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SHOOTING GULLS REDUCES STRIKES WITH AIRCRAFT AT JOHN F KENNEDY INTERNATIONAL AIRPORT, 1991-1993

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ABSTRACT

The collision of birds with aircraft is a serious problem at John F Kennedy International Airport (JFKIA), New York. Laughing gulls (*Larus articilla*) comprised 47% of the birds colliding with aircraft from 1988 to 1990, averaging 170 bird strikes per year. This species is present from May to September in association with a 7,600-nest colony (1990) adjacent to the airport. An experimental program to reduce gull collisions with aircraft was undertaken in 1991-1993 in which 2-5 people stationed on airport boundaries used shotguns to shoot gulls flying over the airport from May to August. In 3,401 person-hours of shooting, 35,692 gulls were killed (13,866 in 1991, 13,466 in 1992 and 7,340 in 1993) comprised of 32,534 laughing gulls and 3,158 other gulls. The number of laughing gulls struck by aircraft during the shooting period (20 May-15 Aug) was reduced by 66% in 1991, 89% in 1992 and 90% in 1993, compared with the mean level of 147 strikes during the same time period for 1988-90. Strikes by the other gull species were reduced by a comparable amount. In spite of the removal of 32,000 laughing gulls in 1991-1993 (over twice the number of adults in the Jamaica Bay colony in 1990), the nesting colony declined by only about 20% from 1990 to 1993. Thus, although shooting is an effective means of reducing the incidence of bird strikes, the program has not significantly reduced the nearby nesting colony. Our recommended long-term solution is to relocate the nesting colony away from JFKIA. A seasonal shooting program should continue to minimise the number of gull-aircraft collisions until this relocation is achieved.

(Keywords: laughing gull, shotgun, population dynamics, bird strike statistics, lethal control)

1. INTRODUCTION

The collision of birds with arriving and departing aircraft is a serious problem at John F. Kennedy International Airport (JFKIA), New York. Port Authority of New York and New Jersey (PANYNJ) personnel reported 100 to 315 aircraft struck by birds per year at JFKIA from 1979-1993 (Table 1). These strikes have caused millions of dollars in damage to aircraft as well as a significant threat to human safety. From 1979-1993, bird strikes at JFKIA resulted in 51 aborted take-offs and 46 damaged engines (31 required repair and 15 were replaced, Table 2). Two recent serious incidents involving heavily loaded Boeing-747 aircraft occurred in May 1991 and March 1992 after gull(s) 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 March 1992 to PANYNJ from Northwest Airlines and Japan Airlines, respectively).

In recent years, laughing gulls have been the species most frequently (47%) struck by aircraft at JFKIA, averaging 157 aircraft incidents involving 170 birds per year from 1988-90 (Table 1). Other gulls (herring [*L. argentatus*], great black-backed [*L. marinus*] and ring-billed [*L. delawarensis*]), which are present year-round, comprised 37% of the strikes and another 52 species of birds comprised the remaining 16%. There is a nesting colony of laughing gulls adjacent to JFKIA in Jamaica Bay Wildlife Refuge administered by the U.S. National Park Service (NPS, Fig. 1). This colony increased from 15 nesting pairs in 1979 to 7,629 pairs in 1990 (Table 1). Almost all laughing gull strikes occur from May to September with most in June and July during the peak of the nesting season (Dolbeer et al. 1989). Many gulls fly from the colony over the airport to off-airport feeding areas throughout the metropolitan New York City area (Griffin and Hoopes 1991).

As required by U. S. Federal Aviation Administration regulation 14CFR139, JFKIA has an active bird management program involving habitat alteration and the use of bird-frightening techniques to discourage birds from feeding, drinking, and loafing on airport grounds. However, these measures do little to prevent laughing gulls and other gull species from flying over the airport (Dolbeer et al. 1989, Sillings et al. 1992).

An international panel of 4 ornithologists selected by the NPS assessed the bird strike problem in 1989 and concluded that "it is self evident that the laughing gull colony in its present location presents an unacceptable hazard to aircraft operations at JFK" (Buurma et al. 1989). The NPS, whose mission is to protect native wildlife within the boundaries of their properties, has been reluctant to agree to control measures that would reduce the nesting population. The NPS, through a cooperative study with the University of Massachusetts funded by

the PANYNJ, undertook an experimental egg oiling program at the colony in 1990 that was unsuccessful in significantly reducing strikes (Griffin and Hoopes 1991:13).

As an alternative approach to solving the problem, U.S. Department of Agriculture (USDA) biologists, under a cooperative agreement funded by the PANYNJ, undertook an experimental management program at JFKIA in 1991 to reduce strikes by gulls, primarily laughing gulls. Biologists used shotguns to shoot gulls attempting to fly over the airport. The hypothesis tested was that shooting would not only directly reduce the population of gulls flying over the runways but also enhance ongoing bird-frightening programs at the airport by conditioning the gulls to avoid the airport. A further objective was to examine gulls shot at JFKIA to determine the source and characteristics of the population. Because strikes by gulls were significantly reduced at JFKIA in 1991, the shooting program was continued in 1992 and 1993. This report incorporates the results from 1993 into a summary of the program for 1991-1993. Previous reports (Dolbeer 1991; Dolbeer et al. 1992, 1993) provide more detailed information for the 1991 and 1992 programs.

2. METHODS

Shooting was conducted on 62 days from 20 May-8 August 1991, on 61 days from 15 May-4 August 1992, and on 52 days from 25 May-9 August 1993. Two to five shooters were stationed along the southwestern and southeastern airport boundaries where gulls often crossed the airport. Eleven shooting zones were established along these boundaries (Fig. 1). Shooting typically was conducted from 0530 to 1400 or from 1200 to 2030 with a 1- to 2-hour break midway. Shooting was done with 12-gauge semi-automatic shotguns using #4 steel shot. Shooters stood or sat in the open and wore blaze orange vests. Shooting was directed away from the airport and only at flying gulls that came within shooting range (about 40 m).

Two biologists were assigned full-time to the project each year and the remaining personnel (16 in 1991, 18 in 1992, and 12 in 1993) rotated in for 1- to 2-week periods. All personnel were experienced field biologists and spent, at minimum, their first day receiving instruction from an experienced airport shooter. All shooters were subpermittees under Federal and New York State permits issued to the USDA.

Shooters retrieved all shot gulls when possible and kept count of gulls killed but not retrieved. At the end of each shooting session, each shooter recorded the location where gulls were shot, the time shooting began and ended, the number of shots taken, the number of gulls retrieved by species and age class (hatching year, subadult, adult; Grant 1986), and the number of gulls killed but not retrieved by species. All retrieved gulls were examined for U.S. Fish and Wildlife Service leg bands. A random sample of 10-40 laughing gulls was usually selected daily

from the retrieved gulls and frozen for later autopsy in 1991 and 1992. Sex was determined by examination of reproductive organs which were also measured to infer reproductive status. The incidence of gulls with brood patches was also noted (Drent 1970:59-61). In 1992, samples of 2-5 birds from the other gull species were occasionally selected for examination and autopsy. In 1993, a sample of 10-40 laughing gulls per week was frozen for later autopsy to determine sex. No examination of brood patches or measurements of reproductive organs were made in 1993. The remaining gulls were buried on airport property or donated to museums.

3. RESULTS

3.1 Number and characteristics of gulls shot

In 3,401 person-hours of shooting, 35,692 gulls were killed (14,866 in 1991, 13,466 in 1992, and 7,340 in 1993), comprised of 32,534 laughing, 2,400 herring, 399 great black-backed, and 359 ring-billed gulls (Table 3). The mean number of gulls killed per person-hour of shooting was different ($P < 0.01$) for all 3 years, declining from 16.6 in 1991, to 10.3 in 1992, and to 6.1 in 1993 (Table 3, Fig. 2). The number of gulls killed per 100 shots also was different ($P < 0.01$) for all 3 years, declining from 55.2 in 1991, to 43.2 in 1992, and to 34.8 in 1993 (Table 3, Fig. 2).

In 1991, kill per person-hour peaked at 28.0 during the second-half of June. No seasonal peak in kill per person-hour was observed in 1992 or 1993. Gulls were killed along the southwestern and southeastern boundaries of the airport as they flew over going to and from Jamaica Bay. Over 1,000 gulls were killed in each of 7 of the 11 shooting zones (Table 4).

Of the 25,767 laughing gulls retrieved in 1991-1993, 93% were ≥ 2 years old, 6% were 1 year old and 1% were hatching-year birds. In contrast to laughing gulls, only 42 to 68% of birds from the other 3 gull species shot were adults whereas 30 to 57% were subadults and <1-2% were hatching-year birds (Table 5). We recovered 525 banded laughing gulls (2.0% of the 25,767 laughing gulls shot and retrieved) of which 522 had been banded as chicks. Over 99% of the 522 known-age laughing gulls (ages of 3 banded birds are unknown) were ≥ 2 -years old with 83% between 3 and 7 years of age. The oldest laughing gulls recovered (2) were 12 years old. Nine banded and known-age herring gulls were recovered of which 1 was 20 years old. Another banded herring gull was ≥ 21 years old (Table 6).

Of the 522 laughing gulls recovered that had been banded as chicks, 511 (98%) were banded by L. R. Pharo near Barnegat Light, New Jersey, 106 km south of JFKIA (Table 7). In addition to the banded gulls shot, 2 adult laughing gulls (1 female, 1 male) marked with pink dye were shot, 1 on 26 June 1991 and the other 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 S of JFKIA, between 6 and 12 June 1991 and between 23 May and 13 June 1992 (D. F. Caccamise, Rutgers Univ., pers. commun.).

The band recovery rate for laughing gulls shot and retrieved (2.0%) was similar ($X^2 = 0.52$, 1 df, $P = 0.40$) to that for gulls struck by aircraft (2.4% of 1,061 laughing gulls struck by aircraft at JFKIA from 1979-1993 were banded [PANYNJ, unpubl. data]). Also, the ratio of 1-year-old to ≥ 2 -year-old laughing gulls shot (0.06:1) (Table 5) was similar ($X^2 = 0.23$, 1 df, $P = 0.60$) to that for laughing gulls strikes in 1991-1993 (0.05:1) (PANYNJ, unpubl. data). Finally, the ratio of other gull species to laughing gulls shot (0.10:1) (Table 3) was similar ($X^2 = 1.23$, 1 df, $P = 0.27$) to the ratio of other gull species to laughing gull strikes (0.14:1) during the shooting period in 1991-1993 (Table 9).

In 1991, the sex ratio of adult laughing gulls was highly ($P < 0.01$) skewed toward males with twice as many males shot as females. In 1992, 1.5 times ($P < 0.01$) as many males as females were shot. In 1993, the sex ratio of males to females was 1:1 (Table 8). Over 95% of the adult (≥ 2 years old) laughing gulls examined in 1991 and 1992 had well developed brood patches (Dolbeer et al. 1992).

3.2 Effect of shooting on bird strikes

In 1991, there was a 66% reduction in the number of laughing gulls struck by aircraft during the shooting period, 20 May-15 August, (50) compared to the mean for the same time period in 1988-90 ($x = 147$, Fig 3). For the period 20 May-31 December, there was a 68% reduction in laughing gulls struck compared to the mean for the previous 3 years. This reduction in strikes occurred despite the fact that in April and early May 1991, before the shooting began, the number of laughing gulls struck (10) was the highest ever recorded for this time of year (Table 9).

In 1992, the reduction in laughing gulls struck was even more pronounced; 89% during the shooting period (20 May-15 Aug) and 87% during the period 20 May-31 December when compared to the means for 1988-90. In 1993, the number of laughing gulls struck (15) during the shooting period represented a 90% reduction compared to the mean for 1988-90. No additional laughing gulls were struck in 1993 after the shooting period ended. Thus, the 15 laughing gulls struck from 20 May to 31 December 1993 represents a 91% reduction compared to the mean for this time period in 1988-90. The 16 and 15 laughing gulls struck by aircraft during the respective shooting periods in 1992 and 1993 were the lowest strike totals since 1982 (11) when the Jamaica Bay nesting colony contained $< 1,000$ nests (Tables 1, 9).

A comparable reduction in strikes was measured for the other 3 gull species (Fig. 3, Table 9). Overall, there was a 69% reduction in all gulls (laughing, herring, great black-backed, ring-billed) struck by aircraft during the shooting period in 1991 (53) compared to the mean for the same time period in the previous 3 years ($x = 173$), and a 72% reduction for the period 20 May-31 December (from a mean of 249 in 1988-90 to 71 in 1991). In 1992, there were only 19 gulls struck during the shooting period (20 May-15 Aug) and 42 during the period 20 May-31 December, an 85-89% reduction compared to the means for the same time periods in 1988-90 (Table 9). In 1993, there was an 88% reduction in all gulls struck during the shooting period (20 May-15 Aug) and an 87% reduction during the period 20 May-31 December compared to the respective mean values for 1988-90.

The number of aircraft movements (arrivals or departures) at JFKIA has been increasing at about 3% per year since 1986, totalling 322,700 in 1992 (U. S. Department of Agriculture 1994). Thus, the reductions ($\geq 66\%$) in gull strikes in 1991-1993 seemed unrelated to aircraft movements.

4. DISCUSSION

Gulls shot on the airport in 1991-1993 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 nontarget species were affected.

Burger (1983) presented data suggesting that for Franklin's gulls (*L. pipixcan*), a species similar to laughing gulls, males were more vulnerable to collection by shotgun than were females. Our data for 1991 and 1992, but not 1993, support this hypothesis. We can not explain why the sex ratio of shot laughing gulls has varied among years.

The fact that 14,191 laughing gulls were killed at JFKIA in 1991 in only 896 person-hours of shooting (15.8 laughing gulls per person-hour or about 1 laughing gull every 3.8 person-minutes) demonstrated the high activity level of these gulls on the airport and the seriousness of the bird hazard problem. The overall number of gulls shot per person-hour declined by 38% in 1992 and 63% in 1993 compared to 1991, indicating there were fewer gulls flying over the airport in the latter 2 years. The number of laughing gulls and other gulls struck by aircraft also declined in 1992 and 1993 to only about 30% of 1991 levels and 11% of 1988-90 levels. However, in spite of the removal of over 32,000 laughing gulls in 1991-1993 (over twice the number of nesting gulls in the Jamaica Bay colony in 1990), the Jamaica Bay colony declined by only about 20% from 1990 to 1993 (Table 1). Thus, although the shooting program apparently resulted in a major decline in laughing gulls and other gulls flying over the

airport, the program has not significantly reduced the nearby nesting colony.

The annual kill of 10,000 to 13,000 adult laughing gulls at JFKIA in 1991 and 1992 represented 5 to 6% of the estimated adult population in nesting colonies on the Atlantic coast from Virginia to Maine (Belant and Dolbeer 1993). Many of these colonies have been growing at annual rates of >5%. Furthermore, band recoveries indicated that many gulls from at least some of these colonies have immigrated to Jamaica Bay to nest. Thus, the lack of a major decline in the colony size despite the removal of over 32,000 laughing gulls indicates there is probably a large cohort of laughing gulls along the Atlantic coast readily available to replace the birds removed. Therefore, an annual shooting program at JFKIA, while extremely effective in reducing the number of gull-aircraft collisions, will not likely eliminate the nesting colony from Jamaica Bay or have a significant impact on the regional population.

5. CONCLUSIONS AND RECOMMENDATIONS

1. The collision of birds with aircraft is a serious problem at John F. Kennedy International Airport (JFKIA), New York City. Laughing gulls comprised 47% of the birds colliding with aircraft from 1988 to 1990, averaging 170 birds struck per 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), which are present year-round, comprised 37% of the strikes and another 52 species of birds comprised the remaining 16%.

2. The airport has an active bird management program involving habitat alteration and the use of bird-frightening techniques to discourage birds from feeding, drinking, and loafing on airport grounds. However, these measures do little to prevent laughing gulls and other gull species from flying over the airport to non-airport feeding sites.

3. An experimental program to reduce gull collisions with aircraft was undertaken in 1991-1993 in which 2-5 people stationed on airport boundaries used shotguns to shoot gulls flying over the airport from mid-May to early August.

4. There was a high level of gull activity at JFKIA in the summer of 1991, as evidenced by the ability of shooters to kill 14,191 laughing gulls and 695 other gulls flying over the airport in only 896 person-hours of shooting (16.6 gulls/person-hr). Shooting did not appear to condition gulls to avoid flying over the airport in 1991.

5. In 1992 and especially 1993, fewer gulls attempted to fly over the airport as the kill per person-hour declined to 10.3 and 6.1, respectively (38 and 63% declines from the 1991 rate). The number of gulls struck by aircraft also declined in 1992 and 1993

to 30% of the 1991 level and 11% of the 1988-90 levels. However, the number of adult laughing gulls nesting in the adjacent colony declined by only about 20% from 1990 to 1993. Thus, laughing gulls associated with the colony appeared to be altering their flight patterns to avoid the airport, especially in 1993.

6. The lack of a significant decline in the colony size from 1990 to 1993, despite the removal of over 32,000 laughing gulls, indicated that gulls from other locations were replacing the shot birds. Band recoveries from laughing gulls shot at JFKIA in 1991-1993 confirmed that many gulls hatched in colonies in New Jersey have immigrated to the Jamaica Bay colony as adults.

7. The annual killing of large numbers of laughing gulls on the airport, while extremely effective in reducing strikes, may not be effective in eliminating the colony from its present location on NPS land adjacent to the airport. An alternative long-term approach to solving the laughing gull strike problem would be to develop a plan 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) as well as efforts to attract laughing gulls to new colony sites away from JFKIA (U. S. Department of Agriculture 1994). However, a seasonal shooting program should continue on the airport to minimize the number of gull-aircraft collisions until the laughing gull colony is relocated from Jamaica Bay.

8. The shooting program was designed to deal with a specific problem of gulls from a large, nearby nesting colony flying over the airport to dispersed feeding sites beyond the airport. Aside from this specialized shooting program, the PANYNJ should continue an aggressive bird management program on the airport, including habitat management and the use of bird frightening techniques, to prevent gulls and other bird species from using the airport for feeding and loafing (U. S. Department of Agriculture 1994).

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TABLE 1. Number of laughing gull (LAGU) nests in Jamaica Bay Wildlife Refuge (JBWR) and, for nearby John F. Kennedy International Airport, the minimum number of birds colliding with aircraft during take-offs and landings and the minimum number of birds involved in these strikes, 1979-1993.

Year	No. of LAGU nests (JBWR) ^a	Number of aircraft involved in strikes ^a (Number of birds involved in strikes)				No. (%) of strikes reported by air carriers	No. (%) of dead birds accounted for by air carrier-reported strikes
		Laughing gull	Other gulls ^b	Other birds	Total birds		
1979	15	2 (2)	86 (103)	29 (34)	117 (139)	21 (18)	38 (27)
1980	235	19 (19)	98 (98)	29 (44)	146 (161)	17 (12)	27 (17)
1981	325	20 (20)	44 (61)	36 (42)	100 (123)	14 (14)	18 (15)
1982	715	14 (14)	68 (72)	38 (64)	120 (150)	20 (17)	50 (33)
1983	1,805	48 (51)	89 (98)	62 (63)	199 (212)	25 (13)	38 (18)
1984	2,802	58 (61)	114 (136)	79 (91)	251 (288)	27 (11)	62 (22)
1985	2,741	82 (86)	139 (198)	72 (102)	293 (386)	37 (13)	130 (34)
1986		59 (60)	42 (43)	37 (47)	138 (150)	14 (10)	17 (11)
1987		118 (135)	73 (77)	35 (36)	226 (248)	22 (10)	28 (11)
1988		164 (180)	114 (154)	36 (40)	314 (374)	25 (8)	65 (17)
1989		171 (187)	108 (143)	36 (41)	315 (371)	34 (11)	52 (14)
1990	7,629	135 (142)	89 (95)	54 (97)	278 (334)	27 (10)	75 (22)
1991		60 (64)	54 (58)	42 (269) ^c	156 (391)	24 (15)	259 (66)
1992	5,117	22 (22)	37 (39)	42 (49)	101 (110)	18 (18)	27 (25)
1993	6,019	18 (18)	25 (25)	37 (73)	80 (116)	16 (20)	49 (42)
Total		990 (1,061)	1,180 (1,400)	653 (1,078)	2,834 (3,553)	341 (12)	934 (26)

^a Unpubl. data from Port Authority of New York and New Jersey. See Burger (1985) for method of collection.

^b Data from 1979 to 1984 from Buckley and Buckley (1984), for 1985 from Buckley and Gurien (1986), for 1990 from Griffin and Hoopes (1991), and for 1992 and 1993 from Belant et al. (1993).

^c Herring, great black-backed and ring-billed gulls.

^d One incident in 1991 involved an aircraft colliding with 194 European starlings.

TABLE 2. Summary of known damage, delays, and safety risks related to air carrier-reported bird strikes at John F. Kennedy International Airport, 1979-1993 (Data provided by Port Authority of New York and New Jersey)*.

Year	No. of air carrier-reported strikes	Strike-related losses and delays										No. of damaged or delayed aircraft known to involve:				
		No. of strikes on departures	No. of aborted take-offs	No. of engines replaced	No. of engines repaired	No. of aircraft with non-engine damage	No. of aircraft with reported damage	Total aircraft with damage or delays	Gulls			Other birds				
									HERG	GBBG	LAGU		HERG	LAGU	Other birds	
1979	21	7	2	2	0	0	2	2	0	0	0	0	0	0	0	2
1980	17	7	1	0	2	0	2	2	2	0	0	0	0	2	0	0
1981	14	6	1	0	2	1	3	3	1	0	0	1	1	1	1	1
1982	20	2	2	1	1	2	4	5	4	0	0	0	3	2	2	2
1983	25	6	2	2	1	2	3	3	3	0	0	1	2	0	0	0
1984	27	11	3	1	1	1	3	3	3	0	1	0	2	0	0	0
1985	37	10	3	1	2	4	6	10	6	3	1	0	4	2	2	2
1986	14	6	3	0	2	1	3	5	3	0	0	1	3	1	1	1
1987	22	13	6	3	4	3	10	10	10	1	1	2	4	2	2	2
1988	26	10	2	0	1	0	1	3	1	1	0	1	0	1	0	1
1989	33	14	7	1	5	3	8	11	8	2	2	1	3	3	3	3
1990	27	16	7	1	4	1	6	9	6	3	1	2	2	2	1	1
1991	23	8	5	2	1	3	6	7	6	0	0	0	3	4	4	4
1992	18	4	2	0	3	0	3	3	3	2	0	0	1	0	0	0
1993	16	7	5	1	2	1	5	6	5	0	0	0	2	2	2	2
Total	340	127	51	15	31	22	65 ^d	87	65 ^d	13	6	10	32	21	10	32

* Information is reported to Port Authority voluntarily by pilots and air carriers; therefore, data are incomplete and the values presented herein should be considered as minimum estimates of damage, delays and safety risks.

^b HERG = herring gull, GBBG = great black-backed gull, LAGU = laughing gull, UNGU = unknown gull.

^c Brant-2, Canada goose-2, European starling-1, osprey-2, peregrine falcon-1, ring-necked blackbird-1, ring-necked pheasant-1, rock dove-1, short-eared owl-1, snow bunting-1, unknown duck-1, unknown bird-7.

^d Five aircraft reported both engine and non-engine damage.

TABLE 3. Person-hours expended, shots fired, and gulls killed at John F. Kennedy International Airport, May-August 1991-93.

Year	Number of days shooting	Person-hours shooting	No. shots fired	No. of gulls ^a killed			Total	No. gulls/person-hr ^b	No. gulls/100 shots ^c	
				LAGU	HERG	GBBG				
1991	62	896	26,947	14,191	508	128	59	14,886	16.6 ^a	55.2 ^a
1992	61	1,310	31,183	11,847	1,338	150	131	13,466	10.3 ^b	43.2 ^b
1993	52	1,195	20,492	6,496	554	121	169	7,340	6.1 ^c	34.8 ^c
Total	185	3,401	78,622	32,534	2,400	399	359	35,692	10.5	45.4

^a LAGU = laughing gull, HERG = herring gull, GBBG = great black-backed gull, RBGU = ring-billed gull.

^b Number of gulls killed per person-hr is different among years ($\bar{E} = 70.48$; 846 df; $\underline{P} < 0.01$), yearly means with different letters are different ($\underline{P} < 0.05$).

^c Ratio of shots killing gulls to shots not killing gulls is different among years ($\bar{E} = 87.31$; 840 df; $\underline{P} < 0.01$), yearly means with different letters are different ($\underline{P} < 0.05$).

TABLE 4. Number of gulls killed by shooting zone on John F. Kennedy International Airport, May-August 1991-93.

Zone (see Fig. 1)	Number of gulls* killed				Total	Gulls killed/ person-hr
	LAGU	HERG	GBBG	RBGU		
A	7,554	778	162	178	8,672	10.2
B	2,129	149	41	39	2,358	7.9
C	1,584	102	34	29	1,749	6.8
D	947	49	12	7	1015	8.2
E	5,602	352	46	34	6,034	11.0
F	3,008	117	10	13	3,148	11.4
G	435	5	2	0	442	13.5
H	335	23	2	2	362	12.3
I	7	4	0	0	11	1.6
J	18	0	0	0	18	9.8
K	10,915	821	90	57	11,883	12.1
Total	32,534	2,400	399	359	35,692	10.5

*LAGU = laughing gull, HERG = herring gull, GBBG = great black-backed gull, RBGU = ring-billed gull.

TABLE 5. 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 1991-93, and projected total number killed for each age class.

Age class (from Grant 1986)	% of retrieved birds (projected total number killed)						
	1991	1992	1993	Total			
Adult ^a	93 (13,209)	95 (11,278)	89 (5762)	93 (30,249)	57 (1,372)	68 (271)	42 (151)
Subadult ^b	6 (889)	4 (486)	7 (487)	6 (1,862)	42 (1011)	30 (120)	57 (205)
Hatching year ^c	1 (93)	1 (83)	4 (247)	1 (423)	<1 (17)	2 (8)	1 (3)
Total killed ^d	14,191	11,847	6,496	32,534	2,400	399	359
Total retrieved ^e	11,530	9,953	4,284	25,767	1,814	306	320

^a Includes 2-year old LAGU's.

^b For LAGU's, subadults are 1-year old gulls. For other gulls, subadults in 1992 and 1993 were further classified as 1 year old (hatched in previous summer) and >1 year old. Forty-five, 55, and 12% 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 July 1991, 22 July 1992, 14 July 1993); HERG (10 July 1991, 27 July 1992, 27 July 1993); GBBG (1 August 1991, 28 July 1992); RBGU (5 August 1991, 28 July 1992).

^d Population from which projected number killed per age class was based.

^e Population from which age class was determined.

TABLE 6. Age distribution of known-age gulls (i.e., banded as chicks) shot at John F. Kennedy International Airport, May-August 1991-93.

Age (year)* of gull when shot in 1991-1993	No. (%) of laughing gulls	No. (%) of herring gulls	No. (%) of great black-backed gulls
0	1 (<1)	0	0
1	2 (<1)	1 (11)	0
2	48 (9)	2 (22)	0
3	134 (26)	1 (11)	0
4	98 (19)	0	0
5	82 (16)	1 (11)	0
6	68 (13)	0	0
7	51 (10)	0	0
8	22 (4)	0	0
9	3 (<1)	0	1 (100)
10	7 (1)	1 (11)	0
11	4 (1)	1 (11)	0
12	2 ^b (<1)	1 (11)	0
19	0	0	0
20	0	1 ^c (11)	0
Total	522 (100)	9 (100)	1 (100)

* An age 1 bird, for example, was a bird shot in the year after the year of hatching.

^b There is possibility that band number of 1 gull was misread because of extreme wear.

^c Another herring gull shot in 1992 had been banded as an after-second-year bird in 1973 and thus was ≥ 21 years old.

TABLE 7. Natal origin of banded gulls shot at John F. Kennedy International Airport (JFKIA), May-August 1991-93.

Gull species	Location where gull was banded as chick ^a	Distance (km) from JFKIA	Number of gulls
Laughing	Barnegat Light, NJ	106	511
	Beach Haven, NJ	130	1
	Stone Harbor, NJ	200	5
	Monomy Isl., MA	250	1 ^b
	Chincoteague, VA	340	3
	Petit Manan, ME	700	1
Herring	Point Lookout, NY	16	1
	New Rochelle, NY	28	2
	Captree State Park, NY	43	1
	Norwalk, CT	70	2
	Barnegat Light, NJ	106	1
	Hingham, MA	250	1
	Cuttyhunk Island, MA	250	1
Great black-backed	Fire Island Inlet, NY	70	1

^a In addition to the 522 recoveries at JFKIA of laughing gulls banded elsewhere as chicks, 3 laughing gulls banded as adults at JFKIA in 1990 were shot, 2 in 1991 and 1 in 1992. Also, a herring gull shot at JFKIA in 1992 had been banded in 1973 as an after-second-year bird at Stonington, CT, 165 km from JFKIA.

^b There is possibility that band number was misread because of extreme wear.

TABLE 8. Percent of males in a sample of adult laughing gulls shot at John F. Kennedy International Airport, May-August, 1991-93.

Year	N	% Males	Chi-square Value
1991	670	66.7	74.9*
1992	1,307	60.1	52.9*
1993	444	50.5	<0.1

* Different ($P < 0.01$) from expected ratio of 1 male: 1 female.

TABLE 9. Number of laughing gulls (LAGU) and other gulls (herring, great black-backed and ring-billed) struck by aircraft at JFK International Airport by seasonal period, 1979-93.

Year	Preshooting (1 Jan-19 May)			Shooting (20 May-15 Aug)			Postshooting (16 Aug-31 Dec)			Yearly total		
	LAGU	Other	Total	LAGU	Other	Total	LAGU	Other	Total	LAGU	Other	Total
1979	0	29	29	1	47	48	1	27	28	2	103	105
1980	0	50	50	8	24	32	11	24	35	19	98	117
1981	1	33	34	19	14	33	0	14	14	20	61	81
1982	0	19	19	11	27	38	3	26	29	14	72	86
1983	0	22	22	43	44	87	8	32	40	51	98	149
1984	1	44	45	50	40	90	10	52	62	61	136	197
1985	1	80	81	71	46	117	14	72	86	86	198	284
1986	0	17	17	52	10	62	8	16	24	60	43	103
1987	2	22	24	126	15	141	7	40	47	135	77	212
1988	1	60	61	163	22	185	16	72	88	180	154	334
1989	7	47	54	164	40	204	16	56	72	187	143	330
1990	1	38	39	114	17	131	27	40	67	142	95	237
1991*	10	41	51	50	3	53	4	14	18	64	58	122
1992*	1	18	19	16	3	19	5	18	23	22	39	61
1993*	3	7	10	15	5	20	0	13	13	18	25	43

* Shooting was conducted from 20 May-9 August 1991, 15 May-4 August 1992, and 25 May-9 August, 1993.

FIGURE 1. Schematic map of John F. Kennedy International Airport (JFKIA) showing the location of the nesting colony of laughing gulls (JoCo and adjacent marshes in Jamaica Bay) and the 11 shooting zones (lettered A to K along the southeastern and southwestern boundaries of the airport).

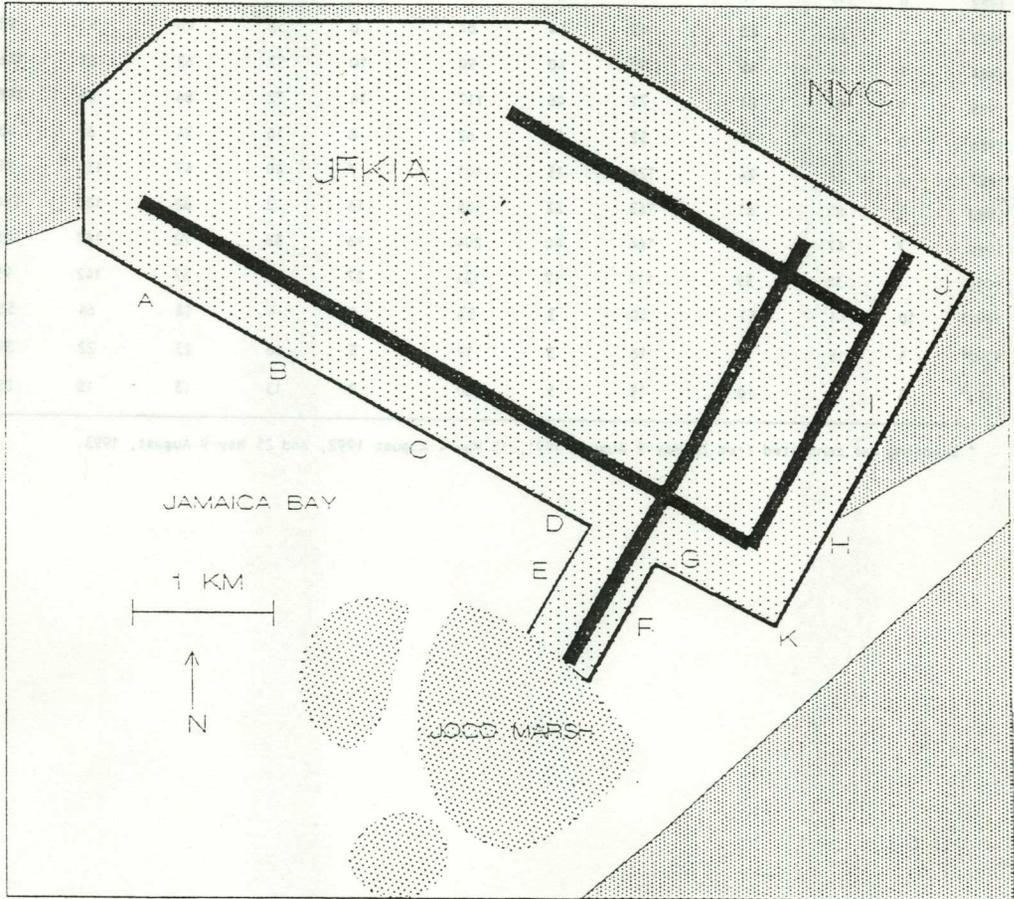
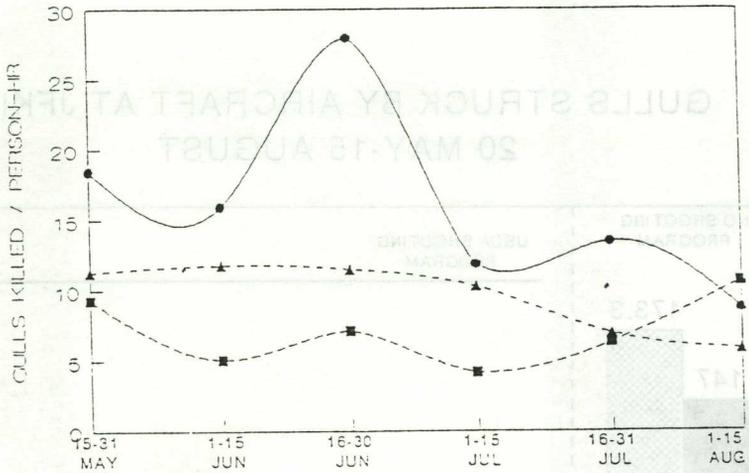


FIGURE 2. Number of gulls killed per person-hour and per 100 shots by half-month interval, May-August, 1991-93, John F. Kennedy International Airport.

GULLS KILLED / PERSON-HR, MAY - AUGUST, 1991-93, JFK INTERNATIONAL AIRPORT



GULLS KILLED / 100 SHOTS, MAY - AUGUST, 1991-93, JFK INTERNATIONAL AIRPORT

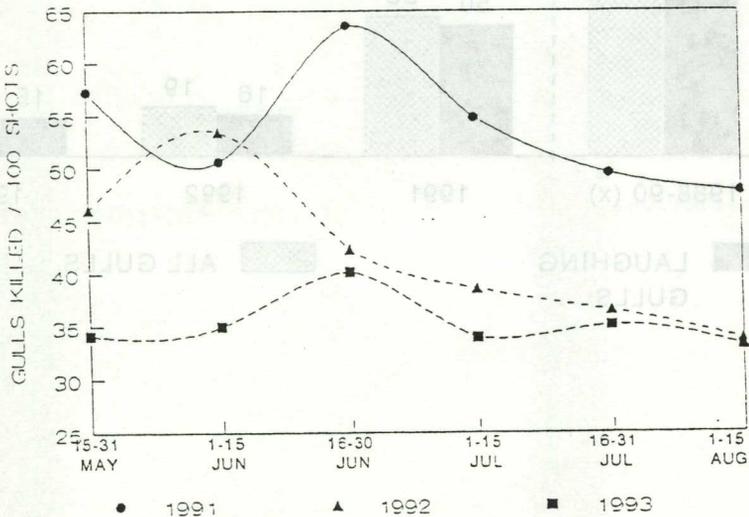


FIGURE 3. Number of laughing gulls and all gulls (laughing, herring, great black-backed, ring-billed) struck by aircraft at John F. Kennedy International Airport, 20 May-15 August, 1988-93. The gull shooting program was from 20 May-8 August 1991, 15 May-4 August 1992, and 25 May-9 August 1993.

