ATST 2012 Hawaiian Petrel Monitoring Report

H. Chen, C. Ganter, J. Panglao
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ABSTRACT
The Advanced Technology Solar Telescope (ATST) Resource Management Team monitored burrows of the Hawaiian Petrel (*Pterodroma sandwichensis*) on the summit area of Haleakalā from February through November of 2012. All data presented in this report was collected prior to the start of construction (November 30, 2012) of the ATST.

This year a total of 306 Hawaiian Petrel burrows were documented and monitored. Of these burrows, 163 were active and 16 were successful at producing a fledged chick at the end of the nesting season. Statistical analysis showed that active burrow density in the ATST Conservation Area was significantly higher than in the Control site when compared to the expected values ($P<0.0001$, $\chi^2= 20.569$, df=1). Invasive mammalian predators were the primary cause (n=6, 85.71%) of mortality.

The Hawaiian Petrel chicks fledged between the first week of October and the first week of November, with the most fledged chicks occurring during the second and third week of October. For burrows monitored by video surveillance, the earliest fledging date recorded on camera was October 12, 2012 and the latest date was October 19, 2012.

The breeding success rate in the Conservation Area was 10.39%, and 0% in the Control site, yielding an overall reproductive success rate of 9.82%. A chi-square test showed there were significantly more active burrows from 2011 that remained active in 2012 when compared to expected values ($P<0.0001$, $\chi2= 20.609$, df=1).

Within the Conservation Area, field monitoring of the FAA/Coast Guard communication towers did not identify any bird collisions at the FAA/Coast Guard communication towers during 2012.

Finally, due to conflicting TMK GIS layers and actual boundary metes and bounds, there is a conflict regarding where the actual boundaries of the Conservation Area are situated. A formal survey will need to be conducted to resolve the issue such that fencing can be constructed within the appropriate the unencumbered land designated as the ATST Conservation Area.

INTRODUCTION

The ATST Resource Management Team submits this annual report and has conducted these monitoring efforts in accordance with the ATST Habitat Conservation Plan (HCP) and the Final Biological Opinion (BO) of the US Fish and Wildlife Service (USFWS, 1-2-2011-F-0085).

Background of the ATST Project

The Advanced Technology Solar Telescope (ATST) is funded by the National Science Foundation (NSF) for the construction of the ATST Project within the 18.166-acre University of Hawaiʻi Institute for Astronomy (IfA) Haleakalā High Altitude Observatory (HO) site at the summit of Haleakalā, County of Maui, Hawaiʻi.

The ATST facilities will include a 143-foot (ft) (43.6-meter (m) tall building housing the telescope, an attached support and operations building, and a utility building. As the largest and most capable solar telescope in the world, the ATST will provide researchers with 2.5-mile (mi) (4-kilometer (km) resolution images of the Sun's surface. The primary goals of the ATST Project are to understand solar magnetic activities and variability, both because the Sun serves as a key resource for understanding the underpinnings of astrophysics and our understanding of magnetic plasmas, and because activity on the Sun drives space weather. Space weather creates hazards for communications to and from satellites, as well as for astronauts and air travelers. Furthermore, and perhaps most importantly, the variability in solar energy induced by solar activity affects the Earth's climate. The key to understanding solar variability and its direct impact on the Earth rests with understanding all aspects of solar magnetic fields, which in turn control the fluctuating Sun.

ATST Habitat Conservation Plan/Incidental Take License

The ATST Habitat Conservation Plan (HCP), which was approved by the State of Hawaiʻi Board of Land and Natural Resources (BLNR) in January 2011, addresses anticipated impacts to state and federal threatened, endangered, and listed species from the construction of ATST at HO, pursuant to Chapter 195D, Hawaiʻi Revised Statutes (HRS 195D). Once construction of ATST is complete, the operations of the ATST facility are not expected to result in incidental take of listed species under HRS 195D. The State of Hawaiʻi Board of Land and Natural Resources (BLNR) issued an Incidental Take License (ITL), No. ITL-13, to the NSF on November 30, 2011. The ITL grants permission of take, if such take is incidental to and not the purpose of the carrying out of an otherwise lawful activity, for 35 Hawaiian petrel individuals: 30 fledglings and 5 adults.

FAA/Coastguard Communication Tower Monitoring

Because the ATST facility may interfere with Federal Aviation Administration's (FAA) ground-to-air signal conveyance, NSF, through AURA/NSO, has funded necessary tower upgrades on two of the existing FAA towers located on FAA property adjacent to HO. By agreement between NSF and FAA, the ATST Resources Management Team also monitored the FAA tower site to collect baseline petrel-tower collision information.

Hawaiian Petrels

Status of the Species

The endangered Hawaiian petrel (*Pterodroma sandwichensis*) is a medium-sized seabird in the family Procellariidae (shearwaters, petrels, and fulmars). The Hawaiian petrel formerly was treated as a subspecies of *P. phaeopygia*, with the nominate subspecies occurring in Galapagos (*P. p. phaeopygia*). Based on differences in morphology and vocalization, the two subspecies were reclassified as full species in 1993 (Monroe and Sibley, 1993) and genetic analysis confirmed the split several years later (Browne, et al., 1997).

Listing Status

The Hawaiian petrel was listed as endangered on March 11, 1967 (32 FR 4001).

Historical and Current Distribution and Threats

Hawaiian petrels were abundant and widely distributed in prehistory; their bones have been found in archaeological sites throughout the archipelago (Olson and James, 1982). Introduced avian diseases (Warner, 1968), collection for use as food (Harrison 1990), and introduction of dogs, pigs, cats, rats, and mongoose predators have resulted in substantial declines in the distribution and numbers of this species and has led to small relict colonies of Hawaiian petrels in high-elevation, remote locations. This species has no natural terrestrial predators other than the Hawaiian owl (Pueo, *Asio flammeus sandwichensis*).

Aside from these threats, other significant anthropogenic sources of Hawaiian petrel mortality are light attraction and collision with communications towers, power transmission lines and poles, fences, and other structures (Simons, 1983). The Hawaiian petrels fly over 30 miles/hour (48 km/hour) (Day and Cooper, 1995), which likely reduces the ability to detect obstacles in the dark and avoid them. This problem is likely to be exacerbated by the continuing development and urbanization throughout Hawaiʻi.

Hawaiian petrels are currently known to nest on at least five islands (Simons and Hodges, 1998), but their distribution is limited to high elevation sites where predation pressure is lower. Maui may harbor as much as one quarter of the breeding population and most of Maui's petrels nest along the rim of Haleakalā Crater (Simons and Hodges, 1998) in Haleakalā National Park and in the vicinity of the ATST action area. The most recent estimate of breeding petrel numbers in these areas is roughly 400 to 600 breeding pairs (Simons and Hodges, 1998; Bailey 2006, personal communication).

An accurate estimate of total numbers of Hawaiian petrels is not available; however, estimates range from the thousands to about 34,000 (e.g., Spear, et al., 1995; Ainley, et al., 1995). Spear, et al. (1995) estimated the at-sea population size of adult and sub-adult Hawaiian petrels of 19,000 birds (with a 95 percent confidence interval of 11,000 to 34,000). Ainley, et al. (1997) estimates a breeding population of about 1,600 pairs on Kauaʻi and Ainley (USFWS, unpublished field notes) estimates that there are a few thousand pair occurring on Lanaʻi and 1,500 on Haleakalā. Darcy Hu (2009, personal communication) located 115 active burrows within the Hawaiʻi Volcanoes National Park (HAVO) in 2006. Jay Penniman currently estimates that between 1,000 and 6,000 Hawaiian petrels come to shore each year on all islands (2009, personal communication).

Nesting Habitat

Nesting habitat of Hawaiian petrels on Maui is currently at elevations above 7,200 ft (2,195 m), although historically the species may have nested at lower elevations (USFWS, 1983). The largest known nesting colony of Hawaiian petrels is located in and around the National Park (Simons and Hodges, 1998). Approximately 30 known burrows are located along the southeastern perimeter of HO, several burrows are northwest of HO, and additional burrows have been found northeast of the ATST Project site (NPS, 2003). Hawaiian petrels are present at Haleakalā from February through October and are absent from November through January.

The Hawaiian petrel nests on Haleakalā in high elevation burrows located beneath rock outcrops, along talus slopes or along edges of lava flows where there is suitable soil underlying rock substrate for excavation of tunnels. Hawaiian petrel nesting burrows are located among rock outcrops, under boulders, within the cinder substrate, and along cliff faces. Vegetation is sparse in nesting areas on Haleakalā Crater owing to the high elevation and dry environment; within the ATST Project area, vegetation is predominantly grass (*Deschampsia australis*) and bracken fern (*Pteridium aquilinum*). The rocky substrate is disturbed in the immediate area around the construction site due to previous construction activities.

The majority of known Hawaiian petrel burrows are located along the western rim of the Haleakalā Crater, where this habitat is most abundant and also where predator control is afforded. Using survey efforts from 1990-1996, previous estimates of burrow density, including part of the mitigation area, range from 5 to 15 burrows per ha, compared to 15 to 30 burrows per ha along the western crater rim. Similarly, in 2004 and 2005, Hawaiian petrel passage rates, collected using ornithological radar, were 4 to 7 times greater during summer and fall at the Visitor’s Center (Western rim), when compared to the Haleakalā Observatory complex, suggesting bird numbers are lower on the western slopes encompassing the ATST mitigation site. Importantly, the population trend at Haleakalā is increasing, which suggests that additional recruitment into this site is possible (Holmes, 2010b).

Burrows are excavated to a depth of three to six ft (one to 1.8 m), but sometimes reach a length of 15 ft (4.6 m) or more. Most of the nests on Haleakalā are in rock crevices in sparsely vegetated, xeric habitat (Simons and Hodges, 1998). Birds spend much of their time at sea where they are known to feed on squid, small fish, and crustaceans displaced to the surface by schools of tuna (Larson, 1967; Simons, 1985). Petrels have been recorded in the Philippines (Rabor, et al., 1970), Japan (Nakamura, 1979), the Gulf of Alaska (Bourne, 1965), and off the coast of Oregon and California (Pyle, et al., 1993). Hawaiian petrels have been tracked taking single trips exceeding 6,200 mi (10,000 km) circumnavigating the north Pacific during the nestling stage (Adams, et al., 2006).

Similar to other members of its family, the Hawaiian petrel has a well-defined, highly synchronous nesting season (Simons, 1985), albeit there is clear evidence of intra-island variation in breeding phenology in Hawaiʻi, with Haleakalā breeders initiating, and completing, breeding approximately one month earlier than Kauaʻi, Lanaʻi, and Hawaiʻi Island. Birds arrive in their colonies in late February. After a period of burrow maintenance and social activity they return to sea until late April when egg-laying commences. Non-breeding birds visit the colony from February until late July (Simons and Hodges, 1998). Many of these may be young birds seeking mates and prospecting for nest sites, but some proportion is thought to be mature adults that do not elect to breed.

Non-breeders and failed breeders typically begin leaving the colony once the eggs have hatched. Chicks fledge between late September and late November. Both adults participate in incubating the egg and feeding the chick; after a brief brooding period, both adults are foraging at sea and will have absences from the nest (Simons, 1985). Although adults are occasionally observed to remain after fledglings depart, colonies generally are empty by the end of November. A hiatus of only about three months occurs between the end of one breeding season and the beginning of the next. Hawaiian petrels are thought to begin breeding at about five or six years of age, and roughly 90 percent of breeders attempt to breed each year (Simons and Hodges, 1998). Beginning in mid-February to early March, after a winter absence from Hawaiʻi, breeding and non-breeding birds visit their nests regularly at night, for a period of social activity and burrow maintenance work. Pairs are site tenacious, returning to the same burrow year after year. From mid-March to mid-April, birds visit their burrows briefly at night on several occasions. Then breeding birds return to sea until late April or early May, when they return to lay and incubate their eggs.

Male and female birds alternate incubation attendance. Total incubation period ranges from 45 to 58 days (Simons, 1985). Egg temperature and evaporative water loss are controlled by the incubating adult. Because the metabolism of awake, resting birds is almost twice that of sleeping birds (Simons, 1985), disturbance of incubating birds' sleep could potentially result in more rapid weight loss and an inability of the adult to stay on the egg until its mate relieves it.

During the incubation period, many non-breeding birds also inhabit the colony. Many of these are young birds gaining experience seeking mates and prospecting for nest sites; the remaining portions are experienced breeders that did not elect to breed. Non-breeders and failed breeders typically begin leaving the colony once the eggs have hatched. They continue to visit their burrows at night through early August (Simons, 1985). By September, the only birds visiting the colony are adults returning to feed their chicks (Simons, 1985). Chicks do not appear to require much brooding from their parents. Adults depart from the nest to forage at sea within one to six days after the chick hatches (Simons, 1985). Chicks spend 66 percent of their time alert, resting quietly, 26 percent of their time sleeping, 6 percent of their time preening or stretching, and 2 percent of their time walking around (Simons, 1985). Nocturnal feeding by one parent occurs approximately every other day until the chick is 90 days old. After 90 days, adults appear to continue to feed chicks until the chick refuses food. Chicks fledge between late September and late October, after an average of 111 days after hatching (Simons, 1985). Although adults are occasionally observed to remain after fledglings depart, colonies generally are empty by the end of November.

There are four Hawaiian petrel burrow clusters, and a number of isolated burrows, within approximately 1,250 ft (381 m) of the ATST Project site, totaling approximately 31 individual burrows. Burrow clusters and individual burrows to the west and the northwest of the construction site historically have not been highly used by nesting Hawaiian petrels (Bailey, 2009, personal communication); approximately 5 to 10 burrows (mostly inactive) are 500 to 800 ft (244 m) from the construction site to the west.

Breeding Success

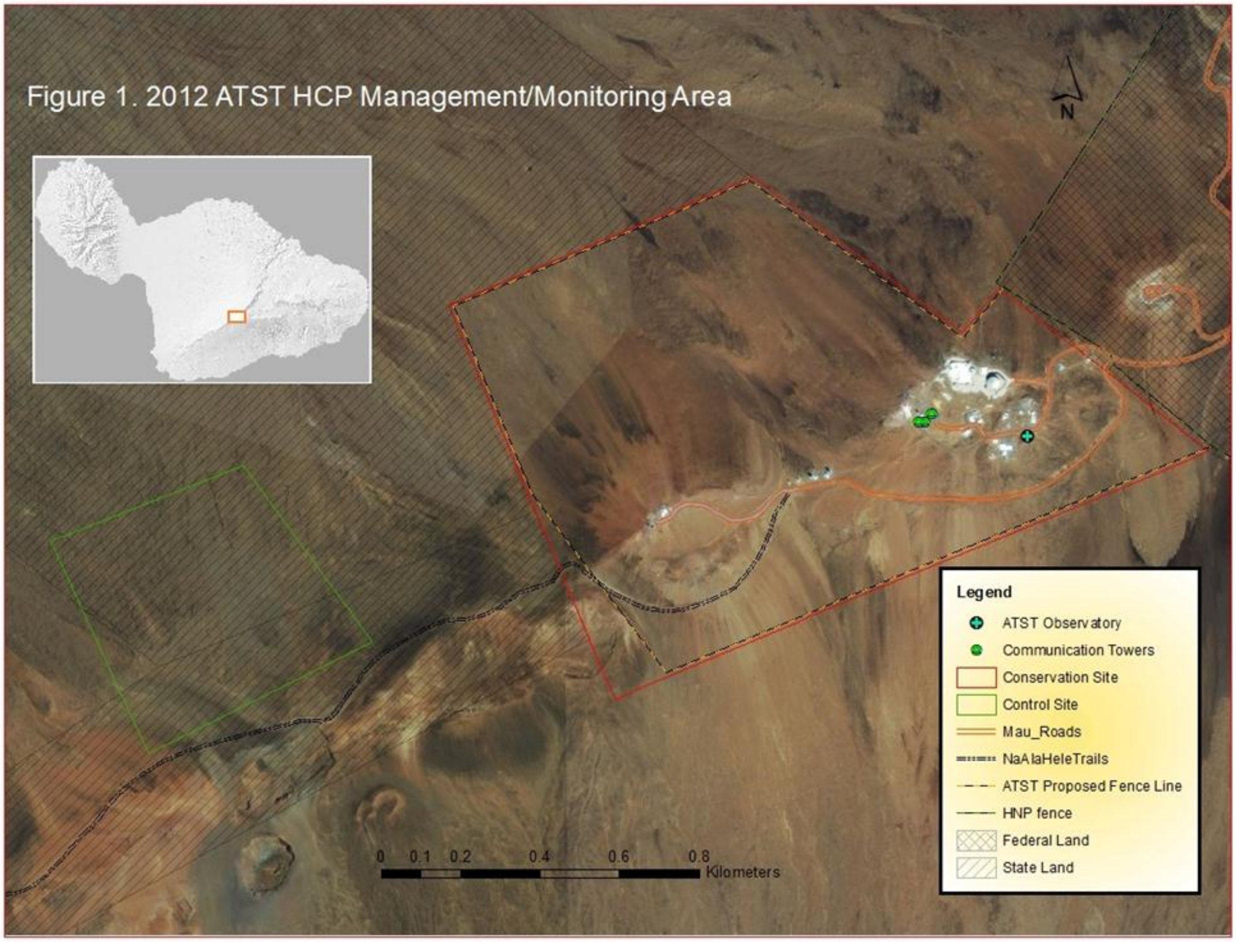
The primary reason for the relatively large numbers of petrels and their successful breeding around Haleakalā summit today is likely due to the fencing and intensive predator control maintained by Haleakalā National Park since about 1982. The petrel's habitat is destroyed or severely compromised by feral ungulates such as goats, and by pigs in wetter and more vegetated environments than the summit of Haleakalā. In addition to collapsing burrows and compacting the substrate, these animals provide vectors for non-native invasive plants that alter the vegetation structure and may hinder the birds' access to traditional nesting areas.

STUDY AREA

The 328 ac (133 hc) ATST HCP Conservation Area includes observatory facilities, broadcast facilities, communication towers, and the portion of Skyline Trail dividing the area from the northeast to southwest. Adjacent lands include the Kula Forest Reserve, Kahikinui Forest Reserve, NPS, DHHL, and private land. The conservation/mitigation site contains a number of cinder cones, of which Puʻu Kolekole is the highest in elevation. This cone is about 0.3 mi (0.5 km) from the highest point on the mountain, Puʻu ʻUlaʻula (Red Hill) Overlook, which is in the Park and outside of the state lands (Figure 1).

The HCP Conservation Area is located between approximately 8,800 to 10,000 ft (2,686 to 3,048 m) in elevation, where snow and hail can occur. The annual average total precipitation on the Haleakalā summit, in the vicinity of the proposed mitigation area, between 1949 and 2005, was 52.92 inches (in) (134 centimeters (cm). At or near the summit, sustained wind speeds of 50 miles per hour are not unusual. The greatest wind speed recorded at the summit is over 125 miles (mi) per hour (201 km per hour). The topography within the conservation site is rugged and barren, and the elevation drops with an average slope greater than 30 percent (ATST 2010). Temperatures at the summit of Haleakalā can range between below freezing to highs of 65°F (18°C, HNP 2011).

In addition to the HCP Conservation Area, a Control Site was selected one kilometer away from the HCP Conservation Area, just north of the Skyline Trail, at an elevation of 8,700 to 9,300 ft. (2652 to 2835 m). This Control Site encompasses 80 acres and will be used to compare and evaluate the ATST's Resource Management Team's conservation efforts within the HCP Conservation Area (Figure 1).



Note: The HCP Conservation Area boundary on the map is based on the State of Hawai'i published TMK GIS layer. The actual metes and bounds on the ground vary from the GIS layer by 12-30 meters.

METHODS

Personnel Training

All current members of the ATST Resource Management Team received extensive training prior to the 2011 nesting season. This training included both field and administrative training. Members were trained on petrel burrow identification, classification of burrow status based on signs of petrel activity, and avoidance of cultural resources during field work. All members were previously trained in the use of GPS and ArcGIS software and all completed First Aid/First Responder and CPR certifications. The Predator Control Technician is certified for Commercial Applicators of Restricted Pesticides.

Petrel Burrow Search

The ATST Resource Management Team (consisting of one to three members) monitored known burrows and searched for new burrows in the HCP Conservation Area from February 22nd to

November 8th, 2012. The team began by visiting all the burrows that were recorded during the 2011 nesting season. Any newly identified burrows were documented as they were discovered. Coordinates of the newly discovered burrows were recorded with handheld Garmin Oregon 450 and 550 GPS units. A systematic search of both the Conservation Area and the Control Site was also conducted using natural landmarks and handheld Garmin Oregon 450 and 550 GPS units to locate and record petrel burrows. Signs of petrel activity (feathers, droppings, egg shells, footprints, regurgitation, smell, and other body parts) and GPS coordinates at each burrow were recorded. Toothpicks were placed vertically along the entrance of each burrow to monitor petrel movement in and out of burrows. Fallen or height-altered toothpicks suggested current activity. Standing toothpicks denoted no activity (Hodges 1994). In addition to mechanical means of monitoring, video cameras were also installed to monitor petrel activities at 18 burrows adjacent to the MEES Observatory.

Breeding success was classified based on signs at the entrance, status of placed toothpicks, and the latest date of activity. Burrows which were classified as “Active” were rechecked weekly until signs of successful or failed fledging were observed. A burrow was defined to be the source of “Successful Fledging” by the presence of petrel chick down feathers at the burrow entrance, and disturbed toothpicks after September 24, 2012. Burrows classified as “Failed” showed signs of activity during initial search, but no further signs were found while conducting the rechecks, which suggested these burrows were either abandoned or the chicks did not reach fledgling age.

FAA Tower Monitoring

An area equal to a seventy-five foot radius of the FAA towers (Figure 1) was delineated. This radius is one and one quarter (1.25) the height of the two FAA towers (60 ft). Due to the close proximity of an additional Coast Guard communications tower which is 100 feet tall, a 125 foot radius around this tower was also searched, since it would be impossible to discriminate the source of collision between these towers in the event a downed bird were to be found

If any collisions were to have occurred, the following information would have been documented: date, time, coordinates, species, photo of the bird in question, and person attending. This information would be included in a report that would be forwarded to the U.S. Fish and Wildlife Service. The carcass would be handled according to the official protocol of the USGS Wildlife Health Center, Honolulu office. Surveys of these towers were conducted from February 1st to November 30th, 2012.

Site Boundary, Conservation Fence Line Surveying/Marking

Using the approved ATST HCP area maps and the Hawaii Government published GIS TMK map as guidance, the ATST Resource Management Team surveyed the Conservation Area and Control Site boundaries with handheld Garmin Oregon 450 and 550 GPS units. The boundaries were marked by tying blue flagging on rocks or branches, or situating white flags on cinder slopes. The resource management team also marked all the archeological sites along the fence/boundary lines with orange flagging, based on the archeological survey done last year (Cochrane 2012). In order to avoid confusion among neighboring landowners, the surveyed fence line was set back at least 30 feet inside the Conservation Area boundary. The team also routed the proposed fence line so that it is at least 10 feet from any petrel burrow and will not block the flight path of petrels traveling in-and out of burrows. The proposed fence line was marked with white flagging. The work has been completed and the fence line plan was approved by USFWS (Figure 1).

Predator Control

Since all monitoring and survey work was done prior to any construction at ATST, no rat traps were set during 2012. However, after examining footage from surveillance cameras, the presence of a feral cat below MEES Observatory was discovered. Camera footage revealed that the feral cat had visited five different burrows and entered at least one. A Havahart trap was set near burrow SC37 just below MEES Observatory on September 13, 2012. Friskies brand cat food was used as bait. The trap was labeled (CT001) along with the GPS coordinates of the trap location.

Data Analysis

For statistical analysis two-tailed probability $\alpha<.05$ was used as the statistical significance level. Since the data analyzed in 2012 was either “count” or “frequency“ data (number of burrows or petrel chicks), Chi-Square Goodness of Fit or Independence tests were employed in this report.

RESULTS

Search Efforts

During 2012, a total of 75 person-days (10 hours per person, per day) were spent monitoring and searching for burrows (old and new) in the HCP Conservation Area, and 12 person-days were spent searching the Control Site.

Burrow Status

A total of 281 Petrel burrows were monitored and documented during 2012 field season within the Conservation Area. Of these burrows, 7 were on or outside the boundary of the Conservation Area; however, since they were less than 3 m from the boundary, these burrows have been included into the data set and will continue to be monitored in the future. Four additional burrows were discovered; however, they were more than 10 meters from the Conservation Area boundary and therefore were not monitored or included in the final data set (Table 1-1).

In the Conservation Area, a total of 259 petrel burrows were previously recorded ("Old") by the National Park, K.C. Environmental biologists, and the ATST Resource Management Team. Among these burrows, 141 were "Active" and 118 were "Not Active" this season. In addition to the previously recorded burrows, 13 new "Active" and nine "Not Active" burrows were discovered and recorded this season inside the HCP Conservation Area. Table 1-1 summarizes the number of new burrows found in 2012 and the success/failure statistics of both new and old burrows.

Table 1-1. 2012 Hawaiian Petrel Burrows and Reproductive Success in ATST HCP Conservation Area on Haleakala, Maui, Hawaii.

Status	New Burrows in HCP Area in 2012	Old Burrows in HCP Area in 2012	TOTAL
Active	**13**	**141**	**154**
Success	0	16	16
Fail	13	125	138
Predation	0	6	6
Unknown	13	118	131
Other	0	1	1
Not Active	**9**	**118**	**127**
TOTAL	**22**	**259**	**281**

In the Control Site, there were 21 previously recorded burrows ("Old"). Among these 21 "Old" burrows, 6 were "Active" and 15 were "Not Active" in 2012. Four "New" burrows were identified this season, of which 3 were classified as "Active" and 1 was "Not Active". Table 1-2 summarizes the new burrows identified in the Control Site in 2012 along with success/failure statistics of old and new burrows.

Table 1-2. 2012 Hawaiian Petrel Burrows and Reproductive Success in ATST HCP Control Site on Haleakala, Maui, Hawaii.

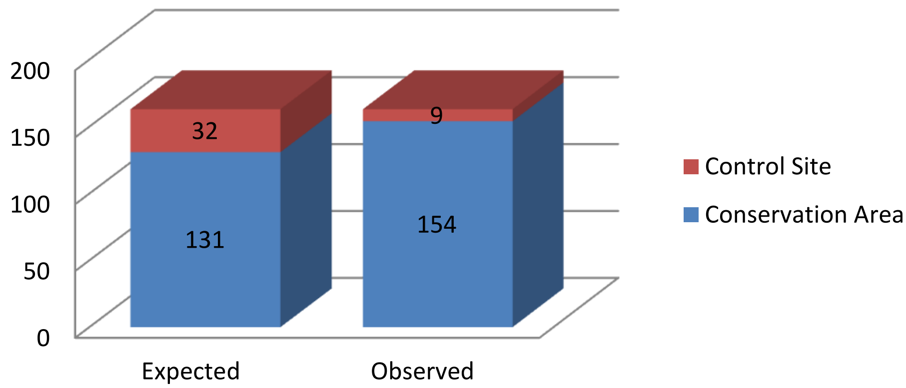
Status	New Burrows in Control Site in 2012	Old Burrows in Control Site in 2012	TOTAL
Active	**3**	**6**	**9**
Success	0	0	0
Fail	3	6	9
Predation	0	1	1
Unknown	3	5	8
Other	0	0	0
Not Active	**1**	**15**	**16**
TOTAL	**4**	**21**	**25**

Based on the proportion of the land area at both the Conservation Area and Control Site (328 ac vs. 80 ac), 131 active burrows in the Conservation Area and 32 active burrows in the Control Site were expected, while 154 and 9 active burrows were recorded within the Conservation Area and Control Site (Figure 2). A Chi-square "Goodness of Fit" test was employed to examine whether the numbers of active burrows were statistically different from expected numbers in proportion to the area in both sites. The test result showed that the number of active burrows in the Conservation Area was significantly higher than at the Control Site (Figure 3, $P<0.0001$, $\chi^2= 20.569$, df=1), when compared to expected numbers of burrows.

[redacted]

When compared with 2011 data, there was a decrease in the number of active burrows in the Conservation Area, from 168 to 154, and in the Control Site from 13 to 9.

Figure 3. 2012 Expected And Observed Number of Active Hawaiian Petrel Burrows in ATST HCP Conservation Area and Control Site



Mortality

In 2012, a total of 7 known Hawaiian Petrel mortalities were recorded; 6 in the ATST HCP Conservation Area and 1 in the designated Control Site (Table 2). Among the known mortalities, invasive mammal predation is the primary cause (n=6, 85.71%). Other causes of mortality included adult petrels that rolled their eggs out of the burrow (n=1). One known predator that killed an adult Hawaiian petrel was a feral cat (indicated by fresh cat footprints inside a burrow in the Control Site).

Table 2. 2012 Hawaiian Petrel Mortality Events in ATST HCP Encompassed Area

	HCP Area	Control Site
Egg	2	0
Chick	1	0
Adult	3	1
TOTAL	6	1

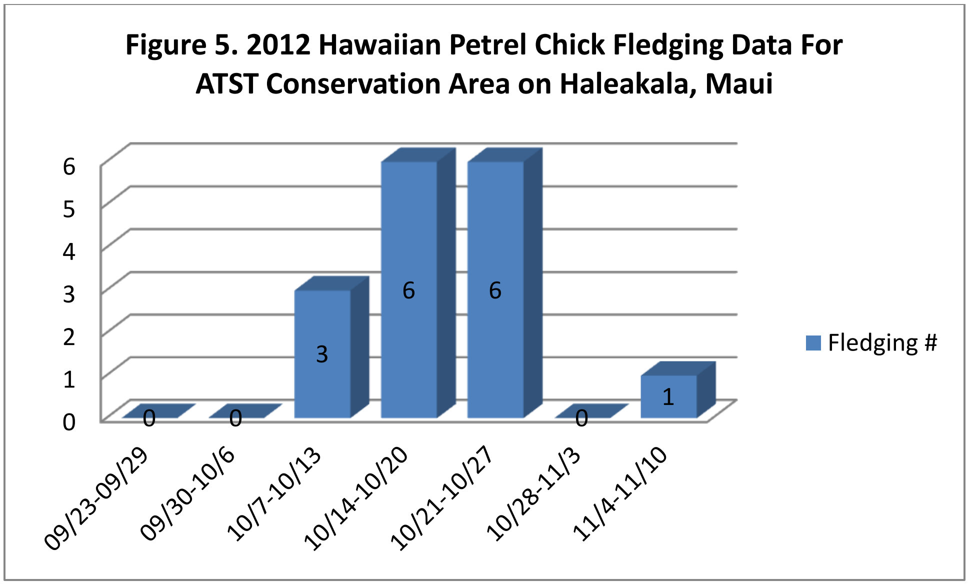
A feral cat was trapped near the ATST construction site on September 18, 2012. This cat was also videotaped at five different burrows between September 10 and September 11, 2012. Three of these burrows each successfully fledged a chick. The adults of one burrow had stopped coming back long before the cat arrived (July 30, 2012). Although no actual predation image was captured on video, no petrel chick was recorded at the last burrow, even though the adults continued to return until September 22, 2012. This cat may also have caused several nest failures at burrows that were without video surveillance this year (Figure 4).

Figure 4. Images of Feral Cat Via Video Monitoring at Hawaiian Petrel Burrow Entrances In ATST HCP Conservation Site.

Due to the small sample size observed this year, further statistical analysis regarding Hawaiian Petrel mortality was not conducted this year.

Fledgling Data

In 2012, Hawaiian Petrel chicks were recorded to begin fledging from their burrows beginning in the first week of October. The second and third week of October showed the highest number of fledged chicks. By the end of the first week of November, all chicks had already fledged and left the breeding colony (Figure 5).



Only six of the 18 burrows that had cameras installed recorded any petrel chick activities after September 15, 2012. Based on the video recordings at the six active burrows around MEES Observatory, the earliest time petrel chicks first emerged from their burrows to exercise their wings was recorded on September 19, 2012 and the latest was on October 12, 2012. The earliest fledging date was on October 12, 2012 and the latest date was on October 19, 2012. The average days between petrel chicks' first emergence and fledging was 18.2 days (7-26 days, SD=6.15).

Among the 18 camera monitored burrows, the adults of seven burrows were last seen between July 25, 2012 and August 10, 2012. These petrels may be the ones that attempted to breed, but did not successfully lay eggs.

Adults of the other five failed burrows stopped returning between September 6, 2012 and September 26, 2012. These adults may have produced eggs or hatched chicks; however, if they did, the chicks did not reach fledgling age for unknown causes. Images of one cat were captured at one of these burrows.

The adults of the successful burrows stopped returning to their burrows between September 25, 2012 and October 3, 2012. The average days between the adults' last visit and the chicks' first emergence was -1.2 days (-11 to 11 days, SD=7.25). In other words, one adult's last return to the burrows was 11 days prior to its chicks' first emergence from the burrow and one adult's last return to the burrows was 11 days after its chicks' first emergence from the burrow, while the others fell in between.

The average days between the adults' last return and the chicks' fledge date was 16.5 days (15-18 days, SD=1.26).

Breeding Success

Based on the number of active burrows and number of active burrows that had a chick that survived until their fledgling date, the breeding success rate for Hawaiian Petrel in the Conservation Area was 10.39%. The breeding success rate for petrels in the Control Site was 0% (Table 1-2). The overall reproductive success for both the 328 acre Conservation Area and the 80 acre Control Site is 9.82%. It is interesting to note that all 16 successful burrows this season were located above 9,600 feet, and all of these successful burrows were "old" burrows (Figure 2).

Due to zero successful burrows in the Control Site, it was not possible to employ the Chi-square "Independence" test to determine if the breeding success rates of Hawaiian Petrel in the Conservation site and Control sites were statistically different.

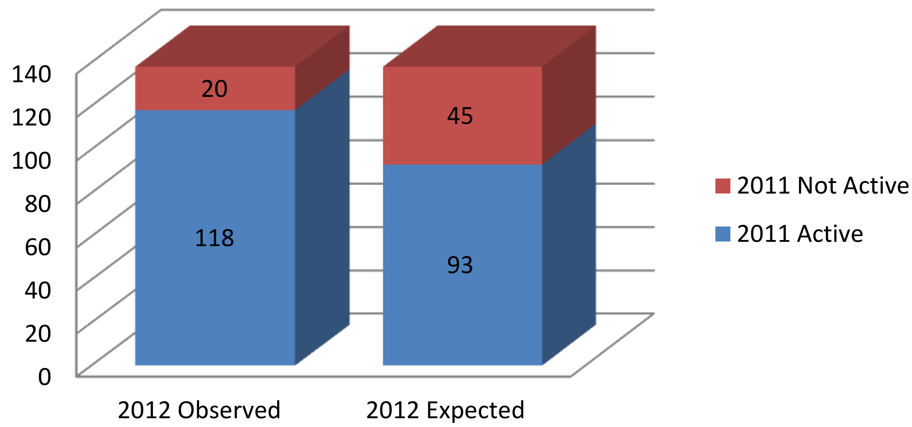
It could not be determined if 2011 and 2012 Hawaiian Petrel nesting success rates were significantly different, due to the "possible success" burrows recorded in2011.

Change of Hawaiian Petrel Burrow Status Between Years

Of the 164 burrows that were "Active" during 2011 inside the HCP Conservation Area, 118 were "Active", 45 were "Not Active" and 1 became a part of an adjacent active burrow in 2012. There were 20 burrows that became "Active" in 2012 that were "Not Active" in 2011, and 2 that were classified as "Not a Burrow" in 2011 that became "Active" this year (Table 3-1).

Based on the proportion of burrow status in 2011, it was anticipated there would be 93 "Active" burrows and 45 "Not Active" burrows in 2012. Instead, 118 "Active" burrows and 20 "Not Active" burrows were observed during 2012. A Chi-square "Goodness of Fit" test was employed to examine whether the numbers of 2012 old active burrows were statistically different from expected numbers in the proportion of burrow status in 2011. The test results showed that significantly more 2011 active burrows remained active in 2012. (Figure 6, $P<0.0001$, $\chi 2= 20.609$, df=1), when compared to expected numbers.

Figure 6. Status of 2012 Old Active Hawaiian Petrel Burrows in 2011



Of the "Successful" burrows from 2011, only 9 were successful this year, 15 failed, and 2 were "Not Active" within the HCP Conservation Area in 2012. There were 6 burrows that failed in 2011 but were successful in 2012. Four burrows that were marked "Possible Success" in 2011 failed in 2012 and 4 burrows marked "Possible Success" in 2011 were "Not Active" this year (Table 3-1).

Based on the numbers in Table 3-1, it appears that proportionally more 2012 successful burrows were also successful burrows in 2011. An attempt was made to test whether a higher proportion of successful burrows in 2012 were successful in 2011 by using the Chi-square "Goodness of Fit". However, due to the small sample size, the expected numbers could not be rounded up to integers and two-thirds of the expected numbers were less than 5, thus this test was not statistically valid.

Table 3-1. Result Comparisons for Hawaiian Petrel Nest Success in ATST Conservation Area in 2011 and 2012

2011	2012	#
	ACTIVITY	
Active	Active	118
Active	Not Active	45
Not Active	Not Active	59
Not Active	Active	20
Not Active	Not a Burrow	1
Not a Burrow	Active	2
Not a Burrow	Not Active	1
	SUCCESS	
Success	Success	9
Success	Fail	15
Possible Success	Fail	4
Fail	Success	6
Fail	Fail	84
Not Active	Fail	19
Not Active	Success	1
Not a Burrow	Fail	2
Possible Success	Not Active	4
Fail	Not Active	39
Success	Not Active	2

Once again, no burrows were successful at producing fledglings this year within the designated Control Site. Of the “Active” burrows from 2011, 5 remained “Active” in 2012, and 9 were “Not Active”. One burrow which was “Not Active” in 2011 was “Active” in 2012, but still failed to produce a chick that was able to fledge at the end of the nesting season. The sample size was small after the burrows were designated into different categories, so no further analysis was done.

Table 3-2. Result Comparisons for Hawaiian Petrel Nest Success in ATST Control Site in 2011 and 2012

2011	2012	#
ACTIVITY		
Active	Active	5
Active	Not Active	9
Not Active	Not Active	6
Not Active	Active	1
TOTAL		**21**
SUCCESS		
Fail	Fail	5
Not Active	Fail	1
Fail	Not Active	9
Not Active	Not Active	6
TOTAL		**21**

*New burrows recorded in 2012 not included

FAA Tower Monitoring

The FAA towers were monitored for a total of 304 days, from February 1, 2012 to November 30, 2012. No bird collisions were recorded during this period.

The FAA began upgrading their towers/antennas on September 18, 2012. The upgrade was completed and all equipment removed from the site by October 8, 2012. There were no detectable changes in Hawaiian petrel collision patterns during this time.

Site Boundary, Conservation Fence Line Surveying/Marking

The ATST Resource Management Team spent 34 person-days surveying/marking the boundaries and fence line and marking the archeological features. The fence line was planned so that it would not intercept any archeological features or Hawaiian Petrel burrows. The ATST Resource Management Team was only able to identify three metes and bounds markers, with two of those being 12-30 meters off the TMK GIS layer location. No other metes and bounds could be located.

After careful examination and discussion, it was decided that the fence line should be moved closer to the actual approved HCP Conservation Area boundary. Instead of building the fence 30 feet from the boundary, the fence line is now 5 ft from the boundary. When the fence is built, more burrows near the boundary's edge will be included into the managed area, thereby benefiting from future predator control efforts.

The southern-most boundary of the Conservation Area is still in dispute, since there is some discrepancy between the field GPS readings, the TMK map boundaries for unencumbered lands, and independently obtained GIS coordinates. DOFAW is working to resolve the metes and bounds for the terminal boundaries between the unencumbered State land that constitutes the ATST Conservation Area and DHHL Kahikinui Forest Reserve lands (Figure 1). This needs to be accomplished before a more specific fence plan can be established and implemented.

Other Species of Concern

In addition to the seven endangered Haleakalā silversword (*Argyroxiphium sandwicense* subsp. *macrocephalum*) plants that were discovered at the southwest corner in 2011, three more Haleakalā silversword seedlings were discovered in 2012 below the Skyline Trail. However, one of the additional plants was located outside the proposed fence boundary (Figure 2).

Predator Control

A juvenile female cat was caught in trap CT001 on September 18, 2012 (which was five days after the trap was set) (Figure 7). Within those five days, the trap had been checked twice. The cat was alive but in a state of stress. The trap was removed from the field and transported to the local Humane Society where the feral cat was dropped off. This was used as a trial run to test the capabilities of the trap and therefore, the trap was not reset. By the request of the U.S. Fish and Wildlife Service (USFWS), any future animals caught in traps within the Conservation site will not be taken to the Humane Society. Instead, they will be euthanized on site in accordance with the standards set by USFWS.

Figure 7. Feral Cat Trapped By ATST Resource Management Team at Haleakala Observatory.

DISCUSSION

The exact burrow counts were based on previous National Park records and the best assumptions by the ATST Resource Management Team regarding what constitutes an active or previously active petrel burrow. Some burrows may have multiple entrances inside the main entrance. There are also burrow entrances that were so close to each other that it was difficult to discriminate between one pair using multiple entrances or multiple pairs using a communal main entrance. In this report, the number of active burrows recorded provides an estimated population size of Hawaiian Petrel breeding pairs based on direct observations in the field.

The data presented did not include any "possible success" burrows this season because monitoring efforts began earlier than 2011, which allowed the staff to check the burrows more frequently. The ATST Resource Management Team was also better able to determine which burrows were successful this season based on past experience in the field, which eliminated any questionable results for this nesting season.

Both video cameras and toothpick approaches were applied to verify petrel reproductive success this season, similar to the approaches applied by Hodges (1994). The video camera demonstrated that it could validate a successful fledging event more accurately and record the exact timing of fledging and other petrel events than the toothpick method. Since the video cameras were connected to cables, the disadvantage of video cameras is that they were limited by the distance to the recording instruments. Burrows outside of the immediate vicinity of the MEES Observatory building (where the recorder was housed) could not be monitored by video cameras. A future alternative to wired video cameras to monitor petrel reproductive success is to employ the more portable game camera traps at cable-inaccessible burrows that are still active at the beginning of the fledging period (mid-September). Two different camera trap models have been purchased and the capacity of both models will be tested during December, 2012. Once the test results are determined, 40 units will be purchased and employed for next season.

During the 2012 field season field work confirmed that the Control Site had significantly fewer active burrows than the Conservation Area. Although the reproductive success was not significantly different between years, it remained at 0% in the Control Site this season. This result is similar to the findings for the 2011 season.

All successful nests were located above 9,600 ft. this year in Conservation Area. This phenomenon may be due to a high predation rate in the lower elevation area again (Chen et al. 2011).

This year the staff recorded a nest failure likely caused by less- experienced adult petrels (first time breeders). They may have pushed their eggs outside the burrows if they excavated the burrow at the wrong angle, or if they were clumsy (Bailey personal communication).

The reduction of active Hawaiian Petrel burrows and reproductive success in both the Conservation Area and Control Site, although inappropriate for statistical tests, is an alarming sign. We found that 44 % of the mortality recorded in the last two seasons was high reproductive potential adults and 74 % of mortality was caused by predation. The start of construction between the 2012 and 2013 nesting seasons will result in full implementation of HCP mitigation measures for the upcoming nesting season.

It should be noted here that due to actual petrel burrow structure and depth in the Conservation Area, and to reduce disturbance to the petrels, the reproductive success statistics presented in this report are prepared differently from Simons and Hodges (1998) in that the number of active burrows was used instead of the number of burrows containing eggs as the denominator in the calculation. The rate is expected to be lower than reported by Simons and Hodges (1998), because pairs that attempted to breed but failed to produce eggs were also included. The percentage of pairs that laid eggs vs. total breeding attempts for Hawaiian petrels at the summit of Haleakalā is not available at this time, as it was not possible to estimate the difference.

Burrows that have been classified as “Not a Burrow” will continue to be monitored each year. As the results demonstrate, it is possible that a bird may attempt to dig a burrow without succeeding, which leads to it being classified as “Not a Burrow.” However, it has been observed that in following years, it may become utilized by other birds who are successful at creating a burrow at that same location causing it to become “Active”. Also, burrows that were once “Active” may collapse or become damaged, which would be the reason a burrow could be later classified as “Not a Burrow”.

Our data also showed that significantly more active petrel burrows would remain active in the following year. Simons (1985) reported high burrow fidelity among Hawaiian petrels and noted that petrels of currently active burrows were likely individuals from previous years.

All 16 successful burrows in 2012 were also successful in 2011. This result demonstrated that younger birds might have lower reproductive potential than older, experienced individuals. Increasing the adult survival rate is the ATST’s Resource Management Team’s highest conservation priority.

There were no bird collisions discovered at the FAA tower site this field season. This may be due to the petrels’ nocturnal behavior pattern of traveling in and out of the breeding colony (Simons and Hodges, 1998), navigating well in the dark. Also, birds of the order Procellariiformes generally have long lifespans of up to 35+ years (Simons 1984). Thus, breeding petrels may have very good knowledge of the surrounding area, allowing them to avoid collision with existing obstacles.

FUTURE MONITORING AND MANAGEMENT

Based on findings this season, intensive predator/rodent control and an ungulate fencing/eradication program will be highly beneficial to the reproductive success of the Petrel in the study area. These are to be implemented during the 2013 nesting season.

In order to have more accurate estimates of petrel reproductive success rates, the monitoring should start no later than mid-September (the early petrel fledgling period), and camera traps will be employed at burrows that are still active after mid-September and are outside of the video camera grid.

For monitoring the population trends of the invasive predators and ungulates and the effects of future predator control and ungulate eradication in the HCP Conservation Area, camera trap monitoring grids will be implemented in both the Conservation Area and Control Site.

The ATST Resource Management Team has submitted a permanent rodent control proposal to the USFWS and is currently awaiting their approval. At least one of the members of the ATST staff has already received certification for commercial applicators of restricted pesticide.

It is important to continue monitoring all burrows recorded, including those that may have been marked "Not a Burrow" in previous years. There were two burrows this year that were "Active" that were marked "Not a Burrow" last season.

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