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Reducing Gull Hazards to Aviation by Controlling Nesting Populations

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ABSTRACT

Gull nesting colonies established adjacent to airports cause serious aviation hazards, and the colony in Jamaica Bay, N.Y. is a current example. These birds can cause damage or the loss of aircraft and occupants when ingested into one or more turbine engines, usually during takeoffs, and populations have increased in many countries -- exacerbating hazards. Gulls are controlled routinely to benefit other birds, but less often for aviation safety. If significant hazard reduction cannot be accomplished quickly by other methods, there should be no reluctance to making habitat unsuitable for nesting or killing gulls using humane methods. Countries that reduce adult gull populations have accepted the premise that if gulls become hazards then they should be controlled. Various strategies are discussed for alleviating or eliminating hazards from nesting colonies adjacent to airports. Gull hazards that originate beyond airport boundaries should be controlled even if the authority to do so must be based on litigation. Enhancement of U.S. bird management programs is needed and would require higher priorities, greater resources, and the adoption of a stronger safety ethic by the responsible agencies.

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1.0 Introduction

This paper is prompted by a serious gull hazard problem at John F. Kennedy Airport (JFK), N.Y., N.Y. caused by a colony of nesting laughing gulls (See Appendix A for scientific names) located in Jamaica Bay Wildlife Refuge within 0.4 km (0.25 mi) of the airport. The refuge consists mostly of open bays and salt marsh islands and is part of Gateway National Recreation Area administered by the U.S. National Park Service (NPS).

The gulls nest on three islands encompassing 477 acres: Joco Marsh, East High Meadow, and Silver Hill Marsh. The gulls arrive in April and migrate south in October. The nesting population began with 15 pairs in 1979, increased to 325 pairs in 1981, 2741 pairs in 1985, an estimated 3000 pairs in 1989 (Table 1.0), and about 6000 pairs in 1990 (R.A. Dolbeer, pers. commun.). This accelerated growth was much greater "than could have occurred from reproduction in the colony, suggesting that many of the gulls immigrated from expanding colonies in New Jersey" (Dolbeer et al. 1989:38). New Jersey laughing gull colonies are about 113 km (70 mi) from JFK and were censused in 1989 using a helicopter. About 59,000 birds were counted. This figure represents a minimum estimate of the total population (R.M. Erwin, pers. commun.)

Collisions between laughing gulls and aircraft have increased considerably from two strikes in 1979 to 180 strikes in 1988 and 179 in 1989 (Table 1.0). These high numbers of strikes in 12-month periods probably were only exceeded in the United States by the large numbers of Laysan and black-footed albatrosses struck or killed by aircraft on Midway Island (Robbins 1966).

Table 1.0 Birds involved in strikes with aircraft, JFK Airport, and estimated number of nesting pairs in laughing gull colony on Jamaica Bay, 1979-89 (Excerpted from Dolbeer et al. 1989, Table 2).

	Number of gulls (% of all gulls)					Estimated
Year	Laughing gulls	Other gulls	All gulls	Other birds	All birds	Nesting Pairs a/
1979	2 (2)	111 (98)	113	25	138	15
1980	19 (17)	96 (83)	115	28	143	235
1981	18 (22)	63 (78)	81	40	121	325
1982	14 (17)	70 (83)	84	61	145	715
1983	43 (29)	106 (71)	149	55	204	1,805
1984	60 (30)	139 (70)	199	90	289	2,802
1985	86 (30)	199 (70)	285	100	385	2,741
1986	62 (57)	46 (43)	108	25	133	3,000
1987	137 (65)	75 (35)	212	32	244	2,875
1988	180 (55)	149 (45)	329	32	361	2,665
1989	179	109	288	29	317	>3,000
Totals	800 (41)	1,163 (59)	1,963	517	2,480	

a/ Laughing gulls -- Jamaica Bay Wildlife Refuge.

In addition to the great number of laughing gull strikes at JFK, airport records indicate that since 1986 three DC-10 takeoffs were aborted because of laughing gull ingestions into engines. One incident required an engine change and another involved a damaged engine. Therefore, even though the laughing gull weighs less than several other species commonly involved in bird strikes, e.g., herring, great black-backed, and the ring-billed gull (See Appendix B for bird weights), this species is hazardous to aircraft since even one 10-12 ounce (284-283g) bird can cause severe engine damage. Furthermore, laughing gull strikes involving three or more birds have been increasing (Dolbeer et al. 1989). Because laughing gulls account for the majority of strikes at JFK, it would seem prudent that all measures should be taken to reduce this hazard.

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2.0 Actions to Resolve the Laughing Gull Hazard at JFK Airport

In 1989, at the invitation of the NPS, a panel of four biologists from other countries assessed the hazard at JFK caused by laughing gulls nesting on NPS marshes in Jamaica Bay, and made recommendations for reducing the hazard. Their report states in part, "that the laughing gull colony in its present location presents an unacceptable hazard to aircraft operations at JFK." The panel also expressed the opinion that an effective control program for the 1990 nesting season should include the oiling of all eggs in the colony (Thomas et al. 1989).

3.0 Bird Hazards to Aviation

3.1 Incidents and Accidents

An extensive literature documents that many species of birds, especially gulls, are serious hazards to aviation in many countries. Most of the serious incidents are bird strikes on engines and windscreens. Gulls account for a high proportion of bird strikes, and they have caused damage to many aircraft and even the loss of aircraft and occupants (Seubert 1963, 1977, Hild 1969, Blokpoel 1976, Rochard and Horton 1980, Frings 1984, Thorpe 1988, Thorpe and Hole 1988, DeFusco 1988, Hovey and Skinn 1989).

One gull (or bird) at the wrong place at the wrong time can cause an aviation tragedy or high economic loss, especially if ingested into a turbine-powered engine. Although an engine manufacturer has stated that "one bird was not a hazard, and that from a manufacturing viewpoint, he could take responsibility for one bird and for a one engine out situation" (Weaver 1989:8), the accident records show quite clearly that one bird in an engine <u>can</u> result in serious incidents or accidents as follows. A Convair 580 crashed at takeoff at Kalamazoo, Michigan, when one American kestrel was ingested into an engine (Thorpe 1984). A 737 overran a runway at a Gosselies, Belgium, while attempting to abort a takeoff after one wood pigeon was ingested into an engine (the aircraft was a total loss) (Thorpe 1984). At Rio de Janeiro, a CFM 56 engine of a 737 failed during takeoff after a barn owl was ingested. The aircraft successfully continued the takeoff on the remaining engine, but the damage to the failed engine was substantial (B.C. Fenton, pers. commun.).

At the Dublin, Ireland Airport on 7 December 1985, the No. 1 engine (JT8D-9A) of a 737 failed in an uncontained manner during takeoff after ingesting one or possibly two black-headed gulls. The aircraft successfully continued the takeoff on the remaining engine in spite of serious associated problems as described in the official accident report (McStay 1987:24) as follows:

> "The sudden loss and displacement of the No. 1 engine, the loss of the nose cowl, the abrupt reduction in the rate of climb, the slamming closed of the power lever controlling No. 1 engine, the audio and visual warnings and the buffeting and behavior of the aircraft presented the flight crew with an emergency not rehearsed or envisioned."

There are other examples where several birds were ingested into an engine with disastrous results: an aero commander turbo prop crashed at takeoff into Lake Michigan, Chicago, Illinois, after ingesting gulls (<u>Larus</u> sp.) into one engine (Seubert 1978) and a DC-10 was destroyed by fire at JFK after ingesting great black-backed gulls into the right engine (Seubert 1976).

In addition, very costly and extremely dangerous incidents have occurred when birds are ingested into more than one engine. An example of such an event occurred at Los Angeles Airport in September 1989 when a 747-300 ingested four domestic pigeons into the No. 1 engine and five into the No. 2 engine on takeoff. Violent compressor stalls occurred on both engines. The No. 1 engine recovered, but the No. 2 did not, and was shut-down. Fuel was dumped and the aircraft landed at 630,000 pounds, gross weight. The No. 1 engine suffered extensive fan damage, and the No. 2 engine underwent transverse fracture of one fan blade, extensive fan and cowl damage, and loss of tailcone. These bird ingestions occurred during a critical takeoff regime -- at rotation, where the pilot was committed to continue the takeoff. If the No. 1 engine had not recovered in this incident, it is doubtful that the takeoff could have safely continued.

3.2 Bird Hazards to Turbofan Engines

Although birds are seldom ingested into turbofan engines, when this does occur it results in damage in about one half of the incidents. To obtain a better understanding about this problem, the Federal Aviation Administration (FAA) has been conducting studies to assess the extent of bird hazards to engines. Some of their results are presented in this paper, since they bear directly on my concerns regarding bird hazards to aviation, especially when large numbers of a hazardous species are nesting very close to an airport.

The FAA has assessed the potential hazards of dual engine bird ingestions to large, high-bypass turbofan engines during the take off/climb phase of flight (Cheney et al. 1981). The executive summary and conclusions include the following:

-- Parties concerned about bird hazards to aviation, such as aircraft and engine certification personnel, airframe and engine manufacturers, and airport evaluators, have difficulty in assessing overall bird strike hazards and in identifying safety trends because of a fragmented data base for bird strikes.

-- The risk of bird strikes will increase with the addition to air fleets of more wide-body transport aircraft with high-bypass turbofan engines in the short and medium haul airline markets.

-- An analysis of the best bird engine ingestion data available indicates that a dual engine failure involving a current wide-body aircraft will occur within the service life of the aircraft type, and it is estimated that several additional dual engine failure events will occur within the service life of newly certified wide-body aircraft.

-- Overall bird strikes and engine ingestions involving flocks of birds can be significantly reduced through airport bird control procedures, especially at major foreign and domestic airports.

The study by Cheney et al. (1981) presented good information for its time (B.C. Fenton, pers. commun.). However, another similar study (FAA) presently underway, will provide a much greater base of data for the years 1989-1991. A final report should be completed in early 1992.

In 1981, an investigation was begun by the FAA to determine the numbers, weight, and species of birds that are ingested into large high-bypass ratio turbine aircraft engines during service operation and to determine what damage, if any, resulted (Frings 1984). This information was requested from the three major engine manufactures under contracts with the FAA. The aircraft involved were the DC8, DC10, B747, B757, B767, A300, A310, and L1011. The executive summary and conclusions included the following:

-- Most bird ingestions, engine damage, and engine failures occurred in the bird weight range between 9 ounces (255g) and 24 ounces (680g). United States birds are heavier than birds in foreign environments. For example, Rochard and Horton (1980) report that during an 11-year period in the United Kingdom, 62.5 percent of 1541 bird strikes involved species weighing 10.6 ounces (300g) or less.

-- Gulls are the most commonly ingested bird worldwide, accounting for 35 percent of all ingestions.

-- Four-engine (wing-mounted) aircraft experience about twice the ingestion rate of wing-mounted two-engine aircraft.

-- The majority of bird ingestions resulted in either minor or some damage to engines.

-- Most ingestions occurred during takeoff or landing.

-- The probability of an engine failure resulting from the ingestion of one or more birds is about five percent.

The FAA also has a 3-year study underway to determine the numbers, sizes, and type of birds that are ingested into medium and large inlet area turbofan engines and to determine what damage, if any, results. Bird ingestion data are being collected for the B737 aircraft equipped with either JT8D or CFM 56 engines. Preliminary findings were presented in the executive summary and conclusions of an interim report that covered the first year of this 3-year study (Hovey and Skinn 1989). The findings include the following:

-- Ingestion rates appear to be proportional to either the inlet area or diameter of the engine, since no statistically significant difference in the ingestion rate of the two engines was detected after the data were adjusted for inlet area or diameter.

-- When more severe damage is inflicted on an engine, unusual crew actions are more likely.

-- The majority of bird ingestions (273 of 302) involved a single bird and a single engine on the aircraft and resulted in little or no engine damage.

A final report covering three years of data collection will not be completed until late 1990.

3.3 Engine Out Procedures

Transport turbofan aircraft with two, three, and four engines are designed to be able to takeoff even if one engine fails at V-1 a/ or later (FAA 1989). If an engine fails during takeoff the pilot can take action to abort the takeoff up to V-1. If an engine fails at V-1, the pilot can either abort or takeoff. If there is an engine failure above V-1, then the pilot is committed to takeoff (Federal Aviation Administration 1978) and should be successful if all remaining engines and systems function properly. Unfortunately, accidents have occurred with one engine out (See Bird Hazards to Aviation). The matter becomes more serious in a worst case scenario (aircraft at maximum weight), if power is lost in more than one engine shortly (a few seconds) after V-1 and the pilot is committed to continue the takeoff.

a/ V-1 - Takeoff decision speed. Formerly denoted as critical engine failure speed. [Speed that an aircraft can accelerate to and still abort a takeoff.]

To obtain some idea about the performance of various aircraft, I asked several experts if either 2, 3, or 4-engine aircraft would be able to continue a takeoff shortly after V-1 if thrust was lost from the equivalent of 1 1/2 engines. Such a situation would result in a loss of 75 percent of the thrust in a 2-engine aircraft, 50 percent loss in a 3-engine aircraft, and 37.5 percent loss in a 4-engine aircraft. The consensus was that the takeoff probably could not continue.

Also, Cheney et al. (1981:39) discuss a worst case scenario involving a dual engine failure during the takeoff or climb regime. The authors state that "figures do not directly estimate the probability that an aircraft will be lost due to such an occurrence" and that "there are too many variables to predict the sequence of events following a dual engine failure at or above V-1, but that it should be assumed that the aircraft will overrun the runway or make a forced landing at best."

A bird ingestion into a large high bypass ratio turbine engine "is considered a rare (2.33×10^{-4}) but probable event" (Frings 1984:ix). Nevertheless, in my opinion, one would not want to lose even one engine to a bird(s) on a heavily laden aircraft shortly after V-1.

4.0 Gull Populations

4.1 Growth

The large growth in the NPS laughing gull colony adjacent to JFK is not unique. Gull populations in many countries have grown dramatically during the past 40-50 years. Drury (1963) and Kadlec and Drury (1968) document increases in New England herring gull populations, and conclude that these populations had been doubling about every 12 to 15 years, growing to an estimated 623,700 birds by 1965 (excluding the Great Lakes and the Gulf of St. Lawrence). Harris (1970) reports that herring gulls have increased greatly in Britain, probably doubling in numbers between 1950-1970. Hickling (1969) reports that black-headed gulls increased in England and Wales in excess of 25 percent during a 20-year period. A colony of silver gulls increased from 8 pairs in 1970 to 50,000 pairs in 1986 at Devonport, in northern Tasmania, according to P.M. Davidson (pers. commun.). The black-headed gull and the herring gull increased significantly in Denmark during the past several decades (Asbirk and Joensen 1974). Herring gulls increased in The Netherlands to such an extent that gulls have been controlled since 1934 (Bruyns 1958). Gibson (1979) states that a silver gull population breeding on the Five Islands, New South Wales, Australia, increased spectacularly from about 1000 pairs prior to 1940 to over 50,000 pairs in 1978. In 1989 (P. Straw, pers. commun.) estimates this population at 30,000 pairs.

An enormous increase in the number of gulls (Larus sp.) in the Ontario, Canada, portion of the Great Lakes has occurred since 1976, when the ring-billed gull (RBG) population increased from 40,787 to 163,593 nests in 1984. The RBG population in the entire Great Lakes area increased from 281,000 pairs in 1976 to 648,000 pairs in 1984 -- an average annual growth rate of 11 percent. Substantial future increases are predicted in the numbers of RBGs nesting in the Great Lakes and St. Lawrence River region (Blokpoel 1983, Blokpoel and Tessier 1986). The growth of the RBG population at the Eastern Headland of the Toronto Outer Harbour is another good example. In 1973, 21 pairs of RBGs nested; in 1982 and 1983 there were 75,000 to 80,000 pairs (Blokpoel 1983:2).

The increase in gull populations has been attributed mainly to legal protection, availability of nesting habitat, characteristics of gulls that are suitable to man's environment, and an abundance of food -- man's waste, especially garbage, and fish waste in some areas. The use and importance of garbage is well documented (Bruyns 1958, Harris 1965, Drury and Nisbet 1969, Spaans 1971, Kihlman and Larsson 1974, Conover et al. 1979, Burger 1981, Horton et al. 1983, Patton 1988).

4.2 Gull Problems and Control

The destruction by gulls of the eggs and chicks of many other species (e.g., Sandwich, common, Arctic, and roseate terns; black guillemot; Atlantic puffin; razorbill; redshank; storm petrel; common eider; avocets) nesting on their traditional breeding grounds and gull hazards to aviation are the principal problems caused by gulls (Larus spp). These problems have become exacerbated by the growth of gull populations. Many countries have implemented control programs and the principal methods have been the oiling or pricking of eggs; shooting; harassment; exclusion; collection of eggs; destruction of eggs and nests; the use of narcotics (alpha chlorolose, alpha chlorolose plus seconal); or the use of poisons (3-chloro-4-methyl benzeamine hydrochloride [DRC-1339] or strychnine).

4.3 Rationale for Gull Control

Many countries have accepted the fact that if certain bird species are to be retained and if aviation hazards are to be reduced, other species that are detrimental to man's interests must be controlled (Monaghan 1984, Blokpoel and Tessier 1986, Mullen and Goettel 1986). Thus, for many people concerned about gull depredations and hazards to aircraft, moral or ethical questions regarding such control activities have long since been resolved.

4.4 Gull Control to Benefit Other Birds

Many world-wide examples of gull control to reduce damage to other birds have been reported: Europe (Bruyns 1958, Drost 1958); Great Britain (cited by Thomas 1972, Duncan 1978); and the United States (Kress 1983, Mullen and Goettel 1986, Folger and Drennan 1988). Some are as follows: About 38,000 herring gulls were killed with alpha chlorolose (A-C) on the Isle of May in Scotland during the years 1972-1977 (Duncan 1978). In a moorland colony near Lancashire, England, about 50,000 herring and lesser black-backed gulls were killed with A-C during the period 1978-1982 (Wanless and Langslow 1983). In The Netherlands, about 29,000 herring gulls were killed with strychnine during the period 1954-1956 (Bruyns 1958). A total of 3000 great black-backed and herring gulls were killed with DRC-1339 in 1987 and 1988 at Matinicus Isle,. Maine (T.A. Goettel, pers. commun.).

The destruction of eggs and nests was used successfully during a 5-year period to limit gull production on Monomoy National Wildlife Refuge, Massachusetts (Lortie et al. 1984) and on Matinicus Rock, Maine during the late 70's (Mullen and Goettel 1986). According to T.A. Goettel (pers. commun.), herring and great black-backed gull nests located in the middle third of South Monomoy Island, Monomoy National Wildlife Refuge, Massachusetts were sprayed with oil and formalin in 1979 with a high degree of effectiveness. Ring-billed gull eggs have been sprayed with oil and formalin or oil during the period 1984-1990 to control reproduction on an island in Banks Lake, Washington. J.G. Oldenburg and M.E. Pitzler (pers. communs.) report that the number of RBG nests declined from 5445 in 1986 (the first year that all nests were sprayed), to 3626 nests in 1990 -- a decrease of 34 percent. An estimated 958,421 herring gull eggs were pricked or oiled during the period 1934-1952 in gull colonies located on islands along the northeastern U.S. coast mainly to reduce gull populations (method reported to be 95 percent effective), but in part to benefit terns (Gross 1952).

4.5 Gull Control to Reduce Hazards to Aviation

Gulls have been controlled frequently for the benefit of other birds, however, examples are fewer where this has occurred for reasons of air safety, even when nesting colonies are very near an airport (Dolbeer et al. 1989, Tessier 1989). Since gulls are viewed by those concerned with aviation safety as a serious hazard, there are instances where actions have been taken to reduce or eliminate dangerous local populations. My first experience with a serious airport gull hazard was in 1961 when I observed about 750 pairs of herring gulls on breeding territories at Logan Airport, Boston, Massachusetts (Drury 1963). The U.S. Fish and Wildlife Service immediately recommended that the gulls should be killed. The airport population was controlled as the result of two years of shooting -- 4468 gulls were killed (Seubert 1963).

A colony of about 8000 silver gulls, on a small coastal island near the city of Devonport in northern Tasmania, Australia, was eliminated after two years of baiting (1986-1987) with A-C bread baits. The colony was about 2.5 km (1.6 mi) from the airport. No nesting occurred on the island in 1988, although some gulls still fed at a local solid waste site. This is an example where local population elimination was very successful (P.M. Davidson, pers. commun.).

Caithness (1968, 1969, 1984) presents a chronology of 19 years of effort to control a nesting colony of southern black-backed gulls located about 0.4 km (0.25 mi) from an airport at Napier, New Zealand. Alpha chlorolose was used very successfully to kill several thousand gulls, but repeated poisoning (and some shooting) has been necessary to keep the colony free of birds each nesting season. The author believes that the control efforts have reduced bird strikes at the airport, but does not have pre-control strike statistics with which to compare. The control program will continue.

Thousands (ca 44,000) of RBG eggs were collected in 1985 and 1986 at Mugg's Island 1 km (0.62 mi) from Toronto Airport and on the airport to reduce and eliminate threats to air safety. During the same years a RBG colony of 75,000 - 80,000 nests located at the Eastern Headland, Toronto Outer Harbor, was reduced to 40,160 pairs through non-lethal means (e.g., harassment, distress calls, flying raptors). This colony is about 5 km (3.1 mi) from the Toronto Airport (Blokpoel and Tessier 1987, Tessier 1989).

Efforts to reduce herring gull hazards at Kastrup Airport, Denmark, have been reported by Lind 1971, Lind and Glennung 1977, 1984, Dahl 1984, Lind 1986, Glennung 1988. Thousands of eggs were oiled beginning in 1969 at a nesting colony located 5 km (3.1 mi) from Saltholm Island. The oiling reduced the 1969 breeding population (ca 40,000 pairs) to about 20,000 pairs by 1976. To accelerate the reduction, A-C was used for several years beginning in 1976 until the population was reduced to 5,000 pairs. Only oiling has been used since about 1987. Gull control measures at Saltholm resulted in fewer herring gulls and fewer herring gull strikes at the airport during 1976-1981. However, the total number of strikes has not decreased since 1981, and the authors suggest that the black-headed and common gulls have become more prominent. They have requested that they be able to include these species in the control program.

Finland has had an extensive gull control program for many years to reduce gull hazards at the Helsinki-Vanta Airport (and to benefit other species). To reduce the number of young herring gulls that concentrated in the airport area, the reproduction of about 6500 nesting pairs was restricted at almost all colonies in the Helsinki Archipelago located within 40 km (24.8 mi) of the airport. Collecting eggs twice during the nesting season was the most frequently used control method. Birds also were shot on the airport and shot and trapped at a garbage dump located 4 km (2.5 mi) from the airport. The trapped birds were killed with carbon monoxide. These measures have resulted in reduced gull hazards at the airport (Kunsela and Stenman 1979, Helkamo et al. 1982, Helkamo and Stenman 1984, O. Stenman, pers. commun.).

Rochard (1987) reports that a mixture of A-C and seconal was used successfully over a 3-year period to control great black-backed and herring gull colonies located on the Royal Air Force Tain Air Weapons Range. He also reports that 350 nests in a herring gull colony located in an explosive storage area were treated successfully with the same narcotic mixture. An effort to control Mediterranean gulls at RAF Gibraltar was not successful.

Also, many thousands of gulls have been shot at airports. For example, 3840 gulls were shot at the Aalborg Airport, Denmark during a 12-month period (Eis 1986). In 1978, more than 1000 herring and black-backed gulls were shot at the Helsinki-Vanta Airport, Finland (Kunsela and Stenman 1979).

5.0 Strategies for Controlling Nesting Colonies of Gulls Near Airports

The selection of methods to control nesting gull colonies should be based on the gull species involved, other birds that might be affected, the distance of a colony from an airport, the history of bird strikes, the degree of continuing risk aviation authorities are willing to assume, Federal and State regulations, the attitudes of conservation interests, and bird biology and behavior. Each problem situation requires an ecological assessment before control measures are selected and implemented. Various control strategies are as follows.

5.1 Habitat Elimination or Alteration

Much of the literature about bird hazards to aviation places the utmost importance on habitat modification as the key to permanent or long-term solutions. Aldrich et al. (1961:6) state that "steps should be taken to make the habitat on and in the vicinity of an airport less attractive to them (birds)." This early recognition of the importance of habitat has been acknowledged by many subsequent researchers. But the emphasis has been on the airport per se and not to the environment surrounding an airport except for concerns about garbage dumps. In the airport services manual published by the International Civil Aviation Organization (ICAO) methods are discussed in Chapter 7, Part 7.10, for reducing gull populations in nesting colonies that occur only in the immediate vicinity of airports (ICAO 1978). No mention is made, however, about managing or altering the habitat of nesting colonies on or off an airport. The value of environmental management is emphasized, however, under Part 6.1.3 (ICAO 1978:15) where it is stated that "with reference to bird hazards to aircraft on an airport, killing and scaring birds are therefore palliatives that should be temporary, but environmental management is the basic remedy."

Thomas (1987:5) discusses the importance of adopting a program for bird management beyond an airport, so that the numbers of birds coming to the vicinity of an airport can be reduced, thereby decreasing the amount of bird control needed on an airport. He states that "it is self evident that the close proximity of a breeding colony to an airport is incompatible with aviation safety; however, sites of this nature can often be of significant biological importance so the case for control has to be strong." Burger (1983) reports that the carrying capacity of the environment can be altered by habitat manipulation that includes the elimination of roosting areas, food sources, and fresh water. Burger (1983:123) does not include nesting colonies, yet states that "the most effective means of reducing bird strikes and maintaining low rates of them near airports are to use habitat manipulation to reduce drastically the carrying capacity of the environment for birds,...."

Wright (1968:104 and 105) reviews various methods of bird control by means of habitat modification and states that the "ultimate answer is to make airfields and their immediate surroundings unattractive to birds, or at least those species that constitute the major hazard." He further states that "Environmental control is costly, but it offers the best hope for a long-term solution to bird control." The author suggests that species that breed on the ground might be discouraged by cultivation of the land.

Thomas (1972:122) examines habitat modification, including breeding habitat, as one means of limiting adult and immature gulls, and is of the opinion that habitat change to limit gull numbers could be a costly and time-consuming activity that "could have profound implications on non-gull species as well." He further states that habitat modification activities might have to be restricted to areas where only gulls occur in high numbers, and "to places where extreme habitat manipulation could be tolerated (e.g., alongside airstrips)." Solman (1970, 1973a, 1984) also stresses the importance of habitat modification, especially on airports, as a means of effecting long-term hazard reduction.

If as a last resort, a decision was made to eliminate or alter U.S. gull nesting habitat for reasons of aviation safety, it would be very difficult to accomplish because of the need to comply with Federal regulations concerned with environmental protection (unless prompted by an aviation disaster caused by gulls from a nearby colony). For example, if the destruction of nesting habitat would entail the placement of fill material in a wetland, a permit would be required from the Army Corps of Engineers in accordance with Section 404 of the Clean Water Act (Corps of Engineers, Department of the Army 1986). The Corps issues such permits in accordance with Section 404(b)(1) guidelines promulgated by the Environmental Protection Agency (EPA 1980). These guidelines have specific requirements for considering practical alternatives to such filling activities, and for mitigating unavoidable impacts (replacement of habitat). The procedures these agencies will use to define mitigations are addressed in a recent Memorandum of Agreement (MOA) between these agencies (EPA 1990, D.G. Buechler, pers. commun.).

Furthermore, if an action by a Federal agency might potentially adversely impact migratory birds, the need to prepare an Environment Assessment (EA) must be considered under the National Environmental Policy Act (NEPA). If such an EA determines that a significant impact will occur, an Environmental Impact Statement (EIS) would be required. Also, any taking of a migratory bird or its eggs or young requires an advance permit from the Law Enforcement Division of the U.S. Fish and Wildlife Service (USFWS) (D.G. Buechler, pers. commun.).

Under the USFWS Coordination Act, the USFWS, the National Marine Fisheries Service, and State Fish and Wildlife agencies are consulted for advice under both the Clean Water Act and NEPA. The USFWS recommendations regarding habitat will be provided in accordance with its Mitigation Policy which states a preference for replacement of in-kind habitat values on or near a project site for a species regarded as important (USFWS 1981, Buechler, pers. commun.).

In NEPA, the term mitigation includes: "(a) avoiding the impact altogether by not taking a certain action or parts of an action; (b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (e) compensating for the impact by replacing or providing substitute resources or environments" (USFWS 1981:7657). These steps are also essentially described in the USFWS mitigation policy which the Service follows when fulfilling its advisory role to the Corps of Engineers. This sequence of mitigation is further defined in the recent MOA between the Corps and the EPA which provides guidance on how to meet the requirements of EPA's Section 404(b)(1) guidelines (EPA 1990, D.G. Buechler, pers. commun.). Mitigation is generally considered to include avoiding or minimizing adverse impacts on fish and wildlife and their habitat, and compensating for unavoidable losses of those resources (Soileau et al. 1985).

The acquisition of permits to alter habitat involves a complex process. Nevertheless, if other options are inappropriate or unavailable, there should be no reluctance to obtain permits to alter or remove habitat if <u>such actions are needed to accomplish a permanent solution to a serious bird hazard</u>, even if the habitat is located at a sanctuary or refuge. An example of how aviation hazards might be affected by the modification of gull nesting habitat very near to an airport is given in Table 5.1.

Table 5.1 Eliminate or Alter Nesting Habitat a/

	Result/Outcome
Degree of Control Achieved	100 percent
Number of Gulls b/	None
Number of Young Produced	None
Degree of Hazard c/	None

a/ Plow, cultivate, plant, dredge, fill, pack, etc.
b/ In nesting colony.
c/ If habitat change was made between nesting seasons, and if gulls returning to nest would not remain in the airport area.

5.2 Gull Population Control

Although there have been only a few instances where gull nesting colonies have been depopulated for reasons of air safety, the methods used have been very successful and hazards to aviation presented by these colonies have been eliminated or significantly reduced. If gulls establish nesting colonies in very close proximity to an airport and pose a serious hazard to aviation, colony depopulation is an option that should receive serious consideration. However, because of societal concerns for the environment and wildlife and because of international agreements and State and Federal regulations that safeguard man's environmental interests, the killing of a migratory species, even for purposes of aviation safety, would require very strong justification and a broad base of support from all interested parties. A proposal to depopulate a gull colony in the United States would require adherence to mitigation procedures under the USFWS Mitigation Policy.

In North American there appears to be little hesitancy (with few exceptions) on the part of resource managers, biologists, State and Federal agencies, and conservation organizations to support the killing of gulls on local nesting grounds for the benefit of other birds. My perception is that there is less enthusiasm for killing gulls on nesting grounds for aviation safety. Control of regional gull populations by use of narcotics or poisons is purported to be: impractical, too time consuming, too costly, ineffective because of immigration of birds from other areas, a potential hazard to nontarget species, subject to criticism from animal rights organizations, socially unacceptable in many countries, unfeasible, logistically difficult, and probably would require international cooperation (Thomas 1972; Solman 1973b, 1983; Blokpoel 1976, 1983, 1984; Blokpoel and Tessier 1986). These are real concerns, however, these potential drawbacks should not preclude the use of lethal measures to eliminate local gull nesting populations that pose hazards to aviation. Thomas (1972:125) states that "at homogeneous colonies of gulls, direct narcotization or poisoning seem the most efficient methods even if the work must be done annually, and one does not have to resort to the laborious time-consuming activities directed against eggs and chicks."

My point is that local gull nesting populations have been successfully eliminated or significantly reduced and the concerns heretofore mentioned regarding large scale population control programs have not been obstacles. When gull nesting colonies cause severe hazards to aviation, there should not be a reluctance to kill gulls, if significant hazard reduction cannot be accomplished quickly by other methods. Logically, gull control to benefit aviation safety should have a higher priority (or just as high a priority) than control to benefit other birds, and should not require a greater level of justification than needed to control gulls for the benefit of other birds. For society to place a higher value on bird life rather than human life is sheer hypocrisy. The knowledge and means exist today that would permit the control of nesting gull populations humanely, safely, and efficiently. An example of how aviation hazards might be affected by the depopulation of gull nesting colonies very near to airports is given in Table 5.2.

Before programs to kill gulls for aviation safety could be initiated, however, various necessary elements must be present as follows: (1) high motivation to enhance aviation safety; (2) strong justification for a proposed action supported by biological data and objective ecological rationale documenting that alternative measures were evaluated; (3) the availability of approved or registered lethal or narcotic agents; (4) the availability of humane methods; (5) professional public relations programs about the need for a proposed action; (6) adequate resources and time; (7) effective program management; (8) adherence to all applicable State and Federal regulations; (9) program monitoring and assessment; and 10) international cooperation (if needed).

Table 5.2 Depopulate Nesting Colony, i.e., Kill Adults a/

	Result/Outcome
Degree of Control Achieved	Almost 100 percent
Number of Gulls b/	None/Very Few
Number of Young Produced	None/Very Few
Degree of Hazard c/	None/Very Low

a/ Use DRC-1339 or alpha chlorolose; some shooting required. Control method would be needed each year that gulls nested.
b/ In nesting colony.
c/ The hazard probably would be high the first spring of control before gulls are killed. Hazard probably would be low to moderate in successive springs prior to subsequent depopulations, depending on the number of new gulls that would attempt to nest.

5.3 Control of Reproduction

5.3.1 Collect Eggs or Destroy Eggs and Nests

Examples have been given in this paper about programs to reduce or eliminate gull depredations on other birds and gull hazards to aviation either through collection of gull eggs or the destruction of eggs and nests. For such strategies to be most effective, control of colonies (elimination or reduction) should be accomplished when they are relatively new, when only a few gulls are involved, and before they have become well established. New gull colonies can increase to thousands of birds in two or three years (Blokpoel and Tessier 1987), especially if there are other populations nearby that could be a source of immigrants. The laughing gull colony in Jamaica Bay, N.Y. is a good example.

If airports with a gull problem similar to that at JFK were not able to effect more permanent solutions to abate gull hazards (e.g., alter gull nesting habitat or depopulate a colony), a strategy of collecting eggs or egg and nest destruction might be considered. However, Morris and Siderius (1990:125), state that "Removing eggs usually proves unsatisfactory because adults will renest after a brief refractory period." Thus, egg collections must be made several times during the nesting season, and the adults could cause aviation hazards between nesting attempts.

According to the Royal Society for the Protection of Birds (RSPB), if the intent is to prevent gull nesting, the success of egg and nest removal (destruction) could depend on the species of gull (RSPB 1982:2). The RSPB statement is as follows:

> "The removal of eggs and nests is successful in discouraging the breeding of gulls in small, new gull colonies and also in the large

colonies of black-headed gulls. Herring and lesser black-backed gulls however, do not respond to such methods when in large colonies. They remain faithful to their nesting territories and fight off all other gulls and terns."

Thus, if other gull species reacted as do black-headed gulls to egg and nest destruction, nesting would be discouraged and the control method might be used at a colony located adjacent to an airport so long as gull activity between nesting attempts did not cause increased aviation hazards. However, if other gull species reacted to egg and nest destruction as does the herring gull in Great Britain, additional measures such as harassment might be necessary. This was the case in several Canadian operations where harassment was used in addition to egg collections to reduce or eliminate ring-billed gull colonies (Blokpoel and Tessier 1987). Egg and nest destruction or the collection of eggs plus harassment, would not be an appropriate strategy at a gull colony located adjacent to an airport because harassed birds could present hazards to aviation. An example of how aviation hazards might be affected by the collection of eggs or the destruction of eggs and nests at a gull colony very near to an airport is given in Table 5.3.1.

Table 5.3.1 Control of Reproduction: Collect Eggs or Destroy Eggs and Nests a/

	Results/Outcome
Degree of Control Achieved	>95%
Number of Gulls b/	Many thousands
Number of Young Produced	Very Few
Degree of Hazard c/	High

a/ Control method would be needed each year that gulls nested.
b/ In nesting colony.
c/ The hazards (mostly adults) probably would be high before nesting, between nestings, and after final egg collection or egg and nest destruction (if most of the adults remained in the airport area).

5.3.2 Oil Eggs

As has been reported earlier, gull reproduction has been controlled by spraying eggs in nests with a mixture of oil and formalin. The treating (spraying) of eggs with petroleum products appears to have a direct toxic effect on embryos (Eastin and Hoffman 1978). White, et al. (1979) reported that when No. 2 fuel oil was applied experimentally to laughing gull eggs in the field (20u/per egg), embryonic mortality occurred in 83 percent of the eggs. Morris and Siderius (1990) experimentally treated

RBG eggs in the field with two or three applications of a mixture of 65 percent light grade commercial petroleum oil (dormant oil) and 35 percent water. The authors report that with two applications of the oil, irrespective of the stage of embryo development, the hatchability of RBG eggs was reduced to zero. Also of considerable interest is that incubation of treated eggs continued for more than 6 weeks after the usual time of hatching. Gull reproduction appears to be effectively controlled by oiling eggs, especially if more than one application of oil is made in the case of the RBG. An example of how aviation hazards might be affected by the oiling of eggs at a gull colony very near to an airport is given in Table 5.3.2.

Table 5.3.2 Control of Reproduction: Oil Eggs a/

	Results/Outcome
Degree of Control Achieved	>95%
Number of Gulls b/	Many thousands
Number of Young Produced	Very Few
Degree of Hazard c/	High

a/ Control method would be needed each year that gulls nested.
b/ In nesting colony.
c/ Hazard (mostly adults) probably would be high before nesting and after nest abandonment (if most of the adults remained in the airport area), and low while clutches of oiled eggs are being incubated.

Before gull eggs could be oiled operationally in the United States, a State or an EPA registration would be needed. If a Federal registration were needed, considerable time and expense could be required. Field research can be conducted under an Experimental Use Permit (EUP) if issued by EPA. Gull control operations per se must be conducted under a State-issued Special Local Needs Registration (24-C), or under a Federal EPA Section 3 Registration that usually includes all of the United States. A Section 18 Special Exemption may be issued by EPA to resolve an acute health, safety, or economic problem (EPA 1989).

If the goal is to prevent the production of young to stabilize or reduce nesting populations, the technique of oiling gull eggs appears to be an effective management strategy (Gross 1952, Lind 1971, Dahl 1984). However, if the goal is to eliminate gull colonies because they present unacceptable hazards to aviation, oiling would be a very poor strategy, because no information from world-wide sources indicates that oiling of eggs has ever resulted in gulls completely abandoning a colony. Thus, oiling would curtail reproduction, but a significant reduction in the adult breeding population is highly unlikely. If a colony were adjacent to an airport, many adult gulls would be in close proximity to the airport during nesting seasons and present hazards to aviation as long as the population existed.

To rely on interference with gull reproduction at nesting colonies located very near airports as a means of controlling hazards to aviation exposes air carrier passengers and crews to unnecessary risks in view of the availability of more effective means of hazard reduction. Gull control measures should be used that will eliminate hazards as soon as possible.

5.4 Other Control Methods

Other methods have been examined for preventing gulls from nesting at a colony very close to an airport, but for one or more reasons were not considered appropriate.

Harass birds using pyrotechnics (shell crackers), broadcast distress calls, owl models, the flying of raptors, vehicle patrols, foot patrols, whistles, tethered hawks and owls, dead gulls thrown into the air (Blokpoel and Tessier 1987), propane cannons, shellcrackers, scarecrows (Lortie et.al. 1984), shooting, and human disturbance (Kress 1983). According to H. Blokpoel (pers. commun.), RBGs can be prevented from nesting with intensive harassment using a variety of methods. Constant harassment of herring and black-backed gulls eventually results in the temporary abandonment of a colony site (Mullen and Goettel 1986). Harassment, however, could adversely affect nontarget birds, and probably would cause increased hazards to aviation. For example, Lortie et al. (1984) reported that laughing gulls either ignored harassment or were seriously disrupted.

Introduce predators such as red foxes and raccoons. Decreases in the size of herring gull colonies and the abandonment of islands as breeding sites occurred after red foxes and raccoons were released on gull nesting islands (Kadlec 1971). Predators, however, would adversely affect nontarget birds, and disturbance of a colony could cause increased hazards to aviation.

String wires or monofilament lines above ground to exclude gulls from nesting habitat (Blokpoel and Tessier 1983). Gulls would be excluded from the wired or lined areas, however, the suitability of this technique would depend on the size of an area, the nesting density, topography of a site, type of substrate, and the availability of resources to ensure proper maintenance -- repair structure and remove birds that became entangled (H. Blokpoel, pers. commun.). Nontarget birds could be adversely affected.

Mow or burn vegetation. Nontarget birds could be adversely affected.

6.0 Discussion

I view any situation where thousands of gulls are in a nesting colony very close to an airport (e.g., < 1.6 km or < 1 mi) as a very serious hazard -- one that warrants prompt and aggressive corrective measures. Furthermore, allowing such a colony to continue to exist places airport managers in the untenable position of being responsible for ensuring that an airport is safe from bird hazards, yet leaves managers unable to control the source of such hazards. Persuading those in control of such sites to eliminate hazards probably would be difficult, especially if nesting colonies were located on sanctuaries or refuges. Those responsible for airport safety could be practicing the state-of-art in bird management on an airport, but with thousands of birds nearby, could they ensure a high level of safety? Thus, in case of accidents caused by gulls from nearby colonies not under the control of airports, the courts would be faced with a dilemma - who would be held responsible?

Scorer (1988), a solicitor who has been involved in bird hazard litigation, discusses how airports may avoid liabilities due to bird strikes by the adoption of effective, efficient, and well documented bird control procedures. His paper does not indicate, however, how an airport can protect itself from being overwhelmed with birds, when bird attractants, such as breeding colony sites, roosts, and garbage dumps are near an airport, and cause high hazards to aviation when the birds intrude onto or over the airport.

The record clearly shows that when even one bird of relatively light weight is ingested into a turbine powered engine during a critical takeoff regime, severe engine damage, engine failure, and the loss of an aircraft and occupants can occur. Thus, overall airport bird management should have the goal of providing safe airport environments vis-a-vis bird hazards regardless of the source of birds. Therefore, management of birds and habitat beyond airport boundaries must receive a much higher priority -- even if litigation is needed to obtain approval to eliminate certain highly hazardous bird species or alter their habitats.

Actions have been taken or are underway in the United States to address certain aspects of the problem. Completed or near-completed FAA studies to determine the hazards from birds ingested into turbofan engines will be "useful in re-evaluating engine certification test criteria specified in 14 CFR 33.77, and, as a result, future jet engines can be designed to withstand more realistic bird threats" (Cheney et al. 1981, Frings 1984, Hovey and Skinn 1989:1). In a very recent development, the FAA issued a new order in January 1990 (5200.5A Waste Disposal Sites On Or Near Airports), that provides guidance on the establishment, elimination, or monitoring of landfills, open dumps, waste disposal sites or similar facilities on or in the vicinity of airports.

In addition to these FAA activities, the Aerospace Industries Association (AIA) has a propulsion subcommittee on bird ingestions with the objective of reviewing FAA Federal Air Regulations (FAR) regarding the adequacy of 14 CFR 33.77, Bird Ingestion Standards, and of making recommendations for changes, if needed. The Flight Safety Foundation (FSF) has established an ad hoc power plant working group to: identify airports throughout the world viewed as the most hazardous to transport aviation with regard to flocking birds; advise airport and government officials about the significance of bird hazards at certain airports to create an appreciation of the magnitude of the concern of industry; and offer, if requested, technical advice on methods of hazard reduction (A.K. Mears, pers. commun.).

Although some progress is being made to reduce hazards, integrated bird hazard management programs are needed that involve all aspects of the problem -- what Miller (1985) might identify as a program of "System Safety." He defines "system safety" as "the application of engineering, operations, and management tasks specifically organized to achieve accident prevention over the life cycle of the air vehicle under consideration." The FAA made a commitment to air safety in their policy statement of March 1972 (still current), that states, in part, that ..."The agency will assume the initiative not only in attempting to identify unsafe conditions, but also in seeking to implement improvements or corrections before actual incidents occur..." (Cited by Miller 1985:3.2-4-5). There are examples, however, where safety measures were not adequately enforced, even though the hazards that caused them had been previously identified (Seubert 1976, Briscoe 1989).

In my opinion, significant enhancement is needed in the United States in bird hazard reduction programs. This includes: a much higher priority and greater resources; less concern about personal and institutional philosophies that oppose controlling bird species to benefit aviation safety -- safety should be the overruling priority; and the adoption of a stronger safety ethic of proactive hazard reduction by the responsible agencies -- the need is for the full implementation of safety measures as soon as bird hazards develop, not after serious incidents or accidents.

7.0 Literature Cited

Aldrich, J. W., C. S. Robbins, and W. W. Dykstra. 1961. Bird hazards to aircraft. U.S. Fish and Wildl. Ser. Leafl. 429. 10 pp.

Asbirk, S. and A. H. Joensen. 1974. Breeding populations of gulls in Denmark. Proc. Bird Strike Comm. Europe (BSCE). 9:1-2. 18-21 June. Frankfurt.

Blokpoel, H. 1976. Bird hazards to aircraft. Clark, Irvin & Co. Ltd. Toronto, Canada. [Govt catalogue CW 66-47/1976, Ministry of Supply and Services Canada] 236 pp.

___________. 1983. Gull problems in Ontario. Canadian Wildl. Ser. Ottawa, Ont. Inf. Leafl. 9 pp.

___________. 1984. The ring-billed gull versus flight safety: a continuing conflict in Ontario, Canada. Proc. Bird Strike Comm. Europe (BSCF). 17:377-381. 15-19 October. Rome.

___________, and G. D. Tessier. 1983. Monofilament lines exclude ring-billed gulls from traditional nesting areas. Proc. Bird Control Semin. 9:15-20.
4-6 October. Bowling Green State University. Bowling Green, OH.

___________, and ___________. 1986. The ring-billed gull in Ontario: a review of a new problem species. Canadian Wildl. Serv. Occas. Pap. 57. 34 pp.

___________, and ___________. 1987. Control of ring-billed gull colonies at urban and industrial sites in southern Ontario, Canada. Pages 8-17 in N.R. Holler, Ed. Proc. Third Eastern Wildl. Damage Conf. 18-21 October 1987. Gulf Shores, Ala.

Briscoe, D. 1989. Once again, design of DC-10 comes under scrutiny. The Associated Press. 21 July. Washington, D.C.

Brough, T. 1983. Average weights of birds. Unpubl. Rep. filed with Aviation Bird Unit, Worplesdon Lab. Minist. of Agric. Fish. and Food. 131 pp.

Bruyns, M. F. M. 1958. Gulls which are a menace to other species. Bull. Int. Comm. Bird Preservation 7:103-107.

Burger, J. 1981. Feeding competition between laughing gulls and herring gulls at a sanitary landfill. Condor 83. 328-335.

___________. 1983. Bird control at airports. Environ. Conserv. 10:115-124.

Caithness, T. A. 1968. Poisoning gulls with alpha-chlorolose near a New Zealand airfield. J. Wildl. Manage. 32:279-280.

___________. 1969. Research on bird hazards to aircraft in New Zealand. Pages 95-99 in Proc. World Conf. on Bird Hazards to Aircraft. Nat. Res. Counc. of Canada, 2-5 September. Ottawa. 542 pp.

__________. 1984. Controlling a gull colony near a New Zealand Airport 1965-1984. Proc. Bird Strike Comm. Europe (BSCE). 17:350-356. 15-19 October. Rome.

Cheney, D. I., J. F. Tigue, M. J. Harrison. 1981. Federal Aviation Administration assessment of dual engine ingestion hazards to large, high-bypass turbofan powered transport aircraft. Fed. Aviation Adm. Washington, D.C., 57 pp.

Conover, M. R., B. C. Thompson, R. E. Fitzner, and D. E. Miller. 1979. Increasing populations of ring-billed and California gulls in Washington State. Western Birds 10:31-36.

Corps of Engineers, Department of the Army. 1986. Regulatory Programs of the Corps of Engineers; Final Rule. 33 CFR., Parts 320 through 330. U.S. Government Printing Office. Washington, D.C.

Dahl, H. 1984. The bird strike situation and its ecological background in the Copenhagen Airport, Kestrup. Pages 287-290 in Proc. Wildl. Hazards to Aircraft Conf. and Training Workshop. Sponsored by the Fed. Aviation Adm. Report No. DOT/FAA/AAS/84-1. 22-25 May. Charleston, S.C.

DeFusco, R. P. 1988. United States Air Force bird Strike summary 1986-1987. Proc. Bird Strike Comm. Europe (BSCE). 19:387-397. 23-26 May. Madrid.

Dolbeer, R. A., M. Chevalier, P. P. Woronecki, and E. R. Butler. 1989. Laughing gulls at JFK airport: safety hazard or wildlife resource? Pages 37-44 in S. R. Craven, Ed. Proc. Fourth Eastern Wildl. Damage Control Conf. 25-28 September. University of Wisconsin, Madison, Wis.

Drost, R. 1958. The herring gull problem in Germany. VII Bull. of ICBP. pp. 108-11.

Drury, W. H. 1963. Herring gull populations and movements in southeastern New England. Unpubl. Rep. filed with Patuxent Wildl. Res. Cent. U.S. Fish and Wildl. Ser. Laurel, Md. 104 pp.

__________, and I. C. T. Nisbet. 1969. Strategy of management of a natural population: the herring gull in New England. Pages 441-455 in Proc. World Conf. on Bird Hazards to Aircraft. Natl. Res. Counc. of Canada. 2-5 September Ottawa. 542 pp.

Duncan, N. 1978. The effects of culling herring gulls. (Larus Argentatus) on recruitment and population dynamics. J. of Appl. Ecol. 15:697-713.

Dunning, J. B. 1984. Body weights of 686 species of North American birds. Western Bird Banding Assoc. Monogr. No. 1. 10 pp.

Eastin, W. C., Jr., and D. J. Hoffman. 1978. Biological effects of petroleum on aquatic birds. Pages 561-582 in Proc. World Conf. Assessment of Ecol. Impacts of Oil Spills. Am. Inst. Biol. Sci.

Eis, S. 1986. Report on permissions granted by the wildlife administration in 1985 in accordance with the ECC council directive of April 2, 1979 on the conservation of wild birds. Proc. Bird Strike Comm. Europe (BSCE). 18:217-218. 26-30 May. Copenhagen.

Environmental Protection Agency (EPA). 1980. Guidelines for specification of disposal sites for dredged or fill material. 40 CFR Part 23b. U.S. Government Printing Off. Washington, D.C.

__________. 1989. Federal Insecticide, Fungicide, and Rodenticide Act (as amended October 1988). Doc. No. 617-003/843-46. U.S. Government Printing Off. Washington, D.C.

__________. 1990. Memorandum of agreement between the Environmental Protection Agency and the Department of the Army concerning the determination of mitigation under the Clean Water Act section 404(b)(1) guidelines. EPA. 2 February. Washington. D.C. 6 pp.

Federal Aviation Administration. 1978. Federal Aviation Regulation. Part 25 Section 109. Amendment 25-42. 1 March. Federal Aviation Administration. Washington, D.C.

__________. 1989. Federal Aviation Regulation. Part 1. Definitions and Abbreviations. Change 12. 9 February. Federal Aviation Administration. Washington, D.C.

Folger, D. C. and M. P. Drennan. 1988. Petit Manan National Wildlife Refuge. 1987. Changes in nesting seabird populations after four years of gull management. Coop. agreement between: US Fish & Wildl. Ser. (USFWS), Petit Manan Natl. Wildl. Refuge, Milbridge, Me. 04658 and The Island Institute, 60 Ocean Street, Rockland, Me. 04841. Unpubl. Rep. to USFWS. 41 pp.

Frings, G. 1984. A study of bird ingestions into large high bypass ratio turbine aircraft engines. Final Rep. DOT/FAA/CT-84/13. U.S. Dep. of Transp., Fed. Aviation Adm. September 1984. 41 pp. plus appendices.

Gibson, J. D. 1979. Growth in the population of the silver gull on the Five Islands group, New South Wales. Corella. 3:103-104.

Glennung, A. M. 1988. Birds at Copenhagen airport. Kastrup. Proc. Bird Strike Comm. Europe (BSCE). 19:247-249. 23-27 May. Madrid.

Gross, A. O. 1952. The herring gull - cormorant control project. Unpubl. rep. to the US Fish and Wildl. Ser. Boston, Mass. 14 pp.

Harris, M. P. 1965. The food of some Larus gulls. Ibis. 107:43-53.

__________. 1970. Rates and causes of increases of some British gull populations. Bird Study. 17:325-335.

Helkamo, H, O. Stenman, and M. Vickholm. 1982. Bird control at Helsinki-Vantaa airport in 1978-81. Proc. Bird Strike Comm. Europe (BSCE). 16:1-6. 18-21 August. Moscow.

__________, and O. Stenman. 1984. Progress in bird control at Helsinki-Vantaa Airport. Proc. Bird Strike Comm. Europe (BSCE). 17:371-373. 15-19 October. Rome.

Hickling, R. A. O. 1969. The increase in gulls. Ibis 111:445.

Hild, J. 1969. Bird Strikes in the German air force. Pages 33-42 in Proc. of the World Conf. on Bird Hazards to Aircraft. Nat. Res. Counc. of Canada. 2-5 September. Ottawa. 542 pp.

Horton, N., T. Brough, and J. B. A. Rochard. 1983. The importance of refuse tips to gulls wintering in an inland area of southeast England. J. of Appl. Ecol. 20:751-765.

Hovey, P. W. and D. A. Skinn. 1989. Study of the engine bird ingestion experience of the Boeing 737 aircraft. Inter. Rep. DOT/FAA/CT-89/16. US Dep. of Transp. Fed. Aviation Adm. October 1989. 62 pp. plus appendices.

International Civil Aviation Organization. 1978. Airport Services Manual Part 3. Bird Control and Reduction. Intern. Civil Aviation Organ. (ICAO). Doc 9137-AN/898/2, Part 3. Second Edition. Montreal, Que. Canada. 60 pp.

Kadlec, J.A. 1971. Effects of introducing foxes and raccoons on herring gull colonies. J. Wildl. Manage. 4:625-636.

Kadlec, J. A. and W. H. Drury. 1968. Structure of the New England herring gull population. Ecology 49:644-676.

Kihlman J. and L. Larsson. 1974. On the importance of refuse dumps as food source for wintering herring gulls (*Larus argentatus*). Ornis Scandinavia 5:63-70.

Kress, S. W. 1983. The use of decoys, sound recordings, and gull control for re-establishing a tern colony in Maine. Colonial Waterbirds 6:185-196.

Kunsela, S. and O. Stenman. 1979. Bird control at Helsinki-Vantaa Airport, Finland. Proc. Bird Strike Comm. Europe (BSCE). 14:1-2. 22-26 October. The Hague.

Lind, H. 1971. An attempt to reduce the herring gull population on Saltholm near Kastrup Airport. Proc. Bird Strike Comm. Europe (BSCE). 6:1-3. 15-16 June, Copenhagen.

__________. 1986. The problem of black-headed gulls (*Larus ridibundus*) breeding near airports. Proc. Bird Strike Comm. Europe (BSCE). 18:209-216. 26-30 May. Copenhagen.

__________, and A. M. Glennung. 1977. Attempts to control the breeding population of the herring gull (Larus argentatus) near Copenhagen airport. Proc. Bird Strike Comm. Europe (BSCE) 12:1-4. 20-28 October Paris.

__________, and __________. 1984. Bird strikes in Copenhagen airport during a 10-year period, 1974-83. Proc. Bird Strike Comm. Europe (BSCE). 17:276-281. 15-19 October. Rome.

Lortie, J. P., D. W. Holt, R. C. Humphrey. 1984. An evaluation of gull control methods used on Monomoy National Wildlife Refuge, Massachusetts, 1980-84. Unpubl. draft manuscript. U.S. Fish and Wildl. Ser. Boston, Mass. 20 pp.

McStay, J. 1987. Accident to B737-248 Aircraft. Report of Investigation Made Under Air Navigation (Investigations of Accidents) Regulations 1957 (S.I. No. 19 of 1957. Department of Communications. Ireland. 7 December 1985. 31 pp.

Miller, C.O. 1985. U.S. Civil aviation and system safety. Proc. Intern. System Safety Conf. 7:3.2-4-1 through 19. 25-29 July. San Jose, CA.

Monaghan, P. 1984. Applied ethology. Anim. Behav. 32:908-915.

Morris, R. D. and J. Siderius. 1990. A treatment for prevention of hatching in field-incubated ring-billed gull eggs. J. Wildl. Manage. 54:124-130.

Mullen, D. and T. Goettel. 1986. Colonial seabird management on Seal Island National Wildlife Refuge and Matinicus Rock. An Environ. Assessment Prepared for the Director, Reg. 5, US Fish and Wildl. Ser. 12 May. 27 pp.

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

Robbins, C. S. 1966. Birds and aircraft on Midway Islands: 1959-63 investigations. Spec. Sci. Rep.--Wildl. No. 85. US Fish and Wildl. Ser. Washington, D.C. 63 pp.

Rochard, J. B. A. 1987. The use of stupefacients to control colonies of great black-backed gulls and herring gulls. Unpubl. Rep. Filed with Aviation Bird Unit, Worplesdon Lab. Minist. of Agric., Fish. and Food Res. and Dev. Ser.
16 pp.

__________, and H. Horton. 1980. Birds killed by aircraft in the United Kingdom, 1966-76. Bird Study 27:227-234.

Scorer, T. 1988. Bird strikes -- prevention is better than legal liability. Proc. Bird Strike Comm. Europe (BSCE). 19:491-502. 23-26 May. Madrid.

Seubert, J. L. 1963. Biological studies of the problem of bird hazard to aircraft. Pages 143-171 in Collogue of Le Probleme des Oiseaux sur les Aerodromes. Institut National De La Recherche Agronomique. Paris. 25-27 November. Nice, France.

___________. 1976. DC-10 incident at John F. Kennedy international airport. Proc. Bird Strike Comm. Europe (BSCE). 11:1-9. 24-28 May. London.

___________. 1977. Bird strike hazards to turbine-powered aircraft. Pages 53-68 in Proc. of the Third World Conf. on Bird Hazards to Aircraft. (Meet. organized by Bird Strike Comm. Europe). 25-27 October. Paris.

___________. 1978. Report of accident investigation for National Transportation Safety Board (NTSB), Bureau of Aviation Safety. [Report about ecological aspects of the loss of a Rockwell Commander Turbo-prop aircraft that ingested gulls into one engine at takeoff at Chicago Meigs Airport on 23 April 1977. Unpubl. Rep. 17 pp.

Soileau, D. M., J. D. Brown, and D. W. Fruge. 1985. Mitgation banking: A mechanism for compensating unavoidable fish and wildlife habitat losses. Trans. North Am. Wildl. and Nat. Resour. Conf. 50:465-474. Wildl. Manage. Inst. Washington, D.C.

Solman, V. E. F. 1970. Bird hazards to aircraft. Proc. Bird Control Semin. 5:39-45. 15-17 September. Bowling Green State University, Bowling Green, Oh.

___________. 1973a. Influence of garbage dumps near airports on the bird hazard to aircraft problems. Pages 1-8 in Proc. Natl. Conf. on Urban Engineeering Terrain Problems, Montreal, Que. Canada. 7 May. Natl. Res. Counc. Ottawa.

___________. 1973b. Birds and aircraft. Biol. Conserv. 5:79-86.

___________. 1983. Keeping unwanted gulls away -- a progress report. Page 311 in D.J.Decker, Ed. Proc. First Eastern Wildl. Damage Control Conf. 27-30 September. Cornell University. Ithaca, N.Y.

___________. 1984. Birds and aviation. Pages 1-7 in Proc. Wildl. Hazards to Aircraft Conf. and Training Workshop. Sponsored by the Fed. Aviation Adm. Rep. No. DPT/FAA/AAS/84-1. 22-25 May. Charleston, S.C.

Spaans, A. L. 1971. On the feeding ecology of the herring gull Larus argentatus in the northern part of the Netherlands. Tijdschrift N. Orni. U. 59:73-188.

Tessier, G. D. 1989. Bird strike committee Canada meeting No. 10. 30-May-1 June. Montreal. pp 11-12.

The Royal Society for the Protection of Birds (RSPB). 1982. RSPB gull management fact sheet, RSPB. The Lodge Sandy Bedfordshire. Great Britain. Unpubl. Rep. 2 pp.

Thomas, C. S. 1987. Bird control beyond the airport boundary. Pages 1-9 in Symp. on Bird Hazards to Aviation by the Royal Aeronautical Soc. 14 October. London.

___________, L. S. Buurma, J. E. Karlsson, and V. E. F. Solman. 1989. Bird Hazards to aircraft at JFK International Airport. Unpubl. Rep. filed with Aeronautical Serv., Div. JFK Airport, Jamaica, NY and Gateway Natl. Recreation Area, Floyd Bennett Field, Brooklyn, N.Y. 29 June, 3 pp.

Thomas, G. J. 1972. A review of gull damage and management methods at nature reserves. Biol. Conserv. 4:117-127.

Thorpe, J. 1984. Serious bird strikes to civil aircraft 1981 to 1984. Proc. Bird Strike Comm. Europe (BSCE). 17:329-339. 15-19 October. Rome.

___________. 1988. Serious bird strikes to civil aircraft 1985 to 1987. Proc. Bird Strike Committee Europe (BSCE). 19:331-339. 23-27 May. Madrid

___________, and I. Hole. 1988. Bird strikes during 1985 to European registered civil aircraft. Proc. Bird Strike Comm. Europe (BSCE). 19:165-186. 23-27 May. Madrid.

US Fish and Wildlife Service. 1981. US Fish and Wildlife Service mitigation policy; notice of final policy. Fed. Register 46:7644-7663.

Wanless, S. and D. R. Langslow. 1983. The effects of culling on the Abbeystead and Mallowdale gullery. Bird Study 30:17-23.

Weaver, A. 1989. Bird strike committee. Canada meet. No. 10. 30 May -1 June. Montreal. pp 5-9.

White, D. H., K. A. King, and N. C. Coon. 1979. Effects of No. 2 fuel oil on hatchability of marine and estuarine bird eggs. Bull. Environ. Contam. and Toxicol. 21:7-10.

Wright, E. N. 1968. Modification of habitat as a means of bird control. Pages 97-105 in The Problems of Birds as Pests (Ed. R.K. Murton & E.N. Wright) Academic Press. NY. 154 pp., illustr.

8.1 Appendix A

Common and Scientific Names

Birds

American Kestrel	*Falco sparverius*
Arctic Tern	*Sterna paradisaea*
Atlantic Puffin	*Fratercula arctica*
Avocet	*Recurvirostra avosetta*
Barn Owl	*Tyto alba*
Black-footed Albatross	*Diomedia nigripes*
Black-headed Gull	*Larus ridibundus*
Black Guillemot	*Cepphus grylle*
Common Eider	*Somateria mollissima*
Common Gull	*Larus canus*
Common Tern	*Sterna hirundo*
Great Black-backed Gull	*Larus marinus*
Rock Dove (domestic pigeon)	*Columba livia*
Herring Gull	*Larus argentatus*
Laughing Gull	*Larus atricilla*
Laysan Albatross	*Diomedea immutabilis*
Lesser Black-backed gull	*Larus fuscus*
Mediterranean Gull	*Larus melanocephalus*
Razorbill	*Alca torda*
Redshank	*Tringa totanus*
Ring-billed Gull	*Larus delawarensis*
Roseate Tern	*Sterna dougallii*
Sandwich Tern	*Sterna sandvicensis*
Silver Gull	*Larus novaehollandiae*
Southern Black-backed Gull	*Larus dominicanus*
Storm Petrel	*Hydrobates pelagicus*
Wood Pigeon	*Columba palumbus*

Mammals

Red Fox	*Fulvus vulva*
Raccoon	*Procyon lotor*

8.2 Appendix B

Bird Weights

Common Name	Weights	Source
American Kestrel	F-120±9.2g M-111±9.3g	Dunning 1984
Barn Owl	F-490g(382-580g) M-442g(299-580g)	do
Black-headed Gull	Avg. wt of 275g (116-390g)	Brough 1983
Great Black-backed Gull	F-1488g(1033-2085g) M-1829g(1380-2272g)	Dunning 1984
Herring Gull	F-1044g(717-1385g) M-1226g(755-1495g)	do
Laughing Gull	325±15.9g	do
Ring-billed Gull	F-471±46g M-566±42g	do
Rock Dove (domestic pigeon)	542±32.2g (494-616)	do
Wood Pigeon	Avg. wt. of 465g (258-739g)	Brough 1983