Historical Decline and Future Efforts Needed for the Conservation of the Ua’u (Hawaiian Petrel)

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Introduction

The dark-rumped Petrel (Pterodroma phaeopygia) is a tropical seabird that ranges across much of the Pacific. However, it is only found to breed on two remote island chains: the Galapagos and Hawaiian islands (Simons & Hodges, 1998). These two breeding populations are composed of similar yet distinctly different sub-species, the Galapagos Dark-rumped Petrel (P. p. phaeopygia) and the Hawaiian Dark-rumped Petrel (P. p. sandwichensis) also know by its Hawaiian name Ua’u (Browne, et al, 1997).

The Hawaiian Petrel is a gadfly petrel with an average wingspan of 98 cm and a mean weight of 434g, making it one of the largest Petrels in the Pterodroma petrel family (Judge & Hu, 2006). The upper portion of their body is typically grayish-black with a mostly white underside. They have a black bill and small pink feet (Judge & Hu, 2006).

In this paper I am going to cover the history of petrel decline in Hawai‘i, current issues that continue to threaten populations, and what conservation efforts are taking place in order to determine what possible studies and conservation should occur to conserve future populations of Hawaiian Petrels.

Historical Human Impacts

Fossil records of Hawaiian petrels prove that they were once wide spread across all the major Hawaiian Islands (Olson & James, 1982). Upon the arrival of the early Hawaiians, lowland habitat was converted for inhabitance and agriculture. Lowland degradation, cultural hunting of the birds for food, as well as the introduction of dogs, pigs, and rats by early Polynesians most likely led to the extirpation of the birds from much of the preferred lowland habitat and eventually from the Island of Oahu (Olson & James, 1982). In fact, it is now believed that the birds were extirpated from the Island of Oahu before the arrival of the Europeans (Olson & James, 1982).

The early extirpation from Oahu may have resulted from the cultural practice of gathering the birds. Hawaiian Petrels were thought of as a delicacy and were reserved only for the highest classes in Hawaiian society (Simons, 1985). Frequent hunting groups were sent to the mountainous colonies, and petrel caves were excavated to widen the opening of the nest for easy removal of the juvenile petrels by the twisting of a stick into the chicks thick down (Judge & Hu, 2006). Even today these human-modified pits have continued to have a lasting effect on the bird’s survival. Although many of these altered nests have been re-colonized by breeding petrels, it has been demonstrated that these nests suffer higher predation by introduced predators (Hu, 2001).

It is now clear that Petrel decline was well underway before the first contact with Europeans, but with a new visitor to the Hawaiian Islands came an entire new set of problems for Hawaiian Petrels and their habitat. With the arrival of the Europeans came the arrival of black rats, Norway rats, disease-caring mosquitoes, goats, sheep, and cattle; all of which had an effect on the remaining petrel population and their habitat (Simons & Hodges, 1998). Feral ungulates foraged on native biota thus degrading habitat, as well as increasing erosion. Mosquitoes carried avian malaria that many native birds had no resistance to. Rats foraged on native plant seedlings, predated on petrel eggs and small chicks (Hodges & Nagata, 2001).

Other introduced predators, such as the Indian mongoose, only perpetuated the petrel decline (Hodges & Nagata, 2001). Mongooses where introduced by sugar plantation owners to control rat populations in 1883. While their effect on rat population is negligible, mongooses are known to predate on petrel eggs, chicks, and even the adult bird. (Hodges & Nagata, 2001).

In addition to mongooses, feral cats also prove to be detrimental to native bird populations (Hodges & Nagata, 2001). Introduced by Europeans, the cats were gifts to the Hawaiian royalty and the upper class and established themselves in most of the ecosystems in the Hawaiian Islands, including sub-alpine and montane zones (Hess, Hansen & Banko, 2007). Feral cats were recorded by Perkins in 1903 to prey on native forest bird populations late in the 19th century (Hess et al, 2007). They pose one of the
greatest risks to endangered species, and possess large home ranges that apparently are not affected by the presence of lava flows (Hess, Hansen & Banko, 2007).

After pressures from habitat degradation and new species introductions, remaining native birds, including the Hawaiian petrel, were forced to move into less desirable upland habitat (Cooper & Day, 2003). Residual populations of petrels are found in sub-alpine and montane areas of the Lanai, Maui, and Hawaii'i islands (Simons & Hodges, 1998). From 1910 to the 1940s, ornithologists suspected that the species was extinct in Hawaii'i because no observations of the bird had been made (Munro 1941,1944 cited in Simmons, 1985). Those fears were squelched when a Hawaiian petrel grounded itself during a storm on Kilauea volcano in 1948 (Baldwin & Hubbard 1949 as cited in Simmons, 1985). After this discovery, evidence from various surveys found proof of petrel existence on most of the main Hawaiian Islands. Petrel calls have been recorded on Molokai and Kauai, and some small populations may exist on these islands (Day & Cooper, 2002; Simmons & Hodges, 1998). The largest population exists within Halakala National Park on the island of Maui (Simons, 1985), and their existence on higher altitudes of Mauna Loa has been documented (Judge & Hu, 2007). Ua’u use these upland areas for breeding and nest selection (Simmons 1985).

Fragile Ecology
While this pelagic bird spends most of its life at sea in the tropical waters of the Pacific feeding on squid, fish and crustaceans (Simmons & Hodges, 1998), it utilizes the upland habitat of Hawaiian islands for breeding from February to November (Simmons, 1985). It is here at higher altitudes that the petrels mate and locate a burrow from mid March to mid April (Simmons, 1985). The female builds a nest shortly before laying a single egg early in May. If the male is present while the female is laying the eggs, he takes the first and longest shift (Simmons, 1985): the pair takes shifts during incubation, and on average, the male spends more time incubating the egg than the female does. Incubation behavior continues for the duration of the 55-day incubation period (Simmons, 1985). After the hatching of the egg, the male and female take alternating feeding runs in order to produce a highly concentrated feed that is later regurgitated for the chick. This feeding continues until fall when the parents start to starve the fattened chick in order to prepare it for fledging(Simmons, 1985). At this time, the chick starts to emerge from the burrow stretching its wings while perched on a rock in order to prepare to fledge. Fledging behavior starts in October and is usually completed by November (Simmons, 1985). This breeding process is very strenuous for the adults and chicks. Weight loss by adults has been documented during incubation period, and feeding runs may range thousands of kilometers (Simmons, 1985).

All of this behavior may increase stress on Ua’u. At any time during the breeding period the adults, egg, and chicks, especially during fledging behavior, have an increased risk of predation by introduced predators. Like most seabirds, the Ua’u nest on the ground, a result of their evolution on islands absent of any predators. Their naive evolution has caused for ground nesting behavior has made them more vulnerable to even the smallest predator such as rats, mongooses, and feral cats (Hodges & Nagata 2001). In fact, the havoc on native island biota by feral cats is not just limited to Hawaii'i: it is an all too common problem on islands worldwide (Nogals et al, 2004).

Current Threats
The presence of cats has led to the extinction of at least 33 species of birds on islands worldwide (Nogals et al, 2004). While introduced predators have a greater effect on land birds, it has been documented that seabird populations can be effected as well. In the Aleutian Islands many populations of petrels and other seabirds have led to long-lasting declines in population size (Bailey, 1993; Byrd, Renner & Renner, 2005). Therefore, it was determined that more should be learned about the threat feral cats pose on native biota, thus resulting in the ecological study of feral cats in Hawaii'i.

Ecological studies of these introduced predators help to determine how, and to what extent, they prey on endangered species such as Hawaiian petrel (Hess, Hansen & Banko, 2007). The stomach contents examined of feral cats found on Kilauea and Mauna Loa mountains revealed the presence of many other birds as well as a number of native forest birds and the Hawaiian petrel. This study documented the first existence of petrel remains inside the digestive tract of a cat found on Mauna Loa (Hess et al., 2007). Ecological studies of feral cats within Hawaii'i Volcanoes National Park revealed that these animals have large home ranges and show no qualms about crossing large portions of bare lava (Hansen & Banko, 2007). They also revealed that a diet of mice and rats, as well as introduced game birds, could allow feral cats to remain in harsh areas long enough to prey on the less abundant endangered species (Hess et al, 2007; Hansen & Banko 2007). Both of these behaviors of feral cats pose a direct threat to the populations of...
Hawaiian petrels, but other causes of mortality also exist.

The nature of petrel behavior, mainly its movements over land, often can result in mortality. One such cause of mortality is night collisions with man-made structures such as lights, poles, antennas, power lines and even ungulate exclusion fences (Hodge & Nagata, 2001, Simmons & Hodge, 1998): primarily because petrel movement over land has only been recorded after sun down and these seabirds fly at fast speeds (Hodge & Nagata, 2001; Simmons & Hodge, 1998). This fast night flying causes these birds to become confused by lights thus, causing mortality from collisions or accidental grounding (Cooper & Day, 2003, Simmons, 1985). Environmental impact statements issued within petrel breeding areas have addressed concerns with accidental bird collision as well as determined flight patterns on Maui (Day et al, 2005, Cooper & Day 2003). In fact resent efforts have been taken to remove television transmitters from the Halakala summit area earlier than planned in order to avoid movements during breeding (Eagar, 2008).

**Variety Within Subspecies**

Studies have shown breeding does not occur between the Hawaiian Dark-rump petrel and the Galapagos Dark-rump petrel populations (Browne et al, 1997). The isolation between these two populations has caused the classification of the Hawaiian petrel as a subspecies of the Dark-rump petrel in the Galapagos Islands (Browne et al, 1997). Additionally, Galapagos Dark-rump petrels have been separated into three groups based on differences in their breeding chronology, behavior, and call vocalizations (Tomkins & Milne, 1991). These differences in behavior suggest that breeding may not be occurring between different populations on different islands within the Galapagos (Tomkins & Milne, 1991). This breeding behavior would mean that populations found on different islands are isolated populations, and may have varying sizes. Furthermore, the Galapagos Islands are closer together than the Hawaiian Islands and just like their closely related relatives it would not be surprising to discover that Hawaiian petrels are exhibiting similar behavior. If breeding isolation were discovered on different Hawaiian Islands, it would suggest that different populations could exist on different islands and that population size could vary within each island.

Knowing the size of the population is extremely important when attempting to conserve a species. The minimum viable population, or m.v.p., is the minimum size a population can be in order to prevent extinction (Shaffer, 1981). Consequently, smaller populations are more susceptible to extinction from an array of different causes (Shaffer, 1981). If isolated populations exist on the different Hawaiian Islands then diversity in population size of each also exists. Therefore a true population size for each island and m.v.p. should be assessed. Ultimately, population size should influence research and management of each population, but presently much of the research has been focused on the Halakala petrel population, and only a few studies have been conducted on the Mauna Loa population.

Currently a gap in knowledge exists pertaining to the degree of isolation of each island population as well as an assessment of population size. This lack of understanding is especially true when dealing with the populations on Mauna Loa. This information is important because if populations are reaching critically low levels they begin inbreeding. This would make them susceptible to inbreeding depression, resulting in reduced fitness as well as reduced egg fertility (Keller & Waller, 2002). Moreover, a small population could be lacking genetic diversity, and ultimately not contain alleles that could be crucial for survival. These phenomenon could be affecting current populations of petrels in Hawai‘i; however there exists a lack of available information pertaining to gene flow between and within populations.

**Conservation Efforts**

Predator control efforts have proven successful in maintaining breeding success on Halakala (Hodge & Nagata, 2001). After predator control programs were established breeding success increased significantly (Hodge & Nagata, 2001). Many threats account for petrel decline. The greatest single cause of petrel mortality in the heavily studied Halakala population is predation (Hodge & Nagata, 2001). While rats cause most of the mortality from predation of the egg or young chick, active predator control is focused on mongoose and cats (Hodge & Nagata, 2001). Cats and mongoose account for the second highest cause of predation (Hodge & Nagata, 2001). After models preformed by Simmons (1984) projected the decline and possible extinction within 20-30 years of the largest population of the bird, a predator control program was developed (Hodge & Nagata, 2001). This program has proven to have a positive effect on the breeding success and ultimately the conservation of the species within Halakala National Park (Hodge & Nagata, 2001).

While differences between populations of Ua‘u on different Hawaiian Islands may be unknown, conservation efforts remain similar despite drastically
different geography and species distribution. Similar efforts of predator control are in place on Mauna Loa, but due to the remote location of the colonies, and the large geographic range on Mauna Loa, predator control remains difficult (Simmons & Hodge 1998; Judge & Hu 2007). Some areas on Mauna Loa are only accessible by long hikes or helicopter (Simmons & Hodge 1998). Due to the harsh and expansive geographic range of petrel colonies on Mauna Loa, trapping of predators is more difficult (Simmons & Hodge 1998). This difficulty means that some of the more remote breeding areas do not have predator control on Mauna Loa. Another method for controlling introduced predators involves administering poison by air, however as outlined in the management plans for the recovery of this species by U.S. fish and wildlife service, the use of effective poisons have been prohibited or severely restricted (1983). This presents a dilemma for petrel conservation efforts on Mauna Loa as predation by introduced predators is still affecting petrel breeding success (Hu, 2001).

Other more aggressive methods have been used to eradicate introduced predators on different Islands. Cats have been eradicated from at least 48 islands worldwide, including four Pacific Islands (Nogals et al, 2004). On the largest islands where cat eradication occurred, it involved the use of traps, poison, hunting with dogs and introduced disease (Nogals et al, 2004). The use of introduced diseases has shown to be very effective in different types of applications, and various types of biocontrols exist for different cases (Courchamp & Sugihara, 1999). Although proven to be very effective, some conservation groups warn of possible harm that an introduced virus could cause to native biota (Nogals et al, 2004). Some of the most successful and applicable cases of predator control are in New Zealand using a poison 1080 or sodium monofluoroacetate (Alterio, 2000). This poison can be administered two different ways: the use of poisoned bait intended for direct consumption by the predator, or secondarily, by poisoning the prey that later kills the predator. In cases involving feral cats in New Zealand, secondary poisoning using 1080 has proven to be 100% effective (Alterio, 2000). While 1080 can be administered using airborne methods, it has also proven successful in ground baiting near roads (Nogals et al, 2004, Alterio, 2000). With more research, any or all of these approaches may prove useful when trying to control feral predators on Hawai‘i Island.

Conclusion

The gaps in knowledge unearthed in this paper suggest the need for more study, mainly in comparisons between the populations, documentations of the degree of gene flow between populations, and the possible effects and different methods of more aggressive predator controls. While the initial decline of the Hawaiian petrel may have occurred with immigration of the Polynesians, the introductions made by the Europeans furthered aided in the decline of the species. Today, while mitigations try to minimize man-made mortality of the birds, these mammalian introductions, mainly predators, continue to account for large portion of petrel decline. Whereas predator trapping is showing signs of relative success in the Halakala population, the same methods may be proving less effective on the large scale and rugged terrain of Mauna Loa. It is also unknown to what degree these two populations are mixing, thus potentially creating an increased urgency and added value to protecting the smaller Mauna Loa population. In fact, the first and foremost studies should be population assessments for each island followed by behavior and genetics studies to determine the degree of isolation for each population. Knowing this could persuade policy makers to reconsider other more aggressive measures of predator control such as the use of effective poison and introduced viruses as biocontrols. Nevertheless, despite the urgent need for more radical conservation, the largest opposition to changes in policy are current regulations and possible public outcry. In the meantime, Hawaiian Petrel populations still remain at risk and continue their decline.

BIBLIOGRAPHY


