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Immigration and recruitment of Ring-billed Gulls and Common Terns on the lower Great Lakes

by H. Blokpoel[1] and P.A. Courtney[1, 2]

Abstract

The rates at which Ring-billed Gulls *(Larus delawarensis)* and Common Terns *(Sterna hirundo)* moved from their natal colonies to colonies at the Eastern Headland (Lake Ontario) and Port Colborne (Lake Erie) were examined. Band numbers for the two species at both colony sites were obtained in 1978 by reading them through binoculars or by trapping banded birds on their nests. Analysis of that information showed that the number of banded immigrants was largely determined by (a) the distance between the receiving colony and the natal colonies, and (b) the number of banded chicks fledged on the natal colonies.

The rates at which Ring-billed Gulls moved to the Eastern Headland from their natal colonies were used in an effort to determine where the 22 735 pairs that nested there during the peak of the nesting season in 1978 had come from (in 1973 only 21 pairs nested at the headland). The total number of immigrants from all known colonies larger than 400 pairs and within 550 km of the headland was estimated. At least 62% of the 45 470 individuals were 3- to 6-year-old birds that had immigrated from 44 different natal colonies or that had been recruited from the headland itself. The remainder nesting in 1978 presumably consisted of birds younger than 3 years, older than 7 years, and of any age from colonies that were either unknown or for which population information was lacking.

Introduction

For the purpose of this paper, we consider recruitment as the process whereby birds born at a given colony become breeding members of that colony, and immigration as the process whereby birds born at other colonies move to, and become breeding members of, a given colony. For larids breeding on the Great Lakes, aspects of recruitment and/or immigration have been reported for Herring Gulls *(Larus argentatus)* by Ludwig (1963); for Ring-billed Gulls by Ludwig (1974), Southern (1967, 1977), and Blokpoel and Haymes (1979); and for Caspian Terns *(Sterna caspia)* by Ludwig (1965). We know of no published studies that have dealt with immigration and recruitment of Common Terns in the Great Lakes region.

CWS has been studying the Ring-billed Gull colony at the Eastern Headland of the Toronto Outer Harbour, Lake Ontario. As that colony increased from 21 pairs in 1973 to 22 735 pairs counted at the peak of the season in 1978, we wondered where all those gulls had come from. After obtaining band numbers of nesting gulls at the headland in 1977, CWS used them to determine the colonies of origin of the banded birds (Blokpoel and Haymes 1979). A colony of origin is a colony where a bird was banded as a chick. Analysis of the numbers of banded birds contributed by the different colonies of origin to the headland showed a significant correlation between (a) the contribution of banded birds from the different colonies of origin, and (b) the distances between the colonies of origin and the Eastern Headland.

To further examine this relationship, we obtained in 1978 band numbers for two larid species (Ring-billed Gulls and Common Terns) nesting on two colonies in the lower Great Lakes (the Eastern Headland and Port Colborne, Lake Erie).

Because the results of the 1978 work, presented in the first part of this paper, largely confirm the main findings of the 1977 study, we are now in a position to use those findings to make reasonable speculations about the origins of the 45 470 gulls at the headland in 1978; that topic is dealt with in the latter part of this paper. The data were inadequate to speculate on the origins of the Ring-billed Gulls at the Port Colborne colony or on those of the terns at either colony.

Materials and methods

Study areas

The Eastern Headland is a man-made spit of clean fill and dredged spoil (Blokpoel and Fetterolf 1978). Common Terns began nesting there in 1971; their numbers increased to 1310 nesting pairs during the peak of the 1978 nesting season. Ring-billed Gulls began nesting in 1973; their numbers increased to 22 735 pairs during the peak of nesting in 1978.

The Port Colborne study area comprised two sites on opposite sides of the Lake Erie terminus of the Welland Canal. At the land-based "Canada Furnace" site, we counted 17 637 nests of Ring-billed Gulls and 542 nests of Common Terns at the peak of the season in 1978. Ring-billed Gulls and Common Terns have nested at that site since at least 1969 (A.R. Clark, pers. commun.). The insular breakwater or "Lighthouse" colony, containing 224 nests of Ring-billed Gulls and 660 nests of Common Terns at the peak in 1978, has been a nesting site for Common Terns since 1945 and for Ring-billed Gulls since 1965 (Blokpoel and McKeating 1978).

Origin and age of immigrants and recruits

We obtained band numbers of Ring-billed Gulls at the Eastern Headland (N = 320) and at Port Colborne (N = 68) mostly by reading the bands with binoculars. However, birds wearing worn bands were trapped with walk-in traps placed over the nests. We took band numbers of Common Terns at the Eastern headland by trapping only (N = 61), whereas at Port Colborne we obtained 14 band numbers by trapping and 18 by reading

[1] CWS, Ottawa, Ontario K1A 0E7.
[2] Present address: 162 Heise Crescent, Saskatoon, Saskatchewan S7K 1 4V3.

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them with a spotting scope. All of the foregoing numbers refer to birds that had been banded as chicks. Birds banded as adults are not considered in this paper.

We use the term "encounter" here to refer to obtaining band numbers by reading them with optical equipment or by trapping the bird involved (CWS 1976). Information on the origin and age of all encountered banded birds was obtained from the Canadian and US banding offices.

Calculation of contribution indices

In order to assess the rate at which banded birds had moved from the colonies of origin to the study sites, we calculated for each colony of origin a "contribution index" (i.e., the *actual* number of banded birds encountered at either study site expressed as a proportion of the number of banded birds *expected* still to be alive in 1978). We calculated the number of banded birds of a given year-class and given colony of origin expected still to be alive in 1978, using (1) banding effort (i.e., the number of birds banded at each colony as reported to the Canadian and US banding offices), (2) survival rates, both before and after fledging, and (3) correction for band loss.

We calculated contribution indices only for 3- to 6-year-old Ring-billed Gulls because most of them do not begin to breed until they are 3 years old, and the great majority of our sample was in this age group. For similar reasons, we calculated contribution indices for 4- to 9-year-old Common Terns.

For Ring-billed Gulls, we used a pre-fledge survival rate of 60%, a post-fledge survival rate to 2 years of 40%, and an 88% annual survival rate thereafter (Southern 1977). As a correction for band loss, we used 6% loss of bands during the 5th year (i.e., between age 4 and 5 years) and 24% during the 6th year (Ludwig 1967).

For Common Terns, we used different pre-fledge survival rates, depending on the kind of banding that had been done at a particular colony and during a particular year. One group of banders (type 1) banded chicks of all ages and usually avoided banding very young chicks that did not readily retain bands. For this group, we used a pre-fledge survival rate (i.e., percentage of banded chicks that fledged) of 80% (based on our own estimate and that of Nisbet 1978). The other group of banders (type 2) banded all chicks within 48 h of hatching (R.D. Morris, pers. commun.). For these we obtained the different pre-fledge survival rates from published and unpublished reports (Morris 1974 for Mugg's Island and the Eastern Headland 1973, Morris *et al.* 1976 for Mugg's Island and Port Colborne 1972, Hunter 1976 for Port Colborne 1973 and 1974). We distinguished between the two types of banders because the pre-fledge survival rates for type 2 were much lower than for type 1, due to the high mortality of chicks in type 2 samples during the 1st week after hatching (Morris 1974, Morris *et al.* 1976, Hunter 1976).

We used for Common Terns a post-fledge survival rate to 4 years of 10% (Nisbet 1978) and an annual survival rate of 83% thereafter (Nisbet 1978). As a correction for band loss, we used a 6% loss during the 7th year, 14% during the 8th, and 20% during the 9th year (J.P. Ludwig, pers. commun.).

Calculation of total immigration of Ring-billed Gulls at the Eastern Headland

To estimate the total number of banded and non-banded 3- to 6-year-old immigrants at the Eastern Headland from a colony of origin, we multiplied the number of survivors by the contribution index. We estimated the number of survivors in 1978 from a colony of origin using estimates (1) of the size of that colony in 1972–75, (2) of the total annual production of Ring-billed Gull chicks at that colony during 1972–75, and (3) of annual mortality after fledging. The estimates of colony size came from published and unpublished information. We used a production figure of 1.36 chicks fledged per pair (the mean for four studies—Morris 1972, Dexheimer and Southern 1974, Chardine 1978, Haymes and Blokpoel 1978*b*) and a post-fledge survival rate of 40% to 2 years and 88% annually thereafter (Southern 1977).

We underestimated our contribution indices because we did not encounter all the banded birds present at the headland. Before applying the contribution indices to the corresponding numbers of birds expected to be alive, we corrected those indices for incomplete encounter effort. In 1977, Blokpoel and Haymes (1979) encountered several old (6 or more years) banded gulls at the headland, and in 1978 we re-encountered 73.3% of those birds (after allowing for mortality and band loss; see Blokpoel and Courtney 1980). Assuming that those old birds would have 100% site tenacity, our encounter effort in 1978 was apparently 73.3%. Thus, to all contribution indices for the headland, we applied a correction factor of $\frac{100}{73.3} = 1.36$.

Results

Colonies of origin and their contribution indices

The colonies of origin that contributed the banded Ring-billed Gulls and Common Terns encountered as nesting birds at the Eastern Headland and at Port Colborne are shown in Figures 1 and 2, and listed in Tables 1 and 2.

Ring-billed Gulls

At the Eastern Headland, we encountered banded 3- to 6-year-old birds from 19 colonies of origin. Contribution indices were highest for the Port Colborne and Niagara River colonies, and lowest for the Lake Huron (US portion) and Lake Michigan colonies (Table 1).

At Port Colborne, we encountered banded 3- to 6-year-old birds from 11 colonies of origin. Contribution indices were highest for Port Colborne itself and the Niagara River colonies, and lowest for the Lake Huron (US portion) and Lake Michigan colonies (Table 1).

Common Terns

At the Eastern Headland, we encountered banded 4- to 9-year-old birds from nine colonies of origin. Contribution indices were highest for the headland itself and for Mugg's Island, and lowest for Thunder Bay Island (Lake Huron) and Jones Beach (coastal New York, Table 2).

At Port Colborne, we encountered 4- to 9-year-old birds from four colonies of origin. Contribution indices were highest for Port Colborne itself and lowest for Great Gull Island and Cedar Beach (coastal New York, Table 2).

Table 1
Estimated number of survivors in 1978 of Ring-billed Gull chicks banded in 1972–75, number of banded 3- to 6-year-old birds encountered in 1978 at the Eastern Headland and Port Colborne, and contribution indices for the colonies of origin

Colony of origin (Nos. refer to Fig. 1)	Est'd. no. of birds banded 1972–75, alive in 1978 (a)	E. Headland		P. Colborne	
		No. of banded 3- to 6-yr.-old birds encount'd. in 1978 (b)	Contrib. index $\left(\frac{b}{a}\right)$	No. of banded 3- to 6-yr.-old birds encount'd. in 1978 (b)	Contrib. index $\left(\frac{b}{a}\right)$
1. South Manitou I.	624	2	0.003	1	0.002
2. Île aux Galets	1950	10	0.003	0	—
3. Calcite Pier	2358	16	0.007	1	0.004
4. Thunder Bay I.	177	1	0.006	1	0.006
5. Sulphur I.	121	2	0.017	0	—
6. Black River I.	122	1	0.008	0	—
7. Channel/Shelter I.	152	1	0.007	0	—
8. Chantry I.	111	1	0.009	1	0.009
9. I. near Oliphant, Ont.	44	3	0.068	0	—
10. South Limestone I.	6	1	0.167	0	—
11. Mud I.	34	2	0.059	0	—
12. Mohawk I.	97	10	0.103	2	0.021
13. Port Colborne	144*	32	0.222	23	0.160
14. Donnelly's Pier	85	18	0.212	9	0.106
15. Buckhorn I.	301	50	0.166	10	0.033
16. Mugg's I.	220	32	0.145	5	0.023
17. Gull I.	1296	85	0.066	11	0.008
18. Little Galloo I.	267	5	0.019	1	0.004
19. Four Brothers I.	125	4	0.032	0	—

*When calculating the number of survivors, the number of bandings obtained from the banding office was increased to include bands put on chicks that were found dead before fledging, and which had been reported as "bands destroyed". These bands were not included in the total given us by the banding office.

Contribution versus distance from colony of origin

The natural logarithm of the contribution index for the different colonies of origin contributing either gulls or terns to either the headland or Port Colborne was plotted against distance from those receiving colonies. In addition, we calculated the regression equations (Fig. 3). For each species at either colony, there was a significant correlation between the natural logarithm of the contribution index and the distance from colony of origin. In all four cases, all data points were within the 95% confidence belt for individual points.

The elevation of the regression lines is determined by (1) the abundance of banded birds on the two receiving colonies, and (2) our encountering efforts (i.e., the number of pairs checked for bands) at those two colonies. Because our encountering efforts were not the same for the two species and the two colonies, we did not compare the elevations of the regression lines. The slopes, however, are comparable because they are not affected by encountering effort. We compared the slopes of the regression lines obtained for Common Terns and Ring-billed Gulls at the headland and at Port Colborne in 1978, using a three-step test described by Snedecor and Cochran (1967). We also compared the slopes of the regression lines obtained for Ring-billed Gulls nesting at the headland in 1977 (Blokpoel and Haymes 1979) and in 1978. We compared residual mean squares and slopes for all species-location combinations, using F-tests, and found no significant differences.

We used the regression equations to predict how many banded birds from colonies not listed in Tables 1 and 2 we should have encountered as nesters at the headland and Port Colborne in 1978.

The 20 colonies of origin listed in Table 1 contributed 3- to 6-year-old Ring-billed Gulls to the headland. An additional 23 ring-bill colonies on the Great Lakes did not

Figure 1
Locations of colonies of origin of banded Ring-billed Gulls nesting at the Eastern Headland and at Port Colborne in 1978 (the numbers refer to Table 1)

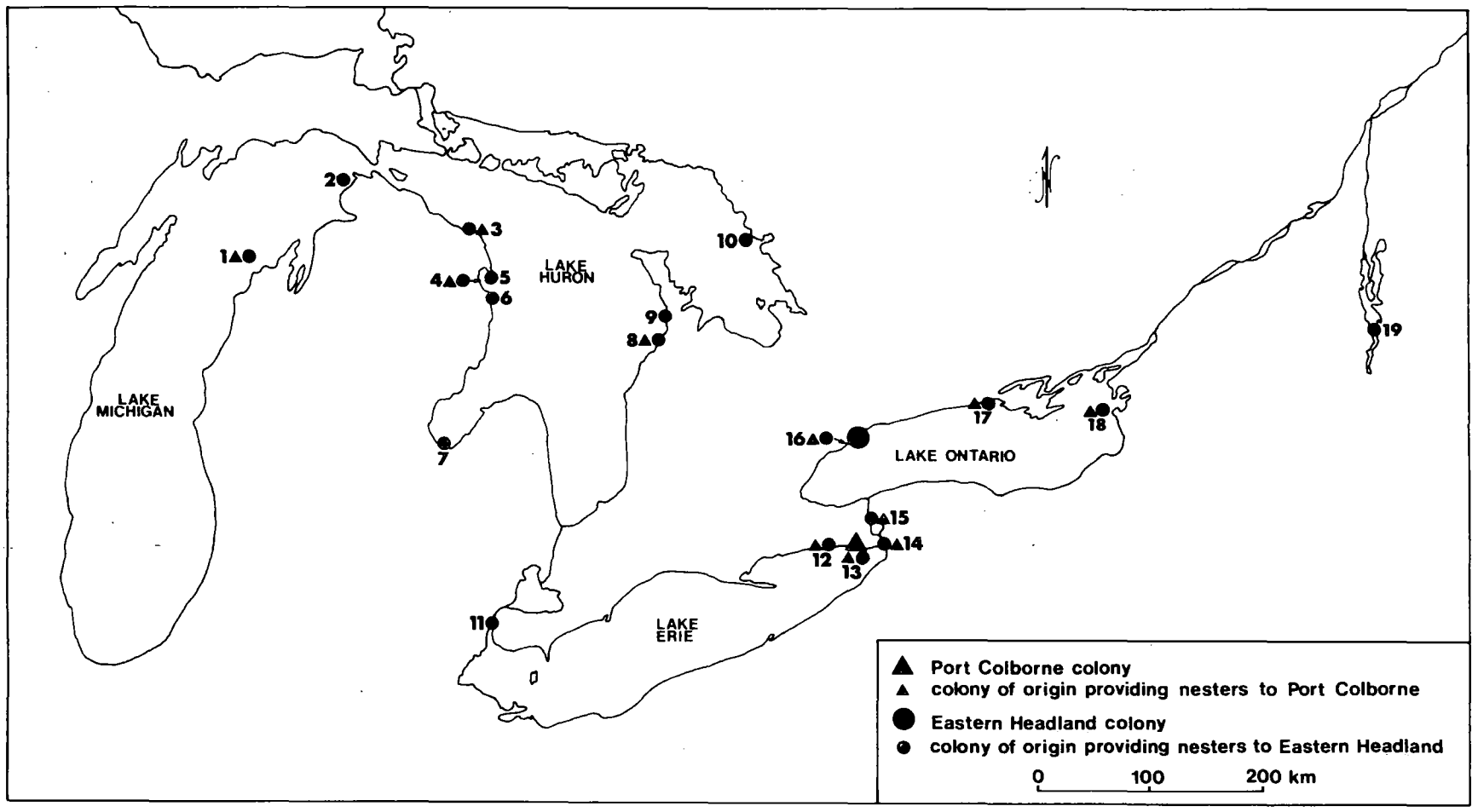
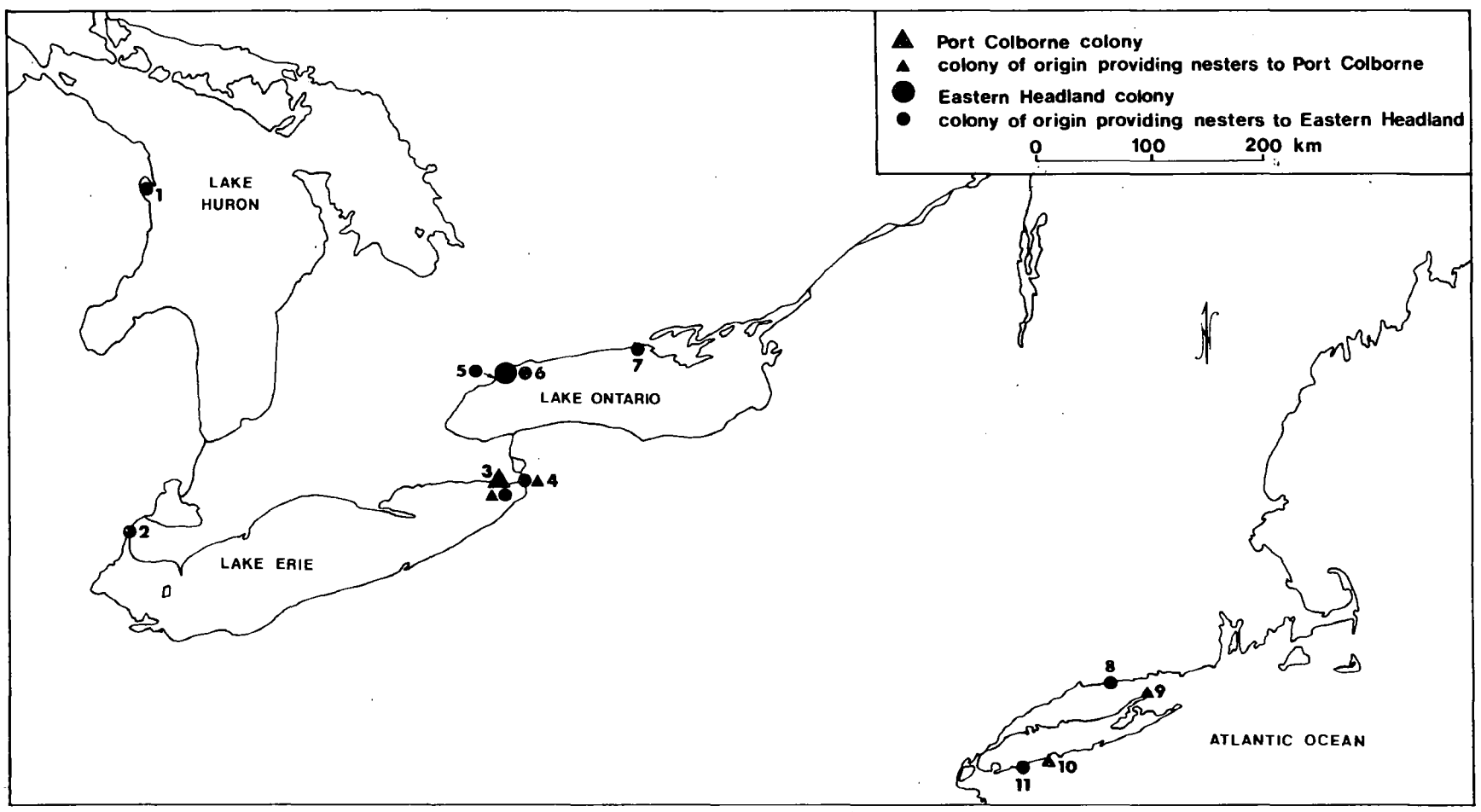


Figure 2
Locations of colonies of origin of banded Common Terns nesting at the Eastern Headland and at Port Colborne in 1978 (the numbers refer to Table 2)



contribute, even though chicks had been banded there during 1972–75. From those additional colonies, we should have encountered two banded birds from East Mary Island (in the North Channel of Lake Huron) and one from High Island in Lake Michigan. For Port Colborne, there were 32 additional ring-bill colonies from which we should have encountered one banded bird from Ile aux Galets, Lake Michigan.

Considering Common Terns, Table 2 lists nine colonies of origin that contributed banded 4- to 9-year-old birds to the headland. Fifteen other colonies in the Great Lakes, where chicks had been banded in 1969–74, contributed none in 1978, nor were any expected. Similarly, there were 21 Common Tern colonies from which we should have encountered, at Port Colborne in 1978, four banded birds from Gull Island, Lake Ontario and one from Thunder Bay, Lake Huron.

Total immigration and recruitment of Ring-billed Gulls at the headland

Colonies of origin

Table 3, showing the total number of 3- to 6-year-old immigrants from the various colonies of origin, indicates that the major contributors were Port Colborne, South Limestone Island, the Lake Ontario colonies on Gull, Little Galloo, and Mugg's islands, and the colonies at Donnelly's Pier and Buckhorn Island in the Niagara River. The total number of immigrants estimated from the sources listed in Table 3 is 25 088 birds, or 55% of the 45 470 Ring-billed Gulls that were counted at the headland in 1978.

Table 2

Estimated numbers of survivors in 1978 of Common Tern chicks banded in 1969–74, number of banded 4- to 9-year-old birds encountered in 1978 at the Eastern Headland and Port Colborne, and contribution indices for the colonies of origin

Colony of origin (Nos. refer to Fig. 1)	Est'd. no. of birds banded 1969–74, alive in 1978 (a)	E. Headland		P. Colborne	
		No. of banded 4- to 9-yr.-old birds encount'd. in 1978 (b)	Contrib. index $\left(\frac{b}{a}\right)$	No. of banded 4- to 9-yr.-old birds encount'd. in 1978 (b)	Contrib. index $\left(\frac{b}{a}\right)$
1. Thunder Bay I.	127	1	0.008	0	—
2. Mud I.	73	2	0.027	0	—
3. Port Colborne	171*	28	0.164	20	0.117
4. Donnelly's Pier	44	3	0.068	4	0.091
5. Mugg's I.	6*	2	0.333	0	—
6. Eastern Headland	7*	4	0.571	0	—
7. Gull I.	93	13	0.140	0	—
8. Falkner's I.	20	1	0.050	0	—
9. Great Gull I.	423	0	—	1	0.020
10. Cedar Beach	142	0	—	1	0.070
11. Jones Beach	372	1	0.003	0	—

*See footnote, Table 1.

Other sources

The large number of birds of unknown origin may have come from one or more of the following sources:

(1) 3- to 6-year-old birds from any colony not listed in Table 3,

(2) 2-year-old birds from any colony,

(3) 7 or more-year-old birds from any colony.

Source 1. Within a 550-km radius of the Eastern Headland (i.e., the greatest distance from which encountered birds originated), there are numerous Ring-billed Gull colonies of significant size (i.e., > 400 pairs) that are not accounted for in Table 3. We know of 26 colonies, including the headland itself, that had more than 400 pairs in 1972–75. The total number of possible immigrants (and recruits in the case of the headland) from those 26 colonies was estimated at 2944 (Table 4). Calculations involved the procedure described in footnote (‡) to Table 4, and the use of the values for survival given in the methods section.

Source 2. We were unable to estimate the contribution of 2-year-old birds because not all of them breed (Ludwig 1974, Southern 1977), and because many of those that do, breed late in the season and are often more difficult to approach and/or capture than older, earlier-nesting birds. Because of those biases, and because we tried to account for only the 22 735 nests counted at the peak of nesting, we did not estimate the contribution from this source.

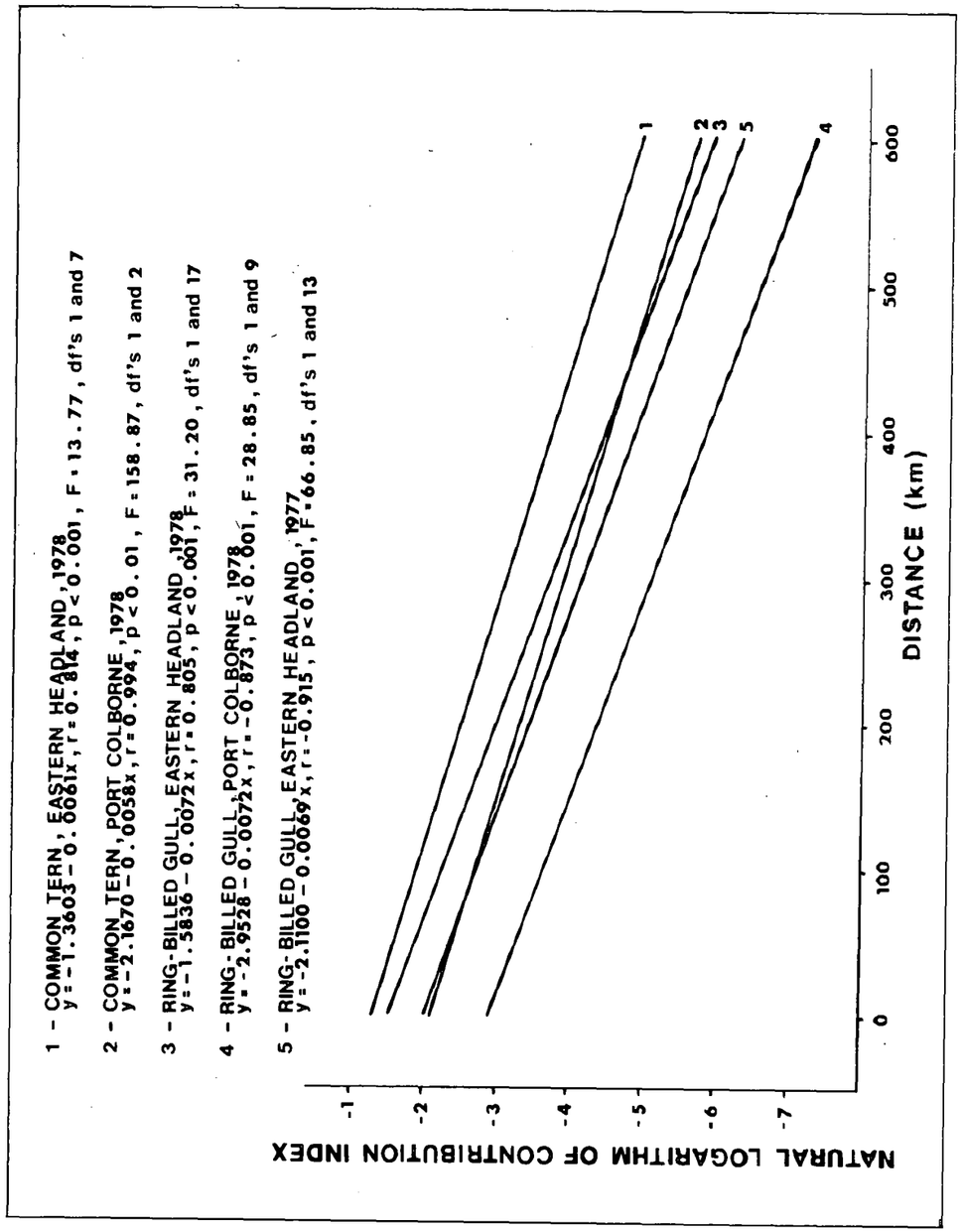


Figure 3
Regression lines showing the relationship between the natural logarithm of "contribution index" (see text) and the distance between colony of origin and receiving colony (Eastern Headland and Port Colborne)

Source 3. The contribution from 7 or more-year-old birds is also difficult to assess. There are few such banded birds remaining because of the combined effects of band loss and mortality (Ludwig 1967). We encountered 16 birds in this age category, which had come from 12 colonies of origin (3 from Gull Island; 2 each from Calcite Pier, Île aux Galets, and Channel/Shelter Islands; and 1 each from Sulphur, Mugg's, Buckhorn, Chantry, South Manitou, Little Galloo, and Grassy islands). The data are inadequate to enable us to estimate the contribution from this source.

Discussion

Colonies of origin and their contribution indices

The differences in distribution of the colonies of origin for Ring-billed Gulls (Fig. 1) and for Common Terns (Fig. 2) are largely a reflection of the breeding range of those two species. Ring-bills belonging to the eastern population nest abundantly on the Great Lakes (except for Lake Superior, where there are only a few relatively small colonies), the upper St. Lawrence River (Cornwall, Ontario, and Montreal area), and northern New York State (Oneida Lake and Lake Champlain, Bull 1974). Ring-bills do not nest on the US Atlantic coast. Common Terns, however, nest in large numbers on the US Atlantic coast (Nisbet 1973), but are not as numerous on the Great Lakes.

The calculations of some of the contribution indices may be imprecise because (1) pre-fledge survival rates varied among the colonies of origin, (2) yearly variation in conditions at those colonies of origin (e.g., fluctuating lake levels) may have changed the normal level of recruitment to those natal colonies, and (3) sample sizes of banded birds were small from some colonies of origin. Despite these possible biases, we found that the slopes of the regression lines obtained from the 1978 data (1-4, Fig. 3) were all very similar. In addition, the slope of the regression line obtained for the 1977 data for ring-bills at the headland was virtually the same as that for the 1978 data (Fig. 3). The similarity in the slopes of the five regression lines indicates that the pattern of contribution of immigrants is similar for the two species and the two colonies. The distance-dependency of contribution first reported by Blokpoel and Haymes (1979) for headland ring-bills thus appears to be consistent for the two species and two colonies under consideration.

Common Terns from Gull Island

One puzzling aspect of immigration for Common Terns concerns Gull Island. While the headland was increasing in numbers of Common Terns, the once-large Gull Island ternery was largely abandoned: i.e., about 10 000 pairs in the late 1950s (Scovell 1960), "several thousands" of nests in the mid 1960s (Ontario Nest Record Scheme), about 7600 nests in 1968 (J.M. Richards, pers. commun.), no more than 5000 nests in 1970 (J.M. Richards, pers. commun.), about 1000 nests in 1972 (M. Gilbertson, pers. commun.); 79 pairs in 1975 and 53 pairs in 1976 (Blokpoel 1977), 3 pairs in 1977 (J.W. Chardine, pers. commun.), and 6 pairs in 1978 (G.A. Fox, pers. commun.).

It would be reasonable to assume *a priori* that many of those Gull Island birds relocated to the headland because the distance between the two locations is short, and no other terneries in the Great Lakes have shown a large increase in numbers (Blokpoel 1977, Scharf *et al.* 1978, Blokpoel and McKeating 1978) that would indicate that the Gull Island terns went elsewhere. However, the contribution index for Gull Island terns (4- to 9-year-old birds) at the Eastern Headland was not unusually high considering its distance from the headland (Table 2 and Fig. 2). In addition, of the 3257 chicks banded at Gull Island between 1965 and 1968, none were encountered at the headland in 1978. Because essentially no terns nested on Gull Island in 1978, at least some of those older birds should have been encountered at the headland if relocation had taken place. One might speculate that, through mortality and band loss, few if any of those birds were still alive and still banded in 1978. However, we encountered at Port Colborne, in 1978, three of the 1026 birds banded as chicks at Port Colborne between 1965 and 1968.

Given these data, we do not believe that the Gull Island terns largely relocated to the Eastern Headland. Thus our data do not support the suggestion, made in the December 1977 Newsletter of the Ontario Bird Banding Association, that such a relocation had occurred. Although we can explain the rapid growth of the tern colony at the headland (Blokpoel and Fetterolf 1978), we do not know why we did not encounter more Gull Island birds at the headland in 1978. We do not have adequate data to examine other possible explanations such as (1) no or very poor reproduction in successive years at Gull Island, and (2) massive die-offs after the breeding season, during migration, or on the wintering grounds.

Common Tern immigration from Atlantic coast

The five encounters with Atlantic coast Common Terns at Port Colborne and the Eastern Headland (four 4- to 9-year-old birds, Table 2, and one 2-year-old bird) are of interest in view of the few previous reports of movements of this kind (Austin 1953, Ludwig 1962, Haymes and Blokpoel 1978*a*). From the early 1920s to 1976, as Haymes and Blokpoel (1978*a*) mentioned, only 19 movements of banded birds between the Great Lakes and the Atlantic coast had been reported; 15 from the Great Lakes to the East Coast, 4 in the opposite direction.

Total immigration and recruitment of Ring-billed Gulls at the Eastern Headland

It is difficult to "account" for the 45 470 Ring-billed Gulls that nested at the headland at the peak of nesting in 1978 and, at best, such an exercise is highly speculative. We believe that the greatest sources of error in our treatment are the generalizations made about pre-fledge survival rates and colony size; because of lack of detailed information, we have not taken into account the variation from colony to colony and from year to year. The greatest errors in these cases are apt to arise with respect to the large colonies (i.e., Little Galloo Island, Gull Island, Eastern Headland, Port Colborne, and South Limestone Island)

since those colonies collectively comprise a good portion of the Ring-billed Gull population on the Great Lakes. Unfortunately, due to their size, it is difficult to get good estimates of the numbers of their nests and pre-fledge survival.

The generalizations regarding colony sizes are particularly difficult to justify when many colonies are fluctuating markedly in numbers of breeding pairs. While numbers of Ring-billed Gulls at most colonies seem to have remained fairly stable, in some instances, predation or inundation have greatly affected pre-fledge survival and number of nesters, particularly in some of the Lake Huron and Lake Michigan colonies (Dexheimer and Southern 1974, Patton and Southern 1977, Scharf *et al.* 1979).

Another source of error is our lack of information on the numbers and distribution of Ring-billed Gull colonies within 550 km of the headland and Port Colborne *during 1972–75*. For example, the results of a survey in 1979 of the Fishing Islands area, off the Bruce Peninsula in Canadian Lake Huron, indicated that about 17 600 pairs of ring-bills nested there in seven colonies (D.V. Weseloh, pers. commun.). As we do not have any information on those colonies for 1972–75, we do not know whether they existed then or what their contribution to the birds nesting in 1978 at the headland and Port Colborne would therefore have been.

Our analysis suggests that the Eastern Headland Ring-billed Gull colony is presently comprised mainly of immigrants from Port Colborne, Gull Island, Little Galloo Island, and South Limestone Island. Of the 45 470 Ring-billed Gulls nesting at the headland in 1978, we estimate that 62% were 3- to 6-year-old birds. As shown above,

Table 3
Estimated number of 3- to 6-year-old Ring-billed Gulls nesting in 1978 at the Eastern Headland, by colony of origin

Colony of origin (see Fig. 1)	Contrib. index (corrected)*	Est'd. no. nests/yr. (1972–75)†	Est'd. no. chicks hatched 1972–75, and alive in 1978	Estd. total immigrants	Reference or source
1. South Manitou I.	0.004	4 100	6 547	26	Scharf *et al.* 1979
2. Ile aux Galets	0.007	4 000	6 388	45	Scharf *et al.* 1978, 1979
3. Calcite Pier	0.009	4 200	6 707	60	Dexheimer and Southern 1974, Southern 1977
4. Thunder Bay I.	0.008	2 700	4 312	34	Scharf *et al.* 1978, 1979
5. Sulphur I.	0.002	1 700	2 715	60	Scharf *et al.* 1978, 1979
6. Black River I.	0.011	1 100	1 757	19	Scharf *et al.* 1978, 1979
7. Channel/Shelter Is.	0.009	4 100	6 547	59	Scharf *et al.* 1978, 1979
8. Chantry I.	0.012	5 500	8 783	105	D. Busby, pers. commun.
9. I. near Oliphant, Ont.	0.093	150	240	22	H. Krug, pers. commun.
10. South Limestone I.	0.228	16 000	25 551	5 826	Morris and Hunter 1976
11. Mud I.	0.080	5 000	7 985	639	Scharf *et al.* 1978, 1979
12. Mohawk I.	0.141	800	1 278	180	Blokpoel and McKeating 1978
13. Port Colborne	0.303	16 000	25 551	7 742	Blokpoel and McKeating 1978
14. Donnelly's Pier	0.288	600	958	276	A.R. Clarke, pers. commun.
15. Buckhorn I.	0.226	4 000	6 388	1 444	A.R. Clarke, pers. commun.
16. Mugg's I.	0.198	3 500	5 589	1 107	Blokpoel 1977
17. Gull I.	0.090	25 000	39 947	3 595	Blokpoel 1977
18. Little Galloo I.	0.026	80 000	127 756	3 322	Ludwig 1974, T. Carolyn, pers. commun.
19. Four Brothers I.	0.044	7 500	11 984	527	Peterson 1978
				Total 25 088	

*Contribution indices (Table 1) increased by a factor of 1.36 (see Calculation of total immigration, in Methods).
†Figure often based on an estimate for 1 year only; the estimate(s) may have been made during the 1972–75 period or closely preceding or succeeding that period; an average was used when a number of estimates had been made over a number of years; all estimates were rounded off to the nearest 100 pairs.

as well as by Blokpoel and Haymes (1979), the contribution of birds from nearby colonies has been an essential feature of the growth of the Ring-billed Gull colony at the headland. As the results of this section indicate, that tremendous growth has been due to the fact that those nearby colonies have been very large.

Table 4
Estimated number of 3- to 6-year-old Ring-billed Gulls nesting in 1978 at the Eastern Headland from colonies of 400 pairs or more and within 550 km of the headland

Colony*	Location	Estd. no. nests/yr. (1972–75)†	Estd. no. chicks fledged 1972-75, and alive in 1978	Estd. total immig. or recruits‡	Reference or source
Round I.	L. Superior	1500	2395	17	Scharf *et al.* 1978, 1979
Moon I.	St. Mary's R.	1000	1597	13	Scharf *et al.* 1978, 1979
S.W. Neebish I.	St. Mary's R.	1300	2076	17	Scharf *et al.* 1978, 1979
Andrews I.	St. Mary's R.	1800	2875	35	Scharf *et al.* 1978, 1979
Green I.	L. Michigan	1500	2395	19	Scharf *et al.* 1978, 1979
High I.	L. Michigan	3300	5270	26	Scharf *et al.* 1978, 1979
E. Grape I.	L. Michigan	1200	1916	13	Scharf *et al.* 1978, 1979
W. Grape I.	L. Michigan	4000	6388	45	Scharf *et al.* 1978, 1979
Elm I.	N. Channel	800	1278	26	J.P. Ludwig, pers. commun.
Cousins I.	N. Channel	2100	3354	64	J.P. Ludwig, pers. commun.
West I.	N. Channel	650	1038	17	J.P. Ludwig, pers. commun.
E. Mary I.	N. Channel	800	1278	43	D.V. Weseloh, pers. commun.
S. Watcher I.	Georgian Bay	2500	3992	348	Ontario Nest Record Scheme, D.A. Sutherland, pers. commun.
Gull Rocks	Georgian Bay	1000	1597	61	S.M. Teeple, pers. commun.
Halfmoon I.	Georgian Bay	2000	3194	134	J.P. Ludwig, pers. commun.
Papoose I.	Georgian Bay	2000	3194	105	J.P. Ludwig, pers. commun.
Snake I.	Georgian Bay	2500	3992	168	J.P. Ludwig, pers. commun.
Bird I.	Georgian Bay	2300	3673	84	Scharf *et al.* 1978, 1979
Lyal I.	Georgian Bay	2500	3992	224	J.P. Ludwig, pers. commun.
Grassy I.	Detroit R.	1600	2555	49	Scharf *et al.* 1978, 1979
Tower I.	Niagara R.	1200	1916	339	Blokpoel, unpubl. data
Table Rock I.	Niagara R.	400	639	114	Blokpoel and McKeating 1978
E. Headland	L. Ontario	5000	2394	670	Blokpoel and Fetterolf 1978§
Pigeon I.	L. Ontario	1800	2875	155	Blokpoel 1977
Strachan I.	St. Lawrence R.	4800	7665	107	Goodwin 1975, Blokpoel 1977
St. Lambert	St. Lawrence R.	4000	6388	51	David and Gosselin 1977
				Total 2944	

*All know colonies not already listed in Table 3.
†See footnote †, Table 3.
‡Contribution indices used to calculate total immigration and recruitment were derived from the regression equation ($y = -1.5836 - 0.0072x$, see Fig. 3) and were corrected (i.e., increased by a factor of 1.36, see text).
§ "Small numbers" seen in 1974; 10 382 nests counted in 1976; estimated 5000 for 1975 by interpolation.

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