AIRPLANE-ALBATROSS COLLISIONS ON MIDWAY ATOLL

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The possible results of collisions between aircraft and birds are well known—death of human beings and birds, economic loss, and disruption of schedules. On Midway Atoll in the north-central Pacific Ocean, the problem is intensified by the presence of numbers of large birds breeding no more than three quarters of a mile from the runways on Midway's Sand Island, by many heavily loaded military planes, and by the fact that the birds primarily concerned are Laysan Albatrosses (*Diomedea immutabilis*).

Perhaps more than a third of the world's population of Laysan Albatrosses breeds on Midway (Rice and Kenyon, 1962:369), and any catastrophe that seriously depleted or eliminated this major segment of their numbers might eventually have serious consequences for the survival of the species.

Biologists are thus concerned about the control activities undertaken to alleviate the conflict as well as about the dangers to human life and the economic losses. It is improbable that the airplanes themselves would eliminate the birds, but some of the suggested methods of control might do so if continued in the future.

Midway's albatrosses have survived the depredations of feather poachers, the construction activities of war and peace, and even battles. But these acts of destruction of the birds and their habitat have not been continuous; respites for recovery have occurred. The current pressure against the albatross has now been in force for nine years, each year seeing the death toll and habitat destruction increased, purposively or incidentally.

It is the purpose of this report to evaluate the controls being used, especially those activities that result in decreases in the populations of the albatrosses and in the destruction of their ancient nesting sites, but not those methods which only frighten the birds away from a part of the island. The latter, however, have been singularly unsuccessful.

THE CONTROL PROGRAM

When the airplanes operating on Midway's Sand Island began hitting numbers of birds, the United States Navy asked the U.S. Fish and Wildlife Service to study the problem and make recommendations. These studies were reported by DuMont and Neff (1955), Kenyon *et al.* (1958), Rice (1959), and Robbins (1960, 1961) who is continuing the work.

Rice (1959:1) stated the recommendations. "Leveling and clearing the land to eliminate updrafts on which birds are prone to soar is the only method known so far of obtaining any measure of relief immediately," and many different experimental procedures have indeed been attempted. Rice continued (p. 39): "It is concluded that killing is an impractical means of obtaining immediate reduction of the aircraft hazard." But in 1958 Kenyon *et al.* had suggested that to reduce the collisions substantially would require ". . . the elimination of all nesting and unemployed Laysan Albatrosses from an area extending *at least* [italics mine] 750 feet each way from the center of operational runways; that this program would have to be continued for an *unknown number of years* [italics mine] to eliminate influx of birds from all sources. . . ."

These two recommendations were implemented in 1956–1957 and are being continued.

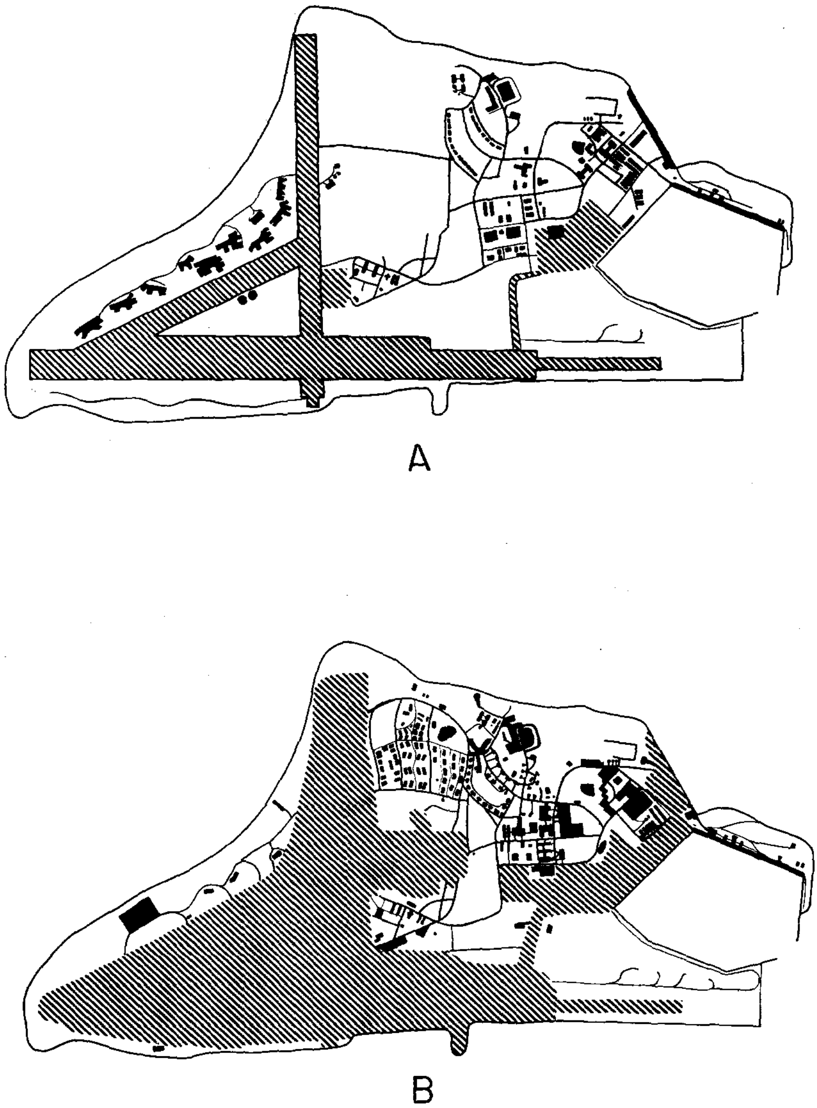

Figure 1. Sand Island, Midway Atoll, indicating areas of pavement and buildings that usurp the breeding grounds of the Laysan Albatross. A. Prior to 1956; B. In 1964–1965.

IMMEDIATE EFFECTS OF THE CONTROL

More than 50 per cent of Sand Island's surface is now paved or otherwise covered (figs. 1, 2) after being flattened (U.S. Navy, 1964). Perhaps no more than half of this can be attributed to the control program, but nonetheless albatrosses can no longer breed on most of their former colony grounds.

Removal of sand-holding vegetation and flattening of protective dunes has permitted blowing sand to invade the runways and the interior of the island, wherever the surface was not covered by pavement (fig. 3).

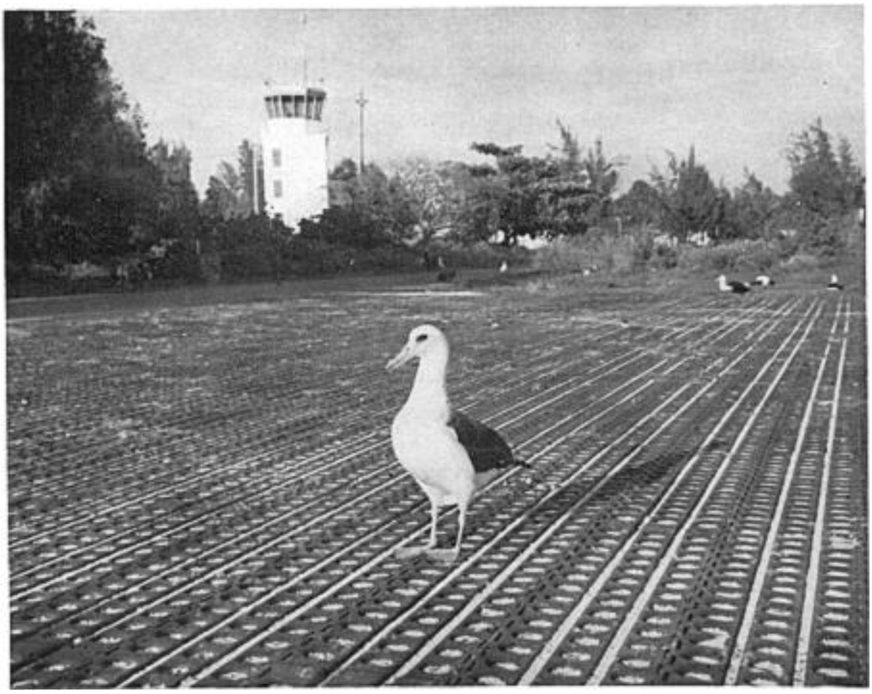

Figure 2. Metal paving covers flattened sand, the former nest sites of some Laysan Albatrosses.

With one exception, I believe, the bulldozing, grading, and surfacing operations, which have removed existing vegetation like that shown in figure 4, have been carried out during the breeding season. Observers have not always been present during these operations, but in December 1959 I estimated that 10,000 nesting albatrosses were killed by bulldozers in one area of Sand Island. The records for this area show only that 21,865 Laysans were killed by clubbing during the period January to March 1958. The records do not indicate the total of chicks killed or left parentless or eggs destroyed in these land-moving labors, although in some years a tally of chicks or eggs was kept.

The known kill is as follows:

1955	200,000 eggs of various species
1957 (April)	4688 adults
	1371 chicks
1958 (January–March)	26,600 adults
1959 (December)	*ca.* 10,000 adults
1964 (January)	18,000 adults

Incidental deaths are excluded in the above tabulation. By "incidental" is meant deaths that result from the presence of naval activities not a part of the control program recommended by the Fish and Wildlife Service. Included are birds killed in construction away from the runways, by vehicles including airplanes, by navy crews killing birds next to the runways, by hitting antenna wires and other obstructions, and by individuals in violation of the regulations of the Midway Naval

Figure 3. Above. Drift fences are now necessary to keep blowing sand off plane-parking areas. Below. Sand invades when the grass and *Scaevola* are removed.

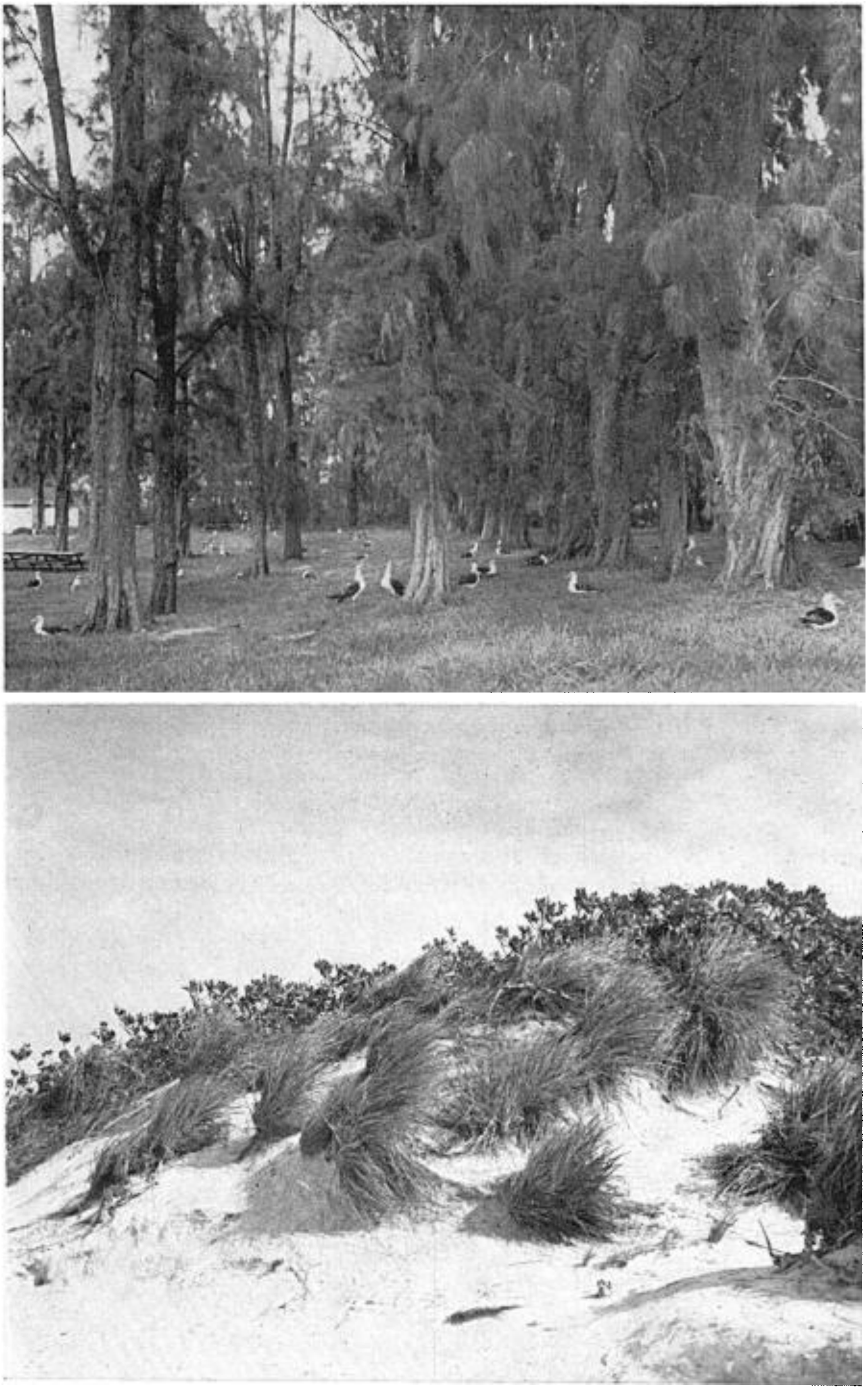

Figure 4. Above. Many of these ironwood trees (*Casuarina*) were planted by the Commercial Cable Co. in 1903. Below. Bunchgrass and *Scaevola* held the sand in place on the dunes which formerly protected the interior of Sand Island.

Station. Each year such deaths are estimated as being at least 3000 breeding adults, and Kenyon *et al.* (1958) estimated 7000 "killed on Sand Island by unauthorized persons and by accidents" from November 1956 to May 1957.

No records of the years 1960 to 1963 are available to me, but I was present at least twice each year during 1961, 1962, and 1963. The control program consisted mostly of minor eliminations, perhaps no more than a few thousand birds each year. Since I am told (Robbins, personal communication) that the Fish and Wildlife Service authorized no control in these years, I must conclude that these deaths were part of a program separately instituted by the U.S. Navy. Whatever the program, the populations were thus reduced.

In 1956–1957 the kill in the control program was more than 4 per cent of the breeding population of Sand Island. For 1957–1958 and 1958–1959 we have no estimates of the population, but in 1959–1960 Robbins estimated 34,500 breeding pairs of Laysans. That year the kill was probably in the neighborhood of 15 per cent of the breeding birds. In 1964 the known control amounted to 18 per cent.

However, the total number of deaths of breeding individuals of this long-lived, monogamous species does not give a complete picture of the effect on the reproductive potential of the colony. When one member of a pair is lost, the remaining member (male or female) does not nest the following year. At least this was usually true in our five-year study of marked birds, although Rice (1959) reported that 13 per cent of the bereaved mates do breed the next season. Thus even if only one member of a pair is slain, the reproductive potential of the remaining bird is usually destroyed for two years.

EFFECT OF THE PROGRAM ON THE INCIDENCE OF AIRPLANE-ALBATROSS COLLISIONS

Assembling the Data

In table 1 is summarized all the available, pertinent information on the numbers of Laysan Albatrosses striking airplanes. Most of these data came from records kept by the Naval Station. However, the bird-strike data for 1956–1959, although also gathered by the Naval Station, were no longer in its files, and I

Table 1

Albatross Strikes as Per Cent of Takeoffs and Landings of Planes

	1956–57	57–58	58–59	59–60	60–61	61–62	62–63	63–64
November	↑	↑	1.6	1.1	0.5	2.8	3.0	2.3
December	|	|	1.8	4.8	1.4	2.7	4.9	1.5
January	|	|	0.7(?)	3.4	2.9	4.1	4.6	2.4
February	6.6	7.8	6.8	4.0	2.5	6.3	6.0	2.8
March	|	|	6.7	3.1	5.8	9.8	4.9	4.8
April	|	↓	8.3	3.0	5.2	7.7	8.1	8.0
May	↓	(7.3)[a]	7.3	1.6	5.5	5.9	4.6	3.8
June	(2.5)[a]	(2.5)[a]	2.0	0.8	2.5	2.5	1.2	0.9
July	(2.3)[a]	(2.3)[a]	1.7	0.2	1.2	2.3	1.9	0.6
Mean	(5.7)	(6.5)	4.1	2.4	3.1	4.9	4.4	3.0

[a] Estimates based on maximum percentages observed in subsequent years. See text.

used information published by others closely connected with the investigation of this problem. The early data were not complete, nor as accurate as those after 1960, when the Navy systematized the keeping of such information.

For each month the Navy summarized the number of airplane operations (take-offs and landings) and maintained records on time, place, and species of bird for each bird-plane collision. However, its daily record of operations is destroyed at the end of each monthly period and is kept only as a monthly summary. It is thus impossible to correlate more closely than by months the percentage of strikes and the activity of the albatrosses. This is unfortunate because the changes in avian activity do not coincide with calendar months, and these records would have been valuable for any evaluation of the program.

The real incidence of collisions is lower than the reported rate. In 1956–1957 the Navy counted all dead birds on the runways as strikes no matter what the cause of death. Birds caught in the slipstream and thrown about were often counted although they did not touch the airplane. Kenyon *et al.* (1958) tried to correct these data, and I have used their information (table 1). But since June and July, for which they had no data, are normally freer of strikes than are the spring months, their 6.6 per cent incidence for the first year of the program could not be compared with that in subsequent years.

To complete the monthly data for 1956–1957 and 1957–1958, I have assumed that the collision rate was as high as in the same month in later years. Thus, the 7.3 per cent of 1958–1959 has been included in parentheses for May of 1957–1958 for the computation of a yearly mean.

For 1957–1958 Rice (1959) reported that an average of 9.8 per cent of the airplanes landing or taking off were struck by Laysan Albatrosses, but at the same time he indicated through other data that the average was 15 to 20 per cent too high. Therefore, I reduced by 15 per cent the average calculated after the inclusion of the three months for which he published no data.

Information for 1958–1959 and 1959–1960 is from the reports of Robbins (1960, 1961). For the period 1960 to 1965 the figures are my summaries of Naval Station records. Estimates of bird populations in these years are based on censuses that are reported in detail elsewhere (Fisher, 1966).

The data on bird-airplane collisions in August, September, and October are excluded, for no Laysan Albatrosses are present then. However, 107 nocturnal collisions attributed to this species have been included, although almost certainly few albatrosses were involved.

Since the Laysan Albatrosses arrive in November, the "years" in the tables are really "breeding years"; this grouping, rather than the calendar years used in previous evaluations, is necessary if one is to make accurate comparisons between successive breeding populations which are often of quite different size.

In past analyses of these data, the simple, average percentage of airplane operations that hit birds was compared from year to year, or the percentages of strikes for a particular month in successive years were contrasted. Thus in table 1 one might conclude that 1960–1961 (3.1 per cent) was an improvement over 1956–1957 (5.7 per cent). But this kind of reasoning takes into account not at all the numbers of birds present, and obviously the more birds the greater the percentage of planes involved in collisions.

We then based the percentage of strikes on the relative numbers of birds (table 2). The year 1956–1957 (Kenyon *et al.*, 1958), the first year with a population

TABLE 2
ALBATROSS STRIKES IN RELATION TO BREEDING POPULATIONS DURING THE BREEDING SEASON

	1956–57	57–58	58–59	59–60	60–61	61–62	62–63	63–64
Strikes:								
Actual	5.7	6.5?	4.1	2.4	3.1	4.9	4.4	3.0
Expected	5.7	6.5?	4.1?	3.3	2.0	2.6	4.4	5.0
Nesting pairs	60,000	?	?	34,500	21,000	27,800	46,000	53,000

estimate, was used as a base, and by simple proportions the figures in "Expected Strikes" were calculated.

ANALYSIS OF THE DATA

Comparison of the Actual and the Expected Strikes for the 1960–1961 season indicates one and one-half times as many Actual Strikes as would be expected for a population of that size (table 2). In other words, the collision situation in 1960–1961 after four years of the program was nearly twice as bad as in 1956–1957 when the control program was initiated.

Using this type of analysis we can see that only in 1959–1960 and 1963–1964 was there a significant decrease from the level of 1956–1957. In 1959–1960 the decrease was 30 per cent, and in 1963–1964 it was 40 per cent. These were, of course, the years in which massive "control" had taken place, the years when from 15 to 18 per cent of Sand Island's total breeding population may have been eliminated, when the breeding grounds had been so disrupted that additional thousands of individuals and of pairs, freed of nest duties, left the island and returned only at long intervals rather than flying back and forth frequently, or daily as when feeding young.

But what of the 1960–1961 and 1961–1962 breeding seasons? And 1962–1963, when the rate of collision was the same as in 1956–1957? The number of birds on the island in these years should have been reduced to the extent that the young birds not produced because of massive control from 1957 to 1959 did not enter the breeding grounds from March to May. Also, the elimination of at least 60,000 breeding birds from the areas regarded as troublesome should have had some effect, if those areas were really the primary ones causing the majority of the bird-plane collisions.

Perhaps it is not correct to use the breeding populations or the censuses of November-December-January to adjust the strike percentages throughout the year; at least the data are open to criticism because the strikes are more numerous in the spring and have been largely attributed to "unemployed birds" (Kenyon *et al.*, 1958).

But the censuses of November and early December are valid for use in adjusting the percentages of strikes to a common denominator for these months (table 3). There has been no downward trend in Actual Strikes in November; in fact, the last four years have had more strikes. The strikes in the last two Decembers were not appreciably different from those in 1958–1959 and 1960–1961. December strikes in 1959–1960 and 1962–1963 equaled each other and were nearly three times as many as in 1958–1959.

TABLE 3

ALBATROSS STRIKES IN NOVEMBER AND DECEMBER AND FROM NOVEMBER TO APRIL IN RELATION TO BREEDING POPULATIONS

	1956–57	57–58	58–59	59–60	60–61	61–62	62–63	63–64	64–65
November:									
Actual	–	–	1.6	1.1	0.5	2.8	3.0	2.3	1.7
Expected	–	–	?	(2.3)	(1.4)	1.8	3.0	3.5	1.7
December:									
Actual	–	–	1.8	4.8	1.4	2.7	4.9	1.5	1.5
Expected	–	–	?	(3.7)	(2.2)	3.0	4.9	5.6	2.7
November–April:									
Actual	6.6	9.8	4.3	3.2	3.1	5.6	5.3	3.6	–
Expected	6.6	9.8(?)	?	3.8	2.3	3.1	5.1	5.8	–
Nesting pairs	60,000	?	?	(34,500)	(21,000)	27,800	40,000	53,000	25,700

We are hampered in the comparison of Actual and Expected Strikes in November and December by having estimates of breeding populations during the last of the egg-laying period for only four years (1961–1965). Censuses later in the season, "corrected for nest loss," are inaccurate, for this loss may vary from 5 to 20 per cent by mid-December in successive years. Adults which "lose a nest" leave and visit the colony only infrequently for the remainder of the season. Thus the estimates of populations on the island may be considerably in error. These late-in-the-season censuses and their derived data are in parentheses in table 3. In the Novembers from 1961 to 1965 the percentages of Expected Strikes were the same as Actual Strikes in two instances, higher in one, and lower in one—with no trend up or down in the four years. Two of the Decembers showed significant decreases in the number of collisions, and two were essentially the same. It may be of significance that the December records of 1963–1964 and 1964–1965 showed incidences of Actual Strikes that were approximately half of the incidence in 1961–1962 when the breeding population was the same size (1961 and 1964) or much smaller (1961 versus 1963).

Estimates in table 1 for 1956–1957 and 1957–1958 are based on the strike percentages for later years and may be erroneous. To check this, the original, unmodified data published by others for the November-April period are included at the bottom of table 3. The season of 1956–1957 is again used as the base. Comparison shows that the only apparent reductions were in 1959–1960 and 1963–1964, when major control by killing was undertaken in December or January. The data for the other three years indicate that the number of Actual Strikes was greater than would be expected on the basis of the populations estimated as present. In other words, in three of the five years the incidence of strikes was higher than in 1956–1957, when the program of control was initiated.

Two intangible factors make it more difficult to assign any possible decreases in the number of collisions to the control program. It has been stated that during the actual months and years of massive control there was an increased hazard. If this was actually the case, which it certainly was not in 1959–1960 and 1963–1964, then the percentage of strikes in the early years of management (1956–1959) was higher than it would have been without the control. In other words it is possible, if one accepts the view that the "management" disturbed and confused the albatrosses and caused more of them to fly over runways, that the calculated 6.5 per cent incidence of collisions in 1957–1958, for example, was higher than it would have been without the control. There is no way to assess the extent, if any, of this effect. However, since the incidence of collisions in these early years of management is used as a basis for comparison with recent years, it is evident that any unnaturally produced increase in the number of collisions in the base years would amplify the presumed decrease in the number of strikes in later years. Thus we cannot be certain in table 1 that there exists a true 1.6 per cent decrease between 1957–1958 and 1961–1962, for example, in the occurrence of collisions.

The fact that some adjustment in plane operations has occurred must also be considered; early-morning operations are now avoided when possible. This surely has lowered the strike percentage in recent years over and beyond any effect the control program may have produced.

Although it is impossible to judge the effects of weather on the number of strikes, and since the multiple facets of the population dynamics of the Laysan Albatross are yet to be unraveled, in my opinion this review of the results of the control program indicates that its effectiveness remains to be demonstrated, even after nine years.

ANALYSIS OF THE PREMISES UPON WHICH THE PROGRAM WAS BASED

The incidence of bird-airplane collisions may not be solely, and possibly not even primarily, a function of the number of birds within 100 or 750 or 1000 feet of the runways. Much of the total population of Laysan Albatrosses on Sand Island may be involved, without regard to the distance between the nesting sites and the runways.

To understand this we must first examine the geography of Midway Atoll and then re-evaluate the program of bird destruction and land leveling in the light of the flight habits of the albatrosses.

Many of the data used in developing the concept that birds near runways constituted the major hazard came from Kenyon *et al.* (1958), and figures from three of their four counting stations (p. 27) included birds flying into and out of a triangle of breeding ground surrounded by paved runways (fig. 1A). The birds had to cross runways or plane parkways or taxiways to move to and from the sea. Inclusion of these birds, it would seem, would bias the data for the island as a whole.

Sand Island is in the southwest part of the atoll near the reef; deep water where the albatrosses feed begins less than 200 yards south of the island. To the north, deep water is five miles across the lagoon. The runways are on the south and west sides of the island. To move directly to the nearest deep water, the albatrosses must cross runways.

One may say that a distance of five miles means little to an albatross, and that it is fallacious to reason that they proceed immediately to the nearest deep water. To check this we made counts of the albatrosses that flew north across the lagoon to the sea and of those that took the shorter route to the south and west. Nine two-hour counts made when the wind was consistently from the southwest to west on successive days in the first week of December 1964, a time when 90 per cent of the birds on the island were breeders, showed 2133 moving off the island to the south, 1922 to the west, and 217 north across the lagoon. Thus at least on these occasions only 5 per cent of the birds went north, despite the fact that most of the breeding birds are now located in the northeast part of Sand Island.

Similar counts, made in mid-January 1965, when the wind was from the northeast and when "unemployed birds," as used by Kenyon *et al.* (1958), constituted 30 per cent of the birds in our test plots, showed less than 10 per cent of the birds traveling north over the lagoon.

Evidence from Eastern Island supports the hypothesis that Laysan Albatrosses tend to depart toward the closest deep water and to return the same way. The bulk of breeding adults on Eastern move eastward and southward from the land, and the reefs are closest to these sides.

Immatures of all ages show the same tendency to move to the closest deep water. Two summers of daily censusing of marked nestlings that had left the nest sites and gone seaward showed that the majority moved to the beaches on these sides of Eastern Island.

Our recoveries in 1964–1965 of immatures, banded in 1961 and 1962 as nestlings in all areas of Eastern Island, indicated that many first landed on eastern and southern shores before moving to their natal areas. The main body of young birds banded on the western shore was caught in the southern part of the island, but few of the southern birds were captured on the west side. Young banded in the central triangle of Eastern Island were in later seasons often first found to the south and east and only seldom to the north or west. We frequently found these birds in the triangle a few hours later. The tentative conclusion is that the birds have "traditional avenues" of approach to the colonies, perhaps established during the juvenile trek to the shore.

Rafts of floating Laysan Albatrosses are frequently observed to the south of the reef and only infrequently to the north by persons on the recreational fishing boats and by the pilots of the sea-air rescue unit.

It is possible, of course, that the difference between my data relative to the source of birds that fly over the Sand Island runways and those of Robbins (1960), who reported that two thirds of them come from within 750 feet of the runways, is the result of the elimination of that two thirds, leaving only the others to fly across. If this is true, the frequency of collisions should have been reduced. But this has not been demonstrated.

That the incidence of strikes is a function of the total population of albatrosses on Sand Island is well illustrated, I think, by the data of Robbins (1960), who noted a 27 per cent decrease in birds flying over the runway. His estimate of populations was 30,000 to 39,000 (averaged in table 2), a decrease of from 35 to 50 per cent, and the incidence of strikes was 36 per cent less than expected. The gross similarity between the degree of these three reductions is significant.

Persons reporting on the control program have repeatedly referred to albatrosses "soaring" over runways. To most ornithologists soaring implies a circular pattern of flight, which in turn produces a vision of albatrosses wheeling back and forth across the runways. This is not the case at all, as Frings and Frings pointed out in 1959. I have never observed Laysan Albatrosses soaring in thermals generated by runways.

Albatrosses do not ordinarily employ flapping flight for more than seconds at a time and most often at the time of takeoff. Once airborne they progress in a zigzag manner, rising into the wind to gain altitude and moving obliquely across wind and losing altitude to gain speed for the next rise, occasionally flapping a few times. Most of the time the bird is below 100 feet of altitude at sea and on land where there are no obstructions such as trees.

Since the habit of flying albatrosses is to stay low to the ground and water, since the north side of Sand Island has an uneven covering of trees and buildings that produces difficult spots of turbulence without providing a continuous pathway of updrafts leading to the sea, and since the southern and western parts are now devoid of most obstructions to low flight or to an even flow of wind, it is suggested that more of the albatrosses now travel south or west, and cross the runways. In the past they may have flown north. Thus the extensive "terrain modification" undertaken in the southwestern part of Sand Island (fig. 1B) to relieve the problem actually may have increased the number of birds that fly across the runways to reach nests at more distant spots.

Most of the birds are hit as they are crossing the runways between the sea and their breeding areas. What has been the effect of the leveling of dunes, the removal of trees, and the widening of the flat spaces along the runway?

Intervening strips of vegetation or sand dunes deflect the wind upward to produce updrafts along which the birds glide; they seldom deviate more than 50 feet from the line of maximum lift which is to be found over the edge of the obstruction, the edge toward the wind. The turn to make the return trip along the updraft is fairly sharp, taking in no more than perhaps 50 feet; a longer loop takes the birds away from the area of the most effective rising currents and increases their labors.

Thus birds gliding on updrafts produced by trees or dunes alongside 300-foot-wide runways which have a truck road on either side seldom get over the runway and even less frequently are hit by airplanes in the middle of the 350- to 400-foot space. The presence of "updraft" paths alongside runways would probably decrease the number of birds using the airspace above the runways. The birds would follow the line of easier progression.

Further, when there are dunes and/or trees on either side of the runway, the winds are carried upward above the level of planes no more than 50 feet above the runway. This is, of course, no aid during ascent or descent of the plane above this level, but the layer of birds above 100 feet is thin and scattered. Planes are in this "strike zone" a very short time compared with the time they are moving below an altitude of 50 feet.

Removal of updraft-producing terrain on the windward side of the runway causes winds to move across at low levels. Widening of cleared areas causes more of the cross winds to drop onto the runway, or to pass across in an uninterrupted manner which produces better flying conditions for albatrosses over the runways.

Since albatrosses fly at low altitudes and are largely dependent upon winds, the direction and placing of air currents affect them greatly. Man should manipulate the currents as far as possible to produce avian flight patterns least dangerous to him and his airplanes. Ideally, the leveled width of a runway and its aprons should perhaps be just as narrow as is compatible with mechanical safety. Dunes, brush, and trees to produce updrafts should line the edges of the runway and should be of a height to throw the main wind currents above the level of planes still on the runway. Breaks in the lines of updrafts could be made to produce "bird crossings" where desired—where there would be the least danger to planes.

Such control would not be 100 per cent effective. But it would, I think, be more efficient than the present program which causes all traversing albatrosses to fly over increasingly wider spaces at the altitude of airplane operations. If the strikes have been reduced in the past few years, which is not at all certain, it is my opinion that the decrease is primarily the result of the reduction in the population of birds and changes in airplane operations and not the result of the "terrain modification," which would, if anything, increase the opportunity for collisions. Frings and Frings apparently came to this same conclusion in 1959.

If terrain modification is the major factor as Aldrich (1961) and others state, why not modify the terrain without killing the birds? This could be easily accomplished in late August, September, or early October when the breeding grounds are free of both Laysan and Black-footed albatrosses. The evidence suggests that the birds would select other sites within a year or so.

GENERAL COMMENTS

There are other areas of misunderstanding of this problem, some based on lack of information, and some arising from the manner of gathering and publishing data (Aldrich, 1958, 1964; Brown, 1962).

As long as major airplane operations continue the problem will be serious. But the situation has been somewhat exaggerated. There is no evidence that "40 per cent" of airplane operations ever did involve bird strikes. No plane has been wrecked, and only one to my knowledge was ever in actual danger of being wrecked.

No planes have been "out of service for months." Economic losses are not "in the millions" or even in the hundreds of thousands of dollars. In one 10-month period during one of the worst years, the reported loss was $83,000. The actual loss was apparently less than $5000; the remainder was "depreciation" at $565 a day (Rice, 1959:22). There is nothing wrong with such a system of accounting; expensive airplanes do depreciate, but publication of such large "costs" without explanation imparts an exaggerated impression of what a bird does to an airplane.

When a bird is struck during takeoff, safety demands that the damage be assessed immediately. Sometimes this means the takeoff is "aborted"; the plane never leaves the ground. At other times it is impossible to halt the takeoff run, and the plane circles Midway while the effects of the strike are being determined. If necessary, fuel is dumped and the plane lands—an expensive procedure. During the period from November 1960 to 1 January 1965, there were approximately 19,000 takeoffs. Only 58 of these resulted in either of the two procedures mentioned.

Airplanes which are not part of round-the-clock schedules and planes moving through Midway could operate when there was the least chance for collisions with birds. Passenger, freight, and strictly military flights from Honolulu could arrive and depart in darkness, rather than in the daytime. Many of the trans-Pacific military flights using Midway for refueling could do the same. The military could do more to help itself in these ways and thus decrease collisions appreciably.

The elimination in May 1965 of the Pacific Barrier, the Advanced Early Warning system of radar planes, one base of which was Midway, means that air traffic will be very much reduced. Remaining traffic can often be on a daily or seasonal schedule which takes into account the diurnal and seasonal activities of the albatrosses and the consequent varying incidence of bird strikes. Further, it seems likely that new technological advances in airplanes, communication, and detection have revealed that Midway is no longer an absolutely necessary part of our national defense in peacetime.

The Office of Naval Research (Contract 3479(00)) and the Graduate School of Southern Illinois University are supporting my studies of the Laysan Albatross.

Although my investigations are not primarily directed toward the problem discussed here, they do provide a broad base for understanding and evaluating the situation. I am grateful for the help being given.

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