# THE EFFECT OF WEATHER ON THE MIGRATION OF SHOREBIRDS COMMON TO THE EASTERN SHORE OF LAKE ONTARIO

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The effects of weather on bird migration have been studied since the late 1800's. However, there is still little agreement about the effect of weather on migrating birds (Brooks, 1965). This study was designed to correlate weather changes with the fall and spring migration of shorebirds.

There are three fundamental beliefs concerning weather and migration. Griffin (1964) did not consider weather to be a primary factor affecting bird migration. He stated that migration was "more closely correlated with calendar date than with immediate weather conditions". Among those who stated very definitely that migration does depend upon the existing weather conditions were Eaton (1910), Shaver (1933), and Hoehbaum (1960). Hoehbaum believed that weather had a "trigger effect" that caused migration, even though this was at about the same time each year. Although agreeing that weather does have an effect on migratory movements, Hinde (1951) suggested a role that was not as definite. His idea was that the effect any particular weather factor had on migration was modified by the other weather factors present and the physiological state of the birds at the time. Similar ideas were also expressed by Curtis (1969).

Bird migration has been associated with the various weather factors making up the total weather picture by a large number of studies. Eaton (1910), Shaver (1933), Bennett (1952), Develin (1954), Mascher (1955), Stolt (1959), Hoehbaum (1960), and Brooks (1965) all have placed a great deal of importance on changes in temperature as a factor influencing migratory movement. Shaver, Mascher, and Eaton have even suggested that it is the single most important factor affecting the presence of birds in an area. Curtis (1969), on the other hand, found no correlation at all between temperature changes and migration.

Wind direction has also been found to have a definite effect on migration by Eaton (1910), McMillan (1938), Bagg et al. (1950), Develin (1954), Hoehbaum (1960), Lack (1962, 1963), Brooks (1965), Mueller and Berger (1966), and Curtis (1969), with a north to northwest wind positively correlated with fall migration and a southerly wind present during spring migration. Brooks, Hoehbaum, and McMillan decided that this is the outstanding feature of the environment during migration.

Although temperature changes and wind direction have received the most support as factors affecting migration, positive correlations have also been found with other factors. Precipitation was found to be a factor by Shaver (1933) and Brooks (1965) with Brooks pointing out, however, that its effect may be an indirect one by affecting such things as food supply, which in turn causes migration. Relative humidity as a weather factor affecting migration has been discussed by Shaver (1933) and Hoehbaum (1960). A decrease in relative humidity was found to be associated with fall migration and an increase with spring migration by Hoehbaum. Bennett (1952) and Brooks (1965) have also found a significant positive correlation between fall migration and the passage of cold fronts. Shaver (1933) and Hoehbaum (1960) have indicated that barometric pressure was another weather factor affecting migration. Hoehbaum associated rising pressure with fall migration and falling pressure with spring migration.

The fact that these studies were not done with the same or similar species of birds may or may not have caused their apparent agreements and disagreements. As Bissonnette (1937) and Hoehbaum (1960) have pointed out, migratory habits vary considerably among the vast number of species of birds. Bissonnette stated that "it is likely that different species are conditioned by different factors in their environment" and any one species may respond to one or any number of these factors.

## METHODS

The migratory data for this study were obtained at Eldorado Beach which is located on the eastern shore of Lake Ontario in the township of Ellisburg, on the boundary of Oswego and Jefferson Counties, New York. This area was selected because it is a "prime shorebirding area" in northern New York State (Scheider. 1969).

Trips were made to Eldorado Beach once a week between 13 September 1969 and 16 November 1969 to gather fall migration data, and 5 April 1970 and 14 June 1970 to gather spring migration data. Most of the observations were made between the hours of 9 AM and 12 noon with a few being made later in the day. Each observation trip consisted of a walk from the northern end of the three-fourths of a mile shoreline to the southern end and a return. Species names and the number of each seen were recorded during the walk with care being taken not to count any bird more than once.

Weather data for the area were obtained from the weekly series of Daily Weather Maps published by the Environmental Science Services Administration of the U.S. Department of Commerce. The seven weather conditions compared with shorebird migration in this study were: decreasing daily maximum temperatures, decreasing daily minimum temperatures, wind shifts to the direction of migration, the passage of cold fronts, the occurence of precipitation, a drop in relative humidity and rising barometric pressure. These particular weather conditions were selected because they are the weather conditions commonly compared with migratory movements in the literature.

The method used by Brooks (1965) for correlating specific weather conditions and observational bird migration data was used in this study. Either a (+) or a (—) rating was given to each period between observations for each of the seven weather conditions, depending upon whether or not the condition occurred during the period. For each weather condition the number of each species and total number of shorebirds migration during (+) and (—) periods were found. The mean number of shorebirds migrating for (+) and (—) periods was then found. By summing these for each weather condition and dividing this into the mean for the (+) periods, the percentage for the mean of the (+) periods was determined. This figure was used as the percent correlation between migratory movements and weather conditions (Figure 4). The chi-square test was then applied to determine if the percentages varied significantly from 50%, which if they did, would indicate either a positive or negative correlation.

Only migration out of the area was considered in this study. Since weather data for the eastern end of Lake Ontario only was used, the weather conditions existing in the areas from whence migrant shorebirds came was not considered. This makes it possible for a bird (or birds) to enter the area during a period that was given a (—) rating for the area and yet might have been given a (+) rating in the area from whence they came; or vice versa. These facts make any conclusions that could be drawn from inward migration correlations questionable; which is why they are not considered here.

## RESULTS

The fourteen species of shorebirds that were seen at Eldorado Beach are: Dunlin *(Erolia alpina)*, Killdeer *(Charadrius vociferus)*, Semipalmated Plover *(Charadrius semipalmatus)*, Spotted Sandpiper *(Actitus macularia)*, Sanderling *(Crocethia alba)* Greater Yellowlegs *(Totanus melanoleucus)*, Ruddy Turnstone *(Arenaria interpris)*, Black-bellied Plover *(Squatarola squatarola)*, Pectoral Sandpiper *(Erolia melanotos)*, Least Sandpiper *(Erolia minutilla)*, Short-billed Dowitcher *(Limnodromus griseus)*, Semipalmated Sandpiper *(Ereunetes pusillus)*, Red Phalarope *(Phalaropus fulicarius)*, Avocet *(Recurvirostra ameriacana)*. All of these species are discussed as a whole below. This is a logical procedure because they all responded similarly to the weather conditions discussed.

Figures 1–3 are designed to give a mathematical picture of how many of each species were observed during the different observation trips, and the total number of each species observed. An idea of when during the migratory periods each species passes through the eastern end of Lake Ontario can also be derived from these data.

TABLE 1

Fall 1969 and Spring 1970 Migration Data from Eldorado Beach

| *Species* | *Arrival* | *Departure* | *Peak Date(s)* | *Peak No.* |
|---|---|---|---|---|
| | | Fall 1969 | | |
| Dunlin | Sept. 20 | Nov. 11 | Oct. 18 | 51 |
| Least Sandpiper | – | Oct. 8 | Sept. 28 | 32 |
| Sanderling | – | Oct. 18 | Sept. 28 | 21 |
| Short-billed Dowitcher | Oct. 8 | Oct. 24 | Oct. 18 | 6 |
| Black-billed Plover | Oct. 4 | Nov. 11 | Oct. 8, Nov. 2 | 1 |
| Pectoral Sandpiper | Sept. 20 | Nov. 11 | Oct. 8 | 5 |
| Ruddy Turnstone | – | Oct. 18 | Sept. 28 | 4 |
| Greater Yellowlegs | – | Oct. 4 | Sept. 20 | 3 |
| Red Phalarope | – | Oct. 4 | Sept. 20, 28 | 3 |
| Semipalmated Plover | – | Oct. 18 | Sept. 20 | 8 |
| | | Spring 1970 | | |
| Killdeer | April 5 | – | May 17 | 9 |
| Spotted Sandpiper | May 2 | – | June 14 | 6 |
| Dunlin | May 2 | May 31 | May 17 | 7 |
| Sanderling | May 31 | – | June 7 | 6 |
| Least Sandpiper | May 10 | May 31 | May 17 | 4 |
| Semipalmated Plover | May 10 | May 31 | May 24 | 4 |
| Ruddy Turnstone | May 10 | May 31 | May 17, 24 | 2 |
| Semipalmated Sandpiper | May 17 | May 31 | May 24 | 3 |
| Black-bellied Plover | May 10 | May 24 | May 17 | 1 |
| Avocet | May 31 | June 14 | June 7 | 1 |

The actual correlations between migration and weather conditions are shown in Figure 4. A positive correlation (above 50%) indicates that migration was favored by that condition. A negative correlation (below 50%) indicates that migration was not favored by that condition. If the correlation value is 50%, the indication is that half of the birds moved when the condition occurred and half moved when the condition did not occur, thus showing no correlation between the weather condition and movement.

## DISCUSSION

A factor that may have affected the observational data, and thus the correlations, was the fact that all of the birds observed were not just passing through the area on their migratory flights. Killdeer and Spotted Sandpipers were both breeding there, and one active nest of each was found. These breeding birds also may have affected the correlations of out-going spring birds as they remained rather than passing on. The data from these two species were included with the data from the migrational species although its effect on the results is not known.

Precipitation, cold fronts, wind shifts toward the north,[1] decreasing

[1] wind blowing from the north toward the south

daily maximum temperatures, and falling relative humidity showed significant positive correlations with fall migration (Figure 4). Although precipitation correlated highest (81%), it is possible that its effect is indirect. This has been pointed out by Brooks (1965) who did a study on a pond; a much smaller area than Lake Ontario. He noted that increased precipitation made the level of the pond rise, thus eliminating a portion of the shorebirds' feeding area. This, he said, caused them to leave. This phenomenon did not occur at Eldorado Beach and it would be therefore much more logical to assume that the effect of precipitation was a direct one.

The correlations between cold fronts (69%), wind shifts toward the north (68%), decreasing daily maximum temperatures (63%), and falling relative humidity (60%) and outward migration were nearly the same. This indicates that these factors have the same positive effect.

Of the seven weather conditions correlated with fall migration, only one showed a significant negative correlation. This condition was decreasing daily minimum temperatures. With a correlation value of 17% it is likely that this factor not only did not favor migration, but in fact hindered it.

Correlation with outward spring migration showed that wind shifts toward the south,[2] decreasing daily minimum temperatures, falling relative humidity, and precipitation were positively correlated. Wind shifts toward the south (82%) and decreasing daily minimum temperatures (80%) showed the highest degrees of correlation but the correlation values of falling relative humidity (68%) and precipitation (64%) showed that these factors also had definite positive effects.

Decreasing daily maximum temperatures (36%) and the passage of cold fronts (0%) both showed significant negative correlations. This indicates that decreasing daily maximum temperatures did not favor spring migration and that the passage of cold fronts stopped migration in the spring altogether.

From the preceeding facts it can be concluded that the weather factors affecting migration were different for fall migration and spring migration. Precipitation, falling relative humidity, and wind shifts so that the wind was blowing in the direction of migration were positively correlated for both. Decreasing daily maximum temperatures and the passage of cold fronts were positively correlated with migration in fall but negatively correlated with migration in spring, and decreasing daily minimum temperatures which was positively correlated with spring migration was negatively correlated with fall migration.

It was also noted that rising barometric pressure showed no correlation with either fall or spring migration out of the area. This indicated that

[2] wind blowing from the south toward the north

the movement of shorebirds out of Eldorado Beach was not related to this condition, at least in any direct way.

## SUMMARY

The migratory movements of shorebirds in fall and spring were compared with seven different weather conditions. For migration out of the area in fall, significant positive correlations occurred with precipitation, decreasing daily maximum temperatures, wind shifts toward the north, the passage of cold fronts, and falling relative humidity. Of these five weather conditions, precipitation showed a significantly higher correlation than the others, which had correlation values nearly the same. Thus it can be concluded that the presence of precipitation was the primary weather stimulus affecting fall migration through this area with the other four conditions mentioned above also playing direct roles.

For migration out of the area in spring, significant positive correlations occurred with wind shifts toward the south, decreasing daily minimum temperatures, falling relative humidity, and precipitation and it was concluded that these were the weather stimuli affecting spring migration through the area. Thus it has been shown that different weather conditions were associated with migration through the eastern end of Lake Ontario during fall and spring.

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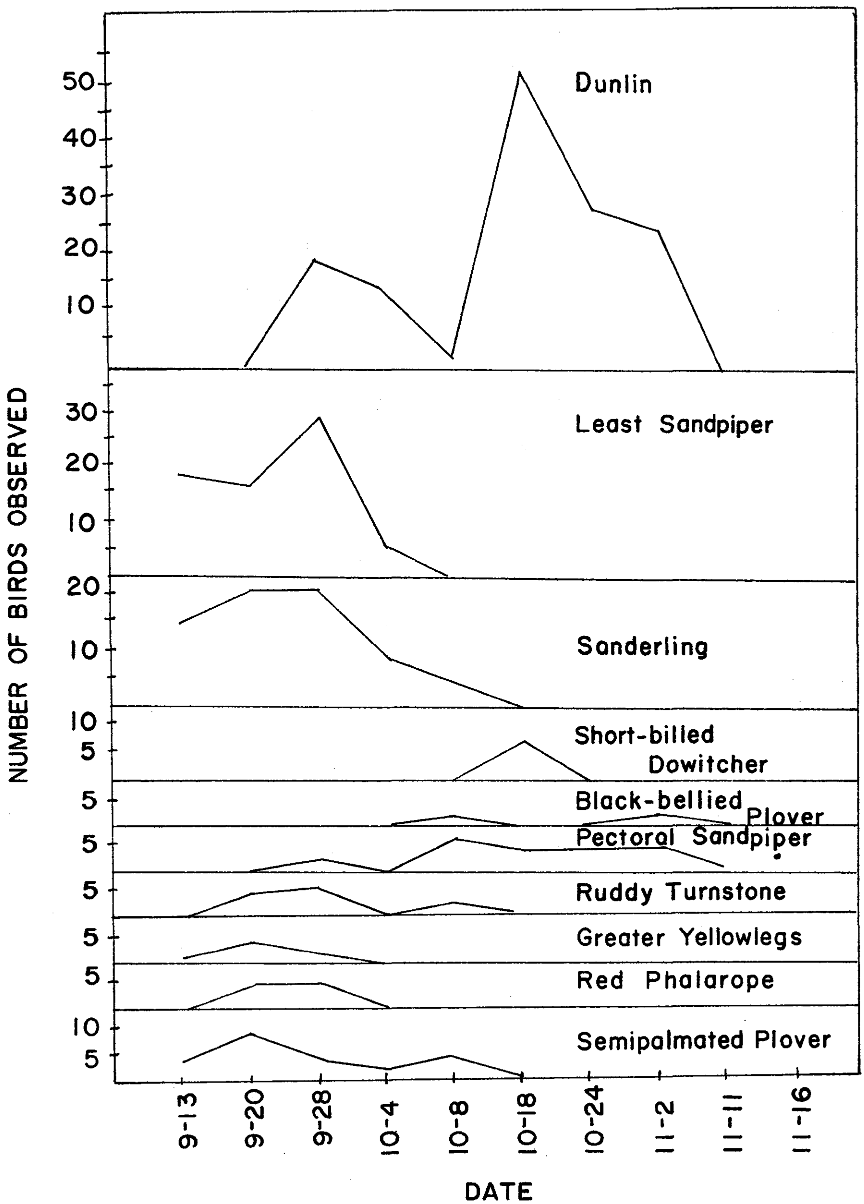


Figure 1. Observational data collected at Eldorado Shores during the Fall of 1969.

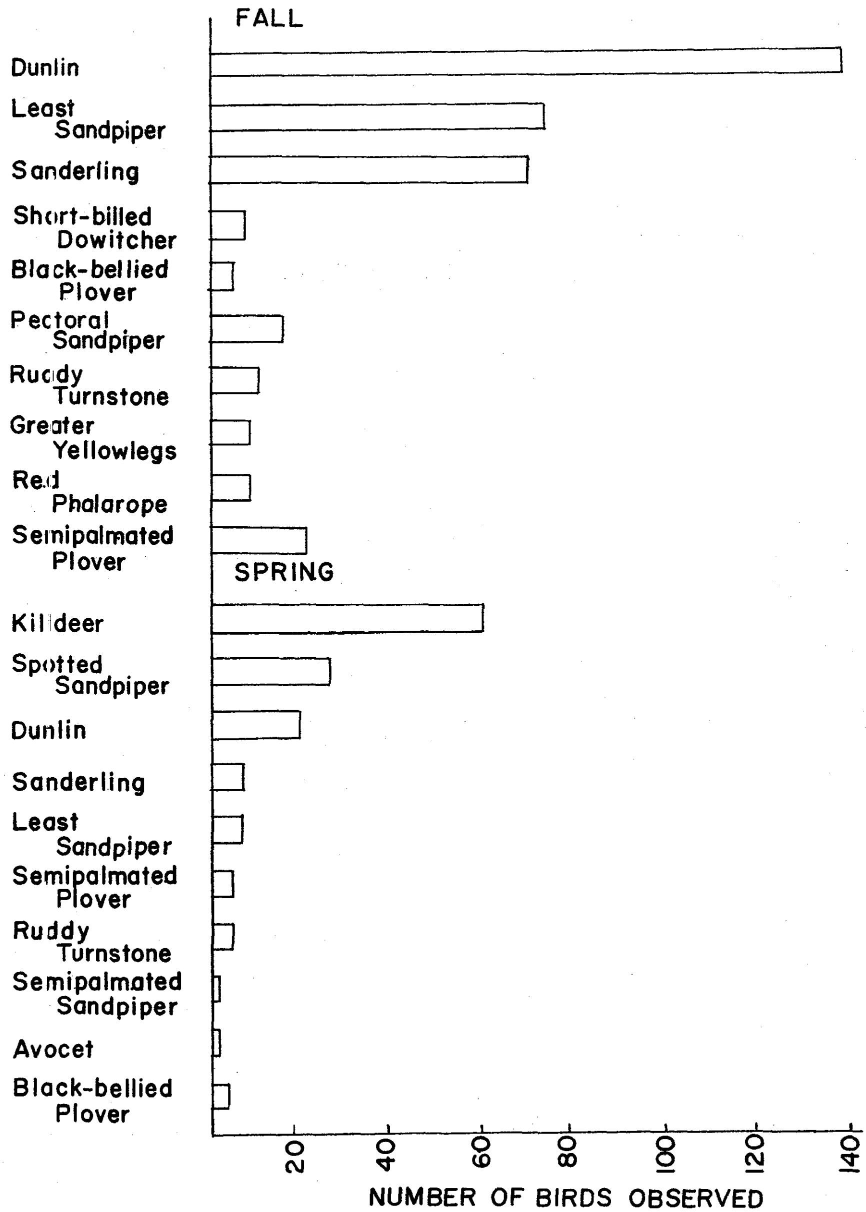


Figure 2. Total number of each species of shorebirds seen during the Fall of 1969 and Spring of 1970.

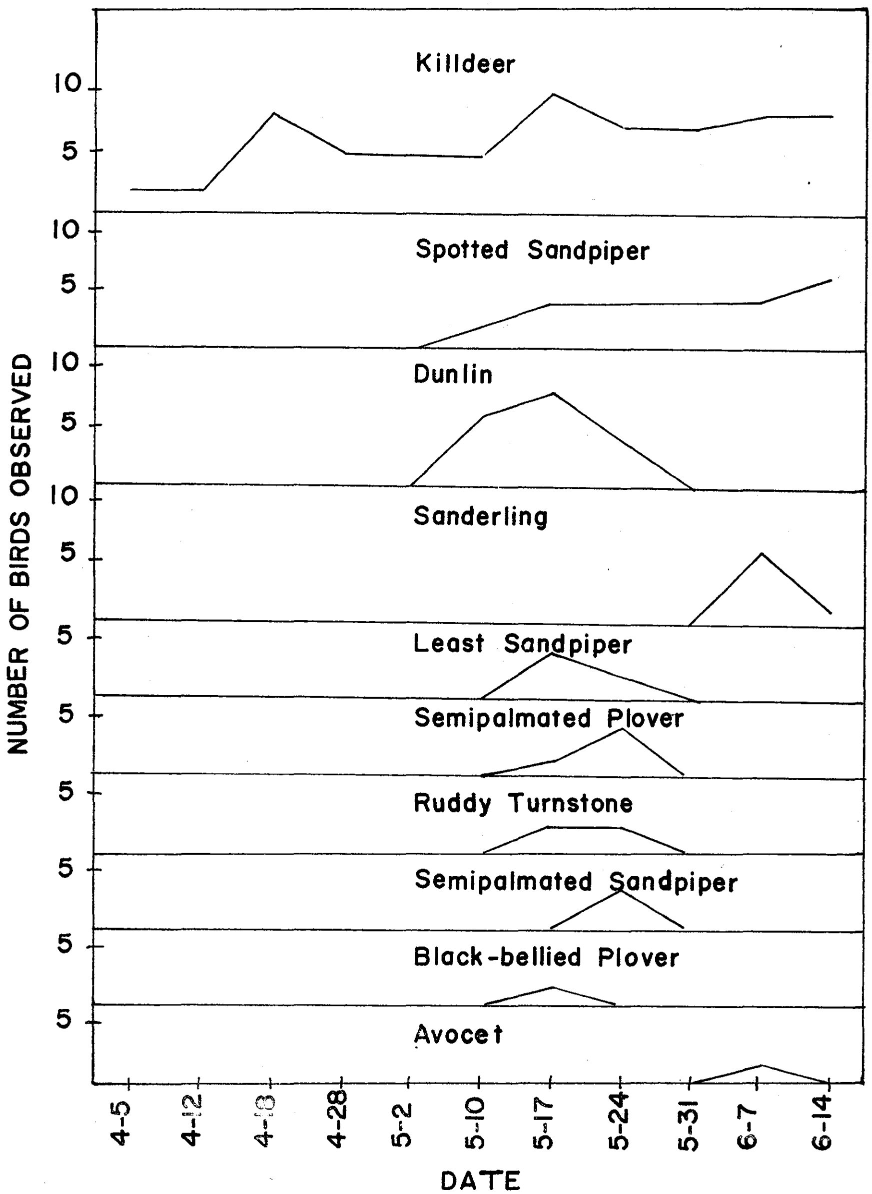


Figure 3. Observational data collected at Eldorado Shores during the Spring of 1970.

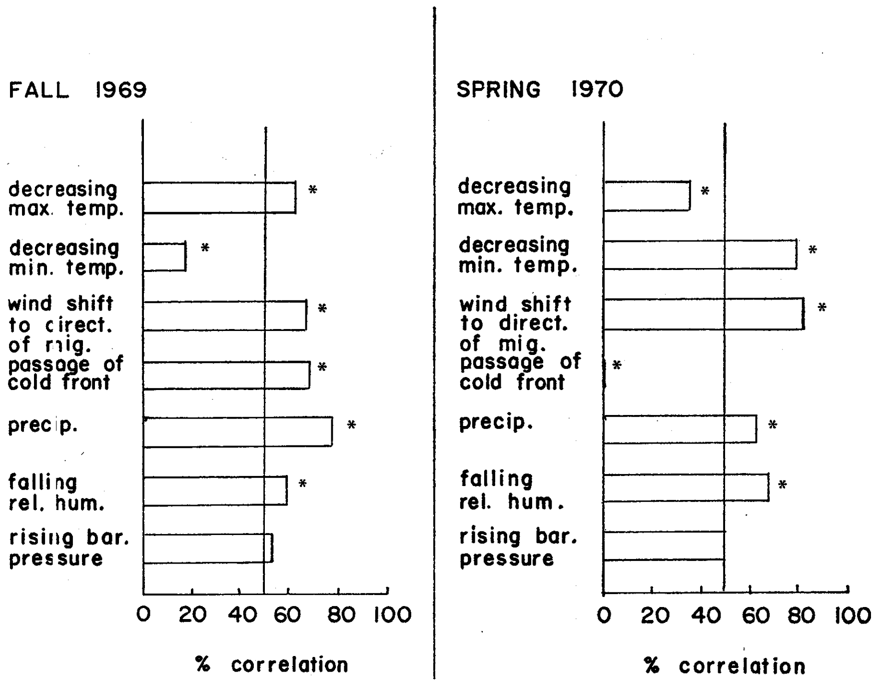


Figure 4. Per cent correlation of migratory movements of shorebirds out of Eldorado Shores during the Fall of 1969 and Spring of 1970 with maximum daily temperature changes, minimum daily temperature changes, wind shifts in the direction of migration, passage of frontal systems, precipitation, falling relative humidity, and rising barometric pressure. Starred bars indicate that the correlation is statisically significant ($p < 0.05$).

## APPENDIX

Actual weather conditions as they existed at the eastern end of Lake Ontario during the periods between shorebird observations in Fall and Spring 1970.

Abbreviations: d. max. t. — daily maximum temperatures, d. min. t. — daily minimum temperatures, w. s. — wind shift, p. f. s. — passage of frontal systems (cold or warm), precip. — precipitation, r. h. — relative humidity, b. p. — barometric pressure

Fall

Sept. 8 to Sept. 13 — d. max. t. decreased from 84° to 71°, d. min. t. decreased from 67° to 51°, south to southwest winds, no p. f. s., .22 inch of precip., r. h. remained steady, b. p. fell from 1020.0 mb. to 1018.5 mb.

Sept. 15 to Sept. 20 – d. max. t. decreased from 85° to 65°, d. min. t. decreased from 58° to 40°, w. s. to north (9/17), cold front passed (9/17), .51 inch of precip., r. h. fell from 57% to 36%, b. p. rose from 1020.7 mb. to 1034.3 mb.

Sept. 22 to Sept. 28 – d. max. t. decreased from 70° to 60°, d. min. t. increased from 43° to 48°, east wind, cold front passed (9/24), .23 inch of precip., r. h. remained steady, b. p. rose from 1006.7 mb. to 1015.3 mb.

Sept. 29 to Oct. 4 – d. max. t. decreased from 71° to 64°, d. min. t. increased from 47° to 53°, w. s. to north (10/3), cold front passed (10/3), .71 inch of precip., r. h. fell from 52% to 37%, b. p. rose from 1021.7 mb. to 1024.0 mb.

Oct. 5 to Oct. 8 – d. max. t. increased from 53° to 71°, d. min. t. increased from 37° to 40°, east wind, cold front passed (10/7), no precip., r. h. increased from 37% to 48%, b. p. fell from 1029.7 mb. to 1015.9 mb.

Oct. 13 to Oct. 18 – d. max. t. decreased from 68° to 59°, d. min. t. decreased from 50° to 32°, east and west winds, no p. f. s., .20 inch of precip., r. h. fell from 46% to 34%, b. p. remained steady.

Oct. 20 to Oct. 24 – d. max. t. decreased from 58° to 41°, d. min. t. decreased from 45° to 29°, w. s. to north (10/21), cold front passed (10/20), 1.20 inches of precip., r. h. fell from 43% to 18%, b. p. rose from 1009.9 mb. to 1025.5 mb.

Oct. 27 to Nov. 2 – d. max. t. increased from 59° to 62°, d. min. t. remained steady, east wind, no p. f. s., no precip., r. h. rose from 32% to 43%, b. p. fell from 1036.9 mb. to 1022.2 mb.

Nov. 4 to Nov. 11 – d. max. t. remained steady, d. min. t. increased from 35° to 41°, w. s. to north (11/6), no p. f. s., r. h. remained steady, b. p. fell from 1015.0 mb. to 1013.2 mb.

Nov. 12 to Nov. 16 – d. max. t. decreased from 50° to 42°, d. min. t. remained steady, east and south winds, no p. f. s., .33 inch of precip., r. h. fell from 39% to 21%, b. p. rose from 1002.1 mb. to 1020.4 mb.

Spring

March 30 to April 5 – d. max. t. varied, d. min. t. varied, east and west winds, no p. f. s., 2.44 inches of precip., r. h. remained steady, b. p. rose from 999.5 mb. to 1015.2 mb.

April 6 to April 12 – d. max. t. decreased from 50° to 40°, d. min. t. remained steady, w. s. to south (4/8), no p. f. s., .10 inch of precip., r. h. remained steady, b. p. rose from 1004.2 mb. to 1019.0 mb.

April 13 to April 18 – d. max. t. increased from 50° to 65°, d. min. t. increased from 23° to 32°, east, west, and north winds, no p. f. s., no precip., r. h. remained steady, b. p. increased from 1017.5 mb. to 1023.8 mb.

April 20 to April 28 – d. max. t. increased from 57° to 76°, d. min. t. increased from 41° to 49°, w. s. to south (4/27), no p. f. s., .79 inch of precip., r. h. rose from 36% to 50%, b. p. rose from 1014.1 mb. to 1015.6 mb.

April 29 to May 2 – d. max. t. increased from 80° to 85°, d. min. t. increased from 50° to 57°, w. s. to south (5/1), warm front passed (4/30), no precip., r. h. rose from 52% to 54%, b. p. fell from 1016.0 mb. to 1018.4 mb.

May 4 to May 10 – d. max. t. increased from 54° to 64°, d. min. t. increased from 41° to 51°, w. s. to south (5/10), warm front passed (5/10), .42 inch of precip., r. h. rose from 39% to 54%, b. p. fell from 1022.5 mb. to 1012.6 mb.

May 11 to May 17 – d. max. t. decreased from 83° to 57°, d. min. t. decreased from 57° to 50°, w. s. to south (5/17), no p. f. s., .61 inch of precip., r. h. remained steady, b. p. fell from 1024.0 mb. to 1014.4 mb.

May 18 to May 24 – d. max. t. increased from 58° to 79°, d. min. t. varied, w. s. to south (5/19), no p. f. s., .48 inch of precip., r. h. remained steady, b. p. rose from 1016.5 mb to 1020.2 mb.

May 25 to May 31 – d. max. t. increased from 57° to 74°, d. min. t. decreased from 45° to 38°, w. s. to south (5/31), warm front passed (5/26), .88 inch of precip., r. h. remained steady, b. p. rose from 1027.9 mb. to 1031.4 mb.

June 1 to June 7 – d. max. t. varied, d. min. t. varied, w. s. to south (6/1), no p. f. s., .86 inch of precip., r. h. remained steady, b. p. varied.

June 8 to June 14 – d. max. t. decreased from 84° to 78°, d. min. t. decreased from 60° to 49°, east and west winds, no p. f. s., no precip., r. h. fell from 54% to 45%, b. p. rose from 1018.7 mb. to 1024.3 mb.