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Scope of Study: The basis for this study is the problem of bird and aircraft collisions on and near airplane runways. This study was conducted on the habits of the Laysan albatross (Diomedea immutabilis) which is contributing to the airstrikes on Midway Island in the north Pacific. The study involves the population, distribution, nesting and flight patterns of the albatross. Emphasis is placed on the experimental methods that have been tested as means of alleviating the strikes near the airstrips on Midway.

Findings and Conclusions: The Laysan albatross nest only on the Leeward chain which is part of the Hawaiian Archipelago. They return to these islands every year to lay their eggs and to raise their young.

The population of the birds has recently been found to be considerably higher than was previously recorded. This revised estimate is the result of the banding program that is in progress on Midway Island.

The birds spend a good deal of the time in the air soaring over the ocean looking for food. During the nesting season they soar over the runways at Midway where they are occasionaly in collision with aircraft.

Two killing programs have been conducted on Midway by the U.S. Fish & Wildlife Department. Over 34,000 birds have been killed yet this failed to reduce the number of birds that soar over the runways.

It is the feeling of most of the biologists that the problem can be reduced considerably if the area seven hundred fifty feet from the center of the runway be flattened; this will reduce the air currents in which the birds love to soar.

ADVISER'S APPROVAL L. Herbert Bruneau

THE LAYSAN ALBATROSS AND ITS ECONOMIC IMPORTANCE

By

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THE LAYSAN ALBATROSS

AND ITS ECONOMIC

IMPORTANCE

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PREFACE

The purpose of this paper is to investigate the bird and plane collisions which are occurring on a small island in the north Pacific. This island, though small, is very vital to the nation's defense. The Laysan albatross (Diomedea immutabilis) is the bird involved in these strikes; therefore a comprehensive study of its life habits were made. The study involves the population, distribution, nesting and flight patterns of the albatross. Emphasis is placed on the experimental methods that have been tested as means of alleviating the strikes near the airstrips on Midway Island.

The major portion of the material for this study came from the literature in the Oklahoma State University Library. Several articles were obtained through the very efficient interlibrary loan service conducted by the library named above.

The writer wishes to express thanks to Dr. F. M. Baumgartner for suggesting the problem, and to Dr. L. H. Bruneau and Dr. James H. Zant for their assistance and helpful advise during the study.

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CHAPTER I

INTRODUCTION

The Problem. Large numbers of nesting and resting black-footed and Laysan albatrosses and sooty terns occupy Sand Island, one of the two atolls that make up Midway Islands. Sand Island is the site of an important United States Naval Airbase which is operating one of our early warning radar tracking stations. These birds while in flight over the runways are frequently hit by aircraft and are considered to be a serious hazard to planes and human life. The currently expanding facilities at Midway for handling an expected great increase in air traffic, particularly in jets and specialized types of aircraft, make it imperative to find methods of reducing the hazards to planes by collisions with birds.

Importance of the Problem. Since Midway has been used as an airbase there are no records of human lives being lost or of an aircraft having crashed because of the bird strikes; but the birds do dive into propellers, smash against rudders, flaps, and expensive radomes causing approximately $300,000 damage a year. Far worse is the ever present danger that a bird may foul a plane and cause a fatal crash. We only have to recall October 4, 1960 to realize the seriousness of one of these crashes. This was the date the Eastern Airlines Flight 375 roared down runway 9 of Bostons' International Airport, lifted into the clear afternoon sky, then, a few hundred feet in the air,

wheeled suddenly on its left wing and dived to destruction in the cold waters of Winthrop Bay taking seventy-three lives with it. The cause of the crash was due to birds that had been ingested by the jet engines on take off.

From previous investigations it has been established that the Laysan albatross is the major contributor to the strikes on Midway; therefore, this paper will be devoted to the life history of the bird which will include the investigations made by the Fish and Wildlife Service in recent years. What is said about the Laysan albatross can also be said about the black-footed albatross; although, because they are fewer in number than the Laysan, they are not so important economically.

CHAPTER II

THE ALBATROSS

"they...that do business in great waters"
(psalm 107:23)

Among pelagic birds the Procellariiformes stand first. They belong to the marine environment more fully than any other bird; for, like sea turtles and fur seals, many of them come to shore only for reproduction, remaining at other seasons permanently in the wastes of water, and even shying away from coasts so thoroughly that they scarcely sight land other than annual breeding stations. The Procellariiformes are an ancient and primitive group doubtless more abundant and certainly more wide spread during geologic ages. We know from fossils that there were once albatrosses in the north Atlantic.

Albatrosses and their small relatives, the fulmars, shearwaters, and petrels, belong to the order Procellariiformes, or Tubinares, birds with prominent external nostril structures which differ from other birds. All of the species show many common traits, in both anatomy and behavior. All, for instance, possess tubular nostrils; and all are so strictly maritime that they are very difficult to keep alive in captivity; whereas, penquins, cormorants, gulls and other oceanic fowl have lived for several years in suitable aviares (Murphy, 1938).

Apart from various characters of the skelton and internal parts the most distinctive features of an albatross is its bill. This is

stout, with the upper mandible hooked, and is covered with a number of distinctive horny plates. The nostril openings form short tubes on each side of the middle plate of the upper mandible.

One of the very fascinating physiological aspects of the albatross is its possession of nasal glands which are situated in bony sockets above the eyes, with ducts leading to the external openings. These glands have been known to exist since 1834, but their function was unknown until 1958. Jorgenson (1958) and his colleagues found that the glands enable the birds to use sea water as a source of water, in spite of its hypertonicity. Jorgenson fed the birds fish loaded with heavy concentration of salt and immediately the glands excreted drops of liquid which had almost twice the concentration of Na^+ ions as that of sea water. He concluded that the nasal glands remove sodium and potassium ions from the blood.

Flight. In flight the albatross, like an airplane, must rise against the wind; with its wings fully extended the bird runs swiftly along the ground or water until it has gained enough head-way to rise. Dill (1916) reports that if the bird is thrown into the air it cannot fly as do most birds, but instead falls heavily to the ground.

Wing areas apparently determine the character of flight; the hummingbird depends mostly on wing motion, while the albatross, with its great wing spread, finds soaring flight most efficient. Hoffman (1931) indicates that soaring flight caused by air pulsations appears to be distinct from soaring flight resulting from rising air currents. Soaring flight in a rising air current is circular, except where the rising current is caused by a cliff or other obstruction.

Alexander (1954) reports that the albatross spends a great part of its life in the air, gliding over the waves with its narrow pointed wings held motionless. The birds usually rise in a slanting direction against the wind, then make a turn in a large circle during which one wing points downward, the other upward, and finally make a rapid descent downwind. Only when the wind is rather strong can the albatross continue its sailing flight for any length of time; when the wind drops it begins to flap its wings much more frequently. Hoffman (1931) terms the specific flight pattern as quartering flight. Quartering flight means flight not directly against the wind, but rather at a sustained angle with the wind, perhaps fifteen to forty degrees. It appears that birds wishing to take advantage of quartering flight fly at low elevations, particularly over the water, where air pulsations are caused by wave motion of the water. Blackman (1949) theorizes that the birds follow ships because the vessel creates air currents which help support them on their continued search for food.

Alexander (1954) reports that when the birds tire of flying they settle gently on the water. When settled on the water with their wings closed they float very high. In order to start off again in flight they commence by running along the surface with outstretched wings in order to obtain sufficient impetus to carry them up into the air, usually flapping the wings continuously until clear of the waves.

Food. Henderson (1934) reports that the albatrosses are voracious feeders, but are maritime birds, therefore, are of slight economic importance. They are omnivorous, feeding upon anything edible from the surface of the sea, including garbage from ships galleys, dead animals, living marine invertebrates and small vertebrates.

Fisher (1904) found on the nesting grounds of the Laysan albatross solid pellets that had been disgorged by the albatrosses, consisting entirely of squid beaks and the opaque lenses of the eyes. Candle nuts, the large seed of (Aleurites molluccanna), are also found in the pellets and the nearest are found many miles from the nesting islands. This indicates that the seeds are picked up in the ocean by the birds, because they are not uncommon in the ocean, probably swept there by mountain streams.

Guthrie (1932) reports that venomus sea snakes are caught and eaten by albatrosses. His reports came from sea captains that told of the albatrosses dragging these serpents from the waves and flying to the rigging of the ship to kill and devour them.

Iredale (1931) states that albatrosses never perch either on mast or shroud; they settle only on water. However, the gannet a somewhat similar looking bird, has the habit of perching upon ships masts. From the literature cited it seems that an albatross would have trouble landing or sitting on a mast because of the trouble it experiences at times landing on the ground.

Distribution. Of the thirteen kinds of albatrosses, nine occupy temperate and sub-antarctic areas of the southern hemisphere, one is an equatorial species inhabiting the Galapagos Islands, and three formerly ranged over the waters of the north Pacific; but one of these, the short-tailed (Diomedea albatross) which nested on the Bonin Island is possibly extinct (Bailey, 1952). The other two northern hemisphere albatrosses, the Laysan (Diomedea immutabilis) and the black-footed (Diomedea nigripes) are common birds in their restricted nesting habitat on the coral islands of the Leeward group, which ex-

tends northwestward from the Hawaiian Islands.

Rice (1959) indicates that outside of the Hawaiian Islands both Laysan and black-footed albatrosses formerly nested on Wake, Marcus, and Johnston Islands. Albatrosses no longer occur on these islands, according to observers who have visited them in recent years. Laysan albatrosses once nested on Tori Shima in the Izu Islands, but were extirpated. It thus becomes apparent that both the Laysan and the black-footed albatrosses have become extinct throughout their former breeding range outside the Hawaiian Archipelago, and at the present time are virtually confined as breeding species to the Leeward chain of islands.

CHAPTER III

NESTING ISLANDS OF THE LAYSAN AND BLACK-FOOTED ALBATROSSES

The Leeward chain of the Hawaiian Islands, between latitudes 23 degrees and 29 degrees N. and longitudes 160 degrees and 180 degrees W., extends northwest from the main group for approximately twelve hundred miles, terminating with Ocean Island. Midway Islands, latitude 28 degrees 13 minutes N. and longitude 177 degrees 23 minutes W., consisting of Sand and Eastern Islands, surrounded by a fringing reef, are well known and accessible to air travel, but the other islands and shoals of the chain are remote from regular means of transportation. As the name implies, Midway is centrally located in the Pacific, being 3,200 miles west of San Francisco, 3,600 miles east of Shanghai, and 3,800 miles north of Australia. Pearl and Hermes Reef are ninety miles east of Midway; and Laysan, latitude 25 degrees 46 minutes N. longitude 171 degrees 44 minutes W., is some three hundred miles east of Midway or eight hundred miles northwest of Honolulu. Other islands include Lisianske, Maro Reed, Gardiner Pinnacles, French Frigate Shoal, Necker and Nihoa Islands. All of the above except Ocean and Midway were named in Executive Order No. 1019 by President Theodore Roosevelt on February 3, 1909, setting them aside as "a preserve and breeding grounds for nature birds" (Henshaw, 1911).

All the islands of the group are uninhabited except Midway, which is now under control of the United States Navy, with the Civil

Aeronautics Authority and the Commercial Pacific Cable Company which was established in 1903, both carrying on important work.

The first people to stay on this island, however, were shipwrecked sailors from the schooners General Seigel and the Wandering Minstrel, in 1886 and 1888 respectively. The crews of these wrecked vessels lived upon the sea birds which obviously have lived there many centuries as shown by the amount of guano deposited and the fossilized eggs uncovered (Bailey, 1956).

Dill (1916) reports that in 1890 Laysan Island, some three hundred miles southeast of Midway, was leased by the United Kingdom of Hawaii to a guano company. Thousands of tons of guano were exported annually, and it was thought that it was being deposited as rapidly as it was removed. The amount of guano deposited by the albatrosses and other sea birds on Laysan was estimated to be about one hundred tons daily. The workers often found the eggs of the albatross and the shearwater bedded in the rock like guano deposits in a semifossil condition according to Bryan (1915). Dill (1916) reports that the business was abandoned in 1898 due to the low grade fertilizer, caused by the frequent rains that removed the ammonia from the fertilizer.

CHAPTER IV

ORNITHOLOGICAL WORK ON THE LEEWARD CHAIN

Comparatively few naturalists have been privileged to visit the islands of the Leeward chain. From the literature cited it is probable that the first bird observations were made on Laysan Island by the German naturalist, F. H. von Kittlitz. In 1826 Kittlitz traveled on the Russian transport Senjouin, which sailed on the north Pacific in the vicinity of the Laysan Island where Kittlitz was able to observe the teeming bird life of the coral atoll.

The first real expedition to study the birds in the Leeward Islands was led by Henry Palmer, assisted by George C. Munro. They collected birds throughout the islands from May until August, 1891, spending a few days on Laysan and Midway. Their field notes were compiled by Walter Rothschild (1893-1900) and published in three parts under the title "Avifauna of Laysan" which is a beautiful printed edition of 320 pages including many colored plates and also photographs which were taken on the expedition.

Professor Schauinsland visited Laysan in 1896 and spent a few months collecting birds and writing notes on the fauna. While he was there he was the guest of Max Schlemmer, the manager of the guano company, which was in operation at that time. It is from the expedition that the Laysan albatross received its taxonomic name. Schauinsland sent Rothschild a series of twelve skins in all stages of growth and

plumage. Walter Rothschild (1893-1900) wrote:

> the nestling as hatched is covered with down of a greyish white colour, the basal half of the down being dark sooty-brown. When we examine the next stage, in which the young is covered with dark brown down, it becomes evident how the change from the downy stage to the first plumage takes place without a real moult. The dark brown down when it displaces the first nestling down appears to be composed of intergral downy plumes. As the birds grow the down is pushed out further and further until we perceive that it is not composed of intergral plumes, but that it is attached to the end of the webs of the feathers. These downy filaments are then gradually worn off until we see the final feathers of the first plumage, which induced me to name the species D. immutabilis, to distinguish it from most of the other albatrosses which had a first plumage different from that of the adults.

Professor Schauinsland also sent Rothschild two albanistic specimens and a hybrid which evidently was of (Diomedea immutabilis) and the black-footed albatross (Diomedea nigripes).

Walter K. Fisher (1904), while a member of an expedition aboard the U. S. Fish Commission steamer Albatross, was on Laysan from May 16 to 23, 1902. Those seven days were spent on the island studying the bird life. He took several pictures and made many valuable observations on the nesting birds. His observations have been noted to be especially good.

W. A. Bryan (1903) was another fine naturalist to visit these islands. He was on Midway in August of 1902, and reported upon the activities of Japanese feather hunters who destroyed thousands of birds for the millinery trade. He found carcasses scattered over the entire island as testimony of the slaughter. In 1905 other Japanese carried on their wanton work on Lisianski, and it is estimated that they eliminated some 300,000 albatrosses and other sea birds, before they were stopped. As a result of Bryan's account of the destruction of birds

by Japanese feather hunters, all the Leeward Islands except Midway and Ocean were set aside as the Hawaiian Islands Reservation. This did not prevent a raid on Laysan Island, however, for during the same year (1909) a party landed and killed more than 300,000 birds, notably albatrosses, for millinery purposes.

The University of Iowa sent an expedition led by H. R. Dill (1912) who spent approximately six weeks on Laysan Island. As a result of this expedition, Professor Dill constructed the Laysan Cyclorama in the Museum at the University of Iowa.

The U. S. Biological Survey sent an expedition on Laysan Island in the winter of 1912-1913. The party was sent there to kill the rabbits, which were introduced to the island by the manager of the guano company, that were devegetating the island. The expedition was unsuccessful because the party did not have the proper equipment to do the job completely. Bailey (1952) was a member of the party and he reports that they killed more than five thousand rabbits with rifles, but this only slowed up the destruction of the vegetation. The rabbits were so numerous that they killed as many as twenty under one (Scaevola) bush.

The next twenty years very few people observed the birds except for the men managing the Commercial Cable Company on Midway.

Pan American Airways inaugurated trans-Pacific air travel in 1935 when they established a base on Midway, and since that time, especially during the war years, thousands of people have observed albatrosses upon their nesting grounds. Comparatively few have published data however. Bailey (1952) reports that the most important observations were made by Fred C. Hadden who was employed as an ento-

mologist by the Hawaiian Sugar Planters Association from November, 1936 to December, 1941.

During the war many naturalists and military personnel came in contact with the albatrosses on Midway, and Paul H. Baldwin and Harvey I. Fisher (1946) made important observations.

In the spring of 1949 Bailey accompanied by Robert J. Neidrock, collected specimens and took photographs for the Denver Museum. Bailey has visited the islands three times and has written several articles which are very informative.

Since that time three investigations have been conducted by the Fish and Wildlife Service. The investigations were to study the feasibility of discouraging the albatrosses from nesting near the plane runways, and so to reduce the hazards of planes striking the birds. New investigations are in progress at the present time, and some of the data will be added later in the text.

CHAPTER V

THE LAYSAN ALBATROSS

The Laysan albatross (Diomedea immutabilis), sometimes called white albatross, white goney, gooney bird or cape sheep, is almost pure white with a black patch in front of the eye; upper surface of wings blackish-brown; tail black; bill gray; legs and feet fleshy pink. The sexes and young are similar. When nearly fledged the young carry a ruff of down around the neck, giving them a peculiar appearance. On the sea it may be identified easily as it is the only near white albatross in the north Pacific. It has a wing spread of approximately six feet and eight inches and weighs approximately seven pounds.

Abundance. The total population of the Laysan albatross is estimated at 1,500,000; this includes about 800,000 sexually mature breeding birds, of which about 560,000 nest in any given year. Rice (1959) reports that this is one hundred per cent more than was reported previously because of the change in their concept of the size of the portion of the population at sea. They believe that for every nesting bird on the island that there are three others at sea. This is based on the fact that birds never return to the nesting island until they reach at least five years of age; also thirty-three per cent of the nesting birds fail to nest the following season. These conclusions are based on a banding program which is being conducted on Midway Island.

At least ninety-six per cent of the population uses only four atolls in the Leeward group; Midway, Pearl and Hearmes, Lisianski and Laysan. Midway supported about thirty-five per cent and is second only to Laysan which is supporting forty-six per cent (Rice, 1959).

Some of the early estimates made by naturalists were from 250,000 to 1,000,000 birds. These were only the nesting birds and they were not considering those birds at sea. Palmer in 1893 took photographs on Laysan Island of the nesting birds present. These photographs have caused considerable discussion because the birds were nesting so close to each other that they looked as though they were touching. Rothschild (1893-1900) wrote that Palmer found the birds this way over the entire island. If this was true, a conservative estimate of 2,000,000 nesting birds which Max Schlemmer gave would probably not be out of reason. Therefore, the total population would have been well over 6,000,000 birds from the island of Laysan.

From the data above one could assume that the total population is now less than in previous years. Much of this can be attributed to the number of birds killed by the plume hunters from 1895-1910. Fisher (1946) reports that the number of this species are definitely much lower now than before World War II; therefore, the combination of plume hunters and the war is probably the reason for the great decrease in the number of birds.

Distribution. Bailey (1956) reports that after the birds leave the nesting grounds in July and August they are never seen again until they return in the late fall. It is probable from the literature cited which concerned observations at sea, that they range the eastern and

northern Pacific, with a great area of ocean centering on the Aleutians being the favored habitat, with a few individuals occasionally appearing to the southward along the California coast in Lower California waters.

Unlike the black-footed albatross which follows ships, the Laysan are not attracted by ships; therefore, observations are fewer on this species. They will follow ships but not for any length of time, and they do not fly as close to the ships as the black-footed albatross (Kenyon, 1950).

Because of the pelagic wonderings of albatrosses, ornithologists find relatively few opportunities to observe them. The difficulties involved in collecting these birds in the open sea from ocean going vessels often compel us to accept sight records of their occurrence. Thus the knowledge of the geographical and seasonal ranges of albatrosses is largely fragmentary when we compare it to our knowledge of other species (Kenyon, 1950).

Arrival on the nesting grounds. Each year some of the birds return from the waters of the Pacific to nest on these islands. They begin to arrive by the middle of October and continue to do so all through the winter months, and until the young are ready to leave with their parents the following July they are inhabitants of the island. Murphy (1938) reports that they begin to arrive at their nesting grounds on almost the same day each year. So nearly are they on schedule that men at the Commercial Cable Company at Midway have betting pools based on the exact time they arrive each year.

The order in which the birds arrive seems to be unknown. It has

been determined by banded birds that a pair normally remain intact until broken by death or disappearance of one of the partners. It was also noted that if a pair were broken up by death they would not nest the next year the majority of the time (Rice, 1959). From this evidence it seems probable that the mated birds would arrive together and begin the nesting activities soon after arriving. This would leave only the unmated birds and non-breeding birds to come in alone.

The banding data also has found that the young unmated birds never return to the nesting island until they are five years old or older. The records also indicate that the bird is approximately seven years old before it becomes sexually mature; therefore, a large number of birds on the nesting island are non-breeding birds (Rice, 1959).

The arrival of the birds must be very fascinating to watch according to most of the observations in the literature. Frelinghuysen (1952) said it was very amusing to watch the first landings of these birds after they had lost their land legs during the months at sea. At first they crash and somersault clumsily; later they relearn the approved techniques and let themselves down on the flats of their feet with very nice precision. Bebee (1926) wrote:

> I saw one coming in from the open sea steadily as a triplane, without a quiver or shift or balance of wing. When over the level ground the wings were tipped backwards--the under surface presented as a brake, the legs lowered, the head held up, and with all its might the albatross bore back and began paddling furiously with its great webbed feet, seeking hold as it taxed over the rough ground. Slower and slower becomes the speed, and finally the wings half reefed and gave up their power. But the feeling was too unaccustomed a thing---the bird sagged sideways, tripped over a pebble, half fell across its fellows, and turned over, rolling undignifiedly several times before it quite stopped. Then it rose unsteadily, gathered itself together and looking around, clattering its beak and shaking its head, doubtless saying to itself the land was not what it used to be.

Nesting. After a few days on the island nesting begins. The old birds tend to return each year to the same place on the island to nest. This may be under a bush, tree, or on the lawn of the post office on Midway. The nest construction is usually very simple with only a little sand being pushed up into a pile and a hollow worn in the top for the egg.

Early in the nesting before the eggs are laid, pairs of birds will be noted "dancing" the performance often followed by coition, after which one of the birds will settle upon the nest. This strange dance or performance is most conspicuous and has evoked comment from every naturalist who has had the privilege of observing it. Kittlitz (1834) made comments on this peculiar behavior performance when he saw it as the first naturalist. The U. S. Navy personnel on Midway say that the gooney birds have a courtship dance as formal and stately as anything found in the royal ball room. They have dubbed the dance as the "Midway Mambo", and have compared it to a minuet. This strange ritual is carried on by two or several birds throughout the entire period they are on the island. It was noticed by Fisher (1904) that at the beginning of nesting time there is less activity than later on in the season. Fisher has given an excellent account of the procedure in midseason as follows:

> Two albatrosses approach each other bowing profoundly and stepping rather heavily. They circle around each other nodding solemnly all the time. Next they fence a little, crossing bills and whetting them together, pecking meanwhile and dropping stiff little bows. Suddenly one lifts its closed wing and nibbles at the feathers underneath, or rarely, if in a hurry, merely turns its head and tucks its bill under its wing. The other bird during this short performance assumes a statuesque pose and either looks mechanically from side to side or snaps its bill loudly a few times. Then the first bird bows once and pointing its head and beak straight

> upward, rises on its toes, puffs out its breast, and utters a prolonged nasal groan, the other bird snapping its bill loudly and rapidly at the same time. Sometimes both birds raise their heads in the air either one or both utter the indescribable and ridiculous bovine groan. When they have finished, they most always begin bowing at each other again, almost always rapidly and alternately, and presently repeat the performance, the birds reserving their role in the game, or not. There is no hard and fast order to these antics, which the seamen of the Albatross rather aptly called a "cake walk", but many variations occur. The majority of the cases, however, follow the sequence I have indicated. Sometimes three engage in the play, one dividing its attention between two. They are always most polite, never losing their temper or offering any violence. The whole affair partakes of the nature of a snappy drill, and it is more or less mechanical.

Fred C. Hadden spent several years with the nesting albatrosses on Midway, and some of his observations are written somewhat different than Fishers. Hadden writes:

> Usually a pair dance together, then a third edges in and all three dance together. This will sometimes cause a fight, the intruder often being attacked by one of the two original dancers. During the mating season there are many fights between males desiring to court the same female.
>
> Sometimes these fights are very vicious affrays, at other times they last only a few moments, with one or the other running away with his swift and comical waddle, and wings spread for balancing. When a real vicious fight is under way they strike at each other's eyes, mouth, tail and wings, trying to obtain a painful hold, which they keep with a bulldog tenacity. Sometimes one is able to insert the upper portion of his long powerful beak down the others throat. The needle pointed, downward-hooked beak slits the throat, sometimes cutting the jugular vein and causing death.
>
> During all this they are madly screaming at each other in a high squeal. If not killed, the loser runs off squealing with wings spread. The winner raises his head and gives the loser a loud squawk. Very few birds are badly enough hurt during these fights to cause death; however, they may be bloody affairs, so that the beak, face and neck will be splotched with blood. When the loser runs away he is usually pursued a few yards by the winner.
>
> Occasionally, after most of the mating is over, one may see 7 or 8 goonies dancing together. Usually, however, not more than 2 or 3 in a group. This dancing continues throughout the year from December to July.

After Hadden stated the above he said that the gooney dance has

nothing to do with mating; but his descriptions of dancing pairs, with an occasional intruder being attacked by one of the original dancers and his statement that during the mating season there are many fights between males desiring to court the same female, would indicate that the ceremonies do have courtship status during the pre-egg stage (Bailey, 1956).

It is probable that the dance after the nesting starts is also carried on by non-nesters, and that the performance serves as a get together medium, resulting in mating and nesting the following year.

Kenyon (1950) reports that the courtship performance is not confined to the land but has been observed in the water. Two of these birds were so tied up in their performance that one was collected from a ship in the fall of 1949 off of the coast of California.

Incubation and hatching. The bird lays one egg, which is as large as that of the goose, and it may be blotched with brownish-maroon, which encircles the egg in a band; or a brownish-buff egg, without any markings. Rothschild (1893-1900) reports that there is a lot of variation in color.

The egg is laid in the middle of November and incubated by both adults. The male takes over shortly after the egg is laid, and may be on continuous duty for as long as twenty-four days before being relieved. The setting bird takes no food or water during this period. While the one is incubating the other is out at sea searching for food. Kenyon (1958a) reports that they will travel great distances during incubation time. One banded on the nest on December 3, 1956, was recovered twenty-three days later over 2,000 miles away off Hakkaido, Japan.

Kenyon (1958b) while working with the birds reported on eighteen adult albatrosses that were removed from their nest on Sand Island, Midway Atoll, and sent by air to distant parts of the North Pacific Ocean. Localities of release were Kwajalein, Marshall Islands; Guam, Marianas Islands; Luzon, Phillipine Islands; Honshu, Japan; Oahu, Hawaiian Island; and Whidby Island, Washington. Fourteen birds, representing all six localities, subsequently returned to their nests. The bird covering the greatest distance returned from the Phillipine Islands, 4,120 statute miles in approximately thirty-two days. The most rapid return was accomplished by a bird liberated at Whidby Island, Washington, which covered a rhumb line distance of 3,200 miles in 10.1 days at an average of 317 miles per day. Kenyon also said that homing is greater while the albatross is nesting than after the young is hatched.

Richdale (1945) reports that the Laysan albatrosses can leave their eggs uncovered for four or five days without hatching being affected. He also gave the incubation time from sixty-three to sixty-seven days.

Dumont (1955) dissected several birds after their nests had been broken up and he is convinced that they will not lay a second egg that year, or, if they do, it will be greatly delayed.

After the young is hatched one parent stays with it until it is six or seven weeks old. While one parent is baby sitting the other is out searching for food. These duties are alternated giving each bird a chance to obtain food and share in the feeding duties of the young.

Care of the young. The old birds seem to be very active at night and apparently do a great part, though not all, of their fishing at

that time. Returning to the island from a fishing expedition, they proceed at once to feed their young. The parent bird settles down beside the nestling which begins to peck the parents beak gently. The old bird stands up, lowering its head, opens its beak and disgorges a mass of partially digested squid and oil; but before it is too late the young bird inserts its bill crosswise into that of its parents, and receives the offering. After regurgitating several times at intervals of a few minutes, the meal is over (Nutting, 1903). Fisher (1904) indicates that the last two or three ejections cost the old bird considerable muscular effort.

After the albatross has finished feeding, the young bird is not reluctant in asking for more, but keeps on petitioning and working its head back and forth until the old bird walks off and usually takes spite out on neighboring young. Fisher (1904) reports that this is not a playful tact, but a very ruffian like proceeding. His explanation was that it was probably due to the muscular fatigue that the bird had just undergone by regurgitating the food.

Though the albatrosses are noted for eating most anything found in the sea, the meal for the young is mostly digested squid. The amount of food that is required to feed this many birds is incredible. Fisher (1904) estimated that if there was 1,000,000 birds, and allowing only one half pound a day for each bird, they would consume no less than 250 tons daily. Many other observers feel that they consume closer to one and one half pounds, which at 1,000,000 birds would be 600 tons of squid a day. These figures are only estimates, but still we must realize that it takes an abundance of food to supply the big birds.

Developement of the young. The young goonies stay near their

nest most of the time, occasionally waddling a short distance for a stick or some other item that attracts their attention. At times two or three young will get together for a playful squabble but this lasts only short periods. At times when they are waddling quite fast they will stumble and fall on their chins, and promptly lose their breakfast. This is very disheartening indeed, as hunger is their chief trouble (Dill, 1916).

The young are very tempermental, and if they are pressured by any means they fly into rage, which consists of darting forward and snapping their beaks very rapidly in attempt to run the intruder off. It was suggested that the personnel working in the crowded colonies wear segments of stove pipe as an effective armor against the snapping bills of the goonies. Their bites are very painful and at times will bring blood (Fisher, 1904).

When undisturbed the young sit for hours on their heels with their feet tilted in the air, gazing ahead, with little intelligence in their stolid countenances. Nearly every article written about the birds included the unusual habit of the young goney sitting on its heels with the webbing sticking out in front. Most comments were that the young bird just stared straight ahead and looked stupid. Now an investigation at the University of California of Los Angeles has proven that the birds are not so stupid as people think. They have found that the albatrosses at Midway survive the extreme temperatures of the desert island sanctuaries by laying their eggs in the winter and raising the young in the spring and early summer. The young albatrosses are equipped with a number of mechanisms for adapting to heat as the summer approaches. One such mechanism is in the webbing of their feet. This

relatively thin membrane contains a large number of tiny blood vessels from which the heat in the blood can be dissipated. The birds sit on their heels with their webbed toes in the air, to keep the webbing off the hot sand, and shade their feet with their bodies to make the most effective use of this heat dissipating mechanism (Science News Letter, 1961).

The young get their water from squid fed to them by their parents. The water from the squid is quite salty, but the birds have an unusual mechanism in their nostrils for excreting salt. Adequate water is thus made available for evaporative cooling of the body.

When the young birds have lost nearly all their down, they begin trying to stretch their wings and rise to their feet as the old bird does. This must be an attractive sight to see when several thousand birds are flapping their wings in the evening breeze. At this age they also waddle down to the sea and paddle around in the water. It is at this time that many birds are preyed upon by sharks which seem to patrol the waters during the nesting season of the albatrosses (Bailey, 1956).

Departure from the Breeding Grounds. Soon after the young goonies take their first flying lessons they become as adept in the air as their parents. They head out to sea with their parents, or a few days later if the parents do not return to feed them. They never return to the island again until they have reached breeding age or nearly that age. From the time they leave until they return is spent out on the waters winging themselves along looking for the ellusive squid or other edible food.

The old birds are out to sea for only a short vacation of three

or four months, then they return and start the cycle over once again.

Enemies. Aside from man and the elements, the albatrosses have few enemies. As was stated above, sharks have been known to eat young albatrosses; that is probably a regular proceedure. The commanding officer on Midway closed the beaches to swimmers in 1949 because the sharks became so abundant. A large shark was killed and was found to have the remains of young gonies in its stomach (Bailey, 1956).

Possibly many albatrosses lose their lives when caught in violent storms, and occasionally torrential downpours cause the undulation of thousands of nests with a great loss of eggs.

The greatest enemies of the albatrosses, in early days, were the Japanese who killed thousands in their ceaseless efforts to obtain feathers for the millinery trade. The nesting colonies which once flourished on little Marcus Island were destroyed in this manner. Bryan (1903) reported that on Marcus Island the Laysan albatrosses were killed and boiled down to make fertilizer, which was shipped to Japan; the long quills were saved and sold as eagle feathers to the milliners. Hornaday (1913) reported that Max Schlemmer, former manager of the guano company on Laysan Island, bought a cheap vessel in Honolulu, hired twenty-three Japanese laborers, and made a raid on Laysan Island in 1909. They killed thousands of birds before the revenue cutter Thetis arrived and stopped the killing. Captain Jacobs, captain of the cutter, found that in round numbers about 300,000 birds had been destroyed, and all that remained of them were several acres of bones and dead bodies, and about three carloads of wings, feathers and skins.

War caused the death of thousands of albatrosses, for airstrips were built on their ancestral breeding grounds, and the airplanes took

their daily toll. In 1941 the Marines on Eastern Island killed several thousand of the birds along the runways where the fighter planes were coming and going constantly. This reduced the number of bird and plane collisions, but also reduced the albatross population by some 80,000 birds (Kenyon, 1958c).

A Japanese officers diary was found on Wake Island in 1949 and one entry read, "August 22, - An order has just come out forbidding us to catch the gooney birds lest they be wiped out." The efforts of this officer to protect the goonies must have been in vain, because the birds were destroyed by the starving Japanese soldiers, although a great colony of Sooty Terns was guarded so that the eggs could be gathered regularly (Bailey, 1956). From Bailey's visit in 1949 it was apparent that the bird population suffered from the Japanese occupation because there was not a single albatross on Wake.

Since the war the expansion of the air base on Sand Island has caused disturbance, and several thousand birds have been killed by biologists trying to alleviate bird and plane strikes (Pierce, 1956a).

CHAPTER VI

MANAGEMENT OF THE LAYSAN ALBATROSS

Management of the Laysan albatross began in 1909 when Theodore Roosevelt set aside the Hawaiian Islands Bird Reservation. This was done primarily to prohibit plume hunters from ridding the islands of all sea birds which they may have done if they had not been stopped. Several times a year a revenue cutter, based at Honolulu, would patrol the islands in the reservation. By this continual check the birds went unmolested for many years.

Not again until 1941 was management necessary. When the Marines established an airbase on Eastern Island, at Midway, in 1941, they had planes coming and going constantly which were experiencing strikes by albatrosses on take offs and landings. Measures had to be taken against the albatrosses because of the hazard they presented on and near the runways. A killing program was conducted in an attempt to reduce the numbers of albatrosses. The program was conducted during late 1941 and its duration was about one week. It was conducted by one hundred fifty men who spent six or seven hours a day killing the birds. Approximately 80,000 albatrosses were to have been killed. The albatross population was temporarily reduced, and for a brief time the hazard to air craft was reduced (Kenyon, 1958).

Since the war several investigations have been conducted by the Fish and Wildlife Service. These investigations have been conducted to

try and eliminate the air strikes which are occurring very frequently on Midway Island. The following material will cover the results of the investigations.

1954-1955 Investigations. Early in July, 1954, the Military Air Transport Service requested assistance of the Fish and Wildlife Service in reducing hazards to aircraft on Midway. Ten bird strikes had already been reported in 1954; damage in all instances was caused by albatrosses.

Johnson Neff and Philip Dumont (1955), a research biologist team, were sent to Midway in November of 1954 to try to divert and discourage the gooney birds from nesting in the immediate vicinity of the runways on Sand Island. They conducted a number of experiments, but their efforts were not successful in diverting the albatrosses from Sand to Eastern Island, a distance of about a mile and half, nor were they successful of discouraging the birds to leave their nesting areas near the runways.

They found that the birds were not discouraged by smoke or noise. Sulphurous flares giving off an orange smoke and old truck tires were burned on their nesting areas, but the birds sat through both. They paid no attention to mortar fire. While fifty rounds of ammunition was fired from a bazooka, one albatross, thirty-six feet from the rear of the tube, continued to set on its egg even though the backflash ruffled its feathers. Birds between the firing and the target did not move. The noise of aircraft did not bother them. Many times planes would take off while birds were on the airstrip. They generally sat tight, only to be upset by the gale from the propellers as the plane passed by.

The possibility of using ultrahigh frequency was tested. Using a signal generator, amplifier, and speaker, it was found that albatrosses evidently receive no sound impulses above 3,000 cycles. Impulses in the ultrahigh frequency range above 20,000 cycles, are in daily use at the station, and no effect on the birds has ever been detected by communication personnel.

This investigation found that damage to aircraft is not caused particularly by birds nesting along the runways, but rather by the birds in the air below two hundred feet. It was also noticed that the birds do most of their flying in daylight hours, and therefore, are not cluttering the runways at night. From these two facts the biologists recommended, since few albatrosses fly at night over the runways, that all planes land after dark. Continued adherence to the practice followed by most planes in using a short field take off will materially reduce the risk to aircraft using Midway. The short run and rapid climb with flaps lowered quickly takes the plane above the two hundred feet danger zone.

1956-1957 Investigations. The purpose of this study was to determine the extent to which certain species of birds contribute to the hazard to aircraft at Midway; to learn more about population dynamics and habits of these species; to determine what type of control measures might be possible without endangering the species; and to test methods of control which were suggested. Most of the study was devoted to the two species of albatrosses and the sooty terns nesting at Midway because these species affect the greatest danger to aircraft safety.

Kenyon (1958) and his colleagues conducted a killing program

under controlled conditions in order to evaluate statistically the effects of a large scale kill. The killing program was done by men armed with short lengths of pipes or wooden clubs. The birds were killed by a blow on the back of the skull where the neck attaches. After being killed the birds were observed and then buried. The first two kills were conducted at night and the final ten were carried out in daylight hours. Twelve sweeps of the experimental killing area resulted in a kill of 4,788 adults, 1,371 young, and 107 albatrosses of unknown age, a total of 6,266.

The results of this experiment indicated that a clean sweep of birds present at any given time eliminated only a part of the total population. It becomes increasingly apparent that in order to be effective, a killing program would have to be systematically carried out during a number of months to eliminate all of the birds occupying the area that particular year. Also, that it would have to be continued for an indefinite number of years to take care of the young birds which are seeking nesting sites for the first time. During this period it is probable that the number of birds over the runways would diminish but slowly unless other measures were taken. No change was noticeable in the number of birds soaring over the runways that could be considered a result of the limited killing program conducted. This indicates that to achieve even temporary relief from the bird hazard, it would require a much more extensive population reduction than was achieved by the killing of about 6,000 birds that year.

Kenyon (1958) reports that stealing the eggs only encourages the parents to fly over the runways more frequently. After the nest is broken up the old birds become "non-nesters" thus flying more frequently.

Observations of albatrosses while in the air over runways has suggested a method of control which strikes at the core of the difficulty and if successfully carried out would be permanent. It was noted that any topographical feature that causes updrafts produce conditions favorable for soaring and large numbers of birds gather in such areas to soar for considerable periods. If these areas are adjacent to runways the birds wheel out over these strips. During their many hours of runway watches they saw certain birds marked with dye, for individual recognition, soar past repeatedly. Not content to ride only the updrafts, they appear to enjoy skimming out a number of yards over nearby level areas, where, under present conditions they sometimes come in contact with aircraft. Sufficient updrafts to invite soaring are created by piles of earth, high bushes, and trees along the runways.

On the basis of observations and information available Kenyon (1958) believes that the most promising method of permanently reducing the aircraft hazard to albatrosses is to clear and flatten the earth for a distance of seven hundred fifty feet from the centerline on both sides of the duty runways. If practicable these areas could be blacktopped. This would give the best assurance of eliminating not only soaring areas, but also breeding and resting areas close to the runways.

1957-1958 Investigations. These investigations were a continuation of the 56-57 studies. There was very little change in the number of airstrikes, but at this time only a small portion of the runways have been flattened as was recommended by Kenyon (1958).

Rice (1959) and his colleagues conducted another killing program in areas near the major runways. In this experiment, 30,041 birds were

killed, and observations subsequent to the killing program indicated neither a reduction in numbers of albatrosses soaring over the runways adjacent to the kill areas nor a reduction in the frequency of airstrikes. Under favorable wind conditions, the density of soaring albatrosses equaled, and often exceeded, that observed before the kill.

At no time did the density of soaring albatrosses over the portions of the runways adjacent to the kill area drop any where near as low as the density over the east end of runway c-24, where the shoulders had been leveled seven hundred fifty feet from the centerline.

It is apparent that any killing program, regardless of its magnitude, would not result in an effective reduction in albatross population during its first season of operation and could not come even close to eliminating the portion of the population which appear in the air over runways in less than five or more years.

Observations indicate that clearing and leveling the shoulders of the runways for a distance of about seven hundred fifty feet on either side of the centerline will eliminate updrafts which are conducive to albatross soaring over these runways. This should reduce the strike frequency by about eighty per cent or more. It was concluded that this is the only practical means for immediately reducing the strike hazard (Rice, 1959).

While working on this paper the author has had several conversations with students pertaining to the economic importance of the Laysan albatross. Several times this question arose; what value are the albatrosses to man if they do not perform any useful duty? This question could be debated, and each individual would have his own personal views. Henshaw (1911) gave an adequate answer when he wrote:

Birds which, although they do not destroy insects or other creatures inimical to agriculture interests, are nevertheless worth of preservation because of their beauty, grace and harmlessness. If such birds add nothing to our material wealth, they beautify the world and greatly increase the joy of living.

CHAPTER VII

SUMMARY AND CONCLUSIONS

The total world population of Laysan albatross (Diomedea immutabilis) is estimated at 1,500,000; this includes about 800,000 sexually mature adult breeding birds, of which about 560,000 nest in any given year.

Laysan and black-footed albatrosses now nest only in the Hawaiian Archipelago. At least ninety-six per cent of the world population of both species use only four atolls; Midway, Pearl and Hearmes, Lisianski, and Laysan. Midway is utilized by thirty-five per cent of the nesting Laysan albatrosses, it is second in importance to Laysan Island, which is utilized by forty-six per cent of the nesting Laysan.

The mated pairs return annually to nest, and usually on or near their old nest sites. Apparently, it is common for young birds to stay away from the place of hatching for a period of years.

The age at which Laysan albatrosses normally return to the breeding grounds for the first time is not definitely known, but thought to be at least five years. The age which they begin to nest is also unknown, but thought to be about seven years of age according to banding data.

The characteristic "dance" of the albatrosses is carried on in a limited way by mated pairs before the eggs are laid, often the ceremonies being followed by coition. The performances are more conspicuous

later in the season however, and at that time the majority of the dancers are the non-nesters. It is probable that the dance of the Laysan albatross after nesting has started, is also carried on by non-nesters, and that the performance serves as a get together medium, resulting in mating and nesting in the following years. Each pair lays one egg, and if it is lost, the birds join the group of the unemployed; they do not attempt to nest again until the following season.

Both adults share the task of incubation, the males taking over shortly after the egg is laid. They may be on continuous duty for as long as twenty-four days before being relieved. The incubation period is approximately sixty-five days. Both parents care for the young, with one being in constant attendance when the babies are small. Feeding is by regurgitation, and again, both parents share the task.

They have few enemies, man, the elements, and sharks probably being the chief causes of destruction. Certainly, man would head the list.

The birds are omnivorous, but squid is probably the chief food during the nesting season. The black-footed albatross, unlike the Laysan, will follow ships to secure scraps thrown overboard.

The Laysan range the eastern and northern Pacific, with a great area of ocean centering on the Aleutians being the favored habitat, with a few individuals occasionally occurring along the California Coast.

A management program was set up in 1909 for the protection of the birds. In 1941 the Marines at Midway had to kill several thousand of the birds which were cluttering the air corridors where fighter planes were coming and going constantly. In 1955 a team of biologists studied

the birds' habits and tried to divert them from Sand Island to Eastern without any success. In 1956-1957 investigations were made on the birds trying to find out why the birds would not leave their annual nesting grounds under heavy harassament. A small scale killing program was also conducted. In 1957-1958 continued investigations were carried out, and several thousand more birds were killed in an attempt to alleviate the plane-bird strikes.

It is the feeling of most of the biologists that the problem can be reduced considerably if the area seven hundred fifty feet from the center of the runway is flattened; this will reduce the air currents in which the birds love to soar.

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