Hawaiian Dark-Rumped Petrel & Newell's Manx Shearwater

HAWAIIAN DARK-RUMPED PETREL AND NEWELL'S MANX SHEARWATER

RECOVERY PLAN

U.S. Fish and Wildlife Service

Portland, Oregon

February 1983

Approved: ______________________________
Director, U.S. Fish and Wildlife Service

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Date

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ACKNOWLEDGEMENTS SHOULD READ AS FOLLOWS:
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PART I

INTRODUCTION

Two Hawaiian races of the family Procellaridae, the 'ua'u or dark-rumped petrel (Pterodroma phaeopygia sandwichensis) and the 'a'o or Newell's manx shearwater (Puffinus puffinus newelli) are the topics of this plan. Both are residents of the central subtropical Pacific Ocean and are known to breed only within the major Hawaiian Islands (Berger 1972). For the sake of brevity, both species will frequently be referred to in this plan by their Hawaiian names. The Hawaiian dark-rumped petrel is one of two subspecies; the other, P. p. phaeopygia, is endemic to the Galapagos Islands and is recognized by the International Union for the Conservation of Nature and Natural Resources (I.U.C.N.) as endangered (Vincent 1971). The Newell's manx shearwater is one of eight races of the manx shearwater, an oceanic superspecies of worldwide subtropical and temperate distribution (King and Gould 1967).

Description: The dark-rumped petrel is one of the gadfly petrels, averaging 40 cm in length and having a wing span of 90 cm. The upper parts are dark gray; the forehead and underparts are white; the undersurface of the wings is white with conspicuous dark margins. The tail is short and wedge shaped (Berger 1972). The legs of the 'ua'u are flesh-colored as are the upper portions of its feet; the webs are black tipped. The bill is grayish-black, relatively short and stout, with a sharp, decurved tip.

The Newell's manx shearwater was first described by Henshaw (1900) from a specimen obtained on Maui by Brother Mathias Newell in 1894. It is a medium sized shearwater of 30 to 36 cm in length. Its upper parts, including the crown, neck, back, wings and tail, are glossy black. Adults commonly appear soft brown in color from feather wear, before they molt into new plumage each winter. The undersides, including the throat, breast, wings and crissum, are white. The bill is sharply hooked at the tip and is colored black, sometimes with a slight brown tint. The webs of its feet are distinctly pink, yet its toes are characteristically gray. It has well developed claws which are well adapted for burrow excavation and climbing.

Past and Present Status: Both the 'a'o and the 'ua'u are believed to have had well established breeding populations on all of the major Hawaiian Islands (Berger 1972, King and Gould 1967, Munro 1944). First-hand historical information on both the 'ua'u and the 'a'o is sparse in the literature. Early ornithologists, including Finsch (1880), Wilson and Evans (1894), Henshaw (1902) and Bryan (1908), based their reports on scant information, most of which they obtained from native Hawaiians who reportedly collected the eggs, young and adult birds for food. King and Gould (1967) stated with reference to the Newell's manx shearwater: "No authenticated record of this race was ever obtained between 1894, when the type specimen was taken, and 1954, when a bird was collected on Oahu." A similar lack of information was true of the dark-rumped petrel in Hawai'i during the same period (Berger 1972). Munro (1944) clearly recognized that the 'a'o and 'ua'u were in danger of extinction by the 1930's. Richardson and Woodside (1954) reported the rediscovery of an 'ua'u nesting colony at Haleakala Crater, Maui and remnant populations on Mauna Kea, Hawai'i. Banko (in Berger 1972) reported other remnant populations on Mauna Loa, Hawai'i in 1968 and Mauna Kea, Hawai'i in 1970, but considered a population once known in the Kohala Mountains to be extinct. Other possible remnant 'ua'u populations were reported by van Riper (1978) on Hawai'i, and Hirai (1978) on Lana'i. Sincock and Swedberg (1969) rediscovered the first Newell's manx shearwater nesting colony since the turn of the century in the Anahola Mountains of Kaua'i in 1967. Subsequently, Sincock and Telfer (unpub. data) have located several other 'a'o nesting colonies on Kaua'i, and there has been some recent evidence found that the 'a'o may nest or be attempting to recolonize other major Hawaiian Islands (Kepler, et al 1979, Hall 1978, Conant 1980). Maps of the known nesting sites of the 'ua'u and 'a'o are attached as Appendix A and B, respectively.

Based upon their very limited present distribution and the marginal status of known breeding populations, the dark-rumped petrel was listed as an endangered species in 1967 and the Newell's manx shearwater as a threatened species in 1975 by the U.S. Fish and Wildlife Service and in 1973 by the State of Hawaii.

Reasons for Decline:

Predation - Although the 'ua'u and 'a'o are not presently known to use common nesting habitat, they do share very similar threats to their survival. The single greatest limiting factor of both species, whether actual or potential, is predation. Munro (1944) named the mongoose (*Herpestes auropunctatus*), as being responsible for the demise of the dark-rumped petrel on Hawai'i, Maui and Moloka'i and pigs (*Sus scrofa*) and cats (*Felis catus*) on Lana'i. He suggested that the ancient Hawaiians exterminated it on O'ahu, presumably for food. King and Gould (1967) considered the mongoose the most destructive predator of the Newell's manx shearwater on those islands where it exists, but also listed feral cats, dogs (*Canis familiaris*) and rats (*Rattus* spp.) as likely predators. Larsen (1967) considered the black rat (*Rattus rattus*) to be the primary predator of the dark-rumped petrel at Haleakala, Maui. King (1971) found the Polynesian rat (*Rattus exulans*) to be present at Haleakala, too. Byrd and Telfer (1980) documented the barn owl (*Tyto alba*) as a predator of several seabird species, including the Newell's manx shearwater on Kaua'i. The short-eared owl (*Asio flammeus*), of which Hawai'i has endemic populations, has been reported as a predator of the dark-rumped petrel in the Galapagos Islands (Harris 1970).

Although the mongoose was almost universally condemned by most ornithologists as the major cause for the extirpation of the 'a'o and 'ua'u in certain populations in the Hawaiian Islands, it does not entirely explain the apparent scarcity of these birds at the end of the 19th century. Mongooses were not introduced into Hawai'i until 1883

(Bryan 1938) and were never established on Kaua'i, Lana'i, Kaho'olawe or Ni'ihau. The 'a'o and 'ua'u were noticeably rare on these islands in spite of the absence of mongooses. The black rat and the Norway rat (Rattus norvegicus) probably gained entrance to Hawai'i from European stock (Tomich 1969) from sailing ships that visited near the end of the 18th century. These may have played a primary role in the reduction of ground nesting seabirds on all of the islands. Even today, rats are recognized as serious predators in threatened and endangered Hawaiian seabird colonies (Simons 1980, Telfer unpub. data, Kepler 1967, Atkinson 1977).

The threat of mongoose establishment on Kaua'i is of great concern to the future of the Newell's manx shearwater. In 1976, a dead mongoose was picked up on the highway on southern Kaua'i (Telfer unpub. report). To date, an established breeding population of mongooses has not been verified on Kaua'i, but over forty alleged sightings have been reported by the public to the Hawaii Department of Land and Natural Resources. It will probably be only a matter of time before the mongoose does become established. Regular shipping of containerized cargo between islands is the most likely accidental mode of introduction of new predators such as the mongoose.

Feral pigs, first introduced by Polynesian settlers and later by European explorers, became well established on all of the larger Hawaiian islands. In some localities they may be important predators of the 'ua'u and 'a'o. In rare instances, hunters have reported the meat of pigs taken on Kaua'i as being unfit to eat because the pigs had consumed shearwaters and taken on a fishy smell (Telfer unpub. data).

Sincock and Swedberg (1969) reported considerable damage to 'a'o nesting habitat caused by rooting pigs in the Anahola Mountains of Kaua'i. Unchecked pig populations in the mountainous areas of all the major islands may have at one time had a devastating effect upon burrow nesting seabirds. It appears, however, that pig predation is only a localized problem where seabird nesting grounds are physically accessible. Feral pigs on Hawai'i range up into the higher elevations on Mauna Kea in the vicinity of where remnant populations of 'Ua'u have been reported, but there is no empirical evidence that they prey on this species.

Goats also may stress the 'ua'u. Burrow mouths trampled by goats have been observed on Hanakauhi Peak, Maui (Kepler unpub. report).

Other ground predators, including rodents, snakes, or other carnivores, could conceivably become established on any of the islands. Recent accidental introductions such as the black-tailed prairie dog (Cynomys ludovicianus) and the California ground squirrel (Citellus beecheyi) are examples of very remarkable verified introductions that have been discovered on Kaua'i in recent years (Telfer unpub. data).

Early descriptions of dark-rumped petrel nesting areas indicated that their burrows were typically found between 1,500 feet and 5,000 feet elevation (Munro 1944). Known dark-rumped petrel nesting areas today are limited to sites above 7,200 feet elevation, which is probably the upper limits of most dense predator populations.

Light Attraction - A second serious limiting factor of the Newell's manx shearwater, and potentially of the dark-rumped petrel, is increasing urbanization and the accompanying increase in man-made lighting. Street lights, resort security lights, athletic field lights and other sources of man-made lighting have resulted in substantial problems for fledgling Newell's manx shearwaters during their first flight to the ocean from their nesting grounds. Both the 'a'o and 'ua'u normally fly to and from their nests overland only after dark. Fledgling shearwaters apparently have a normal attraction towards light. This may be related to the bioluminescence of their pelagic food supply, or a natural tendency to find the ocean from the reflection of moon and starlight from the water's surface. When attracted to man-made lights, fledglings become confused and may suffer temporary night blindness. They often fly into obstructions such as utility wires, poles, trees and buildings and fall to the ground. Occasionally, they seem to be merely confused and alight in brightly lit areas without striking objects. Most fallen shearwaters are only stunned, but they may be hit by automobiles, killed by dogs or cats, or are simply unable to get into a suitable space to get airborne again. Many die of broken wings, concussion, paralysis and other injuries received from their fall. Even though the great majority of the fallen shearwaters are fledglings, a small number of adults meet the same fate each year. Evidently the adults, being more experienced, are less prone to the light attraction than are the fledglings. The fallout of adults is the heaviest on cloudy or rainy nights, probably because visibility is reduced and there is increased glare from the light reflected from wet pavement, or, possibly, because navigation by moon and stars is obscured.

A strong correlation has been found between lunar events and the rate of nightly shearwater fallout (Telfer unpub. report). During periods of sufficient evening moonlight the fallout is reduced substantially, but during periods of the new moon or when the moon reaches its zenith during the daytime, fallout is heavy. If sufficient evening moonlight exists when the fledglings depart their nests for the open ocean, the young birds seem to be able to find their way to sea with little interference from artificial lights. Without sufficient moonlight, a substantial portion of the fledgling population is downed.

Between 1978 and 1981, 5,528 Newell's manx shearwaters fell on Kaua'i's highways, athletic fields and hotel grounds (Sincock, Telfer, Byrd and Brady unpub. data). An annual, publicly supported, salvage effort to pick up and release these fallen birds each year has been very successful (Telfer 1979), but without its continuation, a considerable amount of the annual recruitment would be lost.

Although the light attraction problem has primarily affected the Newell's manx shearwater, 17 dark-rumped petrels, five Harcourt's storm petrels (Oceanodroma castro cryptoleucura), and 20 wedge-tailed shearwaters (Puffinus pacificus chlororhynchus) have also been recovered. Light attraction may not be as great a problem for the dark-rumped petrel as it is for the Newell's manx shearwater. This might be due to the fact that the petrel nests at higher altitudes and may fly higher while enroute to the sea, or there may be fewer lights between the nesting grounds and the route fledglings take to the sea. Also, the 'ua'u exists in much fewer numbers than does the 'a'o and therefore its rare status may be responsible for its limited occurrence in the annual fallout. Additionally, the petrel may not be as susceptible as the shearwater is to light attraction.

Disease - It is unknown what role disease has played as a limiting factor of endangered seabirds. Warner (1968) suggested that mosquito borne avian malaria and other diseases could have been serious decimating factors of the native Hawaiian birds that evolved with little or no immunity to them. Such diseases were evidently brought into Hawai'i by exotic birds, and with the addition of a suitable vector, such as the mosquito, the diseases were spread to the native birds. A close parallel could be drawn between the native Hawaiian avifauna and Hawai'i's native people, who suffered severe decimation as a result of the introduction of common human diseases such as measles and smallpox, not previously extant in the Hawaiian population. The Newell's manx shearwater, in particular, nests in habitat that is heavily infested with mosquitos, possible vectors of avian malaria as well as pox virus. During the 1980 Newell's manx shearwater salvage project, well over 1,000 fledglings were examined; several appeared to exhibit minor poxvirus lesions. Puffinosis is another potential disease that could have had a considerable negative effect upon shearwater and petrel populations that evolved in isolation. Sincock and Telfer noted severe pox-type lesions on Laysan albatross chicks on Kaua'i in 1980 and 1981. The survival of the 'ua'u only in the higher elevations of Maui and Hawai'i suggests the possibility that mosquito borne diseases may also have been involved in the low elevation extirpation of that species, as it likely did with several of the endemic passerines. Telfer (unpub. data) has found large die-offs of wedge-tailed shearwaters at several nesting colonies on Kaua'i, which appeared to be disease related, although the lethal agent was never identified.

Habitat Destruction - Nesting habitat destruction may be a limiting factor in localized areas. Newell's manx shearwater nesting colonies are nearly always associated with dense stands of uluhe (Dicranopteris linearis) and similar ferns. Since the fern constitutes a flash fuel, it is particularly susceptible to damage by forest fires. Burning uluhe supplies sufficient heat to ignite overstory trees and shrubs and constitutes a fire that is very difficult to control. Burning embers of this dense fern are easily lifted by the heat of the fire and readily spread flames to adjacent areas. Once burned off, the fern-covered habitat is susceptible to exotic plant invasion and soil erosion, either of which could render the nesting area unusable.

Historical descriptions of dark-rumped petrel nesting areas indicated that they were located within vegetated areas that likewise often could have been susceptible to fires; however, most existing 'ua'u nesting habitat is found in high elevations with only sparse vegetation.

Today, most land used by the threatened and endangered seabirds in Hawai'i is located at high altitudes and in steep topography. Some urban developments could, however, ultimately destroy nesting areas. Military or civilian communications installations, commonly located on mountainous ridge tops, could directly interfere with nesting habitat, produce light attraction problems or increase fire threats to adjacent areas. Growing urbanization in the lowlands will continue to increase the light attraction problem for threatened and endangered Hawaiian seabirds.

Little is known about the pelagic distribution of either the dark-rumped petrel or the Newell's manx shearwater, but there are potential forms of pelagic habitat destruction that could ultimately affect their survival. The accumulated dumping of nuclear wastes and agricultural or other pollutants into the ocean could affect food supplies or become concentrated by means of the food chain and directly reduce fertility or survival of endangered seabirds. Competition with commercial fisheries for food organisms or fish that relate to the availability of food organisms is another form of pelagic habitat destruction that needs to be considered.

Habitat Requirements:

Newell's manx shearwater: Nesting habitat is by far the most fragile element in the life needs of the 'a'o since it is basic to their reproductive success and is used for over nine months of the year (April through November). Existing 'a'o nest sites are typically within steep mountainous terrain between 500 feet and 2,300 feet elevation. Uluhe is nearly always associated with its nesting areas, although some nests may occur outside but near to it. The affinity of the 'a'o for the dense fern habitat is likely an adaptation for protection from predators, but may also be chosen for its protection from the elements and to stabilize the burrows against soil erosion. Tree cover is usually moderate to light, the roots of which serve to shore up burrow entrances and discourage pig rooting. Rainfall in nesting areas ranges from 40 to more than 100 inches annually, but is quite variable from year to year. Although the 'a'o is capable of climbing shrubs and trees before taking flight, it needs an open downhill flight path through which it can become airborne; therefore, it favors ridge crests or embankments for its nesting burrows. The soil substrate within the 'a'o nesting grounds must be suitable for burrow excavation, yet not prone to erosion or flooding. There may be other subtle nesting habitat requirements including slope of the area and limits of acceptable relative humidity and temperature, but these remain unknown.

Hawaiian dark-rumped petrel: The nesting habitat of the dark-rumped petrel is now quite different from that of the Newell's manx shearwater; however, historically, both species may have shared the same nesting sites (Bryan 1908). The 'ua'u is currently known to nest only at elevations above 7,200 feet. Vegetation is sparse owing to the high elevations and dryer environment. In those dry areas at Haleakala, Maui, vegetation in nesting areas is predominantly grass (*Deschampsia australis*) and bracken fern (*Pteridium aquilinum*). Pukiawe (*Styphelia tameiameiae*) dominates in the moist habitat sites (Manuwal 1978). Bryan (1908) described 'ua'u nesting habitat in wet forested slopes below 4,000 feet on eastern Moloka'i; however, these habitats no longer support known nesting populations. 'Ua'u nesting burrows are commonly located among large rock outcrops, talus slopes or along edges of lava flows with suitable underlying soil for the excavation of tunnels. Burrows are excavated much the same as those of the 'a'o, generally 3 to 6 feet deep, but sometimes reaching a length of 15 feet or more. Those previously existing colonies at lower elevations evidently have been completely devastated by predators. Presently used 'ua'u habitat may not be their preferred habitat, but it nevertheless supports the last known viable breeding colonies. 'Ua'u use their nesting habitat between March and November each year and apparently have a nesting cycle very similar to that of the 'a'o, although perhaps slightly earlier.

The burrows of both the 'a'o and 'ua'u are used year after year, generally by the same pair. If damaged, they are sometimes reexcavated or abandoned for new sites.

A second type of habitat that is critical to both the 'a'o and 'ua'u could be termed transitory habitat: that land area which is transversed by nesting adults and fledglings while flying between their nesting grounds and the ocean. Although the amount of time spent by the birds in this zone is very limited, all the rest of the reproductive effort could be lost if corridors between their nesting grounds and the sea are not available. These corridors must be free of bright lights, particularly on dark nights. High intensity lights that produce an upward glare seem to have the greatest attraction to 'a'o fledglings. Bright lights along the coastline appear to be the most attractive and may, in some cases, even draw birds in from the ocean. The 'ua'u may also require a dark transitory zone between its nesting grounds and the ocean, but to date it has not been noted as a major problem with the species. Maui, on which the 'ua'u nests in the greatest numbers, has large expanses of undeveloped coastline along its eastern and southern slopes, possibly explaining why fallout has not been an extensive problem there.

The pelagic habitat is where the 'a'o and 'ua'u spend most of their lives, yet very little is known about it. King and Gould (1967) reported pelagic observations of 1,742 Newell's manx shearwaters and suspected that breeding adults ranged relatively close to Kaua'i during the nesting period. They reported the 'a'o almost entirely absent from the north-central Pacific during the non-breeding season (December through February). Non-breeders and sub-adults were postulated to concentrate within 10° of the equator, in the vicinity of the boundaries of the North Equatorial Current, Equatorial Countercurrent and the South Equatorial Current. These are localities of enriched oceanic nutrients and comparatively shallow water. Other information on the non-breeding season distribution of the 'a'o is scant, but King and Gould (1967) suggested that some, if not most, Newell's manx shearwaters pass through the north-central equatorial region on their way to the breeding grounds. Five records of Newell's manx shearwaters were made outside of the immediate north-central Pacific: two near Wake Island, one at Saipan, Marianas, one near Baker Island and one north of the Leeward Hawaiian Islands.

The pelagic distribution of the 'ua'u during the non-breeding season is largely unknown, but they obviously remain near the main Hawaiian Islands during the nesting season (King and Gould 1967).

It is likely that the distribution and abundance of a food supply determines the marine distribution of seabirds. Foods are known to include small fish, crustaceans and squid. Although little is known about the distribution and density of seabird food supplies, severe alterations could affect the status of endangered seabirds nesting in

Hawai'i. Procellariform marine distribution in Hawai'i appears to be dynamic. Changes probably occur over time, possibly as a result of the changes in local food supply distribution. The recent colonization of nesting Laysan albatross (*Diomedea immutabilis*) on Kaua'i from the Leeward Hawaiian Islands may be evidence of food supply shifts within the Hawaiian Islands (Telfer 1980). This could also be a factor involved in the apparent increase of the 'a'o on Kaua'i in recent years.

Conservation Efforts:

Predator Control - Early ornithologists recognized that predation was probably responsible for bringing both the 'a'o and 'ua'u near to extinction, but little was done about it until recently. Poisoning and trapping were begun within Haleakala National Park at the 'ua'u nesting colonies in 1966 (Larsen 1967) with noticeable results, and trapping has been continued up to the present time (Simons 1981).

Heavy predation within Haleakala National Park on the nene or Hawaiian goose (*Branta sandvicensis*) and the 'ua'u resulted in a joint effort by the U.S. Fish and Wildlife Service, Hawai'i Division of Fish and Game and the National Park Service to control all predators within Haleakala Crater. The poison 1080 was used and considered to be quite effective (Larsen 1967). Recent predator control, however, has been restricted to trapping because the use of effective poisons has been prohibited or severely restricted.

Bird Salvage-Aid Stations - Recognition of the light attraction problem with Newell's manx shearwaters was first reported by Hadley (1961). Previously, the 'a'o populations were either very low or artificial lighting was too limited to cause the fallout problem to a noticeable extent. During the 1960's the shearwater fallout problem increased. In 1967, over 200 'a'o were picked up at the Kauai Surf Hotel, Kaua'i's first major resort development (Sincock and Swedberg 1969). The Hawai'i Division of Fish and Game issued local newspaper releases asking the public to pick up fallen shearwaters and to toss them back into the air near the ocean. This policy was continued up to 1978, at which time the shearwater "aid station" program was initiated. Aid stations, consisting of wire mammal box traps bundled together, were established at all seven of the Kaua'i County Fire Stations, Kilauea Town and at the Kauai Surf Hotel. During the October-November shearwater fledgling season, the public via the radio and newspaper media was asked to pick up the fallen birds and deposit them at the nearest aid station. State and Federal wildlife personnel cooperated in the pickup of birds turned in each day. Morphological measurements were made, and each shearwater was banded and released. In 1978, a total of 867 birds were picked up. In 1979, 1980 and 1981 the total collections were 1,451, 1,358, and 1,222 respectively. Most of the birds turned in by the public apparently were uninjured and were successfully released the night after they were retrieved. In addition, a number of injured birds were treated and successfully released at a later date (J.L. Sincock unpub. data).

Although the 'a'o made up the great majority of birds turned in at aid stations between 1978 and 1981, 20 wedge-tailed shearwaters, 17 'ua'u and five Harcourt's storm petrels were also turned in. Both species of petrels included fledglings, indicating that at least a few nested on Kaua'i.

In 1979, Cameron Kepler, Research Biologist with the U.S. Fish and Wildlife Service, Meyer Ueoka and Ted Simons set up two aid stations on Maui. Only a few wedge-tailed shearwaters and two dark-rumped petrels have been recovered.

The actual survival rate of fallen birds turned in at aid stations and released is unknown; however, judging from the condition of the fallen birds and previous observations, survival is very probably higher than if the birds had been left alone. Road kills alone accounted for at least 160 'a'o fledgling deaths in 1980 on Kaua'i in spite of the aid station program.

Associated with the aid station program has been a large scale banding project. Approximately 5,000 known-aged shearwaters were banded between 1978 and 1981. Future analysis of band returns should provide information on survival rates, population status, longevity, breeding biology and possibly migration patterns.

Nest Translocation Studies - In 1978, a cooperative study was initiated by the U.S. Fish and Wildlife Service and the Hawaii Division of Fish and Game to experimentally establish a Newell's manx shearwater nesting colony in a coastal or offshore islet habitat using wedge-tailed shearwaters as foster parents. The objective of the cross-fostering technique is to establish nesting colonies in areas that can be more easily protected from predators and away from the hazards of urban lights.

The experimental technique used involved the removal of 'a'o eggs from their natural nesting burrows in the mountains, and then transferal of the eggs to surrogate wedge-tailed shearwater nests located at Kilauea Point and Moku'ae'ae Islet on Kaua'i's northern shoreline. The eggs were transported in foam rubber lined cases to protect them from damage and extreme temperature changes. Within hours, they were exchanged with wedge-tailed shearwater eggs already under incubation. In most cases, the wedge-tailed adults accepted the 'a'o eggs and resumed incubation immediately. Of 91 'a'o eggs transplanted from 1978 to 1980, 76 percent hatched and 67 of the resulting chicks fledged (Byrd, et al. in press). Egg mortality appears to have occurred as a result of abandonment by the wedge-tailed shearwater foster parents and predation by rats and mynah birds (Acridotheres tristis). Mynah predation was a serious problem on Moku'ae'ae Islet in 1979; therefore, all eggs were subsequently transplanted to Kilauea Point. Experimental mynah control was successful at Kilauea Point using chicken eggs injected with various repellent chemicals (Byrd and Moriarty 1980). The intent of the cross-foster experiment is to see if Newell's manx shearwaters, raised by foster parent birds, will return to nesting area where they fledged instead of returning to interior sites.

Follow-up studies are planned to monitor for the returning birds at Kilauea Point. Similar studies have been considered for the dark-rumped petrel, but will not be undertaken until the 'a'o transplant studies have been evaluated. Kress (1980) has successfully reestablished the Atlantic puffin (Fratercula artica) at Muscongus Bay, Maine where they had once been extirpated using a similar imprinting technique. However, he used hand fed chicks raised in artificial burrows. The 'a'o chicks would be much more difficult to hand raise than puffins, since they do not readily accept whole food without regurgitation by the adult. The wedge-tailed shearwater provided an ideal surrogate parent to the Newell's manx shearwater because of its similar nesting season, feeding and brooding habits. The cross-fostering technique, if successful, is much less expensive in terms of man-hours than hand raising.

Light Attraction Studies - During 1979, the U.S. Fish and Wildlife Service contracted with the University of Wisconsin to design and conduct a study of the light attraction problem of shearwaters on Kaua'i. The study was conducted during 1980 to determine if shielding the upward radiation of artificial lights would reduce shearwater fallout. On alternate nights, all major floodlights at the Kaua'i Surf Hotel were affixed with sheet metal shields to eliminate upward light glare. Downed birds were collected each night to measure the effectiveness of the shields in reducing fallout. The preliminary results of that study indicated that light shielding reduced fallout significantly (Reed, Hailman and Sincock unpub. manuscript). Proposals have been made for the study of other light modifications that could assist in the reduction of the annual fallout problem (Hailman 1979). Such other light modifications might include: changing the light spectrum, the use of polarized light, reducing light intensity and possibly the use of flickering or interrupted light. Light shielding, however, probably has the greatest likelihood of providing a practical technique for managing the fallout problem on a wide scale.

John L. Sincock, U.S. Fish and Wildlife Service Research Biologist, Lihue Field Station, has met with State, County and private officials involved with the development and maintenance of street lighting on Kaua'i. He has endeavored to obtain private and public cooperation for the purchase and installation of street light shields for placement in critical fallout areas. He has initiated correspondence with the County of Kaua'i in hopes of obtaining support for a County ordinance that would require shields on all future street lights erected under its jurisdiction. In 1982, The Nature Conservancy purchased shades for 14 streetlights in an area of heavy fallout on Kaua'i. At that time, the Conservancy also leased, and is now managing, a privately owned 'a'o nesting area of 213 acres on that island.

Other Conservation Efforts - The nesting grounds of the 'ua'u in Haleakala Crater, Maui have been extensively mapped and studied by various researchers since 1964: Gill and Huber (1964), Huber (1964), Larsen (1967), King (1971), Kunioki (1968-74) and Simons (1980). Most of the studies involved daytime nest searches and nighttime vigils to locate nesting areas by calling birds. Population status and assessment of predation were the primary objectives of those studies during the 1960's and 1970's. Larsen (1967) discussed most of the aspects of the 'ua'u breeding biology, although his observations were based upon a short period of time and a small number of birds.

A breeding ecology study of the dark-rumped petrel was begun in April 1979 at Haleakala National Park. The objectives were to obtain information on the breeding biology, population status and mortality factors of the dark-rumped petrel in Hawai'i and to develop a management plan for its conservation and husbandry (Simons 1980).

PART II

RECOVERY

The Primary Objective of this recovery plan is to delist the 'a'o (Newells' Manx Shearwater) and the 'ua'u (dark-rumped petrel). Quantifiable goals for recovery for these two species are difficult to establish because of gaps in the knowledge of these species. However, progress towards recovery will require accomplishment of the following interim objectives:

1) Reducing the annual fallout of more than 1,000 Newells' manx shearwaters to less than 100 (or near 0); reducing the annual fallout of dark-rumped petrels to near 0;

2) Providing long-term protection for the eight known Newells' manx shearwater nesting colonies on Kaua'i and the one known dark-rumped petrel nesting colony in Maui; and

3) Developing efficient predator control methods and techniques for use in and around isolated nesting sites.

Attainment of the three objectives would support further consideration for reclassification of 'ua'u from Endangered to Threatened and the 'a'o to delisted.

Control of existing and potential predators within nesting colonies is a key to the fulfillment of this plan's primary objective. The attainment of target populations of 'ua'u and 'a'o alone cannot ensure their survival. Protection of nesting populations from heavy predation must be assured. Even though the Newell's manx shearwater probably already occurs in great enough numbers for continued survival, threatened establishment of a new predator, such as the mongoose on Kaua'i, could easily bring it to the brink of extinction within a very short period of time. Continued control of predators in the 'ua'u nesting colony at Haleakala Crater, Maui, and reestablishment of the species in other habitats will probably be necessary for the recovery of the dark-rumped petrel.

The primary objective is, by necessity, based upon subjective parameters. Just what level of predation might be acceptable depends upon the answers to several unknowns. No reliable population estimates have been made of either the dark-rumped petrel or the Newell's manx shearwater. Productivity and survival rates are poorly known. This information must be determined before their status can accurately be evaluated and possible delisting recommended. The definition of "unacceptable levels of predation" depends in part upon the development of 'a'o and 'ua'u life tables.

Additional goals within this plan are listed as necessary to assist in the accomplishment of the primary goal. Many of them are ongoing management objectives, such as conducting the annual aid station-salvage project and the protection of nesting habitat from fires or human disturbance. These management actions will assist in the maintenance of viable populations and, ultimately, the fulfillment of the primary objective.

Some of the research tasks identified in the plan may not lead directly to the recovery of the 'a'o and 'ua'u, but they are necessary steps to management techniques that can be used to achieve the primary objective.

STEP-DOWN OUTLINE

Objective:

The primary object of this plan is to secure currently known breeding populations of 'a'o and 'ua'u from unacceptable levels of predation and other losses, to determine minimum numbers for self-sustaining populations for each species, to establish new populations as necessary, and ultimately to delist the species. The interim goals for recovery include:

1) Reducing the annual fallout of more than 1,000 Newells' manx shearwaters to less than 100 (or near 0); reducing the annual fallout of dark-rumped petrels to near 0;

2) Providing long-term protection for the eight known Newells' manx shearwater nesting colonies on Kaua'i and the one known dark-rumped petrel nesting colony in Maui; and

3) Developing efficient predator control methods and techniques for use in and around isolated nesting sites.

Attainment of the three objectives would support further consideration for reclassification of 'ua'u from Endangered to Threatened and the 'a'o to delisted.

1. Preserve and maintain existing habitat

    1.1 Identify and publicize essential habitat

    1.2 Protect nesting habitat from fire loss

        1.21 Inform public and land owners of nesting areas about fire threats

        1.22 Administer and enforce zoning and fire laws

    1.3 Prevent noxious plant encroachment in nesting habitat

        1.31 Determine plant composition and ecology in nesting areas

        1.32 Plan for and accomplish reestablishment of favorable vegetation in nesting areas after fire or disturbance

    1.4 Protect habitat from destructive human activities

        1.41 Review land use variance proposals and enforce zoning laws

        1.42 Prevent pollution of pelagic habitat through existing laws and education

2. Control direct mortalities

    2.1 Initiate adequate predator control in each habitat

        2.11 Determine needs and methods for predator control

        2.12 Conduct predator trapping where feasible

        2.13 Manage feral pig and goat populations

        2.14 Fence designated nesting areas as needed and feasible

        2.15 Apply toxicants where needed and where feasible

            2.151 Perfect safe toxicant and methods for application

            2.152 Obtain necessary registration and permits for use of toxicants in nesting areas

            2.153 Apply approved toxicants

2.16 Determine degree of predation by owls and institute control measures as needed

2.17 Prevent introduction of new predators

2.171 Monitor for presence of new predators

2.172 Develop eradication plans and assign responsibility for eliminating new predators

2.173 Inform public of the undesirability of new introductions

2.174 Enforce laws prohibiting certain exotic animal introductions

2.2 Reduce mortalities caused by light attraction

2.21 Conduct aid station salvage project

2.211 Set up and administer aid stations

2.212 Pick up, band and release fallen birds

2.213 Hospitalize injured birds

2.22 Reduce light attractant problem

2.221 Determine efficacy of reducing light intensity on the rate of seabird fallout

2.222 Determine the spectral sensitivity of 'a'o and 'ua'u for possible light modification applications

2.223 Determine efficacy of using polarized light in reducing seabird fallout

2.224 Develop methods for implementing the results of light studies

2.225 Inform government, private and public agencies of light attraction problems and abatement methods

2.226 Locate primary light attraction problem areas

2.227 Obtain funding for light abatement applications

2.228 Obtain legislation to reduce light problem

2.229 Implement program for minimizing attractant problem

2.3 Implement disease control measures (as needed)

2.31 Conduct survey of diseases in Hawaiian seabirds

2.32 Determine the role of disease as a limiting factor of 'a'o and 'ua'u

2.33 Implement disease control program

3. Determine status and distribution

3.1 Survey potential habitat areas for 'a'o and 'ua'u

3.11 Locate potential habitats

3.12 Conduct nighttime auditory sampling for nesting colonies

3.13 Determine extent of colonies

3.2 Monitor 'a'o and 'ua'u population status

3.21 Devise a population estimation technique

3.22 Devise a population trend monitoring technique

3.23 Develop a life table for 'a'o and 'ua'u

3.231 Determine nesting chronology

3.232 Determine nesting success rates

3.233 Determine mortality rates and age stratification

4. Establish additional nesting colonies

4.1 Study nesting ecology of the 'ua'u and 'a'o in natural habitat and apply results of these studies

4.2 Conduct experimental cross-fostering study

4.21 Locate 'a'o and 'ua'u eggs and transplant into surrogate nests

4.22 Monitor cross-fostering success and evaluate findings

4.23 Determine need for interspecific nest site competition control

4.24 Maintain sperm bank

4.3 Conduct experimental reestablishment of former nesting colonies or establishment of new nesting colonies using hatchling transplants just prior to fledging

4.31 Select suitable transplant sites

4.32 Stabilize predator threat in selected transplant sites

4.33 Construct artificial burrows

4.34 Transplant nestlings into artificial burrows

4.35 Monitor transplant success and evaluate findings

4.4 Test additional nesting colony establishment techniques

4.41 Test recorded vocalizations as attractant to nesting birds

4.42 Test use of decoys for attracting nesting birds

4.43 Test olfactory baits as attractants to nesting birds

4.5 Apply results of research work to establish new colonies as needed

5. Develop a public awareness program

5.1 Prepare and distribute information packets to the public, agencies, educational institutions, and libraries

5.2 Regularly inform the public through talks and news releases

5.3 Coordinate with the conservation education program within the State Department of Education and private school system

5.4 Prepare a permanent endangered seabird display

5.5 Prepare and make available an educational movie on the 'a'o and the 'ua'u

NARRATIVE

1. Preserve and Maintain Existing Habitat

Existing nesting habitat, some of which yet remains to be located, is susceptible to degradation or destruction by several causes including: forest fires, undesirable plant invasion, disturbance by human activities and trampling and grazing by feral animals. In order to protect nesting habitat from potential losses, the locations and boundaries of each nesting colony must be mapped and the areas identified as essential habitat (1.1). Most known nesting habitat occurs on government-owned lands and until all nesting habitat has been located, no habitat acquisition is recommended at this time. Education of land owners to the dangers of fire should be intensified near essential habitat zones (1.21). The conservation district laws and other land use zoning laws can be more effectively administered if the locations of sensitive habitats are identified. The issuance of fire permits can also be more restrictive in sensitive habitat areas (1.22). Fire is not as great a threat to 'ua'u habitat as it is to that of the 'a'o since the petrel nesting grounds are typified by sparse vegetation.

The composition of the vegetation in the 'a'o nesting colonies may be an important habitat requirement. The protective cover of uluhe is nearly always associated with 'a'o nesting habitat. Whether or not this cover is important for protection from predators, maintenance of a suitable nesting burrow humidity or temperature, or prevention of burrow erosion is unknown, but it appears to be an important habitat feature. Several species of aggressive noxious plants could conceivably invade 'a'o nesting habitat and reduce the utility of currently used areas (1.3). Such changes commonly follow fires or severe soil disturbance. Prevention of fires and soil disturbance would be preferable to replacing lost habitat; therefore, baseline information on the total makeup of vegetation within the nesting areas is needed so that land managers can endeavor to maintain it (1.31). It also will be useful to know the vegetative composition of preferred habitat, so that the sites of future reestablishment attempts can be more prudently chosen. In the event that existing nesting habitat is destroyed by fire, methods of reestablishing favorable vegetation should be studied, planned and instituted if needed (1.32).

A variety of potential land uses, such as military training, construction of communications facilities, and intensive recreational uses in or near 'a'o or 'ua'u nesting habitat, could pose increased threats of fire, predation or direct disturbance (1.4). In order to prevent such losses, government agencies managing habitat areas will need to consider the birds' needs in their review of land use variance applications, zoning laws and ordinances (1.41).

Although the pelagic habitat of the 'a'o and 'ua'u is not well known, there is possible habitat destruction in the form of pollutants that can be prevented. The practice of dumping highly toxic wastes in the ocean should be discouraged. Government officials managing these wastes should be made aware of the potential disaster to seabirds that could result from contamination of their food supply through the food chain (1.42).

2. Control Direct Mortalities

Two direct threats to the 'a'o and 'ua'u require management actions: (1) predation and (2) losses related to light attraction. A third possible threat, disease, needs to be studied to determine if it has played or is playing a role in the plight of endangered Hawaiian seabirds.

Predation losses must be reduced in all major nesting areas. Both the 'a'o and 'ua'u, having evolved without the threat of predators and therefore without effective defenses against them, have suffered loss because of man's exotic animal introductions. Current levels of predation within nesting colonies is apparently very high and is the primary known limiting factor of the 'ua'u at Haleakala Crater, Maui. Predation may very well be the primary limiting factor of the 'a'o, too. The development of a technique to monitor the degree of predation within nesting colonies is needed so that predator control measures can be applied judiciously (2.11).

Rats, feral cats and mongooses probably can only be controlled practically with the use of toxicants. Trapping probably is not feasible within remote 'a'o nesting colonies and some 'ua'u nesting colonies because of the amount of time needed for trap maintenance. There is an urgent need for a study to be conducted by qualified researchers to find a safe but effective toxicant that can be applied to remote habitats without endangering non-target organisms. The U.S. Fish and Wildlife Service is the most logical agency to carry out this research (2.151). Since Kaua'i does not yet have a well established population of mongooses, a method to protect existing 'a'o nesting colonies from potential predation is paramount to ensure their continued survival.

The use of toxicants is controlled by product registration under State and Federal laws. Various permits will need to be obtained to apply toxicants in habitat areas (2.152). Toxicants will then be available for use to control predators under field conditions as needed (2.153). In some cases, trapping programs will be required where toxicants cannot be used (2.12). Feral pigs and dogs, known predators of the 'a'o, cannot be safely controlled with toxicants because of the inherent risk to hunters' dogs or the hunters themselves, who might eat the flesh of pigs that had consumed a sub-lethal dose (2.15). Safe toxicants and methods to use them must be perfected (2.151). In some cases, liberal hunting seasons or improved hunter access to remote sites may be needed to keep feral pig populations low in nesting areas (2.13). The use of fencing to preclude predators or human disturbance should be considered only if it is practical to construct and maintain, and does not create a hazard to the birds (2.14).

Predation on adult and fledgling shearwaters or petrels by the barn owl and the Hawaiian short-eared owl should be investigated to determine the extent of the problem and the procedures for minimizing or eliminating the problem (2.16).

There is constant threat of new predators becoming established in Hawaii. Further spread of the mongoose to islands where it does not now exist must be prevented. Other ground predators, including rodents, snakes or other carnivores, could conceivably become established on any of the islands. The introduction of new predators must be prevented (2.17). Greater emphasis must be placed in the detection of newly arrived animals and their eradication before they become established (2.171). Agencies with the authority to detect and eradicate undesirable exotics need to clarify the scope of their responsibilities and plan in the event that eradication is needed (2.172). An effort is needed to inform the public on the dangers of introducing exotic animals into native bird habitat (2.173). Existing laws prohibiting certain exotic animal importations need to be vigorously enforced (2.174).

The loss of 'a'o fledglings caused by the light attraction problem could become a very serious limiting factor. A large percentage of the annual 'a'o production on Kaua'i is believed to be involved in the light-related fallout each year. Increasing urbanization and the lighting associated with it can be expected to compound the autumnal fallout problem. The annual shearwater salvage project, using aid stations and the assistance of the general public to pick up fallen birds, will likely be needed indefinitely, unless very effective light abatement methods can be found (2.21). It is very likely that the aid station program will need to be expanded along with the growth in urbanization. If the 'ua'u populations increase, there may be a need for establishment of aid stations on other islands. Effective aid station operation requires a cooperative effort of both State and Federal wildlife agencies (2.211). The annual administration of the aid station program requires the issuance of news releases, coordination with land owners for the use of sites for aid stations, scheduling personnel for the daily pickup and processing of birds, and record keeping (2.212). Injured birds require a holding facility, medical treatment and feeding before they can be released (2.213). Additional personnel need to be hired during the peak fallout period (October and November) to assist in the daily pickup and processing of birds turned in at aid stations.

The reduction and/or prevention of unnecessary upward radiation from urban lights could substantially reduce the total number of threatened and endangered seabird fallout victims that occur on Kaua'i each year. Continued studies are needed to find a means of reducing the light attractant problem (2.22). More information on the efficacy of shielding lights against upward radiation is needed, so that wildlife managers can more effectively negotiate with government and private agencies in the control of unnecessary light (2.221). Such information could be used to assist resort developers and architects in modifying planned lighting to reduce the shearwater fallout problem.

Several actions need to be taken to effectively reduce unnecessary upward radiation from urban lights. A continued effort should be made to inform and educate government agencies responsible for street lighting and lighting of public recreational facilities as to the light attraction problem. Private subdivision and resort developers, as well as the general public, should also be informed of the hazards to threatened and endangered seabirds resulting from unnecessary light radiation (2.225). In many instances, if there were an understanding of the potential light problem during the designing phase of urban developments, consideration could be given to the type and placement of lights, or to the installation of light shields during construction.

An analysis is needed to locate the most critical fallout areas, so that the expenditures made for light shielding can be done prudently (2.226). Critical fallout areas can be located by analyzing fallout data obtained at shearwater aid stations. Private conservation organizations may be willing to fund the purchase and installation of light shields in areas where fallout is known to be heavy (2.227). Additionally, there is a need to consider legislation on the State and County levels requiring light shields on all new street and athletic field lights, especially on Kaua'i (2.228). An overall program to minimize this attractant problem would coordinate the various efforts (2.229).

A fact sheet explaining the light attractant problem and ways to alleviate the problem should be prepared and routinely distributed to government public works agencies, private developers and architects involved with urban developments on Kaua'i or other islands where needed.

Other possible modes of light abatement that need study include modification of the light spectrum, use of polarized light and, possibly, the use of interrupted or flickering light (2.223). These types of light modification may prove to be less acceptable or feasible from the management standpoint. Studies that are approved on the light abatement problem should be specifically aimed toward practical solutions to the problem. In interest of the costs involved, a laboratory study to determine the spectral sensitivity of the Newell's manx shearwater and dark-rumped petrel could reduce the need for large scale field tests of various potential light modification techniques (2.222). When more is learned about the spectral sensitivity of endangered or threatened procellariforms, then means of implementing the findings will need to be developed (2.224).

An indirect means of reducing the problems associated with light-attractant fallout would be to establish breeding populations of endangered seabirds on offshore islets or remote islands, where lights would not interfere with birds in transit between their nests and the feeding areas.

Studies to determine the occurrence of diseases in endemic seabird populations are needed to determine their significance and to propose vector control measures that lend themselves to management actions (2.3). Pox vaccines might be used on these long-lived birds since a large percentage of 'a'o fledglings are brought to the aid station each year.

3. Determine Status and Distribution

Most of the potential 'ua'u nesting habitat at Haleakala Crater, Maui has been surveyed; however, additional remnant populations may exist elsewhere on Maui or on the other major Hawaiian Islands. These need to be located and their status and size determined so that possible future predator control can be applied. Surveys of typical and historical habitat areas need to be made on all islands where 'ua'u and 'a'o were found (3.1). Use of vegetative type maps, aerial photographs, and historical records could narrow down the area to be searched, particularly in the case of the 'a'o, which has an affinity for uluhe fern (3.11). A systematic sampling for unknown colonies, using parabolic microphones in the evening or early morning hours, would also be an efficient method for locating unknown nesting areas (3.12). Ground surveys, following auditory location of nesting colonies, would then be required to determine the size of each nesting area (3.13).

In order to evaluate the recovery progress of both the 'a'o and the 'ua'u, a means of determining their population size will be necessary (3.21). A method will also be needed to monitor population trends (3.22). Population monitoring can be done once every three years. To accomplish these tasks, a life table for each species should be developed. Information on nesting chronology (3.231), nesting success (3.232), longevity, and mortality rates (3.233) will be needed. A large scale banding program, involving adults and nestlings in the nesting colonies and fledglings that have fallen, along with follow-up colony studies will be needed to develop life tables. The birds handled during the annual aid station project (2.21) will permit banding large numbers of known aged individuals sequentially for several years. Such information may be more difficult to determine for the 'ua'u, since relatively few of them are recovered in the fallout each year. Banding data will need to be recorded, stored and analyzed to develop a life table.

4. Establish Additional Nesting Colonies

More information needs to be learned about the nesting ecology of the 'ua'u and 'a'o, so that the findings can be applied to future nest transplant attempts (4.1). The establishment of new nesting colonies by artificial means shows promise for reducing potential and existing predator problems and light attractant problems. The experimental cross-fostering technique, using surrogate wedge-tailed shearwater parents, has been remarkably successful in producing fledglings from coastal habitat as that at Kilauea Point, Kaua'i (Byrd, et al. in press) (4.2). Experiments should continue, thus additional 'a'o and 'ua'u eggs must be collected and transplanted into surrogate nests (4.21). Continued trials and follow-up are needed to determine if the fledglings imprint on the surrogate nesting grounds and return there to nest. In the cross-fostering studies, interspecific nest competition evaluations will be needed to determine if surrogate wedge-tailed shearwaters out compete returning Newell's manx shearwaters for available nesting sites (4.22). Experimentation with artificial nesting burrows and different-sized entrances potentially could be used to solve this problem if it were found to exist (4.23).

One drawback with the wedge-tailed shearwater-Newell's manx shearwater cross-fostering technique is that nest transplants are limited to those areas where the wedge-tail already nests. These areas may, in the end, be unacceptable to either the 'a'o or the 'ua'u as nesting sites; therefore, other methods of nesting colony establishment may need to be considered. In addition, for potential future needs to manipulate populations, it will be advantagous to maintain a sperm bank (4.24).

Another technique that has potential for translocation of both the 'ua'u and the 'a'o would be to transplant full-grown nestlings just before they fledge their natural burrows (4.3). Suitable sites for such transplants must first be selected (4.31). Transplants could be made into artificially constructed burrows in new habitat (4.33) or in historically used habitat. The success of this method would depend upon the time at which imprinting of a nestling takes place. Most shearwaters presumably remain deep within their burrows until a short time before they actually leave their nesting grounds, suggesting that imprinting on their nesting site occurs at or just before the time of fledging. If this is found to be the case with the 'a'o and 'ua'u, then fledglings could be removed from their natural nest and transported in a dark container to artificial nests at a different site just prior to normal fledging date. If imprinting occurs at the new site, they would be expected to return there to breed when they reach sexual maturity (4.34). This method would enable transplants into habitats that were formerly used, or that have similar conditions to their natural nesting habitat.

If transplant techniques are developed and found to be successful, then potential nest reestablishment sites would need to be cleared of and protected against predators (4.32). A follow-up period of nest site monitoring and evaluation of success would be needed to assess the effectiveness of transplants in meeting the primary objective of the recovery plan (4.35).

Outside of the imprinting methods discussed up to this point, there are other possible modes of inducing the 'a'o and 'ua'u to nest in currently unused habitats: the use of recorded vocalizations, decoys and olfactory baits. Kress (1980) used recorded vocalizations and decoys to attract Arctic terns (Sterna paradisaea) to nest at Egg Rock, Muscongus Bay, Maine, from which they had once been extirpated. Recorded courtship vocalizations of the 'a'o and 'ua'u should be tested and, if necessary, used in conjunction with the cross-fostering or fledgling transplant attempts (4.41). The attraction of breeding birds to offshore islets with the use of recorded vocalizations and decoys should also be tried to see if they will attract breeding birds (4.42).

Olfactory "baits" might also be useful for inducing the 'a'o and the 'ua'u to use new nesting sites. The extraction of stomach oils from fresh road kills, and subsequent application at experimental nesting sites should be tested (4.43). Wenzel (1980) and Hutchison (1980) have shown that procellariiform birds have a highly developed sense of olfaction and partially use olfactory cues in the location of food at sea. Shallenberger (1975) discussed the use of olfaction for nest site location by wedge-tailed shearwaters on Manana Island, Hawai'i. The 'a'o and 'ua'u seem to have characteristic odors that are even discernable to humans. These odors may play an important role in nest site selection, and could be easily tested separately and in conjunction with other baits at experimental nesting colony establishment sites.

With the information generated by these research efforts, new colonies can be established as deemed necessary (4.5).

5. Public Awareness

It is important that the public be kept aware of the protected status of these as well as other endangered or threatened species. A program should be initiated informing the public of the value of Hawaii's natural resources in general and the 'a'o and 'ua'u in particular.

Information packets will be prepared and distributed to schools, libraries, government agencies and individuals (5.1). Building on this information, a permanent display will be developed for use at fairs, meetings, open houses and schools (5.4). Information also will be disseminated through the use of news releases and other efforts through the various media (5.2, 5.5).

Through coordination and cooperation with the State Department of Education and the Hawaii Science Teachers Association, educational programs can be developed for use in the state's public and private schools (5.3). Cooperation and assistance also will be sought from conservation organizations such as The Nature Conservancy and the Audubon Society.

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PART III

IMPLEMENTATION SCHEDULE

Table I, which follows, is a summary of scheduled actions and costs for the Hawaiian dark-rumped petrel and Newell's manx shearwater recovery program. It is a guide to meet the objectives of the Hawaiian Dark-Rumped Petrel and Newell's Manx Shearwater Recovery Plan, as elaborated upon in Part II, Action Narrative Section. This table indicates the priority in scheduling tasks to meet the objectives, which agencies are responsible to perform these tasks, a time-table for accomplishing these tasks, and lastly, the estimated costs to perform them. Implementing Part III is the action of the recovery plan, that when accomplished, will satisfy the prime objective. Initiation of these actions is subject to the availability of funds.

GENERAL CATEGORIES FOR IMPLEMENTATION SCHEDULES

Information Gathering - I or R (research)

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomic studies
6. Demographic studies
7. Propagation
8. Migration
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

Acquisition - A

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

Management - M

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depredation control
6. Disease control
7. Other management

Other - O

1. Information and education
2. Law enforcement
3. Regulations
4. Administration

Task Priority

Priority 1 - All actions that are absolutely essential to prevent extinction of the species.

Priority 2 - All actions necessary to maintain the species' current population status.

Priority 3 - All other actions necessary to provide for full recovery of the species.

PART III IMPLEMENTATION SCHEDULE

GENERAL CATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION	RESPONSIBLE AGENCY FWS REGION	RESPONSIBLE AGENCY FWS PROGRAM	RESPONSIBLE AGENCY OTHER	FISCAL YEAR COSTS (EST.) FY 83	FY 84	FY 85	COMMENTS/NOTES
I 2	Locate, delineate and declare essential habitat	1.1	2	5 years	1	SE		3,000	3,000	3,000	
							DLNR	3,000	3,000	3,000	
							NPS	3,000	3,000	3,000	
O 2	Enforce fire laws	1.22	2	Continuous			DLNR	500	500	500	
							NPS	500	500	500	
M 3	Plan for and rees-tablish vegetation after fires	1.32	2	Continuous			DLNR	500	500	300	
							NPS	500	500	100	
					1	SE		100	100	100	
O 4	Review land use zoning variance proposals	1.41	2	Continuous			DLNR	500	500	500	
I 9	Determine need for predator control at each nesting area	2.11	1	Continuous	1	RES		200	200	200	
							DLNR	1,000	1,000	1,000	
							NPS	1,000	1,000	1,000	
R 9	Perfect safe toxicant and application methods within nesting sites	2.151	1	5 years	8	RES		TO BE DETERMINED---------			
							DLNR	0	0	0	
							NPS	0	0	0	
O 4	Obtain toxicant registration and permits for use	2.152	1	unknown	1	ADC		TO BE DETERMINED---------			
							DLNR	0	0	0	
							NPS	0	0	0	
M 4	Predator trapping where needed	2.12	1	Continuous	1	ADC		2,000	2,000	2,000	
							NPS	2,000	2,000	2,000	
							DLNR	1,000	1,000	1,000	
M 4	Manage pig predation with liberal hunting seasons and access	2.13	2	Continuous			DLNR	500	500	500	
							NPS	0	0	0	

PART III IMPLEMENTATION SCHEDULE

GENERAL CATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION	RESPONSIBLE AGENCY FWS REGION	RESPONSIBLE AGENCY FWS PROGRAM	RESPONSIBLE AGENCY OTHER	FISCAL YEAR COSTS (EST.) FY 83	FY 84	FY 85	COMMENTS/NOTES
M 4	Fence nesting habitats where needed and where feasible	2.14	2	unknown			DLNR NPS	To be determined---------			
I 9	Determine degree of owl predation and control if needed	2.16	2	3 years	1	ADC		1,000	1,000	1,000	
							DLNR	1,000	1,000	1,000	
M4	Monitor for presence of new predators	2.171	1	Continuous	1	ADC		1,000	200	200	
							DLNR	1,000	1,000	1,000	
							NPS	500	500	500	
O 4	Develop new predator eradication plans, authority and responsibility	2.172	1	3 years	1	ADC		1,000	500	500	
							DLNR	500	250	250	
							NPS	500	250	250	
O 1	Inform public on undesirability of new predators	2.173	1	Continuous	1	SE		500	500	500	
							DLNR	500	500	500	
							NPS	500	500	500	
O 2	Enforce laws prohibiting certain exotic animal introductions	2.174	1	Continuous			DOA	0	0	0	
							DLNR	1,000	1,000	1,000	
							NPS	0	0	0	
M 7	Set up and administer aid stations for salvage project	2.211	2	Continuous	1		DLNR	2,000	2,000	2,000	
						RWR		2,000	2,000	2,000	
R 14	Pick up, band, and release fallen birds	2.212	2	Continuous	1		DLNR	2,000	2,000	2,000	
						RWR		2,000	2,000	2,000	

PART III IMPLEMENTATION SCHEDULE

GENERAL CATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION	RESPONSIBLE AGENCY FWS REGION	RESPONSIBLE AGENCY FWS PROGRAM	OTHER	FISCAL YEAR COSTS (EST.) FY 83	FY 84	FY 85	COMMENTS/NOTES
R 4	Determine efficacy of reduced light intensity fallout	2.221	1	3 years			DLNR	3,000	3,000	3,000	
R 4	Determine efficacy of polarized light in reducing fallout	2.223	2	1 year	1	SE		20,000	0	0	
R 4	Develop light abatement implementation methods	2.224	1	3 years	1	SE		2,000	2,000	2,000	
							DLNR	0	0	500	
							DOT	0	0	300	
							Others	0	0	300	
O 1	Education - light attractant problem and abatement methods	2.225	1	Continuous	1	SE		500	500	500	
							DLNR	500	500	500	
M 3	Locate primary light attraction problem areas	2.226	1	2 years	1	SE		1,500	1,500		
							DLNR	1,500	1,500		
O 4	Obtain funding for light abatement applications	2.227	2	5 years	1	SE		2,000	2,000	2,000	
							DLNR	2,000	2,000	2,000	
O 4	Obtain legislation to reduce light problem	2.228	1	2 years +	1	SE		2,000	2,000		
							DLNR	2,000	2,000		
R 11	Determine the role of disease as a limiting factor of 'a'o and 'ua'u	2.32	2	5 years	8	RES		10,000	10,000	10,000	

PART III IMPLEMENTATION SCHEDULE

GENERAL CATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION	RESPONSIBLE AGENCY FWS REGION	RESPONSIBLE AGENCY FWS PROGRAM	RESPONSIBLE AGENCY OTHER	FISCAL YEAR COSTS (EST.) FY 83	FY 84	FY 85	COMMENTS/NOTES
M 6	Implement disease control measures if needed and feasible	2.33	2	unknown			DLNR NPS	TO BE DETERMINED---------			
I 1	Locate typical habitat with aerial photos, vegetation type maps, etc.	3.11	2	2 years	1	SE		2,000	1,000	0	
							DLNR	1,000	500	0	
							NPS	1,000	500	0	
I 1	Conduct nighttime auditory sampling for nesting colonies	3.12	2	5 years	1	SE		10,000	5,000	2,000	
							DLNR	2,000	2,000	1,000	
I 1	Determine colony boundaries by ground surveys	3.13	2	5 years	1	SE		2,000	2,000	2,000	
							DLNR	2,000	2,000	2,000	
							NPS	2,000	2,000	2,000	
R 4	Develop population status monitoring technique	3.21	2	unknown	8	RES		1,000	TO BE DETERMINED		
							DLNR	500	TO BE DETERMINED		
							NPS	500	TO BE DETERMINED		
R 4	Devise population monitoring technique and accomplish every 3 years	3.22	2	Continuous	8	RES		3,000	TO BE DETERMINED		
							NPS	1,500	TO BE DETERMINED		
							DLNR	1,500	TO BE DETERMINED		
R 14	Determine nesting chronology	3.231	2	5 years	8	RES		5,000	5,000	5,000	
							DLNR	5,000	5,000	5,000	
							NPS	5,000	5,000	5,000	
R 6	Determine nesting success rates	3.232	1	3 years	1	RWR		5,000	5,000	5,000	
							DLNR	5,000	5,000	5,000	
							NPS	5,000	5,000	5,000	

PART III IMPLEMENTATION SCHEDULE

GENERAL CATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION	RESPONSIBLE AGENCY FWS REGION	RESPONSIBLE AGENCY FWS PROGRAM	RESPONSIBLE AGENCY OTHER	FISCAL YEAR COSTS (EST.) FY 83	FY 84	FY 85	COMMENTS/NOTES
R 6	Determine mortality rates and age stratification by banding program and analysis	3.233	2	Continuous	1	RWR		1,500	1,500	1,500	
							NPS	1,000	1,000	1,000	
							DLNR	1,000	1,000	1,000	
R 14	Study of 'a'o and 'ua'u nesting ecology for application to transplant studies	4.1	1	5 years	1	SE		3,000	2,000	2,000	'Ua'u Study initiated 4/79 in Haleakala National Park
							NPS	3,000	2,000	2,000	
							DLNR	3,000	2,000	2,000	
R 14	Locate eggs and transplant into surrogate nests	4.21	2	Continuous			DLNR	1,000	1,000	1,000	
							NPS	1,000	1,000	1,000	
R 14	Monitor cross-fostering success and evaluate	4.22	2	2 years			DLNR	1,000	1,000		
							NPS	1,000	1,000		
O 1	Prepare information packets	5.1	2	Continuous	1	SE		5,000	2,000	1,000	
							DLNR	500	500	500	

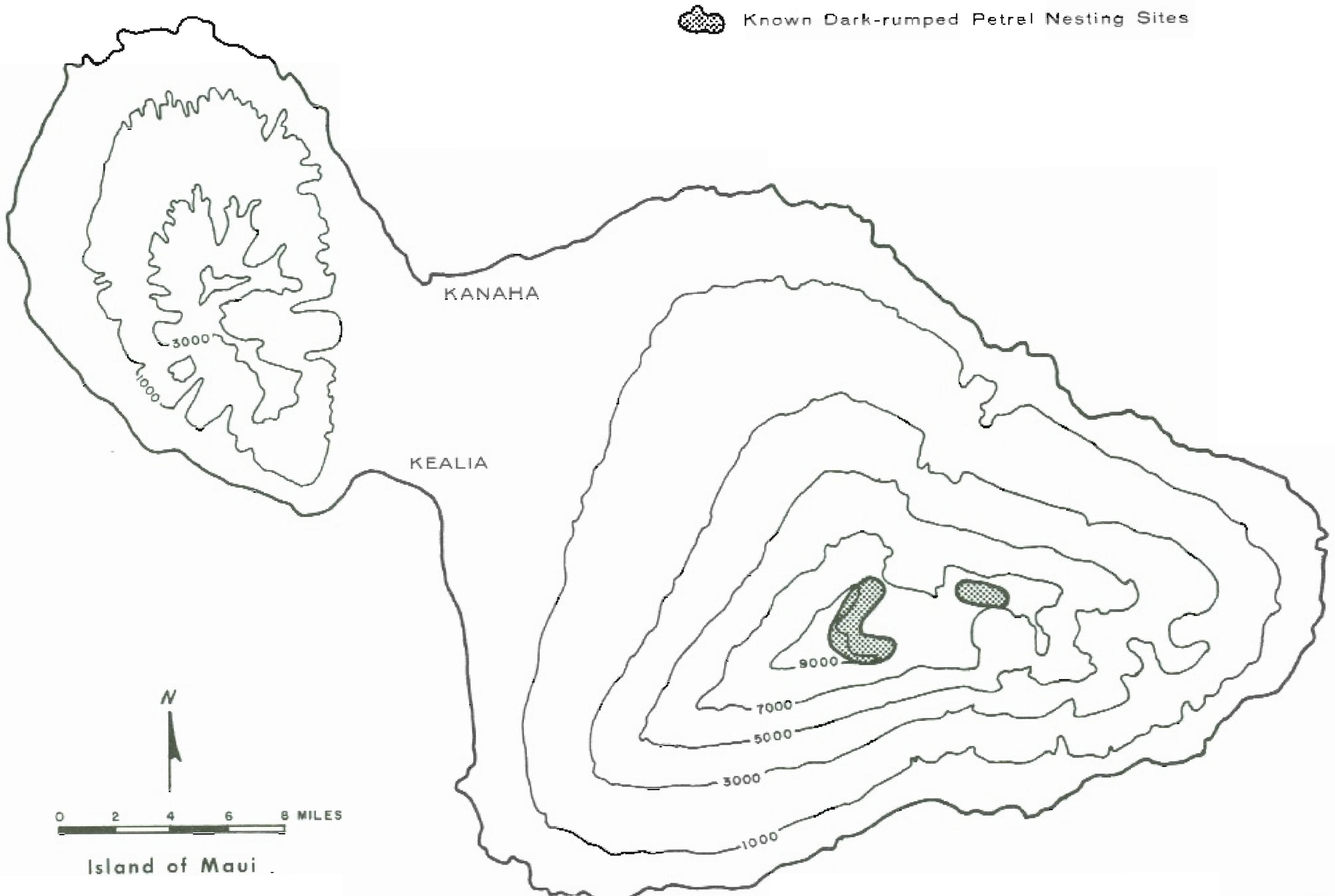
KEY FOR RESPONSIBLE AGENCY

NPS - National Park Service
DLNR - Department of Land and Natural Resources
DOA - Department of Agriculture
DOT - Department of Transportation
TNC - The Nature Conservancy
CG - Coast Guard
RWR - U.S. Fish and Wildlife Servce - Refuges and Wildlife Resources
RES - U.S. Fish and Wildlife Service - Research
ADC - U.S. Fish and Wildlife Service - Animal Damage Control
SE - U.S. Fish and Wildlife Service - Endangered Species

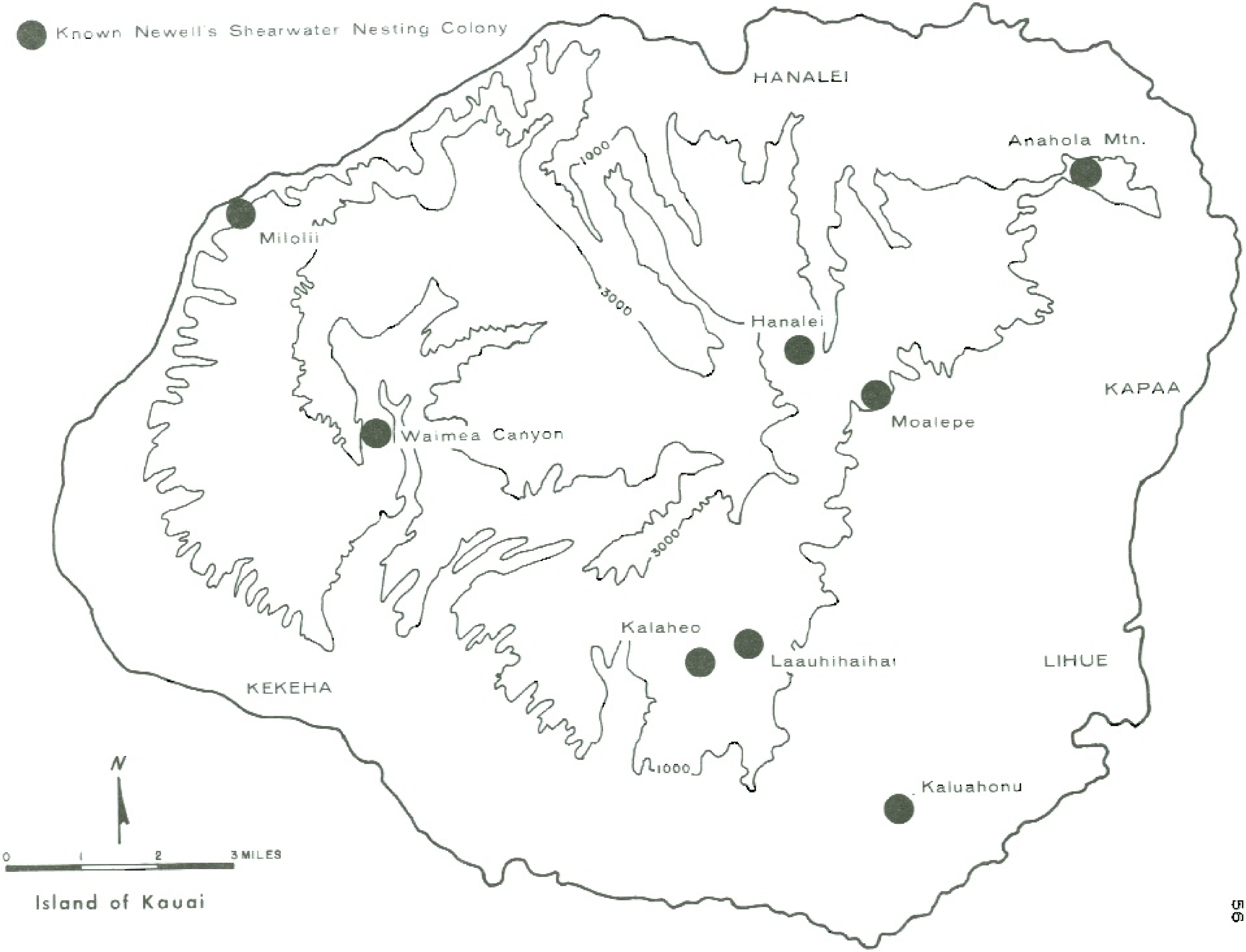
KEY FOR PRIORITY #

Priority 1 - All actions that are absolutely essential to prevent extinction of the species.
Priority 2 - All actions necessary to maintain the species' current population status.
Priority 3 - All other actions necessary to provide for full recovery of the species.

APPENDIX



Island of Maui


Known Newell's Shearwater Nesting Colony
HANALEI
Anahola Mtn.
Milolii
1000
3000
Hanalei
KAPAA
Moalepe
Waimea Canyon
3000
Kalaheo
Laauhihaihai
LIHUE
KEKEHA
1000
Kaluahonu
N
0
1
2
3 MILES
Island of Kauai

AGENCIES CONTACTED DURING AGENCY REVIEW

Federal

Hawai'i Volcanoes National Park

U.S. Coast Guard

State

Department of Land and Natural Resources

Division of Forestry and Wildlife

Department of Agriculture

Division of Transportation

County

Office of the Mayor, County of Kaua'i

Office of the Mayor, County of Maui

Private

The Nature Conservancy