The Condor 95:817–830

IMPORTANCE OF LANDFILLS TO NESTING HERRING GULLS[1]

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Abstract. We determined the importance of three landfills to a population of nesting Herring Gulls (*Larus argentatus*, 3,250 pairs) on Lake Erie, Ohio, from May–July 1992. Fish was the dominant food of adults and chicks throughout the study. Occurrence of garbage in the diet of adults and chicks remained low through chick-rearing then increased after fledging. Presence of telemetered adults at their nest sites decreased from incubation through post-fledging, in contrast to their increased presence at landfills during the same periods. Overall, females visited landfills more frequently and stayed longer than males; however, use of landfills by both sexes was minimal (<4% of total time) during all periods. Overall, gulls spent 43% and 4% of their time daily at the nest site and landfills, respectively. We estimate ≥80% of the time remaining was spent on Lake Erie, presumably to forage. The estimated daily mean number of adult Herring Gulls at the landfills increased from incubation (143) to chick-rearing (723) to post-fledging (1,912). We estimate that 5–7%, 12–19%, and 35–55% of the adult nesting population was present at landfills at least once during incubation, chick-rearing, and post-fledging, respectively. The population turnover rate of adult Herring Gulls at one landfill decreased 50% from incubation and chick-rearing to post-fledging. Significantly more gulls at the landfills were observed on areas other than exposed refuse and were not actively foraging, suggesting that landfills are important to Herring Gulls for other reasons such as loafing or social interaction. We conclude that landfills are unimportant to nesting Herring Gulls when alternate, higher quality food (e.g., fish) is available. The increased use of landfills by Herring Gulls during post-fledging, however, suggests that gull activity at landfills located near airports could dramatically affect aircraft safety during this time of year.

Key words: Herring Gull; food habits; landfill; Larus argentatus; *Ohio.*

INTRODUCTION

Populations of several species of gulls have increased throughout North America and Europe in recent years (Harris 1970, Spaans 1971, Drury and Kadlec 1974, Conover 1983, Blokpoel and Tessier 1986). Suspected causes for these increased populations include the protection of breeding colonies (Kadlec and Drury 1968, Spaans 1971), an increase in nesting habitat from the creation of dredge disposal islands (Patton and Hanners 1984), and exploitation of landfills by gulls as dependable sources of food (Verbeek 1977, Burger 1981, Patton 1988, Belant and Dolbeer 1993).

Sanitary landfills frequently attract large numbers of gulls and other birds, at least seasonally (Horton et al. 1983; Patton 1988; Belant, unpubl. data). Because landfills are often located near urban areas, their increased use by gulls has caused a concurrent increase in conflicts with humans. These conflicts include transmission of pathogens and parasites through contamination of water sources (Mudge and Ferns 1982), damage to buildings (Bradley 1980, Vermeer et al. 1988, Belant 1993), and a hazard to aircraft at airports (Blokpoel 1976, 1983; Dahl 1984; Sherigalin 1990). Therefore, there is critical need for data on the influence of various types of landfills have on gull activity and the importance of landfills to gulls.

Although there is general agreement that putrescible waste at landfills contributes to the overall diet of Herring Gulls (*Larus argentatus*; Kihlman and Larsson 1974, Horton et al. 1983, Pierotti and Annett 1987, Patton 1988, Pons 1992), there are conflicting conclusions from previous studies regarding the importance of landfills to gulls during the breeding season. Several authors have suggested that the availability of garbage increases (Kadlec and Drury 1968, Hunt 1972, Pons 1992), or is essential for (Sibley and McCleery 1983), reproductive success. In contrast, Pierotti and Annett (1987) have suggested

[1] Received 12 February 1993. Accepted 28 April 1993.
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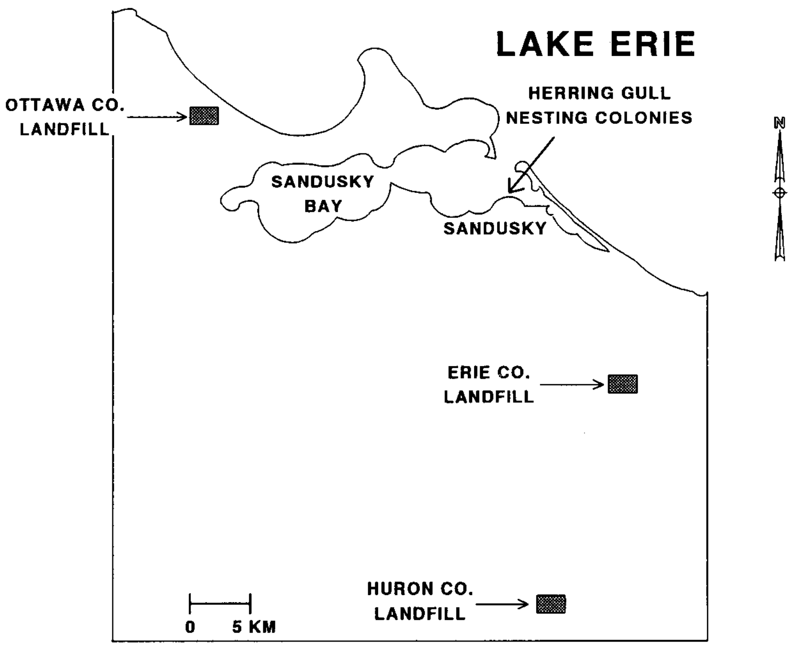

FIGURE 1. Location of three mixed solid waste landfills in relation to nesting colonies of Herring Gulls in Sandusky Bay, Lake Erie, Ohio.

that garbage is a low-quality food compared to other "natural" foods, and could reduce reproductive success.

The objectives of this study were to determine food habits, flight patterns, and population dynamics at landfills of adult Herring Gulls and their chicks during incubation, chick-rearing, and post-fledging periods. Our goal was to determine the importance of landfills to a population of nesting Herring Gulls.

STUDY AREA

The study was conducted in north-central Ohio from 1 May–31 July 1992. The Herring Gull nesting concentration (one of the largest on the Great Lakes, 4,250 nesting pairs in 1989) is located on Sandusky Bay, Lake Erie (Dolbeer et al. 1990, Fig. 1). The gulls nest on Turning Point Island (TPI), coal piles, and breakwalls and have recently expanded to rooftops in Sandusky, Ohio. TPI is a 2.7-ha dredge disposal island created in 1900 and is bordered by riprap (Scharf et al. 1978). About 50% of the island has herbaceous vegetation. Dominant shrub and tree species include red mulberry (*Morus rubra*), red-osier dogwood (*Cornus stolonifera*), and eastern cottonwood (*Populus deltoides,* Scharf et al. 1978).

Three mixed solid waste landfills are located within 36 km of the nesting concentration (Fig. 1). The Erie County Landfill, 7 km south of Lake Erie and 19 km southeast of the nesting concentration, averaged 275 metric tons of refuse per day during the study. The Ottawa County Landfill, 2 km from Lake Erie and 28 km northwest of the nesting concentration, averaged 563 metric tons of refuse per day, May–September 1991. The Huron County Landfill, 30 km from Lake Erie and 35 km south the concentration, averaged 84 metric tons per day during the study. At each landfill, refuse was spread and compacted throughout the day, then covered with soil at the end of the workday using bulldozers. Each landfill generally had <0.5 ha of exposed refuse on any given day. These were the only landfills within 40 km of the nesting concentration.

METHODS

Population census and reproduction. We determined the adult breeding population of Herring Gulls by conducting two complete ground counts of nests containing ≥ 1 egg on TPI, coal piles, and breakwalls between 1 and 21 May. Nests with ≥ 1 egg on rooftops were counted weekly form early May to early July. The largest number of nests counted in each area was combined to obtain a total count of nests for the population.

We individually marked 110 three-egg clutches on TPI using 0.6-m wire surveying flags and checked them one to two times weekly until eggs had hatched, were destroyed, or considered abandoned or inviable (eggs not hatched ≥6 weeks after our initial visit). Nests on rooftops were also individually marked using wood blocks and monitored weekly using the same criteria. We defined hatch success as the number of eggs hatched divided by the total number of eggs laid for TPI and rooftops. Mean hatch date was estimated by interpolation based on the date of the previous check, the number of eggs that had hatched or were pipping, and the relative age of chicks (Kadlec et al. 1969). We defined the length of incubation and chick-rearing periods as 28 and 42 days before and after mean hatch dates, respectively (Kadlec et al. 1969, Drent 1970, Haycock and Threlfall 1975, Pierotti 1982, Paynter 1949). Post-fledging data were collected through 31 July.

Food habits. We collected food remains and pellets of undigested material found ≤1 m from nests. Food remains and pellets were collected on TPI, rooftops, and breakwalls. We recorded date and location for each sample collected. Food items were collected once or twice each week from 4 May–14 July.

We also collected boli from chicks on TPI one to two times weekly. Chicks were captured opportunistically by hand or with a net. If a chick did not regurgitate upon capture, we inserted a finger into its proventriculus and removed the contents (Hunt 1972). We recorded date, body mass, and age class (pre-fledging [age classes 1-3B] or fledging [age class 4], Kadlec et al. 1969) for each chick from which a bolus was obtained. Boli were stored in 80% ethyl alcohol until analyzed.

The contents of each sample were identified and initially classified into broad categories (fish, garbage, etc.). Except for pellets containing remains of fish, we identified boli and food remains to the lowest taxon possible using reference collections. Frequency of occurrence of each food type was recorded. Because mean hatch dates were not determined for gulls nesting on breakwalls, these data were excluded from analyses related to reproductive periods.

Capture and marking. During the censuses, a sample of adult Herring Gulls nesting on TPI and breakwalls were marked on their breast and abdominal feathers by applying 4–5 ml of a mixture of rhodamine-B dye and silica gel to one or three eggs of each clutch or by using a dummy egg (Belant and Seamans, in press). We applied the dye mixture to 535 clutches between 1 and 13 May, thus marking 16% of the nesting population. Because gulls were marked over a two-week period, for data collected during observations conducted at the landfill (see below), we adjusted the proportion of the population of nesting gulls color-marked after each dye application.

We captured nesting Herring Gulls on TPI using walk-in traps (Weaver and Kadlec 1970). We measured head and bill length, and bill depth of captured individuals to determine sex (Fox et al. 1981). Each of 20 gulls received a U.S. Fish and Wildlife Service leg band and a radio transmitter (Advanced Telemetry Systems, Inc., Isanti, MN) with a backpack harness made of 6-mm-wide teflon ribbon. The completed radio package weighed 30 g, or about 3% of the mass of an adult Herring Gull. We did not apply the dye mixture to eggs of telemetered gulls.

Telemetry. We estimated locations of 17 telemetered gulls (nine females, eight males) that successfully hatched ≥1 egg using standard ground and aerial telemetry techniques (Mech 1983). Ground telemetry was conducted ≥3 times each week and aerial telemetry was conducted once per week between 07:30–17:00 hr, weather permitting. For ground telemetry, all receiver locations were plotted using Universal Transverse Mercator Grid System (UTM) coordinates from 7.5 min U.S. Geological Survey topographic maps. For each gull location estimate, we obtained two azimuths within 15 min. The program Locate II (Nams 1991) was then used to estimate gull locations. For aerial telemetry data, gull locations were plotted directly onto topographic maps and UTM coordinates were determined. For each location we recorded date, time, and when possible, habitat in which found. For each sex, we used the location estimates away from the colony to calculate mean daily distance (km) from the colony during each reproductive period.

A data collection computer (DCC II Model D5401, Advanced Telemetry Systems, Inc., Isanti, MN) was used at the Erie County landfill and the nesting colony on TPI to record frequency and duration of presence of 15 telemetered gulls (eight females, seven females). We excluded data from one female and one male because their nest sites were outside the range of

DCC reception. Reception range of the DCC at TPI was about 15 m, and did not extend to open water. Because Herring Gulls are territorial at their nest sites (Burger 1986), we assumed that signals received were of telemetered gulls at their nest sites. Reception range of the DCC at Erie County Landfill was about 300 m, which included all available areas at the landfill where gulls had been previously observed (Belant, unpubl. data). Other areas within the range of reception of the DCC were unsuitable for gulls (woodlots, corn fields); therefore, we were confident that we only received signals of telemetered gulls that were at the landfill. The DCC was moved between sites every 3–7 days and was calibrated to receive the signal of each telemetered bird at 10-min intervals throughout the day.

Observations at landfills. Observations were conducted at the Erie County Landfill by one or two individuals twice per week (from 07:00–12:00 or 12:00–17:00 hr) on randomly selected days. We divided the landfill into three areas: (1) exposed refuse, (2) partially covered refuse, and (3) non-refuse areas. Areas containing partially covered refuse correspond to "secondary feeding" areas described by Greig et al. (1985). At the beginning of each hour, observers used binoculars to identify a group of known size ($\leq$200). The total population of gulls and the number of gulls in each of the three areas was estimated by counting the number of groups of the known size and multiplying by the group size. We usually conducted total counts when gull populations numbered $<$500 individuals. Only gulls on or within 30 m of the ground were included in counts. The age and species composition of gulls (Grant 1986) at the landfill was determined by counting throughout each of the three areas $\geq$10% of the estimated population. The number of adult Herring Gulls counted was extrapolated to the entire population to estimate the total number of adult Herring Gulls present. We also estimated the number of marked adult Herring Gulls present by counting the number of marked gulls observed from $\geq$10% of the adult Herring Gull population, counting only those gulls whose ventral surface was visible. Because of the limited longevity (4–5 weeks) of color-marks and mortality of eggs (Belant and Seamans, in press), data from color-marked gulls at the landfills were used only during incubation.

Immediately after each count, we determined the number of gulls flying to and from the landfill for 10 min to obtain estimates of ingress and egress (i.e., population turnover rates). To estimate the number of flying gulls which were adult Herring Gulls, we assumed that the proportion of flying gulls observed during a 10-min period that were adult Herring Gulls was equal to the proportion of adult Herring Gulls that were present at the landfill during the corresponding total population count.

After completing observations of flying gulls, observers selected 10 gulls from throughout one of the three predetermined areas. Each gull was observed for 5 sec and the most prevalent behavior was recorded. Behavior categories used were: (1) foraging, (2) maintenance, (3) loafing or alert, (4) aggressive and (5) other. Upon completion of observations in one area, the sequence was repeated for the two remaining areas. If the behavior of a selected gull could not be observed for 5 sec, behavior of the gull nearest the selected bird that was completely visible to the observer was recorded. Each series of observations (i.e., $\leq$30 gulls, $\leq$10 for each area) was separated by 3 min. This procedure was conducted three times.

Excluding behavior data, additional observations were conducted at the Erie County Landfill twice each day, five days per week. The twice daily observations were conducted at randomly selected times, one each during the morning and afternoon. Two of these observations were part of the two 5-hr observations periods conducted each week. Thus, we obtained 18 estimates of population turnover data and 18 total counts of adult Herring Gulls at the Erie County Landfill each week. We similarly conducted two to three observations per week at the Huron and Ottawa County landfills.

Populations turnover at landfills. We estimated the mean daily number of individual adult Herring Gulls (G) that visited a landfill during incubation, chick-rearing, and post-fledging, using the formula:

$$G = M \times h/D,$$

where M is the mean number of adult Herring Gulls present per observation at the landfill from 07:00–17:00 hr during a reproductive period, h is the number of hours (10, a constant) within the range of time gulls were observed at the landfill (07:00–17:00), and D is the mean duration of visits recorded for telemetered Herring Gulls for each reproductive period. For example, during the incubation period, if M = 20 gulls (Table 6) and D = 1.4 hr (Table 5), then G = 143 gulls (Table 6). We also determined the number of hours required for the mean number of gulls observed at the landfill at any one time to be replaced by the same number of different gulls within each reproductive period by dividing the mean daily number of individual adult Herring Gulls present at the landfill (G) by the mean number of gulls recorded per observation during that same period (M) and then dividing this quotient into h (10 hr). For example, during incubation, if G = 143 and M = 20, then the population turnover rate (hr) is: 10/(143/20), or 1.4 hr (Table 6).

We estimated the total number of individual adult Herring Gulls that used the landfills during a reproductive period (T) using the formula:

$$T = M \times h/(V \times D),$$

where V is the mean number of visits per gull each day (from radio telemetry data, Table 5). For example, during incubation, if M = 20, h = 10, V = 0.3, and D = 1.4, then $T = 20 \times 10/(0.3 \times 1.4)$, or 476 gulls.

Statistical analyses. Chi-squared tests of independence (or Fisher's exact two-tailed test when necessary) were used to detect dietary differences of adults among reproductive periods and between unfledged and fledged chicks. We used the General Linear Models Procedure (SAS Institute, Inc., 1988) and Tukey multiple comparison tests for all other analyses. All means are reported with ± one standard deviation.

RESULTS

Nesting population census and reproduction. We counted 3,250 gull nests in all areas: 1,918 on TPI, 1,026 on breakwalls, 176 on rooftops, 122 on coal piles, and eight in other areas. Hatch success of three-egg clutches on TPI (71%, n = 105 nests) was similar to hatch success of three-egg clutches on rooftops (62%, n = 138 nests, $\chi^2 = 1.14$, 1 df, $P > 0.10$). Hatch success of eggs of telemetered gulls was also similar (62%, n = 15 nests, $\chi^2 = 0.24$, 1 df, $P > 0.50$). Mean (±SD) hatch date for nests on TPI and rooftops was 19 May ± 6 days and 30 May ± 8 days, respectively; therefore, the respective chick-rearing period for TPI and rooftops was 20 May–30 June and 31 May–11 July.

Food habits. We collected 160 boli from chicks on TPI. Fish was the most frequently recorded item, followed by earthworms, plant material, and garbage (Table 1). Occurrence of fish was higher ($\chi^2 = 7.02$, 1 df, $P < 0.01$) for pre-fledging chicks (84%) than for fledged chicks (64%). Conversely, occurrence of garbage was higher (Fisher's exact, $P = 0.05$) for fledged chicks (21%) than for pre-fledging chicks (8%). Plant material consisted primarily of red mulberry fruit, which coincided with the maturation of this fruit on TPI.

We collected 317 food remains from all locations. Fish was the most abundant item, followed by garbage (Table 1). The diet of gulls at TPI (n = 117) and rooftops (n = 106) was similar with one exception: occurrence of birds was greater ($\chi^2 = 8.23$, 1 df, $P < 0.05$) at nests on rooftops (14%) than at nests on TPI (3%). Because occurrence of fish (72% vs. 72%) and garbage (18% vs. 17%) was similar ($\chi^2 < 0.01$, 1 df, $P > 0.90$) between TPI and rooftops, respectively, data for these food items (n = 223) were pooled to compare among reproductive periods. Frequency of fish was lower (Fisher's exact, $P < 0.01$) during post-fledging (0%, n = 9) than during incubation (65%, n = 31) or chick-rearing (77%, n = 183). Frequency of fish was similar between incubation and chick rearing ($\chi^2 = 2.02$, 1 df, $P = 0.16$). Percent occurrence of garbage was similar between incubation (3%, n = 31) and chick-rearing (17%, n = 183, Fisher's exact, $P = 0.06$); however, occurrence of garbage was greater (Fisher's exact, $P < 0.01$) during post-fledging (67%, n = 9) than during incubation or chick-rearing.

Occurrence of garbage in boli obtained from chicks increased temporally, although occurrence of garbage did not exceed that of fish (Fig. 2). The occurrence of garbage in food remains also increased temporally, however, its occurrence surpassed fish about 10 days before mean fledging. The increased occurrence of garbage and food remains corresponded with increasing occurrence of adult Herring Gulls at Erie County Landfill.

Of 542 pellets collected, 98% contained fish. With the exception of vegetation (8%) and fish, no other food item was represented in >1% of pellets (Table 1).

Nest-site attentiveness. Daily presence of males ($\bar{x} = 11.3 \pm 2.5$ hr per day) and females ($\bar{x} = 9.3 \pm 3.3$ hr per day) at the nest site from May–July was similar ($F = 2.98$; 1, 39 df; $P = 0.09$). Equitability of nest-site attendance remained constant among reproductive periods ($F = 0.14$; 2, 39 df; $P = 0.87$). Daily individual presence of teleme-

TABLE 1. Occurrence (%) of food items in boli from Herring Gull chicks (n = 160), and in food remains (n = 317) and pellets of undigested material (n = 542) found on or ≤1 m from Herring Gull nests in Sandusky Bay, Lake Erie, Ohio, May–July 1992.

Food item	Boli	Food remains	Pellets
All fish species	79	74	98
Alewife (*Alosa pseudoharengus*)	11	17	—
Gizzard shad (*Dorosoma cepedianum*)	9	7	—
Unidentified Clupeidae	11	3	—
White bass (*Morone chrysops*)	4	11	—
White perch (*Morone americana*)	13	26	—
Unidentified *Morone* spp.	1	1	—
Emerald shiner (*Notropis atherinoides*)	24	8	—
Spottail shiner (*Notropis hudsonius*)	0	<1	—
Unidentified *Notropis* spp.	2	0	—
Unidentified fish	14	5	—
Freshwater drum (*Aplodinotus grunniens*)	4	21	—
Brown bullhead (*Ictalurus nebulosus*)	0	<1	—
Channel catfish (*Ictalurus punctatus*)	2	1	—
Smallmouth bass (*Micropterus dolomieui*)	<1	0	—
Largemouth bass (*Micropterus salmoides*)	0	<1	—
Unidentified Centrarchidae	1	0	—
Walleye (*Stizostedium vitreum*)	1	2	—
Yellow perch (*Perca flavescens*)	3	2	—
Unidentified Percidae	0	1	—
Rainbow smelt (*Osmerus mordax*)	0	2	—
Carp/goldfish (*Cyprinus carpio/Carassius auratus*)	<1	2	—
Catostomidae	0	<1	—
Earthworms	20	<1	<1
All plant material	13	2	8
Red mulberry (*Morus rubra*)	6	0	0
Other vegetation	7	2	8
Garbage	11	17	1
All insects	3	1	1
Pentatomidae (Hemiptera)	<1	<1	0
Scarabaeidae (Coleoptera)	<1	<1	0
Tetrigidae (Orthoptera)	0	<1	0
Unidentified larvae	<1	<1	0
Unidentified insects	<1	<1	1
All birds	0	7	1
European starling (*Sturnus vulgaris*)	0	1	0
Rock dove (*Columba livia*)	0	1	0
Blue jay (*Cyanocitta cristata*)	0	<1	0
Unidentified bird	0	4	1
Crayfish (*Orconectes* sp.)	<1	3	<1
Mammals	1	<1	1
Unknown	2	<1	<1
Zebra mussel (*Dreissena polymorpha*)	0	2	<1

tered gulls declined (F = 50.34; 2, 39 df; P < 0.01) from incubation (79%) to chick-rearing (40%) to post-fledging (24%, Table 2). Conversely, the absence of gulls from their nest sites increased from 21% during incubation to 60% during brood-rearing to 76% during fledging. Presence at the nest site generally appeared evenly distributed throughout the day.

Flight radius. The overall mean distance males and females were located away from the colony was similar (F = 0.74; 1, 195 df; P = 0.39; Table 3). Although mean distance increased (Tukey test, P < 0.05) from 5.7 km during incubation to 9.5 km during chick-rearing to 13.0 km during post-fledging, there was an interaction of the sex and reproductive period effects (F = 4.90; 1, 2 df; P

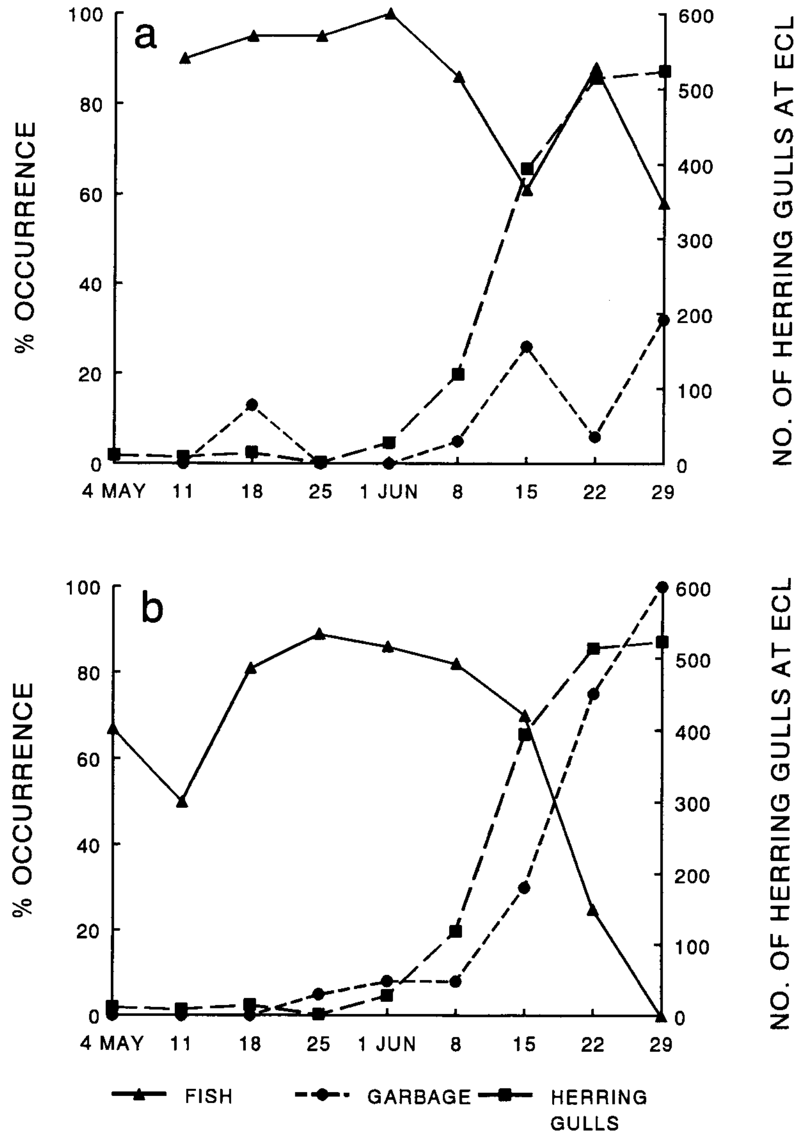

FIGURE 2. Percent occurrence of fish and garbage in the diet of Herring Gulls, Sandusky Bay, Lake Erie, and mean number of adult Herring Gulls observed at the Erie County Landfill (ECL), Ohio, 1992: (a) regurgitations collected from chicks on Turning Point Island (TPI), (b) food remains collected from nests on TPI, breakwalls, and rooftops.

< 0.01). Movements by adult female Herring Gulls increased from incubation to chick-rearing and then remained similar through post-fledging. In contrast, movements by males increased through all 3 periods. Using aerial telemetry data excluding locations at the nesting colony, gulls were present on Lake Erie or Sandusky Bay during 83%, 82%, and 90% of locations during incubation, chick-rearing, and post-fledging, respectively.

USE OF LANDFILLS

No color-marked Herring Gulls were observed at the Huron or Ottawa County Landfills. Only one telemetered gull was located at the Huron County landfill twice during the post-fledging pe-

TABLE 2. Mean hours (±SD) spent by radio-telemetered nesting Herring Gulls (*Larus argentatus*; eight females, seven males) at their nest site by reproductive period and time of day, Turning Point Island, Lake Erie, Ohio, May–July 1992.

Reproductive period	02:00–05:59	06:00–09:59	10:00–13:59	14:00–17:59	18:00–21:59	22:00–01:59	Total hr per day
Incubation (1–19 May)	3.5	3.0	2.8	2.6	3.1	3.7	18.9 ± 2.0
Chick-rearing (20 May–30 June)	1.5	1.4	1.9	1.6	1.6	1.8	9.7 ± 5.1
Post-fledging (1–31 July)	1.0	1.0	0.9	0.8	0.9	1.1	5.7 ± 3.0
All periods (1 May–31 July)	1.7	1.6	1.7	1.5	1.7	2.0	10.3 ± 3.1

riod. Therefore, we concluded that these landfills were not important to nesting Herring Gulls from the Sandusky Bay concentration. Further analyses includes data from Erie County Landfill only.

Gull behavior. Overall, 62% of gull activity at the landfill at a given time was in activities other than foraging (Table 4). Loafing or alert posturing, followed by maintenance activities were the most prevalent behavior exhibited by gulls in areas other than exposed refuse. Foraging was the most prevalent (70% overall) behavior exhibited by gulls on exposed refuse and was infrequently observed in other areas. Frequency of aggressive behavior declined from open refuse to recently covered refuse to non-refuse areas. In areas of exposed refuse, occurrence of aggressive behavior appeared to be related to the number of birds present.

Gull abundance. On average, females spent more ($F = 8.83$; 1, 39 df; $P < 0.01$) time (1.3 ± 0.9 hr) each day at the landfill than did males (0.5 ± 0.4 hr) which was constant among reproductive periods ($F = 0.78$; 2, 39 df; $P = 0.47$; Table 5). Females also frequented the landfill (0.7 visits per day) almost twice as often as males (0.4 visits per day; $F = 3.83$; 1, 39 df; $P = 0.06$); this visitation rate was constant among reproductive periods ($F = 0.32$; 2, 39 df; $P = 0.73$). Mean duration of visits at the Erie County landfill by telemetered Herring Gulls during incubation (1.4 ± 1.7 hr) and brood-rearing (1.1 ± 1.3 hr) was less ($F = 4.15$; 2, 39 df; $P = 0.02$) than time spent during post-fledging (2.3 ± 2.6 hr). Ninety-eight percent of telemetered gull use of the Erie County landfill occurred between 06:00 and 17:00 hr. Approximately 50% of use was between 10:00 and 14:00 hr. No telemetered gulls were at the landfill from 22:00–02:00 hr.

The mean number of adult Herring Gulls observed during each observation at the landfill increased from incubation to chick-rearing to post-fledging ($F = 162.3$; 2, 842 df; $P < 0.01$; Table 4). The number of gulls among exposed refuse, covered refuse, and non-refuse areas at the landfill also differed ($F = 65.52$; 2, 842 df; $P < 0.01$). The mean number of gulls observed on the recently covered refuse ($n = 27$) was less than the number observed on exposed refuse ($n = 62$) which was lower than the mean number observed in non-refuse areas ($n = 130$, Tukey test,

TABLE 3. Mean distance (±SD [n]) radio-telemetered Herring Gulls (*Larus argentatus*; nine females, eight males) were located away from nesting colony by reproductive period, Lake Erie, Ohio, May–July 1992.

Reproductive period	Distance (km) from nesting colony		
	Female	Male	Combined
Incubation (1–19 May)	4.6 ± 2.7 (11)	6.5 ± 5.8 (15)	5.7 ± 4.8 (26)
Chick-rearing (20 May–30 June)	10.3 ± 5.7 (50)	8.7 ± 4.1 (55)	9.5 ± 4.9 (105)
Post-fledging (1–31 July)	10.8 ± 5.5 (31)	14.7 ± 8.5 (39)	13.0 ± 7.5 (70)
All periods (1 May–31 July)	9.8 ± 5.7 (92)	10.5 ± 6.9 (109)	10.2 ± 6.4 (201)

TABLE 4. Mean number (±SD) of adult Herring Gulls (*Larus argentatus*) present and occurrence (%) of behavior at Erie County Landfill, northern Ohio, by reproductive period and location at landfill, May–July 1992.

Reproductive period	Location at landfill	Number of gulls present	Behavior (%) Foraging	Maintenance	Loafing/alert	Aggressive	Other
Incubation	Exposed refuse	9 ± 16	67	1	17	2	13
(1–19 May)	Covered refuse	8 ± 12	2	16	66	1	15
	Non-refuse	3 ± 11	1	34	40	2	23
	Combined	20 ± 29	31	12	41	2	15
Chick-rearing	Exposed refuse	33 ± 51	66	2	25	4	3
(20 May–30 June)	Covered refuse	14 ± 28	11	11	75	1	2
	Non-refuse	46 ± 84	1	14	76	<1	9
	Combined	94 ± 143	40	6	47	3	4
Post-fledging	Exposed refuse	130 ± 96	77	4	12	5	1
(1–31 July)	Covered refuse	55 ± 67	6	13	80	1	1
	Non-refuse	312 ± 274	1	18	76	1	4
	Combined	497 ± 342	39	10	46	3	2
All periods	Exposed refuse	62 ± 83	70	3	20	4	3
(1 May–31 July)	Covered refuse	27 ± 49	7	13	75	1	5
	Non-refuse	130 ± 216	1	17	74	1	7
	Combined	221 ± 302	38	9	46	3	5

$P < 0.05$). There was also an interaction of the nesting period and location effects ($F = 40.21$; 2, 842 df; $P < 0.01$), with similar numbers of gulls observed on exposed and covered refuse during the incubation period in contrast to greater numbers of gulls observed on exposed refuse during chick-rearing and post-fledging periods. The number of gulls present in all areas increased through post-fledging; however, the number of gulls present in non-refuse areas increased at a rate 7 times greater than did the number of gulls observed on exposed refuse (Table 4).

We also divided observations into three time periods: 07:00–09:59, 10:00–13:59, and 14:00–17:00 hr, to approximate that done for analyses of telemetered gulls. The mean number of birds observed among time periods was similar ($F = 1.10$; 2, 842 df; $P = 0.33$), from 258 (07:00–09:59) to 231 (10:00–13:59) to 192 (14:00–17:00). There was no interaction of the time period and reproductive period effects ($F = 0.40$; 4, 842 df; $P = 0.81$).

Population turnover. The estimated daily mean number of individual gulls using the landfill in-

TABLE 5. Mean hours (±SD) spent, and duration and frequency of visits by radio-telemetered nesting Herring Gulls (*Larus argentatus*; eight females, seven males) at Erie County Landfill, northern Ohio, by reproductive period and time of day, May–July 1992.

Reproductive period	Sex	02:00–05:59	06:00–09:59	10:00–13:59	14:00–17:59	18:00–21:59	22:00–01:59	Duration of visits (hr)	Number of visits per day	Total hr per day[a]
Incubation	Female	0.0	0.2	0.4	0.1	<0.1	0.0	1.7 ± 1.8	0.4 ± 0.4	0.6 ± 0.7
(1–19 May)	Male	<0.1	<0.1	<0.1	<0.1	<0.1	0.0	0.5 ± 0.6	0.2 ± 0.3	0.1 ± 0.2
	Combined	<0.1	0.1	0.2	0.1	<0.1	0.0	1.4 ± 1.7	0.3 ± 0.3	0.3 ± 0.6
Chick-rearing	Female	<0.1	0.2	0.5	0.2	<0.1	0.0	1.1 ± 1.5	0.9 ± 0.7	1.0 ± 0.8
(20 May–	Male	<0.1	0.2	0.2	0.2	<0.1	0.0	1.1 ± 1.1	0.5 ± 0.6	0.6 ± 0.7
30 June)	Combined	<0.1	0.2	0.4	0.2	<0.1	0.0	1.1 ± 1.3	0.7 ± 0.7	0.8 ± 0.7
Post-fledging	Female	<0.1	0.5	1.0	0.5	<0.1	0.0	2.6 ± 2.6	0.8 ± 0.6	2.0 ± 1.7
(1–31 July)	Male	<0.1	0.2	0.3	0.1	<0.1	0.0	1.6 ± 2.3	0.4 ± 0.3	0.6 ± 0.5
	Combined	<0.1	0.3	0.7	0.3	<0.1	0.0	2.3 ± 2.6	0.6 ± 0.5	1.4 ± 1.4
All periods	Female	<0.1	0.3	0.7	0.3	<0.1	0.0	1.9 ± 2.2	0.7 ± 0.5	1.3 ± 0.9
(1 May–	Male	<0.1	0.1	0.2	0.1	<0.1	0.0	1.3 ± 1.8	0.4 ± 0.4	0.5 ± 0.4
31 July)	Combined	<0.1	0.2	0.5	0.2	<0.1	0.0	1.7 ± 2.1	0.6 ± 0.5	0.9 ± 0.8

[a] Calculated from mean duration of visits and mean number of visits per day.

TABLE 6. Mean population turnover of adult Herring Gulls (*Larus argentatus*) at Erie County Landfill, northern Ohio, by reproductive period, May–July 1992. See methods for descriptions of calculations.

Reproductive period	Number present per observation	Population turnover rate (hr)	Estimated daily number of individual gulls using landfill	Estimated total number of individual gulls using landfill	Mean total number of movements[a] (arrivals and departures) 07:00–09:59	10:00–13:59	14:00–17:00	07:00–17:00
Incubation (1–19 May)	20	1.4	143	476	140	86	72	298
Chick-rearing (20 May–30 June)	94	1.3	723	1,221	426	429	395	1,250
Post-fledging (1–31 July)	497	2.6	1,912	3,601	1,296	868	1,023	3,188
All periods (1 May–31 July)	221	1.7	1,300	≥3,601	729	447	515	1,691

[a] Calculated from direct observations of gulls arriving and departing from the landfill, see methods.

creased substantially from incubation to chick-rearing to post-fledging, representing a mean maximum of 2%, 11%, and 29% of the nesting population, respectively (Table 6). The hourly population turnover rate of gulls at the landfill was about twice as fast during incubation and chick-rearing than during post-fledging. A maximum of 55% of the adult nesting population used the landfill at least once during post-fledging, as compared to 19% during chick-rearing and 7% during incubation.

From observations of color-marked gulls during the incubation period, on average, we estimated that 10% of the adult Herring Gulls sampled at the landfill were marked. Therefore, approximately 63% ([100%/16%] × 10%) of the adult Herring Gulls observed at the landfill during the incubation period were from the nesting colony. Multiplying this value (63%) by the mean number of gulls observed at the landfill at any one time during incubation (20) yields a mean of 13 adult Herring Gulls from the nesting colony present per observation at the landfill during incubation. We therefore estimate that during the incubation period, on average, 93 nesting Herring Gulls from the Sandusky Bay concentration used the landfill each day and 310 gulls used the landfill during the entire period. These values represent 1% and 5% of the nesting population. If we assume that the 63% of the population of gulls at the landfill during the incubation period were from the nesting colony applies to the proportion of gulls observed at the landfill during other periods, about 12% and 35% of the nesting population used the landfill during chick-rearing and post-fledging periods, respectively. Therefore, based on population estimate, color-marking, and radio telemetry data, minimum (from color-marking) and maximum (from radio telemetry) values for the proportion of nesting Herring Gulls using the landfill during incubation, chick-rearing, and post-fledging are 5–7%, 12–19%, and 35–55%, respectively.

During incubation, we observed a daily mean of 298 movements (arrivals and departures) of individual gulls at the landfill, which indicates a mean of 149 gulls used the landfill daily. This is similar to the estimated total number of gulls (143) that used the landfill daily based on turnover rate estimates. During chick-rearing and post-fledging, the number of gulls arriving and departing the landfill from direct observations was lower than the total number of gulls (number of movements/two movements per gull) that used the landfill daily based on turnover rate estimates during these same periods (Table 6). Except during incubation and early chick-rearing, gulls were generally present at the landfill before 07:00 and after 17:00. The estimated number of movements observed that were attributed to adult Herring Gulls generally corresponded with direct counts of gulls conducted at the landfill. There were more (F = 46.83: 2, 261 df; P < 0.01) movements recorded during post-fledging than during incubation or chick-rearing periods. There was neither a difference (F = 0.87; 2, 261 df; P = 0.27) among time periods or an interaction of time period and reproductive period effects (F = 1.35; 4, 261 df; P = 0.25).

DISCUSSION

Fish was the most prevalent food in the diet of Herring Gulls during incubation and chick-rearing. In contrast, garbage apparently contributed little (<20% overall) to their diet during this same period. Quality and availability of food can influence clutch size and egg size and mass (Pierotti and Annett 1987, Hiom et al. 1991), which affects hatch success and offspring survival (Parsons 1970, 1972; Pierotti 1982). Garbage has been considered a low quality (low-protein) food compared to fish; adult Herring Gulls that specialized on garbage fledged fewer chicks than did adults that specialized on other foods (Pierotti and Annett 1987). Also, Murphy et al. (1984) concluded that Glaucous-winged Gull (*L. glaucescens* chicks fed fish had higher survival rates than chicks fed other foods. Thus, the high proportion of fish in the diet of chicks during our study likely increased their physical condition and subsequent survival.

The number of adult Herring Gulls observed at the Erie County Landfill increased just prior to mean fledging (Fig. 2). This change may be related to a reduction in energetic demands, as adults no longer had to forage extensively for chicks. Pierotti and Annett (1987) found that the diet of adult Herring Gulls changed to a lower quality food after chicks had fledged. Pierotti and Annett (1987) have also suggested that non-breeding Herring Gulls can probably survive well on the protein and caloric values present in garbage, and that the availability of garbage may increase longevity. Garbage is a dependable source of food for gulls, requiring no special handling techniques (Davis 1975). Thus, garbage may be a readily available and nutritionally adequate source of food for adults after the breeding season. In addition, Annett and Pierotti (1989) suggested that garbage may not be detrimental to older gull chicks. We observed an increase in the occurrence of garbage in boli from chicks during mid-June, 4–6 weeks after the mean hatching date. Spaans (1971) also found garbage in the diet of older Herring Gull chicks.

A change in diet may also be due to the availability of food rather than to a preference for specific types of food. Spaans (1971) concluded that a change in the diet of breeding Herring Gulls in the Netherlands was not related to the food requirements of chicks, but to the availability of food. In Witless Bay, Newfoundland, occurrence of fish increased six-fold after the peak in chick hatching (Haycock and Threlfall 1975). However, this change in diet coincided with a migration of spawning fish into the Bay. We observed a decline in occurrence of fish and an increase in garbage in boli and food remains after fledging, possibly a consequence of decreased availability of fish. For example, white perch (*Morone chrysops*), a species we frequently found at Herring Gull nests and in chick boli, spawn near shore in Lake Erie during May, after which the adults move to deeper water (Scott and Crossman 1973).

Time spent at the nesting colony by adult Herring Gulls decreased from incubation through post-fledging and was inversely related to the mean distance adults were observed away from the colony. Maximizing time at the nest site improves reproductive success, allowing increased attentiveness to eggs and care of chicks (Hunt 1972, Morris and Hunter 1976). That the mean distance adults traveled from the nesting colony increased from incubation to chick-rearing is probably related to the additional food required to feed their chicks. Increasing foraging distance from the colony may reduce intraspecific competition by dispersing adults over a larger area, which could improve foraging efficiency (Gorke and Brandl 1986). The greater flight radii from the colony observed during post-fledging are likely a consequence of a reduction in fidelity to the nest site. Adults frequently leave the colony after chicks have fledged (see Coulson and Butterfield 1986).

Frequency and duration of visits to the landfill by female Herring Gulls was greater than that of males. However, overall use of landfills was minimal (<4% of total time). Coulson and Butterfield (1986) and Coulson et al. (1987) found no significant difference in the average number of visits made by males and females to landfills. A greater presence at landfills by females during our study may be attributed in part to aggressive behavior during foraging. In competitive feeding situations at undisturbed sites, the smaller females are subordinate to the more aggressive males (Monaghan 1980, Greig et al. 1985). Females, however, are more maneuverable and are able to compensate somewhat by foraging when landfill equipment is being operated (Greig et al. 1985). Therefore, the greater frequency and duration of visits observed for females may be necessary to provide adequate opportunities to forage.

Most studies of gull behavior at landfills have emphasized foraging behavior on exposed refuse (Verbeek 1977; Burger 1981; Burger and Gochfeld 1981, 1983). We determined that most (62%

overall) adult Herring Gulls observed at the landfill at any one time were not actively foraging. Rather, the majority were engaged in loafing or maintenance activities, suggesting that landfills provide opportunities suitable for other activities, such as social interaction. During the nonbreeding season in England, Coulson et al. (1987) similarly observed 60% of the adult Herring Gulls at any one time in activities other than foraging. Landfills in our study contained large, open areas with sparse vegetation that were relatively undisturbed by people and thus ideal for loafing or social interaction. Additional research is required to determine the proportion of gulls that use landfills for foraging in relation to the total population present. Also, as the majority of adult Herring Gulls observed at the landfill during this study were on non-refuse areas, habitat management techniques such as elimination of standing water and vegetation manipulation (Blokpoel 1976) should be investigated to assess their effectiveness in reducing overall gull use of landfills.

Few studies have presented data on the population turnover of Herring Gull populations at landfills. The turnover rate of gulls at the Erie County Landfill was substantial. We estimated that the daily number of individuals that used the landfill during the reproductive period was 4–7 times greater than the mean number of individuals present at a given time during that same period. This is much faster than the daily turnover of 1.5 times for adult Herring Gulls during fall and winter in England (Coulson et al. 1987). Although gulls in our study arrived and departed slightly earlier in the day, the mean duration of visits (102 min) was similar to the 90 min described by Coulson et al. (1987).

We estimated that ≤19% of the nesting Herring Gull population used landfills during incubation and chick-rearing and 35–55% used the landfill during post-fledging. In contrast, Pons (1992) observed that 71% of a marked population used a landfill during incubation and chick-rearing. Coulson and Butterfield (1986) and Coulson et al. (1987) recorded relatively few observations of banded adult Herring Gulls at landfills outside the breeding season and concluded that landfills were not preferred feeding sites. Coulson and Butterfield (1986) also stated that landfills in their study area were infrequently used by gulls from April through July. Factors affecting the use of landfills by various populations of gulls are not fully understood, but appear related in part to the availability of alternate food and possibly, the distance landfills are from the colony.

During our study, landfills were unimportant to nesting Herring Gulls, probably because alternate, higher quality food (fish) was available. Reutter and Hartman (1988) have reported that Lake Erie is the world's largest freshwater fishery, with an annual harvest frequently greater than the combined harvests of the other four Great Lakes. That differences exist in previous studies on the importance of landfills to gulls suggests that results of a study apply in part only to the area studied. Therefore, the importance of landfills to breeding Herring Gulls currently should be considered on a site-specific basis.

ACKNOWLEDGMENTS

We thank personnel at the Erie County, Huron County, and Ottawa County landfills for access to their facilities. Personnel from American Quality Stripping, Cedar Point, Chesapeake Display and Packaging Company, and Sandusky Dock Corporation granted permission to conduct nest counts. R. A. Dolbeer provided valuable suggestions for study design; R. A. Dolbeer, P. Ewins, and D. V. Weseloh critically reviewed this manuscript; M-K. W. Belant, G. E. Bernhardt, E. J. Bly, B. N. Buckingham, E. C. Cleary, L. C. Gibbs, L. C. Gibbs, Jr., L. A. Hegyes, K. D. Madaras, M. R. Rutger, J. A. Shieldcastle, and P. P. Woronecki provided field assistance. Funds and support for this research were provided by the Federal Aviation Administration (FAA), Office of Airports Safety and Standards, Washington, D. C., and Airports Division, Airport Technology Branch, FAA Technical Center, Atlantic City International Airport, New Jersey.

LITERATURE CITED

ANNETT, C., AND R. PIEROTTI. 1989. Chick hatching as a trigger for dietary switching in the Western Gull. Colonial Waterbirds 12:4–11.

BELANT, J. L. In press. Nest-site selection and reproductive biology of roof- and island-nesting Herring Gulls. Trans. N. Am. Wildl. and Nat. Resour. Conf. 58.

BELANT, J. L., AND R. A. DOLBEER. 1993. Population status of nesting Laughing Gulls in the United States 1977–1991. Am. Birds 47:220–224.

BELANT, J. L., AND T. W. SEAMANS. In press. Evaluation of dyes and techniques to color-mark incubating Herring Gulls. J. Field Ornithol. 64.

BLOKPOEL, H. 1976. Bird hazards to aircraft. Can. Wildl. Serv., Environ. Can., and Pub. Centre., Supply and Serv. Can. Clarke, Irwin & Co.

BLOKPOEL, H. 1983. Gull problems in Ontario. Can. Wildl. Serv., Ottawa, Ontario.

BLOKPOEL, H., AND G. D. TESSIER. 1986. The Ring-billed Gull in Ontario: a review of a new problem species. Can. Wildl. Serv., Occas. Pap. 57.

BRADLEY, T. W. 1980. Gull-scaring trials for landfill studies. Surveyor 155:6–7.

BURGER, J. 1981. Feeding competition between Laughing Gulls and Herring Gulls at a sanitary landfill. Condor 83:328–335.

BURGER, J. 1986. Selection for equitability in some aspects of reproductive investment in Herring Gulls *Larus argentatus*. Ornis Scand. 18:17–23.

BURGER, J., AND M. GOCHFELD. 1981. Age-related differences in piracy behavior of four species of gulls, *Larus*. Behaviour 77:242–267.

BURGER, J., AND M. GOCHFELD. 1983. Behavior of nine avian species at a Florida garbage dump. Colonial Waterbirds 6:54–63.

CONOVER, M. R. 1983. Recent changes in Ring-billed and California Gull populations in the western United States. Wilson Bull. 95:362–383.

COULSON, J. C., AND J. BUTTERFIELD. 1986. Studies on a colony of colour-ringed Herring Gulls *Larus argentatus*: II. Colony occupation and feeding outside the breeding season. Bird Study 33:55–59.

COULSON, J. C., J. BUTTERFIELD, N. DUNCAN, AND C. THOMAS. 1987. Use of refuse tips by adult British Herring Gulls *Larus argentatus* during the week. J. Appl. Ecol. 24:789–800.

DAHL, H. 1984. The bird strike situation and its ecological background in the Copenhagen airport, Kastrup, p. 287–290. *In* M. J. Harrison, S. A. Gauthreaux, Jr., and L. A. Abron-Robinson [eds.], Proceedings wildlife hazards to aircraft conference and workshop. U.S. Dep. Transport., Fed. Aviation Admin., Washington, DC.

DAVIS, J.W.F. 1975. Specialization in feeding location by Herring Gulls. J. Anim. Ecol. 44:795–804.

DOLBEER, R. A., P. P. WORONECKI, T. W. SEAMANS, B. N. BUCKINGHAM, AND E. C. CLEARY. 1990. Herring Gulls, *Larus argentatus*, nesting on Sandusky Bay, Lake Erie, 1989. Ohio J. Sci. 90:87–89.

DRENT, R. H. 1970. Functional aspects of incubation in the Herring Gull. Behaviour Suppl. 17:1–132.

DRURY, W. H., AND J. A. KADLEC. 1974. The current status of the Herring Gull population in the United States. Bird-Banding 45:297–306.

FOX, G. A., C. R. COOPER, AND J. P. RYDER. 1981. Predicting the sex of Herring Gulls by using external measurements. J. Field Ornithol. 52:1–9.

GORKE, M., AND R. BRANDL. 1986. How to live in colonies: spatial foraging strategies of the Black-headed Gull. Oecologia 70:288–290.

GRANT, P. J. 1986. Gulls: a guide to identification. Buteo Books, Vermillion, SD.

GREIG, S. A., J. C. COULSON, AND P. MONAGHAN. 1985. Feeding strategies of male and female adult Herring Gulls (*Larus argentatus*). Behaviour 94:41–59.

HARRIS, M. P. 1970. Rates and causes of increases of some British gull populations. Bird Study 17: 325–335.

HAYCOCK, K. A., AND W. THRELFALL. 1975. The breeding biology of the Herring Gull in Newfoundland. Auk 92:678–697.

HIOM, L., M. BOLTON, P. MONAGHAN, AND D. WORRALL. 1991. Experimental evidence for food limitation of egg production in gulls. Ornis Scand. 22:94–97.

HORTON, N., T. BROUGH, AND J.B.A. ROCHARD. 1983. The importance of refuse tips to gulls wintering in an inland area of southeast England. J. Appl. Ecol. 20:751–765.

HUNT, G. L., JR. 1972. Influence of food distribution and human disturbance on the reproductive success of Herring Gulls. Ecology 53:1051–1061.

KADLEC, J. A., AND W. H. DRURY. 1968. Structure of the New England Herring Gull population. Ecology 49:644–676.

KADLEC, J. A., W. H. DRURY, JR., AND D. K. ONION. 1969. Growth and mortality of Herring Gull chicks. Bird-banding 90:222–233.

KIHLMAN, J., AND L. LARSSON. 1974. On the importance of refuse dumps as a food source for wintering Herring Gulls *Larus argentatus* Pont. Ornis Scand. 5:63–70.

MECH, L. D. 1983. Handbook of animal radiotracking. Univ. of Minnesota Press, Minneapolis.

MONAGHAN, P. 1980. Dominance and dispersal between feeding sites in the Herring Gulls (*Larus argentatus*). Anim. Behav. 28:521–527.

MORRIS, R. D., AND R. A. HUNTER. 1976. Monitoring incubation attentiveness of ground-nesting colonial seabirds. J. Wildl. Manage. 40:354–357.

MUDGE, G. P., AND P. N. FERNS. 1982. The feeding ecology of five species of gulls (Aves: Larini) in the inner Bristol Channel. J. Zool. (Lond.). 197: 497–510.

MURPHY, E. C., R. H. DAY, K. L. OAKLEY, AND A. A. HOOVER. 1984. Dietary changes and poor reproductive performance in Glaucous-winged Gulls. Auk 101:532–541.

NAMS, V. O. 1991. Locate II users manual. Truro, Nova Scotia.

PARSONS, J. 1970. Relationship between egg size and post-hatching mortality in the Herring Gull. Nature 228:1221–1222.

PARSONS, J. 1972. Egg size, laying date and incubation period in the Herring Gulls. Ibis 114:536–541.

PATTON, S. R. 1988. Abundance of gulls at Tampa Bay landfills. Wilson Bull. 100:431–442.

PATTON, S. R., AND L. A. HANNERS. 1984. The history of the Laughing Gull population in Tampa Bay, Florida. Fla. Field Nat. 12:49–57.

PAYNTER, R. A., JR. 1949. Clutch-size and the egg and chick mortality of Kent Island Herring Gulls. Ecology 30:146–166.

PIEROTTI, R. 1982. Habitat selection and its effect on reproductive output in the Herring Gull in Newfoundland. Ecology 63:854–868.

PIEROTTI, R., AND C. ANNETT. 1987. Reproductive consequences of dietary specialization in an ecological generalist, p. 417–442. *In* A. C. Kamil, J. Krebs, and R. Pullium [eds.], Foraging behavior. Plenum, New York.

PONS, J. 1992. Effects of changes in the availability of human refuse on breeding parameters in a Herring Gull *Larus argentatus* population on Brittany, France. Ardea 80:143–150.

REUTTER, J. M., AND W. L. HARTMAN. 1988. A history of human impacts on the Lake Erie fish community, p. 163–176. *In* J. F. Downhower [ed.],

The biogeography of the island region of western Lake Erie. Ohio State Univ. Press, Columbus, OH.
SAS INSTITUTE, INC. 1988. SAS/STAT user's guide, release 6.03 edition. SAS Institute, Cary, NC.
SCHARF, W. C., G. W. SHUGART, AND M. L. CHAMBERLIN. 1978. Colonial birds nesting on man-made and natural sites in the U.S. Great Lakes. U.S. Dep. Int., Fish & Wild. Serv., FWS/OBS-78/15, U.S. Army Engineer Waterways Exp. Stn., Vicksburg, MS.
SCOTT, W. B., AND E. J. CROSSMAN. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bull. 184.
SHERIGALIN, J. E. 1990. Results of ornithofauna study at some Soviet airfields 1972–1988. Bird Strike Committee Europe 20:201–206.
SIBLEY, R. M., AND R. H. MCCLEERY. 1983. Increase in weight of Herring Gulls while feeding. J. Anim. Ecol. 52:35–50.
SPAANS, A. L. 1971. On the feeding ecology of the Herring Gull *Larus argentatus* Pont. in the northern part of the Netherlands. Ardea 59:75–188.
VERBEEK, N.A.M. 1977. Comparative feeding ecology of Herring Gulls *Larus argentatus* and Lesser Black-backed Gulls *Larus fuscus*. Ardea 65:25–42.
VERMEER, K., D. POWER, AND G.E.J. SMITH. 1988. Habitat selection and nesting biology of roof-nesting Glaucous-winged Gulls. Colonial Waterbirds 11:189–201.
WEAVER, D. K., AND J. A. KADLEC. 1970. A method for trapping breeding gulls. Bird-Banding 41:28–31.