# Daniel K. Inouye Solar Telescope (DKIST)
# Habitat Conservation Plan and Biological Opinion 2017 Fiscal Year Report

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## I. INTRODUCTION

This fiscal year report to the State of Hawai`i is being submitted by the Daniel K. Inouye Solar Telescope (DKIST) Resource Management Team, in accordance with the DKIST Habitat Conservation Plan (HCP) and the Final Biological Opinion (BO) of the U.S. Fish and Wildlife Service (USFWS, 1-2-2011-F-0085). The purpose of this report is to provide the collaborative primary agencies with an update on the progress and compliance of the project, as well as to summarize results of mitigation and monitoring activities being implemented for the DKIST project.

## II. SUMMARY OF DKIST HCP/BO ACCOMPLISHMENTS

DKIST began the Hawaiian Petrel monitoring tasks in accordance with the State of Hawaii HCP and USFWS BO in early 2011, nearly two years prior to the actual construction start date in December of 2012. The project has been in compliance with State of Hawaii HCP and USFWS BO requirements from 2013 through June of 2017 (IV).

The data shows that to-date DKIST has had no measurable adverse impacts on the Hawaiian Petrel population, and that the implementation of the mitigation measures prescribed in the HCP and BO has benefited the Hawaiian Petrel population in DKIST's Conservation Area, both in terms of increased productivity and reduced predation rates. The fencing and outplanting of Haleakalā Silversword seedlings has facilitated the Haleakalā Silversword recovery process.

- 306 Haleakalā Silversword seedlings were planted on December 8, 2015 (section IVA, pp 4)
- No damage to burrows was detected during inspections following the 2015- early 2017 breeding seasons. (section IV B, pp 5).
- No ungulate populations have reestablished inside the fenced Conservation Area since September 12, 2013, shortly after construction of the fence began. (section IVD, pp 7-8 and section IVG-i, Table 4, pp 12-13).
- A total of 155 rodents have been removed by long-term rodent control grid traps (section IV F-ii, Table 3 a, pp 10-12).
- Based on additional rodent population monitoring results, the long-term rodent control grid has further reduced the rodent population in the Conservation Area to 3.13% of the Control site level (section IVG-ii, Figure 6, pp 13-14).
- The noise and vibration monitoring results show that construction activities have never exceeded authorized thresholds (section IV H, pp 14-15).

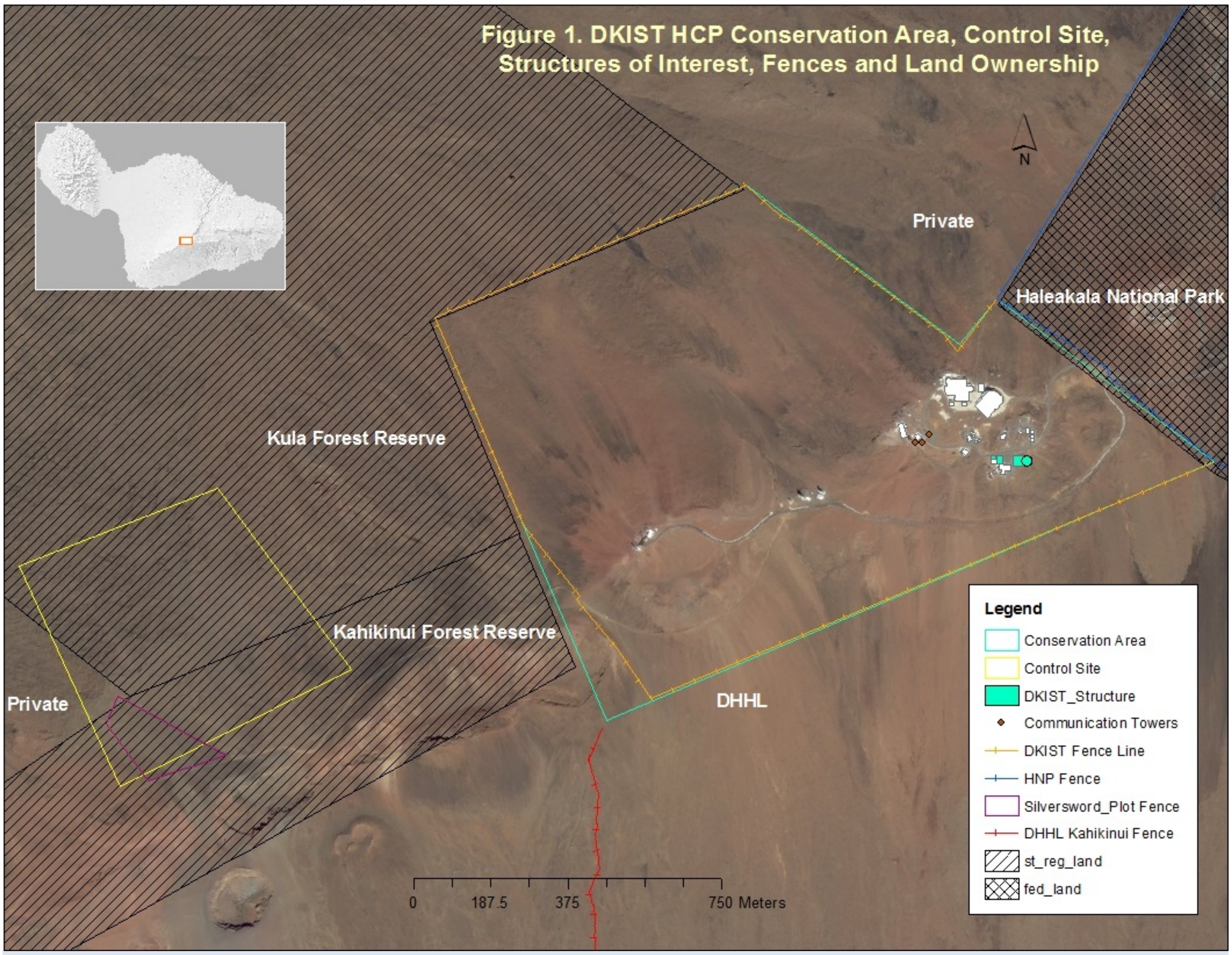
- No petrel collisions were recorded during all the monitoring periods from 2011 to June 30, 2017 at the DKIST construction site (Area A & B), the FAA/Coast Guard towers, or along the conservation fence. (section IV K, pp 16-18).
- A significant ($\chi 2 = 9.324$, $P<0.05$, df=1) increase of 75.4% in "Nesting Success %" has been observed since the conservation measures were implemented in the Conservation Area. (section VI B, Table 5, Figure 10, pp 20-23).
- The Hawaiian Petrel productivity in the Conservation Area increased by 62.7% (69.4% if 2013 is not included) after the HCP was fully implemented (section VI B, Table 5, pp 20-21, Figure 11, pp 23-26).
- DKIST HCP/BO mitigation measures have facilitated Hawaiian Petrel fledging by an average of 16.7 more successful fledglings annually, or by a total of 50 more successful fledglings) from 2014 to 2016 (section VI B, Table 5, pp 20-21, Figure 11, pp 23-26).
- DKIST predator/ungulate control measures have reduced expected annual predation events after 2013 by an average of 90.5% of the (section VI C, Table 6, pp 26).
- DKIST HCP/BO measures have reduced the number of eggs, chicks and adults lost due to predation by 1.5 eggs, 3.2 chicks and 1.3 adults annually, or saving a total of 4.5 eggs, 9.5 chicks and 4 adult petrels from predation between 2014 and 2016 (section VI C, Table 6, pp 26-27).
- It appears that DKIST construction activities have not deterred new petrels from coming to breed and nest in areas adjacent to the DKIST construction site, nor has it reduced the reproductive success of the petrels. (section VI D, Figure 16, pp 28).
- The fledging timing pattern has been similar to that of Haleakalā National Park (HNP) data throughout the monitoring period, indicating that construction has not had an impact on the nesting cycle. (section VI E, Figure 17, pp 30-31).

## III. THE DKIST HCP CONSERVATION AREA AND CONTROL SITE

The DKIST HCP requires the establishment of a Conservation Area to mitigate the potential negative effects related to construction of the DKIST facility. In addition, the HCP also specifies the need to establish a Control Site to compare and evaluate the DKIST Resource Management Team's conservation efforts within the HCP Conservation Area. Both of these areas have been established and maintained since 2011. The Conservation Area, Control Site and other features are shown in Figure 1.

The Conservation Area is located between approximately 8,800 and 10,000 ft. (2,686 to 3,048 m) in elevation, and includes observatory facilities, broadcast facilities, communication towers, and the portion of Skyline Trail dividing the area from the northeast to the southwest. Adjacent lands include the Kula Forest Reserve, Kahikinui Forest Reserve, National Park Service (NPS), Department of Hawaiian Home Lands (DHHL), and private land. The Conservation Area contains a number of cinder cones, of which Puʻu Kolekole is the highest in elevation. Pu'u Kolekole is about 0.3 mi (0.5 km) from the highest point on the mountain; Puʻu ʻUlaʻula (Red Hill) Overlook, which is inside the Park but outside of state land (Figure 1). Based on the State of Hawaiʻi website published TMK GIS layer, the Conservation Area was estimated to be 328 acres (133 ha). However, after the ground survey using existing metes and bounds was completed, it was determined the area covers an area of 321.79 acres (130.22 ha). The topography within the Conservation Area is rugged and barren, and the elevation drops with an average slope greater than 30 percent (DKIST 2010).

The Control Site (Figure 1) encompasses 80 acres and is one kilometer west of the west boundary of the Conservation Area, just north of the Skyline Trail, at an elevation of 8,700 to 9,300 ft. (2652 to 2835 m). The topography within the Control Site is similar to that of the Conservation Area.




**Note: The ground-truth DKIST HCP Conservation Area boundary on the map is different from the State of Hawaiʻi website published TMK GIS layer. The actual metes and bounds on the ground may vary from the GIS layer up to 33 meters.**

## IV. DKIST HCP AND BO COMPLIANCE

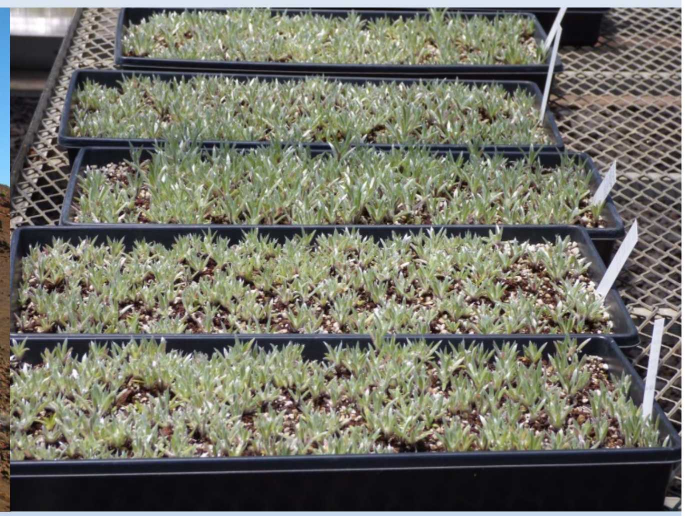
The DKIST Resource Management team continues to meet or exceed compliance with HCP and BO required mitigation measures. Following is a summary in regressing chronological order highlighting compliance activities.

### *IV A. Silversword Seed Propagation and Outplanting: November 2014-December 2015*

Eight hundred seeds from four flowering Haleakalā Silversword (A.K.A. 'ahinahina, *Argyroxiphium sandwicense subsp. macrocephalum*) plants within the DKIST Conservation Area were collected on November 18, 2014 by the subcontractors Starr Environmental, under DLNR permit. The seeds were turned over to Haleakalā National Park (HNP) for propagation. In compliance with the HCP, the DKIST Resource Management team carefully checked the source area during its June 2015 monitoring for natural regeneration from the Silversword seed bank in the area from which the seeds were collected. The resource management team could not locate any seedlings during its June and August 2015 monitoring, and therefore outplanting was initiated to add to the local population. In total, **306 seedlings were planted on December 8, 2015** by Starr Environmental, the DKIST Resource Management team and an HNP employee. Each plant was tagged, foliage crown width was measured and GPS coordinates were also recorded. As of November 2016, 258 of the 306 (84.3%) outplanted seedlings survived the first year. Annual survival and growth monitoring will be conducted during the next few years (Starr and Starr 2016, Figure 2).

**Figure 2. Silversword outplanting in the winter of 2015 in the area where seeds were collected in the winter of 2014.**

**Silversword seed collection (DKIST in background)**



**Silversword propagation**

**Silversword outplanting**

**Silversword outplanting**

*IV B. Monitoring Burrow Structures in the Impact Area: February 2015*

In 2015, KC Environmental, Inc. (KCE) developed a new burrow scope with a remote directional control capacity to maneuver more easily in burrows during inspection. The burrow scope is only used during the non-breeding season to avoid risk of burrow damage. After an initial test period in 2015, routine monitoring for potential impact due to vibration and ground disturbance to burrow structures adjacent to the DKIST construction site was implemented. **No damage to burrows was detected during inspections following the 2015-early 2017 breeding seasons.**

*IV C. Carcass Removal Trials (CARE): Ongoing Since September 2013*

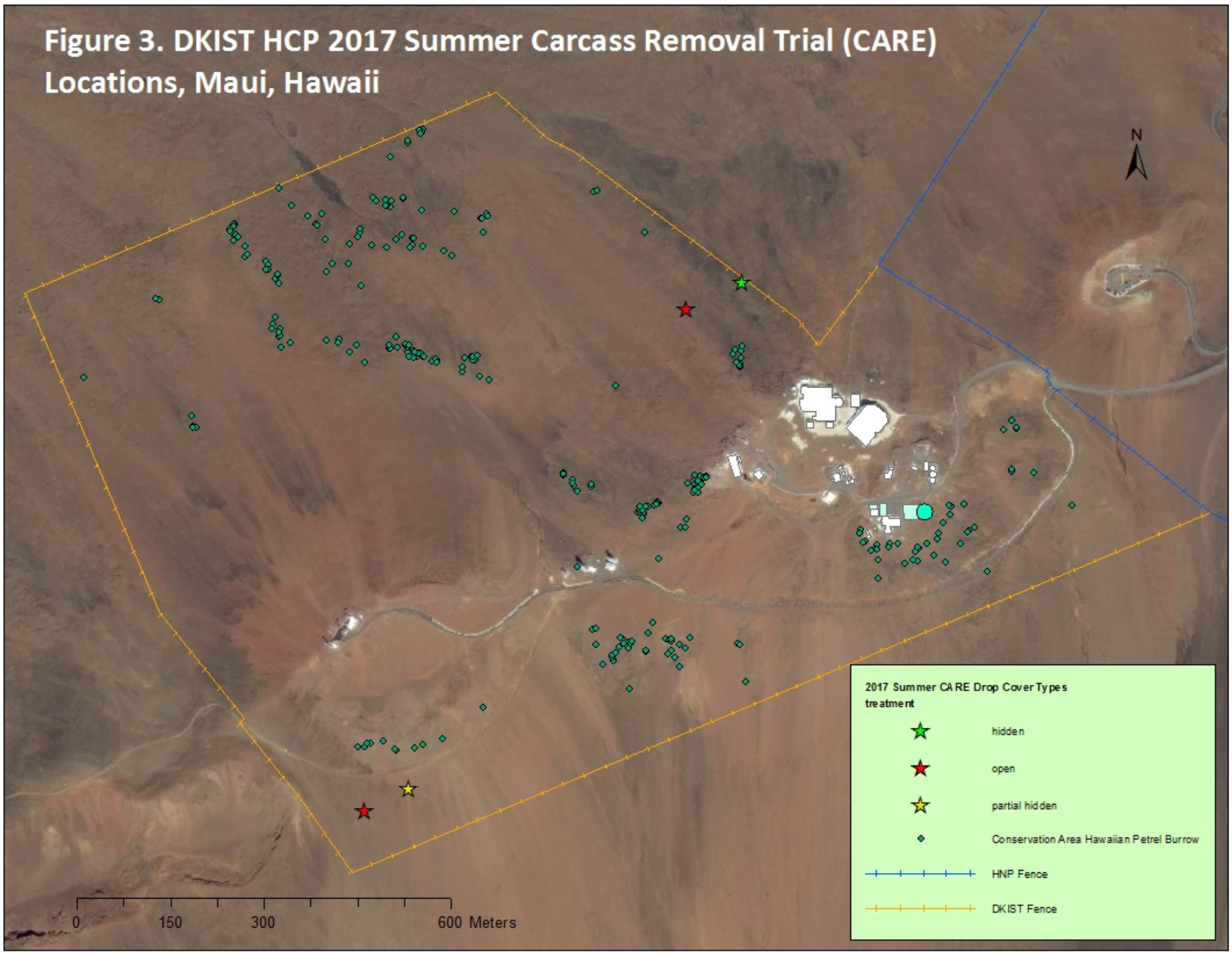



Figure 3. DKIST HCP 2017 Summer Carcass Removal Trial (CARE) Locations, Maui, Hawaii

Carcass Removal Trials are undertaken to determine the scavenging rate by cats, rats, mongoose or other scavengers of birds that may have been killed due to collisions with project structures. Pursuant to the adaptive management changes approved by DOFAW and USFWS for the HCP and BO on July 29, 2014, two CARE trials are to be conducted each year during the remainder of the 6 year construction period. These trials are to be conducted by a third party contractor and the information will be used to guide search intervals for monitoring petrel mortalities that may result from collision with project structures at the DKIST site.

CARE trials have been conducted by KCE since the fall of 2013. Trials are conducted in locations within the DKIST Conservation Area that are approved by USFWS and DOFAW and that are at least 50 meters from a Hawaiian Petrel burrow and 30 meters from baited traps. Figure 3 is an example of surrogate bird placements (from the 2017 summer trial). Four surrogate birds (Wedge Tailed Shearwater, *Ardenna pacificus,* which is morphologically and taxonomically similar to Hawaiian Petrel) carcasses were placed in a variety of positions, including two that were exposed (thrown), one that was hidden to simulate a crippled bird, and one that was partially hidden in each trial.

The results of the CARE trials conducted through the summer of 2017 are presented in Table 1. In trials since 2013, only two birds have been partially scavenged, and even during an extended 60-day trial in the summer of 2014, all four trial carcasses remained intact after the full 60 days. The 2013 fall scavenge event occurred in a partially concealed location within two weeks of placement, with only feathers left behind, while the 2015 summer scavenge event was in a concealed location within two weeks of placement, with a partially dismembered carcass remaining. The overall scavenge rate was 5% (based on ten 30-day trial periods (if the extended trial is counted as two trials) with four birds in each trial, in which two of the 40 total carcasses were scavenged. Most importantly, the rate of total carcass removal has been zero as of summer 2017.

**Table 1. The Outcome of DKIST HCP Carcass Removal Trial Fall of 2013 - Spring of 2016**

| Year | Season | Period (days) | # Birds Scavenged | % Birds Scavenged | % Birds Removed | Remarks |
|---|---|---|---|---|---|---|
| 2013 | Fall | 30 | 1 | 25 | 0 | Remains still detectable at the end of the trial |
| 2014 | Spring | 30 | 0 | 0 | 0 | |
| | Summer/fall | 60 | 0 | 0 | 0 | Extended trial |
| 2015 | Spring | 30 | 0 | 0 | 0 | |
| | Summer | 30 | 1 | 25 | 0 | Remains still detectable at the end of the trial |
| 2016 | Spring | 30 | 0 | 0 | 0 | |
| | Summer | 30 | 0 | 0 | 0 | |
| 2017 | Spring | 30 | 0 | 0 | 0 | |
| | Summer | 30 | 0 | 0 | 0 | |
| **Summary** | | 300 | 2 | 5 | 0 | Based on 10 30-day trial periods |

The results of the CARE trials are consistent with the experience of the DKIST Resource Management team, who has found Hawaiian Petrel carcass remains in the Conservation Area which were often more than a year old, in that Hawaiian Petrel carcasses are rarely totally removed. The CARE trials show further evidence that scavenging rates at these higher altitudes is extremely low. After nine such trials (ten, if the extended trial is considered as two trials), only two surrogate birds showed any sign of scavenging.

The results of CARE trials, corroborating empirical data and knowledge of constraints associated with high alpine xeric ecosystems all continue to suggest that the 10% carcass removal rate used in the calculation of unobserved take for DKIST may be overestimated. Almost all carcasses that were within the search area for DKIST were recorded, because the carcass scavenging rate is very low, and even the rare carcass scavenging that takes place does not seem to remove all evidence of bird mortality for as long as a year or more. The longevity of carcasses in the field also indicates that searches for downed birds at the elevations of the Conservation Area may not have to be as frequent as thought before evidence from these CARE trials and empirical data became available. (Fein and Allan 2013b, 2014b, 2014c, 2015b, 2015c, 2016b, 2016c, 2017b, 2017c.). Based on this information, DOFAW and USFWS have modified the requirements for search frequency, which is discussed in more detail in section IV M, Birdstrike Monitoring.

### *IV D. Conservation Fence and Ungulate Eradication: <u>July 2013</u>*

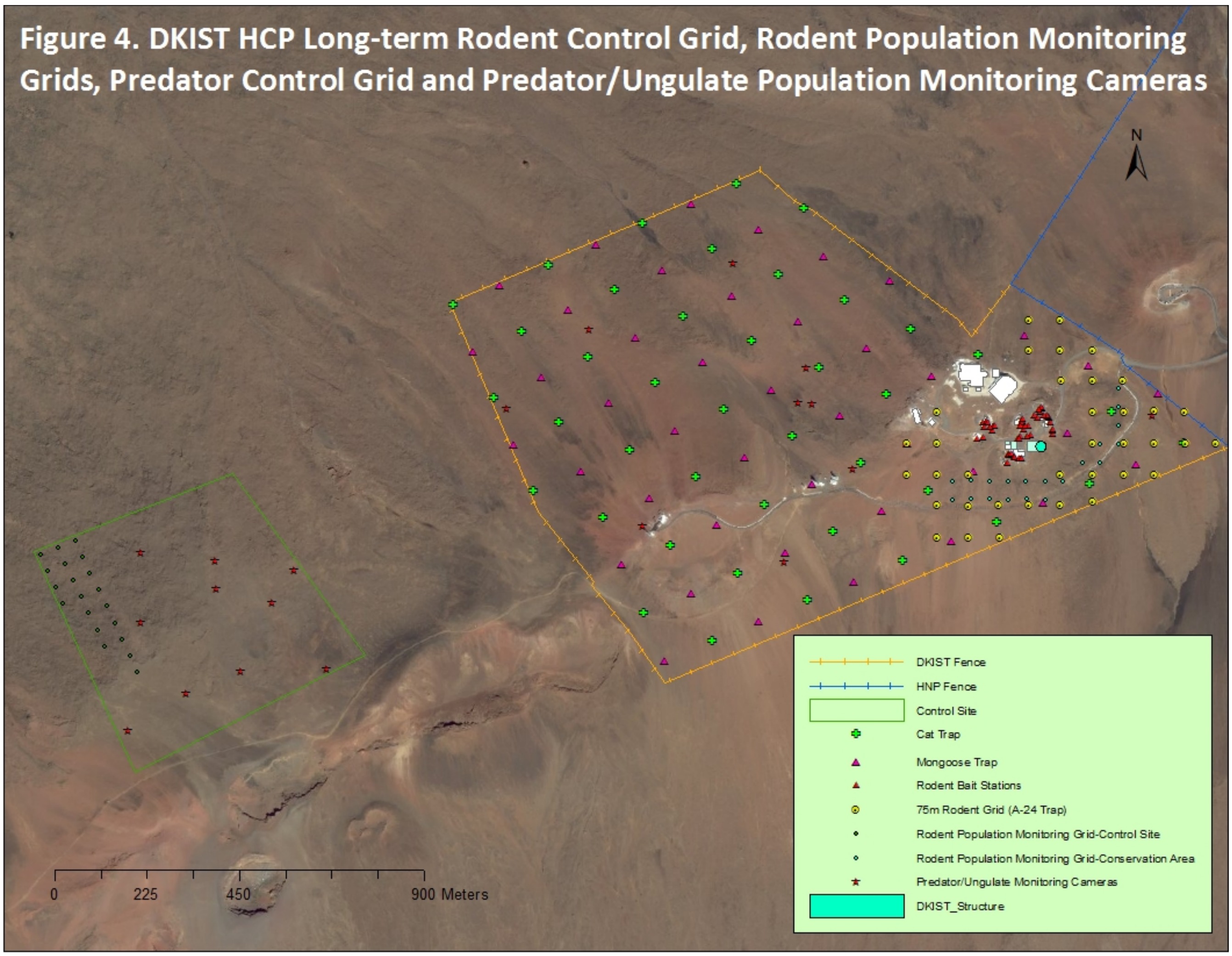


**Figure 4. DKIST HCP Long-term Rodent Control Grid, Rodent Population Monitoring Grids, Predator Control Grid and Predator/Ungulate Population Monitoring Cameras**

A Conservation District Use Permit (CDUP) for the conservation fence was issued on May 17, 2013. On July 25, 2013, Rock N H Fencing, LLC was awarded the contract to construct the conservation fence. The construction started on September 1, 2013 and was completed on November 18, 2013. A total of 4.23 km (2.63 mi) of fence was built and 126.53 ha (312.66 acres) of Conservation Area was enclosed, which included 0.66 ha (1.64 acres) of Haleakalā National Park land outside of the park fence (Figure 1, 3 & 4).

To prevent bird collision with the conservation fence, three strands of steel wire-enforced Poly-tape were installed horizontally along the entire length of the fence, which was completed on March 13, 2014 in compliance with HCP and BO requirements.

As a result of the fence construction process and the intensive monitoring / conservation activities that were being implemented during the fence construction, all ungulates vacated the Conservation Area before the fence was completed. Based on footage from 10 long-term predator/ungulate monitoring camera traps and six additional ungulate monitor camera traps (Figure 4), no ungulates were detected within the Conservation Area since September 12, 2013, until June 1, 2017 when a juvenile goat was observed inside the fenced Conservation Area. The DKIST Resource Management Team systematically searched the area thereafter, however, no further signs of the goat's presence were found, to include any fresh tracks, droppings, or any images of the goat captured via camera traps. We believe it is likely that the goat ingress was due to some Skyline Trail users obstructing the fence gate from closing, and the goat likely left the fenced area either through the same gate, or it may have been able to jump over the fence in one of the few areas where the higher rocky terrain would make it possible. It is also possible the goat died inside the area due to dehydration, hypothermia and starvation, although no carcass has been found. **No ungulate populations have reestablished inside the fenced Conservation Area since September 12, 2013, shortly after fence construction began.**

### *IV E. Searcher Efficiency Trials (SEEF): Annually Since May 2013*

In order to accurately evaluate the overall efficiency of carcass detection in the DKIST project area, SEEF trials are conducted annually, as prescribed in the HCP. Trials were conducted within the DKIST's approved birdstrike monitoring Search Area A, as discussed in detail in Section IV X, and shown in Figures 5 and 7.

In accordance with the requirements of the HCP and BO, these trials are to be conducted by a third party contractor, and are to take place unbeknownst to the searcher(s). KCE was the Maui-based third party contractor selected to conduct the SEEF Trials on behalf of DKIST. In order to recover bird carcasses found during the trials, the DKIST Resource Management team operates as a sub-permittee of KCE's Migratory Bird Permit (USFWS February 27, 2013, # MB97892A-0) and Protected Wildlife Permit (DLNR March 04, 2013, # WL 15-02).

During the 8- week SEEF trials, Wedge-tailed Shearwater carcasses are used as surrogates for the Hawaiian Petrels. Over the trial period, 20 carcasses are placed within the search area on random days and in random quantities, with up to 3 carcasses being placed per day. After each search is completed, the searchers will report the result only to KCE, with the number of shearwater carcasses found, photos, bird tag numbers, and the coordinates at which the carcasses were found included in the report. The carcasses are then returned to the freezer which is maintained by KCE at the site.

**FIGURE 5. Demarcation of Area A and B of the DKIST Construction Site Birdstrike / Search Area. Searcher Efficiency Trials Were Only Conducted in Area A.**

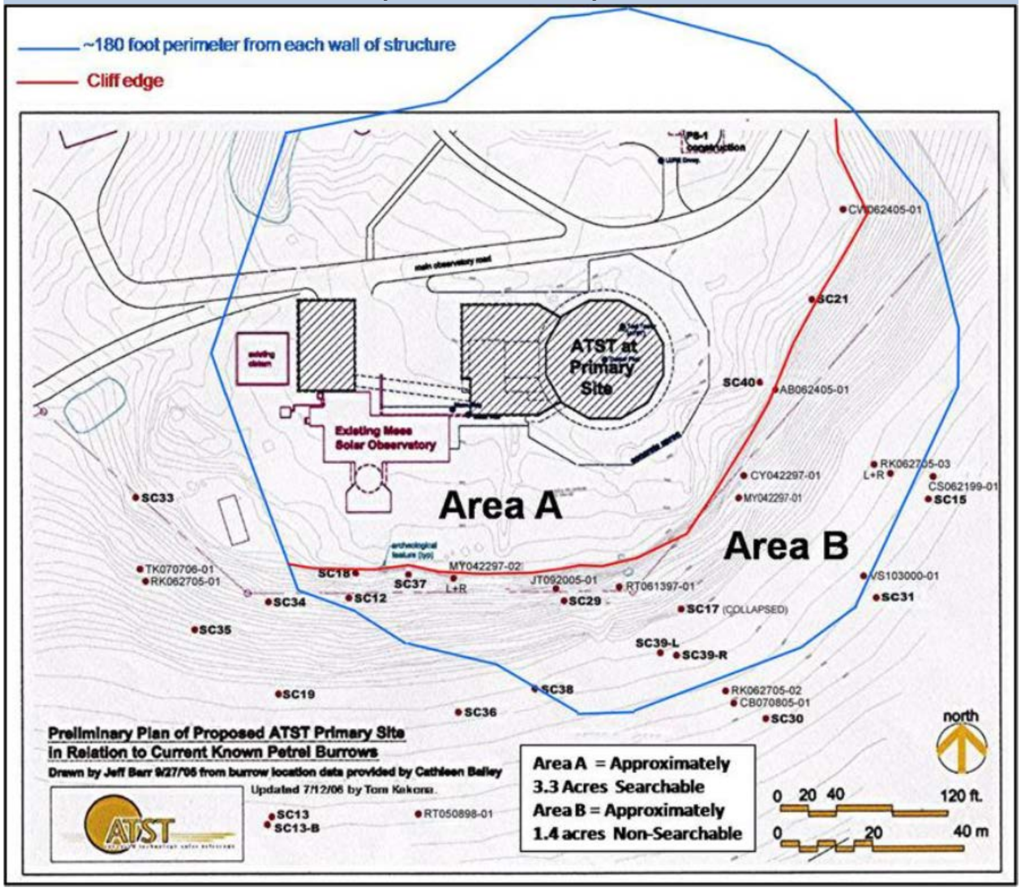



Table 2 shows the results of SEEF trials since 2013, resulting in an overall searcher efficiency rate of 92%. In the most recent trial, in 2017, All 20 dropped carcasses were found, resulting in a searcher efficiency rate of 100%. (Fein and Allan 2013a, 2014a, 2015a, 2016a, 2017a).

**Table 2. 2013-2016 DKIST Searcher Efficiency Trail Results**

| Year | # birds dropped | # birds located | Searcher Efficiency % |
|---|---|---|---|
| 2013 | 20 | 17 | 85 |
| 2014 | 20 | 18 | 90 |
| 2015 | 20 | 18 | 90 |
| 2016 | 20 | 19 | 95 |
| 2017 | 20 | 20 | 100 |
| **Summary** | **100** | **92** | **92** |

### *IV F. Long-term Rodent Control Grid: <u>Ongoing Since March 2013</u>*

#### *i. <u>Methods, grid configurations and the chronicle of their modifications</u>*

The original rodent control grid in the final HCP and BO was a conceptual guideline; it needed to meet the minimum pesticide product Special Local Need Supplemental Label (SLN) requirements. In order to meet the SLN label requirements, a 50 meter grid layout plan was initially submitted to the agencies by the DKIST team. However, after consultations with USFWS, it was agreed that the project would implement a denser 48-meter bait box grid of 51 stations. The newer 48 meter grid layout plan was approved by USFWS in March 2013, and the implementation of the grid was completed April 2, 2013.

Each station is equipped with a Protecta ™ tamper-resistant rat bait box and a mouse box. Due to the ongoing DKIST construction activities taking place on site, 44 of the planned 51 stations are in place as of this report. Each rat bait box was deployed with eight 1-oz Ramik™ diphacinone blocks, for a total of 22 lbs. of diphacinone. The stations were checked after 1 week and then again in 2 weeks to evaluate the diphacinone take (stage one grid). However, the diphacinone SLN label expired on May 30, 2013, and the use of diphacinone had to be discontinued. The blocks were removed May 28, 2013. T-Rex rat and mouse snap traps baited with peanut butter have been deployed subsequently (stage two grid).

The requirements under the new SLN label published in December 2013 prohibited future diphacinone use in the Conservation Area due to boundary issues. The label requires the grid to be extended 225 meters beyond the resource to be protected, which for the Conservation Area would cross the neighboring boundaries of Haleakalā National Park, the U. S. Air Force, and Department of Hawaiian Homelands. In response to these new labeling constraints, the DKIST Resource Management team worked closely with USFWS and DOFAW to develop a new long-term rodent control grid methodology that is not regulated by an SLN label.

A total of 47 Protecta ™ tamper-resistant rat bait boxes were placed every 30 ft. along the perimeter of all permanent structures and trailers (office, storage) within Haleakalā Observatory (HO), with the exception of the US Air Force compound and areas affected by construction activities. For 40 ft trailers/containers, two bait boxes were placed, each at diagonal corners, and for 20 ft or shorter trailers/containers, one bait box was placed. Because diphacinone is not regulated by an SLN label for use next to buildings, each rat bait box was deployed with six 1-oz Ramik™ diphacinone blocks, for a total of 17.6 lbs. We began installing the boxes on April 30, 2015 and completed the installation on May 07, 2015. More boxes will be installed once remaining minor DKIST external construction activities are completed, in order to further reduce the risk of introducing rodents due to these residual construction activities. Outside of the construction area, we began installing a 75 meter A-24 rodent killing trap grid on May 12, 2015 and completed the grid on May 18, 2015. A total of 35 A-24 traps were installed. A 25 meter A-24 trap system will be installed around HO buildings once all remaining DKIST external construction activities are completed (stage three grid, Figure 4).

### *ii. Effectiveness of the long-term rodent control grid*

**Table 3 a. Effectiveness of DKIST Long-Term Rodent Control Grid Between 2013 and 2016 at the Summit of Haleakala, Maui – Rodents Removed**

| Grid Stage | One[1] | Two[2] | Three[3] | Total |
|---|---|---|---|---|
| Time Period | 04/02-05/28/2013 | 05/29/2013-04/20/2015 | 05/07/2015 – 06/30/2017 | |
| Rodent Captured | | | | |
| Field Mice | n/a | 42 | 7[5] | 49 |
| Roof Rats | n/a | 16 | 4 | 20 |
| Norwegian Rats | n/a | 9 | 0 | 9 |
| Unidentifiable Rats | n/a | 21 | 8 | 29 |
| Subtotal | n/a | 88 | 15 | 105 |
| A-24 Trap Hits[4] | n/a | n/a | 50 | 50 |
| Total Rodents Removed by Different Trap Types | | | | 155 |

**1: 48-meter bait box grid of 51 stations- eight 1-oz Ramik™ diphacinone blocks per- Protecta ™ tamper-resistant rat bait box.**
**2: 48-meter bait box grid of 51 stations- T-Rex rat and mouse snap traps baited with peanut butter in each Protecta ™ tamper-resistant rat bait box and mouse bait box.**
**3: 47 Protecta ™ tamper-resistant rat bait boxes baited with six 1-oz Ramik™ diphacinone blocks every 30 ft. along the perimeter of all permanent structures and trailers within Haleakalā Observatory (HO) plus 35 A-24 traps with peanut butter bait in 75 meter grid outside of HO.**
**4: A-24 estimate based on trap counter registered trap triggered without carcasses being found.**
**5. by predator control grid A-24 trap.**

**Table 3 b. Effectiveness of DKIST Long-Term Rodent Control Grid Between 2013 and 2016 at the Summit of Haleakala, Maui – Rodenticide Intake**

| Grid Stage | One | Two | Three | Total |
|---|---|---|---|---|
| Time Period | 04/02-05/28/2013 | 05/29/2013-04/20/2015 | 05/07/2015 – 06/30/2017 | |
| Rodenticide Intake (OZ) | 6.6 | n/a | 130.15 | 136.75 OZ |

Resulting data from the stage one diphacinone grid implemented from April 2, 2013 to May 28, 2013 showed only 6.6 oz. of diphacinone bait was taken. The stage two snap traps used for the remainder of 2013 removed 18 field mice (*Mus musculus*), 10 roof rats (*Rattus rattus*) and 2 unidentifiable rats (*Rattus spp*.). In 2014, 20 field mice, 8 Norwegian Rats (*Rattus norvegicus*), 2 roof rats and 12 unidentifiable rats were caught (prior to November 4). In 2015, prior to changing to the new stage three grid system (before April 20), four field mice, four roof rats, one Norwegian rat and seven unidentifiable rodents were caught.

After the new stage three rodenticide/A-24 killing trap grid system was installed in May of 2015, the A-24 traps recorded 7 hits and two roof rats and two field mice carcasses were found near the traps during the remainder of the 2015 season. In 2016, a total of 35 hits were recorded and two roof rats, four field mice and five unidentifiable rodent carcasses were found near the traps. During the six-month period of 2015, 27.6 oz. of rodenticide were consumed by rodents, in 2016, 72.65 oz. of rodenticide were consumed by rodents and in the first half of 2017, 29.9 oz. were removed. While it is not possible to determine exact removal rates specific to the amount of rodenticide consumed, it can be assumed that there are additional rodents killed which were not accounted for through a carcass count.

A total of 136.85 oz. (=3879632 mg) of diphacinone was consumed or removed from bait boxes, presumably by local rodents (Table 3). However, the amount of bait consumed or removed is difficult to directly correlate to the number of rodents that may have been lethally controlled. Based on information from Cornell University's Extension Toxicology Network (http://pmep.cce.cornell.edu/profiles/extoxnet/dienochlor-glyphosate/diphacinone-ext.html), the oral LD50 (The amount of a chemical that is lethal to one-half (50%) of experimental animals fed) in rats is 0.3 to 7 mg/kg. Even using the maximum LD50 of 7 mg, the amount of diphacinone consumed in the long-term rodent control grid was enough to kill 2,771,165 roof rats with an average body mass of 200 g (150-250 g, http://icwdm.org/handbook/rodents/RoofRats.asp). Although it was not possible to document the exact number of rodents killed by the rodenticide we administered, we are confident that a large number of rodents were killed without being accounted for based on the quantity of rodenticide intake and our rodent population data (IV G ii).

Based on the empirical data, the traps in DKIST's long-term rodent control grid have removed a total of 105 rodents between all trap types. In addition, it can be estimated that the A-24 traps may have also removed as many as 50 unidentifiable rodents for which the carcasses were not located such that **a total of 155 rodents have been removed by long-term rodent control grid traps** (Table 3).

***IV G. Predator and Rodent Population Monitoring*** *[Please Note: The monitoring discussed in this section is not required by the HCP or BO, and is a separate activity from, and in addition to the effectiveness of the predator control and long-term rodent control grids mentioned above. This is intended to evaluate the impact of the predator control and long-term rodent control grids on the local predator and rodent populations]*

Removing many individuals from a population from a specific space during a specific time doesn't always mean the population has been suppressed. While efforts to monitor predator and rodent population trends are not required by the HCP or BO, the DKIST resource management team has implemented invasive mammal monitoring programs, in addition to the control program (discussed in sections IV F & I), to understand what predators exist within the Conservation Area and Control Site and help achieve Net Recovery Benefit through an adaptive management approach. Predator/ungulate population monitoring camera traps and rodent population monitoring grids in the DKIST Conservation Area and Control Site are part of these efforts.

***i. Predator population monitoring: Ongoing Since April 2013***

Ungulate/predator population monitoring data was collected with camera traps. Twenty Bushnell Trophy Cam HD camera traps, 10 at each site (Conservation Area and Control Site), were installed at random locations generated by ArcGIS 10.0 on April 23, 2013 in the Conservation Area and on April 24, 2013 in the Control Site (Figure 4). Six additional camera traps were mounted at six selected fence posts along the fence line between December 3, 2013 and February 11, 2014, where previous goat tracks had been detected. These camera traps were initially used to monitor and determine whether ungulate eradication was needed after the completion of the ungulate fence, and continue to be utilized to obtain predator population data. Table 4 summarizes the number of photos for different animal categories recorded in the camera traps. No goats have been recorded since September 12th of 2013, although a juvenile goat was observed inside the Conservation Area on June 1, 2017. All human photos were images of DKIST Resource Management team personnel. The total numbers of animals (goats, birds and rodents) captured in photos seemed to peak in 2014, and has progressively declined in 2015, 2016 and 2017. No predator images have been captured with these camera traps since 2014.

**Table 4. Number of Pictures of Different Identifiable Animal Categories Captured by DKIST HCP Monitoring Camera Traps.**

| Site | *Year* | Goat | Bird[2] | *Rodent*[3] | *Human*[4] |
|---|---|---|---|---|---|
| **Control** | 2013[1] | 476 | 3 | *0* | *1* |
| | 2014 | 938 | 39 | *6* | *0* |
| | 2015 | 485 | 23 | 0 | 0 |
| | 2016 | 192 | 16 | 0 | 0 |
| | 2017[5] | 26 | 0 | 0 | 6 |
| **Conservation** | 2013[1] | 61 | 11 | *0* | *6* |
| | 2014 | 0 | 29 | *1* | *29* |
| | 2015 | 0 | 16 | 0 | 16 |
| | 2016 | 0 | 13 | 0 | 14 |
| | 2017[5] | 0 | 8 | 0 | 3 |

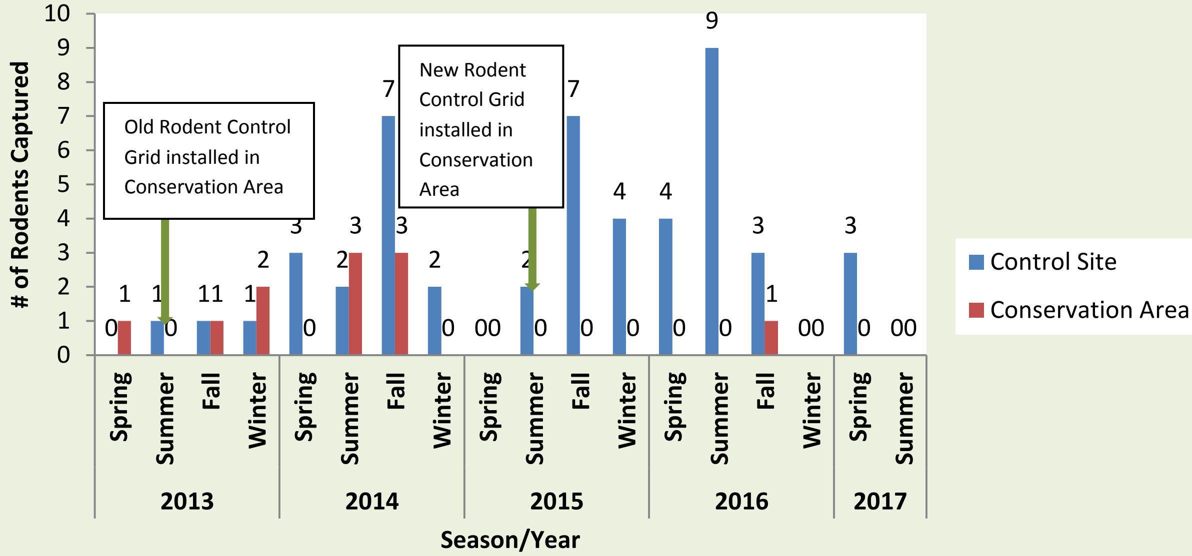
**1: initiated in April**
**2: mostly Chukars (*Alectoris chukar*), with a few Pacific Golden Plovers (*Pluvialis fulva*)**
**3: unidentified rodent species**
**4: including DKIST personnel**
**5. 01/01-06/30/2017**

### ***ii. Rodent Population Monitoring: Ongoing Since March 2013***

The purpose of rodent population monitoring is to evaluate the impacts of the long-term rodent control grid relative to the local rodent population. Due to the proximity and habitat similarity of the two sites, we assumed the rodent capture probability (per-capita) in the Conservation Area was similar to that at the Control Site on the same sampling date. By employing the same trapping effort on these two sites on the same date, we can use the rodent capture rate as the index of local rodent population.

We utilized the 20 remaining bait box stations in what is now the previous Long-Term Rodent Control 48 m grid system in the DKIST Conservation Area, and 20 bait box stations in the 48 m grid system in the Control Site (Figure 4). These two rodent population monitoring grids are 2,030 meters apart to ensure independence of the Control Site grid from the Long-Term Rodent Control Grid treatment. For this monitoring, each station was equipped with a T-Rex rat and a T-Rex mouse trap housed in Protecta tamper-resistant bait boxes. Peanut butter was used as bait and the traps were pre-baited one week before the traps were set. Each monitoring period consisted of 2 trap nights. The rodent population was monitored seasonally in March, June, September and December of each year. Figure 6 summarizes the rodent population monitoring results.

**Figure 6. Rodent Population Reduction Within DKIST Long-term Rodent Control Grid,Between 2013 and First Half of 2017 at the Summit of Haleakala, Maui**




***Based on two-trap-night/season rodent population monitoring data**

Assuming the rodent densities in both the Control Site and Conservation Area are similar, with slightly higher density in the Conservation Area due to human activity in this area, e.g. spring 2013 prior to the installation of the rodent control grid in the Conservation Area (Figure 6). The overall rodent density in the Conservation Area was reduced to 20.4% of the Control Site (2.9 rodents per season in the Control Site vs. 0.6 rodents per season in the Conservation Area) after the Long Term Rodent Control Grid systems were implemented (Figure 6). During the eight seasons when stage one and two Rodent Control Grid systems were employed (summer 2013 to spring 2015), these two older Rodent Control Grid systems had reduced the rodent population in the Conservation Area to 52.94% of the Control site level. (2.13 rodents per season in the Control Site vs. 1.13 rodents per season in Conservation Area). Based on the data collected during the two-trap night population monitoring, in the seven seasons since the stage three grid system was installed, **the long-term rodent control grid has further reduced the rodent population in the Conservation Area to 3.1% of the Control site level**. (3.6 rodents per season in the Control Site vs. 0.1 rodents per season in the Conservation Area).

### *IV H. Noise and Vibration Monitoring: Ongoing Since December 2012*

Hawaiian Petrel burrows nearest to construction are monitored for vibration and noise to ensure the agreed upon thresholds documented in the HCP and BO are not exceeded during ground disturbing construction activities. Noise and vibration monitoring of the construction site is conducted by a third party, KCE, and has been underway since December 1, 2012, the first day of construction.

To measure vibration, measuring stations can be equipped with seismometers; depending on the location of the vibration source, one or more of six measuring stations are used to monitor ground disturbance. Two seismometers have been consistently deployed at the two burrows nearest to construction (SC-40 and SC-21 shown on Figure 5). As required by the HCP and BO, noise producing activity is also monitored at the closest burrow to the construction footprint (SC-40, Figure 5); both at the burrow entrance, and at a distance of 5 meters from the burrow. The data from ongoing vibration monitoring shows that as of this report no construction activity during the four years of measurements have resulted in vibration levels that met or exceeded the threshold of 0.12 in/sec.

Most often, noise has not been above ambient wind levels at the burrow entrances, which can range up to 70+ dBA. KCE reported that noise levels at the burrow entrance have averaged about 56 dBA during construction, and actually decreased by about 10 dBA 5 meters closer to the source of construction. KCE explained that this decrease in noise closer to the construction can be attributed to the location of the burrow entrance being at the edge of a cliff, and often the strong trade winds at those locations induce more noise than the construction activities (due to a Venturi-like effect of higher wind speeds).

Based on KCE monitoring data, **the noise and vibration monitoring results show that construction activities have never exceeded authorized thresholds**.

Most external construction was completed as of early March of 2016, and therefore, as of March 7, 2016 USFWS and DOFAW have agreed that during the period of interior construction noise and vibration monitoring is not necessary at the DKIST site except when large, noisy, or earth-moving operations resume.

### *IV I. Predator Control: Ongoing Since September 2012*

Examination of footage from surveillance cameras in September 2012 identified the presence of a feral cat below the Mees Observatory. 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 on September 13, 2012 just below the Mees Observatory. Friskies brand cat food was used as bait. The trap was labeled (CT001) along with the GPS coordinates of the trap location. The cat was captured and removed from the site. There has been only one cat sighting (in 2015) since this sighting and capture in 2012. However, in the Conservation Area a cat image was recorded on a burrow camera (two weeks after the petrel chick fledged from the burrow) in 2015. After consulting with USFWS, a 125-meter predator control grid system was installed consisting of 18 Havahart traps (for cats) and 19 A-24 automatic traps (New Zealand Goodnature Company, for mongoose) that cover the northern part (the lower portion with higher risk of predation) of the Conservation Area. This grid is not as uniform as it appears in plan - in the actual on-ground layout of the grid; traps were not placed within 50 meters of any known petrel burrow to avoid attracting predators into petrel colonies. Each Havahart trap was equipped with a Telonics TBT-600NH or 503-1 trapsite transmitter to allow the traps to be monitored at least every other day to avoid petrel by-catch and to ensure the welfare of the trapped animals. The installation of the northern trap grid was completed on September 16, 2013, and was operational until November 18, 2013, when all known petrels left the Conservation Area.

In order to improve the predator control efficiency, USFWS predator control experts recommended that the project employ a more unified predator control grid system. Based on this recommendation, the DKIST resource management team installed 22 additional cat traps and 23 new mongoose traps, and relocated the traps in the northern half in 2014. The new grid of 40 cat traps and 42 A-24 mongoose traps was completed on June 19, 2014 (Figure 4).

Peanut butter was used as bait in the A24 mongoose traps at first. Using this bait, the A-24 traps killed three roof rats but no mongoose. In an attempt to better lure mongoose, a change to utilize predator-specific bait was initiated on July 24, 2014, starting with cod liver oil and then changing monthly to include salmon oil, synthetic catnip oil, and then moving to meat-based “Violator 7” and “Feline fix” products. After these changes from the peanut butter bait, no additional predators were caught in these traps. Mongoose images were recorded by a burrow camera for two days at a burrow entrance where only rodent activity was recorded in 2016 in the Conservation Area. In the Control Site, mongoose images were captured by burrow cameras at three different burrows, each on two different days.

The predator control traps are baited for use during the first week of February of each year and decommissioned when the last known petrel departs from the colony in late October to mid-November each year until the next petrel season begins.

In 2014, the Havahart traps caught two roof rats and no cats. As of this report, only one field mouse has been caught in one of the A-24 traps in the first half of 2017.

On May 25, 2017, a petrel was caught in a predator trap and was released unharmed. This is the only petrel that has been caught in a DKIST predator trap.

### ***IV J. Hawaiian Petrel Burrow/Reproductive Success Monitoring: <u>Since June 2011</u>***

Hawaiian Petrel burrow/reproductive success monitoring has been conducted annually since the 2011 breeding season by DKIST’s Resource Management team, in both the Conservation Area and Control Site (Figure 1).

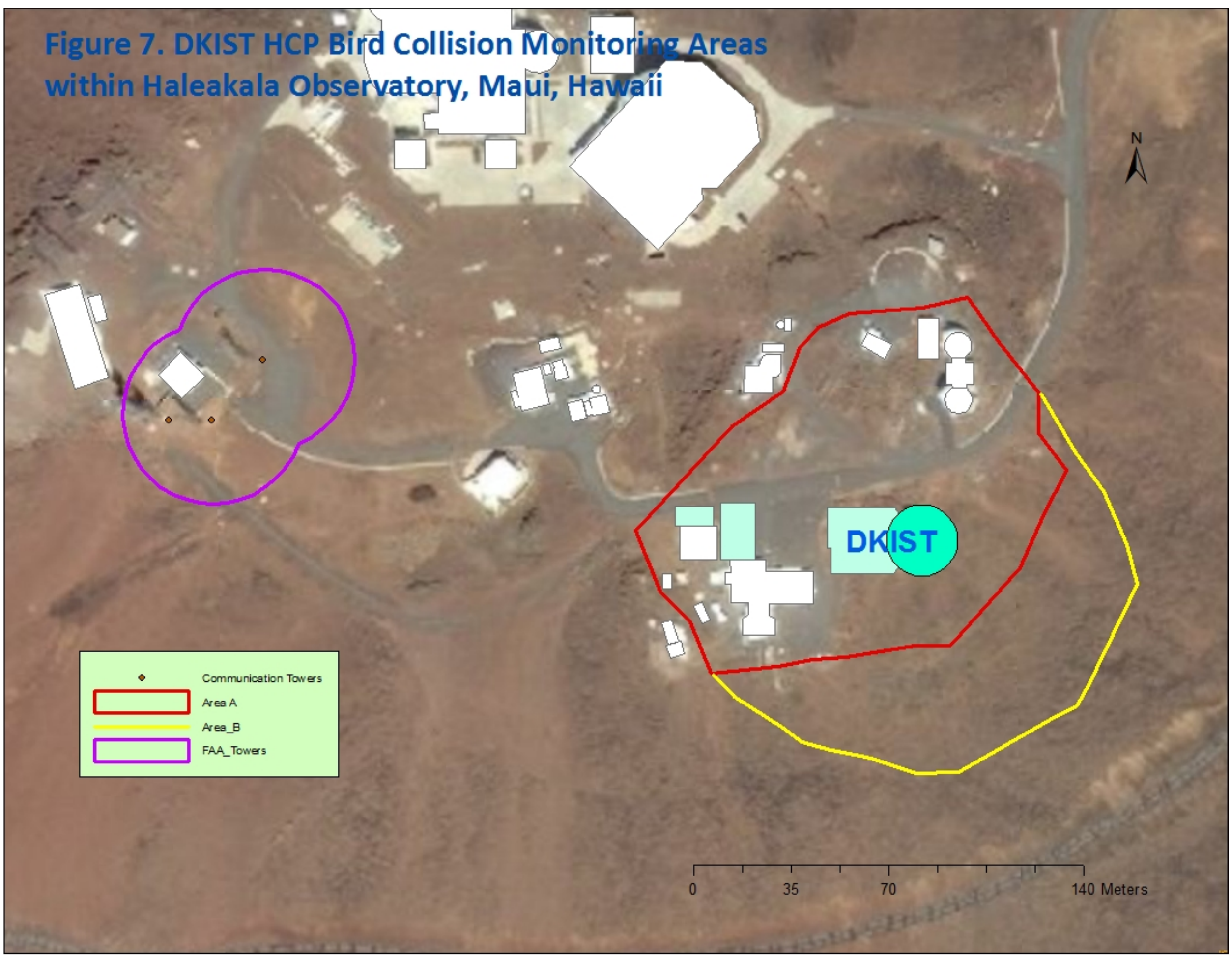
The new burrow scope that is now in use at DKIST is capable of detecting damage to burrow walls or features that may indicate collapse has occurred after nesting season. However, due to the acute angle shapes of petrel burrows and the volcanic rock, utilizing a burrow scope in the Haleakalā summit area to accurately observe eggs within burrows without risk of damage to them has not been feasible to-date. Therefore, data on the number of petrel pairs that laid eggs is not available, and for the purpose of this report, “fledgling success” is being used as a measurement of reproductive success in this area. This issue was discussed with USFWS and DOFAW on February 25, 2014 and September 25, 2014. As a result, DOFAW (October 20, 2014) and USFWS (October 30, 2014) issued letters confirming acceptance of this adaptive management approach.

### ***IV K. Birdstrike Monitoring: <u>Ongoing Since June 2011</u>***

In 2011 birdstrike monitoring took place from June 7 to November 30. Monitoring was conducted between February 1 and November 30 in 2012 and 2013. From 2014 and thereafter, the monitoring period ended on October 31, as required by the HCP and BO.

In 2011 and 2012, prior to the start of construction of the DKIST, only the two FAA communication towers were monitored. An area equal to a 75-ft. radius of the FAA towers (Figure 7) was delineated, and this radius is 1.25 x the height of the two FAA towers (60 ft.). The site was monitored every morning, seven days a week from June 7, 2011 to the second week of March 2014. Since 2014 monitoring has been conducted twice a week (primarily on Mondays and Thursdays) to reflect the HCP and BO required frequency.

Since 2013, HO search areas A and B have been monitored (Figure 7). The perimeter boundary of Area A and B is approximately 1.25 x the height of the DKIST observatory (136 ft.) extending from the perimeter of the DKIST observatory site. DKIST resource management team members conducted birdstrike monitoring within these two sites. Due to the cultural sensitivity of the summit area, no additional transect marking is appropriate, therefore the resource management team uses only existing landmarks to mark search routes and systematically search these two sites. During the search, the team systematically searches Area A twice and scans Area B once. When conducting the second search, the crew swaps their positions in the formation to increase the probability of detecting downed birds.



- Area A (3.3 acres (1.3 ha)): Lies on the more level area of Kolekole cinder cone and includes other observatories. This area includes roads, pathways, and roofs of buildings, plus open rocky habitat with little obstruction for detecting bird carcasses. No restriction within this search area exists, and all monitoring of Area A is done by systematic foot search.
- Area B (1.4 acres (0.6 ha)): Lies on the steep slopes south and east below the relatively flat area of Area A in an existing Hawaiian Petrel habitat. As instructed in the HCP, monitoring of Area B is conducted via use of binoculars to scan through the areas, since frequent monitoring by foot search is discouraged. Foot traffic could degrade breeding habitat in that area. Searchers are able to access the edge of the cliff at the demarcation between Area A and Area B for visual scanning (binocular-assisted) of Area B. However, because Area B includes rocks and boulders of various sizes that would obstruct simple observation of bird carcasses, it cannot be covered adequately enough to accurately count downed birds. Visual scanning, however, is useful in detecting and recovering any downed birds in the open, so that they do not become a predator attraction.

In 2014, monitoring of the conservation fence (Figure 1) was conducted twice a week until July 5. On July 6, 2014, USFWS notified the DKIST resource management team that such monitoring could be reduced to once every other week. An adaptive management amendment to the BO to confirm the change was issued on July 29, 2014. On September 23, 2014, the monitoring schedule was again amended to once each month from February to October, because the extended two-month CARE trial identified no carcasses removed by scavengers. The USFWS was satisfied that fence monitoring once each month is adequate to recover any downed birds.

**No petrel collisions were recorded during all the monitoring periods from 2011 to June 30, 2017 at the DKIST construction site (Area A & B), the FAA/Coast Guard towers, or along the conservation fence.**

However, if any collisions were to occur, the protocol requires recording the following information: date, time, location 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 USFWS, Pacific Islands Fish and Wildlife Office, USFWS Office of Law Enforcement, and DOFAW. In accordance with the protocol, the downed birds or carcasses would be handled according to the official State of Hawai'i Downed Wildlife and the USGS Wildlife Health Center, Honolulu office protocols, and if still alive, injured individuals would be delivered to appropriate local Maui veterinarians. DKIST would fund any acute care and the transport of the bird, if necessary, to a permitted wildlife rehabilitation center (currently located on O'ahu and the island of Hawai'i).

## V. HAWAIIAN PETREL REPRODUCTIVE SUCCESS MONITORING: METHODS

### *V A. Personnel Training*

All current members of the DKIST Resource Management Team received extensive training in 2011. This training included both field and administrative training. Members were trained on petrel carcass search and handling, petrel burrow identification, classification of burrow status based on signs of petrel activity, and avoidance of cultural resources during field work. In addition, the Predator Control Technician is certified for Commercial Applicators of Restricted Pesticides and each member was trained in handling rodenticide and rodent carcasses. Two of the team members were either State of Hawai'i Hunter Education certified or National Rifle Association (NRA) firearm certified. All members were previously trained in the use of GPS and ArcGIS software and all completed First Aid/First Responder and CPR certifications.

### *V B. Petrel Burrow Search*

The DKIST Resource Management Team began monitoring known burrows and searching for new burrows in the Conservation Area and Control site on August 10, 2011 and again on February 22, 2012. Based on experience and data collected during 2012, we realized that starting burrow monitoring in late February is likely to result in an overestimate of the number of active burrows, because petrels returning at this time of the year are just prospecting and forming pairing bonds, so multiple possible burrow sites might be visited by each pair. We changed our burrow monitoring starting date to better coincide with the start of nesting season in the first part of May in 2013 (May 7, 2013, May 7, 2014, May 19, 2015, April 14, 2016 and May 2, 2017). Monitoring ends each season after the petrel chick from the last known burrow fledges, which was November 16 in 2011, November 10 in 2012, October 24 in 2013, November 11 in 2014, November 16 in 2015 and November 28 in 2016. The 2017 season is still on-going as of the writing of this report.

The team begins annual monitoring by visiting all the burrows that were recorded from previous breeding seasons. Any newly identified burrows are documented as they are discovered and a systematic search of the DKIST Conservation Area and Control Site is also conducted. Newly identified burrows may be a previously undiscovered burrow, or a newly excavated burrow. The DKIST resource management team utilizes recorded information provided by the Park regarding established burrows that were confirmed prior to 2011. In order to avoid mislabeling some of the thousands of rock crevices within the Conservation Area as new burrows, a structural feature isn't officially documented as a 'burrow' until its use is established by some evidence of petrel activity. When DKIST began monitoring in 2011, the same burrow identification system was used, following earlier Park convention. That is, the coordinates of the newly identified burrows are recorded with handheld Garmin Oregon 450 and 550 GPS units. Signs of petrel activity (feathers, droppings, egg shells, footprints, regurgitation, odor and other body parts) and GPS coordinates at each burrow are recorded. Toothpicks are placed vertically along the entrance of each burrow to monitor petrel movement in and out of burrows; fallen or height-altered toothpicks suggest current activity, while undisturbed toothpicks denote no activity (Hodges 1994, Hodges & Nagata 2001).

### *V C. Principles of Reproductive Success Monitoring*

Breeding success is initially categorized based on signs at the entrance, status of placed toothpicks, and the latest date of activity. Burrows that were "Active" were then re-checked weekly until signs of success or non-productivity were observed. Using the same methodology as employed by the Haleakalā National Park (Hodges 1994, Hodges & Nagata 2001), a burrow was defined to be "successful" by the presence of petrel chick down feathers at the burrow entrance, and disturbed toothpicks after mid - September of each year. Burrows classified as “non-productive” showed signs of activity during initial search, but no further signs were found while conducting the subsequent re-checks, suggesting that these burrows were either occupied by non-breeders, the nest was abandoned, or the chicks did not reach fledgling age.

### *V D. Camera Monitoring of Reproductive Success*

To establish a baseline for petrel behaviors and burrow activity near the DKIST site in the years before construction, and to supplement means of monitoring reproductive success after construction began, cable surveillance video cameras were installed and monitored by KCE every year since 2006 at burrows adjacent to the Mees Observatory, from February until all petrels left the monitored burrows.

In addition, the DKIST resource management team installed Bushnell “Trophy Cam HD™” camera traps at active burrows outside of the cable accessible area. 16 camera traps were installed in the Conservation Area between October 15 and November 07, 2013, 39 camera traps were installed between September 10 and November 11, 2014; 38 camera traps were installed in the Conservation Area and one was installed in the Control Site. 35 camera traps were installed in the Conservation Area and two were installed in the Control Site between September 08 and November 18, 2015. 70 camera traps were installed in the Conservation Area between September 27 and November 23, 2016 and five were installed in the Control Site between September 22 and November 28, 2016. No camera traps have yet been deployed at this stage of the 2017 season.

## VI. HAWAIIAN PETREL REPRODUCTIVE SUCCESS MONITORING: RESULTS AND DISCUSSION

### *VI A. Number of Petrel Burrows Monitored*:

Based on monitoring data, Hawaiian Petrel burrows were classified as “Active”, “Not Active” and “Not a Burrow” (burrows that were active in at least one of the previous seasons, but for which the burrow passage is no longer present in the current season). Table 5 summarizes the adjusted and updated number of possible Hawaiian Petrel burrows monitored in these three categories within DKIST monitoring areas in the past six nesting seasons. As new burrows were located each year, the number of burrows monitored increased from 272 in 2011 to 365 in 2016. In the updated table, only burrows that are within the 2013 built conservation fence, not the boundary and Control Site burrows were included. The Conservation Area data of 2011 in this report is different from the previous reports, because the previously recorded “Not a Burrow”, newly recorded “Not Active” and newly recorded “Not a Burrow” from 2011 in the Conservation Area were not included in the previous reports.

### *VI B. Burrow Status*

In the analysis, only burrows that were inside the boundary were included. “Nesting Activity %” is the number of “Active” burrows divided by the total number of burrows monitored that year, while “Nesting Success %” is calculated by dividing the “successful” number of burrows by the number of “Active” burrows.

Table 5 summarizes the adjusted status of burrows found between 2011 and early 2017, along with successful/non-productive statistics. In the Conservation Area, both the active burrow number (119) and Nesting Activity % (36%) showed a significant drop in 2016 (36%, compared to 54% in 2015, $\chi 2 = 8.216$, $P<0.05$, df=1, Figure 8), probably as a result of what caused the poor nesting success rate of 2015. Both the successful burrow number of 49 and the "Nesting Success %" of 41.2% recorded in 2016 was the highest ever recorded in the Conservation Area, which significantly increased from 2015 (17.3%, $\chi 2 = 11.261$, $P<0.05$, df=1). All the 2016 statistics in the Control Site were similar to the previous years except no additional successful burrows were recorded in 2016. Twenty three new active burrows were located within the Conservation Area prior to June 30, 2017. 2017 is the first year that no new active burrows were recorded in the Control Site (Table 5). It is too early to determine the status of the 'old' burrows at this stage of the breeding season.

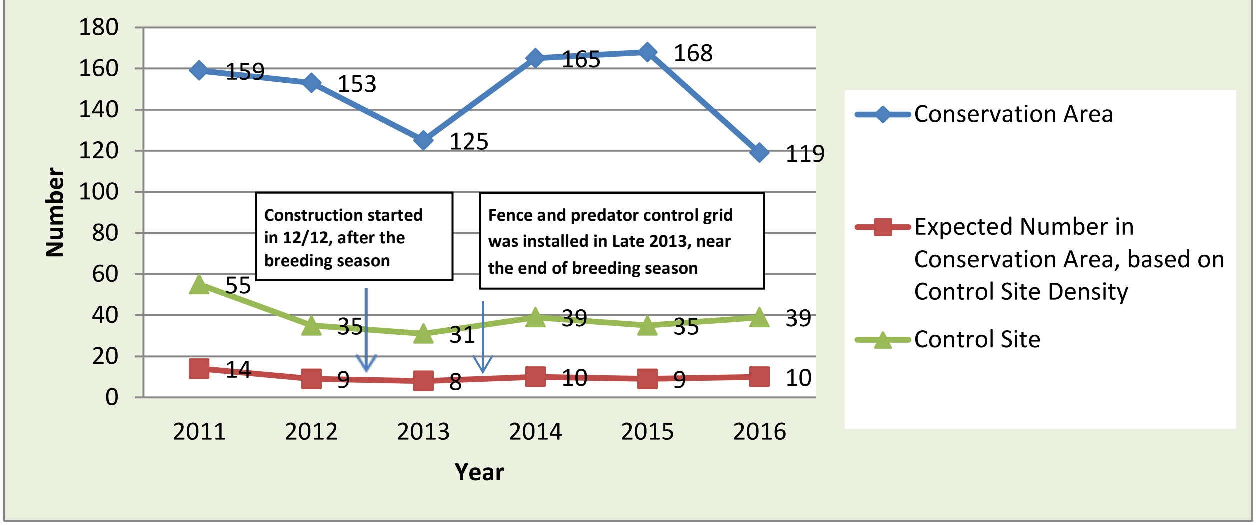
**Table 5. Hawaiian Petrel Burrows and Reproductive Success in DKIST HCP Conservation Area and Control Site on Haleakalā, Maui, Hawaii (Cons. =Conservation Area, Cont. =Control Site).**

| | Year | 2011 | | 2012 | | 2013 | | 2014 | | 2015 | | 2016 | | 2017[5] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Status** | Location | **Cons.** | **Cont.** | **Cons.[1]** | **Cont.** | **Cons.[2]** | **Cont.** | **Cons.[3]** | **Cont.** | **Cons.[4]** | **Cont.** | **Cons.** | **Cont.** | **Cons.** | **Cont.** |
| ***Old*** | **Active** | 73 | 0 | 140 | 6 | 122 | 7 | 158 | 7 | 154 | 7 | 106 | 8 | | |
| | **Successful** | 24 | 0 | 16 | 0 | 26 | 0 | 42 | 1 | 29 | 2 | 48 | 0 | | |
| | **Non productive** | 49 | 0 | 124 | 6 | 96 | 7 | 116 | 6 | 125 | 5 | 58 | 8 | 332 | 33 |
| | **Not Active** | 38 | 0 | 103 | 15 | 151 | 18 | 128 | 19 | 143 | 22 | 200 | 23 | | |
| | **Not a Burrow** | 10 | 0 | 15 | 0 | 8 | 0 | 2 | 0 | 0 | 0 | 5 | 0 | | |
| ***New*** | **Active** | 86 | 14 | 13 | 3 | 3 | 1 | 7 | 3 | 14 | 2 | 13 | 2 | 23 | 0 |
| | **Successful** | 8 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | | |
| | **Non productive** | 78 | 14 | 13 | 3 | 2 | 1 | 5 | 3 | 14 | 2 | 12 | 2 | | |
| | **Not Active** | 39 | 7 | 9 | 1 | 3 | 0 | 1 | 0 | 0 | 0 | 8 | 0 | | |
| | **Not a Burrow** | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| ***Subtotal*** | **Old** | 121 | 0 | 258 | 21 | 281 | 25 | 288 | 26 | 297 | 29 | 311 | 31 | 332 | 33 |
| | **New** | 130 | 21 | 22 | 4 | 6 | 1 | 8 | 3 | 14 | 2 | 21 | 2 | 23 | 0 |
| **Total** | | 251 | 21 | 280 | 25 | 287 | 26 | 296 | 29 | 311 | 31 | 332 | 33 | 355 | 33 |
| **Nesting Activity %** | | 67.37 | 66.67 | 57.74 | 36.00 | 44.80 | 30.77 | 56.12 | 34.48 | 54.02 | 29.03 | 35.84 | 30.30 | n/a | n/a |
| **Nesting Success %** | | 20.13 | 0.00 | 10.46 | 0.00 | 21.60 | 0.00 | 26.67 | 10.00 | 17.26 | 22.22 | 41.18 | 0.00 | | |

1. Seven of the old burrows recorded in 2012 were burrows that were marked prior to 2011, but were found in 2012.
2. One of the old burrows recorded in 2013 was burrows that were marked prior to 2011, but was found in 2013.
3. Including one burrow separated from an old burrow in 2014.
4. Including one burrow separated from an old burrow in 2015, and one burrow found in 2014 w/out recording the coordinates that was re-located in 2015.
5. Ongoing season, 01/01-06/30/2017 data.

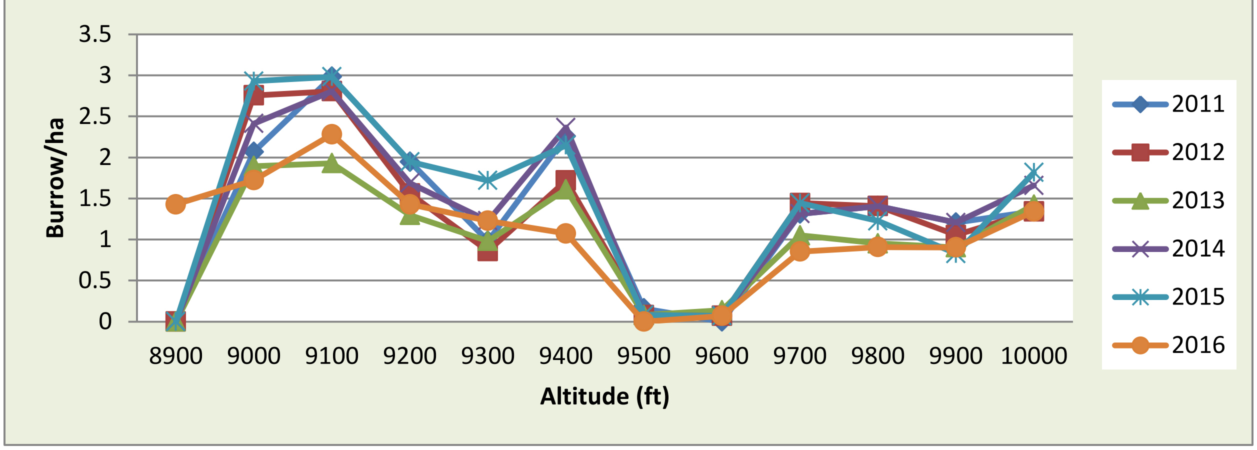
The density of active petrel burrows recorded from 2011 to 2016 in the Control Site (80 acres) was used to predict the number of active petrel burrows in the Conservation Area (312.66 acres). It was found that more active petrel burrows (3-5 times more) were recorded in the Conservation Area than expected from 2011 to 2016, even in the years prior to the installation of the conservation fence and predator/rodent grids (Figure 8). This phenomenon might be explained by the relatively lower quality of petrel nesting habitat or less suitable burrowing sites located in the Control Site. It could also be that this site sustained long term predation pressure due to its proximity to the source of predators.

**Figure 8. Active Hawaiian Petrel Burrow Number Recorded in DKIST HCP monitoring Area on the Summit of Haleakala, Maui from 2011 t0 2016**




Upon examination of the density distribution of active petrel burrows within the Conservation Area in different years and at different elevations, almost identical density distribution patterns in different years can be observed. Although the least active burrow number was recorded in 2016, this was the first time active burrows were recorded below 8,900 ft. elevation. An uninhabited zone between the 9,400 and 9,600 ft. elevation levels (Figure 9) was also observed in 2016. Figure 9 also shows that petrel burrows in the HCP monitored areas are neither evenly nor randomly distributed. Further investigation of the active burrow distribution indicates that burrows are only located in lava rock areas and that cinder areas are vacant of petrel burrows.

**Figure 9. Active Hawaiian Petrel Burrow Density at Different Altitudes Recorded from 2011 to 2016 in DKIST HCP Conservation Area on the Summit of Haleakala, Maui**



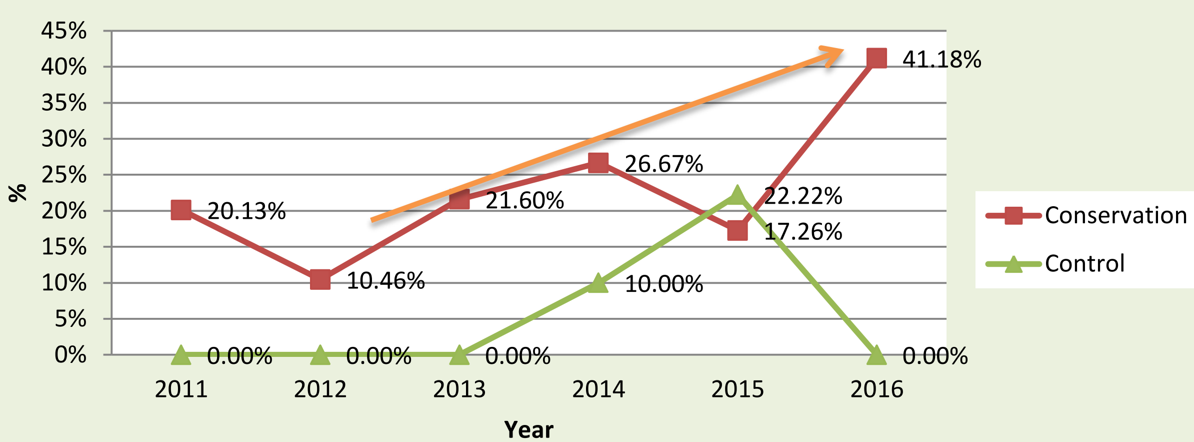

Based on recent genetic and isotope studies (Judge 2011, Welch et. al. 2012, Wiley et al. 2013), the DKIST resource management team assumes that all Hawaiian Petrel colonies on the summit of Haleakalā, Maui form a meta-population. We speculate that petrels from these colonies forage in the same foraging area, and experience the same survival conditions and challenges during the same year. Intrayear comparisons between the Conservation Area and Control Site are examined and presented in order to reduce the uncontrollable effects of inter-year environmental variances; e.g. prey population fluctuation due to yearly climate, pollution, fishery pressure, prey accessibility due to debris, and declined predatory fish population to Hawaiian Petrel reproductive performance, the survival rate of adults/chicks, and young recruitment.

We have attempted to compare trends of active burrow numbers and successful burrow numbers between the Conservation Area and Control Site, to evaluate whether the DKIST conservation fence and predator/rodent control grids have promoted recovery for the Hawaiian Petrel in the Conservation Area. The sample size of active/successful burrows recorded in the Control Site from 2011 to 2016 was too small to conduct appropriate statistical comparisons. Even population trends are difficult to identify due to the small sample size in the Control Site. For example,  in 2015 the 22.2%"Nesting Success %" in the Control Site is higher than in the Conservation Area (17.2%), but the statistic is only based on nine active burrows (Table 5, Figure 10). After the first burrow successfully fledged a chick in the Control Site in 2014, two petrel burrows produced fledglings in 2015, but the number went down to zero again in 2016.

If we compare the average "Nesting Success %" prior to the implementation of all the conservation measures (15.4%, 2011 & 2012)[1] with that of post implementation years (27%, 2014 to 2016)[2] in the Conservation Area, we can observe **a significant ($\chi^2$ =9.324, P<0.05, df=1) increase of 75.4%[3] in "Nesting Success %" after the conservation measures were implemented in the Conservation Area.**

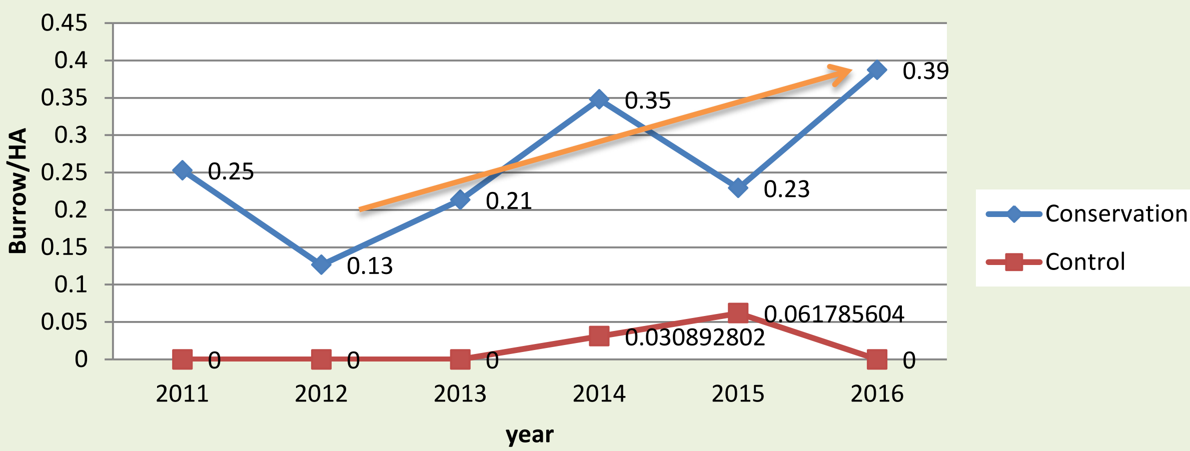
1. **$(32^{\text{2011 successful burrow}}+16^{\text{2012 successful burrow}})/(159^{\text{2011 active burrow}}+153^{\text{2012 active burrow}})$=15.38%**
2. **$(44^{\text{2014 successful burrow}}+29^{\text{2015 successful burrow}}+49^{\text{2016 successful burrow}})/(165^{\text{2014 active burrow}}+168^{\text{2015 active burrow}}+119^{\text{2016 active burrow}})$=26.99%**
3. **(26.99%-15.38%)/15.38%=75.48%**

**Figure 10. Hawaiian Petrel Nesting Success % Recorded in DKIST HCP Monitored Areas on the Summit of Haleakala, Maui, From 2011 to 2016**




Comparing the succesful burrow densities or numbers prior to 2013 and after 2013, when the installation of the mitigation measures was completed (Figure 11), seems to be a more appropiate way of determining whether the DKIST HCP mitigation measures facilitated petrel reproductive performance in the Conservation Area. The attempt to determine the effect by comparing succesful burrow densities or numbers in the Conservation Area and Control Site may be skewed due to the low number of active burrows recorded in the Control Site. Also, the habitat quality in the Control Site and the Conservation Area is very different (as illustrated in Figure 8 of this section).

**Figure 11. Hawaii Petrel Successful Nest Density Recorded in DKIST HCP Monitored Areas on the Summit of Haleakala, Maui, From 2011 to 2016**




Climatologically, 2015 was considered an anomaly in the North Pacific Ocean. Unusually high ocean surface temperatures (A.K.A. "Blob") induced shifting fish distribution and algae blooms, resulting in mass seabird and marine mammal stranding and die-off in this area (Cavole et al. 2016). The 2015 Pacific hurricane season was the most active Pacific hurricane season on record in recent years with 16 named storms (National Weather Service Central Pacific Hurricane Center, http://www.prh.noaa.gov/cphc/summaries/), which was two to three time the number recorded from 2013 to 2016. This extraordinarily active hurricane season might have impacted petrels' traveling between their breeding colonies and foraging grounds in the North Pacific. All of these anomolies in 2015 may have resulted in the high egg abandonment and roll out number observed in 2015 (Table 6). Once again, successive years of data will shed more light on trends of reproductive success within the DKIST HCP monitored areas.

There was a great reproductive performance improvement in 2016 in elevations below 8,900 ft. and in elevations between 9,200 and 9,400 ft. within the Conservation Area. This was likely due to the effectivness of predator control, as no nest predation or trampling has been recorded in this area since 2014, although one adult each was predated in 2014 and 2016 near the conservation fence (Figure 12 and 13).

**Figure 12. Hawaiian Petrel Nesting Success % at Different Altitudes Recorded Between 2011 and 2016 in DKIST Conservation Area, Near the Summit of Haleakala, Maui**

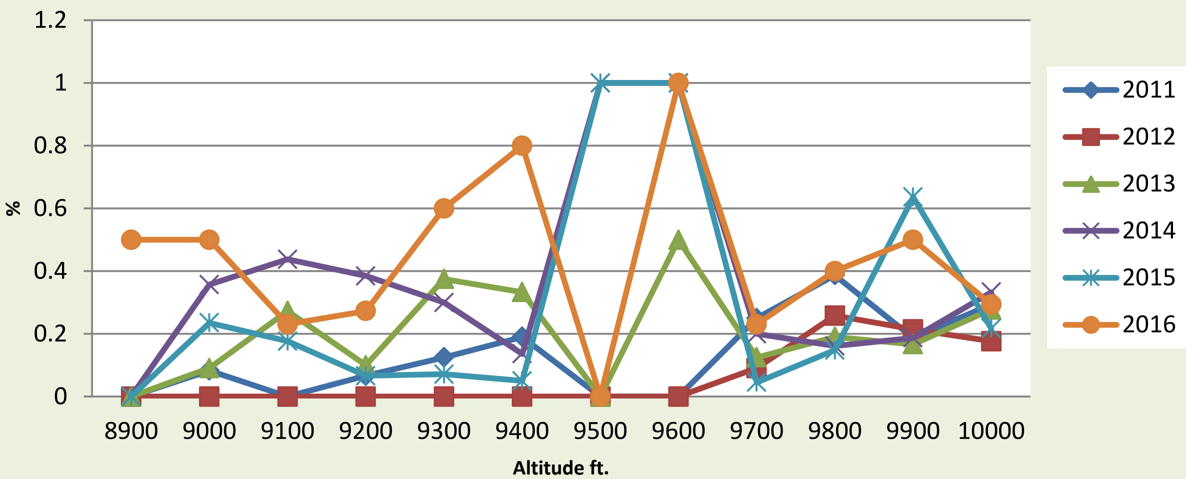
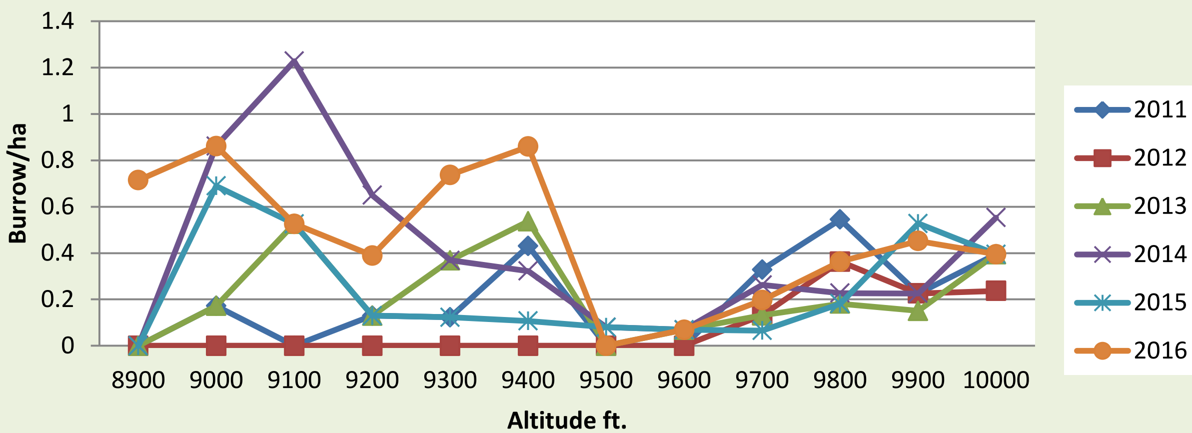



**Figure 13. Successful Hawaiian Petrel Burrow Density at Different Altitudes Recorded From 2011 to 2016 in DKIST Conservation Area, Near the Summit of Haleakala, Maui**




When we look at the number of successful fledglings before and after DKIST implemented the HCP/BO conservation measures, the average annual successful fledgling number from 2011 to 2013 in the Conservation Area was 25 (24 if 2013 is not included), while the average annual successful burrow number from 2011 to 2013 in the Control Site was zero. The average annual successful burrow number from 2014 to 2016 in the Conservation Area was 40.7, while the average successful burrow number from 2014 to 2016 in Control Site was 1.0. **The Hawaiian Petrel productivity in the Conservation Area increased 62.7% (69.4% if 2013 is not included) after the HCP was fully implemented**. Based on the empirical data, **DKIST HCP/BO mitigation measures have facilitated Hawaiian Petrel fledging by 16.7[1] more successful fledglings annually or 50[2] more successful fledglings) from 2014 to 2016**. This result significantly demonstrates the net benefit from DKIST HCP mitigation measures.

1. $40.67^{\text{average successful fledgling \# 2014-2016}} - 24^{\text{average successful fledgling \# 2011-2012}} = 16.67^{\text{annual increased successful fledgling \#}}$
2. $16.67^{\text{annual increased successful fledgling \#}} \times 3\ \text{year}^{2014\text{-}2016} = 50^{\text{2014-2016 total increased successful fledgling \#}}$

### *VI C. Hawaiian Petrel Mortality*

Table 6 summarizes all known mortality events recorded between the 2011 breeding season and the first half of the 2017 breeding season. In the first half of 2017, an adult petrel was found dead with an injured wing outside of its burrow near the DKIST construction site in the Conservation Area. Pre-necropsy examination identified no broken bones, however, the cause of mortality is still undetermined as of the writing of this report. Based on our surveillance camera record, this bird injured its wing inside its burrow, not while flying, so we have temporarily categorized it as 'other' mortality. Two eggs were found outside of two different burrows with no signs of predation on May 22nd of 2017. The first egg was located above the burrow and had cracks at the bottom, but no chew marks. This was during the early incubation period, therefore this egg may have been prematurely laid. A second egg was found in tact outside another burrow, again during the early incubation period, and was likely due to an accidental roll-out.

**Table 6. Known Hawaiian Petrel Mortality Events Recorded between 2011 and 2016 in the DKIST Conservation Area and Control Site (Cons.: Conservation Area, Cont.: Control Site)**

| Year | 2011 | | 2012 | | 2013[1] | | 2014 | | 2015 | | 2016 | | 2017[4] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age/Site | Cons. | Cont. | Cons. | Cont. | Cons. | Cont. | Cons.[2] | Cont. | Cons. | Cont. | Cons. | Cont. | Cons. | Cont. |
| **Other** | | | | | | | | | | | | | | |
| Egg | 4 | 0 | 1 | 0 | 1 | 0 | 2 | 0 | 14 | 1 | 4 | 0 | 2 | 0 |
| Chick | 2 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 2[3] | 0 | 0 | 0 |
| Adult | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1[5] | 0 |
| **Predation/burrow trampling** | | | | | | | | | | | | | | |
| Egg | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chick | 6 | 3 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| Adult | 1 | 9 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| TOTAL | 15 | 12 | 7 | 1 | 9 | 0 | 4 | 1 | 16 | 2 | 7 | 1 | | |

1. Not including a burrow trampled by ungulates in the early stage of breeding season, and an adult and a chick mortality event that occurred prior to 2013.
2. Not including one burrow collapse in each site due to an unknown cause and consequence in early stage of breeding season. The collapsed burrow in Conservation Area was 210 m from the nearest DKIST staging area and more than 400 m from construction site.
3. Two chicks first emerged from their burrows in November still covered with down, one left the same night, which died of emaciation two days later, the other chick, stayed around its burrow for six nights and disappeared. Based on the condition of this chick, we assumed this chick didn't fledge successfully.
4. Ongoing season.
5. The Cause of mortality is still not determined as of June 30, 2017.

Prior to the installation of DKIST's predator control grid and ungulate fence in 2013, invasive mammalian predators were the cause of an average annual predation of 7 birds/year of all detected petrel mortality in the DKIST Conservation Area, but this number has been reduced an average annual predation of 0.7 birds/year between 2014 and 2016. Using 2011 and 2012 data as a baseline, **DKIST predator/ungulate control measures have reduced an average of 90.5% of the expected annual predation events since 2013**, even without any predators being caught in the predator control grid. This fact also demonstrates the effectiveness of the DKIST predator control measures.

Considering all HCP conservation measures implemented by DKIST, we should expect a diminishing trend for predation but not necessarily a direct Hawaiian Petrel population increase, although DKIST has demonstrated both. This is due to the indeterminable and uncontrollable impacts to the ocean from global weather change, pollution and resource overexploitation. For example, the egg roll-out/abandonment observed in 2015 in the Conservation Area (n=14) is equal to the sum of all predation events observed in 2011 and 2012 (n=8+6=14), the years prior to the implementation of predator control measures. Although the implementation of predator control measures had effectively reduced the amount of predation events, egg roll-out/abandonment still occurred, meaning that the factors at play were probably not ones we can control. As the data accumulates, we will likely be able to determine definitively that impacts from outside of the Hawaiian Petrel colonies actually play a more significant role in the petrel mortality observed in DKIST HCP monitored areas than previously thought.

Based on Table 6 Conservation Area data: prior to the completion of implementing the conservation measures (2011-2012), the annual egg loss due to predation was 1.5 eggs/year, the annual chick loss due to predation was 3.5 chicks/year and the annual adult loss due to predation was 2 adults/year. After the completion of implementing the conservation measures (2014-2016); no eggs were lost due to predation, the annual chick loss due to predation was 0.33 chicks/year and the annual adult loss due to predation was 0.67 adults/year. In other words, **DKIST HCP/BO measures have reduced the number of eggs, chicks and adults lost due to predation by 1.5 eggs, 3.2 chicks and 1.3 adults annually, or saving a total of 4.5 eggs, 9.5 chicks and 4 adult petrels from predation between 2014 and 2016**.

It should be noted that Control Site predation diminished more quickly than in the Conservation Area during the period from 2011 to 2016. However, once we factor in burrow density and the difference in size (the Conservation Area is approximately four times larger than the Control Site), we can see that predation in the Conservation Area actually diminished more than in the Control Site.

**Figure 14. Density of Hawaiian Petrel Predation/Burrow Trampling Recorded at Different Elevations in DKIST HCP Conservation Area from 2011 to 2016 on the Summit of Haleakala, Maui**

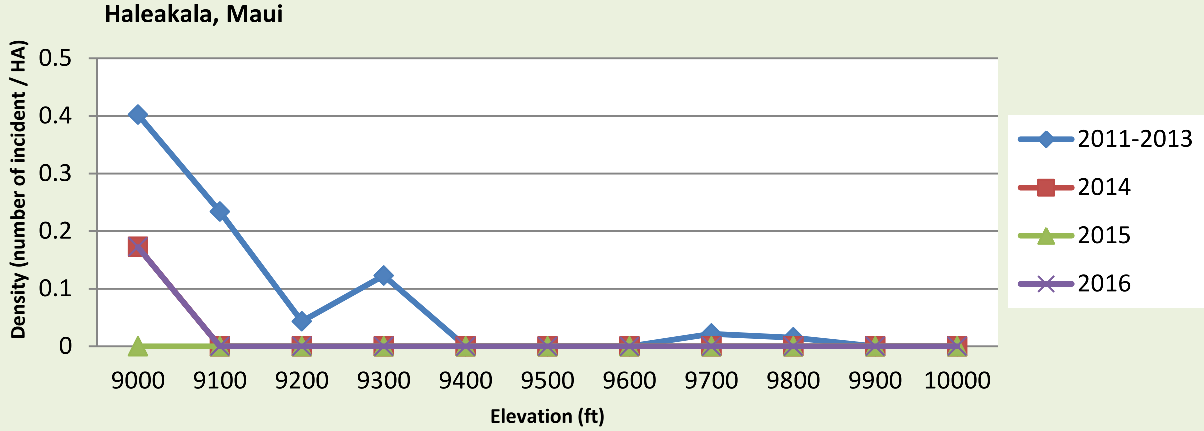
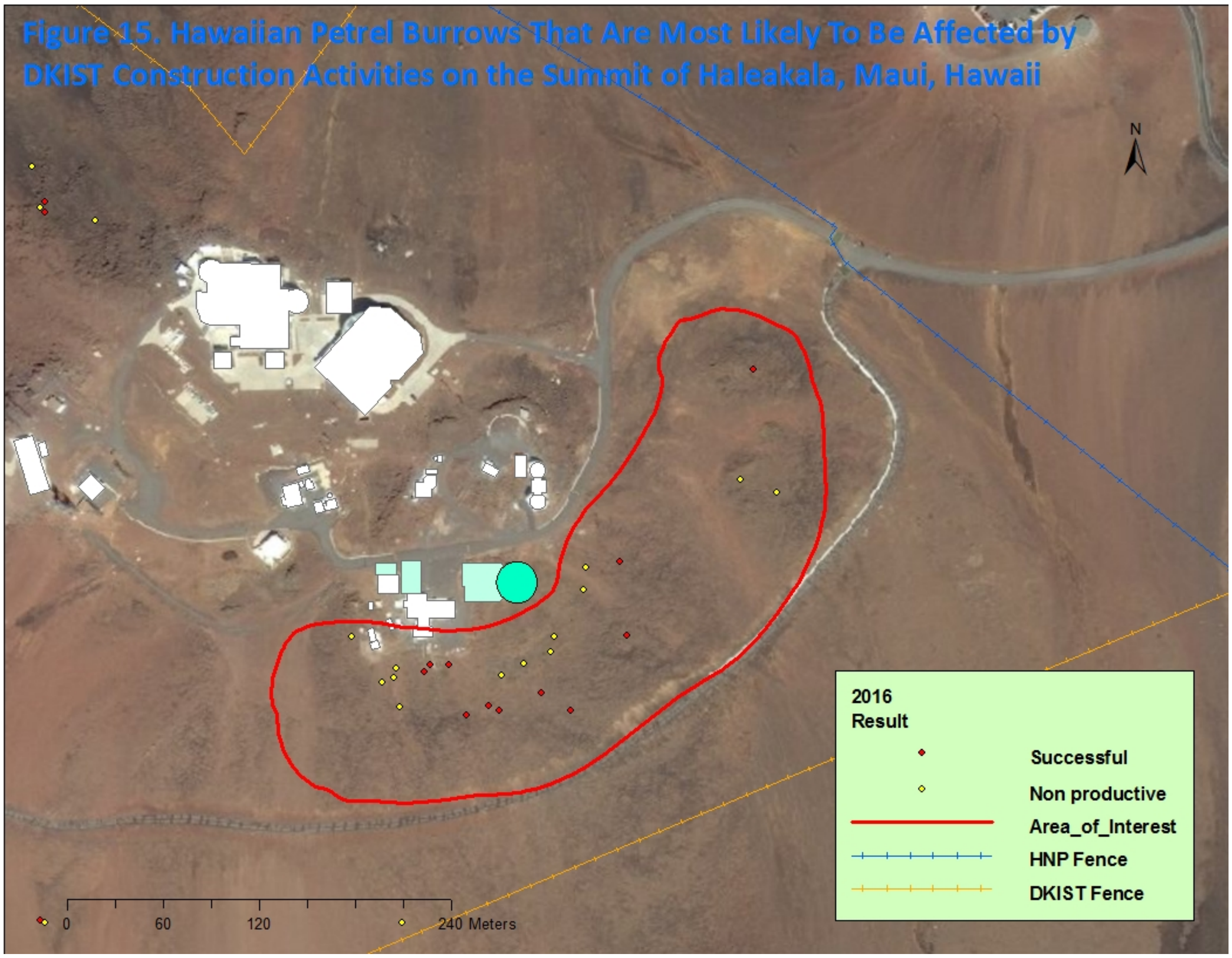



Figure 14 demonstrates the effectiveness of the conservation fence and predator control grid implemented in 2013 and completed in early 2014 in the Conservation Area; all predation events above 9,000 ft. were reduced to zero.

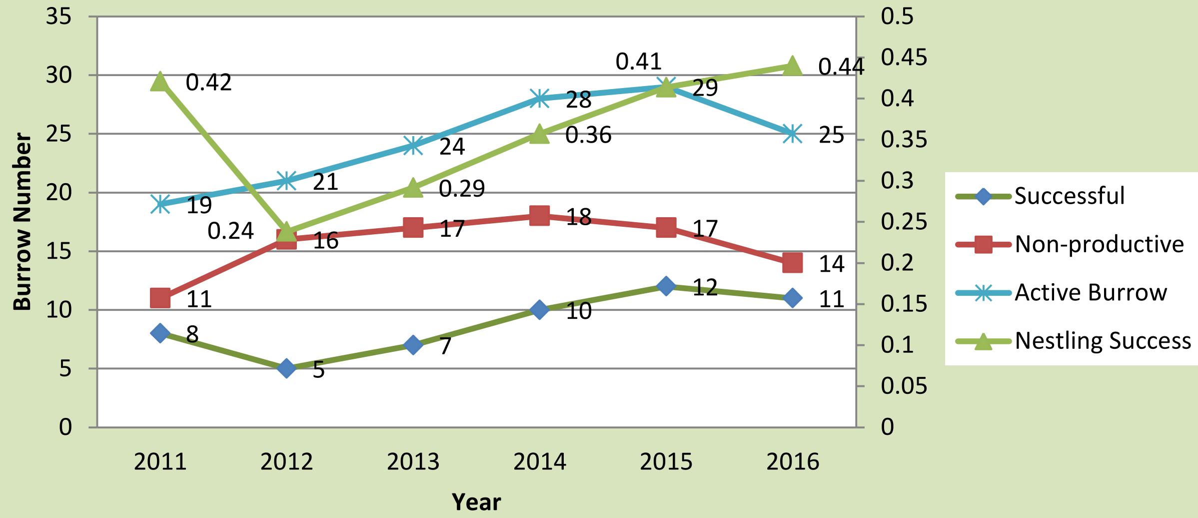
***VI D. Hawaiian Petrel Burrows Adjacent to the Construction Site***




Furthermore, in order to understand whether DKIST construction activities resulted in the decline of active Hawaiian Petrel burrow numbers, the trend of petrel burrow status and reproductive performance adjacent to the DKIST construction site was also examined (Figure 15). Active and successful burrows adjacent to the construction site continued to increase until plateauing in 2016 and Nesting Success % reached the highest point in 2016 (Figure 16). **It appears that DKIST construction activities have not deterred new petrels from coming to breed and nest in areas adjacent to the DKIST construction site, nor has it reduced the reproductive success of the petrels.**

Based on the trend of reduced predation events (which we was assume helped increase the number of active burrows (Figure 14), an increase in the active burrows adjacent to the DKIST site from 2011 to 2016 (Figure 16), and the fact that DKIST construction did not begin until December of 2012 after the 2012 petrel season was complete, it seems highly unlikely that the decrease noted in overall active burrow numbers from 2011 to 2013 (Figure 8) were related in any way to construction activities. The initial decline of active petrel burrows recorded in the larger DKIST HCP/BO monitoring area probably resulted from a combination of invasive predators, ungulates, and factors external to the breeding colonies.

**Figure 16. Number of Active Hawaiian Petrel Burrow Adjacent to DKIST Construction Site Recorded from 2011 to 2016, Near the Summit of Haleakala, Maui**




The data discussed in the sections above suggest some conclusions:

**1.** A reduced predation event density nearest to the DKIST construction site before and after construction began may have been the result of relatively high human activity intensity at the summit area, which may have reduced predator activities or predation frequency.

**2.** A trend of reduced predation/trampling was detected in both the Conservation Area and Control Site although it was not statistically significant due to a small sample size.

**3.** The implementation of the DKIST HCP conservation fence and predator control grid has greatly reduced the number of predation and trampling events in the predator impacted lower portion of the Conservation Area, even though no feral cats or mongooses were trapped.

**4.** It may be that DKIST construction has attracted additional breeding petrels to nests, and the dense rodent control grid installed in this area seemed to benefit petrel reproductive success.

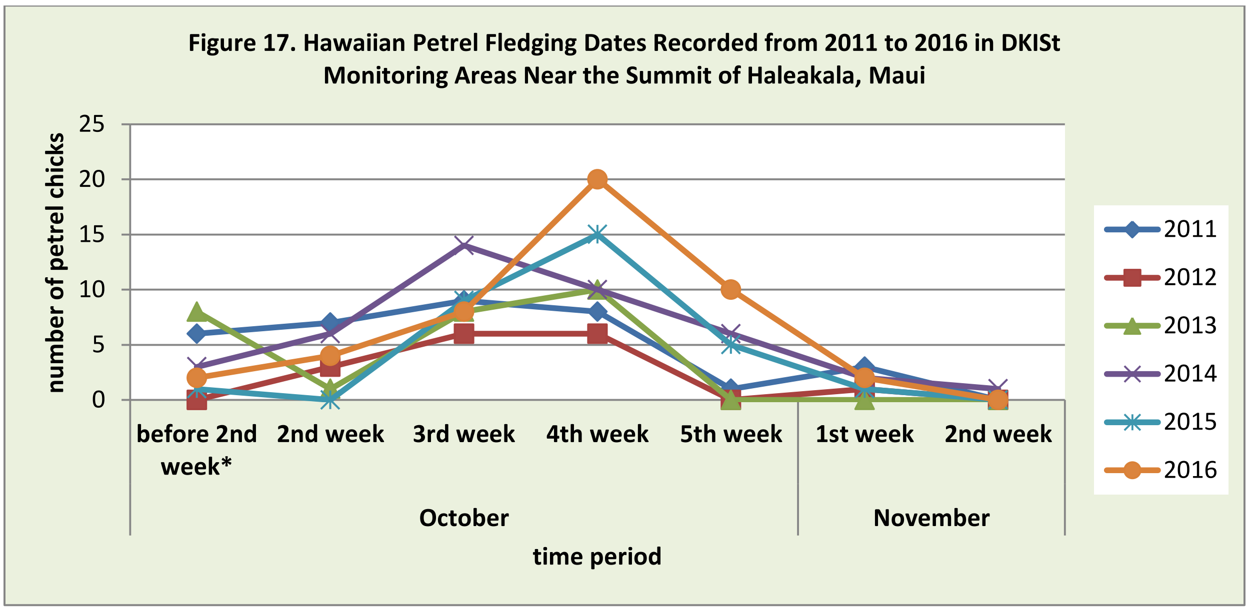
**5.** The type of petrel collision with DKIST construction structures of most concern to biologists prior to construction has not been observed since construction began in December of 2012. As the external construction activity nears its completion, the probability of such events will further diminish.

**6.** Due to the life history and home range of the Hawaiian Petrel, there are still variables that impact petrel mortality and reproductive performance that cannot be controlled or even influenced by DKIST HCP/BO conservation efforts. These include global weather changes, over- fishing of apex predator fish, plastic particles suspended in the marine ecosystem, etc. However, conservation efforts implemented under the DKIST HCP and BO are more likely to reduce predation effects that influence mortality and reproductive performance while petrels are present in the Conservation Area.

***VI E. Fledgling Dates***

<u>Historical Data:</u> During the three years of his study, Simon (1985) reported that the Hawaiian Petrel fledging period extends from October 8 to October 30. The median fledging dates were October 23, 1979 (±6.5 days), October 19, 1980 (±6.7 days), and October 19, 1981 (±6.1 days). To investigate the potential impacts of DKIST construction on fledgling dates, the resource management team has monitored chicks' first appearance outside active burrows and fledgling departures since 2011. Since the number of active burrows varies from year to year, the number of burrows being monitored by cameras also varies from year to year.

<u>Project Data:</u> Figure 17 presents the overall fledging departure dates from 2011-2016 in weekly intervals.




***2011 -2015***

- In 2011, 8 of the 17 burrows being monitored by cable connected surveillance cameras were successful. Based on the video recordings of the eight successful burrows around the Mees Observatory, the earliest fledging date was on October 19 and the latest date was on October 25 (median date: October 22).

- In 2012, 6 of the 18 burrows being monitored by cameras were successful. Based on the video recordings of the six successful burrows around the Mees Observatory, the earliest fledging date was on October 12 and the latest date was on October 19 (median date: October 17).

- In 2013, 7 of the 19 burrows being monitored by cameras were successful in fledging petrels. We also placed 16 camera traps at active burrow sites outside of the Mees Observatory area. Among these 16 additional camera traps, we recorded fledging dates at 10 burrows. Based on

17 image recordings, the fledging dates were between October 10 and October 24 (median date: October 19).

- In 2014, 10 of the 19 burrows being monitored by cameras were successful in fledging petrels. We also placed 39 camera traps at active burrow sites outside of the Mees Observatory area. Among these camera traps, the exact fledging dates at 25 burrows were recorded. The exact fledging dates at 3 burrows manually monitored were also observed. Based on 38 fledging date recordings, the fledging dates were between September 24 and November 09 (median date: October 17).

- In 2015, 11 of the 19 burrows being monitored by cameras were successful in fledging petrels, which is the highest number yet counted. We also installed 35 camera traps at active burrow sites outside of the Mees Observatory area. Among these camera traps, the exact fledging dates at 20 burrows were recorded (including 2 in the Control Site). Based on 31 fledging date recordings, the fledging dates were between September 29 and November 01 (median date: October 22).

The fledging dates collected from 2011 to 2015 were within the range of what Simons (1985) reported, suggesting that no impact on petrel fledging dates from DKIST construction activities could be detected.

***2016***

In 2016, 10 of the 20 burrows being monitored by cameras were successful in fledging petrels. We also installed 75 camera traps at active burrow sites outside of the Mees Observatory area (including 5 in the Control Site). Among these camera traps, the exact fledging dates at 39 burrows were recorded (one burrow was monitored by both systems). Based on 48 fledging date recordings, the fledging dates were between October 1 and November 02 (median date: October 19).

Similar to previous years and historical data; the recorded events of 2016 confirmed that Hawaiian Petrels begin fledging from their burrows during the latter part of September, as has been the case in previous breeding seasons. The 3rd and 4th weeks of October accounted for the largest number of fledged chicks. By the end of the 1st week of November, most chicks had already fledged and left the breeding colony.

Besides the successful petrel fledglings, DKIST also documented two petrel chicks still in their downy plumage that left their burrows as late as November 9, one could not be tracked in darkness, and the other one was found near the DKIST structure and died after arriving at the Maui Nui Seabird Recovery facility the next day due to malnutrition.

Based on the observed petrel fledging dates within our sites, **<u>the fledging timing pattern has been similar to that of Haleakalā National Park (HNP) data throughout the monitoring period, indicating that construction has not had an impact on the nesting cycle.</u>**

## VII. SUMMARY OF RESULTS

Petrel Collision: The DKIST team did not detect any Hawaiian Petrel collisions with any structures between June 7, 2011 and June 30, 2017, including DKIST-related structures that first appeared on site in December 2012.

Impact on Nesting Activity and Fledgling Success:

- No direct take of listed Hawaiian Petrel caused by DKIST construction activities and conservation measures implemented in the Conservation Area was recorded since monitoring started in the summer of 2011.
- No adverse impacts were statistically detected on Hawaiian Petrel Nesting Activity and percentage of Nesting Success that resulted from DKIST construction activities and conservation measures implemented in the Conservation Area.
- The number of active and successful burrows increased adjacent to the DKIST construction site (around Mees Observatory) until 2015 with a small decline in 2016.
- The Control Site has very limited utility for comparison with the Conservation Area. Each has a different quality of Hawaiian Petrel breeding habitat such that even before construction began and mitigation measures were in place, burrow density and nesting success rates in the Conservation Area were four to five times higher. Additionally, we cannot assess whether the DKIST conservation fence and predator/rodent control grids have promoted recovery for the Hawaiian Petrel in the Conservation Area or assess population trends in comparison to the Control Site, because the sample size of active/successful burrows in the Control Site is too small for statistical comparisons.
- Thus far, the largest number of active and highest density of active burrows, were recorded in 2015.
- To date, the highest nesting success rate and density were recorded in 2016.
- The active and successful burrow density increased at the lower boundary area after the predator grid was fully installed in 2014.
- Compared to "Nesting Success %" before mitigation measures were installed in 2011-12, Hawaiian Petrel "Nesting Success %" increased by 75.4% after the DKIST HCP was fully implemented (2014-2016) in the Conservation Area.
- The annual number of petrel chicks successfully fledged from the Conservation Area increased by 69.4% after DKIST conservation measures implementation was completed.
- DKIST HCP increased the number of successful Hawaiian petrel fledglings between 2014 and 2016 by 50 after the mitigation measures were installed.

All of the above have demonstrated that thus far, DKIST construction activities seem to have no adverse impact on petrel reproductive performance in this area, and in 2014 to 2016 DKIST conservation measures were likely aiding petrels in high predator impact areas in the lower part of the Conservation Area.

Predation Mortality:

It appears that DKIST mitigation measures have helped reduce predation mortality by 90.5% within the Conservation Area and reduced the total predation mortality number by 4.5 eggs, 10 chicks and 4 adult petrels from 2014 to 2016.

Fledging Dates:

No obvious fledging date deviation could be detected in the last five years. An extended fledging period in 2014 was recorded; this might be due to higher nesting success observed in the Conservation Area.

Measuring Net Benefit:

Although the implementation of DKIST HCP/BO mitigation measures has demonstrated increased "Percent of Nesting Success", more successful fledglings and lowered predation rate (or less individuals being predated), both "Nesting Activity Percent" and "Percent Nesting Success " or the density of both indexes could be greatly affected by variables that occur outside of petrel breeding colonies, such that over the long term, conservation measures implemented in the DKIST Conservation Area can only reliably reduce predation, not eradicate it completely. Given that the ungulate fence is not predator—proof, ingress by predators will continue. Since sufficient burrow sites and breeding pairs already exist inside the Conservation Area, predation reduction may be DKIST's greatest benefit to the Hawaiian Petrel population sustainability thus far. Ultimately, using the density of predation incidents might be a more objective approach to measuring DKIST's Net Recovery Benefit.

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