THE DYNAMICS OF SEASONAL DISTRIBUTION OF GREAT LAKES HERRING GULLS

By Frank R. Moore

INTRODUCTION

The Herring Gull (*Larus argentatus*) is an abundant species over much of North America, particularly on coastal New England and the Great Lakes. Early range descriptions for this species were presented by Cooke (1915) and Bent (1921), and the postbreeding "migration" of Herring Gulls from the Great Lakes has since received much attention (e.g., Lincoln, 1928; Eaton, 1933, 1934; Gross, 1940; Hofslund, 1959; Smith, 1959; Southern, 1968). The studies of Gross (based on 1,409 band recoveries primarily from Sister Islands, Green Bay, Lake Michigan) and Smith (1,143 recoveries from Michigan colonies in both Lakes Huron and Michigan) are the most detailed to date. However, the seasonal distribution dynamics have not been described for the entire Great Lakes population of Herring Gulls, and no one has analyzed the increased quantity of recovery data currently available for this species.

This study delineates the geographical and seasonal distribution of Herring Gulls from the Great Lakes through a detailed month-by-month analysis of over 12,500 band recoveries. Important aspects of this species' movement patterns and nonbreeding range are stressed, with emphasis placed on age-dependent features of Herring Gull distributional dynamics.

METHODS

The data are based on Herring Gull band recoveries from the files of the Bird Banding Laboratory from 1929 through 1971. Data from juvenile gulls recovered at or within a few kilometers of their colony (banding site) during June or July of the hatching year were not analyzed. Inclusion of such recoveries tended only to distort the picture of Herring Gull movement. In addition, published Christmas Bird Count records in (*American Birds*) were included to supplement the winter analysis. Only Christmas Counts from within the Great Lakes were tabulated, because others (e.g., Atlantic Coast) include birds from other breeding areas (e.g., New England). Each count totals the number of Herring Gulls observed within a prescribed count area, normalized for "count effort" (i.e., per party hour). I averaged counts over at least three years, and in most cases, a five-year period (1969-1973).

The banding data were analyzed by a Fortran computer program, GULL, developed by Jerrold H. Zar. Input data consisted of banding and recovery coordinates calculated to the nearest 10 minutes of a degree, as well as other data provided by the Bird Banding Laboratory, such as dates of banding and recovery. This program allows the user to sort the data into any of 12 categories (e.g., banding locality, age, recovery month, age within recovery month). Distance and direction traveled are computed, with the recovery output plotted according to map coordinates of eastern North America. Each point is accurate to approximately $\pm$ 15 minutes of a degree. Any data for birds outside the map's range were included in calculations and listed. In all calculations the program takes into account the earth's curvature. Once the data are sorted, distance between banding site and recovery site and the mean direction traveled are computed as are their respective standard deviations. The program also performs a Rayleigh test (Batschelet, 1965; Zar, 1974) to determine if the mean heading is significant, and lists the important statistics: mean vector length (r), Rayleigh's R and z, and the Rayleigh test probability. Various attributes of this computer program were discussed by Southern (1974).

In this study, age was calculated chronologically, i.e. recoveries were classed as juveniles if recovered 1 June of the hatching year through 31 May of the subsequent year, as 1-year-olds if recovered 1 June the year after hatching through 31 May of the next calendar year, and so on. The date 1 June was selected because it approximated the peak of hatching for Great Lakes breeding Herring Gulls. Gulls 3-years-old and older were considered adults because most Herring Gulls first breed at three to four years of age (Gross, 1940). I grouped all adults together for my analysis, because I found no significant differences in movement patterns and distribution for the various adult age classes. The term "subadult" technically refers to ages juvenile through 2-years but here is applied only to juvenile and 1-year-old Herring Gulls, because 2-year-old gulls more closely resemble adults in their movement and distribution. The term "movement" is restricted to seasonal distribution dynamics and not to foraging or other nondispersal related movements.

Because of the large amount of computer storage required for data analysis, it was necessary to divide the data into two categories: those birds banded west of 85°W (6,251 recoveries) and those banded east of this longitude (6,430 recoveries). The division is biologically appropriate because it separates banded gulls from Lakes Ontario, Erie, and Huron (eastern population) from those in Lakes Michigan and Superior (western population).

The Chi-Square statistic was employed to analyze the distribution of birds from these western and eastern Great Lakes populations. Recovery data were arranged in fourfold (2×2) contingency tables and the Yates' correction factor was applied to all tests (Zar, 1974).

The reader should be aware that despite the large data base, it represents only a small sample size relative to the entire Great Lakes population of Herring Gulls. Therefore, trends are emphasized, and a certain amount of annual and regional variation may be expected. Furthermore, I assume that the distribution of band recoveries correctly reflects the actual dispersal and distribution of the population.

RESULTS AND DISCUSSION

Current Breeding Range

Herring Gulls usually nest colonially on islands throughout the Great Lakes. Based on the present banding data, the majority of the colonies lies between 44°N and 46°N (Fig. 1). Concentrations of large colonies are located mainly in American waters of northern Lake Huron, particularly the west side, and the northern one third of Lake Michigan, notably around the Beaver Island and Green Bay areas (Ludwig, 1962). Colonies are abundant in the Georgian Bay and the North Channel areas, but are typically smaller (Ludwig, 1962). A limited number of colonies are located in Lake Superior, most on the southern shore. Several colonies are also known for Lakes Erie and Ontario, but contribute little to the overall population relative to the upper lakes. St. Lawrence Seaway colonies, other than those near Lake Ontario, are not considered in this study.

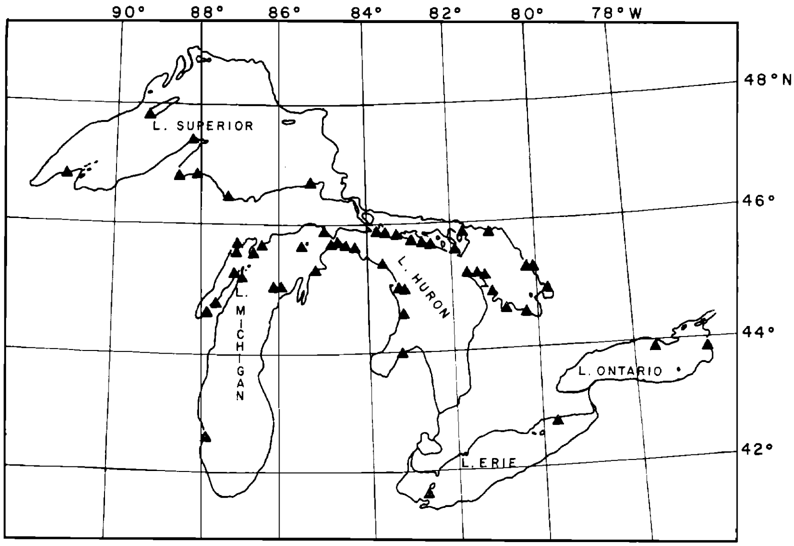

FIGURE 1. Distribution of Herring Gull banding sites (▲) which contributed to this study.

Given man's influence on the Great Lakes ecosystem, it would not be surprising to find colony location and concentration shifts in conjunction with man's activity. Gross (1954) commented on the rapid southward extension of this species' nesting range along the Atlantic Coast, and suggested that the increasing human population along the coast, in great part, was responsible. More recently, Drury and Nisbet (1972) pointed out that larger New England Herring Gull colonies are all close to dumps, fishing ports, and other food disposal areas and that an increasing number of new colonies are being established nearer man-influenced food resources (see also Kadlec and Drury, 1968). Similar findings have been reported for the Glaucous-winged Gull (*Larus glaucescens*) on the North American west coast (Vermeer, 1963; Ward, 1973) and for the Lesser Black-backed Gull (*Larus fuscus*) in Britain (Barnes, 1961; Brown, 1967). Urbanization is no doubt having an effect on Great Lakes populations of Herring Gulls, and should be studied in detail. In addition, the increases in Great Lakes gull and tern populations over the past few decades (Ludwig, 1965, 1966) have probably affected the distribution of Herring Gull colonies over the lakes if not its current breeding range.

Postbreeding Dynamics

A comprehensive picture of the dynamics of Herring Gull seasonal distribution is best portrayed by a monthly analysis of various age classes. Table 1 provides the monthly sample sizes for each age class and permits a better appreciation of the percentages discussed in the text.

TABLE 1.

Number of band recoveries per month for each age class of Herring Gulls from the Great Lakes.

	Age Classes[1]							
	Juvenile		1-yr.-old		2-yr.-old		$\geq$3-yr.-old	
Month	W[2]	E	W	E	W	E	W	E
JAN	242	166	35	24	24	14	29	30
FEB	163	89	39	22	15	15	38	21
MAR	101	116	101	26	33	13	72	21
APR	39	133	155	36	38	34	126	56
MAY	105	154	151	29	39	35	190	101
JUN	—	—	118	130	31	39	250	213
JUL	142	290	112	101	51	65	238	252
AUG	587	861	124	125	65	64	285	271
SEP	517	801	83	72	66	52	193	147
OCT	459	716	75	85	39	33	94	109
NOV	379	380	81	77	32	38	89	63
DEC	293	216	54	45	20	20	39	30
Subtotal	3,027	3,922	1,128	772	453	422	1,643	1,314
Age Totals	6,949		1,900		876		2,956	
Total	12,681							

[1]See text for age definitions.
[2]W and E refer to west and east of 85° W, respectively. See Methods section for further explanation.

Fall Dispersal Phase. Postbreeding dispersal begins by late July and departure from the colonies is complete by the end of August. The period August through November is designated the "fall dispersal phase" of Herring Gull postbreeding dynamics. Throughout this period, all ages travel short distances (Fig. 2) and the vast majority of recoveries (75%) in any age class are confined to the Great Lakes region (Fig. 3). Only a few of the gulls venturing beyond the Great Lakes head south at this time (Fig. 4).

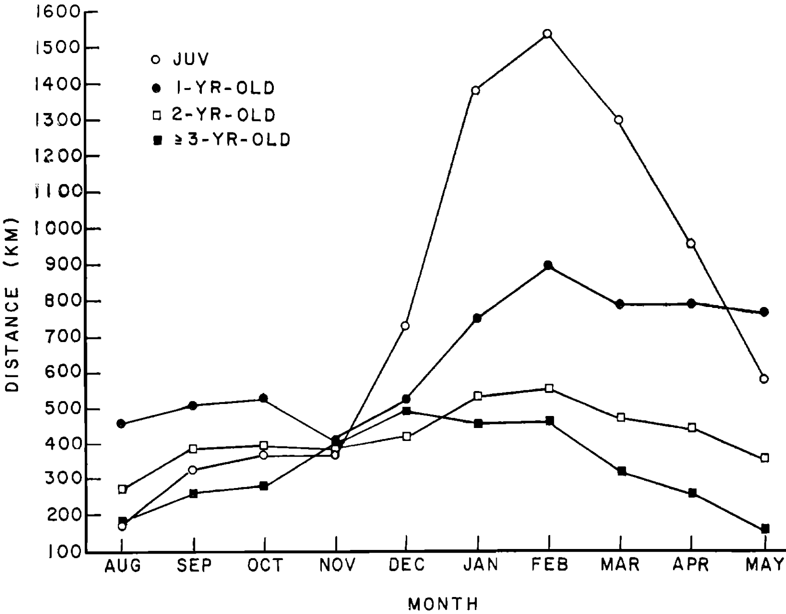

FIGURE 2. Mean monthly distance (km) of Herring Gull band recoveries from the Great Lakes banding sites for each age class.

The fall dispersal pattern is oriented despite movement being directionally widespread. I analyzed statistically the monthly direction of fall dispersal for 28 banding localities and found preferred headings in nearly every instance. Other workers (e.g., Gross, 1940; Smith, 1959) proposed that the directionality of postbreeding movement is dependent on river systems and shorelines as well as prevailing winds. Band recovery evidence presented here tends to support those conclusions, at least relative to landscape features. The direction of fall dispersal for various Great Lake colonies relative to geography and winds is now being analyzed.

The majority of gulls from colonies in Lakes Michigan and Superior tend to disperse SSE to S along the shores of Lake Michigan in the fall. Approximately one third of these western gulls, however, do move ESE to SE into Lake Huron and further into the

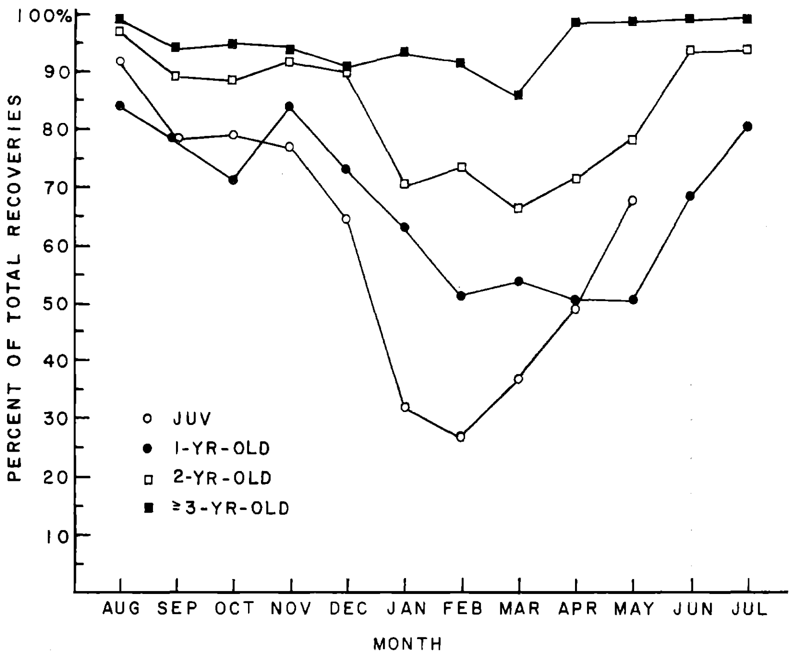

FIGURE 3. Monthly proportion of Herring Gull band recoveries within the Great Lakes region for each age class.

lower Great Lakes (see L. Erie & L. Ontario histogram, Fig. 5). In fact, the period of fall and early winter is the only time that large numbers of gulls from the western lakes were recovered east of 85°W. Herring Gulls from Lake Huron colonies, on the other hand, tend to disperse in a general ESE direction into the southern portion of Lake Huron and the lower Great Lakes. A small percentage (less than 15% of any age) of these eastern gulls move westerly into Lake Michigan. Fall movements of gulls from Lakes Erie and Ontario tend to be restricted to their breeding lakes, with the exception of younger gulls which travel up the St. Lawrence Seaway and also into the Canadian Provinces of Ontario and Quebec later in the fall (see below). Nearly all fall recoveries, regardless of banding location, were associated with Great Lakes shorelines or connecting river systems as shown in previous studies.

The only age-dependent aspect of the fall dispersal phase is a northward trend in recoveries noticeable for juvenile and 1-year-old birds. Smith (1959) reviewed northward fall movements in this species and other larids, but was unable to characterize it in detail. In the fall months of September through November a substantial number of juveniles and 1-year-old Herring Gulls (19% and 12%, respectively) were recovered N and NE of the breeding colonies (Fig. 5). Subadults from the eastern Great Lakes are especially prevalent in Ontario east of Lake Huron, and re-

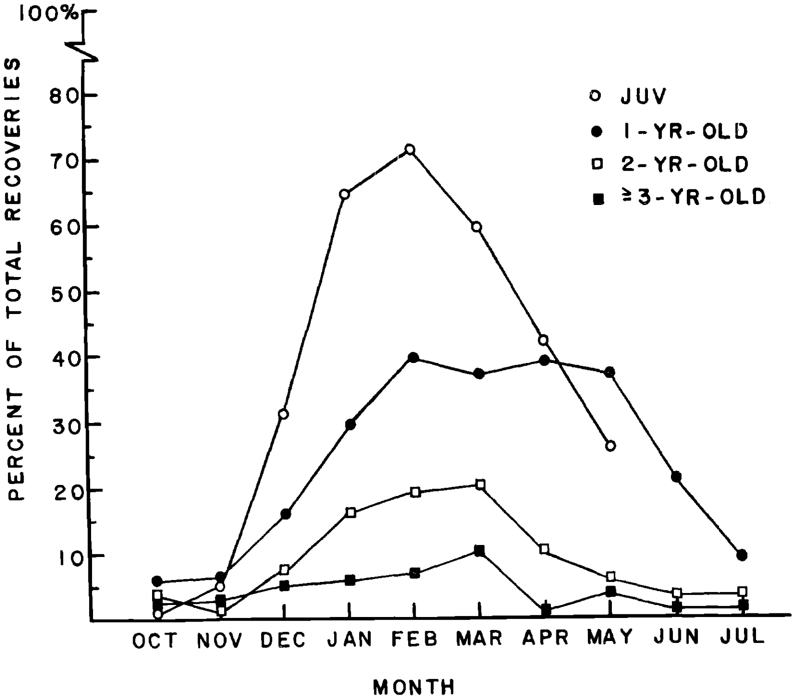

FIGURE 4. Monthly proportion of Herring Gull band recoveries south of the Great Lakes region for each age class.

coveries occur in Quebec particularly along the St. Lawrence Seaway. Recoveries are associated with the numerous rivers and lakes common to these Canadian areas, and no doubt such waterways influence the easterly direction. The St. Lawrence Seaway is obviously a formidable leading line. Many of the gulls from the lower Great Lakes were also recovered north of their lakes and up the St. Lawrence. A few young Herring Gulls were recovered as far east as New Brunswick, Nova Scotia, Prince Edward Island, and even along the coasts of Newfoundland. Despite a northward component in this dispersal, few birds ventured above 50°N (less than 1% of the subadult recoveries for any fall month), suggesting that an easterly directional preference predominates. As mentioned, western birds from Lakes Michigan and Superior also exhibited eastward movement, although only a few subadults (10%) continue beyond Lake Huron into the Canadian Provinces northeast of the Lakes. It is important to note that this northeastward trend in fall dispersal may well be underestimated because of reduced opportunity for recovery in less densely populated areas N and NE of the Great Lakes.

Few gulls of any age are recovered in this region over the winter months (Fig. 5). With the onset of cold weather N and NE of the Great Lakes, many of these subadults probably reverse their movement and return southward toward the Great Lakes or the

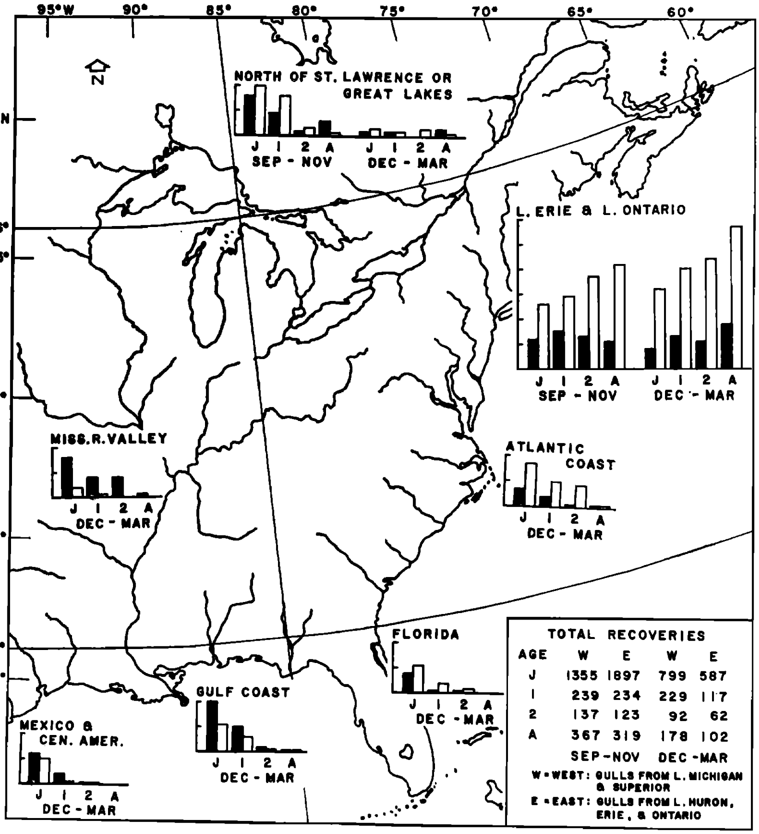

FIGURE 5. Map showing the frequency of Herring Gull band recoveries by age for selected regions during the periods September - November and/or December - March. Histograms plot percent of western (black bars) and eastern (white bars) gulls recovered over that region for given period; ordinate of each histogram in 10% units. Age given by J = juvenile, 1 = 1-year-old, 2 = 2-year-old, A = adult. Insert table presents recovery totals by age and period for western and eastern gulls.

Atlantic Coast. Gross (1940) reported a similar northward movement followed by a southerly flight for Herring Gulls from Kent Island, New Brunswick. This interesting phenomenon is apparent in Figures 2 and 3, especially for 1-year-old birds. Note the decrease in mean distance for 1-year-olds from October to November (Fig. 2), and also the gain in the number of recoveries within the Great Lakes region for the same two months (Fig. 3). The same may occur with juvenile Herring Gulls that disperse northward, but the offsetting influence of the majority of young gulls commencing southward movement at this time may obscure the fact. Alternatively, many juveniles that disperse northward may, in fact, die before beginning southward flight.

Age-dependent Winter Phase. An age-dependent pattern of movement and distribution for Herring Gulls from the Great

Lakes is readily apparent during the winter period from December through March (see histograms, Fig. 5). Herring Gulls show an inverse relationship between age and distance moved, culminating in adults remaining as winter residents on the lakes. As expected, the distance traveled was greatest for all ages during the winter season, but was most dramatic for juvenile and 1-year-old Herring Gulls (Fig. 2). The age-dependency of winter dispersal is also obvious in the number of recoveries outside the breeding range during the winter months (Fig. 3), and more specifically south of the Great Lakes (see Figs. 4 and 5).

The major exodus of subadult Herring Gulls out of the Great Lakes commences rather abruptly in November, and is thoroughly underway in December. The mean distance of juvenile recoveries in December (727 km) is twice that of November (366 km) as a sixfold increase in juvenile recoveries south of the breeding range occurs from November (5%) to December (31%) Fig. 4). A less spectacular, yet still considerable, threefold increase was observed for 1-year-olds. Between December and January the number of juveniles south of the lakes doubles to 63%, and remains high throughout the winter months. Monthly changes in the number of subadult Herring Gulls south of the breeding range are plotted in Figure 6 for selected regions as well as inland rivers and lakes (waterways).

In analyzing the direction of winter movement patterns it is necessary to characterize the "flow" of recoveries month-by-month. Statistics specifying monthly recovery headings (see Methods section) are of little value at this time because the direction of recovery is determined relative to banding site and not, for example, to the site of the gull in the previous month. The overall direction of Herring Gull winter movement from the Great Lakes is south along a broad front stretching from the Mississippi River valley on the west to the Atlantic Coast on the east.

This pattern is variable to the degree that birds from the western and eastern Great Lakes concentrate their southward movement along different portions of the front. Figure 5 helps to portray this pattern. The initial November-December dispersal of subadults from the eastern Great Lakes is generally SE to SSE out of the lower lakes and St. Lawrence Seaway. Several N - S flowing rivers (e.g., Connecticut, Hudson, Delaware, Susquehanna) apparently are followed by many of these birds to the Atlantic Coast. Recoveries also occur along the Allegeny and Ohio rivers as well as the Maumee River (northwestern Ohio) indicating some SW movement from the eastern lakes. On the other hand, many of the subadults from Lakes Michigan and Superior travel south in November-December along the Mississippi River valley. A small number (12%) of the western juveniles reach the coast of the Gulf of Mexico at this time, but most recoveries south of the lakes are scattered along rivers and lakes between the coast and the Great Lakes. As previously mentioned, some western birds disperse in the fall into Lake Huron, and the subadults among them probably move with eastern subadults in early winter.

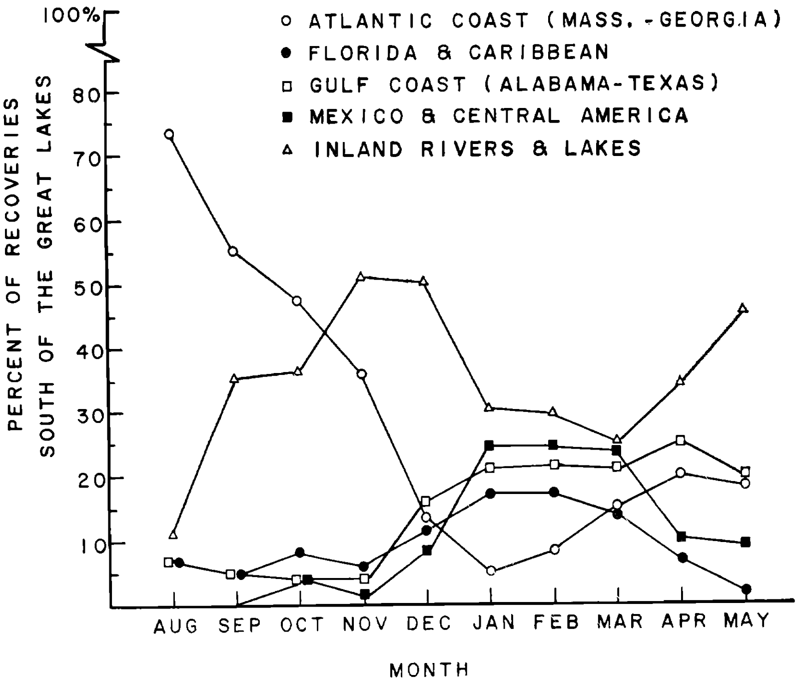

FIGURE 6. Monthly proportion of band recoveries from south of the Great Lakes for selected regions within the postbreeding range. Only subadult (juvenile + 1-year-olds) Herring Gull band recoveries are plotted.

It is evident that southward dispersing subadults are markedly influenced by rivers and coastlines regardless of whether the birds are from western or eastern lakes. Movement from the Great Lakes along river systems and lakes is specially evident in Figure 6—the greatest number of recoveries south of the lakes are located along waterways in November and December. The Mississippi River valley is obviously the most attractive N-S topographical feature for gulls from the western lakes as is the Atlantic Coast for eastern subadults (Fig. 5).

By January and February, the greatest southward extent of movement from the Great Lakes is reached for subadult Herring Gulls (Fig. 4). The mean distance traveled by young gulls has increased considerably (Fig. 2) and many have reached the Gulf Coast, Florida, Mexico, and Central America. Subadult Herring Gulls tended to concentrate along the southern Atlantic seaboard and Gulf Coast during the winter season (Figs. 5 and 6). Nearly one third (32%) of all winter juvenile recoveries are located south of 31°N principally in Florida and the U.S. Gulf Coast where a high of 43% of all juvenile recoveries is found in February. Mexico, particularly its Gulf Coast, is a secondary area of concentration outside the breeding range where 14% of all juvenile recoveries were located during the months January through March. A few young gulls (2%) may be found in Central America at this time. In comparison with the United States the number of Mexican (and Central American) recoveries is probably underestimated because of the lack of reporting. Many juvenile recoveries are also scattered south of the Great Lakes on numerous inland rivers and lakes (Fig. 6). One-year-old Herring Gulls also winter in the southern reaches of the U.S. as well as Mexico, but in far lower numbers (Fig. 5), never more than 40% of the 1-year-old recoveries are south of the breeding range (Fig. 4), and no more than 25% of all recoveries are south of 31°N during the nonbreeding season.

This postbreeding distribution of subadult Herring Gulls tends to be governed by the route of dispersal from the breeding range. The histograms of Figure 5 illustrate the unequal distribution of Herring Gulls as a function of breeding (hatching) lake. Subadults of the western lakes predominate along the Gulf Coast, Mississippi River valley, and Mexico-Central America. Eastern subadults exhibit a more even distribution. Although more abundant along the Atlantic Coast and in Florida, many do range west along the Gulf Coast into Mexico and Central America. The pattern of Mexican recoveries suggests that gulls may reach Mexico and Central America via two routes: a "land" route along the Gulf Coast through Texas and a "sea" route from the Gulf Coast states and Florida across the Gulf to the Yucatan Peninsula.

The distribution of both juvenile and 1-year-old recoveries in both fall and winter suggests a divergence in movement pattern between western and eastern populations, i.e., Lake Michigan-Superior versus Lake Huron-Erie-Ontario gulls (Fig. 5). A Chi-Square analysis of recoveries from various regions validates this divergent pattern. In general, recoveries of subadults from the western Great Lake colonies are disproportionately more frequent south of the breeding range than recoveries from the eastern colonies during the period November through May: juvenile $\chi^2_c = 12.102$, $P < 0.001$; 1-year-old $\chi^2_c = 19.702$, $P < 0.001$ (subscript "c" refers to Yates' correction factor). This imbalance is no doubt due to a higher proportion of eastern subadults overwintering on the lower Great Lakes - 36% of all juvenile and 1-year-old eastern gulls versus only 9% of the western subadults (Fig. 5, L. Erie & L. Ontario histogram). No differences were found for 2-year and older gulls because the majority are recovered on the lakes during the nonbreeding season (Fig. 3).

Because the Mississippi River valley is an attractive topographical feature in Herring Gull dispersal, recoveries from this area are biased in favor of gulls from western lake colonies as shown in Figure 5. This bias is significant: juvenile $\chi^2_c = 89.462$, $P < 0.001$; 1-year-old $\chi^2_c = 21.789$, $0.001 < P < 0.005$ (recoveries based on period of August through May). Similarly, one would expect the predominance of western subadults in Mexico and Central America to be significant: juvenile $\chi^2_c = 4.361$, $0.025 < P < 0.05$; 1-year-old $\chi^2_c = 8.525$, $0.001 < P < 0.005$ (based on recoveries from December through May). I also analyzed Gulf and Atlantic Coastal recoveries expecting the respective distributions to be correlated with banding site, i.e. west versus east of 85°W, and such was the case: juvenile $\chi^2_c = 25.863$, $P < 0.001$; 1-year-old $\chi^2_c = 31.439$, $P < 0.001$ (all months). A distinct difference, therefore, exists in the winter dispersal and distribution of subadult Herring Gulls from the Great Lakes depending upon their origin within the breeding range.

The significance of such differences should not obscure the fact that young Herring Gulls cover a wide geographic range in their postbreeding movements. Present evidence does not suggest the existence of a geographically restricted wintering range for subadults whether they are from western or eastern lake colonies. Despite the noticeable concentration of young birds along the southern U.S. coast (Fig. 6), many juveniles (36%) and 1-year-olds (64%) are recovered north of 41°N, primarily in the Great Lakes region from January through March (Fig. 3). Subadults remaining within the breeding range occur chiefly on Lakes Erie and Ontario and the southern shores of Lake Michigan where over 75% of the Great Lakes subadult recoveries are located.

It is interesting to speculate that the large number of juvenile Herring Gulls (and to a lesser extent 1-year-olds) recovered south of the Great Lakes (particularly long distance recoveries) relative to recoveries within the lakes during the winter months merely reflects differential mortality, i.e., young gulls that travel longer distances south suffer greater mortality. Possibly the subadults that overwinter on the Great Lakes and are capable of competing successfully with resident adults may be at a distinct selective advantage (increased fitness) relative to individuals wintering farther south.

Upon reaching two years of age, Herring Gulls evidence a shift in their winter dispersal pattern. The distance traveled decreased dramatically (Fig. 2) because most recoveries are located within the breeding range (Fig. 3). Few 2-year-olds occur in selected areas south of the Great Lakes during winter (Fig. 5). The residence habit, however, is not fully established in 2-year-olds. A substantial drop in the number of 2-year-old Herring Gulls within the Great Lakes region occurs between December (90%) and January (71%). It is noteworthy that any departure of 2-year-olds from the breeding range takes place at least a month later than that of subadults. Also, only in January and February are 2-year-old birds recovered father than 500 km from their banding site on the lakes, and then only slightly so. No doubt these gulls are more capable of withstanding the rigors of Great Lakes winters as well as adult competition. The proportion of 2-year-olds outside the Great Lakes remains around 30% through March, then declines through the spring months, April and May, until over 90% of this age class are present within the breeding range by June.

Adult Herring Gulls are strictly resident birds within the Great Lakes breeding range. Only in March are more than 10% of the 3-year-old or older gulls recovered outside the Great Lakes region

(Fig. 3), and in no month is the mean distance of recovery greater than 500 km (Fig. 2). The sedentary nature of adult birds is also obvious in Figure 5—less than 1% of the adults are recovered along the Gulf or Atlantic Coasts during the winter. Although Smith (1959) suggested that older Herring Gulls often remain during the winter months within their respective breeding lakes, winter concentrations are most apparent along the shores of the lower Great Lakes (Fig. 5) and the southern shores of Lake Michigan. Similar winter concentrations have been reported for Great Lakes breeding Ring-billed Gulls (*Larus delawarensis*) mainly for the lower Great Lakes (Southern, 1974). This pattern of winter distribution on the lakes is verified by Christmas Bird Count data (Fig. 7) (Cruickshank, 1970, 1971, 1972; Arbib and Heilbrun, 1973; Heilbrun and Arbib, 1974). Count sites along Lakes Erie and Ontario show the greatest relative abundance of Herring Gulls, notably Toledo, Cleveland, and the Buffalo-Niagara Falls area which all reported tallies in excess of 1,000 birds per party hour. Locations along the southern shores of Lake Michigan also counted large numbers of wintering gulls (e.g., Gary-Chicago, Milwaukee, Muskegon, and Ludington). North of these concen-

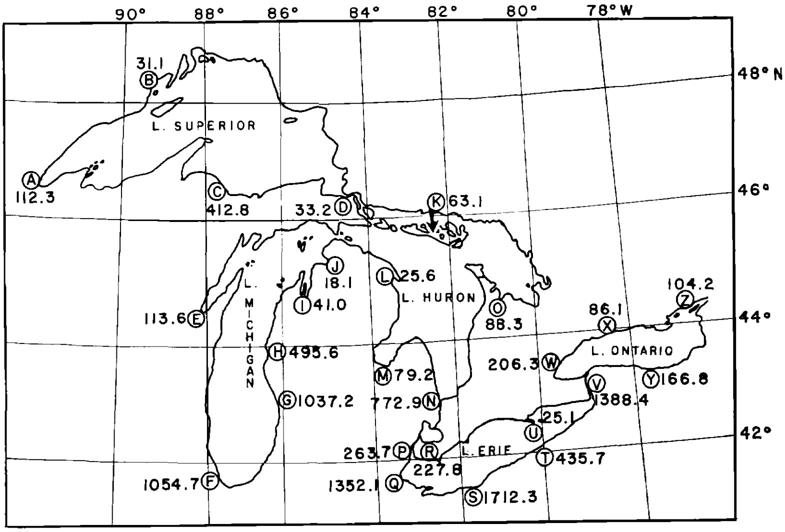

FIGURE 7. Numbers of Herring Gulls reported by Christmas Bird Counts for the Great Lakes region. Totals are based on the 1969-73 counts, and are normalized for party effort (see Text). Count sites are: **A.** Duluth, **B.** Thunder Bay (Ontario), **C.** Marquette, **D.** Sault Ste. Marie, **E.** Green Bay, **F.** Gary-Chicago-Milwaukee, **G.** Muskegon, **H.** Ludington, **I.** Traverse City, **J.** Petosky, **K.** Manitoulin Island (Ontario), **L.** Alpena, **M.** Bay City, **N.** Port Huron, **O.** Owen Sound (Ontario), **P.** Detroit, **Q.** Toledo, **R.** Point Pelee (Ontario), **S.** Cleveland (plus Lorain-Elyria), **T.** Erie, **U.** Long Point (Ontario), **V.** Buffalo-Niagara Falls, **W.** Hamilton-Toronto (Ontario), **X.** Port Hope (Ontario), **Y.** Rochester, **Z.** Kingston (Ontario).

trated wintering areas, the relative abundance of Herring Gulls falls off, although Marquette, Green Bay, and Duluth each reported large numbers of gulls. However, the latter two counts are from rather large urbanized areas.

There is an apparent correlation between winter concentrations of band recoveries and dense urban centers along the lakes, e.g., Cleveland, Toledo, Chicago, Toronto. Christmas Bird Count data also illustrate this concentration well (Fig. 7). For example, counts from large cities on the lower Great Lakes are high relative to less populated count sites along the same lake (e.g., Long Point, Point Pelee, Port Hope). This same trend holds for the other Great Lakes. Such correlation is not unlikely given the abundant food resources associated with urbanized areas. Herring Gulls are known to be opportunistic feeders frequenting refuse dumps, solid-waste disposal sites, and the like (Cogswell, 1970; Cooke and Ross, 1972; Forsythe, 1974). Such activity is obviously advantageous during the winter when natural food sources may be depleted or of limited availability and competition is at a maximum. In fact, Barnes (1961) pointed out that the influence of man-made food resources has apparently altered the migratory habits of Lesser Black-backed Gulls (*Larus fuscus*) in Britain, and Drury and Nisbet (1972) reported altered migration of subadult New England Herring Gulls as the young now move shorter distances, on the average, than in previous decades.

The attraction of these food sources to gulls, especially when near sites of dense air traffic, is of special concern in terms of the bird-aircraft collision problem (Gauthreaux, 1974; Southern, 1974; Forsythe, 1974; Cogswell, 1974). While my data may be somewhat biased by the greater probability of birds being recovered in densely populated regions, this does not obscure the fact that gulls are extremely abundant in such areas and present a potential hazard to air traffic. By defining monthly and seasonal periods of gull concentration for particular areas and regions, my analysis provides some valuable information relative to potential aircraft collision problems with this species.

Prebreeding Dynamics

The spring return of the young birds to the breeding range probably commences in late February and early March. Recoveries south of the breeding range (Fig. 6) indicate a slight decrease between February and March for Florida and Mexico along with an increase in Atlantic Coast recoveries. Not until March, however, do substantial changes in the distribution of these recoveries occur. Florida numbers decrease markedly from March to April and May, and a precipitous drop in Mexico and Central American recoveries is apparent (Fig. 6). Gulf of Mexico recoveries, on the other hand, increase and are probably a function of an influx of subadults from Mexico. Also noteworthy is the spring increase in birds recovered along inland waterways (including the Mississippi River), suggesting movement away from the southern coasts (Fig. 6).

The number of juvenile recoveries outside the Great Lakes begins to decline from a high of 73% in February to 63% in March, and by May over two thirds (68%) of all juvenile recoveries are within the breeding range (Fig. 3). Because subadult Herring Gulls usually will not breed during the forthcoming season, their rate of return may be greatly reduced, with many not arriving until June or July, if at all. If recovery data for June and July are examined for former juvenile and former 1-year-olds, this appears to be the case. In July, 81% of all 1-year-old recoveries are within the breeding range, and over 90% of the 2-year-old recoveries are within the Great Lakes in June and July (Fig. 3).

Because of the many recoveries south of the Great Lakes throughout spring, it is difficult to determine the routes subadults follow as they return to the breeding grounds. The number of recoveries do increase along the Atlantic Coast and inland waterways (primarily Mississippi River) through the spring months suggesting that a reversed path of their winter movement south is followed by many birds. The distribution of recoveries in spring also indicates that many wander slowly north following various rivers between the Mississippi River valley and the Atlantic Coast (35% of all subadult recoveries in April-May are south of the breeding range; 18% are still south of 31°N along the southern coasts).

It is not well understood where the returning subadults settle during the breeding season. My experience suggests that nonbreeding young are not closely tied to breeding colonies. Although Gross (1940) and Kadlec and Drury (1968) found a sizable number of nonbreeders at active colonies, it is likely that many subadults are flocking around urban feeding sites during the breeding season much as they do in the winter.

Despite evidence that young Herring Gulls eventually return to the Great Lakes in considerable numbers, a vernal return does not characterize all subadults, particularly juveniles. Juvenile recoveries for May show 32% of the birds outside the Great Lakes, most south, and 11% still south of 31°N. June recoveries (now one year of age) indicate no increase in Great Lakes numbers (Fig. 3). Even in July, when numerous young gulls are located within the breeding range, 19% of the juvenile (now 1-year-olds) recoveries remain outside the lakes. Both Cooke (1915) and Bent (1921) noted that nonbreeding Herring Gulls were not rare during the summer at many places south of the breeding range. Given the fact that they will probably not breed until at least three years of age, remaining outside the breeding range may not be unusual and, indeed, has been reported for other seabirds (e.g., Robertson, 1969; Thomson, 1974).

In terms of 2-year-old and adult Herring Gulls, the vast majority are winter residents on the Great Lakes (Fig. 3), manifesting only short distance movement away from the colonies in fall and winter. Over three fourths (78%) of the 2-year-olds were recovered within the Great Lakes in May, and over 90% in June. Only recoveries of breeding age birds, however, are confined to the Great

Lakes as early as April (99%), suggesting that potential breeders are well established on the breeding grounds by this time.

The distributional dynamics of Herring Gulls from the Great Lakes is complex and therefore not easily categorized. Certainly the postbreeding movements of adult Herring Gulls cannot be construed as migratory in the sense of Farner (1955), Dorst (1962), or Lack (1968). That only subadults, notably juveniles, exhibit long distance dispersal away from the breeding range, while adults remain sedentary during the nonbreeding season, does suggest partial migration (Lack, 1944). Similar age-dependent movement patterns have been documented for other seabirds and termed migrations, e.g., New England population of Herring Gulls (Drury and Nisbet, 1972), Gannets (*Sula bassana*) (Thomson; 1939, 1974), Sooty Terns (*Sterna fuscata*) (Robertson, 1969), Black-headed Gulls (*Larus ridibundus*), and Kittiwakes (*Rissa tridactyla*) (Lack, 1944).

Smith (1959) dealt with this question in some detail and concluded that young Herring Gulls are nonmigratory, but exhibit strong dispersal tendencies, the direction of which depends on various environmental factors. Alternatively, the movement of Great Lakes Herring Gulls may be termed differential migration, wherein certain elements of a population migrate while others do not, or different portions of the winter range are occupied by different ages or sexes. In this sense, "migration" serves as a dispersal mechanism, spacing individuals (in this case by age) and reducing intraspecific competition.

Whether Great Lakes Herring Gulls are migratory or not seems more a semantical than a biological question. Whatever the phenomenon is labelled is of lesser consequence than determination of the causative factors and adaptive significance of this age-dependent phenomenon (Moore, in prep.).

SUMMARY

The dynamics of seasonal distribution in Herring Gulls from the Great Lakes are presented, and various age-dependent aspects are emphasized. Over 12,500 band recoveries were analyzed with the aid of a Fortran computer program (GULL). Additional information on winter distribution was taken from Christmas Bird Counts.

Postbreeding dispersal from the breeding colonies occurs during the fall period, August through November, movement being confined to the Great Lakes regardless of age of the bird. Gulls from Lakes Michigan and Superior tend to move south down the shores of Lake Michigan, whereas birds from Huron disperse primarily SE into the lower Great Lakes. Northward dispersal was also noted for subadult Herring Gulls at this time, and is discussed in some detail.

Age-dependent movement is characteristic of the winter months. With increasing age, Herring Gulls display increasing sedentariness, culminating with adults remaining winter residents on the Great Lakes. Commencing in November-December juvenile and 1-year-

old Herring Gulls disperse southward in substantial numbers: over 60% of the juveniles and 35% of the 1-year-olds between January and March are recovered south of the breeding range. A significant difference exists in the winter movement pattern and distribution of subadults from Lakes Michigan-Superior (western and Lakes Huron-Erie-Ontario (eastern). The Mississippi River valley is a principal route for the former group, while most gulls from the eastern lakes travel to the Atlantic seaboard and then south. Subadult Herring Gulls tend to concentrate along the southern U.S. coasts, the lower Mississippi River valley, as well as Mexico. Statistically significant differences in winter distribution between eastern and western lake populations were found. A sizable number of juvenile recoveries (36%) and nearly two thirds (64%) of the 1-year-old winter recoveries are located within the Great Lakes region, emphasizing the fact that dispersal from the breeding range is not a clearcut phenomenon.

Spring return of subadults to the Great Lakes begins in late February - early March, and by May two thirds of the juveniles are within the breeding range. By July, 81% of the juveniles and 90% of all 1-year-old Herring Gulls are recovered on the lakes. Some subadults, particularly juveniles, do spend the breeding season south of the Great Lakes.

Two-year-old Herring Gulls are not totally sedentary because nearly 30% of this age class is recovered outside the breeding range in January through March, although seldom traveling farther than 500 km from the banding sites. Most 2-year-olds and nearly all adults winter on the lakes, principally along the southern shores of Lake Michigan and the lower Great Lakes, Erie, and Ontario.

In addition to specifying the dynamics of Herring Gull dispersal and distribution, my results contribute to a better understanding of (1) the importance of this potentially hazardous species relative to bird-aircraft collision problems, (2) the phenomenon of partial migration, and indirectly (3) the age-dependent orientation needs of this species.

ACKNOWLEDGMENTS

I am indebted to Dr. William E. Southern for his guidance during my Herring Gull research. Dr. Jerrold H. Zar developed the computer program used in this analysis, and was most helpful during the research. I wish to thank the Fish and Wildlife Service Bird Banding Laboratory for providing the band recovery data, and the many gull banders for permission to use their data. I also thank Dr. Sidney A. Gauthreaux, Jr. for meaningful discussions relative to the analysis and my manuscript. Dr. Carl W. Helms and Robert C. Beason also critically commented on the manuscript. Finally, an anonymous reviewer offered helpful suggestions for presentation of the results.

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Received 9 August 1975, accepted 25 February 1976.