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Original Contribution

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Abstract: A burgeoning ring-billed gull population along Chicago's Lake Michigan beaches contributes to degraded water quality through fecal contamination. Egg oiling was conducted at Chicago's gull colonies to reduce production and the influx of hatch-year (HY) gulls using Chicago's beaches, with a second, long-term objective of eventually reducing adult gull numbers through attrition. We also investigated swim season water quality trends through the course of this work. From 2007 to 2009, 52, 80, and 81%, of nests at the two primary nest colonies had their eggs rendered inviable by corn oil application. Counts of HY and after hatch-year (AHY) gulls were analyzed during treatment years for 10 beaches. Water quality data were available from the Chicago Park District during our three treatment years and the prior year (baseline) for 19 beaches. HY counts declined at all 10 surveyed beaches from the initial year (52% nests with oiled eggs) to subsequent years with ~80% of nests oiled. Overall, HY gulls numbers on beaches decreased 86% from 2007 to 2009. Decreases in beach usage by AHY gulls were not detected. Compared to pretreatment, the number of beaches with improved water quality test rates increased each year through the course of the study. The frequency of water quality tests showing bacterial exceedances compared to 2006 declined at 18 of 19 beaches by 2009. Egg oiling resulted in fewer HY gulls using Chicago's beaches and was likely a beneficial factor for reduced frequencies of swim advisories and swim bans.

Keywords: bacterial exceedances, *E. coli* contamination, *Larus delawarensis*, population monitoring, swim advisories, swim bans

INTRODUCTION

Gulls and Water Quality

Illinois populations of ring-billed gulls (*Larus delawarensis*) have shown substantial increases in recent years (e.g., Sauer et al. 2011). Conflicts with human interests have increased

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accordingly, including gull fecal contamination of water along Chicago's beaches. Whitman and Nevers (2003) noted bird numbers on a Chicago beach may relate to bacterial contamination of recreational waters. Data from Chicago beaches in 2002 and 2003, respectively, indicated gulls were the source of *Escherichia coli* in 50 and 65% of the samples (Whitman et al. 2004). Gull numbers at beaches appeared positively correlated with water and foreshore sand concentrations of *E. coli* taken 24 h later (Whitman et al. 2004). Moreover, DNA fingerprinting of *Salmonella* isolates from sand and water at Chicago's 63rd Street Beach were well-matched to gull feces isolates, although other birds could also have been vectors. Immediately to the north of Chicago, the Lake County Illinois Health Department used DNA ribotyping to genetically analyze *E. coli* samples from four beaches and "found that gull feces were the predominant source of the bacterial counts" (Lake County Board 2004; RTI International 2011; Souciw and Pfister 2003). The economic impact to Chicago from swim bans was estimated in a University of Chicago study to result in a 45% decline in attendance on beaches, a $17.3 million loss in economic value and an additional $2.1 million lost expenditure value in a single year (Shaikh 2006).

Elsewhere, Edge and Hill (2007) showed bird droppings were primary sources of *E. coli* contamination at a Lake Ontario beach, and Levesque et al. (2000) documented that bacterial content of ring-billed gull droppings can contribute to microbiological contamination of recreational waters. Nugent et al. (2008) described how ring-billed and other gulls contributed to increased fecal coliform levels in a municipal drinking water source. In Racine, Wisconsin gull feces were found capable of carrying human pathogens (Kinzelman et al. 2008) and gulls were a significant non-point source of fecal contamination on beaches (Kinzelman et al. 2004).

Ring-Billed Gull Breeding Biology

A variety of factors have contributed to increasing gull populations in the Chicago area. Ring-billed gulls are gregarious nesters, and colonies often contain thousands of pairs, with the gulls remaining faithful to their nesting regions (Gabrey 1996; Weseloh 1984). Ring-billed gulls are long-lived birds, with the oldest band record over 27 years and an average lifespan of 10–15 years (Ryder 1993). Ring-billed gulls attain sexual maturity in 2–3 years (Ludwig 1974). Because gulls generally nest in isolated areas near water, they have few natural predators, which are more pronounced in an urban setting like Chicago. Gulls begin arriving at Great Lakes Region breeding colonies in late February to early March. Egg laying begins in April with an average clutch consisting of about 3 eggs (Mousseau 1984). In Chicago, hatch-year (HY) gulls fledge and boost gull numbers at the swim beaches around the second week of July, at the height of swim season, and when bacterial growth conditions likely are at their peak.

Management Approach

The concentration and fidelity of gulls at particular nesting colonies suggested that a practical means to slow the HY influx to the beaches and to the growth of the Chicago area gull population would be to reduce production of young. Correspondingly, a reduced surge of HY gulls and their contribution to fecal contamination at Chicago beaches at the height of swim season was also hoped to help reduce rates of swim advisories and swim bans. Here, we present results of HY gull counts on beaches during 3 years of managing gull production at two Chicago gull colonies, and we also examine the rates of swim advisories and swim bans in the same time frame.

Methods

Chicago Ring-Billed Gull Nesting Colonies

Ring-billed gulls nested in two primary colonies in Chicago (Fig. 1). One colony, Dime Pier, was located on Lake Michigan in downtown Chicago (41°53′N, 87°36′W). The site consisted of a rip-rap pier and nearby (0.5 km) breakwalls constructed of concrete and riprap. An average of 4,500 ring-billed gull pairs used this colony. The second nesting colony, Lake Calumet, was located 23 km south of Dime Pier, where the 3.9 ha manmade dike on the east shore of Lake Calumet (41°40′N, 87°35′W) served as the nesting location for approximately 22,000 ring-billed gull pairs (Rader et al. 2008).

Colony Assessment and Egg Oiling

As a safe, effective alternative to physical destruction of nests, we applied 100% food grade corn oil to gull eggs to render them inviable (Blackwell et al. 2000; Pochop et al. 1998). We were concerned that nest destruction might cause a colony to relocate (Ickes et al. 1998), possibly closer to airports or other sites where significant damage could result. Moreover, egg oiling early during nesting is considered a humane means to reduce production (Hadidian

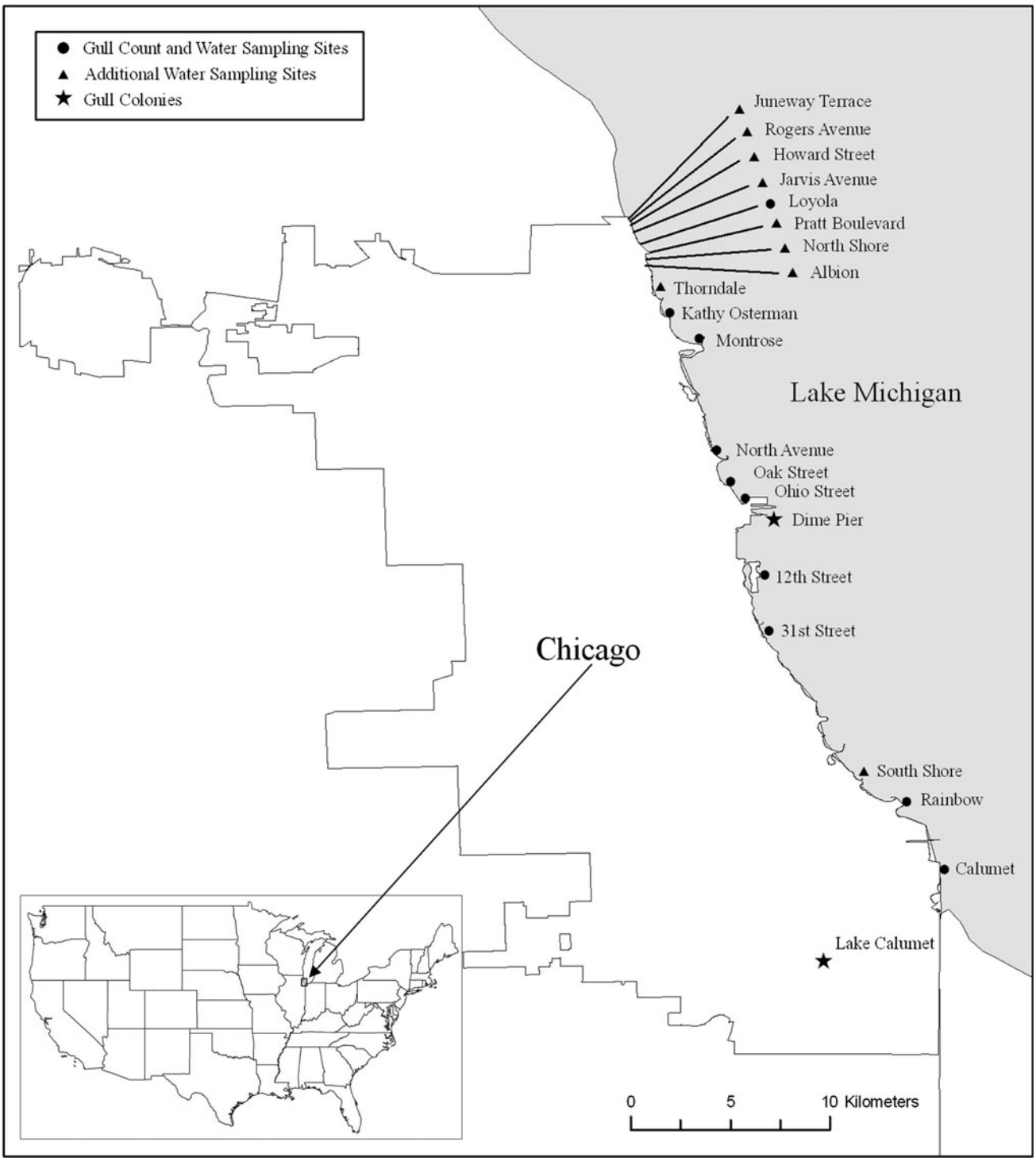

Figure 1. Map showing study beaches along Lake Michigan in Chicago where counts of gulls were made each week during the swim seasons 2007–2009, where water quality test data were used to monitor *E. coli* counts from 2006 to 2009, and the locations of the two ring-billed gull nesting colonies where egg oiling was used to reduce annual production.

et al. 1997). Management of ring-billed gull production was carried out in 2007, 2008, and 2009, with the respective overall targets of oiling eggs in 50, 80, and 80% of nests to obtain meaningful reductions in beach usage by HY gulls.

Egg oiling was carried out by staff from the US Department of Agriculture/Wildlife Services, the Federal agency with responsibility for managing conflicts with wildlife (US Department of Agriculture/Animal and Plant

Health Inspection Service, US Department of Agriculture/Forest Service and Department of Interior/Bureau of Land Management 1997). Limiting oiling to a maximum of 80% of nests (instead of more) was selected to avoid colony abandonment, which could happen if too few nests were left viable (Duerr et al. 2007). To facilitate application of oil early in incubation, nesting chronology was observed and incubation stage estimated by egg floatation as described by Nol and Blokpoel (1983). The numbers of gull nests in the colonies were estimated based on the largest number of nests observed during a single oiling treatment (which may have spanned several days to treat the entire colony). The oiling treatment process consisted of staff walking transects through a colony with backpack sprayers to apply food grade corn oil to all eggs in each selected nest. The pressurized backpacks held up to 15.14 L of corn oil, which was applied using a hand-held spray wand equipped with a tip that produced a fan pattern. Sprayers were pressurized and delivered oil at rates between 3 and 6 mL/s and sprayer tips were held 15–20 cm above each egg and applied approximately 3 mL of corn oil/egg. All eggs in the nest were treated at the same time with follow-up treatments rendering eggs in newly completed clutches inviable.

When the approximate target percent of the nests were oiled, staff flagged and counted the remaining untreated nests to obtain an actual total count. In 2007, access was allowed to only approximately half of the Lake Calumet gull colony to avoid adversely affecting a black-crowned night-heron (*Nycticorax nycticorax*) rookery. Therefore, the total colony size was estimated according to Rader et al. (2008). In 2008, black-crowned night herons were not observed nesting at the Lake Calumet colony, but herons returned in 2009, limiting where nests could be oiled. Following recommendations by the Illinois Department of Natural Resources, gull nests were not oiled within a 23 m buffer of heron nesting. Gull nests within the heron nesting location and buffer zone were quickly counted one time to obtain the total nest count for the Lake Calumet colony.

Gull Count Surveys

Systematic gull count surveys monitored gull usage at Chicago beaches during swim seasons of the three study years. The start of swim season for Chicago's beaches is defined by the Chicago Park District (CPD), typically starting the Friday before the Memorial Day holiday (the last Monday in May). Because we were focused on reducing production of young gulls, we began surveys when HY gulls would begin arriving at the beaches after they fledged. Thus, survey data useful for evaluating the efficacy of the egg oiling program began in Week 5 of the swim season and continued through Week 10. Very few, if any, HY gulls were expected in Week 5, but we wanted to insure we observed HY gulls as they began arriving at the beaches. Surveys of gull numbers on the beaches were conducted during the 3 years when egg oiling was applied (2007, 2008, and 2009). No baseline surveys were funded or conducted in years prior to initiating management actions to reduce gull production. Therefore, our data examined trends within 3 years of oiling, with the first year targeting 50% of nests for oiling and increasing to 80% in the two subsequent years.

Gull count surveys were conducted on foot to monitor gull use at 10 beaches (12th Street, 31st Street, Calumet, Kathy Osterman, Loyola, Montrose, North Avenue, Oak Street, Ohio Street, Rainbow; see Fig. 1). Beach survey sequence started from the northernmost or southernmost beach, with beaches observed sequentially from there. Each beach was traversed on foot and the numbers of HY and after hatch-year (AHY) gulls observed on and within 75 m of the beach were recorded, including from nearby parks, parking lots, and the shoreline. Additional data recorded during surveys included time, weather conditions, and species and number of other waterbirds observed at each location. The nesting colonies at Dime Pier and Lake Calumet were also observed periodically before dawn and after dusk to assess colony fledge date, HY development, and gull movement patterns.

Data on Water Quality and Swim Advisories and Swim Bans

The CPD regularly examines near-shore water quality at swimming beaches in Chicago. Following the US Environmental Protection Agency recommended threshold, swim advisories are implemented in Chicago when the geometric mean of two *E. coli* sample readings exceeds the threshold of 235 most probable number (mpn) per 100 mL of sampled beach water. If the geometric mean of two samples is $\geq$1000 mpn/100 mL, a swim ban will be in effect for the beach the day following sample collection. Together, swim advisories and swim bans are termed exceedances. The CPD's methodology used to monitor beach water quality and to issue exceedances remained unchanged from 2006, the year prior to initiation of management to reduce

gull production, through the course of our study. Thus, in addition to examining exceedance trends across the 3 years of egg oiling, we were able to use the 2006 data as a baseline for comparisons in proportion of tests exceeding 235 mpn/100 mL.

To assess water quality, two water samples were taken by CPD from each beach each day from Monday to Friday of each week in the swim season, and weekend testing was done following an exceedance. The samples are taken approximately 20 m apart where water depth is 45 cm. Sample bottles were lowered vertically and then turned sideways at 10 cm below the surface to obtain the samples at that depth. Water samples were analyzed for *E. coli* concentrations using the Colilert 18-h technology and methodology (Ely 2006).

Data Analyses

Gull observations were analyzed separately for each of the 10 beaches in recognition of intrinsic physical differences between beaches, differences in beach use patterns, and different distances from nest colonies and food resources. For each beach, we analyzed the number of gulls observed during the surveys in each of the six 1-week observation blocks across 2007, 2008, and 2009 using a two-factor factorial analysis of variance with week of the swim season and year as the two main factors. We expected egg oiling to reduce the numbers of HY gulls, and we also knew HY gull numbers on beaches would begin low in July and increase as more gulls fledged and moved to the beaches during the swim season. Thus, we did not expect to detect differences in HY beach usage among years until around Week 7 of the swim season when HY gulls would have completed fledging and arrived en masse at the beaches. We therefore applied a priori linear contrasts to the week-by-year interaction means to identify which weeks of the six (if any) presented detectable differences in observed gull numbers among the 3 years. The analyses were conducted separately for HY and AHY gull observations.

Because water quality test results were available from 19 beaches (Fig. 1) for each year from 2006 to 2009, and testing methodology remained unchanged from the year prior to initiating egg oiling treatments through our study period, we used the year prior to our study as a basis for comparison with the egg oiling years for each of these beaches. The proportion of water quality tests at each beach $\geq$235 mpn/100 mL were compared between years using chi-square contingency table tests, with comparisons of most interest for each beach being between the pretreatment year, 2006, and the final year of egg oiling treatment in this study, 2009.

Results

Egg Oiling and Nesting Chronology

At 52% (18,470 of 35,192 nests), 80% (22,136 of 27,645 nests), and 81% (17,391 of 26,023 nests) for the years 2007, 2008, and 2009, respectively, the actual percentages of nests oiled each year were very close to the respective target levels of 50, 80, and 80 (Table 1). By 19 May, 30 May, and 26 May, respectively, for 2007, 2008, and 2009, we observed gull chicks in untreated nests while birds on treated nests were still incubating eggs. Based on increased beach use and observations of the absence of HY gulls at the Dime Pier colony, we estimated average fledge dates for 2007, 2008, and 2009 to be 10 July, 9 July, and 7 July, respectively.

Table 1. Estimated Number of Ring-Billed Gull Nests and Eggs Oiled at Dime Pier/DuSable Harbor Breakwall and Lake Calumet, Chicago, Illinois, in 2007 Through 2009

	Estimated number of nests			Oiled nests			Oiled eggs			Untreated nests		
	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Dime Pier/DuSable Harbor Breakwall	3,797	4,727	4,668	3,470	3,773	3,750	8,764	9,554	8,889	327	954	918
Lake Calumet	31,395	22,918	21,355	15,000	18,363	17,391	41,753	48,036	41,244	16,395	4,555	3,964
Total	35,192	27,645	26,023	18,470	22,136	21,141	50,517	57,590	50,133	16,722	5,509	4,882

Table 2. Mean Number of HY, AHY, and Total Ring-Billed Gulls Observed on Beaches Per Observational Survey in Chicago, Illinois During Weeks 5–10 of the Observation Period in 2007, 2008, and 2009

Beach	Year	HY	AHY	Total
12th Street	2007	27.4	60.0	87.4
	2008	15.4 (−44%)	80.5 (34%)	95.7 (9%)
	2009	9.8 (−64%)	41.8 (−30%)	51.6 (−41%)
31st Street	2007	86.5	87.9	174.5
	2008	26.6 (−69%)	125.3 (43%)	152.0 (−13%)
	2009	17.3 (−80%)	139.7 (59%)	156.9 (−10%)
Calumet	2007	199.8	72.8	272.6
	2008	37.1 (−81%)	49.8 (−32%)	86.8 (−68%)
	2009	17.4 (−91%)	63.6 (−14%)	80.9 (−70%)
Kathy Osterman	2007	90.4	210.5	300.9
	2008	21.2 (−77%)	209.3 (−1%)	230.4 (−23%)
	2009	6.8 (−92%)	161.8 (−23%)	168.6 (−44%)
Loyola	2007	42.3	81.0	123.3
	2008	15.7 (−63%)	68.8 (−15%)	84.4 (−32%)
	2009	8.8 (−79%)	114.4 (41%)	123.2 (0%)
Montrose	2007	177.3	299.2	476.5
	2008	42.9 (−76%)	301.4 (1%)	344.2 (−28%)
	2009	20.0 (−89%)	222.7 (−26%)	242.7 (−49%)
North Avenue	2007	72.5	154.7	227.2
	2008	12.0 (−83%)	125.3 (−19%)	137.3 (−40%)
	2009	9.7 (−87%)	145.0 (−6%)	154.7 (−32%)
Oak Street	2007	3.2	11.2	14.2
	2008	0.4 (−88%)	7.5 (−33%)	7.9 (−45%)
	2009	0.6 (−81%)	15.8 (41%)	16.4 (14%)
Ohio Street	2007	0.4	5.8	6.2
	2008	0.3 (−25%)	4.5 (−22%)	4.8 (−23%)
	2009	0.1 (−75%)	4.4 (−24%)	4.4 (−29%)
Rainbow	2007	137.6	186.9	324.5
	2008	35.7 (−74%)	275.0 (47%)	310.7 (−4%)
	2009	28.7 (−79%)	186.1 (0%)	214.8 (−34%)
Total	2007	837.4	1170.0	2007.4
	2008	207.3 (−75%)	1247.4 (7%)	1454.7 (−28%)
	2009	119.1 (−86%)	1095.2 (−6%)	1214.3 (−40%)

The lines for 2008 and 2009 show in parentheses the percentage change from 2007.

Observations of Gull Use of Chicago Beaches

As compared to the initial treatment year, 2007, when 52% of nests were oiled, we found a progressive reduction in numbers of HY gulls on the beaches during 2008 and 2009 when 80 and 81% of nests were oiled. By 2009, all 10 beaches showed a reduction from 2007 in the number of HY gulls observed. Examination of the week-by-year interaction term in the two-factor factorial ANOVA was of particular interest to see at what point during the swim season differences in HY gull numbers would be detectable across years. Loyola Beach showed a decline across the 3 years that was not dependent upon the week of the swim season, hence a strong year effect ($F_{10,\ 36} = 16.86$, $P \leq 0.001$), but not a year-by-week interaction ($F_{10,\ 6} = 1.52$, $P = 0.174$). The other nine beaches exhibited year-by-week interactions ($F_{10,\ 34\ \text{to}\ 38}, \geq 1.89$, $P \leq 0.082$ summarizing results for those nine beaches), because differences in HY gull usage across years did not become

apparent until at least 2 weeks of observation had passed (Week 7 of swim season or later). This is what we expected, because beach usage by HY gulls tends to be low at first (and therefore not distinguishable among years), making the later weeks of the swim season where differences in HY beach usage would become evident. Reductions in HY gull use from 2007 to 2009 became evident at Week 7 of the swim season (the third week of observations annually) for seven of the beaches (12th Street, 31st Street, Calumet, Kathy Osterman, Montrose, North Ave, Rainbow). For each of these beaches, both years with an 80% egg oiling target differed at Week 7 from gull usage in 2007 ($F_{10,\ 34\ \text{to}\ 38}, \geq 10.40,\ P \leq 0.006$ summarizing results across those seven beaches). For the final two beaches (Oak Street and Ohio Street), differences between 2007 and the 2 years with 80% egg oiling targets became apparent at Week 8 of the swim season ($F_{10,\ 37\ \text{to}\ 38}, \geq 5.96,\ P \leq 0.019$ summarizing results for both beaches).

Over all beaches, the number of HY gulls observed on beaches declined by 86% from 2007 to 2009 (Table 2). During the initial summer of observations in 2007, when 52% of HY gull production was prevented, HY gulls represented 42.5% of the total gulls observed on beaches during Weeks 5–10, but by 2009 during the same period, HY gulls represented 9.8% of the total gulls observed on beaches (Table 2).

As would be expected for a long-lived species, consistent patterns (e.g., reductions) in beach use by AHY gulls were not detected (see Table 2 for an overview). The total number of gulls observed is the sum of the HY and AHY and therefore not independent of its components, thereby rendering similar statistical analyses inappropriate. Nevertheless, an examination of total gull use of the beaches provided perspective on the influence reductions in HY gulls can have on total gull numbers using the beaches (Table 2). Combining all beaches, the mean number of

Table 3. Water quality test results for *E. coli* from Chicago beaches from 2006 to 2009 where 2006 is the baseline year prior to initiating egg oiling operations at Chicago ring-billed gull colonies to reduce production of young gulls and 2009 was the third of three consecutive years of egg oiling

Beach	2006			2009			*P* value
	# Tests	# Positive	% Positive	# Tests	# Positive	% Positive	
12th Street	77	17	22.1	73	11	15.1	0.271
31st Street	75	20	26.7	72	9	12.5	0.031
Calumet	75	21	28.0	73	17	23.3	0.512
Kathy Osterman	74	13	17.6	73	9	12.3	0.373
Loyola	76	10	13.2	71	6	8.5	0.360
Montrose	74	18	24.3	71	16	22.5	0.799
North Avenue	74	8	10.8	72	4	5.6	0.248
Oak Street	74	7	9.5	72	2	2.8	0.093
Ohio Street	71	9	12.7	72	8	11.1	0.773
Rainbow	74	16	21.6	74	20	27.0	0.444
Albion	74	10	13.5	71	1	1.4	0.006
Howard Street	73	6	8.2	71	2	2.8	0.157
Jarvis Avenue	75	6	8.0	71	1	1.4	0.062
Juneway Terrace	74	7	9.5	71	2	2.8	0.098
North Shore	73	10	13.7	71	1	1.4	0.006
Pratt Boulevard	74	15	20.3	71	5	7.0	0.021
Rogers Avenue	74	6	8.1	71	2	2.8	0.163
South Shore	75	16	21.3	73	12	16.4	0.447
Thorndale	72	11	15.3	72	6	8.3	0.197
Combined beaches	1,408	226	16.1	1,365	134	9.8	<0.001

Information presented for each beach includes the 2006 and 2009 numbers of water quality tests, the numbers of those tests in exceedance of 235 mpn/100 mL, the percent in exceedance, and the *P* value from the chi-square contingency table tests comparing the proportion of tests in exceedance in 2006 with the proportion of tests in exceedance in 2009. The first 10 beaches in the table are those where gull numbers were monitored and water quality tests were made. The second eight beaches had only water quality tests made.

total gulls observed per weekly observation block during 2009 declined 40% compared to 2007 (Table 2).

Frequency of Swim Bans and Swim Advisories on Chicago's Beaches

In comparing swim exceedance data from egg oiling years with those from the year before initiating egg oiling (2006), 6 of the 19 beaches had a lower proportion of exceedances observed in 2007 than in 2006. In 2008, the number of beaches with a lower proportion of exceedances than in 2006 increased to 14, and finally in 2009 18 of the 19 beaches had a lower proportion of tests in exceedance of water quality standards compared to 2006 (Table 3). Of the 18 beaches in 2009 with a lower proportion of tests in excess of the water quality threshold than 2006 (Table 3), the reductions in exceedance rates were statistically detectable for seven beaches (31st Street, Albion, Jarvis Ave, Juneway Terrace, North Shore, Oak Street, Pratt Blvd; $\chi^2_1 \geq 2.75$, $P \leq 0.098$, in summary for those seven beaches, Table 3). Taken as a whole across all beaches, there were 226 exceedances from 1,408 water quality tests (16.1%) in 2006, but only 134 exceedances from 1,365 water quality tests (9.8%) by 2009 (Table 3).

Discussion

The most immediate goal from oiling eggs in the Chicago ring-billed gull colonies was to limit production, and therefore numbers, of HY gulls appearing on Chicago's beaches at the height of swim season. Egg oiling appeared to successfully address the first of the three goals as considerable reductions in beach usage by HY gulls in succeeding years with oiling targets of 50, 80, and 80% of nests from 2007, 2008, and 2009, respectively. No data were available on beach usage by HY gulls prior to the treatment years as our observations were implemented in conjunction with management actions. Having a pretreatment year of data would have greatly improved our assessments of treatment effects, and logically would likely have shown the reductions in HY beach usage through the course of our study to exhibit even larger relative magnitudes to a pretreatment baseline than to a year in which 52% of nests had their eggs oiled. As it was, we were able to show that targeting 80% of nests for egg oiling resulted in fewer HY gulls using the beaches as the swim season progressed than targeting 50% of nests for egg oiling.

A longer term goal, of which these 3 years of egg oiling are a component, was to reduce through attrition the numbers of adult gulls using the beaches. Given the longevity of the species, this effect could only reasonably be expected to become evident after egg oiling had been applied for a number of consecutive years, possibly a decade (e.g., Olijnyk and Brown 1999). With our monitoring data during 3 years of egg oiling we were unable to detect a pattern of reduced beach usage by adult ring-billed gulls, and nest management efforts will require a longer period of implementation to cause a notable decline in Chicago's nesting population. Here too, a baseline year for observation undoubtedly would have made an effect on AHY gulls more detectable.

A third goal was to assess whether a potential human health benefit in the form of lower rates of water quality exceedances was derived through reducing the additional fecal contamination associated with an influx of HY gulls to the beaches. Defining the beneficial effects on water quality from reducing HY gull beach usage is not straight-forward, because a variety of factors combine to affect bacterial counts at the beaches, such as temperatures, wind/wave/rainfall patterns, and beach grooming techniques. Nevertheless, there is well-reported documentation that gull fecal contamination degrades water quality (Kinzelman et al. 2004; Lake County Board 2004; Levesque et al. 2000; Nugent et al. 2008; Whitman et al. 2004). Historically, the frequency of swim advisories and swim bans in Chicago begins to increase during July. This is probably when conditions are most likely optimal for bacterial growth. This is also when the HY portion of the Chicago gull population, and their accompanying fecal depositions, arrive at the beaches. We do not know of data comparing fecal matter generating capacity for HY and AHY gulls. However, a rapidly increasing number of HY gulls to the beaches during the height of swim season would also represent a rapidly increasing supplement of fecal matter beyond the contributions of the AHY gulls already at the beaches. Such a synergism at the height of summer could be a contributing factor for fostering increased rates of water quality exceedances. Reducing gull production reduced HY gull numbers using the beaches at this time, which consequently would reduce their additional contributions of fecal matter at the peak of swim season. Without management there remains a potentially substantial surge of HY gulls to the beaches at the height of swim season. Over a sufficient span of years, it stands to reason that reducing this surge and the concomitant breeding population

recruitment could be valuable for lowering exceedance rates.

If continued management of gull production results in lowered adult breeding populations in the Chicago area, then the frequency or intensity of management activities to reduce production might be reduced accordingly. Concomitant with this, efforts should be made to consistently know the locations of Chicago area breeding colonies. Other colonies could form or current ones could relocate. Without such knowledge, management of production could become less efficient or less effective.

Conclusions

When CPD imposes a swim ban, the public's beach attendance was estimated to decrease by nearly half (Shaikh 2006). *E. coli* contamination from ring-billed gulls is known to contribute to excessive bacterial levels in swim water and likely plays a part in the need for CPD to issue swim advisories or impose swim bans. Reducing the production of HY gulls by oiling eggs reduced their mid-summer surge in numbers at the beaches. Concurrently, over 3 years of egg oiling, there was a declining trend in exceedance rates from water quality tests for Chicago's beaches. Egg oiling provides a method to inhibit local population increases, but additional management efforts at the beaches (e.g., canine patrols) can deter gull usage. Reducing anthropogenic food resources available to gulls should also reduce the attraction of the beach area. Placement of additional trash receptacles and the assertiveness of early morning clean-up crews can help reduce litter and its attraction to foraging gulls. Gulls also are fed by well-meaning humans in many parks and harbors, which might be addressed through education programs. In addition, refuse transfer stations and refuse management facilities in/near Chicago beaches provide nearly unlimited amounts of forage for gulls, thereby encouraging gulls to establish home ranges encompassing beaches. Partnering with refuse management facilities to reduce gull use of their operations and other means to make the area less attractive to gulls would further enhance efforts to reduce gull numbers on the beaches.

As long as the gull colonies responsible for annual production in the Chicago area are identified and managed, continued efforts to limit production of ring-billed gulls in Chicago will likely result in attrition exceeding replacement of AHY gulls with corresponding downward trends in their beach usage. Moreover, locating and limiting production from other nearby gull nesting colonies could further promote and accelerate water quality improvements and reductions in swim advisories and swim bans.

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