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The Rise and Fall of Ring-billed Gulls (*Larus delawarensis*) in Eastern North America

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Abstract.—Ring-billed Gulls (*Larus delawarensis*) were rare at the beginning of the 20th century, possibly because of intensive exploitation. Once they became protected in 1916, their numbers increased throughout eastern North America, reaching a maximum of 875,000 breeding pairs around 1990. Since then, an overall decline of 19% has been recorded in the Great Lakes and the St. Lawrence River while their numbers tripled in Atlantic Canada. The largest concentrations are still found on the Great Lakes with 38% and 42% of the birds breeding in Canada and the USA, respectively. The remaining individuals breed along the St. Lawrence River (15%), on Lake Champlain (2%), and in the Gulf of St. Lawrence including the Atlantic Provinces and Saint-Pierre-et-Miquelon (3%). In 2009, a study was undertaken in the largest colony located on Île Deslauriers near Montreal, Québec, to determine the factors that regulate the number of breeding birds. This colony supported 52,000 pairs in 2000 and 44,000 in 2012. Ring-billed Gulls had a lower reproductive output in 2010-2012 compared to the late 1970s attributed to reduced chick survival. The number of gull-days at the nearest landfill declined from 906,000 in 1995 to 40,000 in 2012 following the implementation of a falconry deterrence program. Limited access to an abundant food supply located near the colony may have reduced chick survival. How this affects annual survival and population size remains to be determined. In the long term, policies that aim to reduce input of organic matter at landfills and discourage citizens from feeding gulls could further contribute to the decline of Ring-billed Gulls in eastern North America. *Received 1 June 2014, accepted 22 June 2015.*

Key words.—anthropogenic food, bird control, breeding success, deterrence, falconry, landfills, *Larus delawarensis*, population dynamics, Ring-billed Gull.

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Two populations of Ring-billed Gulls (*Larus delawarensis*) are recognized in North America: a western group centered on the prairies extending south to Wyoming and Colorado, and an eastern one that breeds in the Great Lakes and along the St. Lawrence River up to the Gulf of St. Lawrence (Gaston *et al.* 2008). It is the most abundant larid species in eastern North America (Cotter *et al.* 2012). However, this has not been always the case, and the species was considered rare at the beginning of the 20th century (Blokpoel and Tessier 1986). Following the signature of the 1916 Convention between the United States and Great Britain (for Canada) for the Protection of Migratory Birds (U.S. Fish and Wildlife Service 2012), the number of Ring-billed Gulls slowly increased until around 1970, then the population grew exponentially during the next two decades. The status of the Ring-billed Gull as a pest species, the call and justification for reducing its number at specific sites, especially in Ontario, and the potential control measures to do this generated vigorous debates in the late 1980s (Blokpoel and Tessier 1988; Southern 1987, 1988). After reaching a peak in the 1990s, the population started to decline (Morris *et al.* 2011; Cotter *et al.* 2012).

Several factors have been proposed to explain the demographic explosion of Ring-billed Gulls, but their ability to adapt to human-related environments is the most often cited explanation (Blokpoel and Scharf 1991; Belant 1997). For instance, they readily nest on artificial islands or roofs of buildings and often forage on anthropogenic food at landfills or on agricultural lands (Blokpoel

and Tessier 1986; Belant *et al.* 1998). Surprisingly, no study has attempted to link their opportunistic behavior to breeding output or annual survival, two parameters that regulate population dynamics. On the other hand, several control programs have been conducted to reduce breeding success of Ring-billed Gulls through nest destruction or egg oiling (Blokpoel and Tessier 1992; Ickes *et al.* 1998), while culling has been mainly conducted as part of deterrence programs (Dolbeer *et al.* 1993; Thiériot *et al.* 2012). Again, the impact of these measures on demographic parameters and population size has not been evaluated.

In Europe, the closing of landfills and implementation of a trawling moratorium have reduced food availability for several gull species with a concomitant reduction in breeding success but not adult survival (Oro *et al.* 1995, 1999, 2004; Pons and Migot 1995). Culling has also been carried out extensively on species like the Yellow-legged Gull (*L. cachinnans*), reducing the number of birds locally but enhancing emigration to other regions within the breeding range (Bosch *et al.* 2000).

In this study, we first summarized population trends of Ring-billed Gulls during the last 40 years in different regions of eastern North America based on published and unpublished information. Next, we examined whether their reproductive output changed during this period. Finally, we investigated the relationship between the number of breeding pairs, reproductive success, and landfill use by Ring-Billed Gulls using data from a recent intensive study conducted in the St. Lawrence River, Québec (Lagarde 2013).

METHODS

Study Area

Details on the number and locations of the colonies in eastern North America can be found in Boyne *et al.* (2011), Davis *et al.* (2011), Morris *et al.* (2011), and Cotter *et al.* (2012). Reproductive success was studied on the 11.4-ha Île Deslauriers located in the St. Lawrence River, 3 km downstream from Montreal, Québec (45° 43′ 1″ N, 73° 25′ 59″ W). The surrounding foraging area encompassed approximately 6,000 km^2 and consisted of a mosaic of high and low density urban areas, agricultural lands of intensive (soybean, maize, and small cereals) and extensive (hayfields and pastures) cultures, as well as riparian habitats along the river and its tributaries (Patenaude-Monette *et al.* 2014). Several landfills and waste transhipment sites are found in the area. Since 1995, the Terrebonne landfill (8 km from the colony) has maintained a deterrence program that includes falconry, distress calls, and pyrotechnics. This program has been in operation every day from sunrise to sunset, preventing all but a few gulls from using the landfill. The Ste-Sophie landfill (37 km from the colony) initiated a deterrence program in 2009 that combines pyrotechnics and selective culling. However, the program has been limited to weekdays from 07:00 hr to 15:00 hr, thereby leaving some feeding opportunities for gulls (Thiériot *et al.* 2012). Finally, the St-Thomas landfill (41 km from the colony) and Lachute landfill (63 km from the colony), as well as two local transhipment sites (12 and 27 km from the colony), have had no deterrence programs.

Population Estimates and Trends

The number of breeding Ring-billed Gulls has been monitored by the Canadian Wildlife Service and the U.S. Fish and Wildlife Service since the 1970s through nest surveys conducted in colonies (Boyne *et al.* 2011; Davis *et al.* 2011; Morris *et al.* 2011; Cotter *et al.* 2012). Surveys were not synchronized between countries nor among Provinces and States and were conducted every 10 years in the Great Lakes (Morris *et al.* 2011), every 5 years in the Gulf of St. Lawrence, every 3 years in the Québec portion of the St. Lawrence River starting in 1990, and sporadically in Lake Champlain (Vermont and New York), Atlantic Canada, and Saint-Pierre-et-Miquelon, a French overseas collectivity off the coast of Newfoundland (Boyne *et al.* 2011; Davis *et al.* 2011; Cotter *et al.* 2012; P. Boez and D. Capen, pers. commun.). We summarized the data for each region and each decade between 1970 and 2010. If more than one count was available for a given period, the maximum number of breeding pairs was used.

To fill the gaps between surveys and to get a more detailed picture of the demographic trend of Ring-billed Gulls in southern Québec, we used data from Étude des Populations d'Oiseaux du Québec (ÉPOQ), a bird checklist database created in 1975 (Dunn *et al.* 1996). Standard checklists are filled by volunteer observers who report the number of birds by species seen or heard at a specific location on a single day. Dunn *et al.* (1996) concluded that this monitoring program was useful for detecting population trends. We therefore selected checklists submitted between 1970 and 2012 for the months of March to July, which corresponds to the pre-breeding and breeding periods (Pollet *et al.* 2012; Lagarde 2013). We determined the sampling area by merging 63-km buffers mapped around each colony, which corresponds to the maximum direct foraging distance traveled by gulls nesting at Île Deslauriers (Patenaude-Monette *et al.* 2014). A total of 48,643 checklists had been submitted during the 43 years for

the 5-month period (annual mean = 1,131 ± 643 SD; Range = 216-2,413). To standardize the sampling effort, annual indices were calculated based on the proportion of checklists reporting at least one sighting of a Ring-billed Gull. Next, a maximum-likelihood method was used to fit different models to the proportion of checklists with a gull sighting across time (Bolker 2008). Four models commonly used to assess density dependence were compared using the Akaike information criterion (AIC; Burnham and Anderson 2002): logistic, Ricker, Holling type IV, and Gompertz (Bolker 2008; Eberhardt *et al.* 2008). Models were fitted with a binomial error distribution, and the parameters were estimated with the bbmle package (Bolker 2012) run in statistical program R (R Development Core Team 2012).

Reproductive Success

Reproduction of Ring-billed Gulls was studied between 2009 and 2012 in six 3.5-m radius plots established in the Île Deslauriers colony using the multiple visits method of Mousseau (1984). Each plot was surrounded by a 1.2-m high enclosure made of chicken wire and established when the first young hatched. Plots were visited as soon as the first eggs were laid and every 2-3 days thereafter until the young had fledged. Visits were as short as possible to minimize disturbance and reduce predation risk. Each nest was identified with a short bamboo stick fitted with a small numbered flag. Eggs were also numbered in laying sequence with a non-toxic permanent marker. At each visit, new nests, the number of eggs in the marked nests, and the fate of the marked eggs were noted. Young were marked at hatching with uniquely numbered web tags (Alliston 1975). All juveniles within each plot were rounded up before fledging and banded with U.S. Geological Survey steel bands and colored plastic bands engraved with a unique alphanumeric code. Clutch size, hatching success (the proportion of eggs hatched in nests with a complete clutch and a known fate), chick survival (the proportion of chicks marked with web tags in successful nests that were subsequently recaptured at banding), and the number of young per pair were compared among years using analysis of variance followed by *a posteriori* tests. Data on reproductive success collected in 1979 on Île Deslauriers by Mousseau and Lagrenade (1980) were used to examine changes over time. We also used published and unpublished data on the number of fledged young per pair recorded at various colonies across eastern North America between 1972 and 2012 to detect temporal trends in reproductive output using a simple linear regression.

Use of Landfills

The use of landfills by nesting Ring-billed Gulls was determined by tracking birds fitted with GPS data loggers from Île Deslauriers (Patenaude-Monette *et al.* 2014). We also conducted daily surveys at the Terrebonne landfill from 1995 to 2012 in the morning, mid-day, and afternoon when deterrence took place. We counted all Ring-billed Gulls observed within a 200-m radius of the active tipping area. We summed the maximum number of gulls observed each day between 1 April and 31 August to obtain the number of gull-days for each year. For days with missing data, we computed the mean numbers between successive counts. Data on the tonnage of residual material brought to the landfill each year were provided by Browning-Ferris Industries Canada (J.-C. Marron, pers. commun.).

RESULTS

Population Size and Trend

The breeding population of Ring-billed Gulls rapidly increased between 1970 and 1990 when it reached a maximum of 875,000 pairs (Fig. 1). Since then, the number of breeding pairs has declined by 35% in the Canadian portion of the Great Lakes while it increased by 8% in the USA colonies. The number declined by 19% in the St. Lawrence River and Lake Champlain while it tripled in the Gulf of St. Lawrence, Atlantic Canada, and Saint-Pierre-et-Miquelon. Globally, the eastern population has declined by 16%. The largest concentrations are currently found on the Great Lakes with 38% and 42% of the birds breeding in Canada and the USA, respectively. The remaining birds breed along the St. Lawrence River (15%), on Lake Champlain (2%), and in the Gulf of St. Lawrence, the Atlantic Provinces and Saint-Pierre-et-Miquelon (3%).

Similar trends were observed in the colonies located along the St. Lawrence River in southern Québec, although the frequency of the nest surveys has not been constant, especially during the exponential growth period (Fig. 2). However, sightings reported by birdwatchers fit closely the available nest survey data. The Ricker function best described the growth and the decline of the population compared to the logistic model that came second but with much less support (ΔAIC_c = 72.4; K = 3). The annual growth rate (y) can be expressed by the derivative of the Ricker function in which x = number of years:

$$y = 0.054 * e^{0.043x} - 0.054x * e^{0.043x} * 0.043$$

The highest nest count along the St. Lawrence River was recorded during the 1994 survey, while the maximum frequency of checklists with a Ring-billed Gull sighting

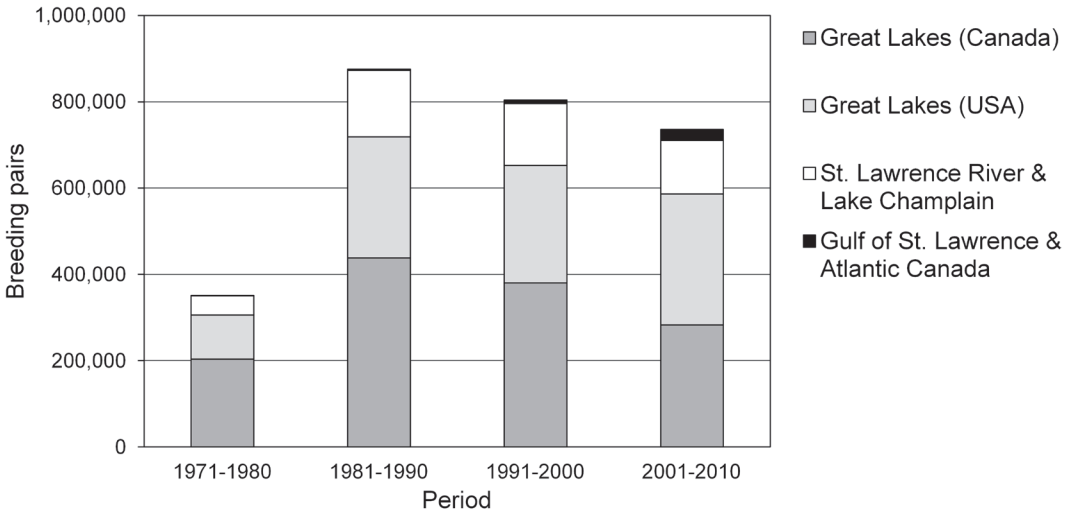

Figure 1. Number of breeding pairs of Ring-billed Gulls in eastern North America, 1970-2010. Data from Morris *et al.* (2011), Davis *et al.* (2011), Cotter *et al.* (2012), P. Boez and D. Capen (pers. commun.).

occurred in 1997 (Fig. 2). There seems to be a short time lag between the maximum population size and the onset of the decline in southern Québec compared to the Great Lakes.

Most colonies in the St. Lawrence River are located in the Montreal area. This includes Île Deslauriers with 44,000 nests counted in 2012, which makes it the current largest colony in eastern North America. The decline started slightly later in this colony where a maximum of 52,000 nests had been tallied in 2000. The delay may have been associated with immigration of birds from Île de la Couvée, which was gradually abandoned between 1994 and 2007. Three birds banded as juveniles on Île de la Couvée between 1994 and 2000 were recaptured on Île Deslauriers in 2009-2010 (J.-F. Giroux, unpubl. data). Île de la Couvée is located 27 km upstream from Île Deslauriers, and the exact reasons for the abandonment of this colony are unknown. However, the persistence of foxes (*Vulpes vulpes*) and the rapid replacement of grasses by forbs and shrubs have reduced the quality of the nesting habitat. The use of rooftops for nesting is still limited to the western portion of the island of Montreal (2,000 nests on three buildings in 2012), and also coincided with the abandonment of Île de la Couvée.

Reproductive Success

We evaluated different breeding parameters of Ring-billed Gulls nesting on Île Deslauriers between 2009 and 2012 and compared our results with those obtained 30 years ago in the same colony by Mousseau and Lagrenade (1980). Unfortunately, the raw data for 1979 were unavailable, precluding any statistical comparisons. Clutch size was lower in 2012 than during the previous 3 years ($F_{3,1264} = 9.607$; $P < 0.001$; Table 1). Although there was no significant difference, clutch size was also lower in 2011 than in 2009-2010. The timing and the length of the 2011 and 2012 breeding seasons were later and longer than during the first 2 years of the study. High water levels of the St. Lawrence River in 2011 flooded some islands or portions of islands where Ring-billed Gulls nested. This prompted some gulls to disperse to Île Deslauriers and other islands to renest (Lagarde 2013). In 2012, a dry spring delayed nest initiation. As a result, late clutches characterized by a lower number of eggs were proportionally more abundant during these 2 years. Clutch sizes during the normal years (2009-2010) were similar to what was reported in 1979 (Mousseau and Lagrenade 1980).

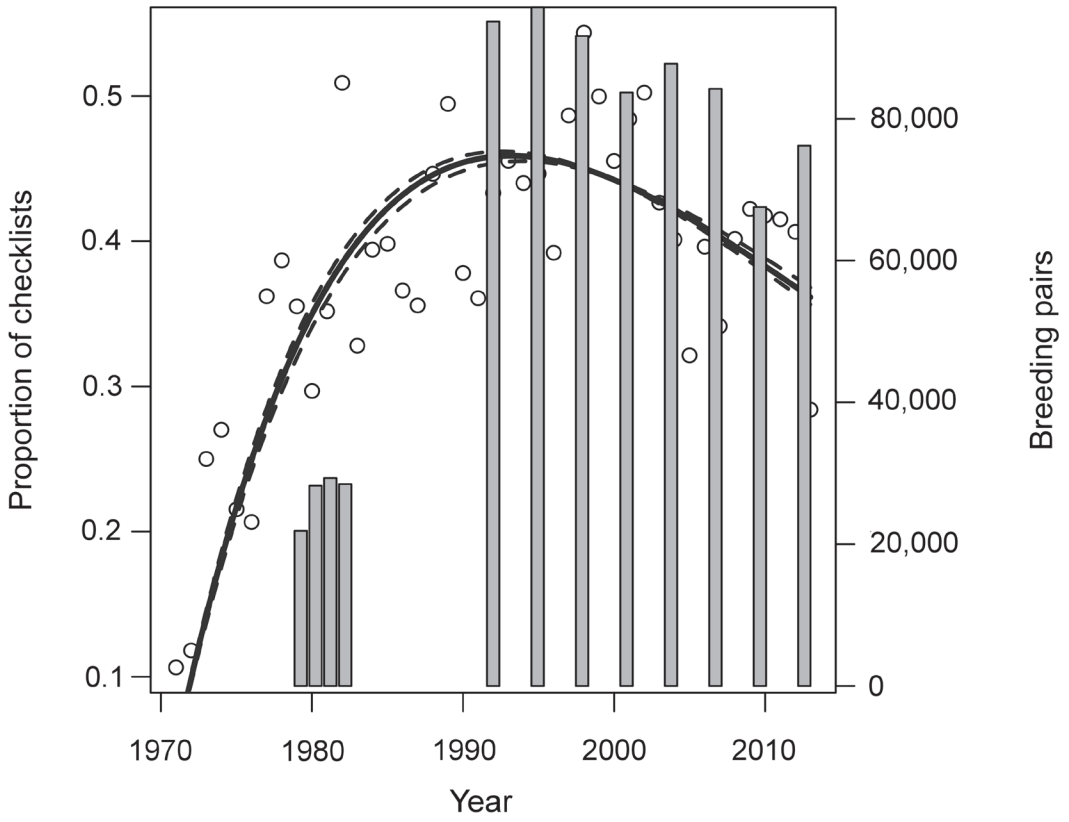

Figure 2. Number of breeding pairs (bars) of Ring-billed Gulls in southern Québec and the proportion of checklists with sightings of the species (dots), 1970-2012. The Ricker function is shown ± 95% CI (lines).

Hatching success was lower in 2011 and 2012 ($F_{3,1118} = 21.51$; $P < 0.001$; Table 1). With the prolonged and delayed nesting season, there was more asynchrony in hatching, resulting in birds rearing young while others were still incubating (Lagarde 2013). We often observed aggressive interactions among pairs, which resulted in more preyed upon eggs in 2011 and 2012. Nevertheless, the hatching rates observed during our 4 years were comparable to what Mousseau and Lagrenade (1980) reported in 1979.

Chick survival was lower in 2011 than in 2010 or 2012 ($F_{2,681} = 8.24$; $P < 0.001$; Table 1). Again, we observed more aggressive interactions among neighboring pairs that resulted in more cannibalism in 2011. Globally, 61% of the 1,511 marked chicks survived to banding, 21% disappeared and 17% were found dead. Some birds that disappeared before marking may have survived, which makes our chick survival a minimum estimate. However, we believe that the majority have died as we never recaptured web-tagged birds that had

Table 1. Breeding output of Ring-billed Gulls on Île Deslauriers, Québec, 1979, 2009-2012. Means (± SE) followed by the same letter for a given parameter are not significantly different ($P < 0.05$). 1979 data are from Mousseau and Lagrenade (1980).

Parameter	1979	2009	2010	2011	2012
Number nests	130	380	289	304	295
Clutch size	2.95	2.94 ± 0.02a	2.91 ± 0.02a	2.86 ± 0.03a	2.76 ± 0.03b
Hatching rate	0.67	0.70 ± 0.02a	0.74 ± 0.02a	0.59 ± 0.02b	0.52 ± 0.02b
Chick survival rate	0.92	n/a	0.65 ± 0.02a	0.55 ± 0.03b	0.69 ± 0.03a
Young/pair	1.83	n/a	1.26 ± 0.06a	0.89 ± 0.05b	0.98 ± 0.06b

not been banded before fledging. We do not have a good assessment of the causes of chick mortality because the carcasses found in the enclosures started decomposing very rapidly. Chick survival at Île Deslauriers was much lower during our study than in 1979. Moreover, Mousseau and Lagrenade (1980) reported chick survival of 0.87 and 0.90 at two other nearby colonies studied in 1979, suggesting that this parameter has declined over time. The median age at banding during our study was 27 days, which is approximately 1 week before the birds can fledge. Finally, the number of young/pair showed a similar trend as chick survival with a lower production in 2011 than during the other 2 years ($F_{2,887} = 11.72$; $P < 0.001$; Table 1). Compared to Mousseau and Lagrenade (1980), our mean value for 2010-2012 was 43% lower.

Using historical data collected across eastern North America, we found that the number of fledged young/pair significantly declined between 1972 and 2012 ($y = 31.324 - 0.015x$; $r^2 = 0.23$; $F_{1,22} = 6.68$; $P = 0.017$; Fig. 3). Based on the predicted values, we calculated a reduction of 35% in reproductive output, which is slightly less than what we observed on Île Deslauriers.

Use of Landfills

In 2009-2010, gulls tracked from the Île Deslauriers colony visited the four landfills and the two transhipment sites (Patenaude-Monette *et al.* 2014). However, data on long-term usage of these sites were only available for the Terrebonne landfill where a significant decline in bird use was recorded following the implementation of a deterrence program based on falconry in 1995 (Fig. 4). The decline could not be associated with a reduction of refuse brought to the landfill. Instead, the tonnage gradually increased up to 2004 when it stabilized at around 1.3 million tons per year (Fig. 4). The 1983-1994 period, characterized by the absence of deterrence efforts and an annual mean of 318,500 tons of waste material brought to the site, corresponds to the exponential growth period of Ring-billed Gulls in southern Québec. No counts were conducted before the use of the scaring techniques, but the number of gulls recorded in 1995 reflects the use of the landfill by gulls at this time, which explain why a deterrence program was put in place (P. Molina, pers. obs.).

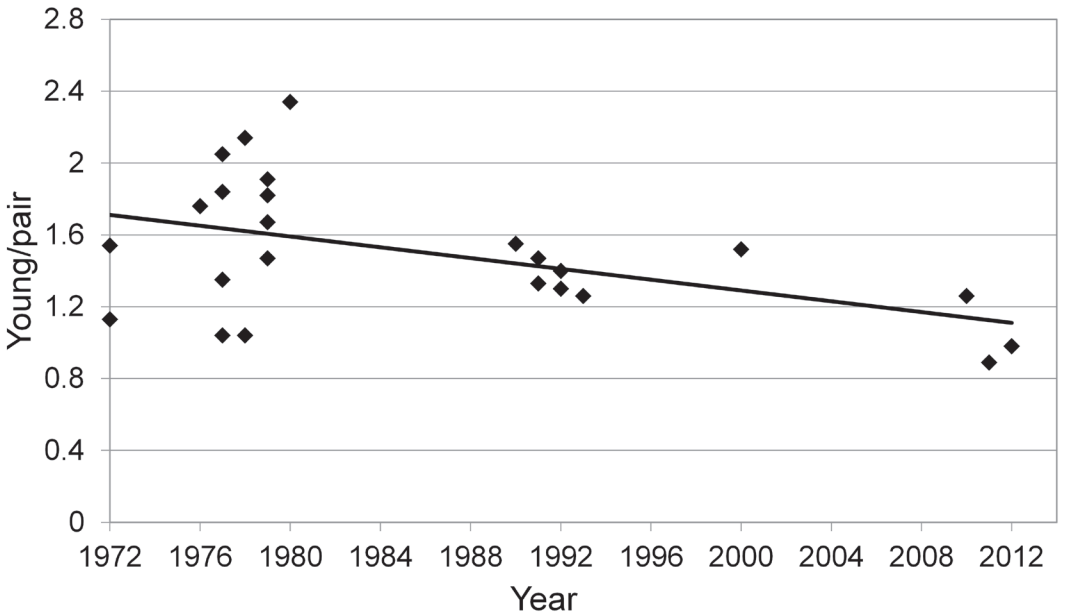

Figure 3. Number of fledged young per pair of Ring-billed Gulls in eastern North America, 1972-2012. See Appendix for data.

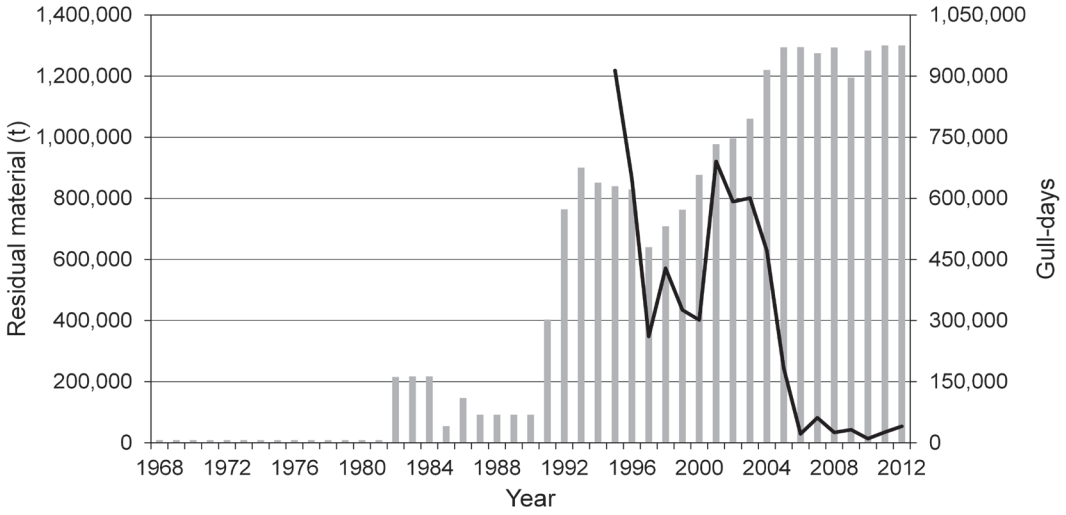

Figure 4. Annual tonnage of residual material (gray bars) at the Terrebonne landfill, 1968-2012 and number of gull-days (black line) recorded at the landfill between April and August, 1995-2012. The deterrence program based on falconry started in 1995 and was conducted each year.

Discussion

The size of the eastern population of Ring-billed Gulls is largely driven by birds breeding in colonies of the Great Lakes. Morris *et al.* (2011) described the limitations of nest surveys and acknowledged the lack of error values associated with these counts. They considered that census data represent minimum conservative estimates and that their interpretation of the observed trends was limited by the low number of data points (four points during 33 years). Nevertheless, similar trends were observed in southern Québec. Very few studies have attempted to determine the demographic parameters that influence the dynamics of the population, and those that did were more interested in the effects of breeding success than survival of the different age classes.

The exponential population growth of Ring-billed Gulls between 1970 and 1990 has often been explained by their use of human-related habitats for nesting and foraging (Blokpoel and Scharf 1991; Belant 1997). For instance, use of the Terrebonne landfill in the absence of a deterrence program between 1983 and 1994 resulted in high chick survival at Île Deslauriers, which became the largest colony in eastern North America. The 1.8 young/pair observed in 1979 at Île Deslauriers by Mousseau and Lagrenade (1980) was much higher than the 0.5 young/pair estimated by Ludwig (1967) to maintain a population stable. Ludwig's estimate, however, must be considered with caution because it was based on several untested assumptions; no recent estimate relying on modern modeling procedures has been produced. Nevertheless, the breeding output estimated by several studies conducted between 1970 and 1990 ($\bar{x}$ = 1.6 young/pair) far exceeded the threshold established by Ludwig (1967).

More recently, a moderate increase in the USA colonies of the Great Lakes has been associated with an increase in mean colony size, but the reasons for such a change have not been determined (Morris *et al.* 2011). Interestingly, the number of Ring-billed Gulls breeding in Atlantic Canada has tripled in the last 20 years, especially in Newfoundland where a large number of small colonies became established (Boyne *et al.* 2011; Cotter *et al.* 2012). Again, there is no explanation for these increases, but emigration cannot be discarded. In Europe, dispersal of birds as a result of lower food availability and management measures has been observed (Brooks and Lebreton 2001; Oro *et al.* 2004). A recent novel explanation for population growth of Ring-billed Gulls has

been proposed by Aponte *et al.* (2014), who found that the consumption of anthropogenic food sources may have contributed to a reduction in gastrointestinal parasites of breeding adults, which may have enhanced their condition and survival.

Between 1990 and 2010, the rate of decline observed throughout the Great Lakes (18%) was similar to that noted in the St. Lawrence River and Lake Champlain (19%), suggesting that similar causes might be involved. Morris *et al.* (2011) found little evidence for a relationship between food availability and the size of the breeding population in the Great Lakes, and concluded that precise causal factors could not be identified. Our results in the St. Lawrence River, however, suggest that decreased food accessibility may have reduced chick survival and thus breeding output. We observed a mean of 1.04 young/pair during our 2010-2012 study, which was 43% less than what Mousseau and Lagrenade (1980) reported 30 years ago. Landfills are attractive feeding sites for gulls because of the higher energy contained in the food resources they provide compared to agricultural lands or riparian habitats (Patenaude-Monette *et al.* 2014). At Île Deslauriers, adults are still feeding chicks with edible refuse despite a significant reduction in gull-days at the nearby Terrebonne landfill due to the effective deterrence program based on falconry. This suggests that gulls must rely on landfills located further from the colony or on transhipment sites (Patenaude-Monette *et al.* 2014). We hypothesize that since the implementation of the deterrence program at this nearby landfill, young are left unattended for longer periods, exposing them to cannibalism. We also suggest that, even though significant amounts of refuse continue to be brought to the Terrebonne landfill, chicks may now receive less food than they did during the 1983-1994 growth period when no deterrence took place at the site. This may have resulted in a reduced body condition and survival of juveniles. These suggestions are supported by the results of Pons and Migot (1995) who observed a reduction in breeding success of Herring Gulls (*L. argentatus*) following the closure of a nearby landfill and those of Oro *et al.* (1999) who established that the abundance of fish discards influences breeding output of Audouin's Gulls (*Larus audouinii*).

We found a general decline in breeding success reported by different studies conducted during the last 40 years in colonies located throughout the Great Lakes and in southern Québec. This result, however, must be interpreted with caution because of the various methodologies used in these studies and the limited number of data points in recent years. Chick survival is difficult to evaluate with precision, and the effect of the observers cannot be neglected (Blokpoel and Tessier 1986). For logistical reasons, most researchers estimated breeding success by considering the number of young that reached 21-23 days, although fledging (initial flight) occurs around 35 days (Pollet *et al.* 2012). Nonetheless, the linear regression predicted a production of 1.2 young/pair in 2010, which was still much larger than the estimate of Ludwig (1967) for stability. Considering the current overall decline of the population, this suggests that the Ludwig's criterion for stability was underestimated or that changes in adult survival might have happened. The use of urban colonies has been associated with a lower breeding output (Belant *et al.* 1998), which may have contributed to population decline.

The decline of the Ring-billed Gull population may have also resulted from various management measures that were aimed at controlling reproductive output. Nest removal and egg oiling have been commonly applied with success in several colonies in Ontario (Christens and Blokpoel 1991; Blokpoel and Tessier 1992). The decline in the St. Lawrence River and Estuary is partly attributable to such a control program (egg removal) in the 1990s at a single colony in Québec City (Daishowa). That colony was estimated at 21,714 pairs in 1991, and by 1998 it had ceased to exist (Cotter *et al.* 2012). It is unknown where the birds dispersed, which emphasizes the need for a coordinated banding program to better estimate emigration following management measures.

The impact of a reduced fecundity on population growth remains speculative even if the trend is consistent with a decline of the population. The relative impact of adult survival in driving population dynamics of long-lived species is often more important than breeding output (Blackwell *et al.* 2002). In Europe, food availability has not been found to influence adult survival (Pons and Migot 1995; Oro *et al.* 1999). Although no systematic culling program has been put in place to control the number of Ring-billed Gulls, limited culling has been allowed at landfills and airports as part of deterrence programs (Thiériot *et al.* 2012). The impact of these measures on survival of different age classes remains unknown. The Ring-billed Gull is the seabird species that was the most banded in Canada between 1955 and 1995 (Gaston *et al.* 2008), but no survival estimates have been generated. During our intensive study in southern Québec, we initiated a color-banding program with over 9,000 marked birds and more than 9,000 resightings as of 2014. We are currently using the latest capture-marking-recapture analytical procedures to provide contemporary survival estimates.

Many jurisdictions have closed their landfills while others are adopting policies that entail reduction of organic matter brought to landfills. We thus predict that the decline of the eastern North American population of the Ring-billed Gull will continue. Nevertheless, an optimal population size has yet to be established. This should include minimum and maximum values and be accepted by a majority of stakeholders. To determine the factors that influence population dynamics and to examine different management scenarios, future work should combine breeding parameters and survival estimates into an individual-based population model similar to what has been done for different European gull populations (Brooks and Lebreton 2001; Oro *et al.* 2004; Sanz-Aguilar *et al.* 2014) and Double-crested Cormorants (*Phalacrocorax auritus*) in the Great Lakes (Blackwell *et al.* 2002). Conflicts and nuisance problems should be lessened if the population continues to decline, but the plea by Belant (1997) to establish integrated management plans is still relevant.

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Appendix. Number of fledged young per pair of Ring-billed Gulls in eastern North America, 1972-2012. MI = Michigan, ON = Ontario, QC = Québec. Data are shown in Fig. 3.

Year	Colony, Location	Young/Pair	Source
1972	Bird Island, MI	1.13	Dexheimer and Southern (1974)
1972	Calcite Island, MI	1.54	Dexheimer and Southern (1974)
1976	Mugg Island, ON	1.76	Fetterolf (1983)
1977	Eastern Headland, ON	1.35	Haymes and Blokpoel (1978)
1977	Granite Island, ON	1.04	Ryder and Ryder (1981)
1977	Gull Island, ON	1.84	Chardine (1978)
1977	Mugg Island, ON[1]	2.05	Fetterolf (1983)
1978	Île de la Couvée, QC	1.04	Lagrenade and Mousseau (1981)
1978	Mugg Island, ON	2.14	Fetterolf (1983)
1979	Granite Island, ON	1.47	Boersma and Ryder (1983)
1979	Île de la Couvée, QC	1.67	Lagrenade and Mousseau (1981)
1979	Île Deslauriers, QC	1.82	Mousseau and Lagrenade (1980)
1979	Îles de Contrecoeur, QC	1.91	Mousseau and Lagrenade (1980)
1980	Eastern Headland, ON	2.34	Fetterolf (1983)
1990	Port Colborne, ON	1.55	Brown and Morris (1994)
1991	Port Colborne (insular), ON	1.47	Brown and Morris (1994)
1991	Port Colborne (mainland), ON	1.33	Brown and Morris (1994)
1992	Daishowa, QC	1.30	P. Brousseau, unpubl. data
1992	Port Colborne, ON	1.40	Brown and Morris (1996)
1993	Daishowa, QC	1.26	P. Brousseau, unpubl. data
2000	Île de la Couvée, QC	1.52	Mousseau (2000)
2010	Île Deslauriers, QC	1.26	this study
2011	Île Deslauriers, QC	0.89	this study
2012	Île Deslauriers, QC	0.98	this study

[1]Moderate disturbance.