A Notable Autumn Arrival Of Reverse-Migrants In Southern Nova Scotia

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ABSTRACT

Unprecedented numbers of apparent reverse-migrant and vagrant southern birds arrived the afternoon of 11 October 1998 in southernmost Nova Scotia. Their relative abundances were largely predicted by numbers of tower kills recorded during the fall season from 1955 to 1980 in northeastern Florida, as well as by the number of each species present in Nova Scotia just prior to the 1998 fallout. Among species that were unusually common or scarce relative to the northwestern Florida records, excessively large numbers of Scarlet Tanagers, Blue Grosbeaks, and Indigo Buntings diminished sharply soon after arrival and evidently reappeared in coastal Massachusetts. The many vireos and warblers lingered, and did not later appear in numbers further south. Weather patterns suggest that the birds departed coastal southeastern United States the evening of 9 October, following a stalled cold front that began to move rapidly offshore. Evidently some birds reached a southwesterly flow beyond the front and were carried (and probably flew downwind) to the east side of a deepening low south of Nova Scotia. This then propelled them on easterly gales to a small stretch of coast and islands at the southern extremity of the province.

INTRODUCTION: THE EVENT

On 11 October 1998, Nova Scotia was experiencing what locals casually refer to as "weather"— gale-to-storm-force easterlies, with driving rain. In late afternoon, Maybank, who then maintained the Nova Scotia Bird Society Bird Information Line, received a phone call from Rina Nichols, supervisor of the Atlantic Bird Observatory's banding station on Bon Portage (Outer) Island (Fig. 1). She excitedly described how, during a just-completed 1.5-hour walking census on the island, observers had tallied 62 Indigo Buntings and 10 Scarlet Tanagers, and many more in the general area. Although such numbers were unprecedented, both species are regular here in late autumn and neither would require a rare bird alert. However, it was tempting to speculate what other species might be around.

Maybank's musings were cut short by a phone call from Murray Newell, a tireless birder on Cape Sable Island at the southern extreme of the province (Fig. 1). Newell could not restrain his jubilation as he reported waves of birds coming in from the sea and hitting the coast at Dan'ls Head (Fig. 1) in the late afternoon. Many birds took shelter in stacked lobster traps, and in one confined area Newell and John Nickerson had encountered four Hooded Warblers, a Worm-eating Warbler, and "many" Indigo Buntings, as well as a few Blue Grosbeaks. This was clearly a major event.

Although many other birders had familly commitments the next day, Canadian Thanksgiving, Maybank drove to Cape Sable Island and met Murray Newell at dawn. The weather was still inclement, with northwest gales, overcast skies, and low temperatures, but the rain had halted. They headed first for the site of the previous evening's event and managed to coax two Hooded Warblers from the lobster traps. Following a hunch that more species might be found in nearby sheltered areas of vegetation in the region known as The Hawk (Fig. 1), they investigated further and found Indigo Buntings everywhere, including a single flock with more than 100 birds. There were several Blue Grosbeaks and Baltimore Orioles, and warblers and vireos flitted in the alders and spruces, among them a White-eyed Vireo and a Yellow-throated Vireo. Then, in a small hollow sheltered from the gales were four additional White-eyed Vireos, a sight heretofore never reported in Atlantic Canada. Among numerous American Redstarts, Northern Parulas, and Black-and-white Warblers, there were an adult male Prothonotary Warbler, two Scarlet Tanagers, and both cuckoos. By this time Newell had to depart, leaving Maybank to savor another adult male Hooded Warbler, another Yellow-throated Vireo, a male Blue-winged Warbler, a female Summer Tanager, and a female Western Tanager.

Curious to learn if the fallout had also occurred on neighboring peninsulas with a similar east-facing exposure, Maybank headed northeast to Baccaro Point (Fig. 1), where in less than an hour he located a second Prothonotary Warbler, another Yellow-throated Vireo, and 10 Indigo Buntings. Blanche Peninsula (Fig. 1) was next, where he remained until dusk. Memorable sights there also included two Blue-winged Warblers, one White-eyed Vireo, and a Golden-winged Warbler in a single bush. Other Blanche highlights included a male Hooded Warbler, a Yellow-throated Vireo, and 70 Indigo Buntings, as well as an immature Harris's Sparrow that might have arrived with an influx a few days earlier of White-crowned Sparrows, which were still present.

Other observers made further discoveries, but Maybank alone recorded 27 individuals of nine species that would normally be

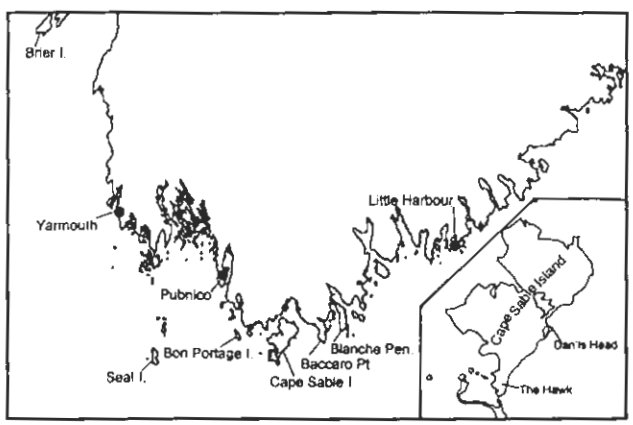


Fig. 1. Southern Nova Scotia with place names mentioned in the text.

Table 1. Occurrences of species during the fallout in southern Nova Scotia and killed at a northwest Florida TV tower 1–20 October 1955–1980 (Crawford 1985). Numbers for Bon Portage and Seal islands are combined daily estimates of birds on censussed areas 11–13 October; numbers in parentheses are combined counts (if > 0) of the same species during the three days prior to the fallout, 8–10 October. The "mainland" Nova Scotia count was made 12 October on Cape Sable Island and nearby peninsulas (see text). An asterisk indicates that the species was recorded in the areas of the fallout during the week following 11 October. Species mapped in National Geographic Society (1999) as breeding no closer to Nova Scotia than southern Maine are designated as "(S)."

Species	Bon Portage I.	Seal I.	"Mainland" NS	Florida
Black-billed Cuckoo	0	0	1	16
Yellow-billed Cuckoo	3	5	2	214
Eastern Wood-Pewee	1	1	0	8
Yellow-bellied Flycatcher	0	1	0	1
"Traill's" Flycatcher*	0	0 (1)	0	3
Least Flycatcher	0	1	0	0
Eastern Phoebe*	0	0 (4)	0	0
Great Crested Flycatcher	0	0	0	4
White-eyed Vireo (S)	7	8	7	216
Blue-headed Vireo	3 (2)	0 (1)	1	12
Yellow-throated Vireo (S)	5	3	6	102
Warbling Vireo	0	0	1	0
Philadelphia Vireo	3	1	0	12
Red-eyed Vireo	180 (2)	100 (4)	32	1374
House Wren	0	1	0	142
Marsh Wren	1	0	0	88
Ruby-crowned Kinglet	22 (11)	68 (15)	2	93
Veery	1 (1)	0	0	177
Gray-cheeked Thrush	0	0	0	98
Swainson's Thrush	0	0	1	280
Hermit Thrush	0	3	0	29
Wood Thrush	0	0	0	213
Gray Catbird	10	13 (4)	1	662
Brown Thrasher	0	0	0	187
Blue-winged Warbler (S)	0	1	4	25
Golden-winged Warbler (S)	1	0	1	19
Tennessee Warbler	6	2	0	345
Orange-crowned Warbler*	0	0	0	6
Nashville Warbler	0	7	0	2
N. Parula	52	20	19	457
Yellow Warbler	0	1	0	18
Chestnut-sided Warbler	13	7	1	305
Magnolia Warbler	14 (2)	21 (2)	9	430
Cape May Warbler	1	0	0	11
Black-throated Blue Warbler	2 (5)	0	2	17
Yellow-rumped Warbler	190 (57)	220 (125)	50	4
Black-throated Green Warbler	13	19 (2)	4	40
Blackburnian Warbler	2	1	0	105
Yellow-throated Warbler (S)	4	1	0	25
Pine Warbler*	0	0	0	54
Prairie Warbler* (S)	0	0	0	134
Palm Warbler	19 (3)	15 (2)	2	1506
Bay-breasted Warbler	1	0	0	251
Blackpoll Warbler	6 (8)	8 (3)	5	1
Cerulean Warbler (S)	0	0	0	1
Black-and-white Warbler	22	45	4	224
American Redstart	91	77 (8)	17	473
Prothonotary Warbler (S)	0	0	2	3
Worm-eating Warbler (S)	0	1	0	41
Swainson's Warbler (S)	0	0	0	35
Ovenbird	20 (4)	31	2	436
Northern Waterthrush	4	5	0	179
Louisiana Waterthrush (S)	0	0	0	3
Kentucky Warbler* (S)	0	0	0	38
Connecticut Warbler	2	0	0	0
Mourning Warbler	1	0	0	0
Common Yellowthroat	125 (11)	163 (9)	6	824
Hooded Warbler (S)	8	2	4	320
Wilson's Warbler	0	2	1	1
Canada Warbler*	0	0	0	4
Yellow-breasted Chat* (S)	0	0	0	28
Summer Tanager (S)	0	0	1	88
Scarlet Tanager	31	5	5	98
Rose-breasted Grosbeak	1	3	0	55
Blue Grosbeak (S)	27	31	6	27
Indigo Bunting	255	102	190	571
Orchard Oriole (S)	0	0	0	1
Baltimore Oriole	0	0	2	8

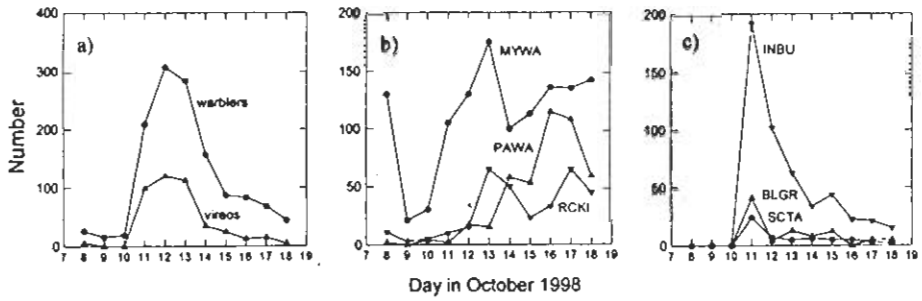


Fig. 2. Numbers of birds of certain species or species groups of birds estimated in daily census areas on Bon Portage and Seal islands, NS, October 1998. The "warblers" in panel a) exclude Yellow-rumped ("Myrtle") and Palm Warblers. The species in panel b) are: Yellow-rumped Warbler (MYWA), Palm Warbler (PAWA), and Ruby-crowned Kinglet (RCKI). The species in panel c) are Indigo Bunting (INBU), Blue Grosbeak (BLGR), and Scarlet Tanager (SCTA).

reported to local rare bird alerts, some of which would require documentation. (And that excludes the remarkable count of almost 200 Indigo Buntings.)

Through the week the teams on Bon Portage and Seal islands continued their banding and standardized censussing, and were astonished by peak daily estimates totaling over 500 warblers and vireos, including up to 24 southern vagrant individuals among them. Interestingly, although Scarlet Tanagers, Blue Grosbeaks, and Indigo Buntings continued to be abundant, their numbers declined sharply after the first day.

The cornucopia poured out all week. Maybank returned 16 October with McLaren, Eric Mills, and Elizabeth Stockwell. The weather was again blustery, but the birds continued to delight at most spots searched earlier in the week by Maybank (although the party did not visit Baccaro Point due to lack of time). Despite daily observation by others in the interim, new discoveries were still made, and the party found several RBA-reportable species, including six White-eyed Vireos, three Yellow-throated Vireos, a Golden-winged Warbler, a Yellow-throated Warbler, two Kentucky Warblers, and four male Hooded Warblers.

The extraordinary magnitude of the fallout was evident to all who witnessed it. For comparison, between 1964 and 1997 on 144 birding days on Seal Island during the first 20 days of October, none of the above-mentioned maximal day counts was exceeded (many observers, from unpublished daily lists collected by McLaren). The 1998 fallout was notably focused on east-facing areas of southernmost Nova Scotia. To the northwest, no unusual numbers of migrants and vagrants were reported during the week of 11 October from actively birded locations around Pubnico and Yarmouth (Fig. 1). More pertinently, a Nova Scotia Bird Society field trip on Brier Island (Fig. 1) found many birds 11-12 October, but no southern vagrants among them (F. Lavender pers. comm.). However, around Little Harbour, some 35 mi (60 km) northeast of Cape Sable Island (Fig. 1), David Young (pers. comm.) found about 20 Red-eyed Vireos and the following vagrants in four hours on 12 October: a White-eyed Vireo, a Blue-winged Warbler, a Blue Grosbeak, and an Indigo Bunting. There were no reports of vagrants northeast of this area during the next few days.

A weaker and later fallout event occurred in coastal Massachusetts. Numbers and dates can be gleaned from Ellison and Martin (1999) and Rines et al. (1999), and most thoroughly from newspaper accounts by E. Vernon Laux (Vineyard Gazette: 23 November 1998, "Bird notes;" 30 November 1998, "Autumn Storm Leads to Rare Bird Landings"). The earliest reported Indigo Buntings were eight at Truro, Cape Cod, 12 October; others were found that day on Martha's Vineyard, along with nine Blue Grosbeaks. Greater numbers of Blue Grosbeaks appeared later on Martha's Vineyard: 16 on 14 October and 26 on 16 October. There is no mention of large numbers of northern vireos and warblers, but southern vagrants included a White-eyed Vireo at Truro on 12 October, and four-five Scarlet Tanagers, a Yellow-throated Vireo, and a Yellow-throated Warbler and three Prothonotary Warblers during 13-14 October. Two Hooded Warblers were netted at Tuckernut on 12 October. The only published mention of a timely occurrence in relation to the Nova Scotia arrivals were the four Blue Grosbeaks found 11 October on Block Island, RI, quite far from the storm's center (Ellison and Martin 1999).

THE LIST

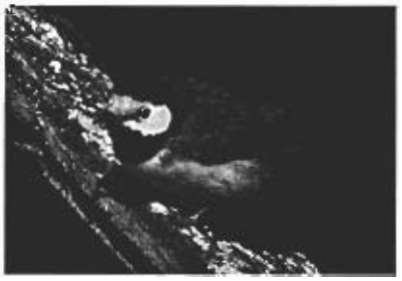
Estimated numbers of individuals of the various species involved in the fallout in Nova Scotia have been publicized previously (Brinkley 1999, Ellison and Martin, 1999). Those numbers were generated by Maybank partly by extrapolations from reports that concentrated only on rarities and vagrants to estimate numbers of more

common species. Maybank had also used counts made by various observers through the week following the fallout, when there were considerable changes in relative abundance of the fallout species.

In the combined daily estimates in censussed areas of Bon Portage and Seal islands, abnormally late migrant and vagrant warblers and vireos (along with a handful of flycatchers, thrushes, and Gray Catbirds) peaked on 12 October, the day after the storm (Fig. 2a). By contrast, the notable numbers of Indigo Buntings, Blue Grosbeaks, and Scarlet Tanagers dropped sharply (Fig. 2c). Three abundant, hardy species that normally have peak abundances in Nova Scotia in early October or later (Tufts 1985)—Ruby-crowned Kinglet, Yellow-rumped Warbler (which also winters in numbers) and Palm Warbler (Fig. 2b)—continued to increase for some days after the storm.

For further analysis, we used only the estimated daily numbers of each species in the island census areas 11–13 October, along with numbers tallied by Maybank during his extensive survey 12 October. We excluded some sparrows that are routine, often in large numbers, at this time of year and that also winter in Nova Scotia; those species generally reckoned as day-migrants or otherwise unlikely to have flown offshore further south (other sparrows, most icterids other than orioles; the western vagrants Western Tanager and Harris's Sparrow); and those not noted amongst trees and brush that were searched (swallows and Bobolink). The final lists (Table 1) represent relative abundances of the species that arrived in the fallout.

Blue Grosbeaks, like this one sitting in a spruce in southern Nova Scotia in mid-November 1995, are scarce vagrants in the province; more than 60 during the first three days of the fallout in October 1998.



The most abundant "southern" Warbler in the 1998 fallout was the Hooded, most of them males like this one glowing amidst building debris on Sable I. in mid-September 1974.

A few Indigo Buntings, like this one on Seal I. in October 1987, are regular late-fall vagrants in Nova Scotia, but occurred in unprecedented numbers as the most abundant species in the 1998 fallout.

SPECIES COMPOSITION AND ORIGIN OF THE BIRDS

Here we use the relative abundances of the fallout species in Table 1

as an indication of their possible origin. Clearly some species marked as "southern" in Table 1 had undergone reverse migration from somewhere south of New England; presumably some associated species had also done so. South of New England, a "good flight" of warblers was in coastal Virginia 23 September 1998 (Iliff 1999), and a few concentrations were also found in the southern Atlantic States in September (Davis 1999). By early October, however, most warbler species would have vacated the mid-Atlantic states while still showing peak or near-peak numbers in Florida or on the Gulf Coast (Dunn and Garrett 1997). Indeed, there were notable numbers of vireos and warblers in Florida during late September and early October 1998 (Pranty 1999). Local banding records may be uninformative. For example, on a capture list of 22 species from Orlando, FL, 10–12 October (Parks Small, Florida Park Service, pers. comm.), only the Common Yellowthroat was among the top ten in found Nova Scotia (Table 1). Many of the fallout species also occur in the fall on the Bahamas. There are no quantitative records available from the Bahamas for early October 1998 (Rick Oliver and Tony White, pers. comm.), and records of kills at two towers on Grand Bahama 22 October 1966 (Kale et al. 1969) do not seem helpful; among 133 individuals of 22 species, more than half consisted of Gray-cheeked Thrushes (39), Blackpoll Warblers (21) and Northern Parulas (14), only the last of which was among the top ten in Nova Scotia.

Without sufficient combined records of numbers from banding stations or other quantitative lists from southeastern U.S. at the time of the fallout, we use the extensive data in Crawford (1981a). He presented numbers killed at a northwest Florida TV tower during the three 10/11-day periods of each month from 1955 to 1980. From these we combined the counts for the first two 10-day periods of October. As with the Nova Scotia list (see above), we included only those species that are primarily night migrants and excluded those that routinely winter in Nova Scotia. Of the 10 most abundant species in the Nova Scotia fallout (Table 1; estimates >80), six were among the top 10 in Florida. Among the Nova Scotia top 10, all had peak Florida mortalities during the first third of October except for Red-eyed Vireo, which had peaks in the first and second third periods (differing age groups?).

The similarity of the ranked abundances at the three Nova Scotia locations ($R^S = 0.66$–0.77 in the three comparisons, all $P << 0.001$) is as expected. The high correlation of the combined Nova Scotia estimates with those from Florida ($r^S = 0.51$, $P << 0.001$) is also not surprising, as the same would probably be true of any other pair of substantial autumn lists from eastern North America. Of greater interest is the extent to which observed species abundances in Nova Scotia can be explained by their relative numbers at that time in Florida and by other possible influences. Regressions using raw numbers (Table 1) have severe statistical problems, with residuals far from normal (Kolmogorov-Smirnov tests, $P << 0.001$). Logarithmic transformation of numbers (+1) produces well-fitting models. Almost one-third of the variation ($r^2 = 0.29$) in the combined Nova Scotia counts is predicted by the Florida counts alone ($t = 5.25$, $P << 0.001$). However, some of the presumed fallout birds were obviously in the vicinity before 11 October. To correct for the expected presence of such individuals during 11-13 October, we also used models that included the average abundances (log [n + 1]) of all species that had been detected in the three days prior to 11 October on Bon Portage and Seal islands (Table 1). Understandably, this sharply increased the amount of variation explained ($r^2 = 0.53$), but slightly weakened the relationship of the fallout and Florida estimates ($t = 4.91$). Similar models fit separately to the data for each island (no pre-fallout estimates available for the mainland counts) increased the amounts of variation explained ($r^2 = 0.56$ for Bon Portage, $r^2 = 0.52$ for Seal Island), but the relationship between the fallout and Florida abundances was strengthened only for Bon Portage Island ($t = 5.88$ for Bon Portage, $r^2 = 4.63$

for Seal Island). A surprisingly large amount of variation among the fallout species can thus be explained by expected "background" numbers and the Florida tower kill records.

Regression can also incorporate features that might reflect the abilities of species to undertake or survive sustained flight over the ocean. We hypothesized as additional independent variables: migration span, crudely as the difference between median latitude of summer and winter ranges (from Howell and Webb 1995; National Geographic Society 1999; Ridgely and Tudor 1989, 1994); average or median wing length (from Pyle 1997); average body weight (mostly from Dunning 1993); and interactions among them. The only variable, along with the pre-fallout counts, that added slightly to amount of variation explained ($r^2 = 0.55$) and to the relationship between the Nova Scotia and Florida abundances ($t = 5.21$) after stepwise regression, was body weight ($t = -1.88$, $P = 0.063$). This seemingly counterintuitive, weakly negative effect of body weight appears to reflect consistent under-representation of the relatively large thrushes and mimids, not compensated by over-representation of fewer large species like Blue Grosbeak.

Probably the most reliably counted birds were the vireos and warblers, which occurred in similar wooded habitats, often flocked together, and were keenly sought. The tower kills for this selected group, along with the average abundances on the islands prior to the fallout, indeed explain more variation ($r^2 = 0.68$, $t = 4.99$ for the effect of the Florida counts) among the fallout abundances, with no other significant variables. The model using data from Bon Portage Island alone explained no more overall variation in fallout numbers ($r^2 = 0.66$), but enhanced the apparent explanatory power of the Florida counts ($t = 6.19$). Use of data from Seal Island alone greatly increased the amount of variation explained in fallout numbers ($r^2 = 0.72$), largely attributable to the prior island counts ($t = 7.21$ vs. 4.84 for the effect of Florida counts).

Given the variations among the various models, it would be unwise to attempt to explain all remaining differences between the Nova Scotia and Florida lists. In statistical terms, only the regression for all species on Table 1, using both pre-fallout abundances and body weights, had a species significantly too common in Nova Scotia relative to Florida This was the Indigo Bunting (standardized residual = +3.54), with the Blue Grosbeak (+2.79) and then Scarlet Tanager (+1.97) next most deviant, although not significantly so (at $P = 0.05$). These deviations do not detract from the general conclusion that the fallout originated from an assemblage of species resembling the set of birds usually present at the same season in the southeastern United States

WEATHER PATTERNS AND ORIGIN OF THE BIRDS

The easterlies that brought the birds ashore were associated with deepening low pressure centered south of Nova Scotia and east of Cape Cod (Fig. 2, 11 October, 18 Z, 13:00 ADT). The lack of fallout in localities in the wind "shadow" to the northwest (Fig. 1), is in keeping with this pattern. The fewer birds around Little Harbour, NS (Fig. 1), and lack of recorded sightings beyond that to the northeast also indicate that a quite compact mass of birds had become entrained close to the storm's center (see the isobar patterns Fig. 3, 11 October, 18 Z). The limited number of species, smaller number of individuals, and evidently later appearances of apparent fallout species in coastal Massachusetts (see Introduction) suggest that those were birds that had resumed southward migration from Nova Scotia. This hypothesis is reinforced by the sharp diminution of numbers of Blue Grosbeaks and Indigo Buntings the day after the Nova Scotia fallout.

Where did they originate? In early evening Oct. 10 (Fig. 3, 10 October, 00Z) and for more than 24 hours previously, a characteristic "Carolinas front" was nearly stalled along the U.S. east coast, from

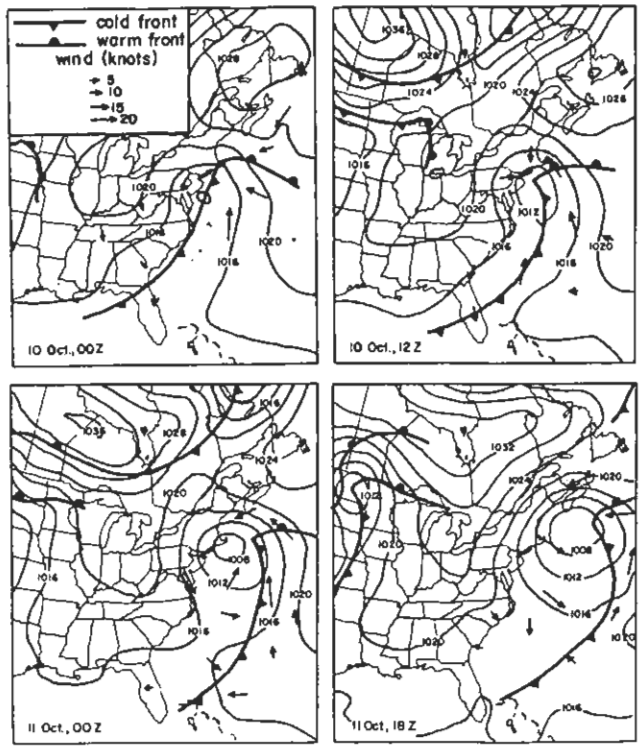


Fig. 3. Surface atmospheric pressure and wind patterns 9–11 October 1998. The wind directions, where strong, probably reflect quite well those at higher altitudes, where birds migrate. The universal times (Z), 00, 12, and 18, are equivalent to 21:00, 09:00, and 15:00 ADT respectively in Nova Scotia, and one hour earlier in Florida.

Cape Cod in the north to across northern Florida in the south. The front was embedded in a shallow trough, with cyclonic flow beginning to develop at its northern end, and moved sharply offshore overnight 9-10 Oct. (Fig. 3, 10 October, 00 Z and 12 Z). Although the cold front was weak, with following surface flow only ~5 knots in the southeastern United States, these conditions generally encourage migration. As Richardson (1972) found from radar studies in eastern Canada: "Offshore flights to the SE or S were most common or densest when there were W or NW winds. Such winds usually occurred immediately after the passage of cold fronts." Richardson (1976) also found that landbirds flying toward the West Indies generally continued southeast–south-southwest at dawn even over the sea. Southeast movement of birds on 5-knot northwest winds with passage of a cold front is pertinently evident in ground distribution of bird kills at a TV tower at the Tall Timbers Research Station in Leon County in the Florida panhandle (Crawford 1981b, his Fig. 1, depicting 25 September 1965). On the other hand, ahead of such cold fronts where southwest flow prevails, there can be reverse, downwind migration, although this is variable in occurrence and intensity (Richardson 1978, 1982).

Thus, a large movement of birds off the southeast U.S. coast could have occurred on the night of 9–10 October. The slackness of winds (open isobars on Fig. 3) southeast of Florida might suggest that mass departures would not have originated from the Bahamas. However, there was also strong convection (cumulus and thunderstorms) over the Bahamas that could have carried birds aloft. North of the Bahamas the strong southerly flow in the warm sector could have triggered downwind, reverse migration by offshore migrants.

More insight can be gained tracking hypothetical parcels of air using the Canadian Meteorological Centre's trajectory model. Back-trajectories of air arriving at Cape Sable (Fig. 1) at 12 Z proved somewhat unrevealing. Parcels at 1000 (surface) and 925 hPa (~0.5-mile altitude) arrived from the northeast. However, air at 850 hPa

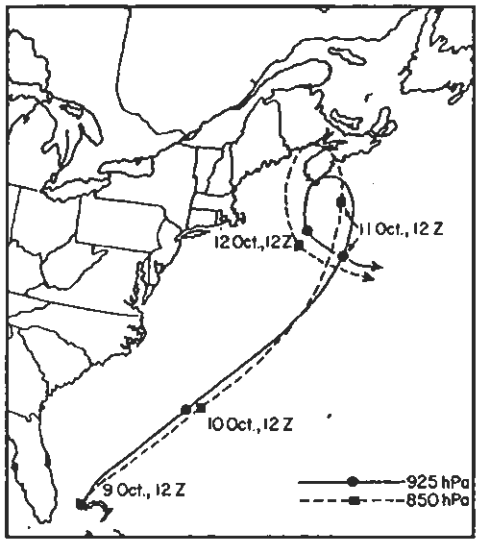


Fig. 4. Trajectory of an imaginary parcel of air originating at Freeport, Bahamas, and tracked over the next three to four days. Positions each day at 12 Z, or 08:00 in Freeport and 09:00 ATD in Nova Scotia, are indicated.

(~1 mile up) was traceable to a position ~100 miles north of Bermuda 24 hours earlier. Passerines in the Caribbean region can certainly fly at such heights (Richardson 1976), but Bermuda is a most unlikely origin of the fallout.

Another approach is to trace forward-trajectories from plausible sources. A hypothetical origin from Bahamas (Fig. 4) is revealing. For birds to have left Freeport, convected locally to 925–850 hPa (0.5-1 mile) levels, and then to be carried passively to Nova Scotia by afternoon 11 October, would have required departure almost a half-day prior to 9 October at 12 Z (the evening of 8 October). This would have meant staying aloft almost three days. However, the Freeport air parcel was greatly accelerated at these altitudes beginning next day (Fig. 4). Passerines departing east to southeast on the evening of 9 October from the Carolinas to Florida and traveling at flight speeds of ~20-25 m.p.h. could easily have been 200 miles offshore at dawn the next day (Ehrlich et al. 1988). This would have placed them near dawn on 10 October somewhere between the hypothetical positions (Fig. 4) of the Bahamas air parcel at 12 Z on 9–10 October. The accelerated southwest flow would then have taken them quite close to Nova Scotia by early morning 11 October (Fig. 4). Abetted by downwind flight, an arrival in southwest Nova Scotia a few hours later, less than two days after departure, is highly plausible. It is also noteworthy that the hypothetical air masses, after reaching Nova Scotia, did not pass near coastal Massachusetts (Fig. 4).

It is also possible that meteorological conditions had concentrated the birds at departure sites prior to their offshore movements. There were broad south-southeast airflows in the southeastern United States in advance of the progressing front before it reached the coast. If many such migrants had oriented downwind, as noted previously at sites in Louisiana and Georgia by Gauthreaux and Able (1970), they might have become concentrated along the front as it progressed. However, this in itself cannot explain the arrival of such large numbers from offshore in Nova Scotia.

CONCLUSION

It is clear that the large and diverse assemblage of birds that arrived at southern extremity of Nova Scotia from the east originated much farther south, plausibly from the southeastern U.S., 1500-2500 km distant. This contrasts with Richardson (1982), who could not conclude from radar tracking that autumn reverse migrants in Nova Scotia had traveled more than 400 km from New England. The combination of offshore movements of cold fronts in the southern U.S., with low pressure developing farther north, is a common meteorological pattern, and may help explain the unusual frequency of southern vagrants during autumn on Nova Scotia islands (McLaren 1981). The particularly spectacular example of 11 October 1998, after the birds became caught up in southwesterly flow, may have resulted from the slow movement of the storm center off southern Nova Scotia, which ultimately propelled them ashore. Such centers usually move rapidly to the northeast and offshore, and must on such occasions carry many more landbirds to a watery end. A plausible case has indeed been made that severe North Atlantic storms in autumn may negatively influence songbird breeding populations the following spring (Butler 2000). The arrival of much greater numbers of Indigo Buntings, Blue Grosbeaks, and Scarlet Tanagers relative to their abundances on the Florida list may indicate that they were better able to sustain the long flight. The sharp drop in their numbers the day after arrival and their apparent reappearance in coastal Massachusetts may also reflect a robust condition for resumed migration compared with the many, mostly smaller, obligate insectivores. More insights on effects of the 1998 fallout and similar reverse-migration events could be gained by analysis of banding recapture rates and changes of body condition of individuals of the species involved.

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