	2	26	8
31	6	3	0	1	1	2	2	0	1	0	2	1	1	1	21	7
Sept. 1	13	5	7	4	0	1	4	1	0	2	1	1	1	2	42	10
2	6	3	5	3	2	1	5	0	0	0	2	0	0	2	29	7
3	11	3	9	8	1	1	0	0	1	0	1	2	2	0	39	7
4	34	42	25	23	9	9	11	4	3	1	4	5	5	3	178	26
5	28	13	27	24	26	22	6	11	4	18	5	3	5	2	194	27
6	8	7	15	4	11	6	5	8	3	2	1	1	1	3	75	19
7	19	8	17	9	5	1	1	1	0	1	3	3	0	2	70	14
8	7	4	7	9	4	1	1	1	1	0	0	2	0	0	37	10
9	9	11	18	16	7	6	5	3	1	0	1	2	3	1	83	19
10	40	33	23	19	11	7	6	3	1	2	0	1	2	1	149	24
11	72	19	25	36	15	12	2	1	6	2	4	1	3	1	199	29
12	88	73	70	44	35	23	12	7	9	2	6	1	6	4	380	34
13	69	67	33	28	29	10	7	9	4	3	3	4	2	9	277	32
14	23	25	45	31	36	12	1	5	3	5	0	4	1	2	193	24
15	13	11	15	3	1	4	2	0	0	1	1	1	0	0	52	19
16	0	6	10	4	5	3	1	11	2	1	4	5	2	1	55	19
17	34	29	11	16	4	7	2	3	2	0	0	2	2	0	112	25
18	30	24	17	11	13	5	2	5	5	1	1	0	2	2	118	22
19	28	40	17	7	13	6	4	1	2	2	1	2	2	1	126	24
20	30	23	18	26	14	1	2	9	3	0	1	1	5	5	138	22
21	17	12	3	3	4	1	1	1	1	2	1	1	0	0	47	16
22	32	23	12	4	7	6	2	6	4	0	1	0	4	0	101	18
23	55	35	38	32	19	6	11	6	8	4	3	2	1	1	221	23
24	27	16	8	5	7	0	2	3	0	0	0	0	0	0	68	18
25	38	26	14	9	11	6	0	0	2	0	2	3	1	2	114	23
26	12	7	5	4	1	1	1	0	1	2	3	2	3	2	44	13
Total	749	570	501	384	294	160	98	102	71	53	51	50	56	49	3,188	

The pattern of captures of birds at Island Beach differs from the patterns for Swainson's Thrushes at Cedar Grove, Wisconsin, and for all species at Ashby Bird Observatory, Massachusetts. In Wisconsin there is a marked evening peak of captures of Swainson's Thrushes (Mueller and Berger, 1966). In Massachusetts about 60 percent of captures occurs in the first five of the 10 banding periods spanning the day between sunrise and sunset (Ralph, 1976). Evening activity never occurs at Island Beach (Tables 3 and 4), and almost 80 percent of captures occurs at Island Beach in the first five of 14 banding periods spanning the day between sunrise and sunset (Tables 2, 3, 4).

Something different is occurring at Island Beach, and inasmuch as migrants are seen coming from over the ocean, I think that the birds we capture at Island Beach are migrants intercepted as they pass from the ocean to the mainland and that the declining numbers of captures during the morning are a reflection of the declining numbers coming off the ocean.

This interpretation is supported by the pattern shown by non-same-day repeats, that is, those birds that had been captured

TABLE 4

Daily and hourly captures of thrushes, vireos, and warblers in 1960

	Time (hours)														Total	Species
	0700	8	9	10	11	12	13	14	15	16	17	18	19	20		
Aug. 26	8	1	0	0	1	2	0	0	0	0	2	0	0	0	14	4
27	6	0	0	0	0	0	1	0	0	0	0	0	0	0	7	1
28	14	12	0	7	1	1	3	0	0	0	2	1	1	0	42	12
29	10	7	3	3	1	1	1	0	1	0	0	0	0	0	27	14
30	8	2	3	2	1	0	0	0	0	0	0	1	0	2	19	11
31	41	15	12	27	4	13	0	7	5	3	1	1	0	0	129	24
Sept. 1	10	1	8	0	0	1	1	0	1	0	0	1	2	0	25	11
2	39	24	14	5	9	6	2	6	3	5	2	10	4	7	136	25
3	17	7	11	12	2	8	5	6	2	4	0	4	12	7	97	24
4	30	8	5	2	5	2	1	2	2	1	0	2	5	4	69	20
5	30	12	13	2	2	5	0	8	4	2	3	2	2	1	86	23
6	78	25	27	15	4	1	1	1	2	2	1	2	3	3	165	24
7	30	14	4	4	3	0	1	0	1	0	0	0	1	0	58	16
8	18	3	9	1	3	1	0	0	2	1	0	1	0	1	40	15
9	8	2	1	2	0	2	0	1	0	1	1	0	0	0	18	11
10	11	11	5	9	3	2	6	1	1	1	2	0	4	2	58	15
11	42	33	20	10	6	1	11	11	0	15	4	6	10	0	169	23
14	23	11	6	14	5	1	5	2	0	1	3	4	1	1	77	21
15	50	24	6	14	6	8	1	1	4	2	2	2	0	1	121	24
16	26	28	1	4	5	3	8	0	2	1	0	1	1	0	80	24
17	6	3	6	3	0	3	2	1	1	1	0	2	0	0	28	15
18	5	5	1	2	0	1	3	0	1	0	0	0	0	0	18	12
19	2	5	3	5	1	0	1	0	0	2	0	0	0	0	19	10
20	2	2	5	1	2	1	1	0	1	0	0	0	3	0	18	12
21	120	50	118	43	6	1	5	3	4	3	3	0	2	0	358	33
22	5	2	4	0	1	1	1	0	0	1	0	1	0	0	16	9
23	1	1	5	2	1	0	1	1	0	0	0	0	1	0	13	4
24	33	13	5	8	12	2	0	0	2	2	1	2	0	0	80	20
25	3	2	1	1	0	0	2	0	0	0	0	3	0	0	12	8
26	2	4	2	5	0	2	6	0	1	0	0	0	0	0	22	11
27	5	2	16	8	5	5	4	2	1	2	0	0	0	0	50	16
28	17	20	33	0	13	7	1	9	2	1	2	0	1	0	106	21
29	22	15	15	9	10	9	2	2	5	8	8	0	1	0	106	18
30	57	8	1	15	6	5	2	2	0	0	1	2	0	0	99	18
Oct. 1	13	20	29	8	20	19	11	14	4	2	0	1	3	0	144	20
Total	792	392	392	243	138	114	89	80	52	61	38	49	57	29	2,526	

on a previous day and therefore were present the night prior to recapture. Although most non-same-day repeats were captured in the morning hours, the distribution of captures throughout the day is not significantly different from random (Tables 5 and 6).

We might consider alternative explanations for the pattern of captures of newly caught birds. First, perhaps later arriving migrants fly over Island Beach and on to the mainland. This seems unlikely because later arrivals have been flying longer and should be more tired and thus more likely to land at Island Beach.

Being more tired, perhaps later arriving migrants immediately rest upon alighting. Because they have not foraged since the preceding day, foraging would be expected later in the day after resting, but the data do not show increasing activity in the afternoon. Further, it seems improbable that birds that have not

TABLE 5

Results of statistical analysis of captures—1959

	Number birds captured	Number days birds captured	Rank of sum of ranks[1] Time (hours) 7	8	9	10	11	12	13	14	15	16	17	18	19	20	Probability[2] df = 13
Swainson's Thrush	386	20	1	3	4	2	5	6	7	8	9	12	11	14	10	13	<0.001
Gray-cheeked Thrush	73	14	1	3	2	4	5	7	12.5	12.5	6	9.5	12.5	12.5	9.5	8	<0.001
Veery	63	16	1	2	5	4	3	11	13.5	8.5	6	13.5	7	11	11	8.5	<0.01
Red-eyed Vireo	336	27	5	1	2	4	3	6	9.5	7	8	11	9.5	12	13.5	13.5	<0.001
Black-and-white Warbler	89	24	5	2.5	1	2.5	4	7	11	6	9	14	13	8	10	12	<0.02
Yellow Warbler	55	15	1	3	2	4	5	6	12.5	12.5	12.5	10	8.5	7	12.5	8.5	<0.01
Cape May Warbler	122	22	1	3	2	9	4	5	7	13	8	11.5	10	11.5	6	14	<0.001
Magnolia Warbler	109	21	2	1	3	4	5	7	13.5	6	10.5	8	12	13.5	10.5	9	<0.001
Black-throated Blue Warbler	96	20	1	4	3	2	7	6	9.5	5	14	12.5	11	8	9.5	12.5	<0.01
Blackpoll Warbler	142	19	2	1	3	4	5	6	12	7	9	8	13.5	10	13.5	11	<0.001
Palm Warbler	100	18	1	2	3	4	9	8	11.5	5	13	14	10	6	11.5	7	<0.01
Ovenbird	70	20	1	2	3	4	5	11	7	8.5	11	6	8.5	13.5	11	13.5	<0.01
Northern Waterthrush	205	25	1	3	2	4	5	7	10	12	14	10	6	13	10	8	<0.001
Connecticut Warbler	60	18	1	2	3	5	4	6.5	6.5	10	13	8	13	13	11	9	<0.02
Common Yellowthroat	267	27	1	3	2	4	5	6	9	8	14	13	12	11	7	10	<0.001
Yellow-breasted Chat	121	27	1	2	4	3	6	7	5	8	9	12.5	12.5	10	14	11	<0.02
American Redstart	492	28	1	2	3	5	4	6	7	11	8	13	10	14	9	12	<0.001
Non-same-day Repeat Warblers	90	26	3	1	2	5	6	4	10	11.5	13	11.5	14	9	7	8	<0.20

[1]For each day each species was captured, the numbers captured per hour were ranked: "1" for the hour period of most catches, "2" for the next most, etc. For each hour period the ranks are summed, resulting in a "sum of ranks." These are the values that are tested. *For presentation* here I have ranked the "sum of ranks." Thus, in this table a rank of "1" means that on most days most birds were captured during the indicated period, etc.

[2]The probability that the "sum of ranks" for the various hourly periods differ, that is, that captures are not evenly distributed throughout the day.

TABLE 6

Results of statistical analysis of captures—1960

	Number birds captured	Number days birds captured	Rank of sum of ranks[1] Time (hours) 7	8	9	10	11	12	13	14	15	16	17	18	19	20	Probability[2] df = 13
Swainson's Thrush	229	22	1	2	6	3	7	9.5	5	4	8	12	14	9.5	11	13	<0.01
Veery	61	17	1	2	4	7.5	3	14	13	10.5	10.5	6	7.5	10.5	10.5	5	<0.01
Red-eyed Vireo	412	32	4	1	2	3	6	5	7	8	9	10	11	12	13	14	<0.001
Black-and-white Warbler	68	20	1	4	5	3	2	6.5	11.5	6.5	8	11.5	9.5	9.5	11.5	11.5	<0.01
Cape May Warbler	102	28	1	6	2	4	9	8	14	10	13	11	7	3	5	12	<0.30
Black-throated Blue Warbler	93	23	1	2	3	4	5.5	5.5	7	10	10	10	13.5	10	13.5	10	<0.001
Blackpoll Warbler	204	25	1	2	3	4	6	7	5	9	11	8	12	10	13	14	<0.001
Palm Warbler	89	22	1	3	2	4	13	5	6.5	9	10.5	8	12	6.5	10.5	14	<0.001
Ovenbird	60	22	1	3	2	8	4	6	9	5	13.5	7	11	11	11	13.5	<0.02
Northern Waterthrush	91	25	1	2	3	4	7	5	10	9	11	8	12.5	14	6	12.5	<0.01
Common Yellowthroat	226	28	1	3	2	4	5	10.5	10.5	8	13	12	14	9	7	6	<0.001
Yellow-breasted Chat	93	25	1	4	2	6.5	3	5	8.5	12	13	11	8.5	10	6.5	14	<0.01
American Redstart	286	31	1	2	3	4	5	6	9	12	10	11	13	8	7	14	<0.001
Non-same-day Repeat Warblers	56	22	4	1	5	3	2	11	7.5	14	11	11	12.5	6	7.5	12.5	<0.50

[1], [2] See footnotes to Table 5.

foraged since the preceding day would (1) leave the area and cross another 2 to 4 miles after resting without foraging, (2) remain overnight without foraging, or (3) depart during the night without foraging.

Perhaps there is a decreasing density of migrants seaward. This is difficult to measure quantitatively, but a consideration of the various factors that affect the course of a bird (e.g., birds' speed, direction, and altitude; differential wind speed and direction with altitude) and other factors (e.g., area of origin and density at origin) does not suggest any combination of these variables that might result in a consistent pattern of decline in density of migrants eastward. Also, if the migrants departing or passing over eastern Massachusetts (Drury and Keith, 1962; Drury and Nisbet, 1964) and eastern Canada (Richardson, 1972; Williams et al., 1974) in southeastward, southward, and even southwestward directions were to maintain their direction, then the eastern edge of the broad front would be far offshore the following morning.

Finally, perhaps the migrants arrive at night and the banding data reflect the activity of birds prior to departure during the morning with the total population of migrants at Island Beach decreasing. There is little evidence that nocturnal passerine migrants regularly land at night, especially those crossing coastlines. Also, Island Beach migrants have the lightest weights recorded for the species (Murray and Jehl, 1964), and it seems unlikely that they would depart after stopping without foraging.

If the migrants at Island Beach are arriving from over the ocean, how might the pattern of captures be explained?

Let us assume that most migrants off the New Jersey coast are flying at altitudes between 1,000 feet (330 m) and 5,000 feet (1,500 m), as do migrants that have been observed on radar off the coasts of Nova Scotia (Richardson, 1972), Massachusetts (Nisbet, 1963), and Bermuda (Ireland and Williams, 1974).

Next, let us assume that only those birds that can see land can orient toward and return to the mainland. If so, the point of no return would vary with altitude (Figure 1). Because Island Beach is only slightly above sea level, the maximum distance at which the point of no return can be is 42 miles for birds at 1,000 feet and 93 miles at 5,000 feet. (If the shoreline rises precipitously from the sea to a high elevation, the point of no return is extended farther seaward, but on the other hand the distance may be limited, or further extended, by meteorological phenomena.)

If only the birds that could see land returned, one would predict that observations from the shore would show peak numbers early in the morning, followed by decreasing numbers, until there was a cessation of the movement. Sunrise is around 0630 (DST), and assuming a ground speed of 15 to 20 miles per hour, the movement of birds returning from 90 miles should cease around 1100 to 1200. These predictions are remarkably in accord with the facts that (1) there is a decline in banding from the early morning peak until around noon (Tables 2, 3, and 4) and (2) visible migration ceases before noon (Stone, 1937; Baird et al., 1958; Baird and Nisbet, 1960; Bagg and Emery, 1960).

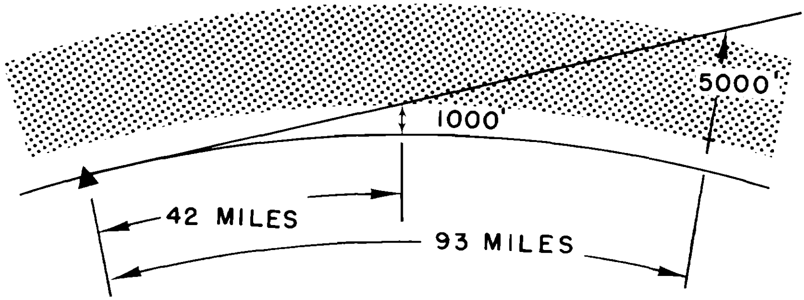

FIGURE 1. An east-west cross-section through the earth's surface at Island Beach showing the point of no return, the line tangent to the earth's surface at Island Beach. The dotted area represents the migrating birds between the altitudes of 1,000 and 5,000 feet. The point of no return is farther to seaward for birds at higher altitudes. The drawing is of course not to scale.

I conclude that birds do not usually return from farther out to sea than about 100 miles, and that orientation toward the mainland is cued by the sight of land.

Migrants out of sight of land. What happens to those migrants that are out of sight of land? Apparently, they do not direct their flight toward land. These birds may continue across the Atlantic Ocean to the West Indies and South America on oriented flight (Drury and Keith, 1962; Nisbet et al., 1963; Drury and Nisbet, 1964; Nisbet, 1970; Richardson, 1972; Hilditch et al., 1973; Ireland and Williams, 1974; and Williams et al., 1974), a theory that I have not found convincing (Murray, 1965, 1966). Even if some species are on oriented flight across the Atlantic Ocean, other species drifted over the sea by northwesterly winds (Baird and Nisbet, 1960) may take up a direction that is random with respect to land, a response similar to that of Gannets (*Morus bassanus*) (Griffin and Hock, 1949), passerines over the North Sea in fog (Lack, 1959), and inexperienced Pintail (*Anas acuta*) (Hamilton, 1962), whose flight directions are random with respect to the "home," "goal," etc., when they are without their usual orientational cues.

A return to land by these disoriented migrants may occur, however, in any one of four ways: (1) by joining other birds that have already reoriented, having been at a higher altitude, (2) by flying to a higher altitude, from which land can be seen, (3) by chance, or (4) by passive downwind drift around a high pressure cell. The latter hypothesis was suggested by Baird and Nisbet (1960) to account for the occurrence of migrants at Nantucket on days following nights of other than northwesterly winds. Migrants returning by methods (3) and (4) may make landfall at any time during the day or night, which may account for the few late afternoon arrivals reported by Stone (1937).

Migrants have been observed at sea heading toward land, which they could not see at the altitude at which they were flying. These birds were probably at a higher altitude earlier in the day when reorientation occurred; surely, those migrants heading toward land at wave top level were not flying at this altitude during the preceding night. After redirection in response to sight of land, these birds could have dropped to a lower altitude, *maintaining* their direction by reference to the waves, wind, or sun. These birds are usually flying more or less into the wind, and this explanation is consistent with the generalization that birds fly at lower altitudes against a headwind than with a tailwind.

Direction of flight. The coast of the northeastern United States has a northeast-southwest trend and is north, northwest, or west of a bird at sea, so one would expect to see birds, which are heading toward land, to be heading between north and west.

The effect of land may be illustrated best by observations of directions taken by day-flying nocturnal migrants departing Block Island, Rhode Island, and Nantucket, Massachusetts (Baird and Nisbet, 1960). At Block Island the migrants depart north-northwest; at Nantucket, west-northwest. The nearest land to Nantucket is Martha's Vineyard, Massachusetts, about eight miles to the west-northwest, whereas the nearest land to Block Island is the southern Rhode Island shore, about eight miles to the north-northwest. It seems that the birds are heading toward the nearest land. These two islands are about 75 miles apart on approximately the same latitude. An orientational cue, other than the land configuration, which could account for this difference in characteristic departure directions, has not been suggested.

This does not mean to imply that all birds will be orienting toward the *nearest* land at all times. As they approach the coastline from the sea, their direction may be influenced by other cues that have come into their field of vision. Also, individuals may respond differently. Some may continue directly inland, some may change direction at the coast (diversion-line), and others may alight immediately. All these responses have been observed in diurnal passerine migrants arriving at the coast of England after crossing the North Sea (Lack, 1959).

Wind direction can also affect a bird's course. A bird heading toward land and flying with a quartering wind or beam wind will eventually take up a direction into the wind, if it heads for a fixed point. This is known as the "pursuit" or "duffers" course (Smith, 1945; Hochbaum, 1955). Because most observations are of birds flying on days with winds between westerly and northerly, it is not surprising again that the birds are flying in these directions as they near shore.

The trans-Atlantic flight. The data provide no information on the orientational cues of the birds alleged to be flying directly to the West Indies or South America across the Atlantic Ocean. The suspect species (Drury and Keith, 1962; Drury and Nisbet; 1964) are among the commonest migrants at Island Beach (Murray, 1965) and their patterns of capture do not differ from the other species' patterns (Tables 2, 3 4). However one feels about the existence of the trans-Atlantic flight, many individuals of species that are not involved in this flight occur over the Atlantic Ocean off the coast of New Jersey, either drifting there by northwesterly winds (Baird and Nisbet, 1960) or simply migrating across this part of the Atlantic Ocean from New England to New Jersey. So many birds occur far at sea and in Europe that Newman and Lancaster (1960) suggested the notion of a "point of no return." It is the orientational cues of these birds that I have discussed here.

ACKNOWLEDGMENTS

I am most grateful to the many banders and banders' assistants who took part in the Operation Recovery program at Island Beach, especially to the directors, the late Elise Dickerson, Albert Schnitzer, and Mabel Warburton.

Without the full cooperation and hospitality of the late F. I. Dewald, Chief, Forests and Parks Section of the New Jersey State Department of Conservation and Economic Development, John B. Verdier, Superintendent of Island Beach State Park, and the members of his staff, the banding program could not have been undertaken.

R. D. Alexander, J. Baird, F. B. Gill, C. T. Collins, J. R. Jehl, Jr., R. W. Storer, J. Swinebroad, and H. B. Tordoff provided stimulating discussions and helpful criticisms. F. E. Smith counseled me on statistics.

SUMMARY

During the late summer and early fall large numbers of day-flying nocturnal passerine migrants are seen flying northward or northwestward at coastal observation points. Data from the Island Beach (New Jersey) Operation Recovery banding station bear on the problem of the orientation of these migrants that might be expected to be flying southward or southwestward. Data are analyzed on 5,714 individuals of six species of thrushes, six species of vireos, and 31 species of warblers that were captured in 1959 and 1960.

On days when many migrants arrived, the peak hourly catch during the day usually occurred before 0900, after which time the catch per hour sharply decreased until around noon. On days when few migrants arrived the differences in catch per hour are not striking.

These data and observations on the direction and timing of visible migration reported in the literature support the hypothesis that at dawn those birds that see land turn and fly toward land. Other possible interpretations of the data are considered and rejected pending further evidence.

LITERATURE CITED

Alexander, W. B., and R. S. R. Fitter. 1955. American land birds in western Europe. *British Birds*, **48**: 1-14.

Bagg, A. M., and R. P. Emery. 1960. Fall migration. Northeastern Maritime Region. *Aud. Field Notes*, **14**: 10-17.

Baird, J., and I. C. T. Nisbet. 1960. Northward fall migration on the Atlantic coast and its relation to offshore drift. *Auk*, **77**: 119-149.

Baird, J., C. S. Robbins, A. M. Bagg, and J. V. Dennis. 1958. "Operation Recovery"—The Atlantic coastal netting project. *Bird-Banding*, **29**: 137-168.

Bradlee, T. S., L. L. Mowbray, and W. F. Eaton. 1931. A list of the birds recorded from the Bermudas. *Proc. Boston Soc. Nat. Hist.*, **39**: 279-382.

Drury, W. H., Jr. 1960. Radar and bird migration—a second glance. *Mass. Aud.*, **44**: 173-178.

Drury, W. H., and J. A. Keith. 1962. Radar studies of songbird migration in coastal New England. *Ibis*, **104**: 449-489.

Drury, W. H., Jr., and I. C. T. Nisbet. 1964. Radar studies of orientation of songbird migrants in southeastern New England. *Bird-Banding*, **35**: 69-119.

Griffin, D. R., and R. J. Hock. 1949. Airplane observations of homing birds. *Ecology*, **30**: 176-198.

Hamilton, W. J., III. 1962. Initial orientation and homing of inexperienced Pintails. *Bird-Banding*, **33**: 61-69.

Hilditch, C. D. M., T. C. Williams, and I. C. T. Nisbet. 1973. Autumnal bird migration over Antigua, W.I. *Bird-Banding*, **44**: 171-179.

Hochbaum, H. A. 1955. Travels and Traditions of Waterfowl. Minneapolis, Univ. Minn. Press.

Ireland, L. C., and T. C. Williams. 1974. Radar observations of bird migration over Bermuda. Pp. 383-408 *in* A Conference on the Biological Aspects of the Bird/Aircraft Collision Problem (S. A. Gauthreaux, Jr., ed.).

Lack, D. 1959. Migration across the sea. *Ibis*, **101**: 374-399.

Mueller, H. C., and D. D. Berger. 1966. Analyses of weight and fat variations in transient Swainson's Thrushes. *Bird-Banding*, **37**: 83-112.

Murray, B. G., Jr. 1965. On the autumn migration of the Blackpoll Warbler. *Wilson Bull.*, **77**: 122-133.

———. 1966. Blackpoll Warbler migration in Michigan. *Jack-Pine Warbler*, **44**: 23-29.

Murray, B. G., Jr., and J. R. Jehl, Jr. 1964. Weights of autumn migrants from coastal New Jersey. *Bird-Banding*, **35**: 253-263.

Newman, R. J., and D. A. Lancaster. 1960. A summary of the 1959 fall migration with emphasis on navigational factors. *Aud. Field Notes*, **14**: 4-9.

Nisbet, I. C. T. 1963. Measurements with radar of the height of nocturnal migration over Cape Cod, Massachusetts. *Bird-Banding*, **34**: 57-67.

———. 1970. Autumn migration of the Blackpoll Warbler: evidence for long flight provided by regional survey. *Bird-Banding*, **41**: 207-240.

Nisbet, I. C. T., W. H. Drury, and J. Baird. 1963. Weight loss during migration. Part I: Deposition and consumption of fat by the Blackpoll Warbler *Dendroica striata*. *Bird-Banding*, **34**: 107-138.

Ralph, C. J. 1976. Standardization of mist net captures for quantification of avian migration. *Bird-Banding*, **47**: 44-47.

Richardson, W. J. 1972. Autumn migration and weather in eastern Canada: a radar study. *Amer. Birds*, **26**: 10-17.

———. 1976. Autumn migration over Puerto Rico and the western Atlantic: a radar study. *Ibis*, **118**: 309-332.

Scholander, S. I. 1955. Land birds over the western North Atlantic. *Auk*, **72**: 225-239.

Siegel, S. 1956. Nonparametric Statistics for the Behavioral Sciences. New York, McGraw-Hill.

Smith, S. 1945. How to Study Birds. London, Collins.

Stone, W. 1937. Bird Studies at Old Cape May. Vol. I. Philadelphia, Delaware Valley Ornithol. Club.

Williams, J. M., T. C. Williams, and L. C. Ireland. 1974. Bird migration over the North Atlantic. Pp. 359-382 *in* A Conference on the Biological Aspects of the Bird/Aircraft Collision Problem (S. A. Gauthreaux, Jr., ed.).

Department of Science, Rutgers University, New Brunswick, New Jersey 08903. Received 22 July 1976, accepted 22 September 1976.