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SHOOTING GULLS REDUCES STRIKES WITH AIRCRAFT AT JOHN F. KENNEDY INTERNATIONAL AIRPORT

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The collision of birds with aircraft is a serious problem at John F. Kennedy International Airport (JFKIA), New York City. Port Authority of New York and New Jersey (PANYNJ) personnel reported 98–315 aircraft striking birds each year at JFKIA from 1979 to 1992 (Fig. 1). These strikes have caused millions of dollars in damage to aircraft and represent a significant threat to human safety. From 1979 to 1992, bird strikes at JFKIA resulted in 46 aborted take-offs and 43 damaged engines (29 required repair, 14 required replacement). Two recent serious incidents involving heavily loaded Boeing-747 aircraft occurred in May 1991 and March 1992 after gulls were "ingested" into engines. One aircraft aborted take-off and required replacement of brakes and 10 tires after a high-energy stop on the runway. The other aircraft released 90,700 kg of fuel to return safely to JFKIA (letters of 10 May 1991 and 17 Mar 1992 to PANYNJ from Northwest Airlines and Japan Airlines, respectively). From 1979 to 1992, JFKIA has averaged 270,000 aircraft movements (arrivals and departures) with >30 million passengers annually (PANYNJ, unpubl. data).

A nesting colony of laughing gulls (*Larus atricilla*) is adjacent to JFKIA in Jamaica Bay Wildlife Refuge (Fig. 2), which is administered by the U.S. National Park Service (NPS). This colony increased from 15 nesting pairs in 1979 to 7,629 pairs in 1990; the number of aircraft striking laughing gulls increased concurrently (Fig. 1). From 1988 to 1990, 52% of bird strikes ($\bar{x}$ = 156 aircraft/yr) at JFKIA involved laughing gulls. Other species of gulls (herring [*L. argentatus*], great black-backed [*L. marinus*], and ring-billed [*L. delawarensis*]) comprised 35% of the strikes, and another 52 species of birds comprised the remaining 13%. Almost all laughing gull strikes occurred during May–September and peaked during the chick-rearing period in late June and July (Dolbeer et al. 1989). Laughing gulls flew from the colony over the airport to feeding and loafing sites throughout parts of the metropolitan New York City area (Griffin and Hoopes 1991:17–22).

The airport has an active bird management program that incorporates habitat alteration and use of bird-frightening techniques to discourage birds from feeding, drinking, and loafing on airport grounds. However, these measures do little to prevent gulls from flying over the airport to feeding sites (Dolbeer et al. 1989, Sillings et al. 1992:20).

An international panel of 4 ornithologists selected by the NPS in 1989 assessed the bird strike problem and concluded "it is self evident that the laughing gull colony in its present location presents an unacceptable hazard to aircraft operations at JFK" (L. S. Buurma, J. E. Karlsson, C. S. Thomas, and V. E. F. Solman, Gateway Natl. Rec. Area, Brooklyn, N.Y., unpubl. rep., 1989:2). The NPS has been reluctant to reduce the nesting gull population at Ja-

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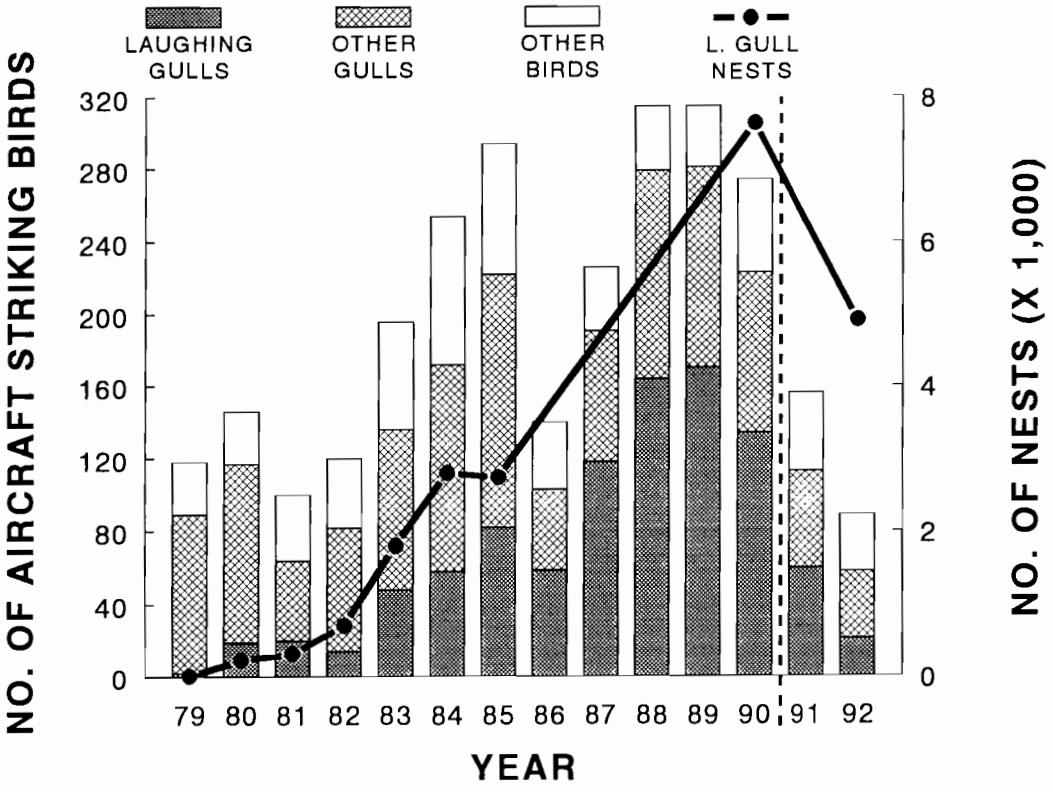

Fig. 1. Number of laughing gull nests in Jamaica Bay Wildlife Refuge and, for adjacent John F. Kennedy International Airport, New York City, the minimum number of aircraft striking birds, 1979–1992. Bird strike data are from Port Authority of New York and New Jersey (Burger 1985). Nest census data are from Buckley and Buckley (1984), Buckley and Gurien (1986), Griffin and Hoopes (1991), and J. L. Belant and R. A. Dolbeer (U.S. Dep. Agric., Denver Wildl. Res. Center, Denver, Colo., unpubl. rep., 1992). For 1979–1990, the number of nests and annual number of aircraft strikes with laughing gulls were correlated ($r = 0.97$, 6 df, $P < 0.01$). Shooting occurred from May to August, 1991 and 1992.

maica Bay Wildlife Refuge because 1 of their mandates is to protect native wildlife within NPS boundaries. However, based on recommendations of Buurma et al. (unpubl. rep., 1989:2), an experimental egg-oiling program was conducted at the Jamaica Bay colony in 1990 that was unsuccessful in significantly reducing gull collisions with aircraft at JFKIA (Griffin and Hoopes 1991:13).

During 1991 and 1992, U.S. Department of Agriculture (USDA) biologists attempted to reduce gull strikes by aircraft at JFKIA by shooting gulls flying over the airport. The hypothesis tested was that shooting would reduce the number of gull collisions with aircraft by directly reducing the population of gulls flying over the runways and by enhancing ongoing bird-frightening programs at JFKIA to condition gulls to avoid the airport. A further objective was to examine gulls shot at JFKIA to determine the source and characteristics of this population.

METHODS

Shooting occurred on 62 days from 20 May to 8 August 1991 and on 61 days from 15 May to 4 August 1992. Two to 5 shooters were stationed among 11 shooting zones along the southwestern and southeastern air-

port boundaries where gulls crossed the airport (Fig. 2). Shooting typically was conducted during 0530–1400 hours or 1200–2030 hours with a 1- to 2-hour break midway through each period. Shooters used 12-gauge semi-automatic shotguns and No. 4 steel shot, stood or sat in the open, and wore blaze-orange vests. Shooting was directed away from the airport and only at flying gulls within shooting range (about 40 m).

Two biologists were assigned full-time to the project each year and 16 biologists in 1991 and 21 in 1992 rotated in for 1- to 2-week periods. All personnel received ≥1 day of safety and shooting instructions from the full-time biologists. All shooters were subpermittees under federal and New York State permits issued to the USDA.

Shooters retrieved gulls when possible and kept count of gulls killed but not retrieved. At the end of each shooting session, shooters recorded the location where gulls were shot, the time shooting began and ended, number of shots taken, number and age class (hatching yr, subadult, adult [Grant 1986]) of gulls retrieved by species, and number of gulls killed but not retrieved by species. All retrieved gulls were examined for U.S. Fish and Wildlife Service leg bands to determine their origin and to compare the proportion of shot gulls that were banded to the proportion of gulls involved in aircraft strikes that were banded. Ten to 40 laughing gulls were randomly selected each day from the retrieved gulls and frozen for later examination and necropsy. In 1992, samples of 2–5 birds from the other gull species occasionally were selected for later examination and necropsy. The remaining gulls were buried on airport property.

Necropsied gulls were weighed and examined for brood patches (Drent 1970:59–61). The reproductive organs were examined to determine sex.

Birds struck by aircraft have been consistently recorded daily at JFKIA by the PANYNJ Bird Patrol Unit since the mid-1970's (Burger 1985). We used gull strike data from 1988 to 1990 as a baseline to compare with gull strike data during the shooting program (1991–1992) because the population of nesting laughing gulls at Jamaica Bay Wildlife Refuge during these years most closely approximated nesting populations present during 1991 and 1992. Because the laughing gull population rapidly expanded during the 1980's, comparisons with earlier years seemed inappropriate. To determine if the amount of air traffic affected the strike rate, we compared mean number of aircraft movements at JFKIA (PANYNJ, unpubl. data) for 1988–1990 (baseline years) with 1991 and 1992.

We used the General Linear Models procedure (SAS Inst. Inc. 1988:552–574) to determine if the number of gulls killed/person-hour and the number of gulls killed/100 shots varied among half-month intervals and between years (1991–1992). Chi-square statistics for proportional data (Fleiss 1973:14–22) were used to compare characteristics of the gull population that was shot to characteristics of the gull population struck by aircraft. Chi-square statistics also were used to examine the sex ratio of adult laughing gulls and to compare the frequency of gulls struck by aircraft during the shooting program (1991–1992) to the frequency of gulls struck by aircraft during baseline years (1988–1990). We used a t-test to compare mean adult body mass of male and female laughing gulls.

RESULTS

Number and Characteristics of Gulls Shot

In 2,206 person-hours of shooting, 28,352 gulls (26,038 laughing, 1,846 herring, 278 great black-backed, and 190 ring-billed) were killed (14,886 in 1991, 13,466 in 1992) (Table 1). Gulls were killed at all 11 shooting zones; >800 were killed at each of 7 zones (A–F, K) (Fig. 2). The mean number of gulls killed/person-hour of shooting was higher ($P < 0.01$) in 1991 (16.6) than in 1992 (10.3) (Table 1). There were differences ($F = 6.44$; 1,5 df; $P < 0.01$) in the number of gulls killed/person-hour among half-month intervals; the year by half-month interval interaction also was significant ($F = 6.44$; 5,5 df; $P = 0.04$) (Fig. 3). In 1991, kill/person-hour peaked at 28.0 during the second half of June; no peak was observed in 1992. The number of gulls killed/100 shots was higher ($P < 0.01$) in 1991 (55.2) than in 1992 (43.2) (Table 1). There also were differences ($P < 0.01$) in the number of gulls killed/100 shots among half-month intervals, and the year by half-month interval interaction was significant ($F = 4.93$ and 4.08; 5,5 df; $P < 0.01$) (Fig. 3). For both years, the largest number of gulls killed/100 shots occurred during June.

Of 21,483 laughing gulls retrieved in 1991 and 1992, 94% were adults (≥2 yr old), 5% were subadults (1 yr old), and 1% were hatching-year birds (Table 2). In contrast, 46–68% of birds from the other 3 gull species shot were adults, 29–53% were subadults, and <1–3% were hatching-year birds.

Of 468 laughing gulls with leg bands (2.2% of 21,483 laughing gulls shot and retrieved), 458 (98%) were banded as chicks near Barnegat Light, New Jersey, 106 km from JFKIA. The farthest recoveries were 3 laughing gulls

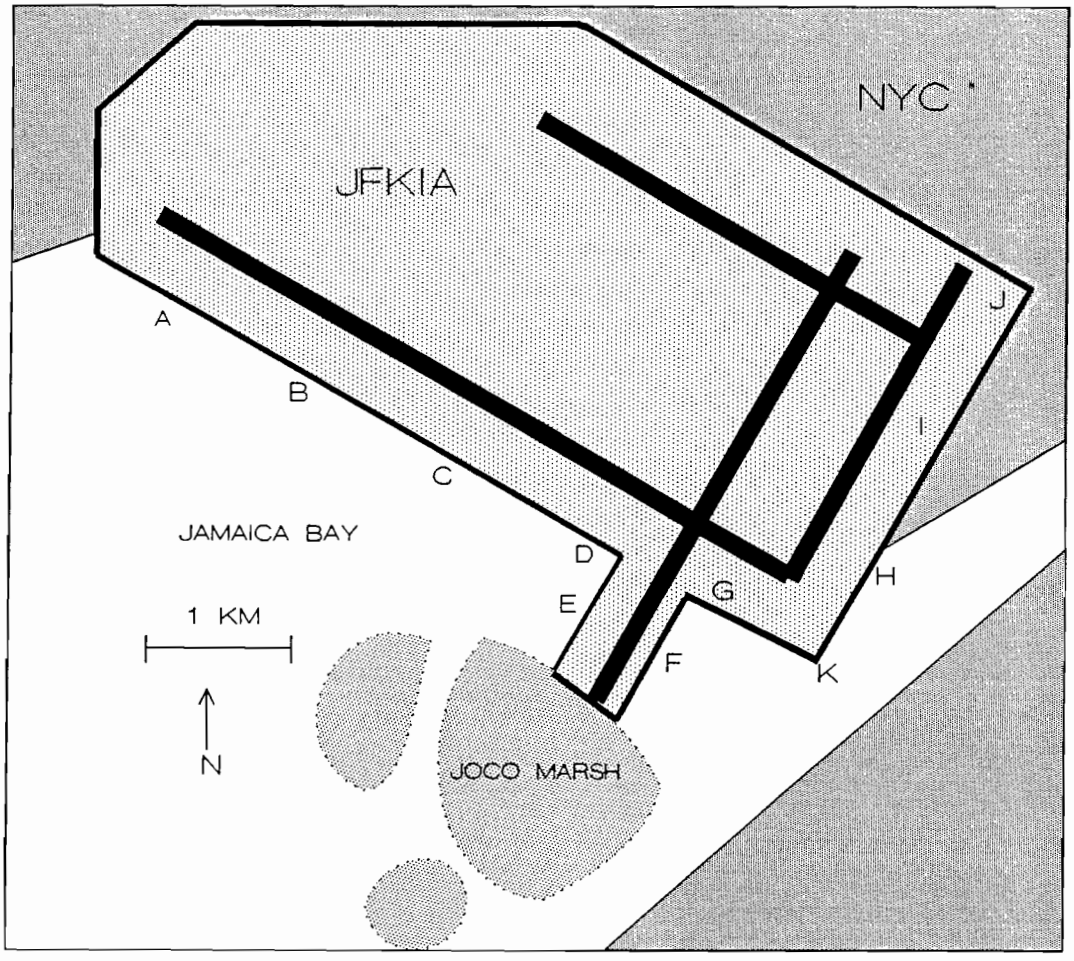

Fig. 2. John F. Kennedy International Airport (JFKIA), New York City (NYC), showing the 11 shooting zones (1991–1992) along the boundaries of the airport (A–K) and JoCo and adjacent marshes in Jamaica Bay Wildlife Refuge where laughing gulls nest.

Table 1. Person-hours expended, shots fired, and gulls killed at John F. Kennedy International Airport, 20 May to 8 August 1991 and 15 May to 4 August 1992.

Year	No. shooting days	Person-hr shooting	No. shots fired	No. gulls[a] killed					No. gulls/ person-hr	No. gulls/ 100 shots
				LAGU	HERG	GBBG	BBGU	Total		
1991	62	896	26,947	14,191	508	128	59	14,886	16.6[b]	55.2[c]
1992	61	1,310	31,183	11,847	1,338	150	131	13,466	10.3[b]	43.2[c]
Total	123	2,206	58,130	26,038	1,846	278	190	28,352	12.9	48.8

[a] LAGU = laughing gull, HERG = herring gull, GBBG = great black-backed gull; RBGU = ring-billed gull.
[b] Number of gulls killed/person-hour differed between years ($F = 30.97$; 1,111 df; $P < 0.01$).
[c] Ratio of shots killing gulls to shots not killing gulls differed between years ($F = 56.97$; 1,111 df; $P < 0.01$).

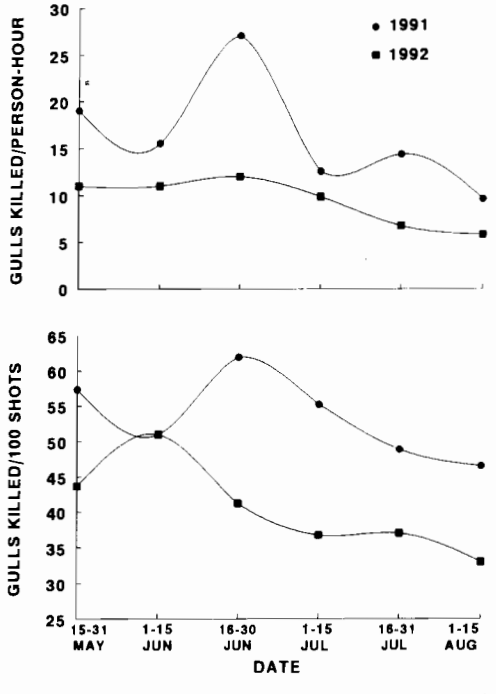

Fig. 3. Number of gulls killed/person-hour and killed/100 shots by half-month interval, May–August, 1991 and 1992, John F. Kennedy International Airport, New York City.

banded as chicks 340 km from JFKIA near Chincoteague, Virginia. Also, 2 adult laughing gulls (1 female, 1 male) marked with pink dye were shot, 1 on 26 June 1991 and 1 on 21 July 1992. These gulls had been marked (in the same year they were shot) as incubating birds at a nesting colony at Forsythe National Wildlife Refuge in coastal New Jersey 145 km south of JFKIA, between 6–12 June 1991 and 23 May–13 June 1992 (D. F. Caccamise, State Univ. New Jersey, Rutgers, pers. commun., 1992). Over 99% of the banded (known age) laughing gulls were ≥2 years old when shot.

The band recovery rate for laughing gulls shot and retrieved (2.2%) was similar (χ^2 = 0.27, 1 df, $P = 0.60$) to that for gulls struck by aircraft (2.4% of 1,042 laughing gulls struck by aircraft at JFKIA from 1979 to 1992 were banded [PANYNJ, unpubl. data]). Also, the ratio of 1-year-old to ≥2-year-old laughing gulls shot (0.06:1) (Table 2) was similar ($\chi^2 < 0.01$, 1 df, $P > 0.90$) to that for laughing gull strikes in 1991 and 1992 (0.06:1 [PANYNJ, unpubl. data]) and from 1979 to 1989 (0.07:1 [Dolbeer et al. 1989]). Finally, the ratio of other gull species to laughing gulls shot (0.09:1) (Table 1) was similar ($\chi^2 = 0.03$, 1 df, $P > 0.90$) to the ratio of other gull species to laughing gull strikes during the shooting period (20 May–15 Aug) in 1991 and 1992 (0.09:1) (Fig. 4).

The sex ratio of adult laughing gulls was skewed ($\chi^2 = 62.91$, 1 df, $P < 0.01$, $n = 2{,}059$), with 1.6 times as many males (62%) shot as females (38%). The predominance of males

Table 2. Age composition of laughing (LAGU), herring (HERG), great black-backed (GBBG), and ring-billed (RBGU) gulls shot and retrieved at John F. Kennedy International Airport, May–August 1991 and 1992, and projected total number killed for each age class.

Age class (from Grant 1986)	Percent of retrieved birds (projected total no. killed)					
	LAGU[a]					
	1991	1992	Total	HERG	GBBG	RBGU
Adult[a]	93 (13,209)	95 (11,278)	94 (24,487)	58 (1,066)	68 (190)	46 (87)
Subadult[b]	6 (889)	4 (486)	5 (1,375)	42 (769)	29 (81)	53 (100)
Hatching year[c]	1 (93)	1 (83)	1 (176)	<1 (11)	3 (7)	1 (3)
Total killed[d]	14,191	11,847	26,038	1,846	278	190
Total retrieved[e]	11,530	9,953	21,483	1,433	220	177

[a] Includes 2-year-old LAGU's.
[b] For LAGU's, subadults are 1-year-old gulls. For other gulls, subadults in 1992 were further classified as 1 year old (hatched in previous [1991] summer) and >1 year old. Forty-one, 56, and 17% of the subadult HERG's, GBBG's, and RBGU's, respectively, were classified as 1-year-old birds.
[c] The initial hatching-year birds shot for each year were: LAGU (17 Jul 1991, 22 Jul 1992); HERG (10 Jul 1991, 27 Jul 1992); GBBG (1 Aug 1991, 28 Jul 1992); RBGU (5 Aug 1991, 28 Jul 1992).
[d] Population from which projected number killed age class was based.
[e] Population from which age class was determined.

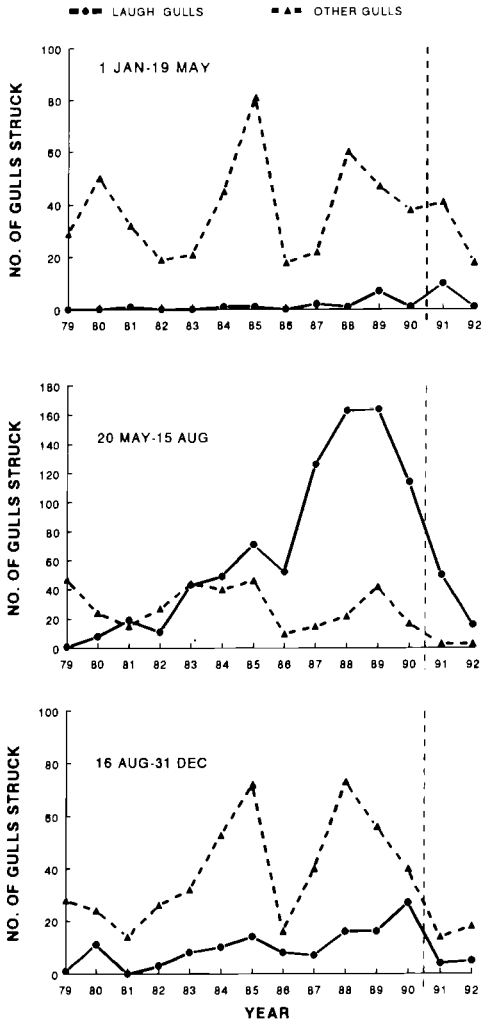

Fig. 4. Number of laughing gulls and other gulls (herring, great black-backed, and ring-billed) struck by aircraft at John F. Kennedy International Airport, New York City, by seasonal period, 1979–1992. Shooting occurred from 20 May to 8 August 1991 and from 15 May to 4 August 1992.

was consistent ($\chi^2 = 3.43$, 2 df, $P = 0.18$) among collections during morning (0530–1030 hr), midday (1031–1530 hr), and afternoon (1531–2030 hr). However, there was a difference ($\chi^2 = 21.23$, 5 df, $P < 0.01$) in the proportion of males shot by half-month interval, with the greatest proportion shot during late May and the lowest proportion shot during late June.

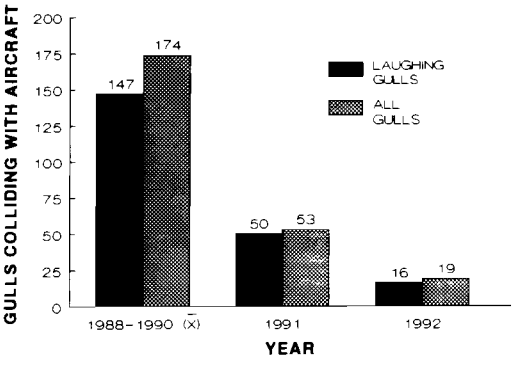

Fig. 5. Number of laughing gulls and all gulls (laughing, herring, great black-backed, and ring-billed) struck by aircraft at John F. Kennedy International Airport, New York City, 20 May–15 August, 1988–1992. Shooting occurred in 1991 and 1992.

Body mass of adult laughing gulls was greater ($t = 20.10$; 1,522 df; $P < 0.01$) for males ($\bar{x} = 345$ g, SD = 31, $n = 942$) compared to females ($\bar{x} = 312$ g, SD = 30, $n = 582$). Of 1,921 adult laughing gulls examined, 97% had distinct brood patches.

Effect of Shooting on Bird Strikes

In 1991, there was a 66% reduction ($\chi^2 = 47.76$, 1 df, $P < 0.01$) in laughing gulls struck by aircraft during the shooting period, 20 May–15 August (50), compared to the mean (147) for the same time period in 1988–1990 (Fig. 5). During 20 May–31 December, there was a 68% reduction ($\chi^2 = 57.78$, 1 df, $P < 0.01$) in laughing gull strikes (54) compared to the mean (167) for the previous 3 years. This reduction in strikes occurred despite the fact that in April and early May 1991, before shooting began, the number of laughing gull strikes was the highest (10) ever recorded at that time of year (Fig. 4). In 1992, the reduction in laughing gull strikes during the shooting period was even more pronounced ($\chi^2 = 105.28$, 1 df, $P < 0.01$), 89% compared to the mean for 1988–1990. The 16 laughing gull strikes that occurred during the shooting period in 1992 was the lowest annual total since 1982 (11) when the Jamaica Bay nesting colony contained <1,000 nests

(Figs. 1 and 4). During 20 May–31 December 1992, there was an 87% reduction ($\chi^2 = 113.38$, 1 df, $P < 0.01$) in laughing gull strikes (21) compared to the mean (167) for 1988–1990.

A comparable reduction in strikes was measured for all gull species (Fig. 5). There was a 70% reduction ($\chi^2 = 64.50$, 1 df, $P < 0.01$) in all gull (laughing, herring, great black-backed, ring-billed) strikes by aircraft during the shooting period in 1991 (53) compared to the mean (174) for the same time period in the previous 3 years, and a 72% reduction ($\chi^2 = 99.82$, 1 df, $P < 0.01$) during 20 May–31 December (from a mean of 250 [1988–1990] to 71 [1991]) (Fig. 4). In 1992, there was an 89% reduction ($\chi^2 = 124.48$, 1 df, $P < 0.01$) in gull strikes (from a mean of 174 [1988–1990] to 19) during the shooting period (20 May–15 Aug) and an 83% reduction (from a mean of 250 to 42: $\chi^2 = 148.16$, 1 df, $P < 0.01$) for the period 20 May–31 December.

The number of aircraft movements was 3% higher ($\bar{x} = 101{,}805$) during May–August and 2% lower ($\bar{x} = 274{,}618$) annually for 1991–1992 compared to 1988–1990. Thus, reductions ($\geq 66\%$) in gull strikes in 1991 and 1992 seemed unrelated to aircraft movements.

DISCUSSION

The 14,191 laughing gulls killed at JFKIA in 1991 in 896 person-hours of shooting (15.8 laughing gulls/person-hr or about 1 laughing gull/3.8 person-min) demonstrated the high activity level of these gulls over the airport and the seriousness of the bird hazard problem. The high sustained kill rate (kill/person-hr remained constant or increased through the first 6 weeks of shooting in both years) and our observations indicated that laughing gulls did not avoid shooters or alter their flight patterns away from the airport. The reduction in laughing gulls struck by aircraft in 1991 and 1992 (and in kill/person-hr in 1992) seemed more closely related to direct reduction of the population flying over the airport than to changes in flight patterns caused by shooters.

Gulls shot on the airport were representative of the population struck by aircraft based on comparisons of band recovery ratios, species composition, and age-class ratios. Thus, the shooting program seemed directed only at the population of gulls responsible for strikes with aircraft at JFKIA. Furthermore, no individuals of nontarget species were killed.

Burger (1983) presented data suggesting that male Franklin's gulls (*L. pipixcan*) are more vulnerable to shooting than females. Thus, the greater number of male laughing gulls shot may not reflect more males than females flying over JFKIA. However, Griffin and Hoopes (1991:87) determined that 63% of a sample of 35 laughing gulls struck by aircraft at JFKIA in 1990 were males, similar to the 62% males we shot in 1991 and 1992. Determining if and why male laughing gulls are disproportionately struck by aircraft is important because the probability of damage to an aircraft engine increases with the mass of the bird that strikes it (Hovey et al. 1991:67–72). Laughing gulls are sexually dimorphic; males were 11% heavier than females in this study.

Because >90% of the laughing gulls shot were adults with brood patches, and because the next nearest nesting colony was 106 km south of JFKIA (Belant and Dolbeer 1993), we conclude that most laughing gulls flying over JFKIA were from the Jamaica Bay colony. Although less pronounced in 1992 than in 1991, the highest kill/person-hour occurred in late June in both years. This peak in kill rate was synchronized with the time of peak hatching in the colony (Buckley and Gurien 1986:10–11, Griffin and Hoopes 1991:16) and probably reflected increased flights over the airport by adults in search of food for chicks. Laughing gull strikes at JFKIA also have consistently peaked in late June (Dolbeer et al. 1989).

The removal of 13,209 adult laughing gulls in 1991 was probably well over half of the

nesting birds in the Jamaica Bay colony. However, even with this removal, there was only a 36% reduction in nests in the colony from 1990 to 1992 (Fig. 1) and the number shot in 1992 was only 17% less than in 1991 (Table 1).

The annual kill of 11,000–13,000 adult laughing gulls at JFKIA in 1991 and 1992 represents 5–6% of the adult population in nesting colonies on the Atlantic coast from Virginia to Maine (Belant and Dolbeer 1993). Many of these colonies have been increasing at annual rates of >5% (Belant and Dolbeer 1993). Furthermore, band recoveries indicated that gulls from some of these colonies have immigrated to Jamaica Bay Wildlife Refuge, presumably to nest. Thus, we surmise that a large cohort of laughing gulls along the Atlantic coast is available to replace the birds removed in 1991 and 1992.

We conclude that the shooting program at JFKIA was effective in reducing the number of gulls struck by aircraft. However, we view the shooting program as an interim solution. A preferred long-term solution is to relocate the colony from Jamaica Bay. This plan could include habitat alteration, nest destruction, and other harassment and management techniques at the colony (Seubert 1990). However, a seasonal shooting program should continue on the airport to minimize the number of gulls struck by aircraft until the laughing gull colony is relocated from Jamaica Bay.

SUMMARY AND RECOMMENDATIONS

The collision of birds with aircraft is a serious problem at JFKIA, New York City. Laughing gulls comprised 52% of the bird strikes from 1988 to 1990, averaging 156 aircraft strikes/year. This species is present from May to September in association with a 7,600-nest colony (1990) adjacent to the airport. Other gulls (herring, great black-backed, and ring-billed), present year-round, comprised 35% of the strikes. Another 52 species of birds comprised the remaining 13% of strikes.

An active bird management program at JFKIA involves habitat alteration and use of bird-frightening techniques to discourage birds from feeding, drinking, and loafing on airport grounds. However, these measures did little to prevent gulls from flying over the airport to other feeding sites.

An experiment to reduce gull strikes by aircraft was undertaken in 1991 and 1992 in which 2–5 people with shotguns stationed on airport boundaries shot gulls flying over the airport from mid-May to early August. Shooters killed 26,038 laughing gulls and 2,314 other gulls flying over the airport during 2,206 person-hours of shooting. The shooting program at JFKIA substantially reduced the number of strikes between all species of gulls and aircraft, by 70% in 1991 and 89% in 1992 relative to the previous 3 years.

The laughing gull nesting colony in its present location presents an unacceptable hazard to aircraft. The shooting program, although effective in reducing the number of gulls struck by aircraft, did not condition gulls to avoid flying over the airport. A long-term solution is to relocate the colony from Jamaica Bay Wildlife Refuge. However, the interim shooting program should continue on the airport to minimize the number of gull strikes until the laughing gull colony is relocated.

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