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WAR AND THE BIRDS OF MIDWAY ATOLL

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Concern about the fate of the Laysan Rail and the Laysan Finch and about the possible effect of war activities on insular populations of birds in the Hawaiian Archipelago led the National Park Service, the Fish and Wildlife Service, and the Board of Agriculture and Forestry of the Territory of Hawaii to make a survey of the bird life of Midway Atoll. The United States Navy cooperated in furnishing air transportation to and from Midway. This report combines the observations of Baldwin who represented the federal bureaus, and of Fisher who represented the territorial board. The original plan was to capture, if possible, rails and finches for transplanting back to their original home, Laysan Island, and to observe the effects of the war on populations of birds at any islands visited.

A careful search from May 7 to 18, 1945, convinced us that no rails or finches remained on either Eastern or Sand islands, the two islands constituting Midway; consequently, we did not go to Laysan but spent the entire time observing the birds on Midway. We attempted to obtain accurate estimates of the number of colonies and of the sizes of the populations of the various species. This information was to provide the basis for comparing present bird life with pre-war bird life to determine the trend of the populations. Subsequent perusal of published notes and articles, however, indicated that few observers had estimated the numbers of birds present, and those doing so did not distinguish between breeding and migrating individuals and did not record the means by which they arrived at their estimates.

ESTIMATES OF POPULATIONS

Our methods of estimating populations involved (1) counts on sample areas yielding a density figure for the number of birds per acre, (2) an estimate of the size of the bird habitat in acres, and (3) adjustments to arrive at a final figure representing the adult or in some cases the adult breeding population. The methods necessarily varied in application to each species, as some could be counted more satisfactorily than others. We tried to use methods which could be duplicated in the future and thus to provide a basis for comparable estimates which would reveal changes in the populations.

Although we believe the general order of magnitude expressed by the figures in table 1 is valid, a high percentage of error is possible in several instances. When the habits and daily movements of the various species are well known, more accurate counts should be obtainable. For certain species we found it necessary to make counts in mid-morning and mid-afternoon and by flashlight at night to obtain an average estimate. Because of these and other sources of variation in our method of estimating, it seems desirable to state briefly the method employed for each species.

Laysan and Black-footed Albatrosses.—Nestlings were counted and the total number estimated by the density-times-area method. Two adults were allowed for each chick. A slight additional allowance was made for non-breeding adults, but this adjustment probably falls within the limits of error. Night counts were made on resting adults.

Wedge-tailed Shearwater.—Adults above ground were counted on Eastern Island, where there were few burrows, and the density-times-area method was used. Since most of the birds were paired and on the ground, only 10 per cent was allowed to represent single adults in burrows and in flight during the day. A similar method was used on Sand Island, but the figures are less reliable due to the great numbers of burrows present.

Christmas Island Shearwater.—The adults were counted and the density-area method was used. Because none was found in burrows and because more than 75 per cent of the birds were incubating individuals, each representing a pair, 75 per cent of the computed total was added to correct for absent members of the pairs.

Bonin Island Petrel.—Density-area figures were used, but the figures are difficult to interpret because of the irregular distribution of this species over the island, the great number of occupied burrows, and the separation of members of most of the pairs.

Bulwer Petrel.—Simple density-area figures were used since there were no burrows, and the birds were almost invariably found in two's. The estimate probably is low because it is thought that the birds were just coming in to the island.

Red-tailed Tropic Bird.—Adults on the ground were counted. A density-area figure was computed and 94 per cent was added because 94 per cent of the adults on the ground were alone and incubating. Although one half-grown chick was found, it is likely that the breeding season was just getting well under way. The figures may be low because it was impossible to consider the many birds wheeling overhead.

Blue-faced Booby.—Only three adults were observed and they were in a single group at a nest containing one young and one infertile egg.

Red-footed Booby.—Nests in the only colony were counted and the number doubled to yield the number of breeding adults. Few immatures were noted, and most of the nests contained young or a well incubated egg. The estimates may therefore be considered reliable.

Frigate Bird.—This species was counted as a flock in the air and on the *Scaevola* bushes on several occasions.

Pacific Golden Plover, Bristle-thighed Curlew, and Ruddy Turnstone.—Estimates were based on numbers observed.

Gray-backed Tern.—Estimated number is that in the colony on Eastern Island. No individuals were observed away from this colony.

Sooty Tern.—We made density-area computations during the day and at night in the colonies. These figures were checked against numbers in flight when the colonies were disturbed. Because egg-

Table 1
Estimated Numbers of Individual Birds on Midway Atoll

	Sand Island	Eastern Island
Black-footed Albatross	35,000	18,000
Laysan Albatross	75,000	35,000
Wedge-tailed Shearwater	40,000	22,000
Christmas Island Shearwater	0	400
Bonin Island Petrel	25,000	0
Bulwer Petrel	0	600
Red-tailed Tropic Bird	10,000	9,000
Blue-faced Booby	3	0
Red-footed Booby	0	450
Frigate Bird	60*	60*
Chinese Pheasant	2 or 3	0
Pacific Golden Plover	150	100
Bristle-thighed Curlew	12	8
Ruddy Turnstone	250	100
Gray-backed Tern	0	750
Sooty Tern	170,000	4,000
Noddy	0?	10
Hawaiian Black Noddy	1,350	750
Fairy Tern	15,000	5,000
Domestic Pigeon	50	0
Domestic Canary	30	0

*Same birds on both islands.

laying was just beginning at the time of our visit, it is possible that other colonies formed after we left. Noddy.—Estimate was based on number observed.

Hawaiian Black Noddy.—For Eastern Island density-area computations were made to arrive at the number of birds present in individual colonies and in all the colonies together. This figure was arbitrarily doubled to include birds in the air and birds away fishing. Counts for Sand Island were made similarly but were complicated by the necessity of estimating numbers in the tall ironwoods (*Casuarina*).

Fairy Tern.—This was the most difficult of all the species to estimate because of its wide and variable distribution in many different situations on both islands and because all stages of the breeding cycle were represented. The final estimate was based on density counts in various habitats and was augmented by adding 75 per cent to include absent mates of nesting adults.

The methods described above were used independently by the two of us, and the numbers presented in table 1 represent a compromise of the two estimates. It should be pointed out, however, that the independent estimates varied less than 15 per cent.

ACCOUNTS OF SPECIES

Diomedea nigripes. Black-footed Albatross. This species has apparently not been disturbed as much by war activities as the Laysan Albatross, the principal reason being that in general it confines its activities to the outer fringes of the beach where there has been less disturbance of its physical surroundings and where it is less subject to the activities of man.

Aside from usurpation of some of its nesting areas, the greatest harm from war has come to this species through the use of barbed wire and the occasional use of it as a target. Its numbers have not decreased as much as those of the Laysan Albatross, and its decrease is not such a serious matter for it is known to be more widely distributed. Birds banded on Midway in December, 1940, have been retaken at such widely separated places as Tokyo, Japan, Oregon, and Cape Omeny, Alaska. Its breeding, however, is confined to islands of the North Pacific (Bryan and Greenway, 1944:92).

Judging from size, molt, and behavior at the time of our visit, the young appeared to be about of the same age or slightly older than those of the Laysan Albatross.

Diomedea immutabilis. Laysan Albatross. The numbers of this species are definitely much lower now than before the war. A number of factors mentioned elsewhere in the text are responsible. In 1941, Hadden estimated the number at 20,000, probably based on the figure of 2,000 in the Pan American Compound. This compound is very small compared to the remaining area of Sand Island which is also used by this species. Consequently, we feel his estimate was unduly low. Further, there is no mention of the month in which the estimate was made. Certainly there are no factors which would have increased the numbers of Laysan Albatrosses on either Sand or Eastern island. Mr. Pitko of the cable company thinks there are only half as many goonies now as before the war.

We would estimate that less than one-half of the total area formerly occupied by this species is now used. Some of this decrease is due to disturbance by war activities, but there are other sites that seem suitable which are not used for some unknown reason. A large, recently filled area on the southeast corner of Sand Island is not used at all although it apparently is just as suitable as other parts. The most concentrated nesting, as indicated by the young now present, is that in the middle of the barracks area and alongside the most used road on the island. It may be that the birds tend to go back to the same spot for nesting each year and that the young also go back to the same area for their nesting. This might explain the failure of the birds to use the newly added land as a nesting site and might also account for the concentration on a site where it is thought disturbance would now be most severe.

Puffinus pacificus cuneatus. Wedge-tailed Shearwater. This species is especially vulnerable to disturbance by man. In spite of this, employees of the cable company think it has increased in numbers during the last twenty years—a notion we are inclined to doubt. The population might have been increasing up to the beginning of the war, but since that time it must have declined. One factor that may affect our census is the tendency of individuals of this species to leave the nesting grounds in late May and early June for a period of two to four weeks. This is known to occur on some islands and it may take place on Midway.

Individuals of this species were almost always observed in pairs on the ground under *Scaevola* bushes. On Sand Island night observations revealed them in pairs and digging burrows. Only infrequently were they observed on the surface of this island by day. On Eastern Island no burrows were found, and here pairs might be observed at any time of the day. For the most part they were resting quietly under *Scaevola* bushes, but some were flying overhead at all times.

Egg-laying had not yet begun. The eggs of this species are frequently laid on the sand at the entrance to a burrow. This peculiar habit gives rise to another form of depredation by man. We were told that on this and other islands the eggs were picked up carefully from certain areas each morning. By continuing this practice the eggs were always fresh and edible. On certain islands during the war this probably was a necessary procedure, but no longer is there any need for such exploitation. With a large company of men carrying on such hunts, it would be entirely too easy to wipe out the annual

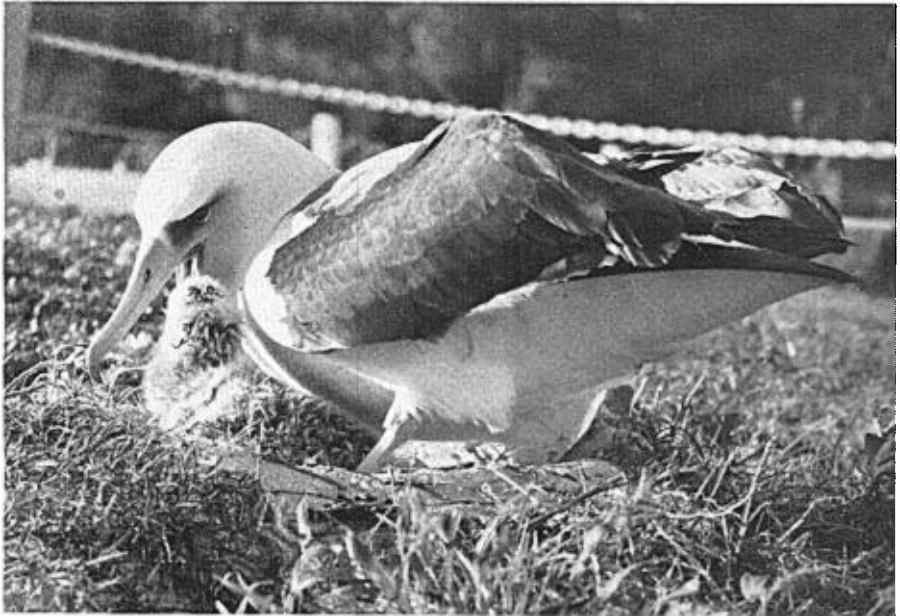


Fig. 1. Laysan Albatross feeding young. Note the nest "bowl" on the lawn. Photo by courtesy of United States Navy.

increment for a few years and thus to destroy all of a population using any one island for nesting. This possibility is increased because all the birds in an area tend to lay their eggs within a period of three to eight days.

Bryan (1906:39-40) stated that in 1902 most of the surface of Eastern Island was honey-combed with the burrows of the Wedge-tailed Shearwater and that the central portion of the island had vegetable mold and guano mixed with the coral sand. In 1945, we found neither mold nor guano on this island; for the most part there were only piles of sand and coral rock, evidently dug up by bulldozers during the period of construction work. Bryan also found this species only occasionally on Sand Island.

Puffinus nativitatis. Christmas Island Shearwater. This species occurs only on Eastern Island and at the time we were there was relatively scarce. It does not dig burrows. The birds were found under the *Scaevola* brush, usually as single individuals sitting on a single white egg placed in a slight depression. Sometimes the depression contained leaves of *Scaevola* which probably had fallen or been blown into it. Often the egg was merely placed among rocks as big as a man's fist. Eggs were present when this species was first seen on May 9.

Disturbance of the brush and of the rocky parts of the island have probably adversely affected this species, but no information is available. If the numbers we saw represent the entire breeding population, the species must be watched closely in the future.

Bryan in August, 1902, did not find this species on either island. Munro (1941*b*: 16-18) found a few individuals on Eastern Island in 1891 but many on Laysan and other leeward islands; Donaghho (1941:33) found it on both Eastern and Sand islands in May, 1941.

Pterodroma leucoptera hypoleuca. Bonin Island Petrel. This petrel was found only on Sand Island. A possible reason for this may be the fact that it uses burrows, and most of the surface of Eastern Island is now too rocky for burrowing. Another reason may be the fact that a major part of the

interior of Eastern Island is covered with paved runways. This pavement may cover its former nesting area which very likely was localized in the central part of the island.

At the time of our visit, the nesting season of this species was over. A few young with partial development of flight feathers were observed in the entrances to burrows and in depressions in the sand during daylight hours. Either a great percentage of the young was already flying or the season's nesting was particularly unsuccessful, for we saw few young and could find none in most of the burrows examined.

The species is affected by the same factors as those affecting the Wedge-tailed Shearwater, but the decimation in numbers is more important because the Bonin Island Petrel is not so widely distributed. Atsatt (1945:51) states that rats live in the burrows of this species and consequently exert a greater pressure on it.

In 1941, Hadden made what he called a conservative estimate of 500,000 "on the island." Even though he may have included both islands in this estimate, comparison of this figure with our estimate in May, 1945, of 25,000 shows a decided and alarming decrease in numbers.

Bulweria bulwerii. Bulwer Petrel. This species was found almost exclusively in pairs, crouched among rocks under dense *Scaevola*, but not in burrows. It was confined to Eastern Island. Its absence on Sand Island is unexplained unless extermination has occurred. Men from the cable company said the bird used to nest on Sand Island several years ago. Donaghho banded three on Sand Island in September, 1940; and Munro (1941a:2) states that the species was abundant and nesting on Eastern Island in July, 1891. It is probable that these birds were just coming in to the islands for nesting; consequently, the estimates given in table 1 may be too low. On Popoia Islet off Kailua, Oahu, this petrel has been practically wiped out by rats in the last few years. Hence, the birds on Midway must be watched carefully.

Phaethon rubricauda rothschildi. Red-tailed Tropic Bird. Ninety-four per cent of the birds observed on the ground were incubating single eggs. One half-grown bird was found. For the most part individuals were nesting in clumps of *Scaevola*, but some were nesting in relatively open sand, under lumber piles, and in the grass around the buildings.

Both islands have fairly large breeding populations, and at present there seems to be little cause for alarm about their numbers. Unquestionably the species has been affected by the surface changes, but seemingly it is adjusting itself. Nesting concentrations were evident in certain areas of shrub growth, although nests were distributed generally over the islands, even in recently disturbed and highly artificial surroundings. We doubt that rats would have opportunity to destroy eggs or young when an adult is present at a nest; the adults are reluctant to leave and they use their sharp bills most effectively.

Sula dactylatra personata. Blue-faced Booby. Only three adults were found, and these were around a single nest on the open sand of Sand Island. One newly hatched young and an infertile egg were in the nest. It is highly unlikely that this colony will survive. The one nest was found at the edge of a colony of Sooty Terns alongside a road and a runway. Jeeps and trucks pass within a few feet, and if one takes to the sand, as the tracks indicate they often do, the young will be destroyed.

Sula sula rubripes. Red-footed Booby. One colony located on Eastern Island now contains all the individuals of this species on Midway Atoll. In May the colony was well into the nesting season. Some nests contained a single egg, others had newly hatched chicks, and still others had half-grown chicks. Only one of the 194 nests was in process of construction.

Disturbance of the *Scaevola*, which is used as a nesting site, and the presence of man and his impedimenta are the factors tending to decrease the numbers of this booby. Another factor may be operating now and certainly will harm this species in the future; we refer to increased parasitization by the Frigate Bird as a consequence of the virtual elimination of the other two species of boobies on Midway Atoll. Since the Frigate steals fish from the adult and is not averse to eating a young booby, this added pressure may cause a serious drop in the size of the colony. At present there are about eight adult boobies to one Frigate. If the Frigates survive at the expense of the young boobies, the colony will be eliminated within the next few years.

Sula leucogaster plotus. Brown Booby. No individuals were seen on either island. In 1941, Hadden reported that this was the most common of the three species of boobies at Midway. Donaghho (1941:33) also reports three species in August of 1941. Utilization of its colonial nesting areas for military purposes and perhaps rat infestation are the factors involved in its extermination. The second factor probably is unimportant, for it would seem almost impossible for a rat to enter with impunity a colony of these strong, sharp-billed birds.

Fregata minor palmerstoni. Frigate Bird. The numbers of this species seem destined to decrease at Midway in the near future. Since the population now consists of only 60 individuals, the colony is in a vulnerable state. Several unfavorable factors resulting from the war have brought this

about. The decrease of boobies, which the Frigates parasitize, removes a source of food. The wide disturbance of the shrub vegetation appears to have upset nesting, since no nesting has as yet been observed this year. Destruction of the *Scaevola* brush also affects the birds by elimination of perching sites. The Frigates' feet and legs are so constructed that take-off from the ground is difficult if not impossible. Regrettably this conspicuous bird is a tempting target for sport shooting and it is subject to popular anathema because it is known as a "hawk." Frigate birds perching on trees at Sand Island rose into the air each time an airplane passed overhead.

We were told that the Frigates used to nest on Sand Island, and one point of this island is named Frigate Point. No nests were found on either island, but men stationed there stated that in 1944 this species nested near the one remaining colony of Red-footed Boobies on Eastern Island. In August, 1902, Bryan found Frigates nesting only on Eastern Island. The one group of birds we saw moves back and forth between the two islands almost daily, but it is not a regular movement. Sometimes the Frigates are on Sand Island in mid-morning and sometimes they perch in the ironwood trees there in the dusk. In December, 1938, Hadden (1941) observed more than 500 Frigates in the air.

Phasianus colchicus. Chinese Pheasant. A single cock was heard on several occasions about the farm on Sand Island, and a hen was seen. In 1944 some young were raised but did not survive many weeks. There is little chance of this species surviving in the wild state on Midway; there is too little native food. However, to prevent increase in numbers, if necessary, the birds should be collected. In a small spot of land as saturated with entertaining bird life as is Midway, it appears undesirable to establish foreign species.

Porzanula palmeri. Laysan Rail. Eastern Island of Midway Atoll was probably the last home of this rail, as E. L. Caum and Sergeant Lewis W. Walker, U.S.M.C., saw two there in July, 1944. On Eastern Island there is now no bunch-grass habitat, and there are only about 75 acres of *Scaevola frutescens*. *Scaevola* is found in patches ranging in extent from a few square yards to several hundred square yards. Much of it is or has been disturbed. We examined most of this shrub growth by crawling through it on hands and knees, waiting quietly and observing. On about 6,500 square yards in 27 representative samples of vegetation thus searched, counts of all other species seen were made. Had the rail been present it is likely that at least one individual would have been seen during these careful observations. Likely feeding places, such as the carcasses of dead birds where the flies were swarming, were also watched.

We were unable to find this species on Sand Island using similar methods of search. Messrs. Smith and Pitko, of the commercial cable station, have each served several tours of duty on Midway in the last 20 years; both are well acquainted with the rail and its habits because of its abundance during past years. The last rail observed by either was in November, 1943, when Smith saw a young rail and heard another on Sand Island. We could learn of no naval personnel who had actually seen rails within the past year; one or two reports which we investigated turned out to have been based on observations of the Ruddy Turnstone. Since our visit to Midway, Munro (1945:14) reports that Captain John Jayne, U.S.N., was certain he saw a rail in the first week of June, 1945, presumably on Midway and only three weeks after our visit.

The main factor in the extermination of the rail was the overrunning of both islets with rats, which escaped to Midway from ships in 1943. Had the birds survived the extreme rat infestation of 1943 and 1944, they might still find cover and continue reproducing now that the numbers of rats are reduced. Much suitable rail habitat has been destroyed or modified by "clean-ups" of rank grass and brushy undergrowth in certain areas and cutting of *Scaevola* brush into small and isolated blocks. This may have been a secondary cause of their extermination. A surviving clump of especially tall grass in the cable station area was pointed out as having harbored a number of rails in the past.

There may be rails on Pearl and Hermes Reef, but we think it unlikely. In 1929, Captain Anderson moved seven pairs of Laysan Rails to Pearl and Hermes Reef from Midway (letter from G. C. Munro); however, Mr. George O. Kaufmann, who lived at Midway from 1929 to 1931, visited the reef in 1930 and found no rails, no living vegetation and very few birds of any kind. Galtsoff (1933:1-49) does not list the rail. Since the rail depended upon insects, birds' eggs, and meat scraps for food, it seems impossible that the colony could have survived.

Pluvialis dominica fulva. Pacific Golden Plover. Individuals and flocks of as many as 40 were observed on all areas of both islands. The population figures for this species mean relatively little since Midway is but a resting place for them on their long migratory route. Most of the birds were in breeding plumage. We were told that individuals in winter plumage remain there throughout the year. Summering individuals which we have seen on the main Hawaiian Islands were invariably in winter plumage or in only partial breeding plumage.

Numenius tahitiensis. Bristle-thighed Curlew. Only a few individuals were observed. Since the birds only stop here in the course of migration, war activity on Midway probably has had little effect

on them. Usurpation of the surface for other purposes has of course decreased the area available to them, but if they can always feed on the leavings around the nests of albatrosses as was observed, their food supply is plentiful. The birds were not limited to any one part of the island or to any certain habitat.

Arenaria interpres. Ruddy Turnstone. As is the case of the plover and curlew, the turnstone is widely distributed over the Pacific. Some apparently winter on Midway. This species was not found on the sandy or rocky beaches as is usually true on continental shores; they were inland, foraging on lawns, in the brush and under ironwood trees.

Sterna lunata. Gray-backed Tern. Within a single colony of this species on Eastern Island, egg-laying was just beginning at the time of our visit. Formerly, we were told, this species nested on Sand Island. The present colony was located under a clump of *Scaevola*. The birds were not nesting in open sandy areas as the Sooty Terns were, but they perched in the *Scaevola*, over the colony or on the sand in the colony. Mixed with the colony were Sooty Terns which had not yet laid their eggs. At the time we left, the Sooties were still in the colony, but it is not possible to say whether they actually nested with the Gray-backed Terns.

Destruction of the *Scaevola* has probably had a more deleterious effect on this species than have other factors. The population has been reduced since the war started and must be watched with care since it contained only about 750 birds.

Rothschild (1900:38) states that, "The Gray-backed Tern was met with on all islands, *except Midway Island* [italics ours], and was breeding in great numbers on Laysan Island." It is not likely that Palmer, Rothschild's collector, would have missed this bird had it been present. Nor can we find any mention of it in the running account of the Rothschild Expedition on Midway, as given by G. C. Munro in volume 3 of *The Elepaio*. Bryan (1906) reported that in 1902 he also could not find it on Midway. Consequently it appears that the present colony has been established since 1900. Hadden in 1941 reported 500 Gray-backed Terns on Sand Island, where we found none in 1945.

Sterna fuscata oahuensis. Sooty Tern. The Sooty Tern is now the most numerous species found on the islands of Midway. At the time of our visit, individuals were just arriving on their nesting grounds and new colonies were forming almost daily. At the time of our departure there were at least ten colonies on Sand Island and only one on Eastern Island. The colonies on Sand Island are larger than the one on Eastern Island, varying in size from 4,000 to 100,000 individuals. In 1902, Bryan (1906) found more Sooties on Eastern Island. On both islands colonies were found in open sandy areas and under clumps of *Scaevola*. When the colonies were visited on May 7, no eggs were found; the first eggs were seen on May 10. Defense of territory, copulation, and egg-laying were going on simultaneously in all colonies within a day after the birds had settled down.

Great numbers of these birds are killed by ground vehicles and planes. Because of their wide distribution and the great numbers now present, the species is in no danger of extinction on Midway. However, there has been a significant drop in numbers since 1941 which, if occurring on other islands of the chain, might threaten the subspecies *oahuensis* in this archipelago. Hadden (1941:19) reported nearly 600,000 Sooty Terns on Sand Island in 1941.

Anous stolidus pileatus. Noddy. It is questionable whether the Noddy was ever abundant at Midway. The extremely small number seen by us indicates either that this species is nearing elimination from this atoll or that the main numbers of this species were not present on the breeding grounds when we visited them. The former is more likely, as W. K. Fisher (1903:15) found the noddies just beginning to lay eggs on Laysan between May 16 and 23. W. A. Bryan (1906) in August, 1902, found but few examples of this species on either island at Midway. In 1941, however, Hadden reported about 2,000 on Sand Island. If the population has indeed dropped, rats and destruction of nesting grounds are most likely the decimating factors.

The Noddy was found breeding on all the leeward islands of the archipelago by the Rothschild collectors in 1891, but nowhere in large numbers. It breeds today on certain islets offshore from islands of the main Hawaiian group. Munro (Elepaio, 1(12):2-3) reported that on Swain's Island near Samoa this species was nesting in the tops of tall coconut trees, evidently to escape from pigs that ranged the island. We did not see Noddies in the ironwood trees at Midway but found them perching on the ground, on bushes, and on rocks at the lagoon shore.

Anous minutus melanogenys. Hawaiian Black Noddy. Nests of this species were characteristically found rather high in the *Scaevola* scrub and in groups of 5 to 20. Some nests were unoccupied, some had fresh eggs, and others had young of varying ages up to those which were completely feathered. This indicates that the species has a long breeding season; it may even nest throughout the year. If the latter is true, it may aid in maintaining the species by decreasing the depressing effect of certain seasonal factors.

This species has begun to nest in the high ironwoods, where they are relatively safe from man

and rats. It is in no apparent danger on Midway, and it also breeds on other islands of the archipelago. Men of the cable company believe the birds are more numerous on Sand Island now than they were 15 years ago. This is corroborated by the finding in 1902 by Bryan (1906) of only 12 to 20 individuals on Sand Island. It may well be that the growth of the ironwood trees, of *Scaevola*, and lately of other shrubs has encouraged them during the past 40 years. Sand Island was practically barren of vegetation in 1902.

Gygis alba rothschildi. Fairy Tern. Except for possible damage to eggs and young by rats (Atsatt, 1945:49-51) this species is probably the least adversely affected by war activities of all kinds of birds now on Midway; it may have actually increased in the last 20 years. Bryan in 1902 found only a few on Sand Island. Hadden estimated 3,000 to be present on Sand Island in 1941, whereas our estimate for Sand Island is 15,000. It nests throughout the year apparently, and it is numerous in all areas of both islands. Nests may be found in *Scaevola*, on ridgepoles of buildings, on signposts and in ironwood trees. There is no built nest; the egg is laid in a slight depression or crack atop a post, pole or building or in the forks of trees and shrubs.

W. K. Fisher (1903:9, 17) found *Gygis alba* nesting on Necker Island in bowl-like hollows in the rock and thought it was more abundant on Necker than on Laysan because the rocks on Necker provided better nesting sites.

Columba livia. Domestic Pigeon. About 50 individuals are to be found on Sand Island; none is present on Eastern Island. They have started nesting in the ironwood trees and are gradually expanding the area they use. Although they are now limited to the region of the compound of the cable company, it is likely they may spread. In the past the men of the company have prevented spreading by shooting birds found nesting away from the farm area. This practice should be continued if pigeons are to be kept on the island, and all nests in trees should be destroyed. The effect of competition between pigeons and terns is unknown, but a definite competitive struggle for nesting sites could develop.

Telespiza cantans. Laysan Finch. The absence of the Laysan Finches on Midway was attested by the presence of a hibiscus hedge in full bloom. We were told that when the finches were present, they snipped off the buds so rapidly that seldom was a red blossom found. Records concerning the present status of the finch are incomplete. It is gone from Midway. The only other known colony was on Laysan. According to E. H. Bryan, Jr. (letter dated April 3, 1937, to G. C. Munro), W. F. Coultas saw "at least 1000" finches on Laysan in 1936. Bryan (personal communication) desires to retract his statement (Bryan and Greenway, 1944:136) that the finch is extinct, because his writing on the statement published in 1944 antedated the findings of Coultas in 1936.

Hadden (1941:194) condemns the finch and states that it should be outlawed and destroyed at every opportunity. It is unfortunate that such an attitude ever existed on Midway. In all probability, rats and man are the factors responsible for its extermination on Midway. Atsatt (1945:49-51) states that the disappearance of the finch was as abrupt as that of the rail, but the rail was exterminated first.

Serinus canarius. Domestic Canary. There are perhaps 30 individuals about the lawns and ironwood trees of the cable compound; we never saw more than 17 at any one time. No evidence of nesting was observed, but we were told that in late years the canaries have nested high in the ironwoods, probably to escape the rats.

From the high population of about 500 several years ago this species was reduced to negligible numbers; at one time it was thought to be extinct, and the rats were blamed. Apparently canaries are breeding with at least some success now, possibly as a result of their having moved into the higher trees to nest.

WAR-TIME FACTORS DECREASING POPULATIONS OF INSULAR BIRDS

Physical disturbance.—1. The removal of and injury to nesting and roosting sites by bulldozing for construction projects of many sorts, trampling everywhere by men, driving across open and semi-open areas in vehicles of many types, landscaping of grounds for ornamental purposes, clearing of vegetation around utility areas, erection of barbed wire barriers and similar contrivances exerted major influences upon the birds. The *modus operandi* of these is obvious: usurpation of nesting area by permanently constructed physical developments, churning and removal of top soil or sand, breaking of vegetation, grading of surfaces, and establishment and maintenance of many artificial cover conditions. These changes have affected all ground- and bush-nesting species, indeed the entire bird life at Midway.

2. Death of individual birds was caused by airplanes, ground vehicles, traps and

pits (foxholes, gun emplacements), attacks upon disliked species, target shooting, and construction work. Almost all species present were seen to be affected. The clearing of carcasses was a regular, daily operation to keep down the flies and to reduce the food supply of the rats. Carcasses were evident daily on airfields and roads, in gooney colonies, and in pits. As an example, planes, during normal approaches to a landing strip where a small colony of 5,000 was situated, were seen to cut up about a dozen Sooty

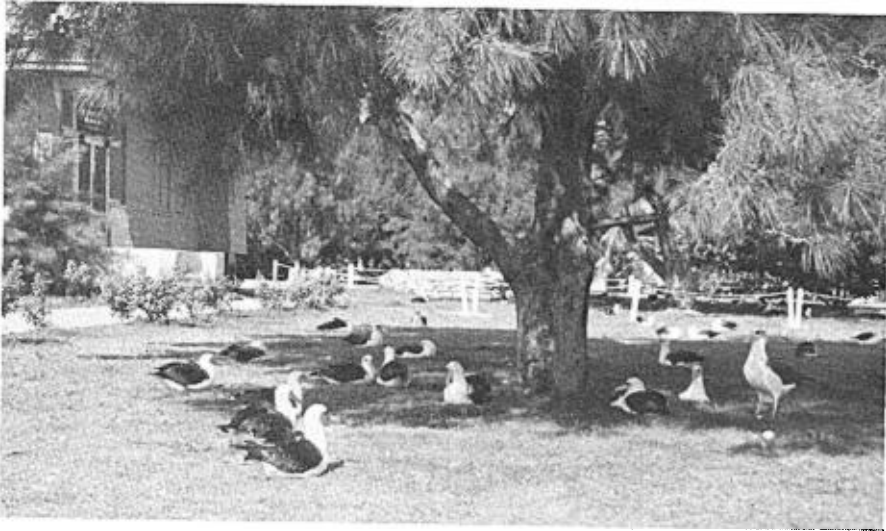


Fig. 2. Adult Laysan Albatrosses resting on lawn at Midway Post Office. Many young were present here in May, 1945. Photo by courtesy of United States Navy.

Terns. Dead albatrosses and tropic birds could always be seen near the mats. Night flying was especially destructive to birds and resulted in greater slaughter of the Sooty Terns than did daytime flying. Petrels and shearwaters were vulnerable at night, also. Ground vehicles accounted for large numbers of dead, noticeably along roads, from which unwitting, young albatrosses had to be removed each morning by the first driver, and near airfield mats where vehicles occasionally ran through the edges of bird colonies. One such colony of Sooty Terns lost 83 birds to ground vehicles in one night and 68 in the following night. The death toll would have been greater had young been present. Foxholes and other types of steep-sided pits caught albatrosses, shearwaters, petrels and tropic birds. The birds were found starved to death. Many holes had already been filled in at the time of our visit to reduce bird destruction but many still remained open. Black-footed Albatrosses, and other species to a lesser extent, became entangled in barbed wire along the beaches. The "moaning birds," of which the Wedge-tailed Shearwater was the most dismal-voiced, were generally disliked by the men. They received little sympathy, burrows were purposely tramped down and adults were persecuted constantly. This was the only openly discussed form of deliberate destruction of adult birds we found, as irresponsible target shooting was done more or less on the sly and was not generally approved. Many Bonin Island Petrels were in areas desired for lawns and consequently were destroyed. Bulldozing in certain areas must have killed thousands of shearwaters and petrels in their burrows.

3. The destruction of eggs by factors already discussed and possibly by egg gatherers probably reduced the bird populations significantly. As mentioned in connection with Wedge-tailed Shearwaters, the collection of eggs for eating may be a serious matter. The extent of such collecting on Midway Atoll is unknown, but the practice was common throughout the Pacific. On small islands this one factor could mean extinction if it were to operate for several years.

4. The exigencies of war have resulted in the use of certain small islands for bombing and strafing practice (Green, 1942:16-17). Frequently these are small rocky offshore islands covered with bird rookeries. With the cessation of hostilities the justification for the continued use of small islands for targets should be reexamined. However, according to a news dispatch from Headquarters, AAF, dated September 8, 1945, a group of small islands off the coast of Oahu, T.H., is still in use as bombing and gunnery targets. In battle zones many of the islands have been more or less completely denuded of their flora and fauna. This was unavoidable, but the effect is nonetheless disastrous.

Psycho-biological disturbance.—1. Men walking through nesting colonies to take short-cuts or to see the birds caused almost continual disturbance. It is hard to conceive how the normal, complex breeding cycle could proceed effectively under extreme disturbance of this sort in such species as the colonial terns. The Sooty Terns in their colonies were posturing, defending territories, laying eggs and making a great noise throughout the day. This sight drew many watchers, and when one of them walked into a colony the terns would rise in a wheeling, squawking uproar.

2. Rats inadvertently introduced in 1943 destroyed large numbers of small birds and their eggs. Mice introduced at the same time probably exerted a much less drastic effect on the birds. Rat damage was greatly curtailed by an intensive poisoning and trapping program initiated on both islets in 1944, but the germ of a potential rat problem remains, as no means are available at present of completely eradicating them. Control measures must be maintained indefinitely on all bird islands where rats exist if the smaller birds are to survive. Since many of the Pacific islands offer no large quantities of vertebrate animal food other than birds and eggs, the pressure from increases in numbers of rats would be directly exerted upon bird populations.

3. Dogs and probably other domestic animals have complicated the ecological situation. Rabbits now kept in captivity may escape and cause additional damage. In view of the possibility of egg damage and psychological disturbance, and of the development in dogs and other animals of habits harmful to birds, it would be a wise policy to keep in force the pre-war practice of exclusion of mammalian pets.

4. Exotic birds in a way are an even greater threat than pets. As previously mentioned, it is a matter of far-reaching consequence to endanger the nesting grounds of oceanic birds by attempts to establish game birds and song birds. The environment on Midway is eminently unsuited to such birds; they require barnyard care to build up their populations. Another strong reason against introductions of bird species is that the oceanic birds are "the best entertainment we have on this island," as the Midway newspaper termed it, and attempts to augment the avifauna are not in the best interests of recreation. Unknown and unpredictable psycho-biological reactions between the birds are certain to take place, and some will be detrimental to the native birds. Resulting losses may far outweigh any recreational benefits afforded by such continental species as have been introduced.

5. Changes in plant life have resulted from extensive clearing followed by extensive replantings. Grasses, shrubs, and trees have been planted widely on Sand Island. Dense

vegetation may restrict the breeding of albatrosses, but it creates new sites for many other species. Grasses have been used extensively for sand stabilization; shrubs such as *Scaevola*, *Meibomia* (tree heliotrope), and *Coccoloba* (sea grape) have been set out on sand dunes, and ironwood trees have been planted in large numbers. Sand Island has many more exotic plants than Eastern Island, where the prevalent shrub is still *Scaevola*. In some areas it was noticeable that grass and underbrush were removed for landscaping and rat-control purposes. This removal destroyed the cover used by such birds as the Laysan Rail. As a whole, the changes have resulted in decrease of the bird populations during the past few years more than they have helped to increase them. When new plantings are established, however, the birds should be generally benefitted. A large-scale spatial readjustment of many bird colonies has been necessitated by the changes in the plant life and ground surface. Species unable to adjust rapidly have suffered.

SUGGESTED MEANS FOR ALLEVIATING DAMAGE TO OCEANIC BIRDS

On militarily occupied islands, such as Midway, we think that the following measures, if carried out, would effectively reduce the loss of bird life.

1. Educate men to the recognition of companionship and interest inherent in the birds.
2. Protect breeding grounds from disturbance caused by over-clearing for construction, by vehicles running off roads, and by men watching the birds. Off-limit areas should be posted and the posting kept up-to-date as colonies settle down to breed.
3. Prevent introduction of rats and carry out a program of rodent control.
4. Prevent target shooting, egg gathering, and destruction of birds whenever possible.
5. Eliminate all unnecessary or unused pits and screen the necessary ones.
6. Remove flight hazards such as overhead wires, towers, and barbed-wire barriers when no longer needed.
7. Exclude exotic birds and mammalian pets.

On non-militarily occupied bird islands of importance we think that temporarily no recreational or economic use should be permitted until scientific and administrative surveys resulting in plans for bird protection can be completed. We suggest consideration of a permanent non-use policy for the more important bird islands such as Laysan, Lisiansky, Nihoa and probably others. Such a policy now appears to offer the only assurance for perpetuation of the endemic Hawaiian seabirds of the bird refuge on the leeward islands of Hawaii, and such a policy would still permit economic developments to be made, if desirable, on islands not important to bird life.

SOME PROBLEMS CONCERNING SURVIVAL OF INSULAR BIRDS

W. K. Fisher (1903:8) noted the vast numbers of birds breeding on Laysan and their severe competition for surface area. There was a vertical as well as horizontal distribution of birds: petrels and shearwaters beneath the surface, terns, albatrosses, Christmas Island Shearwaters, and tropic birds on the surface, and boobies, some terns and frigates in the bushes above. Schauinsland (1899) earlier had noted that the seasonal distribution was an important factor in permitting the nesting of so many individuals of so many species. It is probable that on certain islands the horizontal, vertical, and seasonal distribution of the several species has arisen as an adaptation for survival, resulting from competition for breeding space. Populations on saturated islands are probably reduced in direct proportion to the extent of removal of space, vegetation, and soil from these islands.

Pan-oceanic breeders are naturally less likely to become extinct as a result of various disturbances than are birds breeding in only one archipelago. However, the activities of man are now so widely spread over the Pacific Ocean that even pan-oceanic island breeders should not be considered safe from destruction as species merely because they nest at widely separated localities. Careful and complete surveys are needed at present, as it would be impossible on the basis of information at hand to list all the islets and islands where the oceanic birds discussed in the foregoing accounts are breeding. The fewer the islands used by any one species of bird, the more actively should protective measures be put into effect for that species. We do not know what chance there is for any species, once exterminated from an island, to re-colonize it. We should watch the colonies of boobies at Midway with this in mind. Some poly-insular Hawaiian endemics needing extreme protection are the Hawaiian Black Noddy, the Laysan Albatross, and the Necker Island Tern.

Mono-insular endemics are in a precarious position. Immediate consideration should be given to transferring breeding stock of these species to other places to insure the continuance of the species. The species life of the Laysan Rail was prolonged some 20 years in this way without critical harm to any other birds on Midway. The Laysan Teal, Laysan Finch, Nihoa Finch, and Nihoa Miller Bird are mono-insular endemics which may still be in existence today.

Although there are seemingly large populations of certain species of seabirds at Midway, there is danger inherent in allowing breeding populations to decrease below certain unknown levels. Work elsewhere has shown that small colonies of some species are slower to breed and are less successful in nesting than are large colonies; when they are too much reduced, no breeding occurs. A psychological interdependence exists among many colonial birds that is apparently an important factor in the initiation and completion of the reproductive cycle. It is important that population data be gathered often enough to make it possible to discern downward trends in the numbers. Since the extinction of birds living in small, circumscribed areas may occur with great speed, such surveys should be started before post-war developments are undertaken on the leeward islands and should be repeated at frequent intervals. Just four years ago the Laysan Rail, the Laysan Finch and the Brown Booby were abundant on Midway.

Since 1940 the degree and rate of environmental change on Pacific islands has increased. War-torn islands of course have suffered most. News reports indicate that starving men on Wake Island ate all the gooneys they could get, and they ate rats too. Before the war a rail endemic to that one island existed, but with rats, bombings, and starving men, there is little hope that it still lives today. Midway also shared in the violence of war, but the bird life there has fared relatively well. From Midway we have learned in detail what may happen on islands used intensively by man, and we have learned that the need for complete protection for bird islands is now greater than ever before.

LITERATURE CITED

- Alsatt, R. S. [= Atsatt, R. S.]
1945. Notes on introduced rats and disturbed birds of Midway. *Elepaio*, 5:49-51.
- Bryan, E. H., Jr., and Greenway, J. C., Jr.
1944. Contribution to the ornithology of the Hawaiian Islands. *Bull. Mus. Comp. Zool.*, 94:79-142.
- Bryan, W. A.
1906. A report of a visit to Midway Island. *Bernice P. Bishop Mus. Occas. Papers*, 2:291-299.
- Donaghho, W.
1941. (Letter from Midway). *Elepaio*, 2(5):33.

Fisher, W. K.

1903. Birds of Laysan and the Leeward Islands, Hawaiian Group. Bull. U. S. Fish Comm., No. 23:1-39.

Galtsoff, P. S.

1933. Pearl and Hermes Reef, Hawaii, hydrographical and biological observations. Bernice P. Bishop Mus., Bull. 107:1-49.

Green, T. H.

1942. Destruction of bird life on Rabbit Island. Elepaio, 3:16-17.

Hadden, F. C.

1941. Midway Islands. The Hawaiian Planters' Record, 45:179-221.

Munro, G. C.

- 1941a. Bulwer's Petrel. Elepaio, 2(1):1-3.
1941b. The Christmas Island Shearwater. Elepaio, 2(3):16-18.
1942. (Letter from Admiral Nimitz). Elepaio, 3(1):1.
1945. The small birds of Midway. Elepaio, 6:13-14.

Rothschild, W.

1900. The avifauna of Laysan and the neighboring islands, with a complete history to date of the birds of the Hawaiian possessions (London, R. H. Porter), 3 vols.

Schauinsland, H.

1899. Das Vogelleben auf der Insel Laysan. Ornith. Monatsb., 7:121-126, 144-150.

Department of Zoology and Entomology, University of Hawaii, and United States National Park Service, Hawaii National Park, Hawaii, October 2, 1945.