

**DOES SHOOTING ALTER FLIGHT PATTERNS OF GULLS: CASE STUDY AT JOHN F. KENNEDY
INTERNATIONAL AIRPORT**

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Abstract

The collision of birds with aircraft (bird strikes) is a serious problem at John F. Kennedy International Airport (JFK), New York. Gulls (*Larus* spp.), of which 60% were laughing gulls (*L. atricilla*), accounted for 86% of bird strikes from 1988-1990, averaging 261 strikes per year. Laughing gulls are present from May-September in association with a nesting colony in Jamaica Bay adjacent to the airport. A program to reduce gull strikes was conducted from May-August 1991-2002 in which 2-5 people stationed on airport boundaries shot gulls flying over the airport. As a result of the shooting program, the number of strikes with laughing gulls was reduced to 38% of 1988-1990 levels in 1991 and to 1-24% of 1988-1990 levels in 1992-2002. Strikes by the 3 other gull species were reduced to 24-52% of preshooting levels over the same time period. The laughing gull colony in Jamaica Bay has declined 58% from 7,629 nests in 1990 to 3,238 nests in 2002. That the colony size declined by only 58% from 1990-2002 while the annual strike rate of laughing gulls declined by 97% (1990-2002) indicated that many laughing gulls altered flight patterns in response to shooting to avoid the airport. Although the shooting program has reduced the local population of gulls flying over JFK, the regional population has not been negatively impacted. Our recommended long-term solution to minimize gull-aircraft collisions and the number of gulls shot is to relocate the nesting colony away from JFK. This study demonstrated that shooting can significantly reduce gull-aircraft collisions at an airport by both reducing the local population and altering flight patterns of surviving gulls. A seasonal gull-shooting program should continue at JFK as part of the integrated management program to reduce bird hazards to aviation.

Key words: airport, bird strike, behavior, gull, *Larus*, shooting

1. Introduction

The collision of birds with aircraft (bird strikes) is a serious problem at John F. Kennedy International Airport (JFK), New York. Port Authority of New York and New Jersey (PANYNJ) personnel reported 80-315 aircraft struck by birds per year at JFK from 1979-2002 [Table 1]. These strikes have caused millions of dollars in damage to aircraft and posed a significant threat to human safety. From 1979-2002, bird strikes at JFK resulted in at least 83 aborted takeoffs and 64 damaged engines (DOLBEER ET AL. 2003). Nationwide, bird and other wildlife strikes cost the USA civil aviation industry an estimated \$470 million per year, 1990-2001 (CLEARY ET AL. 2002).

From 1988-1990, laughing gulls (*Larus atricilla*) were the species most frequently (52%) struck by aircraft at JFK, averaging 157 incidents per year [Table 1]. There is a nesting colony of laughing gulls adjacent to JFK in Jamaica Bay Wildlife Refuge (JBWR) administered by the U.S. National Park Service [NPS, Figure 1]. This colony increased from 15 nesting pairs in 1979 to 7,629 pairs in 1990 [Table 1]. Almost all laughing gull strikes have occurred from May-September with most in June and July during chick rearing (DOLBEER ET AL. 1989). Laughing gulls are a summer resident of New York, migrating to the southern Atlantic and Gulf coast in winter (BELANT & DOLBEER 1993a). During the nesting season, laughing gulls fly from the colony in Jamaica Bay over the airport to off-airport feeding areas throughout metropolitan New York City (GRIFFIN & HOOPES 1991). The next closest laughing gull colony was in New Jersey, 106 km from JFK (ANDREWS 1990, BELANT & DOLBEER 1993b).

Other gulls (herring (*L. argentatus*), great black-backed (*L. marinus*) and ring-billed (*L. delawarensis*)), which are present in New York year-round as breeding birds (herring and great black-back) and migrants (all 3 species), comprised 34% of the bird strikes from 1988-1990 and another 52 species of birds comprised the remaining 14%. A 1997 survey indicated about 2,500 and 400 nests of herring and great black-backed gulls, respectively, in JBWR (K. BROWN, Cornell University, unpublished data). These gulls nest on islands 4-7 km from JFK (as opposed to 0.5-2 km for laughing gulls). Herring gulls and great black-backed gulls also nest in other locations within 100 km of JFK in metropolitan New York-Long Island and in northern New Jersey (ANDREWS 1990).

As required by USA Federal Aviation Administration Regulation 14CFR139, JFK has a bird management program including habitat alteration and the use of bird-frightening techniques to discourage birds from feeding, drinking, and resting 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, U.S. Department of Agriculture 1994, BARRAS ET AL. 2000a).

An international panel of 4 ornithologists selected by the NPS assessed the bird strike problem in 1989 and concluded, among other recommendations, 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 & 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, initiated an experimental management program at JFK in 1991 to reduce strikes by gulls, primarily laughing gulls. Biologists used shotguns to shoot gulls attempting to fly over the airport. Hypotheses tested were that shooting would not only directly reduce the population of gulls flying over the runways but also enhance ongoing bird-frightening programs at JFK by conditioning gulls to avoid the airport. In 1994, an Environmental Impact Statement (EIS) was finalized that addressed the management of gulls to reduce air traffic hazards at JFK (U.S. Department of Agriculture 1994). The EIS recommended that the shooting program be continued as part of an integrated management program until other actions were taken that would result in relocation of the colony. As required by the National Environmental Policy Act, USDA reviewed the EIS in 1999 and determined that the findings and recommendations remained relevant and no revisions or supplements were necessary.

This report examines data collected from 1991-2002 to evaluate the initial hypotheses that shooting would reduce the number of gull strikes by: 1) directly reducing the population of gulls flying over the runways, and 2) enhancing the ongoing bird-frightening programs at JFK by conditioning gulls to avoid the airport.

2. Methods

2.1 Shooting

Shooting was conducted on 31-62 days annually between 9 May-23 August 1991-2002 (*Table 2*). 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 (*Figure 1*; zones G, H, I and J were used only in 1991). Shooting typically was conducted from 0530-1200 hours or from 1300-2030 hours. Shooting was with 12-gauge semi-automatic shotguns using #2 (1999-2002) or #4 (1991-1999) steel shot. Shooters stood or sat in the open and wore blaze-orange vests. Shooting was directed away from the airport at flying gulls that came within shooting range (about 40 m). All personnel were experienced USDA field biologists. All shooters operated under Federal and New York State permits issued to the USDA or PANYNJ.

Shooters retrieved all shot gulls when possible and recorded the number and species of gulls killed but not retrieved. At the end of each shooting session, each shooter recorded the shooting zone, the time shooting began and ended, the number of shots fired, the number of gulls retrieved by species and age class (hatching year, subadult, adult; GRANT 1986, BELANT & DOLBEER 1996).

2.2 Bird strikes

Since 1979, the PANYNJ has maintained a consistent record of all bird carcasses found during daily runway inspections and sweeps that showed evidence of having interacted with an aircraft. Carcasses associated with strikes reported by flight or ground personnel were classified as reported strikes, whereas other carcasses were classified as unreported strikes (BURGER 1985; LINNELL ET AL. 1996, 1999; BARRAS & DOLBEER 2000). Data recorded for each strike event included the date, species and number of birds involved, and location on runway. For reported strikes, data on the time of day, aircraft type, phase of flight, parts struck, and parts damaged also were recorded.

3. Results

3.1 Number and characteristics of gulls shot

From 1991-2002, 72,063 gulls were killed (63,838 laughing, 6,037 herring, 1,423 great black-backed, and 765 ring-billed) in 11,883 person-hours of shooting [*Table 2*]. Of the 53,600 laughing gulls retrieved in 1991-2002, 90% were >2 years old, 8% were 1 year old, and 2% were hatching-year birds [*Table 3*]. In contrast to laughing gulls, only 48-73% of birds from the other 3 gull species shot were adults whereas 22-51% were subadult birds and 1-8% were hatching-year birds [*Table 3*].

3.2 Has shooting reduced the size of the laughing gull nesting colony?

From 1979 to 1990, the nesting colony increased from 15 nests to 7,630 nests. Subsequent to the initiation of shooting in 1991, the colony declined to 6,654 nests by 1993 and has fluctuated between 2,720 and 5,695 nests from 1994-2002 [*Table 1, Figure 2*]. In 2002, the colony contained 3,238 nests, 42% of the 7,629 nests in 1990. Thus, shooting apparently has reduced the size of the nesting colony.

3.3 Has shooting reduced the number of laughing gulls flying over airport?

The number of laughing gulls killed per year declined sharply from 14,191 to 6,167 in the first 5 years of shooting, 1991-1995, and then fluctuated between 1,970 and 3,676 in 1996-2002 (14-26% of numbers killed in 1991). The mean number of gulls killed per person-hour of shooting also declined sharply from 15.8 in 1991 to 7.2 in 1995, and then fluctuated between 2.4 and 4.4 in 1996-2002 (15-28% of kill-per-person-hour in 1991, *Table 2*). Thus, shooting apparently has reduced the number of laughing gulls flying over airport.

3.4 Has shooting reduced the number of laughing gulls struck by aircraft?

In 1991, the number of aircraft striking laughing gulls (60) was only 38% of the annual mean for 1988-1990 ($x = 157$, *Figure 3*). This reduction in strikes occurred despite the fact that from 1 April-19 May 1991 (shooting began on 20 May), the number of aircraft striking laughing gulls (10) was the highest ever recorded for this time of year (DOLBEER ET AL. 1993).

During 1992-2002, the reduction in laughing gull strikes was even more pronounced: 1-24% of the mean for 1988-1990 [*Figure 3*]. The 2-37 strikes per year involving laughing gulls in 1992-2002 were the lowest strike totals since 1979-1982 (2-20/year) when the JBWR nesting colony contained <1,000 nests [*Table 1*]. Thus, shooting apparently has reduced the number of laughing gulls struck by aircraft.

3.5 Is the reduced strike rate a result of population reduction or laughing gull avoidance of airport?

There was a strong correlation ($R^2 = 0.93$, $P < 0.001$) between the size of the nesting colony and the number of laughing gulls struck by aircraft at JFK from 1979 (the first year laughing gulls nested in Jamaica Bay) through 1990 (the year before the shooting program began; *Figure 4*). During this 12-year period, the gull colony grew from 15 nests (1979) to 7,630 nests (1990) and the annual number of strikes increased from 2 (1979, the first year laughing gulls were reported as struck at JFK) to 135-171 (1988-1890). Since shooting began in 1991 and the colony declined, there has been no correlation ($R^2 = 0.19$, $P = 0.18$) between the size of the colony and the number of gulls struck [*Figure 4*].

Based on the strong correlation during 1979-1990 between the size of the nesting colony and the number of strikes, we predicted that laughing gull strike rates in 1992-2002 would have ranged from about 60 to 120 strikes per year in response to the reduction in the nesting colony from 7,629 nests to 3,238 nests [*Figure 4*]. However, the reduction in strikes was much greater than predicted from colony size. For example, the strike rate of laughing gulls in 2002 was 3% of 1988-1990 levels, whereas the colony size only declined to 42% of the number of nests in 1990. This disparity suggests that many laughing gulls altered flight patterns in response to shooting to avoid the airport. The fact that the number of laughing gulls killed per year and per person-hour of shooting declined from 1991 to 2002 by a much greater level than did the size of the colony is also indicative that shooting altered flight patterns. Furthermore, the decline in the kill of laughing gulls per 100 shots in 1992-2002 (20.7-38.0) compared to 1991 (52.5, *Table 2*) also suggested that laughing gulls were more wary and kept at a greater distance from shooters in the latter years. Finally, we conducted a behavioral study in 2000-2001 of gull response to people standing at boundary of airport with guns which supported our hypothesis that shooting influenced laughing and other gull flight patterns (BARRAS ET AL. 2000b, unpublished data).

Thus, the dramatic reduction in laughing gull strikes (2002 level was 3% of level in 1988-1990) was apparently achieved through a combination of an overall reduced nesting population (2002 population was 42% of 1990 population) and laughing gull avoidance of airport.

3.6 Has shooting influenced populations, behavior, and strike rates of other gull species?

Unlike laughing gulls, the number of other gulls (herring, great black-backed, ring-billed) killed did not show a sharp decline from the initial year of shooting. Rather, the number killed has fluctuated from lows of 293-298 in 1994 and 1996-1998 to 1,513-1,619 in 1992 and 2002 [Table 2]. Likewise, the kill-per-person-hour and the kill-per-100 shots fired have shown no clear trend [Table 2].

Nonetheless, the number strikes involving these other 3 gull species in 1991 (54) was only 52% of the annual mean for 1988-1990 (104, Figure 3). During 1992-2002, the reduction in strikes by these other gull species was even more pronounced: 25-36% of the mean for 1988-1990 [Figure 3]. The 26-37 strikes per year involving these other gulls in 1992-2002 were the lowest strike totals for these 3 gull species since records began in 1979 [Table 1]. This reduction in strikes occurred even though these gull species are present at the airport all year, but shooting was only for 3 months (mid-May to mid-August).

Over 200,000 herring gulls and 60,000 great black-backed gulls nest along the Atlantic coast from Virginia to Maine (ANDREWS 1990) with an additional 250,000 herring gulls and 136,000 great black-backed gulls nesting in the Atlantic provinces of Canada (LOCK 1990). BLOKPOEL & TESSIER (1986) estimated 1.4 million nesting ring-billed gulls in the Great Lakes and upper St. Lawrence River. An additional 25,000 ring-billed gulls nest in the Atlantic provinces of Canada (LOCK 1990). Given the abundance and mobility of these species along the Atlantic coast of North America, it is unlikely that the numbers killed per year in 1991-2002 (means of 503, 119, and 63, respectively, for herring, great black-backed and ring-billed gulls) have significantly influenced local population levels. Thus, shooting apparently has influenced the behavior of some of these gulls to avoid the airport, a conclusion supported by behavioral data (BARRAS ET AL. 2000b, unpublished data).

For all gull species combined (laughing, herring, great black-backed, ring-billed), the number of strikes during 1992-2002 (30-68 per year) was 11-34% of the mean for 1988-1990 (261, Figure 3). The 30-68 strikes per year involving gulls (all species) in 1992-2002 were the lowest strike totals for gulls since records began in 1979 [Table 1].

3.7 Has shooting influenced strike rates of non-gull species?

The number of strikes involving non-gull species increased from a mean of 42 per year in 1988-1990 to 63 per year in 1991-2002. This increase demonstrated that shooting directed at gulls had no deterrent effect on non-gull species.

The increase in non-gull strikes was likely related to a slight increase in aircraft movements at JFK (see below) and to general increases in populations of various non-gull species over the past decade (DOLBEER 2000, DOLBEER & ESCHENFELDER 2002). For example, the number of diurnal raptors (northern harrier (*Circus cyaneus*), osprey (*Pandion haliaetus*), peregrine falcon (*Falco peregrinus*), American kestrel (*F. sparverius*), merlin (*F. columbarius*), red-tailed hawk (*Buteo jamaicensis*)) strikes at JFK doubled from 64 in 1979-1990 to 132 in 1991-2002 (PANYNJ, unpublished data). The number of goose (Canada (*Branta canadensis*) and brant (*B. bernicula*)) strikes increased from 17 to 28 over the same time periods.

Because of the dramatic reduction in strikes by gulls, the overall number of strikes (all species of birds) at JFK has declined by 60% from a mean of 302 per year in 1988-1990 to 120 per year in 1991-2002 [Table 1]. This reduction in strikes by gulls, 1991-2002, has resulted in an increase in the proportion of strikes caused by other (non-gull) species [Table 1, Figure 5]. Non-gull species comprised only 14% of strikes in 1988-1990 compared to 38%, 56%, and 62% in 1991-1994, 1995-1998, and 1999-2002, respectively.

3.8 Have the number of aircraft movements influenced strike rates at JFK?

The number of aircraft movements (arrivals and departures) at JFK averaged 329,000 per year from 1991-2001, which was an 8-9% increase over levels recorded in 1980 and 1990 [Table 4]. Thus, annual reductions in strikes (62-99% for laughing gulls; 48-76% for other gulls; 44-74% for all birds) in 1991-2002 compared to 1988-1990 occurred in spite of a slight increase in air traffic during the 1990s.

4. Discussion

The nesting colony in JBWR adjacent to JFK appeared to be the source of most laughing gulls flying over the airport. The fact that 88% of the females ≥ 3 years old shot during June-August in 2000-2001 had laid eggs (DOLBEER & BERNHARDT 2003) established that locally nesting birds were frequenting JFK airspace. The next closest laughing gull colony was in New Jersey, 106 km from JFK (BELANT & DOLBEER 1993b).

The fact that 14,886 gulls were killed at JFK in 1991 in only 896 person-hours of shooting (16.6 gulls/person-hour [15.8 laughing gulls, 0.8 other gulls] or about 1 gull every 3.6 person-minutes) demonstrated the high activity level of gulls on the airport. Our analyses of kill and strikes statistics for 1991-2002 compared to strike data for previous years indicate that the shooting program had a significant influence on local laughing gull numbers and on laughing gull and other gull flight patterns over the airport. By 2002, the laughing gull nesting colony in JBWR had declined to 42% of the 1990 level and strikes had declined to 3% of 1988-1990 levels.

The annual kill of 1,700-13,000 adult laughing gulls at JFK in 1991-2002 represented about 1-6% of the estimated (1987-1991) adult population in nesting colonies on the Atlantic coast from Virginia to Maine and 2-10% of the estimated (1989-1990) adult population in New Jersey and New York (BELANT & DOLBEER 1993b). Many of these Atlantic coast colonies grew at annual rates of $>5\%$ during the 1980s which indicates there has been a large cohort of laughing gulls along the Atlantic coast available to replace birds removed from the JBWR colony. Therefore, an annual shooting program at JFK, while effective in reducing the number of gull-aircraft collisions, will not likely eliminate the nesting colony from JBWR as long as JBWR remains attractive as a nesting location. It is also important to note that, as predicted by BELANT & DOLBEER (1993) and DOLBEER (1998a), the shooting program has not had a negative impact on the overall population of laughing gulls along the Atlantic and Gulf Coasts of the USA (based on population trends estimated from North American Breeding Bird Survey data, 1970-2001; BURGER 1996, SAUER ET AL. 2002). In fact, the overall population of laughing gulls in the USA has shown a mean annual increase ($P = 0.05$) of 4.3%, 1966-2001 (SAUER ET AL. 2002). The laughing gull nesting population north of New York in the Gulf of Maine has increased from about 765 to 3,732 nests, 1991-2002 (L. WELCH, U.S. Fish and Wildlife Service, unpublished data).

The shooting program was designed in 1991 to deal primarily with a specific problem of laughing gulls from a large, nearby nesting colony flying over the airport to dispersed feeding sites beyond the airport. However, laughing gulls are only one component of the bird-strike problem at JFK. As noted above, a 1997 survey indicated about 2,500 and 400 nests of herring and great black-backed gulls, respectively, in JBWR (K. BROWN, Cornell University, unpublished data). These gulls are nesting on islands 4-7 km from JFK (as opposed to 0.5-2 km for laughing gulls), but their larger size (2-4 kg; Dunning 1993) makes them more hazardous to aircraft than laughing gulls (HOVEY ET AL. 1991). In addition, as a result of the shooting program directed at gulls and general increases in populations of many non-gull species, the proportion of strikes caused by non-gull species has increased from 14% (1988-1990) to 62% (1999-2002). The PANYNJ must continue developing an integrated management program to minimize strikes by these other gull and non-gull bird species on the airport.

To this end, the PANYNJ instituted falconry programs at JFK in 1996-2002 as part of an expanded integrated bird management program. The PANYNJ contracted with falconers (different contractor in 1996, 1997, and 1998-2002) to fly trained hawks and falcons, in addition to using traditional bird scaring techniques (e.g., pyrotechnics), from June-October 1996, July-November 1997, June-November 1998 and May-October 1999-2002. An analysis of strike data for 1988-1998 indicated the 1996-1998 falconry programs, although providing positive publicity for JFK and enhancing the overall bird-management program, had little effect on strike rates (DOLBEER 1998*b*, DOLBEER 1999). Strike numbers in 1996-1998 were within the range of values for 1991-1995 when shooting, but not falconry, was active at JFK. The strike data for 1999-2002 [Table 1; Figures 3, 5] indicated a pattern similar to 1996-1998 except that 2000 and 2002 data showed a major decline in strikes of laughing gulls.

5. Conclusions and recommendations

1. A program to reduce gull collisions with aircraft was undertaken at JFK from 1991-2002 in which 2-5 biologists stationed on airport boundaries used shotguns to shoot gulls flying over the airport on 31-62 days annually from 9 May-23 August.
2. There was a large population of gulls flying over JFK in summer 1991, as evidenced by the ability of shooters to kill 14,191 laughing gulls and 695 other gulls (herring, great black-backed, ring-billed) in only 896 person-hours of shooting (16.6 gulls/person-hour). Strikes with laughing gulls and other gulls in 1991 were reduced to 38% and 52%, respectively, of numbers in 1988-1990.
3. In 1992-2002, fewer laughing gulls attempted to fly over the airport as determined by numbers killed, numbers killed per person hour, and numbers killed per 100 shots taken. The number of laughing gulls struck by aircraft also declined in 1992-2002 to about 3% (2002) of 1988-1990 levels. However, the number of adult laughing gulls nesting in the adjacent colony declined to only 42% of the 1990 level (from 7,629 nesting pairs in 1990 to 3,238 in 2002). Thus, at least some laughing gulls associated with the colony appeared to alter flight patterns to avoid the airport.
4. During 1992-2002, the reduction in strikes by the other gull species was also pronounced: 25-36% of the mean for 1988-1990 [Figure 3]. The 26-37 strikes per year involving these other gulls in 1992-2002 were the lowest strike totals for these 3 gull species since records began in 1979. Thus, shooting apparently influenced the behavior of these gulls to avoid the airport.
5. The annual killing of laughing gulls on the airport, while effective in reducing strikes, was not effective in eliminating the colony from its present location adjacent to the airport. A preferable long-term approach to minimize the number of laughing gulls shot each year would be to relocate the colony from JBWR. This plan could include habitat alteration, nest destruction, and other harassment and management techniques at the colony along with efforts to attract laughing gulls to new colony sites away from JFK (SEUBERT 1990).
6. The shooting program was designed in 1991 to deal primarily with a specific problem of laughing gulls from a large, nearby nesting colony flying over the airport to dispersed feeding sites beyond the airport. The shooting program also was directed at other gull species (herring, great black-backed, and ring-billed) that frequented the airport during May-August. As a result of the shooting program that has dramatically reduced strikes by gulls, the overall number of strikes (all species of birds) at JFK has declined 60% from a mean of 302 per year in 1988-1990 to 120 per year in 1991-2002. As a consequence, the proportion of strikes caused by non-gull species has increased from 14% (1988-1990) to 62% (1999-2002). The PANYNJ must continue developing an integrated management program to minimize strikes by these other bird species on the airport.
7. This study demonstrated that shooting can significantly reduce gull-aircraft collisions at an airport by both reducing the local population and altering the flight patterns of surviving gulls. Shooting, if done by professional biologists with close monitoring to ensure that regional populations are not adversely impacted, can be an important component of integrated programs at airports to reduce bird hazards to aviation.

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Table 1. Number of laughing gull nests in Jamaica Bay Wildlife Refuge (JBWR) and, for nearby John F. Kennedy International Airport, the minimum numbers of aircraft striking birds during takeoffs and landings, 1979-2002.

| Year | Number of laughing gull nests (JBWR) ^b | Number of aircraft striking birds (number of birds struck) ^a | | | |
|--------------|---|---|--------------------------|------------------------|---------------|
| | | Laughing gulls | Other gulls ^c | Other birds | Total |
| 1979 | 15 | 2 (2) | 86 (103) | 29 (34) | 117 (139) |
| 1980 | 235 | 19 (19) | 98 (98) | 29 (44) | 146 (161) |
| 1981 | 325 | 20 (20) | 44 (61) | 36 (42) | 100 (123) |
| 1982 | 715 | 14 (14) | 68 (72) | 38 (64) | 120 (150) |
| 1983 | 1,805 | 48 (51) | 89 (98) | 62 (63) | 199 (212) |
| 1984 | 2,802 | 58 (61) | 114 (136) | 79 (91) | 251 (288) |
| 1985 | 2,741 | 82 (86) | 139 (198) | 72 (102) | 293 (386) |
| 1986 | - | 59 (60) | 42 (43) | 37 (47) | 138 (150) |
| 1987 | - | 118 (135) | 73 (77) | 35 (36) | 226 (248) |
| 1988 | - | 164 (180) | 115 (155) | 36 (40) | 315 (375) |
| 1989 | - | 171 (187) | 108 (143) | 35 (40) | 314 (370) |
| 1990 | 7,629 | 135 (142) | 89 (95) | 54 (97) | 278 (334) |
| 1991 | - | 60 (64) | 54 (58) | 42 (269) ^d | 156 (391) |
| 1992 | 6,875 | 22 (22) | 37 (39) | 42 (49) | 101 (110) |
| 1993 | 6,654 | 18 (18) | 25 (25) | 37 (73) | 80 (116) |
| 1994 | 5,334 | 21 (21) | 37 (39) | 45 (73) | 103 (133) |
| 1995 | 5,695 | 36 (47) | 32 (33) | 49 (177) ^d | 117 (257) |
| 1996 | 5,033 | 29 (35) | 33 (33) | 84 (105) | 146 (173) |
| 1997 | 3,872 | 37 (39) | 27 (28) | 105 (398) ^d | 169 (465) |
| 1998 | 5,613 | 17 (18) | 29 (29) | 67 (87) | 113 (134) |
| 1999 | 4,076 | 13 (13) | 36 (40) | 84 (107) | 133 (160) |
| 2000 | 2,720 | 2 (2) | 36 (37) | 57 (128) | 95 (167) |
| 2001 | 4,310 | 21 (22) | 35 (37) | 68 (101) | 124 (160) |
| 2002 | 3,238 | 4 (4) | 26 (27) | 75 (115) | 105 (146) |
| Total | | 1,170 (1,262) | 1,472 (1,704) | 1,297 (2,382) | 3,939 (5,348) |

^a Unpublished data, Port Authority of New York and New Jersey. Includes all reported strikes plus unreported strikes (i.e., carcasses found within 200 feet of centerline of active runway which showed evidence of having interacted with aircraft; BURGER (1985), BARRAS & DOLBEER (2000)).

^b Data from 1979-1984 (BUCKLEY & BUCKLEY 1984), 1985 (BUCKLEY & GURIEN 1986), 1990 (GRIFFIN & HOOPES 1991), and 1992-2002 (DOLBEER ET AL. 1997, DOLBEER & BERNHARDT 2002).

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

^d Single aircraft struck 194 European starlings (*Sturnus vulgaris*) in 1991 and 100-163 tree swallows (*Tachycineta bicolor*) in 1995 and 1997).

Table 2. *Person-hours expended, shots fired, and gulls killed at John F. Kennedy International Airport, May-August 1991-2002*

| Year | No. of days | Person hours | Shots fired | Laughing gulls killed | | | Other gulls ^a killed | | | Total gulls killed |
|-------|-------------|--------------|-------------|-----------------------|------------------------------|---------------|---------------------------------|------------------------------|---------------|--------------------|
| | | | | Total | Per person hour ^a | Per 100 shots | Total | Per person hour ^a | Per 100 shots | |
| 1991 | 62 | 896 | 27,047 | 14,191 | 15.8 | 52.5 | 695 | 0.8 | 2.6 | 14,886 |
| 1992 | 61 | 1,310 | 31,183 | 11,847 | 9.0 | 38.0 | 1,619 | 1.2 | 5.2 | 13,466 |
| 1993 | 52 | 1,195 | 20,492 | 6,496 | 5.4 | 31.7 | 844 | 0.7 | 4.1 | 7,340 |
| 1994 | 31 | 717 | 12,510 | 3,688 | 5.1 | 29.5 | 293 | 0.4 | 2.3 | 3,981 |
| 1995 | 42 | 861 | 16,216 | 6,167 | 7.2 | 38.0 | 592 | 0.7 | 3.7 | 6,759 |
| 1996 | 34 | 657 | 7,651 | 1,970 | 3.0 | 25.7 | 293 | 0.4 | 3.8 | 2,263 |
| 1997 | 35 | 733 | 11,391 | 3,242 | 4.4 | 28.5 | 298 | 0.4 | 2.6 | 3,540 |
| 1998 | 43 | 791 | 9,008 | 2,920 | 3.7 | 32.4 | 298 | 0.4 | 3.3 | 3,218 |
| 1999 | 60 | 1,208 | 11,585 | 2,841 | 2.4 | 24.5 | 538 | 0.4 | 4.6 | 3,379 |
| 2000 | 61 | 1,091 | 15,010 | 3,606 | 3.3 | 24.0 | 613 | 0.6 | 4.1 | 4,219 |
| 2001 | 60 | 1,123 | 13,753 | 3,194 | 2.8 | 23.2 | 629 | 0.6 | 4.6 | 3,823 |
| 2002 | 70 | 1,301 | 17,791 | 3,676 | 2.8 | 20.7 | 1,513 | 1.2 | 8.5 | 5,189 |
| Total | 611 | 11,883 | 193,637 | 63,838 | 5.4 | 33.0 | 8,225 | 0.7 | 4.2 | 72,063 |

^a Other gulls = 74% herring gulls, 17% great black-backed gulls, and 9% ring-billed gulls.

Table 3. *Age composition of laughing, herring, great black-backed, and ring-billed gulls shot and retrieved at John F. Kennedy International Airport, May-August 1991-2002, and projected total number killed for each age class.*

| Age class (from Grant 1986) | % of retrieved birds (projected total number killed) | | | |
|--|--|--------------|--------------|------------|
| | Laughing | Herring | Gr. Blk-back | Ring-bill |
| Adult ^a | 90.4 (57,697) | 55.7 (3,362) | 72.6 (1,034) | 47.9 (366) |
| Subadult (≥1 year old) ^b | 7.9 (5,069) | 36.7 (2,216) | 22.1 (314) | 51.2 (392) |
| Subadult (hatch year) | 1.7 (1,072) | 7.6 (459) | 5.3 (75) | 1.0 (7) |
| Total killed^c | 63,838 | 6,037 | 1,423 | 765 |
| Total retrieved^d | 53,600 | 4,846 | 1,148 | 703 |

^a Includes 2-year old laughing gulls.

^b For laughing gulls, subadults are 1-year old gulls. For other gulls, subadults in 1992-2002 were further classified as 1 year old (hatched in previous summer) and >1 year old. Forty-nine, 62, and 15% of the subadult herring, great black-backed, and ring-billed gulls, respectively, were classified as 1-year old birds in these 11 years.

^c Population from which projected number killed/age class was based.

^d Population from which age class was determined.

Table 4. *Aircraft movements (number of arrivals and departures), air passenger enplanements and air cargo tonnage at John F. Kennedy International Airport, 1980, 1990-2001.^a*

| Year | Aircraft movements | Passengers | Cargo and mail (metric tons) |
|-------------|---------------------------|-------------------|-------------------------------------|
| 1980 | 307,527 | 26,796,066 | 1,190,427 |
| 1990 | 303,716 | 29,794,350 | 1,322,724 |
| 1991 | 277,761 | 26,229,068 | 1,347,100 |
| 1992 | 323,448 | 27,760,912 | 1,351,369 |
| 1993 | 333,813 | 26,796,849 | 1,382,410 |
| 1994 | 343,599 | 28,819,243 | 1,462,064 |
| 1995 | 340,098 | 30,375,378 | 1,592,294 |
| 1996 | 355,214 | 31,155,411 | 1,636,830 |
| 1998 | 343,429 | 31,044,595 | 1,597,489 |
| 1999 | 339,597 | 31,103,366 | 1,617,526 |
| 2000 | 345,311 | 32,827,864 | 1,819,210 |
| 2001 | 292,367 | 29,400,000 | 1,430,984 |

^a Data from Port Authority of New York and New Jersey (1997 data missing; 2002 data not available) (www.panynj.gov/aviation/jhismain.htm#stat).

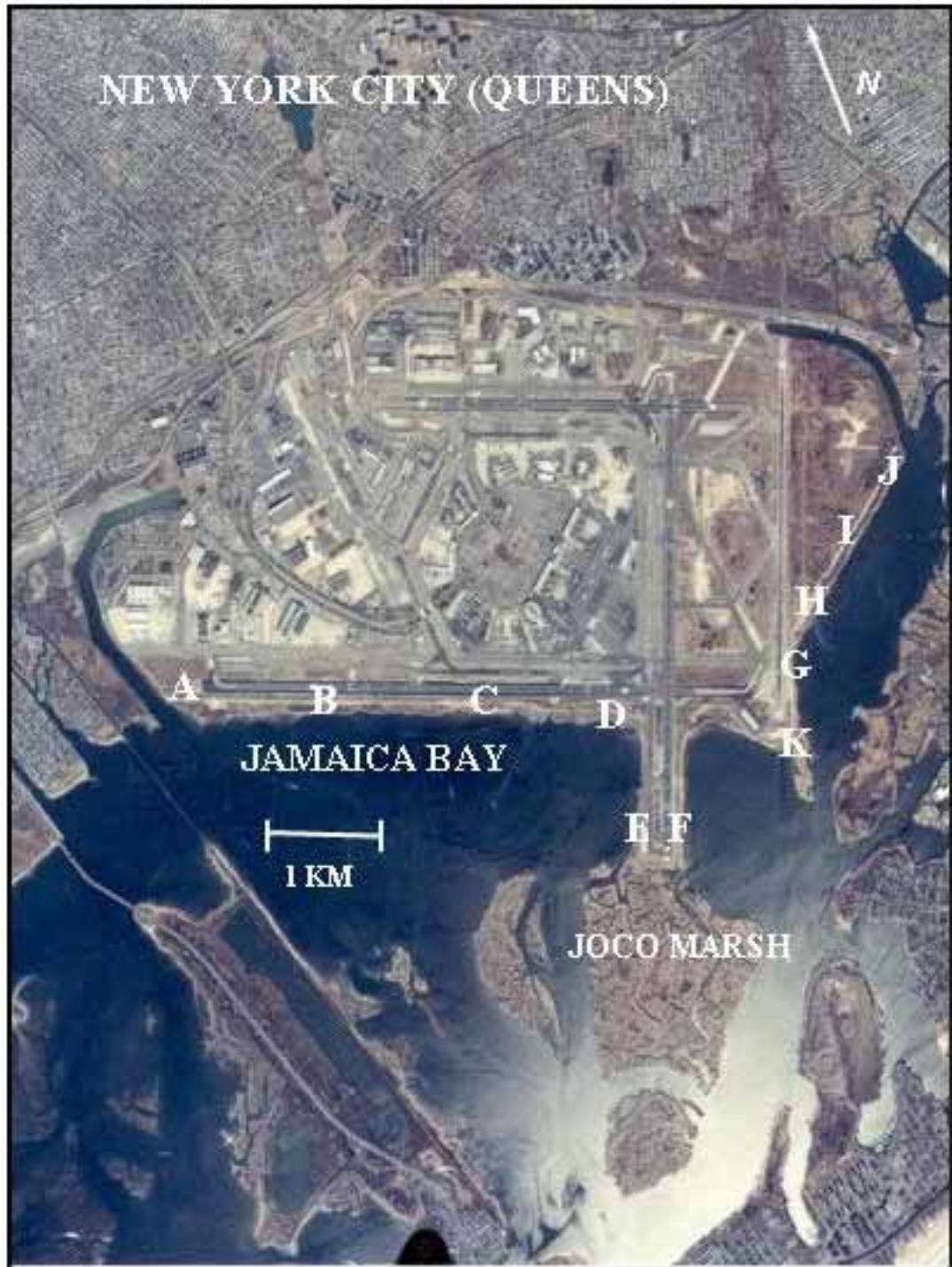


Figure 1. Aerial photograph of John F. Kennedy International Airport showing location of nesting colony of laughing gulls (Joco and adjacent marshes in Jamaica Bay) and the 11 shooting zones (A to K along the southeastern and southwestern boundaries of the airport), 1991-2002. Zones G-J were used only in 1991.

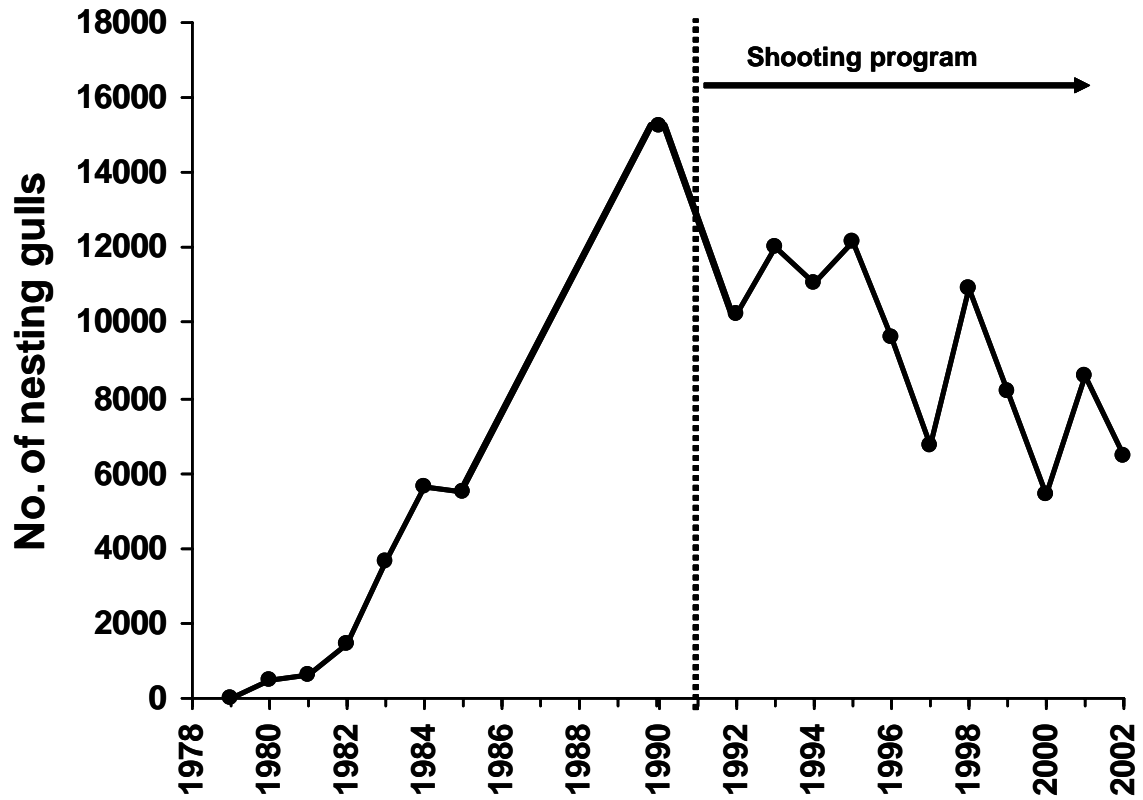


Figure 2. Population trend of laughing gull nesting colony in Jamaica Bay, New York, 1979-2002 (see Table 1 for source of data).

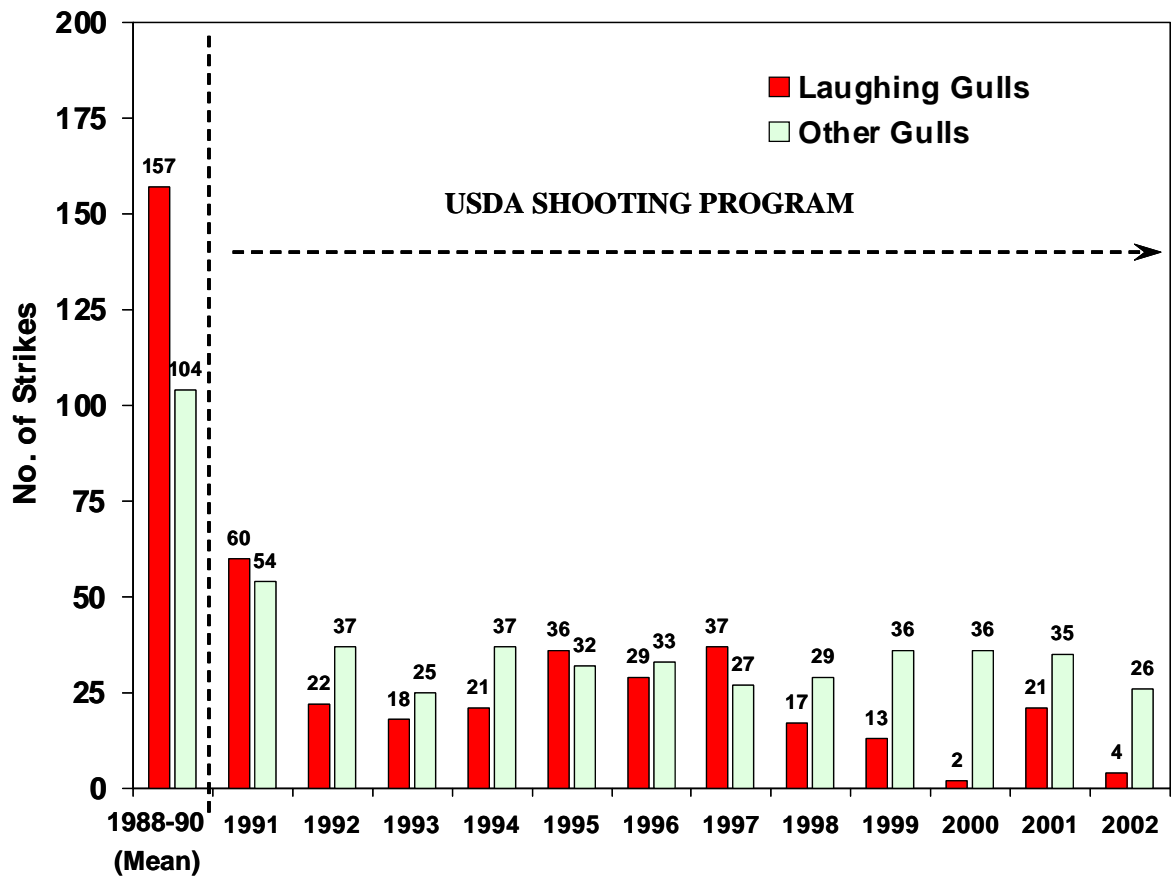


Figure 3. Number of aircraft striking laughing gulls and other gulls (herring, great black-backed, ring-billed), JFK International Airport, New York, 1988-2002.

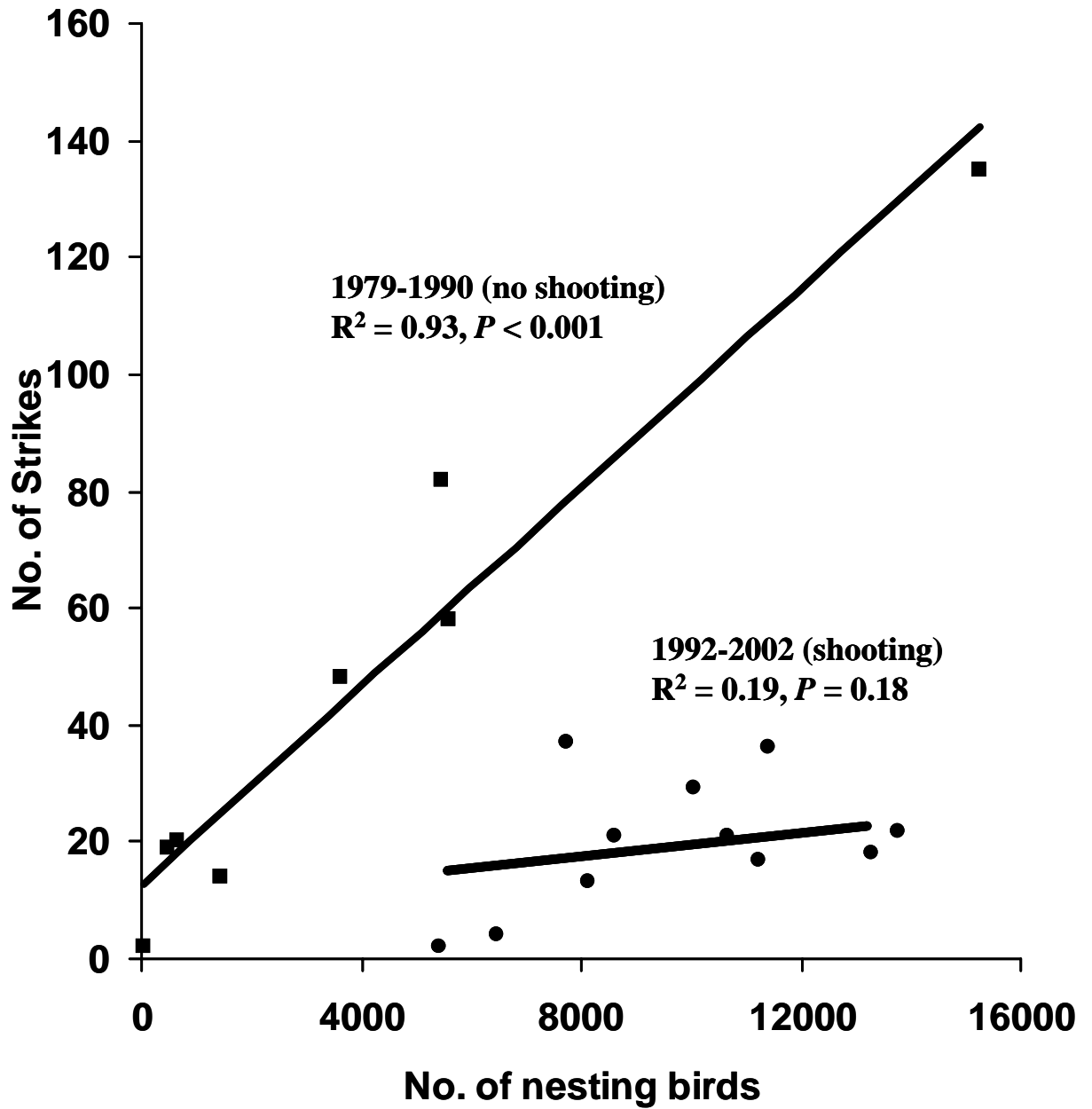


Figure 4. Linear correlation between number of nesting laughing gulls in Jamaica Bay Wildlife Refuge, New York, and the number of strikes with laughing gulls at John F. Kennedy International Airport, 1979-1990 and 1992-2002.

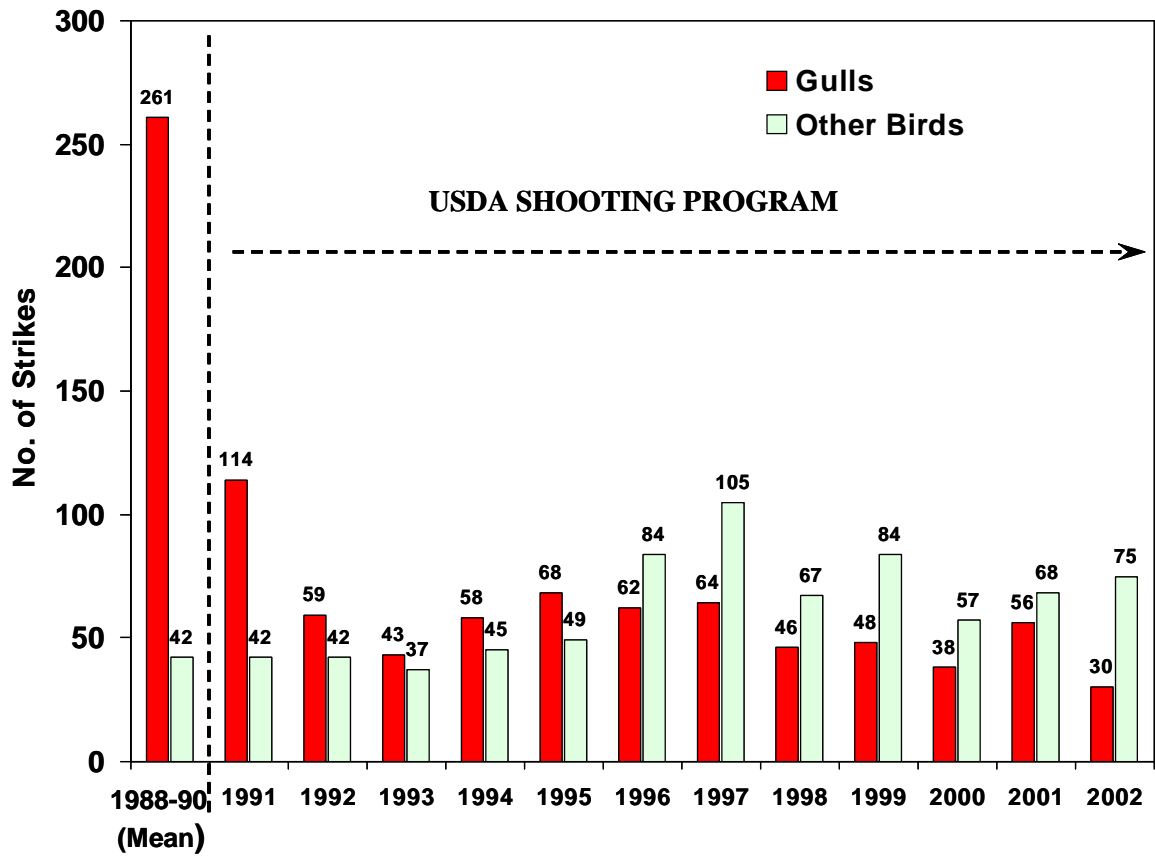


Figure 5. Number of aircraft striking gulls (laughing, herring, great black-backed, ring-billed) and other birds, JFK International Airport, New York, 1988-2002.

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EFFECTS OF DISTURBANCE BY AIRCRAFT OVERFLIGHT ON WATERBIRDS – AN EXPERIMENTAL APPROACH

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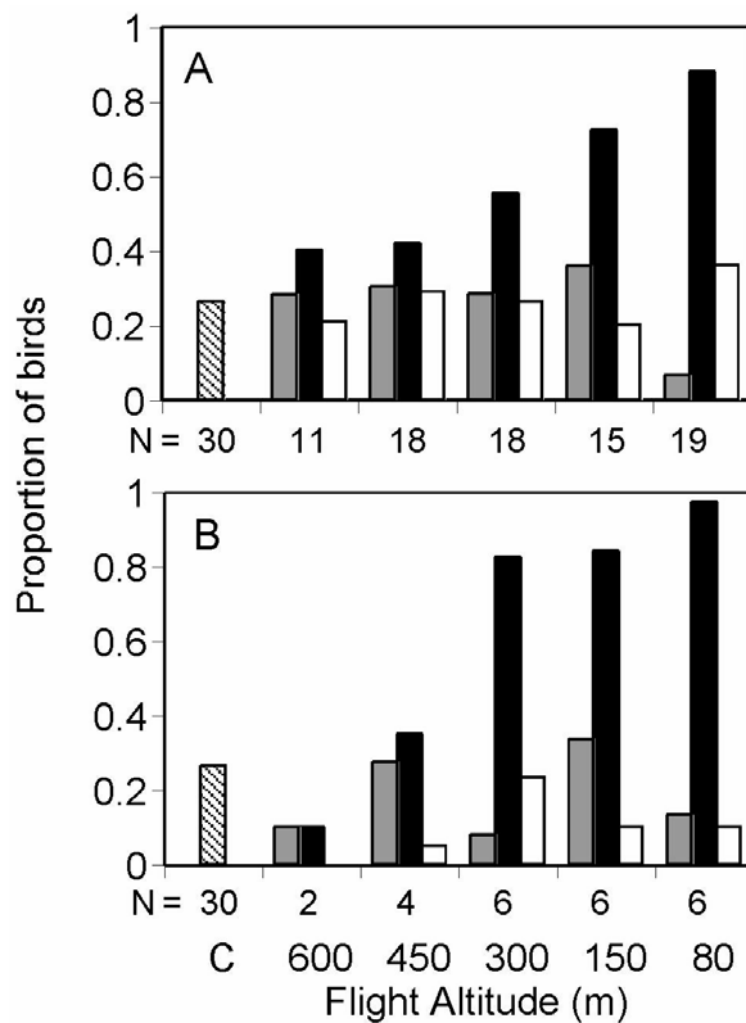


Figure 3. Comparison of the mean proportion of waterbirds with stressed behaviours during the series of overflights with decreasing altitudes (from 600 to 80 m AGL) with the behaviour at days without flights (C control, hatched columns) for helicopters (A) and for aeroplanes (B). The white columns illustrate the behaviour five minutes before, the black during and the grey five min. after the overflights.

