# Kaheawa Wind Power I
# Habitat Conservation Plan
# Annual Report: FY 2016


Kaheawa Wind Power I, LLC
3000 Honoapiilani Highway
Wailuku, Hawaii 96768

August, 2016

ITL-08 and ITP TE118901-0

I certify that to the best of my knowledge, after appropriate inquiries of all relevant persons involved in the preparation of this report, the information submitted is true, accurate and complete.

Mitchell Craig

Hawaii HCP Manager
SunEdison, LLC

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## *Executive Summary*

Kaheawa Wind Power I, LLC (KWPI) has been implementing a Habitat Conservation Plan (HCP) since January 2006. KWPI is currently owned by Terraform Power, LLC and operated by SunEdison, LLC. The HCP supports the federal Incidental Take Permit TE-118901-0 and Hawai`i Incidental Take License ITL-08. KWPI was commissioned to begin operating on June 22, 2006. Species covered under the HCP include the Hawaiian petrel (HAPE), Newell's shearwater (NESH), Hawaiian goose (HAGO or nēnē), and Hawaiian hoary bat (LACI). This report is for the tenth full year of operations and State of Hawaii Fiscal Year (FY) 2016; July 1, 2015 through June 30, 2016. KWPI has previously submitted annual HCP progress reports for FY 2007 through FY2015 to the U.S. Fish and Wildlife Service (FWS) and the Hawai`i state Division of Forestry and Wildlife (DOFAW). The ITL and ITP were amended to add LACI take in FY 2016.

Beginning April 2015 the downed wildlife search area is reduced relative to the previous nine years and now consists of graded roads and WTG pads found within a 70m radius circle centered on each turbine. Teresa Gajate was contracted beginning October 2015 to conduct canine-assisted searching, with visual searching as a secondary method. During FY 2016, the search interval mean and standard deviation (SD) in days was 6.98 (SD = 0.93).

Of the HCP covered species only one nēnē fatality was observed during FY 2016. The total estimated direct take at the 80% credibility level for KWPI HCP covered species is 38, 29 and 13 adults for nēnē, LACI and HAPE, respectively. Indirect take for nēnē is three, for LACI is five, and for HAPE is ten. Lost future productivity accrued for HAPE is 7.4 fledglings. Thirty-two nēnē fledglings have been produced at the Haleakala Ranch pen through FY 2016, including eight in FY 2016. Considering fledglings produced and accounting for indirect take and accrued lost future productivity the net adult nēnē still to be mitigated for is 12.

Independent contractor Kristin Mack conducts searcher efficiency trials (SEEF) trials at KWPI throughout the fiscal year. The mean SEEF for large, medium, and small carcasses was 100% (N = 10), 100% (N = 10), 94.9% (N = 39), respectively.

In four carcass retention (CARE) trials a total of four chickens, four wedge-tailed shearwaters (WTSH), and 21 rats were used. Considering the first 14 days of the 28-day long trials the CARE mean and SD for each size class in days were 14.0 for chicken (SD = 0), 12.3 for WTSH (SD = 3.5) and 10.4 for rats (SD = 4.7).

Wildlife Acoustics SM2BAT+™ bat detectors with one SM3BAT™ microphone each recorded detections at all nine WTG associated ground locations during 10% (243 of 2426) of the total detector nights. Wildlife Acoustics SM3BAT™ bat detectors with one SM3BAT™ microphone each recorded detections at each of the seven nacelle WTG locations during 16% (279 of 1744) of the total detector nights.

A total of 40 site personnel received Wildlife Education and Observation Program (WEOP) trainings in FY 2016 including a refresher for all regular staff.

Vegetation management of the search plots for FY 2016 treated 30.25 acres of total plot area using hand- held weed whackers, and herbicide.

Seabird baseline mitigation for KWPI continues at the Makamaka'ole Seabird Enclosures and currently focuses on trapping and monitoring for potential predators, maintenance of enclosure fences, erosion control and monitoring seabird activity within the Makamaka'ole Stream drainage area and near artificial burrows within the enclosures. Alternative seabird mitigation site surveys began in East Maui in FY 2015 and were completed in FY 2016. Additional HAPE mitigation intended to reduce the loss of productivity accruing from HAPE take not yet mitigated for has been arranged with the FWS and Pulama Lanai and funds provided to a dedicated account with the National Fish and Wildlife Foundation (NFWF). The minor modification to authorize additional bat take and the associated mitigation proposal was approved October 19, 2015 and January 20, 2016 by the FWS and DOFAW, respectively. Nēnē baseline mitigation continued in FY 2016 at the Haleakala Ranch pen. LACI baseline mitigation is complete and Tier 2 mitigation is being planned.

Regular agency and Endangered Species recovery Committee (ESRC) meetings occurred in FY 2016. KWPI also provided quarterly summaries for FY 2016 Q1, Q2 and Q3.

## *Definitions*

| | |
|---|---|
| CARE | Carcass Retention Trial |
| DLNR | Department of Land and Natural Resources |
| DOFAW | Department of Forestry and Wildlife |
| ESRC | Endangered Species Recovery Committee |
| FWS | United States Fish and Wildlife Service |
| FY | Fiscal Year |
| HAGO | Hawaiian Goose (*Branta sandvicensis)* |
| HAPE | Hawaiian Petrel (*Pterodroma sandwichensis*) |
| HCP | Habitat Conservation Plan |
| ITL | Incidental Take License |
| ITP | Incidental Take Permit |
| KWP | Kaheawa Wind Power |
| LACI | Hawaiian Hoary Bat (*Lasiurus cinereus semotus)* |
| Met tower | Meteorological tower |
| NESH | Newell's Shearwater (*Puffinus newelli*) |
| NFWF | National Fish and Wildlife Foundation |
| SEEF | Searcher Efficiency Trial |
| SEOW | Hawaiian Short Eared Owl (*Asio flammeus sandwichensis*) |
| WTG | Wind Turbine Generator |

## *Introduction*

In June 2006 Kaheawa Wind Power, LLC (KWPI) began operating the island of Maui's first commercial wind energy generation facility in the Kaheawa Pastures area of West Maui. The State Board of Land and Natural Resources approved a Conservation District Use Permit (CDUP) for the facility, which is situated on state conservation lands, in January 2003.

In fulfillment of the Endangered Species Act and Chapter 195-D, Hawai`i Revised Statutes, KWPI developed a project-specific Habitat Conservation Plan (HCP) in cooperation with the U.S Fish and Wildlife Service (FWS), the Department of Land and Natural Resources- Division of Forestry and Wildlife (DLNR-DOFAW) and the Hawai`i Endangered Species Recovery Committee (ESRC). Upon final approval of the HCP, the federal ITP (TE-118901-0) and state ITL (ITL-08) were issued in January 2006, each with a duration of twenty years. The ITP and ITL cover four federally-listed and endangered species: the Hawaiian petrel or 'Ua'u (*Pterodroma sandwichensis*), Newell's shearwater or 'a'o (*Puffinus newelli*), Hawaiian goose or nēnē (*Branta sandvicensis*), and the Hawaiian hoary bat or 'ope'ape'a (*Lasiurus cinereus semotus*).

This report summarizes HCP related activities for KWPI during the tenth year of project operations (July 1, 2015 through June 30, 2016).

## *Downed Wildlife Monitoring*

Since operations began, KWPI biologists have been implementing a year-round monitoring program to document downed (i.e., injured or dead) wildlife incidents involving HCP-listed and non-listed species on the project site and in its vicinity. Systematic searches have been conducted on foot within plots centered on the wind turbine generators (WTGs). Beginning in April 2015, after the ESRC gave its approval at the March 31, 2015 public meeting, the search plots were reduced in size relative to the size of the plots searched prior to April 2015. Reduced area searched weekly included only roads and graded WTG pads found within a 70m radius circle centered on each WTG (Figure 1, Appendix 1). This reduced search area makes up approximately 29.6% and 39.6% of the hypothesized total fall distribution of nēnē and LACI (Appendix 1).

The search interval mean and SD in days for the reduced area monitoring was 6.98 (SD = 0.93) (Table 2 and Appendix 2). For the safety of the KWPI technical staff, monitoring is halted during periods when wind speeds are reported higher than 15 meters per second (m/s). During FY 2016 no monitoring schedule interruptions occurred.

Teresa Gajate and her canine Makalani provided canine-assisted searching in FY2016 beginning in October 2015. Canine-assisted searching was the primary search method, with visual searching secondary. In FY 2016 60.9% (N = 635) of WTG searches were canine-assisted and 39.1% (N = 407) were visual (Appendix 3). Canine-assisted searches were postponed or skipped in favor of visual searches if nēnē were present at the turbine or if turbine repairs necessitated. The presence of nēnē halted eight WTG searches.

On April 2$^{nd}$ and April 4$^{th}$ met tower one and two, respectively, were removed by site personnel (Figure 1). Just prior to the met tower removals the area around each met tower out to twice the height of the met tower was searched. No wildlife was found during the searches and the towers were removed without incident. Research from the mainland suggests medium height (116-132m) guyed met towers are associated with a risk to avian species (Gehring *et al.* 2011). At KWPI the two met towers removed were each less than 60m high. In nine years of monitoring only one fatality was recorded (Unknown species, bones only, on 1/30/2013) associated with a met tower but not determined unequivocally to have been caused by collision with the met tower. The monitoring data indicates that small met towers present a very minimal risk to the avian species present at Kaheawa wind. A number of factors may play a role in the reduced risk relative to the Gehring *et al.* (2011) study including: short height of met towers relative to communication towers; the lack of flocking, migratory songbirds in Hawaii; and the absence of lighting on the towers.

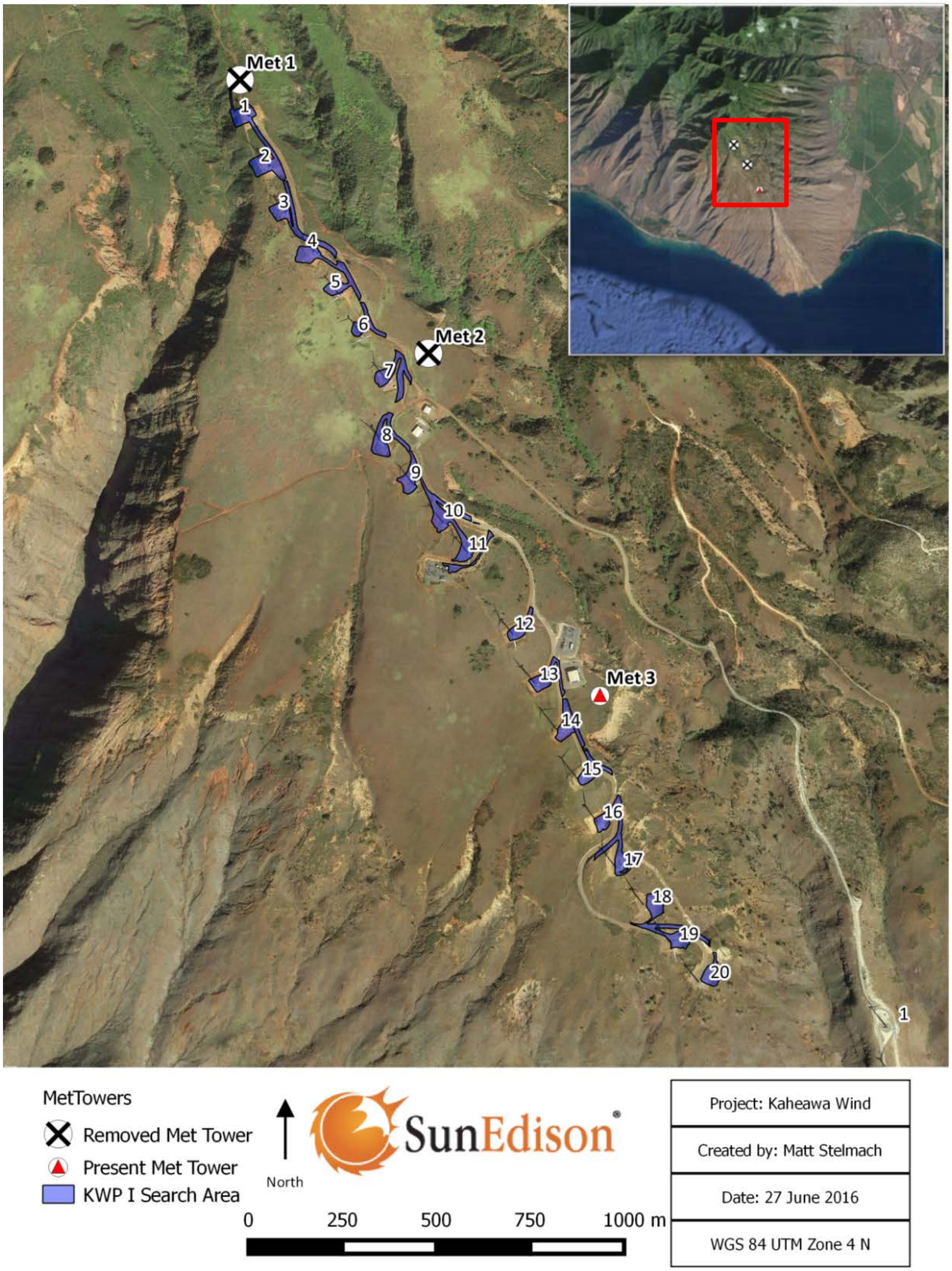


**Figure 1. Met towers 1 and 2 were removed in August 2016. Met tower 3 adjacent to the BESS and turbine 14 is the only remaining met tower at KWPI.**

**Table 1. Search interval mean and standard deviation (SD) in days per WTG plot on KWPI FY 2016.**

| WTG | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 6.98 | 6.98 | 6.98 | 6.98 | 6.98 | 6.98 | 6.98 | 6.98 | 6.98 | 6.98 |
| SD | 0.73 | 0.73 | 0.78 | 0.73 | 0.73 | 0.75 | 0.75 | 0.73 | 0.80 | 0.75 |
| **WTG** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| Mean | 6.98 | 6.98 | 6.98 | 6.98 | 6.98 | 6.98 | 6.98 | 6.98 | 6.98 | 6.98 |
| SD | 0.75 | 0.75 | 0.80 | 0.75 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 |

| | |
|---|---|
| **Mean TOTAL** | **6.98** |
| **SD TOTAL** | **0.93** |

## ***Downned Wildlife Incidents***

Downed wildlife incidents documented at KWPI during FY 2016 are summarized in Table 2. Locations of fatalities found with reference to WTGs and site facilities are displayed in Figure 2. One of these incidents involved HCP covered species: one Hawaiian goose; and three were of a species of concern (Hawaiian short-eared owls). Four incidents involved Migratory Species Treaty Act (MBTA) protected species; two white-tailed tropicbirds and two Eurasian skylarks. These were reported to DOFAW and FWS within 24 hours. Details of all HCP-covered, species of concern, and MBTA protected fatalities were provided in Downed Wildlife Incident Reports submitted to DOFAW and FWS within three days of each discovery.

**Table 2. Downed wildlife incidents in FY 2016.**

| Common Name | Discovery Date | Turbine | Distance to nearest structure(m) |
|---|---|---|---|
| **Endangered, Species of Concern, and MBTA** | | | |
| **Hawaiian Goose** | 1/19/2016 | 14 | 34 |
| **Hawaiian short-eared owl** | 9/28/2015 | 8 | 34 |
| **Hawaiian short-eared owl** | 10/19/2015 | 7 | 87 |
| **Hawaiian short-eared owl** | 12/8/2015 | 19 | 62 |
| **Eurasian Skylark** | 9/8/2015 | 10 | 2 |
| **Eurasian Skylark** | 4/12/2016 | 14 | 30 |
| **White-tailed Tropicbird** | 7/31/2015 | 4 | 22 |
| **White-tailed Tropicbird** | 3/1/2016 | 8 | 50 |
| **Non-Listed** | | | |
| **Black Francolin** | 4/12/2016 | 6 | 74 |
| **Black Francolin** | 5/18/2016 | Other | 260 |
| **Black Francolin** | 5/31/2016 | 14 | 1 |
| **Black Francolin** | 6/1/2016 | 10 | 15 |
| **Gray Francolin** | 4/26/2016 | 19 | 2 |
| **Gray Francolin** | 5/10/2016 | 4 | 1 |
| **Nutmeg Mannikin** | 2/9/2016 | 3 | 1 |
| **Ring-Necked Pheasant** | 8/25/2015 | 18 | 1 |
| **Ring-Necked Pheasant** | 10/7/2015 | Other | 100 |
| **Ring-Necked Pheasant** | 3/29/2016 | 18 | 1 |
| **Ring-Necked Pheasant** | 5/27/2016 | 7 | 1 |
| **Unknown** | 10/19/2015 | 7 | 94 |

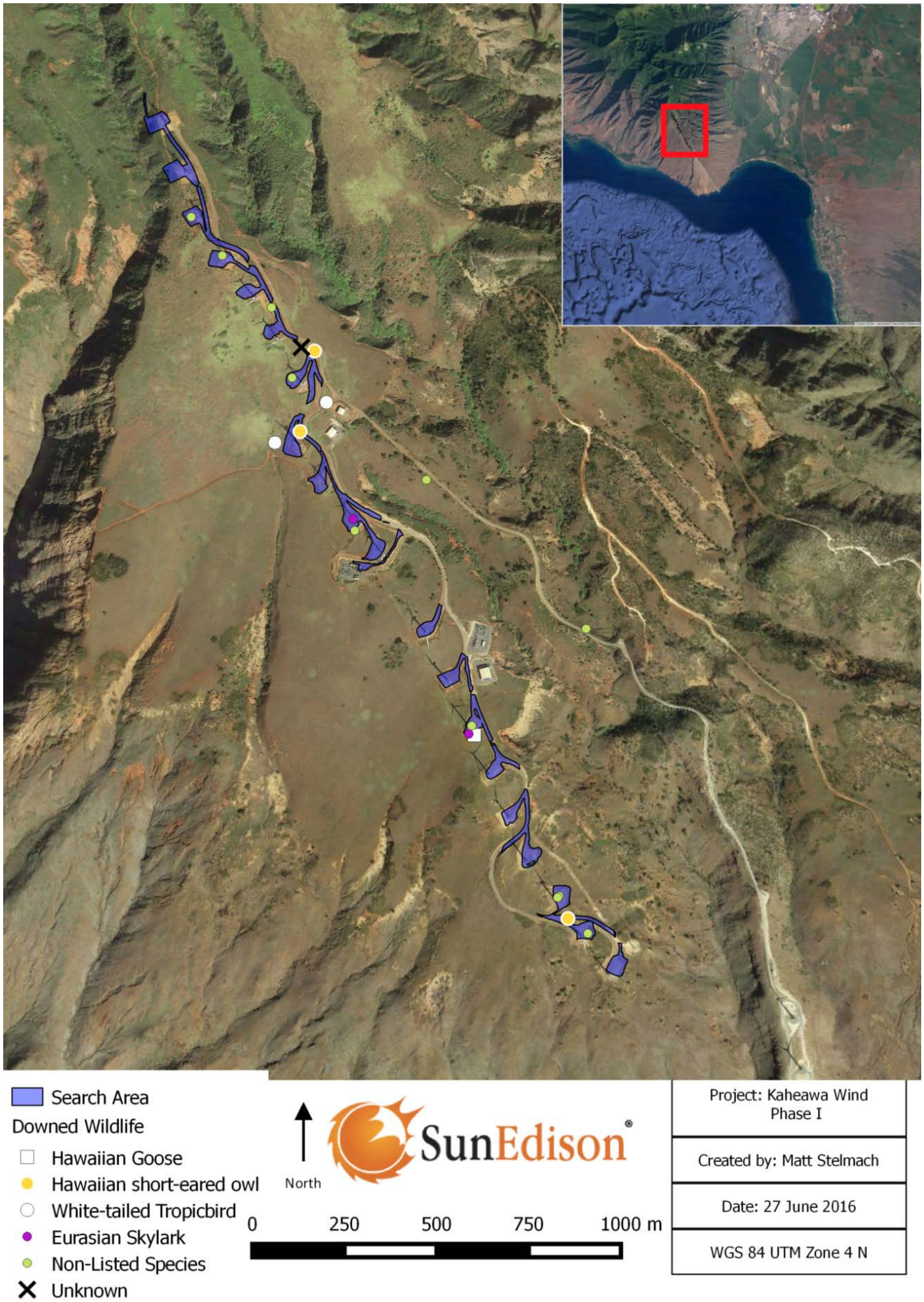


**Figure 2. All downed wildlife observed in FY 2016 throughout KWPI in reference to WTGs.**

## *SEEF and CARE Study*

### ***Searcher Efficiency Trials (SEEF)***

In FY 2016, independent contractor Kristin Mack (SEEF proctor) was chosen to proctor SEEF trials. The SEEF proctor used randomly selected points within the reduced search area for SEEF locations. The schedule was pre-determined by week and unavailable to on-site staff. On site staff would coordinate the search schedule with the SEEF proctor to ensure SEEFs were put out on scheduled search days. At the end of each search day on-site staff would communicate what was found to the SEEF proctor. If any SEEF carcasses were missed a different on-site staff member who did not participate in the searches for the day (typically the HCP manager) would attempt to recover the carcass and report the results to the SEEF proctor.

For the KWPI searcher efficiency trials a total of 60 carcasses were placed; 40 rat, 10 WTSH, and 10 chickens (Appendix 4). The mean SEEF for large, medium, and small carcasses was 100% (N = 10), 100% (N = 10), 94.9% (N = 39), respectively (Table 3 and 4).

**Table 3. Overall searcher efficiency results for FY 2016.**

| SEEF Results FY 2016 | | | | |
|---|---|---|---|---|
| Carcass type | **Count** | **Avg** | **Included** | **Notes** |
| **Large Bird** | 10 | 100.0% | True | |
| **Med Bird** | 10 | 100.0% | True | |
| **Rat** | 1 | 0.0% | False | Placed outside of the search area |
| **Rat** | 39 | 94.9% | True | |

**Table 4. Searcher efficiency by carcass size and search type.**

| SEEF Results | | | |
|---|---|---|---|
| Search Type | **Carcass type** | **Count** | **Avg** |
| **Canine** | Large Bird | 8 | 100.0% |
| **Canine** | Med Bird | 7 | 100.0% |
| **Canine** | Rat | 25 | 96.0% |
| **Human** | Large Bird | 2 | 100.0% |
| **Human** | Med Bird | 3 | 100.0% |
| **Human** | Rat | 14 | 92.9% |

### ***Carcass Retention Trials (CARE)***

CARE trials are used to estimate how long a carcass remains detectable by searchers before complete removal or obscuring by scavengers. Trials proctored by site staff were conducted using Rhode Island crossed chickens as surrogates for nēnē, Wedge-tailed shearwaters for HAPE and NESH, and commercially produced rats for LACI. The chickens were from Maui farmers. WTSH carcasses are generally fledglings and adults found dead by the public and delivered to Sea Life Park on Oahu or collected by DOFAW on Maui. Our state and federal wildlife collection permits for KWPI are numbers WL 15-05 and MB24151B-0, respectively.  Rat carcasses were purchased from Layne Laboratories, Inc. in California, a pet food company.  These rats are brown and/or black and are the Layne Laboratory "Small Colored" size category (approximately 11.3 cm in body length) and were chosen to mimic body size of Hawaiian hoary bats (Figure 3).

During FY 2016, CARE trials used four chickens, four WTSH, and 21 rats (Appendix 5).   All trials were for 28 days.  Fatality estimates use the data as it has been collected (28 day trials).   Considering the first 14 days of the trials to compare current CARE trials to trials in the past the CARE mean and SD for each surrogate in days were 14.0 for chicken (SD = 0), 12.3 for WTSH (SD = 3.5) and 10.4 for rats (SD = 4.7) (Table 5).

**Table 5. Carcass retention trial results for FY 2016, considering only the first 14 days.**

| CARE Statistics FY 2016 | | | |
|---|---|---|---|
| Carcass Type | **Count** | **Average Maximum Days** | **SD Days** |
| **Wedge-tailed Shearwater** | 4 | 12.3 | 3.5 |
| **Rat** | 21 | 10.4 | 4.7 |
| **Chicken** | 4 | 14.0 | 0 |

**Figure 3.  Hawaiian hoary bat and rat surrogate for CARE and SEEF trials.**

## *Canine Interactions with Wildlife*

Special precautions are taken to limit any canine interaction with wildlife.  The handler is directed to immediately call back Makalani if nēnē were observed and to skip turbines if nēnē were present within the turbine search area or vicinity.  Skipped turbines would be preferentially searched later the same day or next day with the canine search team or alternatively visually searched. Throughout the searches no canine wildlife interactions were observed. An example of the canine search pattern and effort is shown in Figure 4.

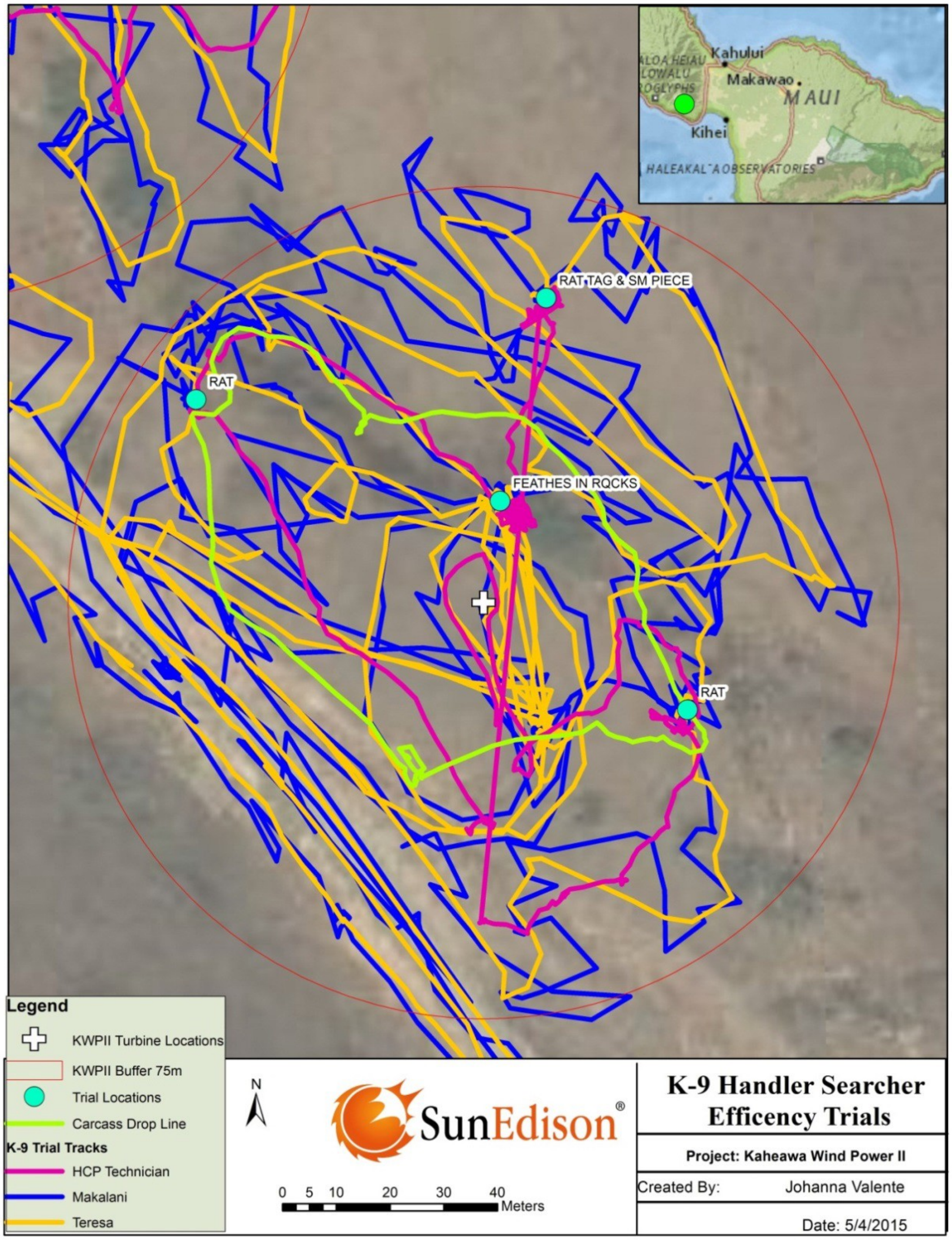


**Figure 4. Makalani's tracks associated with his SEEF detections and the locating a Eurasian Skylark carcass on February 10, 2015 found at KWPII WTG-13.**

## *Scavenger Trapping*

A predator trapping program was re-initiated in August 2015. Trapping included; seven DOC250™ body grip traps, and seven cage traps (Figure 5). During FY 2016, 19 mongoose, two rats and one cat were caught using the approved trapping protocol and monitoring frequency (Table 6).

Trapping is intended to decrease scavenging of carcasses used in CARE trials and also of any downed wildlife, and should have the added benefit of improving nēnē fledgling survival and nesting success. All traps were designed to minimize inadvertent interaction with nesting birds (Figure 6). One black francolin was trapped inside a cage trap and apparently died of exposure.

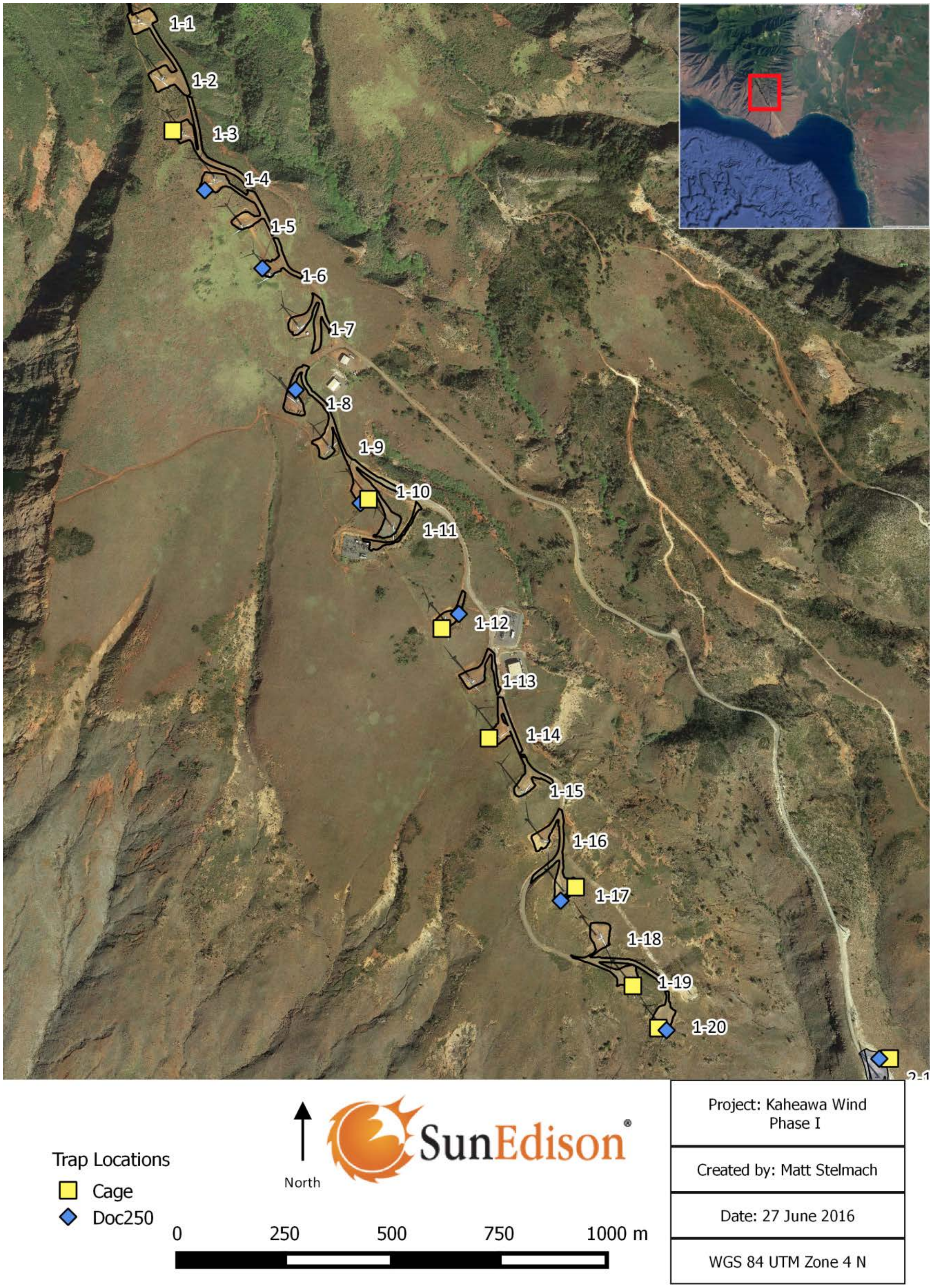


**Figure 5. Location of KWPI predator traps.**

**Figure 6. DOC-250 trap encased in a "bird-safe" box with arrows pointing to the 2 separate entrances that must be negotiated to access and trigger the trap mechanism itself.**

**Table 6. KWPI trapping and monitoring protocol.**

| Trap Type | Species Targeted | Monitoring Frequency | Frequency of Baiting/Re-setting | Frequency of Cleaning and Re-locating |
|---|---|---|---|---|
| DOC 250 | Mongoose, Rat | Weekly | Weekly | Minimum 1x per 3 months |
| Cage | Cat, Mongoose | 24 Hours | 2-7 Days | Minimum 1x per 3 months |

## *Estimating Adjusted Take*

Of the HCP covered species only one nēnē fatality was observed during FY 2016. The total observed take through FY 2016 for each HCP covered species is 22 nēnē, seven HAPE, eight LACI and no NESH. The estimators used in this report were developed by USGS (Huso *et al.* 2015) and have been recommended by DOFAW and FWS. The estimator's output is a value that represents the number of fatalities that has not likely been exceeded during the survey period. Values can be generated for varying levels of "credibility" (confidence), expressed as a percentage (e.g., 50%, 80%, etc.) - the higher the desired level of credibility, the more conservative (higher) the estimated value. At the request of FWS the more conservative 80% credibility level is reported.

The total estimated take at the 80% credibility level for KWPI HCP species is 38, 13 and 29 adults for nēnē, HAPE and LACI, respectively (Appendix 6). Observed take is the only take that has been documented and confirmed at the site. However, for the purposes of estimating potential take for permitting and mitigation, the estimator accounts for additional take that may have occurred but that was not observed. This "unobserved take" attempts to account for fatalities that may have fallen outside of search plots, were missed by searchers, or were removed by scavengers or environmental factors such as high winds.

Indirect take is the possible or known take of offspring that have been negatively affected by the direct take of their parents. Indirect take can be from observed or unobserved direct take. Both parents of nēnē and the two seabirds exhibit equal responsibility for care of young until fledging while only the female LACI cares for their offspring. All four covered species have seasonal breeding periods as described in the KWPI HCP. The point during the breeding season when an adult is taken determines to what extent the offspring is affected (i.e. the chance of survival of an offspring without one or both parents may vary during the season).

Indirect take caused by observed take is calculated for take of female LACI or LACI of unknown sex found between April 1 and September 15. Indirect take estimated from unobserved LACI take is calculated assuming half of the unobserved take would be female and that for each female there is an average probability that she would be pregnant or lactating for three months in a year. Bats fly through the project area throughout the year and the probability of an individual female bat having dependent young during a 12 month period is assumed to be 25% (three out of 12 months). The average period of dependence is based on the information that Hawaiian hoary bats have one brood a year, and that hoary bats in North America have an average 56 day gestation period followed by parental care to weaning averaging 34 days or approximately three months in total (Hayssen *et al.* 1993, Hayes and Wiles 2013, and NatureServe 2015 for *Lasiuris cinereus*). There is not enough information for hoary bats from Hawaii to determine the gestation and pre-weaning dependent period. Consequently, indirect take is assessed to bats lost through "unobserved direct take" at the rate of 0.225 juveniles/bat (0.5 x 0.25 x 1.8 = 0.225). For KWPI two female LACI and three LACI whose sex has not yet been determined were observed during the breeding period since 2006. The sex of all LACI found during the breeding period will be determined in FY 2017 and indirect take recalculated if necessary. Indirect take from observed and unobserved take of LACI is five adult bats (from juvenile indirect take estimated to survive to adult)(Appendix 7).

Indirect take and accrued lost productivity for nēnē and HAPE are detailed in Appendix 8 and 9 and the calculation depends on when the adult take was observed. Indirect take for nēnē and for HAPE is three and 10, respectively. Thirty-two nēnē fledglings have been produced at the Haleakala Ranch pen through FY 2016, including eight in FY 2016. Considering fledglings produced and accounting for indirect take and annual lost future productivity the net adult nēnē still to be mitigated for is 12 (Appendix 8). Nēnē fatalities occurring before 2011 are not included in the lost productivity assessment (May 20, 2014 meeting notes). These fatalities are not included since the pen intended for mitigation was not available to introduce nēnē goslings prior to 2011. Accrued lost future productivity for HAPE and nēnē is 7.37 and 1.92 fledglings, respectively (Appendix 8 and 9).

## *Hawaiian Hoary Bat (LACI) Monitoring*

In order to better understand variations in LACI activity, specifically near the WTGs, we have operated nine Wildlife Acoustics SM2BAT+ ™ detectors with one microphone (mic) since October 2013 throughout KWPI. Prior to October 2013 Titley Anabat™ acoustic detectors had been deployed. All of the SM2BAT+ ™ use SM3BAT™ mics mounted at 6.5 meters height. Eight are placed near the WTGs and one was placed near a gulch edge; each mic is positioned horizontally, pointing SW (away from the prevailing NE trade winds). In addition to the ground units a total of seven Wildlife Acoustics SM3BAT™ detectors were deployed in January 2015 in nacelles equipped with one mic pointing backwards and parallel to the top of the nacelle at 68m height. These seven SM3BAT's were deployed as an adaptive management measure to attempt to better understand LACI activity patterns.

In FY 2016 detectors recorded LACI activity at all nine ground locations during 10% (243 of 2426) of the total detector nights and at the seven nacelle WTG locations during 16% (279 of 1744) of the total detector nights (Table 7, Figures 7 and 8). Activity distinctly peaks before 2300 hours and gradually declines towards morning for both ground and nacelle units (Figure 9).

A portion of the data from 1 July – 4 August was lost due to storage media failure. Therefore this data and time period is excluded from analysis. Data for June was collected on June 16 and reflects data up to that date.

**Table 7. Hawaiian hoary bat nights with detections and total detection nights at KWPI in FY 2016.**

| Detector Location (WTG) | Total Detector Nights | Total Detector Nights with Activity | % Detector Nights with Activity/Total Detector Nights |
|---|---|---|---|
| | | **Ground Detectors** | |
| **1** | 286 | 19 | **6.6%** |
| **3 (Gulch)** | 251 | 55 | **21.9%** |
| **5** | 286 | 32 | **11.2%** |
| **8** | 286 | 20 | **7.0%** |
| **10** | 280 | 21 | **7.5%** |
| **13** | 286 | 32 | **11.2%** |
| **15** | 235 | 26 | **11.1%** |
| **16** | 286 | 16 | **5.6%** |
| **20** | 230 | 22 | **9.6%** |
| Totals | **2426** | **243** | **10.0%** |
| | | **Nacelle Detectors** | |
| **1** | 267 | 53 | **19.9%** |
| **4** | 255 | 45 | **17.7%** |
| **6** | 280 | 38 | **13.6%** |
| **9** | 251 | 32 | **12.8%** |
| **13** | 201 | 10 | **5.0%** |
| **16** | 240 | 81 | **33.8%** |
| **20** | 250 | 20 | **8.0%** |
| Totals | **1744** | **279** | **16.0%** |

***LACI Nightly Presence by Month in FY 2016***

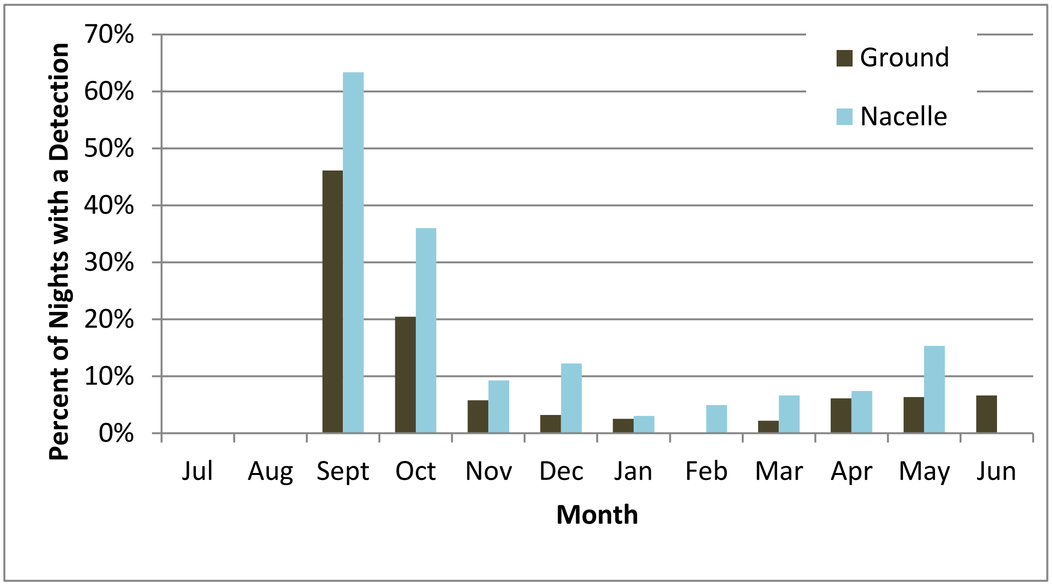


**Figure 7. LACI nightly presence at KWPI by month in FY 2016.**

***LACI Nightly Presence by WTG in FY 2016***

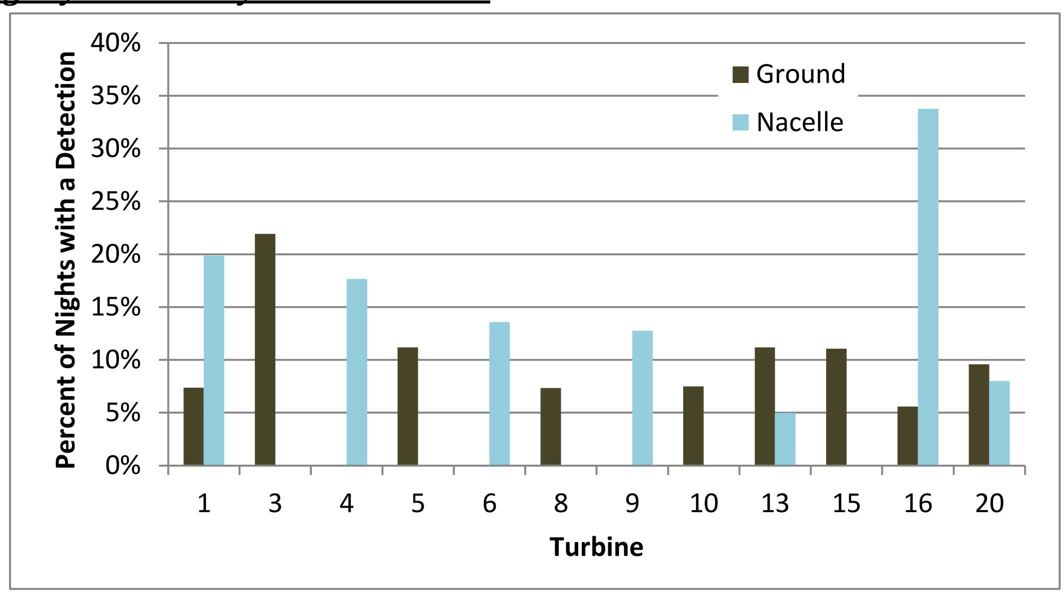


**Figure 8. LACI nightly presence by turbine (WTG) during FY 2016 (these locations range from the highest elevation on the left (WTG-1) and lowest on the right (WTG-20)). WTG 1, 13, 16 and 20 have both ground and nacelle detectors.**

### ***LACI Detections by Night Hour in FY 2016***

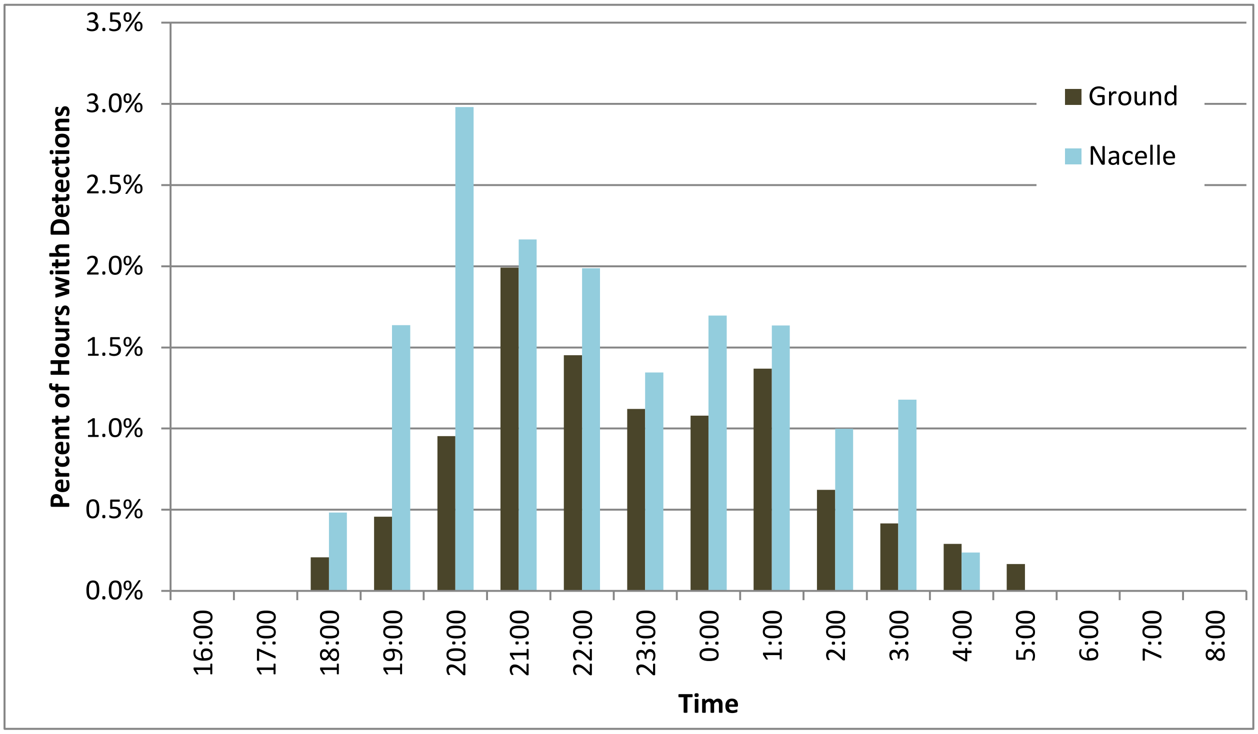


**Figure 9. LACI detections by night hour in FY 2016.**

## *Wildlife Education and Observation Program*

The wildlife education and observation program (WEOP) helps to ensure the safety and well-being of native wildlife in work areas and along site access roadways. The training provides useful information to assist staff, contractors, and visitors to be able to conduct their business in a manner consistent with the requirements of the HCP, CDUP, land use agreements and applicable laws. Records of wildlife observations by WEOP-trained staff are also used by the HCP program to identify the patterns of wildlife use of the site.

WEOP trainings were given to 40 personnel who were on-site regularly for two days or more (Appendix 10). The personnel were trained to identify covered and non-covered species of wildlife that may be found on-site and what protocol to follow, as determined in the HCP, when a downed wildlife is found. The trainees were also made aware of driving conditions and received instruction on how to drive and act around wildlife.

A total of 119 wildlife observations have been reported to date during this fiscal year on KWPI, including 102 Hawaiian geese, and 17 Hawaiian short-eared owls (Figure 10 and 11). Data collected was used to better protect and understand HCP species and their habitat use.

***WEOP Summary of Species and Locations FY 2016***

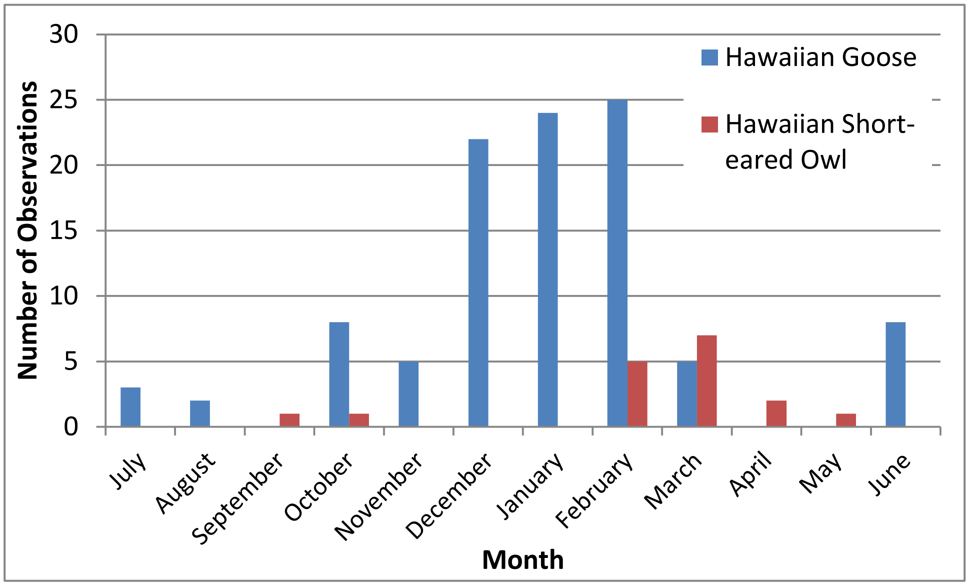


**Figure 10. Wildlife observed and recorded as part of WEOP at KWPI by month.**

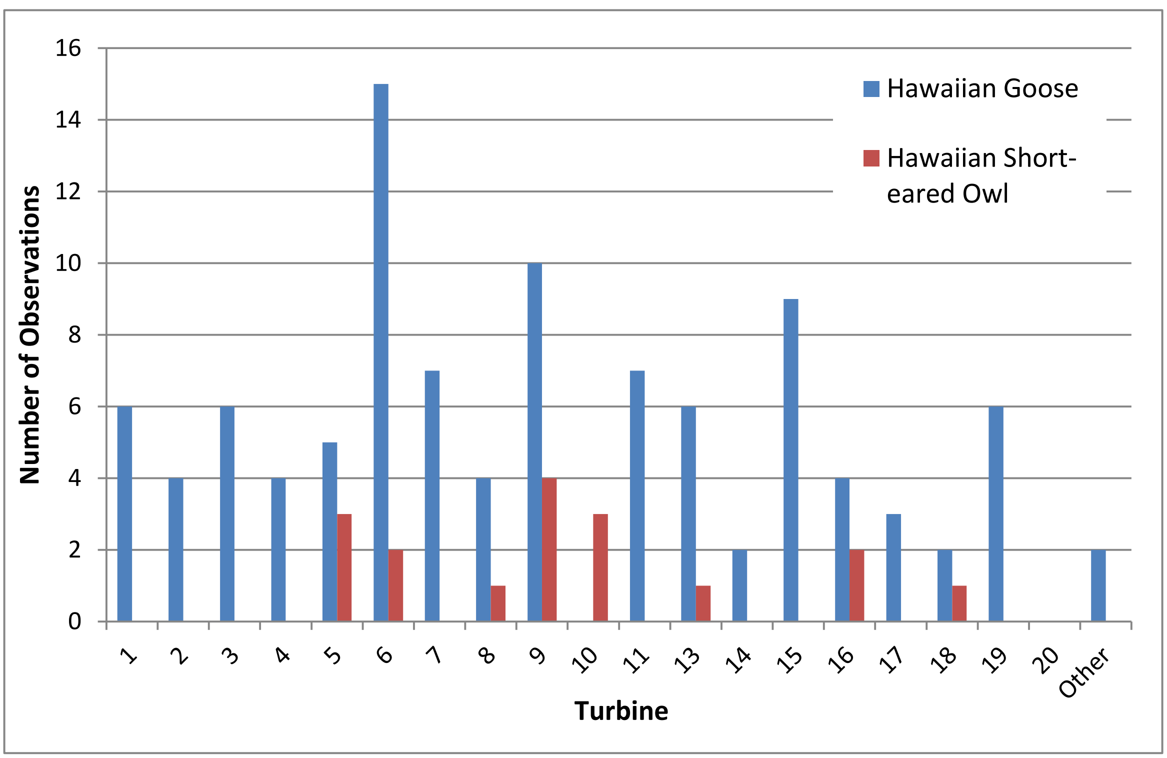


**Figure 11. Wildlife observations by turbine for FY 2016. *numbers represent total observations not unique individuals.**

## ***Vegetation Management***

The HCP team manages ground cover at a stature that will improve monitoring efficiency and minimize impacts to native plants without compromising soil stability. Due to nēnē nesting season vegetation management activities within the plots are currently restricted to April 1 through October 31st, while areas associated with the WTG pads are managed as permitted by DOFAW Wildlife staff.

Treatment of the plot areas for the FY 2016 was conducted in Aug-October and April-May. Primary vegetation management is conducted with herbicide application, and weed whackers. A total of 30.25 acres were treated with glyphosate based herbicide in FY 2016; this area consisted of roads and pads primarily within the search area. Additional control of Ironwood (*Casuarina equisetifolia*) was conducted with Garlon 3A™ and Garlon 4™ Ultra cut stump application on approximately 400 trees. In total, 79 hours of labor was devoted to vegetation management.

# *Mitigation*

## ***Hawaiian Hoary Bat***

Considering the more conservative estimate using the 80% credibility level the estimated take is now 29 and if indirect take is calculated according to the more current KWPII HCP method an additional take of five adult bats (converted from juvenile indirect take) is added for a total of 34 adult bats. The baseline take of 20 bats has been mitigated for. Thirty additional take has been authorized through a minor amendment approved by FWS in October 2015 and DLNR in January 2016.

## ***East Maui Seabird Survey***

In the unlikely event the initial five year mitigation targets at Makamaka'ole for the NESH are not met, East Maui has been surveyed for potential additional mitigation sites. The Maui Nui Seabird Recovery Project was funded with $56,062 to provide equipment and support survey costs, completed this survey in September 2015, and reported results (Appendix 11). The survey assessed areas adjacent to Haleakala National Park, Maui in the area below Ko'olau Gap and above Keanae by deploying Wildlife Acoustics SM2™ and SM3™ acoustic detectors at 60 locations in approximately 8,000 hectares between 3,000-8,000 ft. altitudes (Figure 12).

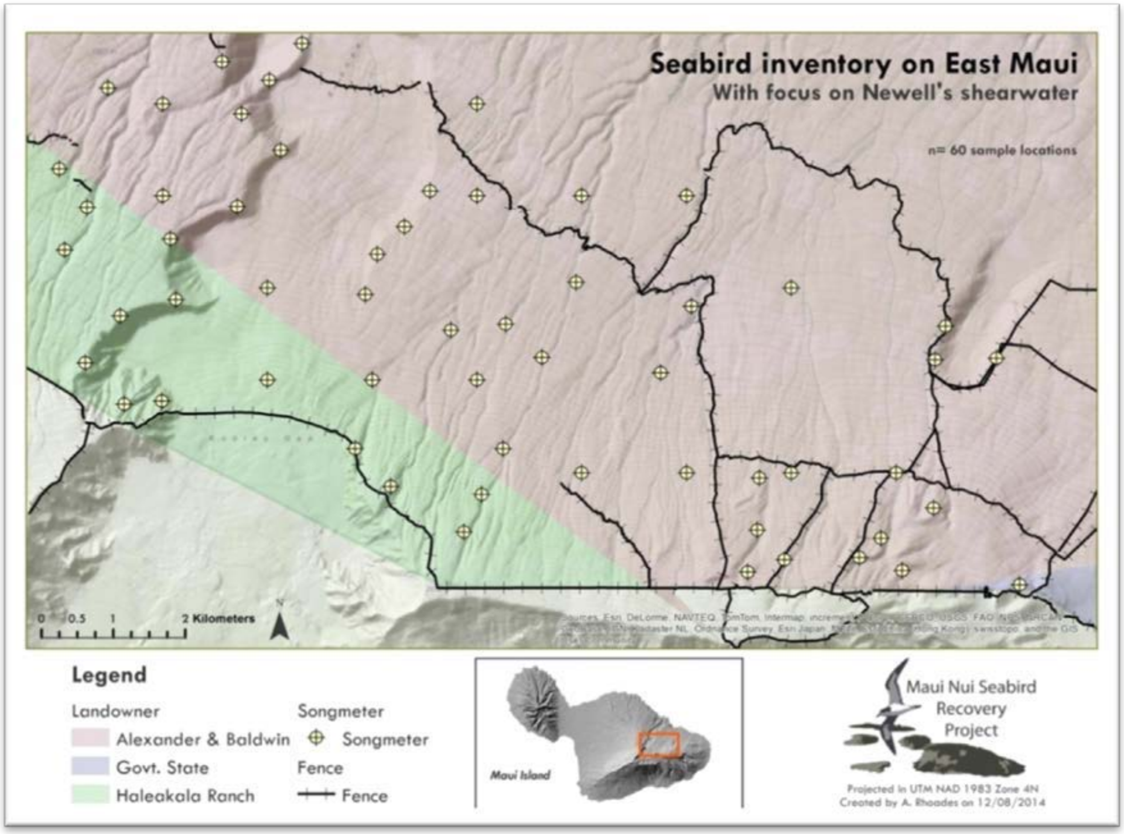


**Figure 12. 60 selected survey sites in areas adjacent to Haleakala National Park in the area below Ko'olau Gap and above Keanae.**

The surveys will help evaluate potential colony locations, estimate the numbers of birds, assess predator activity, and develop a management feasibility assessment.

## ***Hawaiian Petrel and Newell's Shearwater- Makamaka'ole***

**Figure 13. Two completed enclosures on the Makamaka'ole Seabird Mitigation site (Enclosure B is left and Enclosure A is right).**

Weekly site visits to Makamaka'ole (Figure 13) continue and focus on predator trapping and tracking, ongoing maintenance of both enclosures, burrow checks, and game camera operation. Monitoring checklists have been created to ensure consistent oversight. These checklists include sound system battery checks, game camera operation and download, burrow checks for erosion damage, signs of bird activity (visual, scent, and game camera) and ongoing perimeter checks of fences and culverts. The Victor™ rat snap traps, DOC 200™ body grip traps (all encased in bird-safe boxes), and cage traps are also routinely maintained (Figure 14, Table 8). Experimentation with bait and trap types have been ongoing. Game cameras have also been deployed to monitor small mammal activity near culverts where heavy rain may create fence breaches.

The enclosures continue to be an effective but not impermeable barrier to rats. This year we saw an average of 3.5 rats per enclosure per year (N = 7). This translates to an ingress rate of 1 rat per 102 days, which is less than half the rate found at the predator proof fence at Ka'ena Point on Oahu (Young *et al*. 2013). The ingress rates are not uniform throughout the year. Ingress occurrences tend to be clustered, and can be associated with breaches in the enclosure associated with high rain events and fence degradation. Tracking tunnel trials show toxicant and trapping efforts within the enclosures have been an effective 3rd line of defense (after exterior trapping and the fence barrier).

**Figure 14. New victor snap trap bird safe box design.**

**Table 8. Makamaka'ole trapping data by species and enclosure location for FY 2016.**

| Trap Location | Trap Type | Quantity Deployed | Number Caught |
|---|---|---|---|
| Outside A | Cage | 1 | 0 |
| | Victor Rat Snap | 13 | 32 rats, 3 mice |
| | Doc 200 Body Grip | 13 | 28 mongoose |
| Inside A | Victor Rat Snap | 10 | 5 rats, 12 mice |
| | Cage | 1 | 0 |
| | Doc 200 Body Grip | 4 | 0 |
| Outside B | Cage | 1 | 1 mongoose |
| | Victor Rat Snap | 10 | 19 rats, 6 mice |
| | Doc 200 Body Grip | 5 | 21 mongoose, 1 rat |
| Inside B | Victor Rat Snap | 10 | 2 rats, 22 mice |
| | Cage | 1 | 0 |
| | Doc 200 Body Grip | 5 | 0 |

Ten tracking tunnels inside Enclosure A and 10 inside Enclosure B have been inked and baited every other month to assess small mammal activity (Table 9). Since January 24, 2014 no mongoose have been detected or trapped inside either enclosure. On January 7, 2015 we received our approved protocol to continue using Diphacinone bait blocks. Twenty-five and 22 bait stations using Diphacinone bait blocks are currently deployed inside Enclosure A and Enclosure B, respectively. Bait stations within both enclosures continue to be checked biweekly, and re-baited as needed.

**Table 9. Makamaka'ole rodent relative abundance summary, as the number of tunnels with paw prints out of 10 total tunnels deployed.**

| | July 2015 Totals | | September 2015 Totals | | November 2015 Totals | |
|---|---|---|---|---|---|---|
| | % A | % B | % A | % B | % A | % B |
| **Mouse** | 0 | 0 | 0 | 0 | 0 | 0 |
| **Rat** | 0 | 0 | 0 | 0 | 0 | 0 |
| **Mongoose** | 0 | 0 | 0 | 0 | 0 | 0 |
| | **January 2016 Totals** | | **March 2016 Totals** | | **May 2016 Totals** | |
| | % A | % B | % A | % B | % A | % B |
| **Mouse** | 6 | 0 | 0 | 0 | 0 | 0 |
| **Rat** | 0 | 0 | 0 | 0 | 0 | 0 |
| **Mongoose** | 0 | 0 | 0 | 0 | 0 | 0 |

Erosion inside and outside of enclosures continues to be monitored closely. Specially fabricated hydrologic flumes are still attached to the outflow sections of two culverts at Enclosure A. These flumes direct water away from the enclosure, preventing erosion directly outside of the culvert tube and limiting the amount of displaced sediment entering neighboring streams. ` Uki (*Machaerina augustifolia*), `Ohi`a Lehua (*Metrosideros polymorpha*), Naupaka Kuahiwi (*Scaveola gaudichaudii*), `Akia (*Wikistroemia uva-ursi*), Hame (*Antidesma pulvinatum*), and Kupu Kupu (*Nephrolepis cordifolia*) were propagated by Maui Native Nursery and continue to be out-planted in and around both enclosures to stabilize soil in disturbed areas and to add to native flora within the mitigation area. We planted 278 `Uki, 100 `Ohi`a, five Naupaka, five Hame, five `Akia, and 85 Kupukupu during FY 2016 with more variety of out-plantings scheduled for FY 2017.

Acoustic attraction systems ran throughout the entire year and will continue broadcasting calls throughout FY 2017. Sound Files for the acoustic attraction system were updated in July 2016 with a mixture of both HAPE and NESH calls provided by Maui Nui Seabird Recovery Project. HAPE calls were recorded from Waikamoi, Maui in 2015, and NESH calls were recorded on Kaua`i from Pohakea in Hono O Na Pali as well as from Upper Limahuli. KWP Biologists have been conducting monthly night surveys, beginning on March 2nd , to ensure the sound systems work correctly and to monitor bird activity in the area (Appendix 12).

In the 2016 Makamaka'ole Natural Area Reserve Special Use Permit, the NARS staff requested that internal burrow temperature maximum and fluctuation be monitored and if possible reduced. Pacific Rim conservation provided guidance on acceptable tolerance and insight gained at Kilauea Point National Wildlife Refuge. In an effort to determine an effective means to maintain burrow temperatures within tolerance limits we began a temperature monitoring and insulation testing trial. Results of the trial can be found in Appendix 13.

Seabird activity inside enclosure B has been increasing since our first sighting during the 2015 calendar year breeding season on June 22nd, 2015. Throughout the 2015 breeding season, three species of seabird including Hawaiian petrel, Newell's shearwater, and Bulwer's petrel (*Bulweria bulwerii*) frequented two burrows within enclosure B between the months of June and October. On July 25th, 2015 game cameras caught the first footage of a Bulwer's petrel entering an artificial burrow, followed by a Hawaiian petrel burrow entrance on August 12th, 2015 (Figure 15), and a Newell's Shearwater entrance on September 21st, 2015. The first sighting of bird activity (a Bulwer's petrel), for the 2016 calendar year breeding season was witnessed on April 26th, 2016 making this season's first sighting two months earlier than last year's breeding season (Figure 16). Since then, there has been continuous activity throughout May and June at three burrow sites within enclosure B of both Newell's shearwater and Bulwer's petrel (Figure 17). On June 23rd, 2016 a game camera caught the first images of two Newell's shearwaters sharing a single burrow (Figure 18). No HAPE have been observed so far on burrow associated game cameras in calendar year 2016.


**Figure 15. Hawaiian petrel in front of burrow entrance with decoy in background inside enclosure B on August 12, 2015.**


**Figure 16. Bulwer's petrel In front of burrow entrance 42B inside enclosure B on June 22nd, 2016.**


**Figure 17. A Bulwer's petrel (left) and Newell's shearwater (right) in front of burrow entrance 50B inside enclosure B on June 25th, 2016.**


**Figure 18. Two Newell's shearwaters in front of burrow entrance 22B inside enclosure B on June 23rd, 2016 (HAPE decoy in the background).**

***Nēnē – Haleakala Ranch Pen***

As part of KWPI mitigation, the Haleakala Ranch pen was paid for in 2008 by KWPI and constructed three years later by DOFAW. Nēnē have been trans-located from Kauai to the Haleakala Ranch pen since 2011. Through FY 2016 32 fledglings produced in the pen from these trans-located birds have been credited toward KWPI mitigation. In FY 2016, eight fledglings were produced.

FWS and DOFAW have agreed that KWPI will not accrue lost productivity for nēnē take that occurred prior to 2011 before the pen was actually constructed. Six nēnē fatalities were documented at KWPI during this period (2006 to 2011). Lost productivity for these fatalities before 2011 has not been included in the take estimates provided in this report.

## *Adaptive Management*

KWPI began implementing low wind speed curtailment (LWSC) at 5.0 m/s on July 29, 2014. Curtailment includes blades feathered to minimize rotation. Curtailment was increased to 5.5 m/s on August 4, 2014. Curtailment will continue to be in effect from February 15th through December 15th from sunset to sunrise annually. Turbine operations software is being transitioned to an adaptive management system which will automatically update sunset and sunrise times through GPS. KWPI currently operates with two weather stations at ground level, nine ground bat detectors, and seven bat detectors at nacelle height. KWPI continues to investigate ultrasonic bat deterrent technology however it is not yet commercially available for deployment at nacelle height.

## *Agency Visits and Reporting*

KWPI attended and hosted several meetings with the FWS and DOFAW to discuss a variety of topics during FY 2016: on September 21, 2015; January 30, 2016; and June 14, 2016. Three ESRC meetings in FY 2016 involved KWP projects: on September 8, 2015; October 21-22, 2015; and December 17, 2015.

KWP continues to notify agencies of fatalities via email within 24 hours and sends out downed wildlife reports within three calendar days.

A quarterly abbreviated summary report for FY 2016 Q1, Q2 and Q3 was provided.

## *Expenditures*

The total HCP related expenditures in FY 2016 is $409,869 (Appendix 14).

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Lindsay Young, Eric VanderWerf, Michael Lohr, Christopher Miller, Andrew Titmus, Darren Peters, Lindsay Wilson. 2013. "Multi-species predator eradication within a predator-proof fence at Ka'ena Point, Hawai'i" Biological Invasions http://www.pacificrimconservation.org/wp-content/uploads/2013/10/Pub-891.pdf
Conservation Plan: Year 6 Annual Report. First Wind Energy, LLC, Wailuku, HI 96793.

# *Appendices*

**Appendix 1.** Estimating Proportion of Total Fall Distribution Actually Searched during Reduced Monitoring for nēnē and the Hawaiian Hoary Bat at Kaheawa Wind Power I.

<u>Nēnē Fatality Distribution</u>

Kaheawa Wind Power I (KWPI) estimated total fatalities for nēnē to date using the first four years of fatality monitoring data (Appendix 6, this report).

Intensive monitoring at KWPI since 2010 searched the areas around all turbines in circles centered on the WTG and with a radius extending to 70 m. Based on ballistics modeling Hull and Muir (2010) calculated that approximately 20% of the total fall distribution of large birds (nēnē) around “small” turbines may fall beyond 70 m. They considered turbines with a hub height of 65 m to be a “small” turbine in their model; 75 m and 97 m was considered the distance 80% and 99%, respectively, of all large birds might fall around a “small” turbine.

The long-term monitoring is assumed to continue to the end of the permit period at the same reduced search area effort as began in April 2015. The reduced effort at KWPI consists of searching only the roads and graded pads that occur within the 70 m radius circle centered on each turbine (Figure 1). The portion of all nēnē carcasses that could fall from turbine strikes that fall only within the 70 m circle is calculated based on the known fall distribution of all observed nēnē at KWPI and KWPII (Figure 2) and an assumption that 20% of nēnē may have fallen beyond 70 m and not observed. To create a total fall distribution we added five more nēnē beyond those actually observed within 70 m: two at 71-80 m, two at 81-90 m, and one at 91-100 m or 20% more than the actual observed nēnē (N = 26) used in creating the fall distribution. The KWPI and KWPII hub heights (68 and 72 m, respectively) and maximum height of the rotor swept zone (90 and 100 m, respectively) are similar and so we include all of the observed nēnē take from both sites in creating the fall distribution. The fall distribution is assumed to be uniform around the turbine.

A 70 m circle centered on each WTG is modeled to include approximately 84% of all nēnē carcasses expected to fall from turbine strikes (Figure 2). The 70 m circle is divided into six circular adjacent bands around each WTG. The first, closest band is 20 m radius and each band farther from the WTG is 10 m radius (Table 1). The area in acres is calculated for each band. Since more birds are expected to and do fall closer to the WTG there are fewer fatalities per acre as the distance increases (each band is density weighted, the area closer to the WTG will have a higher density of fatalities per acre so the area in each band is weighted according to the observed density of fatalities). The portion of the total area that will actually be searched (roads and pads) in each band is determined using ARCGIS (Table 1). The proportion of the total area in each band actually searched per band and the fatality density per band are multiplied for each band and the results summed for all six bands to determine the portion of the entire fall distribution that is actually searched (Table 1). The reduced search area is estimated to encompass 29.6% of all nēnē fatalities that may occur (Table 1).

**Table 1. Proportion of Nēnē Expected to Fall within the 70 m Search Area**

| Distance Band (m) | Search Area Within Distance Band (ac)* | Total Area Of Distance Band (ac) | Proportion Of Distance Band Searched (A) | Portion Birds Found Within Distance Band (B) | DWA of Distance Band (A x B) |
|---|---|---|---|---|---|
| 20 | 4.95 | 6.2 | 0.8 | **0.162** | **0.129** |
| 30 | 3.29 | 7.76 | 0.42 | **0.194** | **0.082** |
| 40 | 2.24 | 10.86 | 0.21 | **0.323** | **0.067** |
| 50 | 1.8 | 13.97 | 0.13 | **0.065** | **0.008** |
| 60 | 1.71 | 17.07 | 0.1 | **0.032** | **0.003** |
| 70 | 1.99 | 20.18 | 0.1 | **0.065** | **0.006** |
| | | | **Total** | **0.839** | **0.296** |

*determined using GPS of area searched and ARCGIS for acreage determination

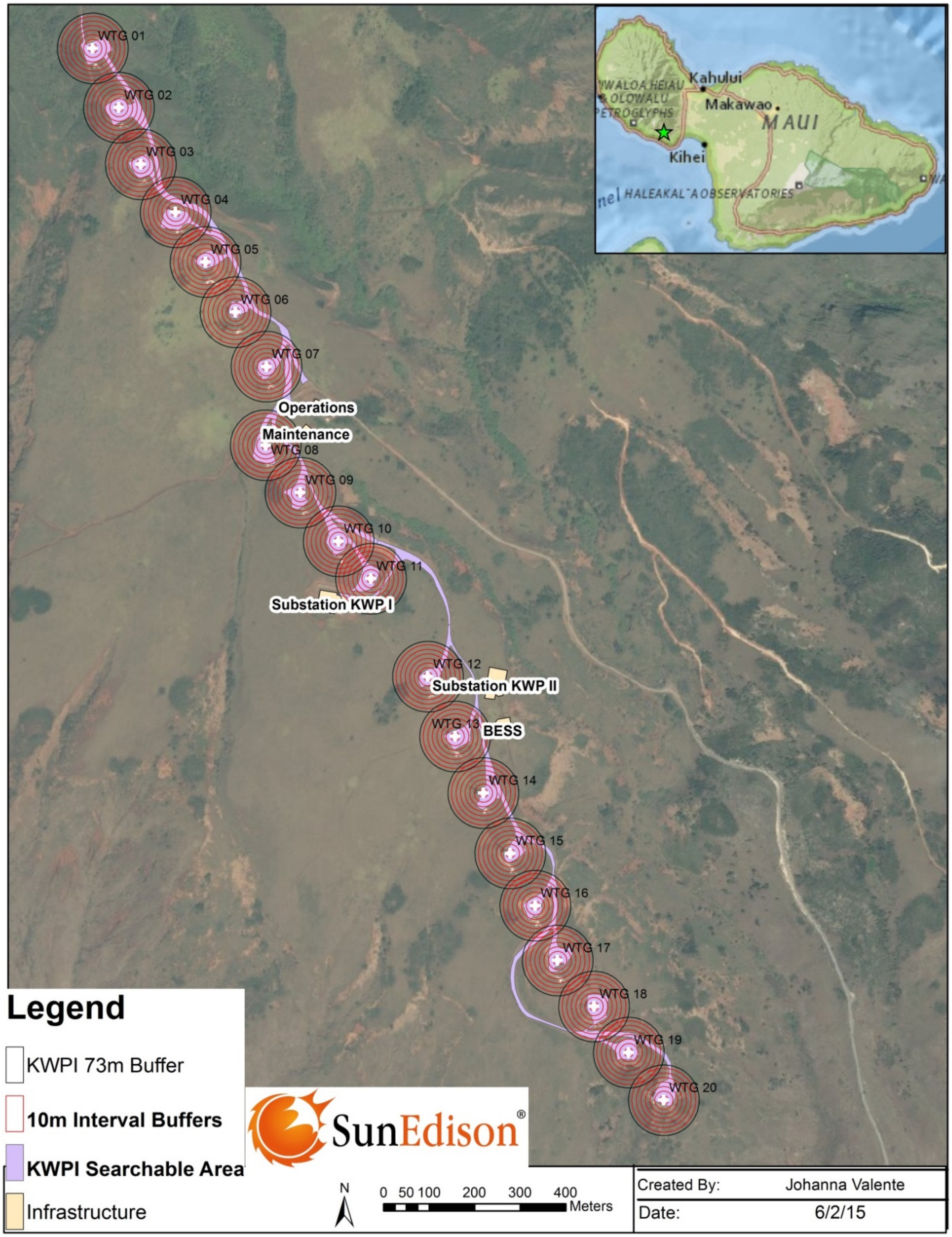


**Figure 1. Long Term Monitoring Search Area for KWPI (Turbines 1-20) with Roads and Pads Out to 73 m (or 75% of the maximum rotor swept zone height). Complete circles are 73 m radius.**

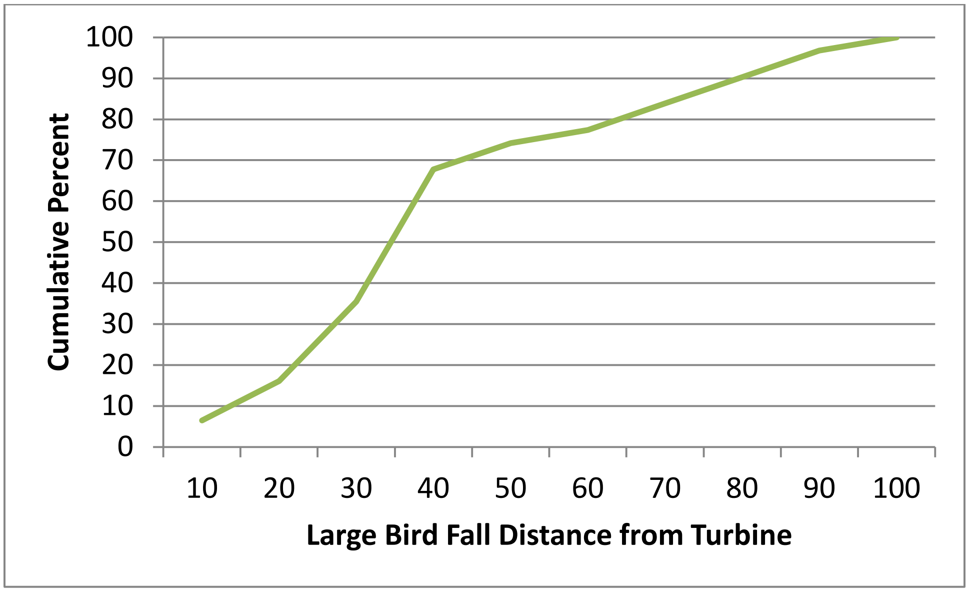


**Figure 2. Cumulative Percent Distribution of Large Birds Found with Distance from Turbine at KWPI and KWPII (N = 26 observed and N = 5 hypothesized).**

Hawaiian Hoary Bat Fatality Distribution

Total expected fatality for the Hawaiian hoary bat for KWPI was estimated using the first four years of fatality monitoring data. The long-term monitoring is assumed to continue at the same reduced search area effort as began in April 2015. The reduced effort consists of searching only the roads and graded pads that occur within a 70 m radius circle centered on each turbine (Figure 1). The portion of all carcasses that fall from turbine strikes that fall only within the 70 m circle is calculated based on the known fall distribution of all bats observed at KWPI and KWPII (Figure 3). The fall distribution is derived from a sample of only 11 bats but there are no other data available in Hawaii for the relatively short height of the KWP WTGs. The fall distribution is assumed to be uniform around the turbine. The KWPI and KWPII maximum height of the rotor swept zone are similar (90 and 100 m, respectively).

A 70 m circle centered on each WTG is modeled to include 100% of all carcasses expected to fall from turbine strikes (Figure 3). The 70 m circle is divided into six bands expanding from the WTG. The first, closest band is 20 m radius and each band farther from the WTG is 10 m radius (Table 2). The total area is calculated for each band. Since more bats are expected to and do fall closer to the WTG there are fewer fatalities per acre as the distance increases (each band is density weighted, aka DWA; the area closer to the WTG will have a higher density of fatalities per acre so the area in each band is weighted according to the observed density of fatalities). The portion of the total area that will actually be searched (roads and pads) in each band is determined using ARCGIS (Table 2). The proportion of the area searched per band and the observed fatality density per $m^2$ per band are multiplied for each band and the results summed for all six bands to estimate the portion of the entire bat fall distribution that is actually searched (Table 2). The reduced search plot size encompasses 39.6% of the fall distribution of bats (Table 2).

**Table 2. Proportion of Hawaiian Hoary Bats Expected to Fall Within the Search Area**

| Distance Band | Search Area Within Distance Band (ac)* | Area Of Distance Band (ac) | Proportion Of Distance Band Searched (A) | Percent Bats Found Within Distance Band (B) | DWA of Distance Band (A x B) |
|---|---|---|---|---|---|
| 20 | 4.95 | 6.2 | 0.8 | **0.27** | **0.216** |
| 30 | 3.29 | 7.76 | 0.42 | **0.18** | **0.076** |
| 40 | 2.24 | 10.86 | 0.21 | **0.45** | **0.093** |
| 50 | 1.8 | 13.97 | 0.13 | **0.09** | **0.012** |
| 60 | 1.71 | 17.07 | 0.1 | **0.0** | **0.0** |
| 70 | 1.99 | 20.18 | 0.1 | **0.0** | **0.0** |
| | | | **Total** | **0.99** | **0.396** |

*determined using GPS of area searched and ARCGIS for acreage determination

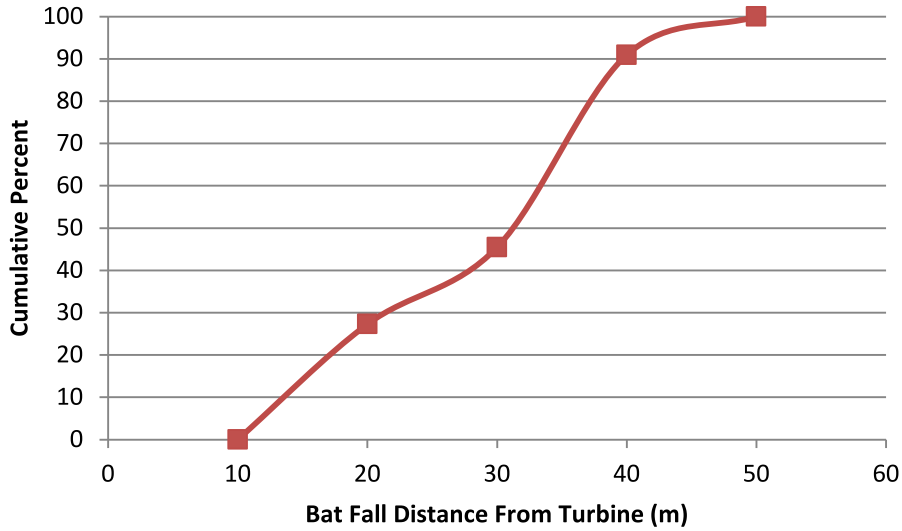


**Figure 3. Cumulative Percent of Bats Found With Distance from Turbine at KWPI and KWPII (N = 11)**

**References:**


Manuela M. P. Huso, Daniel H. Dalthorp, David A. Dail, and Lisa J. Madsen. 2015. Estimating wind-turbine caused bird and bat fatality when zero carcasses are observed. Ecological Applications. http://dx.doi.org/10.1890/14-0764.1

**Appendix 2.** KWPI monitoring interval data.

**KWPI Abbreviated Monitoring**

| Search Date | Turbine # 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 | 7/1/15 |
| | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 | 7/6/15 |
| | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 | 7/13/15 |
| | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 | 7/20/15 |
| | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 | 7/27/15 |
| | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 | 8/2/15 |
| | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 | 8/10/15 |
| | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 | 8/17/15 |
| | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 | 8/24/15 |
| | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 | 8/31/15 |
| | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 | 9/8/15 |
| | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 | 9/15/15 |
| | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 | 9/23/15 |
| | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 | 9/28/15 |
| | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 | 10/5/15 |
| | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 | 10/12/15 |
| | 10/19/15 | 10/19/15 | 10/19/15 | 10/19/15 | 10/19/15 | 10/19/15 | 10/19/15 | 10/19/15 | 10/20/15 | 10/20/15 | 10/19/15 | 10/20/15 | 10/19/15 | 10/19/15 | 10/19/15 | 10/19/15 | 10/19/15 | 10/19/15 | 10/19/15 | 10/19/15 |
| | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 | 10/27/15 |
| | 11/4/15 | 11/4/15 | 11/4/15 | 11/3/15 | 11/3/15 | 11/3/15 | 11/3/15 | 11/3/15 | 11/3/15 | 11/3/15 | 11/3/15 | 11/3/15 | 11/3/15 | 11/3/15 | 11/3/15 | 11/3/15 | 11/3/15 | 11/3/15 | 11/3/15 | 11/3/15 |
| | 11/10/15 | 11/10/15 | 11/9/15 | 11/9/15 | 11/9/15 | 11/9/15 | 11/9/15 | 11/9/15 | 11/9/15 | 11/9/15 | 11/9/15 | 11/9/15 | 11/9/15 | 11/9/15 | 11/9/15 | 11/9/15 | 11/9/15 | 11/9/15 | 11/9/15 | 11/9/15 |
| | 11/17/15 | 11/17/15 | 11/17/15 | 11/17/15 | 11/17/15 | 11/17/15 | 11/17/15 | 11/17/15 | 11/17/15 | 11/17/15 | 11/17/15 | 11/17/15 | 11/18/15 | 11/17/15 | 11/17/15 | 11/17/15 | 11/17/15 | 11/17/15 | 11/17/15 | 11/17/15 |
| | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 | 11/23/15 |
| | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 | 12/1/15 |
| | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 | 12/8/15 |
| | 12/15/15 | 12/15/15 | 12/15/15 | 12/15/15 | 12/15/15 | 12/15/15 | 12/21/15 | 12/15/15 | 12/15/15 | 12/15/15 | 12/15/15 | 12/15/15 | 12/15/15 | 12/15/15 | 12/15/15 | 12/15/15 | 12/15/15 | 12/15/15 | 12/15/15 | 12/15/15 |
| | 12/21/15 | 12/21/15 | 12/21/15 | 12/21/15 | 12/21/15 | 12/21/15 | 12/15/15 | 12/21/15 | 12/21/15 | 12/21/15 | 12/21/15 | 12/21/15 | 12/21/15 | 12/21/15 | 12/21/15 | 12/21/15 | 12/21/15 | 12/21/15 | 12/21/15 | 12/21/15 |
| | 12/29/15 | 12/29/15 | 12/29/15 | 12/29/15 | 12/29/15 | 12/29/15 | 12/29/15 | 12/29/15 | 12/30/15 | 12/29/15 | 12/29/15 | 12/29/15 | 12/29/15 | 12/29/15 | 12/29/15 | 12/29/15 | 12/29/15 | 12/29/15 | 12/29/15 | 12/29/15 |
| | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 | 1/5/16 |
| | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 | 1/12/16 |
| | 1/19/16 | 1/19/16 | 1/19/16 | 1/19/16 | 1/19/16 | 1/19/16 | 1/19/16 | 1/19/16 | 1/19/16 | 1/20/16 | 1/19/16 | 1/19/16 | 1/19/16 | 1/19/16 | 1/19/16 | 1/19/16 | 1/19/16 | 1/19/16 | 1/19/16 | 1/19/16 |
| | 1/26/16 | 1/26/16 | 1/26/16 | 1/26/16 | 1/26/16 | 1/26/16 | 1/27/16 | 1/26/16 | 1/27/16 | 1/26/16 | 1/26/16 | 1/26/16 | 1/26/16 | 1/26/16 | 1/27/16 | 1/26/16 | 1/26/16 | 1/26/16 | 1/26/16 | 1/26/16 |
| | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 | 2/2/16 |
| | 2/9/16 | 2/9/16 | 2/9/16 | 2/9/16 | 2/9/16 | 2/10/16 | 2/9/16 | 2/9/16 | 2/9/16 | 2/9/16 | 2/9/16 | 2/10/16 | 2/9/16 | 2/9/16 | 2/9/16 | 2/9/16 | 2/9/16 | 2/9/16 | 2/9/16 | 2/9/16 |
| | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 | 2/16/16 |
| | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 | 2/23/16 |
| | 3/1/16 | 3/1/16 | 3/1/16 | 3/1/16 | 3/1/16 | 3/1/16 | 3/1/16 | 3/1/16 | 3/1/16 | 3/1/16 | 3/2/16 | 3/1/16 | 3/1/16 | 3/1/16 | 3/1/16 | 3/1/16 | 3/1/16 | 3/1/16 | 3/1/16 | 3/1/16 |
| | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 | 3/8/16 |
| | 3/15/16 | 3/15/16 | 3/15/16 | 3/15/16 | 3/15/16 | 3/15/16 | 3/15/16 | 3/15/16 | 3/15/16 | 3/15/16 | 3/15/16 | 3/15/16 | 3/15/16 | 3/16/16 | 3/15/16 | 3/15/16 | 3/15/16 | 3/15/16 | 3/15/16 | 3/15/16 |
| | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 | 3/22/16 |
| | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 | 3/29/16 |
| | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 | 4/5/16 |
| | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 | 4/12/16 |
| | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 | 4/19/16 |
| | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 | 4/26/16 |
| | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 | 5/3/16 |
| | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 | 5/10/16 |
| | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 | 5/19/16 |
| | 5/24/16 | 5/24/16 | 5/24/16 | 5/24/16 | 5/24/16 | 5/24/16 | 5/24/16 | 5/24/16 | 5/24/16 | 5/24/16 | 5/24/16 | 5/24/16 | 5/24/16 | 5/24/16 | 5/25/16 | 5/24/16 | 5/24/16 | 5/24/16 | 5/24/16 | 5/24/16 |
| | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 | 5/31/16 |
| | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 | 6/7/16 |
| | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 | 6/14/16 |
| | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 | 6/21/16 |
| | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 | 6/28/16 |

**Appendix 3.** Canine-assisted to Visual Search Ratio.

| | Turbine | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Search Type | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Canine | 32 | 32 | 32 | 32 | 32 | 31 | 31 | 32 | 30 | 31 |
| Visual | 20 | 20 | 20 | 20 | 20 | 21 | 21 | 20 | 22 | 21 |
| **Total** | **52** | **52** | **52** | **52** | **52** | **52** | **52** | **52** | **52** | **52** |
| *Canine Percent* | *61.5%* | *61.5%* | *61.5%* | *61.5%* | *61.5%* | *59.6%* | *59.6%* | *61.5%* | *57.7%* | *59.6%* |
| *Visual Percent* | *38.5%* | *38.5%* | *38.5%* | *38.5%* | *38.5%* | *40.4%* | *40.4%* | *38.5%* | *42.3%* | *40.4%* |

| Turbine | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | Total |
| 32 | 31 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 33 | 635 |
| 20 | 21 | 20 | 20 | 21 | 20 | 20 | 20 | 20 | 20 | 407 |
| **52** | **52** | **52** | **52** | **53** | **52** | **52** | **52** | **52** | **53** | **1042** |
| *61.5%* | *59.6%* | *61.5%* | *61.5%* | *60.4%* | *61.5%* | *61.5%* | *61.5%* | *61.5%* | *62.3%* | **60.9%** |
| *38.5%* | *40.4%* | *38.5%* | *38.5%* | *39.6%* | *38.5%* | *38.5%* | *38.5%* | *38.5%* | *37.7%* | **39.1%** |

**Appendix 4.** KWPI SEEF trial results.

| SEEF Results FY 2016 | | | | | | |
|---|---|---|---|---|---|---|
| Trial date | Carcass type | WTG | Found | Not Recovered | Human Searcher | Canine Searcher |
| 7/13/2015 | Rat | 14 | No | False | JV | |
| 8/10/2015 | Rat | 7 | Yes | False | SE | |
| 8/17/2015 | Rat | 15 | Yes | False | SE | |
| 8/17/2015 | Med Bird | 18 | Yes | False | SE | |
| 8/17/2015 | Rat | 16 | Yes | False | SE | |
| 8/25/2015 | Rat | 20 | Yes | False | JV | |
| 8/31/2015 | Rat | 11 | Yes | False | SE | |
| 8/31/2015 | Large Bird | 3 | Yes | False | JV | |
| 9/14/2015 | Rat | 3 | Yes | False | SE | |
| 9/21/2015 | Rat | 9 | Yes | False | SE | |
| 9/28/2015 | Rat | 18 | Yes | False | SE | |
| 9/28/2015 | Rat | 16 | Yes | False | SE | |
| 10/12/2015 | Rat | 4 | Yes | False | SE | |
| 10/27/2015 | Rat | 17 | Yes | False | TG | Makalani |
| 10/27/2015 | Large Bird | 12 | Yes | False | TG | Makalani |
| 11/3/2015 | Rat | 6 | No | False | TG | Makalani |
| 11/3/2015 | Rat | 4 | Yes | False | TG | Makalani |
| 12/1/2015 | Rat | 17 | Yes | False | TG | Makalani |
| 12/8/2015 | Rat | 11 | Yes | False | TG | Makalani |
| 12/15/2015 | Med Bird | 3 | Yes | False | TG | Makalani |
| 12/29/2015 | Rat | 3 | Yes | False | TG | Makalani |
| 12/29/2015 | Rat | 10 | Yes | False | TG | Makalani |
| 1/19/2016 | Rat | 3 | Yes | False | TG | Makalani |
| 2/9/2016 | Large Bird | 6 | Yes | False | TG | Makalani |
| 2/23/2016 | Rat | 2 | Yes | False | TG | Makalani |
| 2/23/2016 | Rat | 14 | Yes | False | TG | Makalani |
| 2/23/2016 | Rat | 7 | Yes | False | TG | Makalani |
| 2/23/2016 | Rat | 3 | Yes | False | TG | Makalani |
| 3/2/2016 | Rat | 11 | No | True | TG | Makalani |
| 3/15/2016 | Rat | 9 | Yes | False | TG | Makalani |
| 3/22/2016 | Med Bird | 3 | Yes | False | SE | |
| 4/5/2016 | Rat | 11 | Yes | False | SE | |
| 4/5/2016 | Rat | 15 | Yes | False | SE | |
| 4/5/2016 | Rat | 2 | Yes | False | SE | |
| 4/12/2016 | Large Bird | 4 | Yes | False | SE | |
| 4/12/2016 | Med Bird | 17 | Yes | False | SE | |
| 5/3/2016 | Rat | 2 | Yes | False | TG | Makalani |
| 5/3/2016 | Rat | 3 | Yes | False | TG | Makalani |
| 5/3/2016 | Rat | 6 | Yes | False | TG | Makalani |
| 5/19/2016 | Rat | 1 | Yes | False | TG | Makalani |

| SEEF Results FY 2016 | | | | | | |
|---|---|---|---|---|---|---|
| **Trial date** | **Carcass type** | **WTG** | **Found** | **Not Recovered** | **Human Searcher** | **Canine Searcher** |
| 5/19/2016 | Med Bird | 1 | Yes | False | TG | Makalani |
| 5/19/2016 | Med Bird | 3 | Yes | False | TG | Makalani |
| 5/19/2016 | Large Bird | 8 | Yes | False | TG | Makalani |
| 5/31/2016 | Rat | 14 | Yes | False | TG | Makalani |
| 5/31/2016 | Rat | 2 | Yes | False | TG | Makalani |
| 5/31/2016 | Large Bird | 19 | Yes | False | TG | Makalani |
| 5/31/2016 | Rat | 18 | Yes | False | TG | Makalani |
| 5/31/2016 | Med Bird | 16 | Yes | False | TG | Makalani |
| 6/7/2016 | Large Bird | 4 | Yes | False | TG | Makalani |
| 6/7/2016 | Rat | 3 | Yes | False | TG | Makalani |
| 6/7/2016 | Large Bird | 10 | Yes | False | TG | Makalani |
| 6/14/2016 | Rat | 19 | Yes | False | TG | Makalani |
| 6/14/2016 | Rat | 16 | Yes | False | TG | Makalani |
| 6/14/2016 | Med Bird | 16 | Yes | False | TG | Makalani |
| 6/14/2016 | Med Bird | 6 | Yes | False | TG | Makalani |
| 6/14/2016 | Rat | 14 | Yes | False | TG | Makalani |
| 6/28/2016 | Med Bird | 20 | Yes | False | TG | Makalani |
| 6/28/2016 | Large Bird | 10 | Yes | False | TG | Makalani |
| 6/28/2016 | Rat | 16 | Yes | False | TG | Makalani |
| 6/28/2016 | Large Bird | 10 | Yes | False | TG | Makalani |

**Appendix 5.** KWPI CARE trials for FY 2016.

| | | | | | Carcass Day | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 11 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trial ID | Turbine | Distance (m) | ID | CARE Start Date | Carcass Type | 7/21 | 7/22 | 7/23 | 7/24 | 7/25 | 7/26 | 7/27 | 7/29 | 7/31 | 8/2 | 8/4 | 8/6 | 8/8 | 8/10 | 8/12 | 8/14 | 8/16 | 8/18 | 8/19 |
| 98 | 13 | 65 | 66 | 7/20/2015 | WTSH | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | | | | | | | | | | | |
| 98 | 10 | 24 | 67 | 7/20/2015 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| 98 | 4 | 19 | 68 | 7/20/2015 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |

| | | | | | Carcass Day | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 11 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trial ID | Turbine | Distance (m) | ID | CARE Start Date | Common Name | 9/2 | 9/3 | 9/4 | 9/5 | 9/6 | 9/7 | 9/8 | 9/10 | 9/12 | 9/14 | 9/16 | 9/18 | 9/20 | 9/22 | 9/24 | 9/26 | 9/28 | 9/30 | 10/1 |
| 99 | 17 | 41 | 69 | 9/1/2015 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | | | | | |
| 99 | 3 | 26 | 70 | 9/1/2015 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| 99 | 10 | 22 | 71 | 9/1/2015 | Rat | TRUE | FALSE | | | | | | | | | | | | | | | | | |
| 99 | 2 | 2 | 72 | 9/1/2015 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| 99 | 17 | 15 | 73 | 9/1/2015 | Chicken | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | | | | | |

| | | | | | Carcass Day | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 17 | 21 | 24 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trial ID | Turbine | Distance (m) | ID | CARE Start Date | Common Name | 12/5 | 12/6 | 12/7 | 12/8 | 12/9 | 12/10 | 12/11 | 12/12 | 12/13 | 12/14 | 12/15 | 12/16 | 12/17 | 12/18 | 12/21 | 12/25 | 12/28 | 1/4 |
| AA | 5 | 75 | 53 | 12/4 | Chicken | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| AA | 5 | 79 | 54 | 12/3 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | | | | | | | | | | | |
| AA | 6 | 37 | 55 | 12/3 | WTSH | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| AA | 9 | 18 | 56 | 12/3 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| AA | 13 | 4 | 57 | 12/3 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | | | |
| AA | 16 | 19 | 58 | 12/3 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |

| | | | | | Carcass Day | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 18 | 21 | 28 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trial ID | Turbine | Distance (m) | ID | CARE Start Date | Common Name | 2/16 | 2/17 | 2/18 | 2/19 | 2/20 | 2/21 | 2/22 | 2/23 | 2/24 | 2/25 | 2/26 | 2/27 | 2/28 | 2/29 | 3/4 | 3/7 | 3/14 | 3/16 |
| AB | 4 | 40 | 83 | 2/15 | Chicken | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | TRUE | TRUE |
| AB | 5 | 10 | 84 | 2/15 | WTSH | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| AB | 9 | 8 | 85 | 2/15 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | | | |
| AB | 16 | 40 | 86 | 2/15 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | | | | | | |
| AB | 17 | 20 | 87 | 2/15 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | |
| AB | 18 | 30 | 88 | 2/15 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | | | | | | | |
| AB | 19 | 5 | 89 | 2/15 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | | | | |

| | | | | | Carcass Day | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 21 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trial ID | Turbine | Distance (m) | ID | CARE Start Date | Common Name | 4/20 | 4/21 | 4/22 | 4/23 | 4/24 | 4/25 | 4/26 | 4/27 | 4/28 | 4/29 | 4/30 | 5/1 | 5/2 | 5/3 | 5/10 | 5/17 |
| AC | 4 | 19 | 97 | 4/19 | Chicken | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| AC | 5 | 25 | 98 | 4/19 | WTSH | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| AC | 12 | 23 | 99 | 4/19 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | | | | | | | | | | |
| AC | 13 | 7 | 100 | 4/19 | Rat | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | | | | | | | |
| AC | 14 | 46 | 101 | 4/19 | Rat | TRUE | TRUE | TRUE | TRUE | FALSE | | | | | | | | | | | |
| AC | 17 | 18 | 102 | 4/19 | Rat | TRUE | TRUE | TRUE | FALSE | | | | | | | | | | | | |

**Appendix 6.** Fatality estimation input parameters for Hawaiian hoary bat, goose and petrel at KWPI.

| Hawaiian hoary bat | | | | | | Hawaiian goose | | | | | | Hawaiian petrel | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *ghat* 95% CI | | | | | | *ghat* 95% CI | | | | | | *ghat* 95% CI | |
| Year | rho | Observed Fatality | *ghat* | lower | upper | Year | rho | Observed Fatality | *ghat* | lower | upper | Year | rho | Observed Fatality | *ghat* | lower | upper |
| 1.5 | 1.5 | 0 | 0.45 | 0.231 | 0.673 | | | | | | | 1.5 | 1.5 | 0 | 0.69 | 0.544 | 0.82 |
| 2.5 | 1 | 0 | 0.47 | 0.294 | 0.656 | | | | | | | 2.5 | 1 | 1 | 0.66 | 0.496 | 0.803 |
| 3.5 | 1 | 1 | 0.47 | 0.298 | 0.655 | | | | | | | 3.5 | 1 | 0 | 0.39 | 0.294 | 0.499 |
| 4.5 | 1 | 0 | 0.43 | 0.257 | 0.603 | | | | | | | 4.5 | 1 | 0 | 0.73 | 0.61 | 0.837 |
| 5.5 | 1 | 1 | 0.28 | 0.14 | 0.454 | 5.5 | 5.5 | 9 | 0.68 | 0.646 | 0.72 | 5.5 | 1 | 0 | 0.81 | 0.743 | 0.869 |
| 6.5 | 1 | 0 | 0.28 | 0.14 | 0.454 | 6.5 | 1 | 1 | 0.68 | 0.632 | 0.722 | 6.5 | 1 | 2 | 0.68 | 0.518 | 0.823 |
| 7.5 | 1 | 2 | 0.24 | 0.11 | 0.403 | 7.5 | 1 | 4 | 0.67 | 0.595 | 0.733 | 7.5 | 1 | 1 | 0.75 | 0.613 | 0.864 |
| 8.5 | 1 | 4 | 0.37 | 0.261 | 0.477 | 8.5 | 1 | 3 | 0.68 | 0.647 | 0.717 | 8.5 | 1 | 1 | 0.81 | 0.766 | 0.853 |
| 9.5 | 0.85 | 0 | 0.29 | 0.189 | 0.393 | 9.5 | 1 | 4 | 0.68 | 0.656 | 0.712 | 9.5 | 1 | 2 | 0.74 | 0.642 | 0.831 |
| 10.5 | 0.85 | 0 | 0.27 | 0.248 | 0.288 | 10.5 | 1 | 1 | 0.29 | 0.279 | 0.31 | 10.5 | 1 | 0 | 0.28 | 0.255 | 0.305 |
| **Overall** | | **8** | **0.36** | **0.29** | **0.436** | | | **22** | **0.64** | **0.599** | **0.688** | | | **7** | **0.66** | **0.542** | **0.762** |
| **M* (estimated mortality, 80% Credibility)** | **29** | | | | | **38** | | | | | | **13** | | | | | |

**Appendix 7.** Indirect take (IDT) calculations for Hawaiian hoary bat at KWPI.

| Component | Input | Value |
|---|---|---|
| A | Total estimated direct take | 29 |
| B | Observed direct take (ODT) | 8 |
| C | Unobserved direct take (UDT) (**A - B**) | 21 |
| D | ODT female or unknown during Apr 1- Sep 15 (2 female, 3 unknown) | 5 |
| E | Proportion of UDT that could be female and probability a female is pregnant or lactating (0.5 x 3/12) | 0.125 |
| F | Survival of twin pups to weaning (0.9 x 2 pups) | 1.80 |
| G | ODT IDT (**D x F**) | 9 |
| H | UDT IDT (**C x E x F**) | 4.7 |
| I | IDT total (**G + H**) | 13.7 |
| J | Survival of juvenile to adult | 0.3 |
| | **IDT as adults (I x J)** | 4.1 |
| | **Total IDT rounded up** | **5** |

**Appendix 8.** Nēnē lost productivity and indirect take at KWPI.

| | | | Fiscal Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Years when loss of productivity is calculated | | | | | | | | |
| Component | Description | Component Calculation | 2007 | 2008 | 2009 | 2010 | 2011 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | **2016 Total** | |
| **A** | Observed Fatality | | 0 | 2 | 1 | 1 | 2 | 3 | 1 | 4 | 3 | 4 | 1 | | |
| **B** | Direct Take Estimated Fatality Multiplier | Total Estimate/Total Observed (38/22=1.727) | | 1.727 | 1.727 | 1.727 | 1.727 | 1.727 | 1.727 | 1.727 | 1.727 | 1.727 | 1.727 | | |
| **C** | **Annual Estimated Fatality** | Each year **A x B** | | **3.454** | **1.727** | **1.727** | **3.454** | **5.181** | **1.727** | **6.908** | **5.181** | **6.908** | **1.727** | **38** | *Estimated Take* |
| **D** | Indirect Take Multiplier | HCP defined | | 0.09 | 0 | 0 | 0.09 | 0 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | | |
| **E** | **Total Indirect Take** | Each year **C x D** | | 0.31 | 0.00 | 0.00 | 0.31 | 0.00 | 0.16 | 0.62 | 0.47 | 0.62 | 0.16 | **2.64** | *Indirect Take* |
| **F** | Next year accrued adult take not yet mitigated for | **Sum** all previous year's **C** (beginning 2011) **+** accrued **K** | | | | | | | 8.64 | 10.36 | 16.98 | 17.02 | 19.20 | **19.20** | *Deficit adults to mitigate for* |
| **G** | **Lost Productivity from accrued adult take (multiplier = 0.1)** | Current year's **F x 0.1** | | | | | | | 0.86 | 1.04 | 1.70 | 1.70 | 1.92 | | |
| **H** | Indirect Take + Lost Productivity (as fledglings) not yet mitigated for | **Sum** previous and current year's **E** (not mitigated for) **+** current year's **G** | | | | | | | 1.64 | 1.66 | 2.16 | 2.32 | 2.08 | | |
| **I** | **Mitigation fledglings produced** | Haleakala Ranch fledglings produced | | | | | | | **-2** | **-8** | **-8** | **-6** | **-8** | | |
| **J** | Net fledglings remain | Each year **H + I** | | | | | | | -0.36 | -6.34 | -5.84 | **-3.68** | **-5.92** | | |
| **K** | Net adults 2 yrs later (annual survival rate multiplier = 0.9) | Two year's previous **J x** $\mathbf{0.9^2}$ | | | | | | | | | -0.29 | -5.14 | -4.73 | **-7.78** | *Surplus fledglings (2015-16) converted to adult* |
| | | | | | | | | | | | | | | **11.42** | ***Accrued adults to mitigate for*** |

**Appendix 9.** HAPE Lost Productivity and Indirect Take at KWPI.

| Year | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2012 | 2013 | 2014 | 2015 | 2015 | 2016 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed Fatality | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | | |
| Estimated Fatality Multiplier | | 1.86 | | | | 1.86 | 1.86 | 1.86 | 1.86 | 1.86 | 1.86 | | **Total** | |
| Estimated Fatality | | 1.86 | | | | 1.86 | 1.86 | 1.86 | 1.86 | 1.86 | 1.86 | | **13.00** | **Direct Take** |
| Indirect Take Multiplier | | 0.66 | | | | 0.66 | 0.50 | 0.89 | 0.89 | 0.89 | 0.66 | | | |
| **Indirect Take** | | **1.23** | | | | **1.23** | **0.93** | **1.66** | **1.66** | **1.66** | **1.23** | | **9.58** | **Indirect Take** |
| Accrued Adult Take | | | 1.86 | 1.86 | 1.86 | 1.86 | | 5.58 | 7.44 | 9.30 | | 13.02 | | |
| Adult Lost Productivity Accrued (0.15 multiplier) | | | 0.28 | 0.28 | 0.28 | 0.28 | | 0.84 | 1.12 | 1.40 | | 1.95 | 6.42 | |
| Indirect Take to Adult (0.9 annual survival rate) | | | | | | | 0.72 | | | | 0.72 | 0.55 | | |
| Fledgling to Adult Lost Productivity (0.15 multiplier) | | | | | | | 0.11 | 0.11 | 0.11 | 0.11 | 0.22 | 0.3 | 0.95 | |
| | | | | | | | | | | | | | **7.37** | **Total Lost Productivity** |

**Appendix 10.** WEOP training log for FY 2016.

| WEOP Training | | | |
|---|---|---|---|
| **Name** | **Date** | **Employer** | **Trainer** |
| Steven Rymsha | 8/17/2015 | First Wind | JV |
| Matt Tores | 9/23/2015 | ACTR | MS |
| Justin Berry | 9/23/2015 | GE | MS |
| Mark Stewart | 9/23/2015 | GE | MS |
| Roberto Hernandez | 9/23/2015 | GE | MS |
| Manny Maddela | 9/23/2015 | GE | MS |
| Ollie Colifer | 9/23/2015 | GE | MS |
| Derwin Haysshida | 9/23/2015 | ACTR | MS |
| William Cair | 9/23/2015 | PPC | MS |
| Jeffery Kuniling | 9/23/2015 | GE | MS |
| James Akery | 10/26/2015 | GE | MS |
| Leram Rangel | 10/26/2015 | Granite | MS |
| Jason Snediol | 10/26/2015 | GE | MS |
| Richard Jenkins | 10/26/2015 | GE | MS |
| Dennis Ball | 10/26/2015 | EVM | MS |
| Spencer Gassett | 10/26/2015 | Omne | MS |
| Joe Rhodes | 10/26/2015 | Omne | MS |
| Juan Avila | 10/26/2015 | GE | MS |
| Chris Ng | 10/26/2015 | SunEdison | MS |
| Dave Doyle | 10/26/2015 | SunEdison | MS |
| Mercer East | 10/26/2015 | SunEdison | MS |
| Casey Cohan | 10/26/2015 | SunEdison | MS |
| Spencer Engler | 10/26/2015 | SunEdison | MS |
| Steven Rymsha | 10/26/2015 | SunEdison | MS |
| Jesse Johnson | 10/26/2015 | SunEdison | MS |
| Matthew Pratt | 10/26/2015 | SunEdison | MS |
| Jason Welsh | 11/3/2015 | GE | MS |
| Chris Hanel | 11/4/2015 | GE | MS |
| Patrick Hannon | 1/8/2016 | Rope Partner | MS |
| Mike Dugan | 1/22/2016 | Rope Partner | MS |
| Kevin Anderson | 2/8/2016 | Granite | MS |
| Ryan Westenhaver | 2/8/2016 | Granite | MS |
| Fawzi Khedahe | 2/8/2016 | Granite | MS |
| Brian Schiemer | 5/20/2016 | GE | MS |
| Chris Robinson | 5/20/2016 | GE | MS |
| Isacc Snell | 5/20/2016 | GE | MS |
| John Smith | 5/20/2016 | GE | MS |
| Ron Scott Broncolillo | 5/20/2016 | GE | MS |
| Deborah Pittman | 5/20/2016 | GE | MS |
| Oskar Villalobos | 6/1/2016 | GE | MS |

**Appendix 11.**

Conservation Metrics

# Exploratory Acoustic Surveys for Hawaiian Petrel, Newell's Shearwater, and Barn Owl in East Maui, Hawaii

*Report*
*November 17, 2015*

**For:** **Jay Penniman, Maui Nui Seabird Recovery Project**


**By:** **Matthew McKown, President, Conservation Metrics, Inc.**
**David Savage, Analyst, Conservation Metrics, Inc.**

Center for Ocean Health
100 Shaffer Drive
Santa Cruz, CA 95060

**email: matthew.mckown@conservationmetrics.com**
**tel: 831.427.7969**

## Summary

This report contains results and analysis of exploratory acoustic monitoring efforts undertaken by the Maui Nui Seabird Recovery Project on the eastern slopes of Haleakalā on the island of Maui. Specifically, the survey was designed to detect the presence of three species: Hawaiian Petrel, Newell's Shearwater, and Barn Owl. Sensors were deployed at 41 sites throughout 4 main regions over the course of 2015 survey effort. Hawaiian Petrel were detected at 25 of these sites, Newell's Shearwater at 2, and Barn Owl at 20.

## Introduction

Two threatened seabird species have been pushed to upland refuge sites on the Main Hawaiian islands; ʻuaʻu (Hawaiian Petrel, *Pterodroma sandwichensis*), ʻaʻo (Newell's Shearwater, *Puffinus newelli*). Once common, these species are now at risk of extirpation from breeding colonies throughout the archipelago, due to habitat loss and introduced predators, such as mongoose, rats and Barn Owls (*Tyto alba*). The largest breeding aggregation of Hawaiian Petrels is thought to be within the boundaries of the Haleakalā National Park (Simons & Hodges 1998). Work is currently underway to reduce threats and increase the availability of habitat for these threatened seabirds in and around the Park, including an ungulate-proof fence is being constructed around the Kahikinui Forest Reserve on the leeward slope of Haleakalā (abutting Haleakalā National Park), an ungulate proof fence around a to be determined section of the Haleakalā National Park, and ungulate/predator removal projects in both restoration areas.

The Maui Nui Seabird Recovery Project and the Park have undertaken surveys to collect baseline data on seabird populations in these restoration areas in order to measure the effectiveness of these management actions through time. Reliable data on the status and distribution of these seabirds is extremely challenging because both return to breeding colonies at night, nest in cryptic underground burrows, and generally breed in isolated, delicate, and treacherous terrain. This makes traditional surveys expensive, labor intensive, logistically complicated and potentially damaging to fragile habitat (particularly when related to long-term colony monitoring). New technology, such as automated acoustic monitoring techniques, have proven effective for monitoring these elusive species.

Here we report the results of continued acoustic monitoring surveys by the Maui Nui Seabird Recovery Project (MNSRP) designed to search for seabird activity on the eastern slope of Haleakalā, in Ko'olau Forest Reserve and Haleakalā National Park. Specifically the surveys were designed to:

1) Document presence and nightly patterns of acoustic activity by *ʻuaʻu*, *ʻaʻo*, and Common Barn Owl at specified locations across the landscape of East Maui, adjacent to and within Haleakalā National Park;
2) Establish an inventory (base line) of acoustic activity by each of the three target species at selected sites on East Maui, adjacent to Haleakalā National Park;

3) Search for *'ua'u*, *'a'o*, and common barn owl acoustic activity at exploratory sites; and
4) Continue the development of automated acoustic monitoring as a tool for a) detecting seabird population dynamics and changes and b) assisting with development of appropriate management actions.

### Automated acoustic sensors for ecological monitoring

Acoustic cues have long been an important part of bird monitoring projects (Sauer et al. 1994). Recent technological innovations now make it possible to deploy weatherproof acoustic sensors that can reliably sample the acoustic environment for months at a time without maintenance. Hundreds of hours of field recordings can then be processed with pattern recognition software using deep learning and artificial neural network techniques to derive measures of acoustic activity rates for species of interest. This combination of passive acoustic sensors and automated call detection is especially powerful for monitoring rare/elusive species and species in remote locations (Acevedo & Villanueva-Rivera 2006; Agranat 2007; Brandes 2008a, 2008b).

Passive acoustic sensors and automated classification techniques have increasingly been employed to search for rare bird species including many seabirds (McKown 2008; Buxton & Jones 2012; Buxton et al. 2013; Borker et al. 2014; Oppel et al. 2014). Conservation Metrics has partnered with local biologists to conduct acoustic surveys for Newell's Shearwater, Hawaiian Petrel, and Band-rumped Storm-petrel across the Hawaiian Islands, including four years of intensive surveys on the island of Kaua'i.

## Methods

### Acoustic sensor hardware

A mixture of Wildlife Acoustics SM2, SM2+, and SM3 automated recorders were used for this project. Each of these sensors is a single-board computer in a weatherproof housing containing, four D cell batteries. SM2 and SM2+ sensors used SMX-II and SMX-US microphones, and SM3 sensors use their own integrated microphones.

### Recording schedule

Song Meter 3s were programmed to record 1 out of every 5 minutes, for 5 hours starting at sunset, then record 1 out of every 10 minutes for the 5 hours preceding sunrise. They were set to record in UTC -10, using sunrise and sunset information for 20.71 N, 156.26 W. Recordings were made in stereo WAC format at a 24KHz polling rate, with +24dB of gain and a High Pass filter at 220Hz and Zero Crossing off. A program file (Seabirds_WestMaui_2015_SM3_24dB_stereoWac.PGM) has been provided to MNSRP.

Song Meter 2(+) sensors were programmed to record on the same schedule and with +48dB gain. CMI tests have indicated that this gain level is comparable to +24 dB gain on a SM3. A program file (Seabirds_Maui_stro24k_2015.SET) has been provided.

## Survey Sites

A total of 18 sensors were placed at 44survey points in East Maui: 26 in Ko'olau, 19 in Waikamoi, 2 in Nuu Mauka, and 2 in Puu Pahu (Figure 1). Five of these sensors (KAW115, KAW125, NAK3, HAL1, and MNSRP18) were only deployed at one location, while the rest were moved between locations throughout duration of survey effort. For 5 days in June, 9 sensors were placed together at one area in Ainaho, and continued recording during this period. For purposes of analysis, this was treated as a single site, 'LZ—Ainaho'.

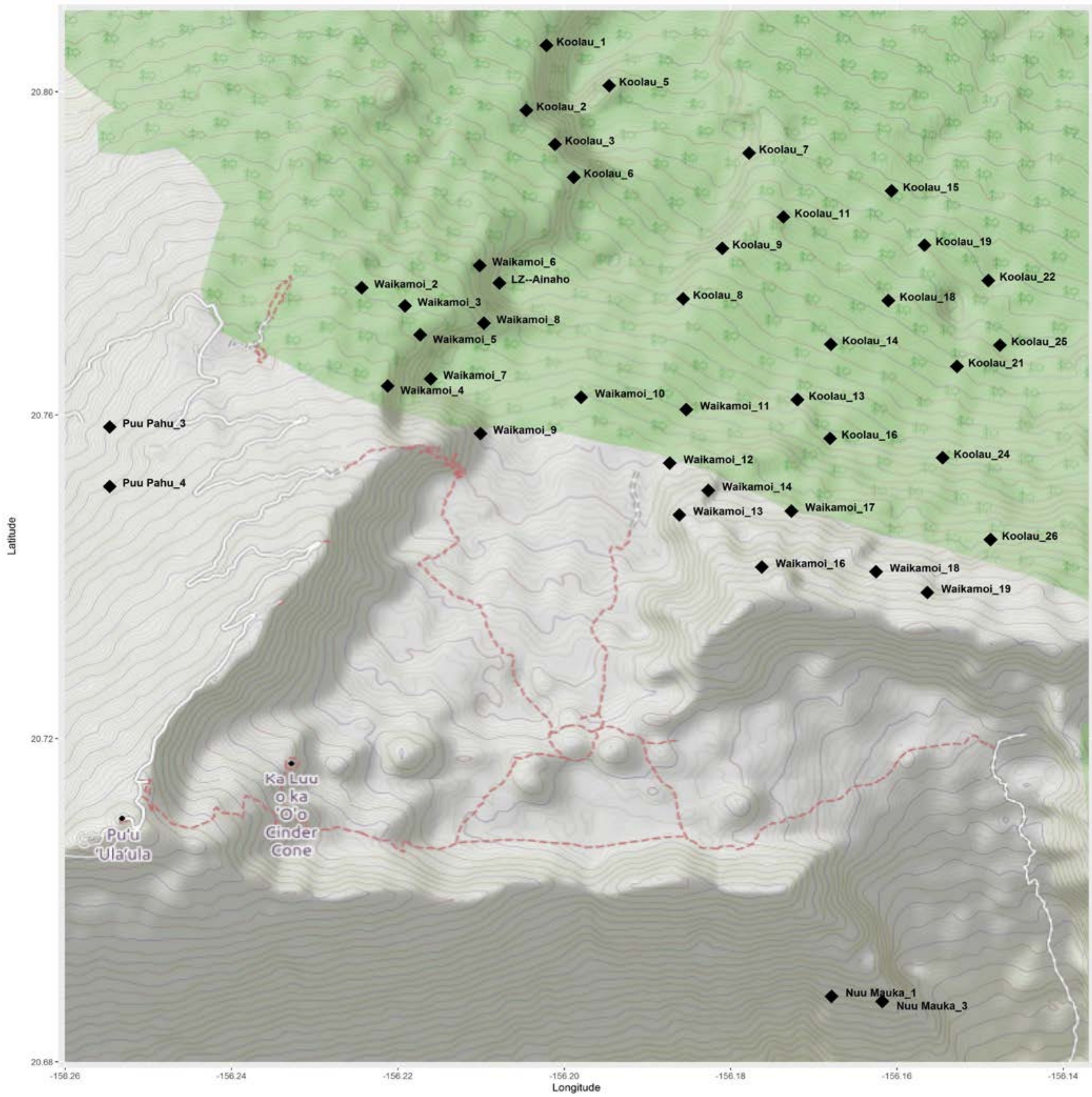


**Figure 1: Acoustic survey points in East Maui.**

### Automated call detection

Automated acoustic analysis of all field recordings was carried out with custom detection and classification software created by Conservation Metrics. This approach uses machine learning algorithms known as Deep Neural Networks to detect sounds on field recordings with spectro-temporal properties that are similar to signals produced by target species. Deep Neural Networks (DNNs) are a powerful classification tool used in speech recognition(Deng et al. 2013) for image recognition (Krizhevsky et al. 2012; Ciresan et al. 2012) and computer vision (Deng et al. 2013) problems.

CMI's approach splits field recordings into 2-second clips and extracts measurements of 10 spectro-temporal features typically found in animal sounds. A DNN classification model is then trained for each species of interest using training and cross-validation datasets containing examples of positive sounds (vocalizations from target species) and a representative example of negative sounds from the soundscape at all survey sites. The DNNs learn which spectro-temporal features best differentiate target sounds from other sounds in the environment, and each model can then be applied to raw acoustic data. The models return a probability that a given 2-second window contains a sound produced by the target species. This method has proven better (more sensitive and more accurate) at detecting target sounds than other widely available bioacoustics analysis software.

## Results

### Survey Effort

This report presents data of an analysis of 2,134 hours of survey effort in 2015. Eighteen sensors were placed at a total of 44 survey points over the course of a combined 1,515 sensor-nights (Table 1, Figure 2, Figure 3).

**Table 1: Survey Effort at all sites. Sites with 0 Total Nights and Total Hours are sites that were deployed but for which CMI did not receive data—some units were lost in the field.**

| Recording Unit | SPID | Longitude | Latitude | Deployment Date | Retrieval Date | Total Nights | Total Hours |
|---|---|---|---|---|---|---|---|
| MNSRP01 | Koolau_1 | -156.202151 | 20.80573 | 5/16/2015 | 6/18/2015 | 34 | 48.1 |
| MNSRP18 | Koolau_10 | -156.178673 | 20.783284 | 6/18/2015 | 7/20/2015 | 33 | 44.82 |
| MNSRP04 | Koolau_11 | -156.173659 | 20.784506 | 6/18/2015 | 7/20/2015 | 33 | 46.24 |
| MNSRP17 | Koolau_13 | -156.171969 | 20.761903 | 6/24/2015 | 7/20/2015 | 27 | 36.33 |
| MNSRP09 | Koolau_14 | -156.167956 | 20.768747 | 6/24/2015 | 7/20/2015 | 27 | 37.27 |
| MNSRP02 | Koolau_15 | -156.160647 | 20.787738 | 6/18/2015 | 7/20/2015 | 33 | 46.23 |
| MNSRP09 | Koolau_16 | -156.168044 | 20.757118 | 7/21/2015 | 9/4/2015 | 46 | 68.84 |
| MNSRP04 | Koolau_18 | -156.161042 | 20.774163 | 7/21/2015 | 9/4/2015 | 46 | 68.84 |
| MNSRP02 | Koolau_19 | -156.156698 | 20.78102 | 7/21/2015 | 9/4/2015 | 46 | 68.84 |
| MNSRP04 | Koolau_2 | -156.20457 | 20.797711 | 5/16/2015 | 6/18/2015 | 34 | 47.76 |

| Recording Unit | SPID | Longitude | Latitude | Deployment Date | Retrieval Date | Total Nights | Total Hours |
|---|---|---|---|---|---|---|---|
| MNSRP17 | Koolau_20 | -156.162497 | 20.752078 | 7/21/2015 | 9/4/2015 | 0 | 0 |
| MNSRP06 | Koolau_21 | -156.152784 | 20.766022 | 7/21/2015 | 9/4/2015 | 46 | 68.84 |
| MNSRP18 | Koolau_22 | -156.149021 | 20.776646 | 7/21/2015 | 9/4/2015 | 35 | 51.7 |
| MNSRP01 | Koolau_23 | -156.146277 | 20.782958 | 7/21/2015 | 9/4/2015 | 0 | 0 |
| MNSRP10 | Koolau_24 | -156.154518 | 20.754719 | 7/21/2015 | 9/4/2015 | 46 | 68.84 |
| MNSRP05 | Koolau_25 | -156.147624 | 20.768651 | 7/21/2015 | 9/4/2015 | 46 | 68.84 |
| MNSRP12 | Koolau_26 | -156.148747 | 20.744598 | 7/21/2015 | 9/4/2015 | 46 | 67.5 |
| MNSRP05 | Koolau_3 | -156.20113 | 20.793482 | 5/16/2015 | 6/18/2015 | 28 | 39.98 |
| MNSRP18 | Koolau_4 | -156.19758 | 20.798079 | 5/16/2015 | 6/18/2015 | 34 | 46.09 |
| MNSRP02 | Koolau_5 | -156.194611 | 20.800748 | 5/16/2015 | 6/18/2015 | 34 | 47.52 |
| MNSRP06 | Koolau_6 | -156.19886 | 20.789427 | 5/16/2015 | 6/18/2015 | 34 | 47.78 |
| MNSRP01 | Koolau_7 | -156.177784 | 20.792411 | 6/18/2015 | 7/20/2015 | 33 | 46.22 |
| MNSRP06 | Koolau_8 | -156.185717 | 20.774384 | 6/18/2015 | 7/20/2015 | 33 | 46.29 |
| MNSRP05 | Koolau_9 | -156.181005 | 20.780625 | 6/24/2015 | 7/20/2015 | 4 | 1.69 |
| MNSRP05 | LZ--Ainaho | -156.207806 | 20.7763387 | 6/18/2015 | 6/24/2015 | 3 | 2.9 |
| MNSRP10 | LZ--Ainaho | -156.207806 | 20.7763387 | 6/18/2015 | 6/24/2015 | 7 | 8.92 |
| MNSRP11 | LZ--Ainaho | -156.207806 | 20.7763387 | 6/18/2015 | 6/24/2015 | 7 | 8.88 |
| MNSRP13 | LZ--Ainaho | -156.207806 | 20.7763387 | 6/18/2015 | 6/24/2015 | 6 | 5.81 |
| MNSRP12 | LZ--Ainaho | -156.207806 | 20.7763387 | 6/18/2015 | 6/24/2015 | 7 | 8.46 |
| MNSRP09 | LZ--Ainaho | -156.207806 | 20.7763387 | 6/18/2015 | 6/24/2015 | 7 | 8.46 |
| MNSRP14 | LZ--Ainaho | -156.207806 | 20.7763387 | 6/18/2015 | 6/24/2015 | 7 | 8.48 |
| MNSRP17 | LZ--Ainaho | -156.207806 | 20.7763387 | 6/18/2015 | 6/24/2015 | 3 | 2.82 |
| MNSRP15 | LZ--Ainaho | -156.207806 | 20.7763387 | 6/18/2015 | 6/24/2015 | 7 | 6.73 |
| HAL1 | Nuu Mauka_1 | -156.1678695 | 20.68810755 | 6/15/2015 | 7/13/2015 | 29 | 40.47 |
| HAL1 | Nuu Mauka_2 | -156.1644935 | 20.68869455 | 7/13/2015 | NA | 0 | 0 |
| NAK3 | Nuu Mauka_3 | -156.1617715 | 20.68748254 | 6/15/2015 | 7/14/2015 | 30 | 42.19 |
| NAK3 | Nuu Mauka_4 | -156.1600775 | 20.68536855 | 7/14/2015 | NA | 0 | 0 |
| KAW115 | Puu Pahu_1 | -156.2516997 | 20.75638499 | 6/23/2015 | NA | 0 | 0 |
| KAW125 | Puu Pahu_2 | -156.257231 | 20.74675386 | 6/23/2015 | NA | 0 | 0 |
| KAW115 | Puu Pahu_3 | -156.2546482 | 20.75852913 | 7/22/2015 | 8/27/2015 | 37 | 55.16 |
| KAW125 | Puu Pahu_4 | -156.2546578 | 20.75116777 | 7/22/2015 | 7/30/2015 | 9 | 12.19 |
| MNSRP07 | Waikamoi_1 | -156.2211284 | 20.78295385 | 5/16/2015 | NA | 0 | 0 |
| MNSRP12 | Waikamoi_10 | -156.197984 | 20.762208 | 6/24/2015 | 7/20/2015 | 27 | 36.39 |
| MNSRP10 | Waikamoi_11 | -156.185343 | 20.760696 | 6/24/2015 | 7/20/2015 | 27 | 37.46 |
| MNSRP13 | Waikamoi_12 | -156.187328 | 20.754067 | 6/24/2015 | 7/20/2015 | 27 | 36.43 |
| MNSRP15 | Waikamoi_13 | -156.186168 | 20.74766 | 6/24/2015 | 7/20/2015 | 27 | 36.34 |
| MNSRP14 | Waikamoi_14 | -156.182698 | 20.750679 | 6/24/2015 | 7/20/2015 | 27 | 36.39 |
| MNSRP11 | Waikamoi_15 | -156.179189 | 20.755763 | 6/24/2015 | 7/20/2015 | 0 | 0 |
| MNSRP13 | Waikamoi_16 | -156.176255 | 20.741211 | 7/21/2015 | 9/4/2015 | 46 | 67.5 |
| MNSRP11 | Waikamoi_17 | -156.172692 | 20.74813 | 7/21/2015 | 9/4/2015 | 46 | 68.84 |
| MNSRP14 | Waikamoi_18 | -156.162519 | 20.740623 | 7/21/2015 | 9/4/2015 | 46 | 67.5 |

| Recording Unit | SPID | Longitude | Latitude | Deployment Date | Retrieval Date | Total Nights | Total Hours |
|---|---|---|---|---|---|---|---|
| MNSRP15 | Waikamoi_19 | -156.156351 | 20.738053 | 7/21/2015 | 9/4/2015 | 46 | 67.5 |
| MNSRP10 | Waikamoi_2 | -156.224365 | 20.775763 | 5/16/2015 | 6/18/2015 | 34 | 47.82 |
| MNSRP11 | Waikamoi_3 | -156.21915 | 20.773526 | 5/16/2015 | 6/18/2015 | 34 | 47.51 |
| MNSRP13 | Waikamoi_4 | -156.22124 | 20.7636 | 5/16/2015 | 6/18/2015 | 34 | 44.88 |
| MNSRP12 | Waikamoi_5 | -156.217327 | 20.769924 | 5/16/2015 | 6/18/2015 | 34 | 46.1 |
| MNSRP09 | Waikamoi_6 | -156.210171 | 20.778509 | 5/16/2015 | 6/18/2015 | 34 | 47.49 |
| MNSRP14 | Waikamoi_7 | -156.216063 | 20.76447 | 5/16/2015 | 6/18/2015 | 34 | 46.07 |
| MNSRP17 | Waikamoi_8 | -156.209663 | 20.771364 | 5/16/2015 | 6/18/2015 | 34 | 46.09 |
| MNSRP15 | Waikamoi_9 | -156.210076 | 20.75771 | 5/16/2015 | 6/18/2015 | 21 | 27.84 |
| **Totals** | | | | | | **1515** | **2134.18** |

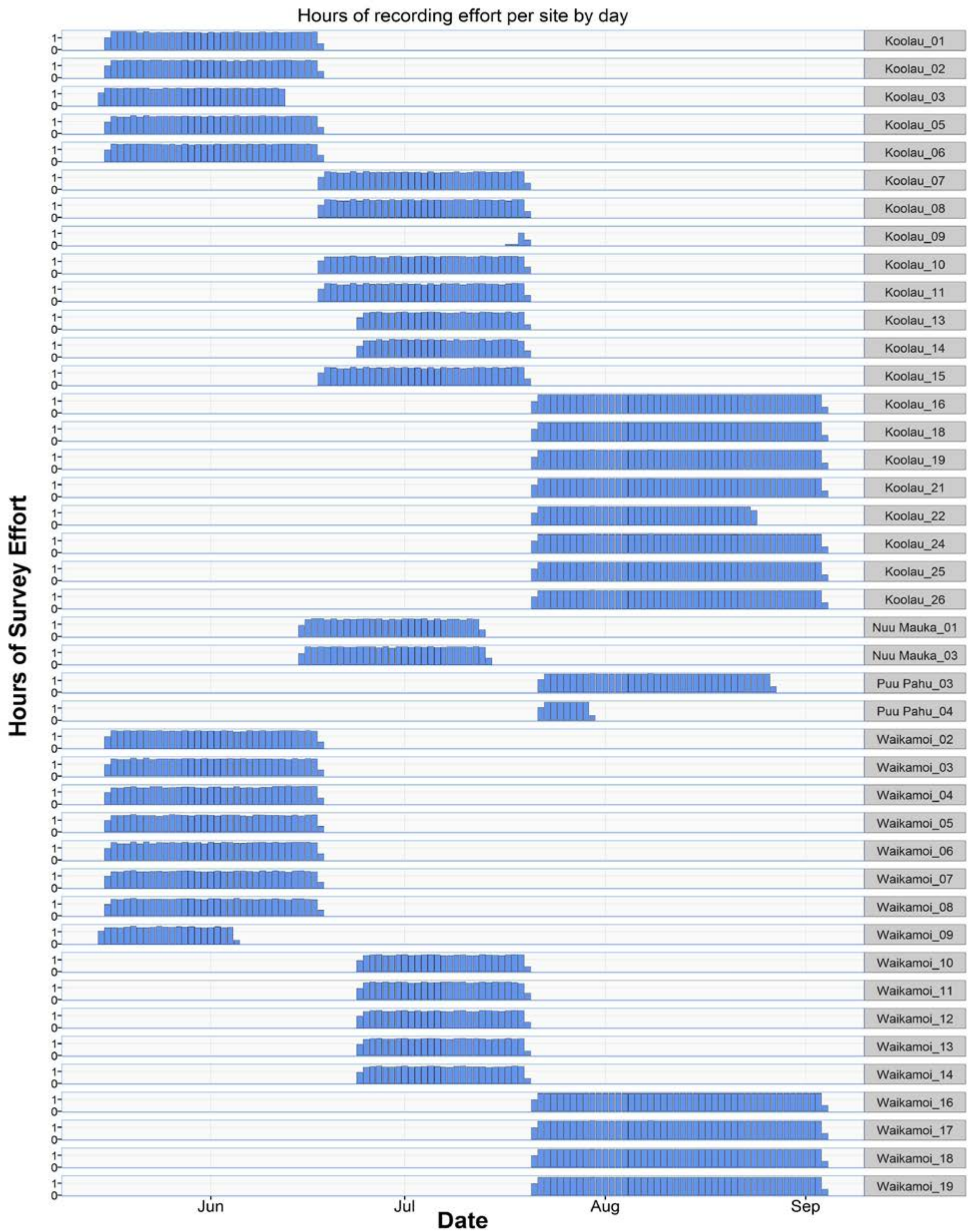


**Figure 2: Hours of survey effort per survey site over time, excluding recordings from the staging area in Ainaho.**

## Hawaiian Petrel

Hawaiian Petrel activity peaked between 20 and 80 minutes after sunset (Figure 3). Seasonally, activity exhibited distinct peaks in mid-late May and early July (Figure 7, Figure 8), though seasonal trends would likely be more apparent if more sites had been surveyed continuously through the entire nesting season. Overall, petrel activity was detected at 13 sites in Ko'olau, 16 sites in Waikamoi, both sites in Nuu Mauka, and the staging area at Ainaho (Figure 4, Figure 5, Figure 6, Figure 9). The highest call rates during Round 1 were at Waikamoi_9 (3.208 +/- 3.121 s.d. Calls/Min) (Figure 4). The highest call rates during Round 2 were at Waikamoi_13 (1.681 +/- 2.088 s.d. Calls/Min) (Figure 5). The highest call rates during Round 3 were at Koolau_25 (0.00741 +/- 0.0497 s.d. Calls/Min.) (Figure 6).

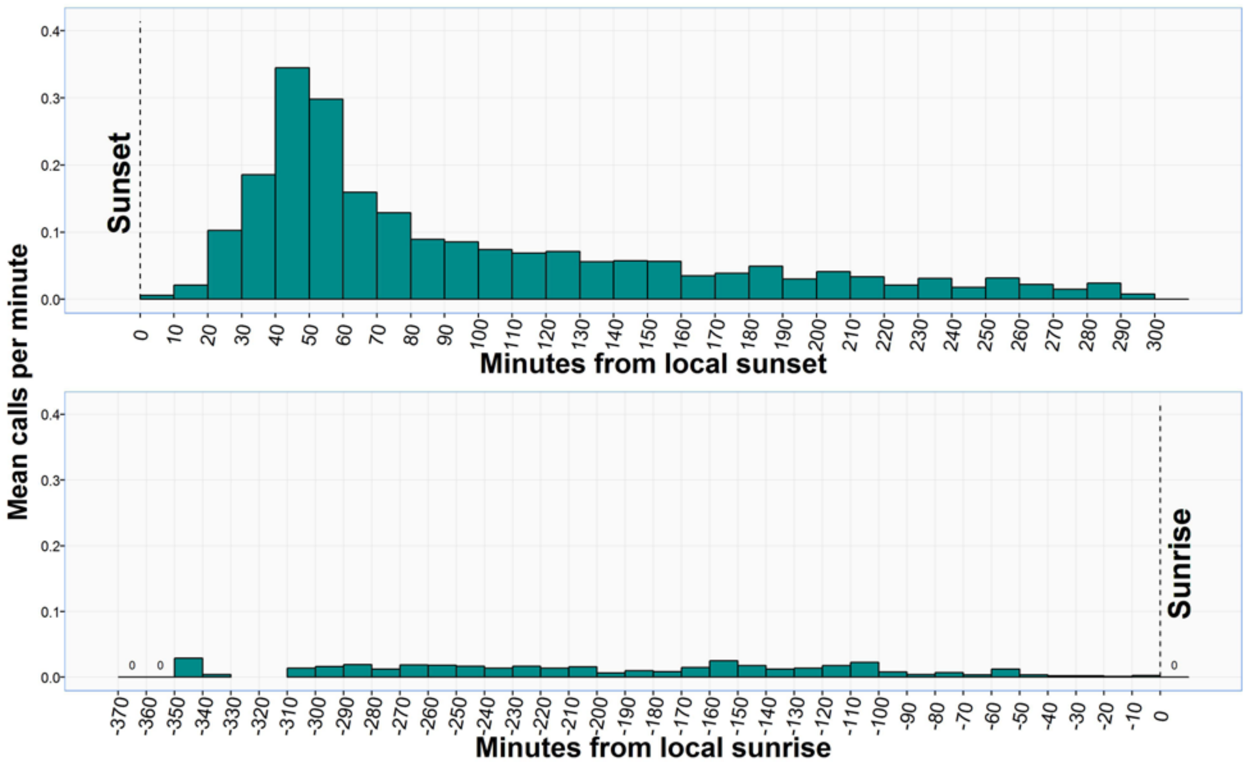


**Figure 3: Hawaiian Petrel activity as a function of time from sunset and sunrise, aggregating all sites and the complete survey duration.**

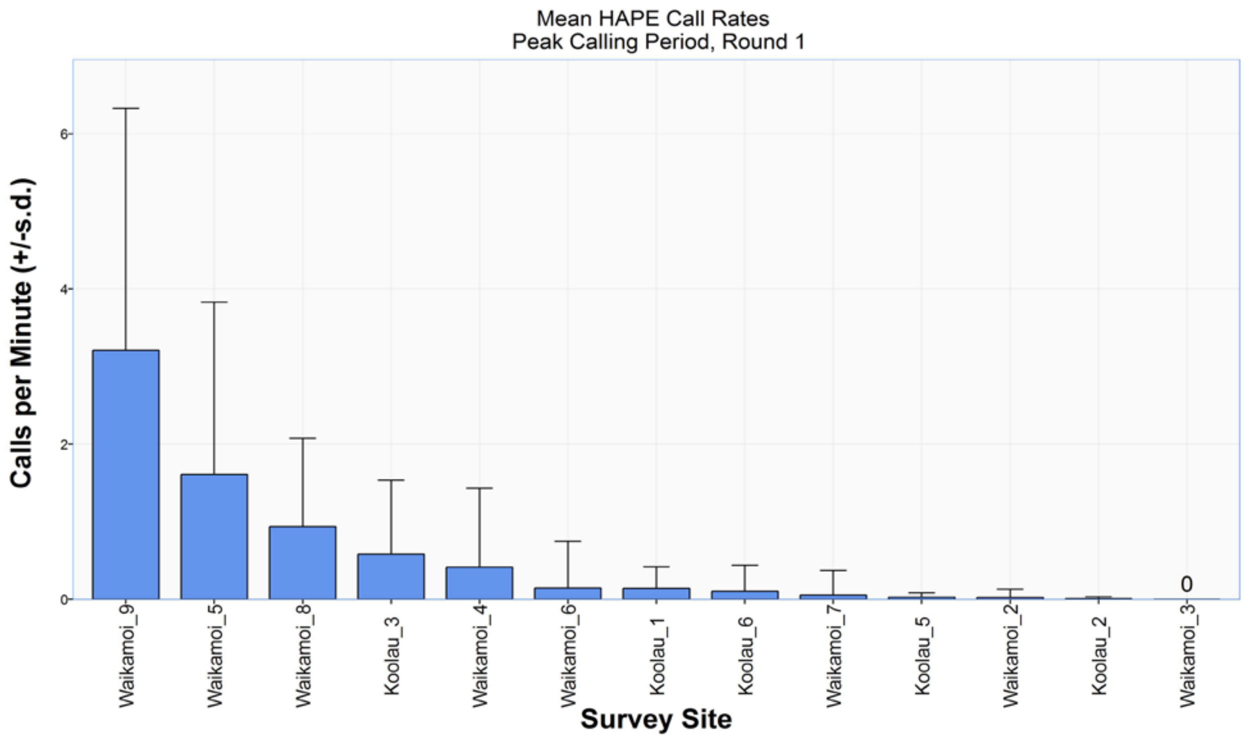


**Figure 4: Hawaiian Petrel mean call rates at each site during peak calling hour (20-80 minutes after sunset), comparing sites from Round 1 (05/15/2015 to 06/18/2015).**

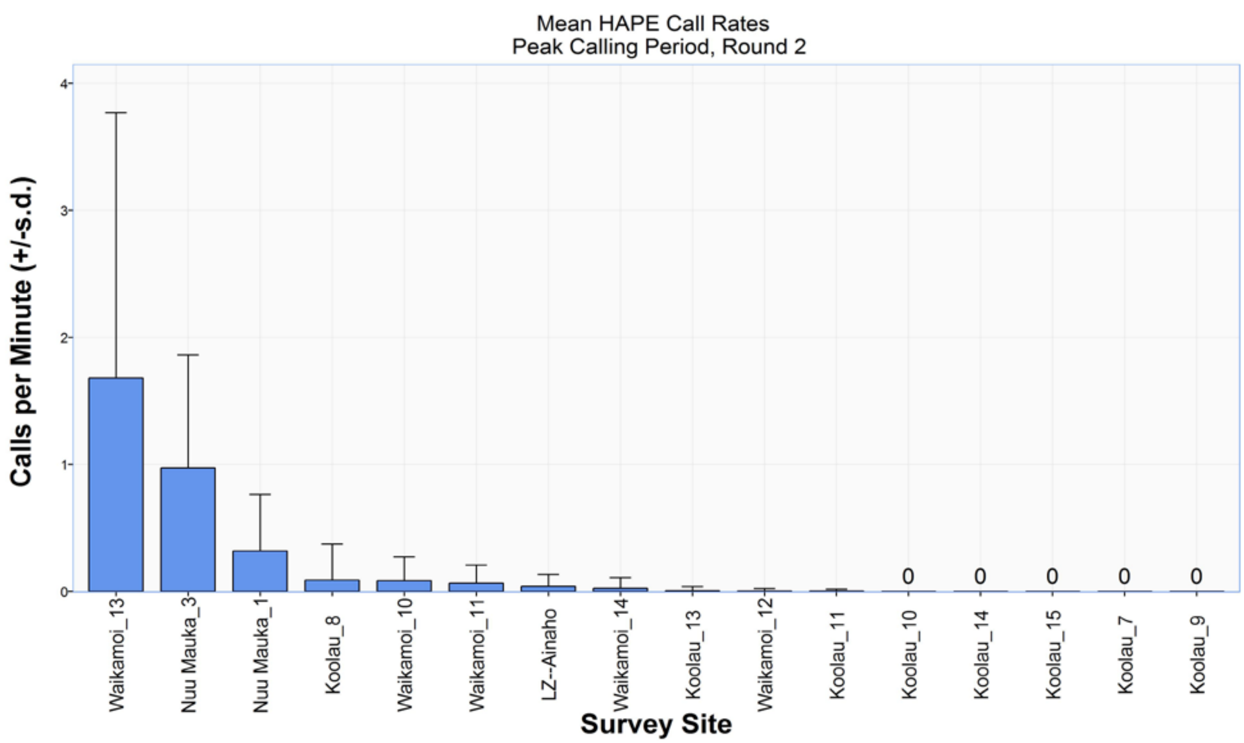


**Figure 5: Hawaiian Petrel call rates at each site during peak calling period (20-80 minutes after sunset), comparing sites from Round 2 (6/18/2015 to 7/20/2015).**

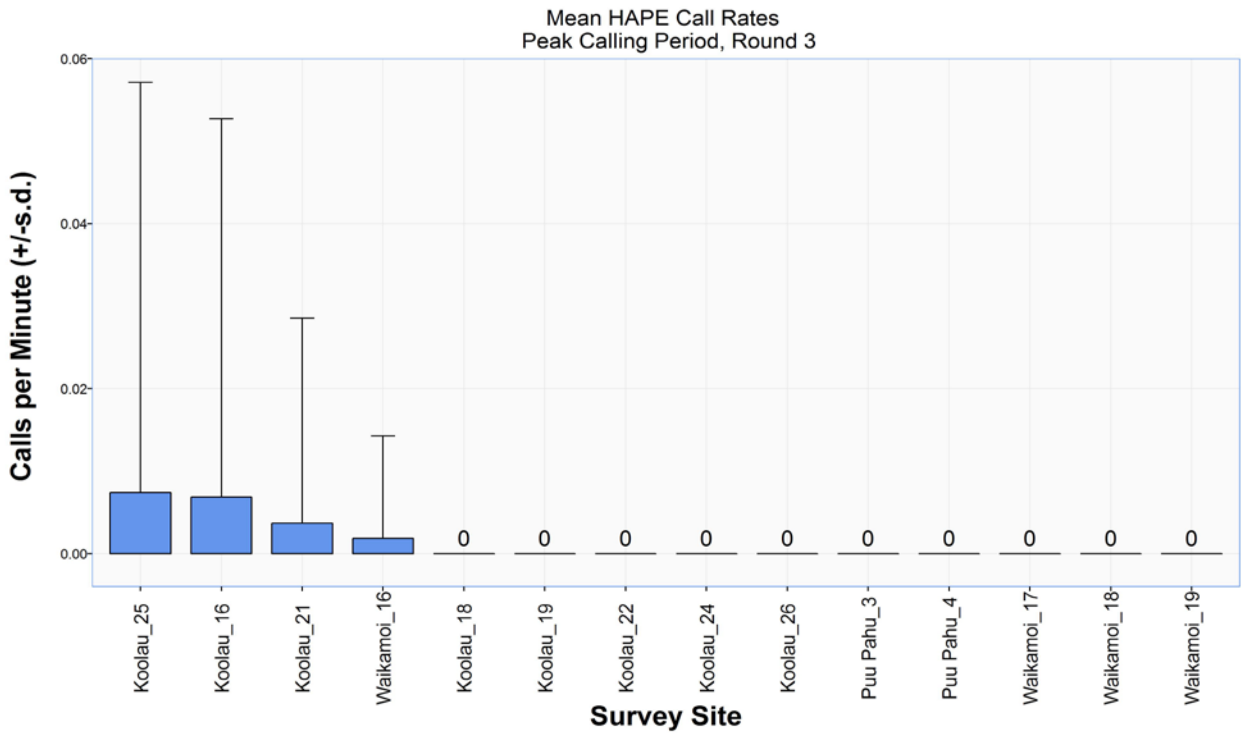


**Figure 6: Hawaiian Petrel call rates at each site during peak calling hour (20-80 minutes after sunset), comparing sites from Round 3 (7/21/2015 to 09/04/2015).**

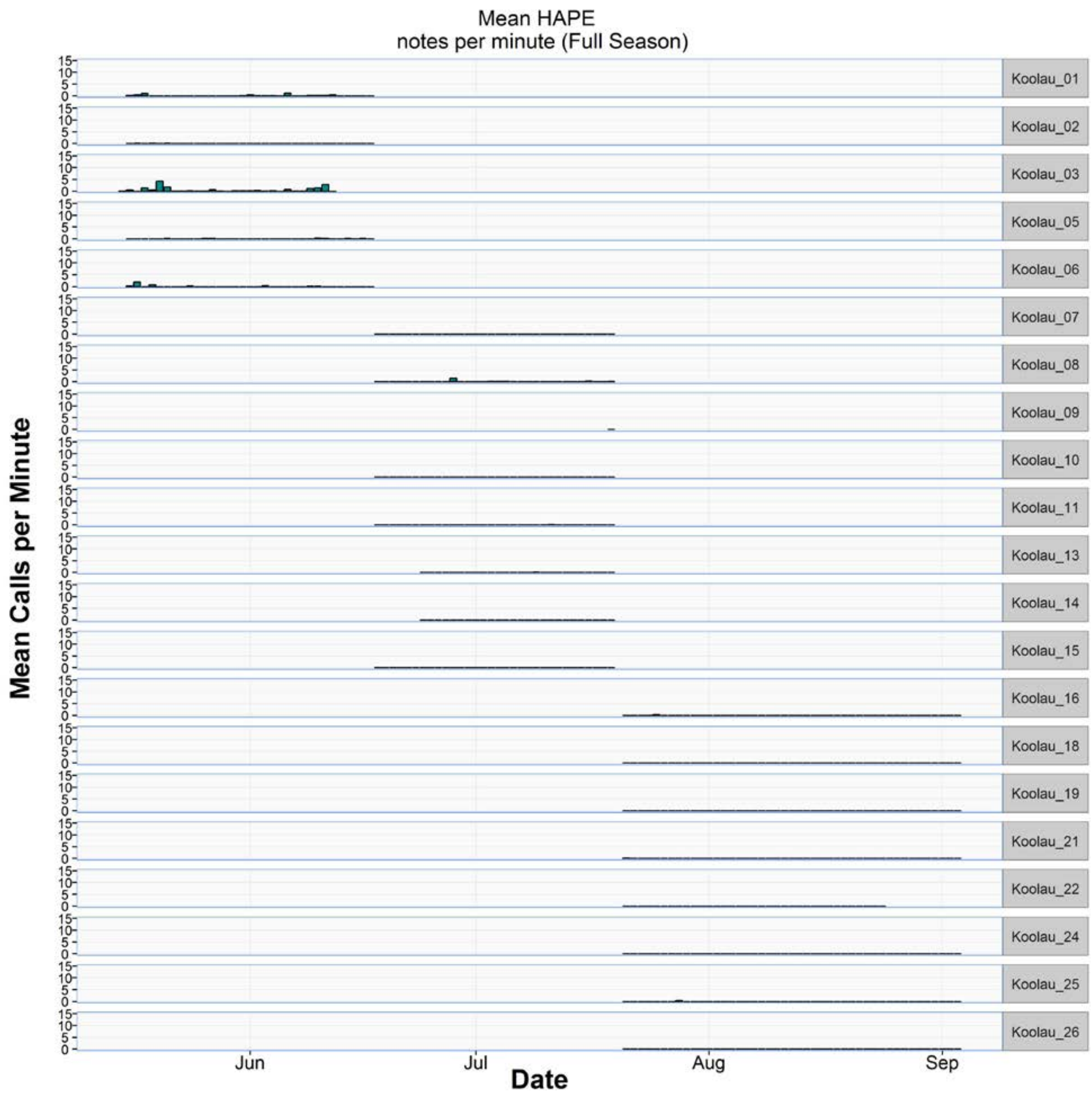


**Figure 7: Hawaiian Petrel call rates over time at Ko'olau sites. Call rates were calculated during peak calling hour (20-80 minutes after sunset).**

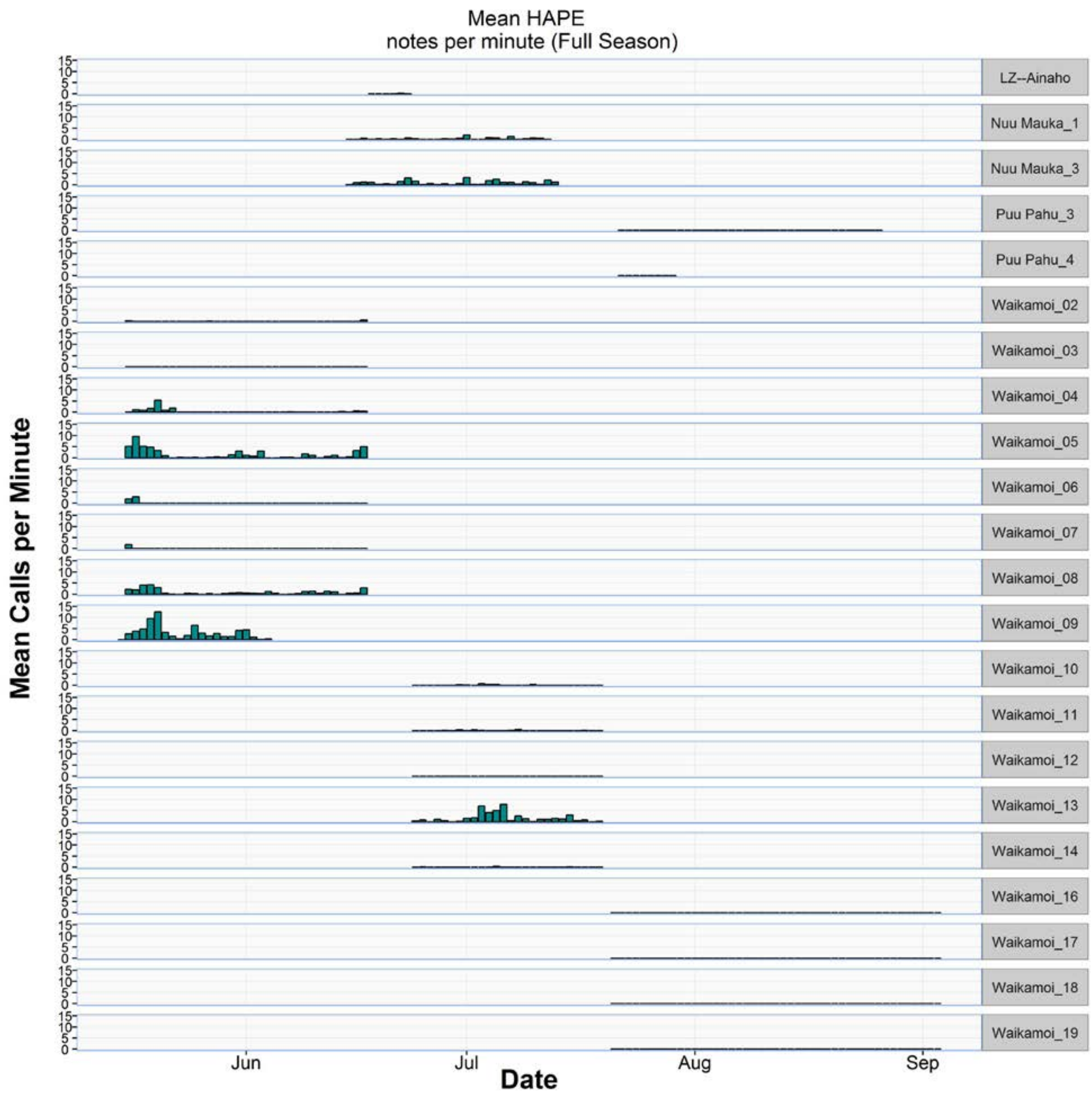


**Figure 8: Hawaiian Petrel call rates over time at non-Ko'olau sites. Call rates were calculated during peak calling hour (20-80 minutes after sunset).**

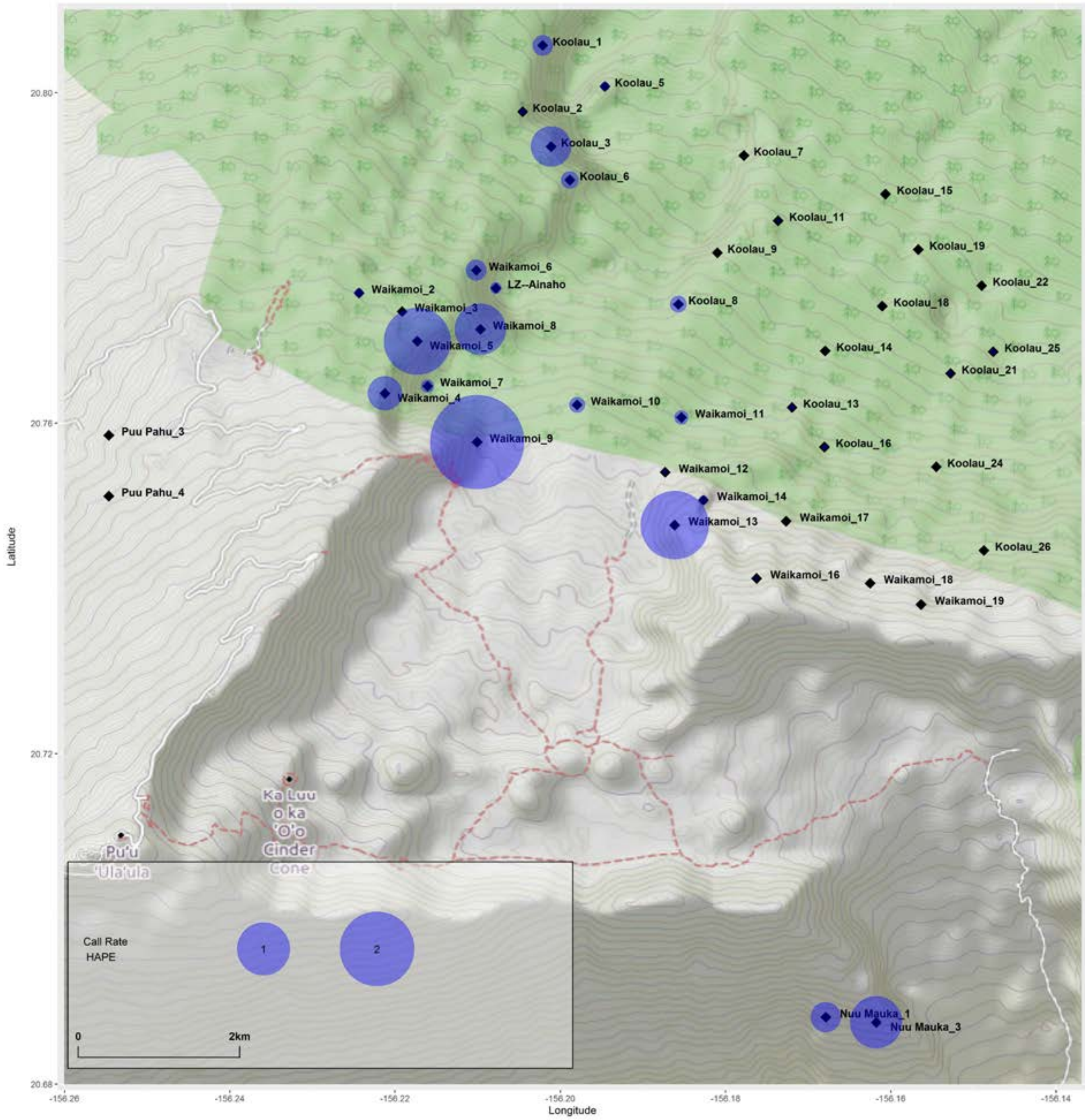


**Figure 9: Map showing Hawaiian Petrel call rates during peak calling hour (20-80 minutes after sunset).**

## Newell's Shearwater

Newell's Shearwater calls were detected in low numbers at 5 sites: 4 in Ko'olau and 1 in Nuu Mauka (Figure 9). Only Ko'olau_3 (Figure 9) had regular activity and so seasonal or nightly phenology for Newell's Shearwater populations on East Maui is difficult to characterize beyond a minor peak in activity at Ko'olau_3 during the beginning of survey effort (Figure 10).

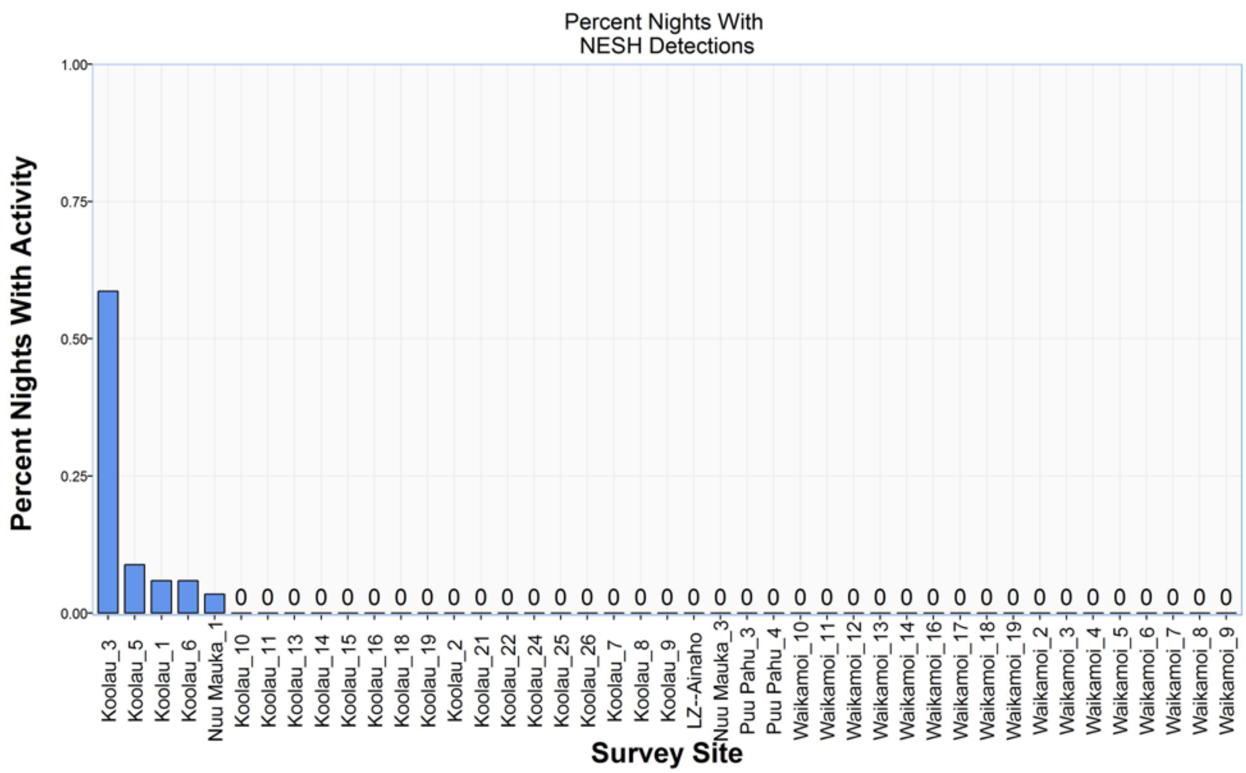


**Figure 10: Percentage of survey nights at each site that have one or more Newell's Shearwater detections**

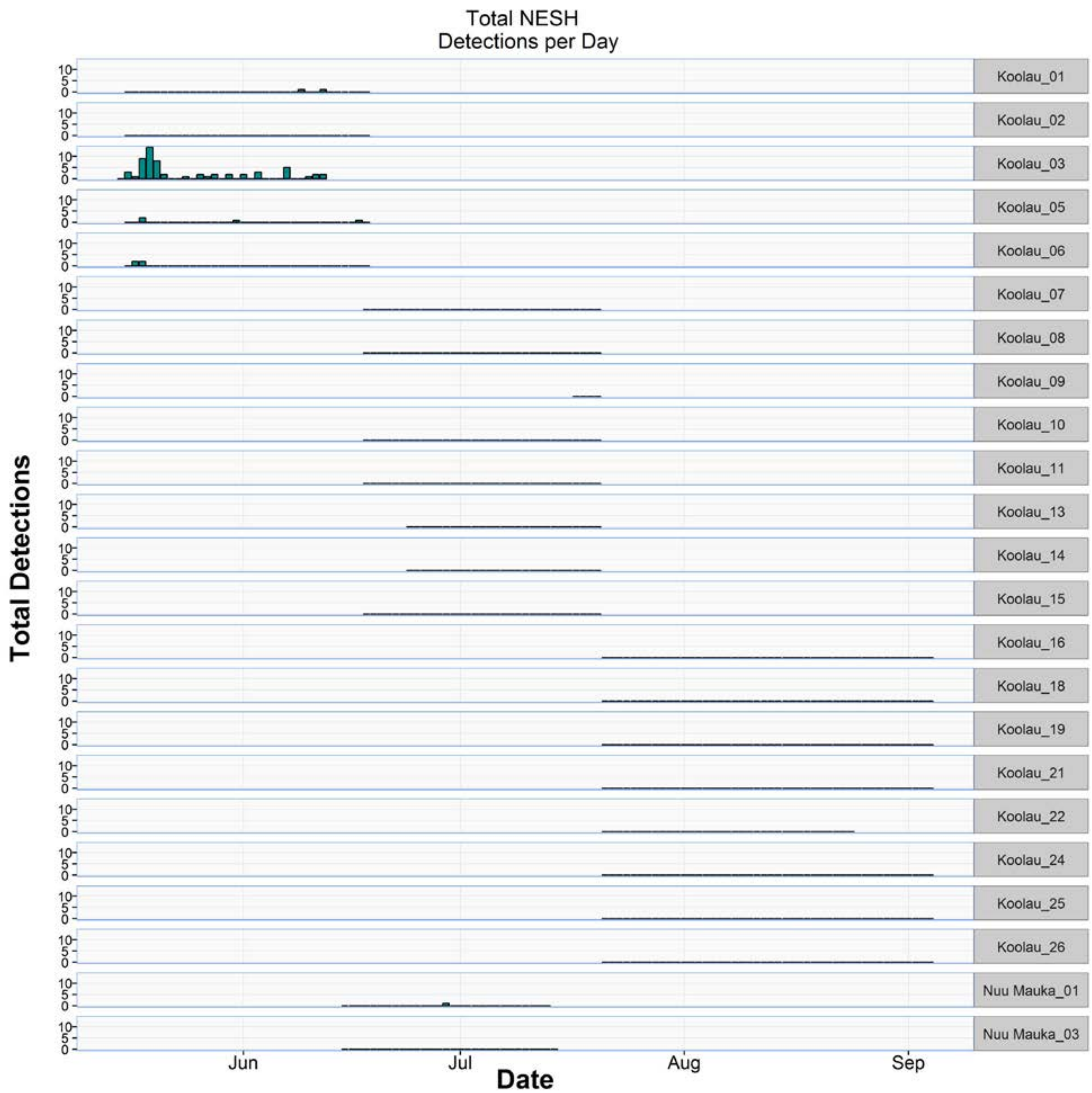


**Figure 11: Total Newell's Shearwater detections by day at Ko'olau and Nuu Mauka sites**

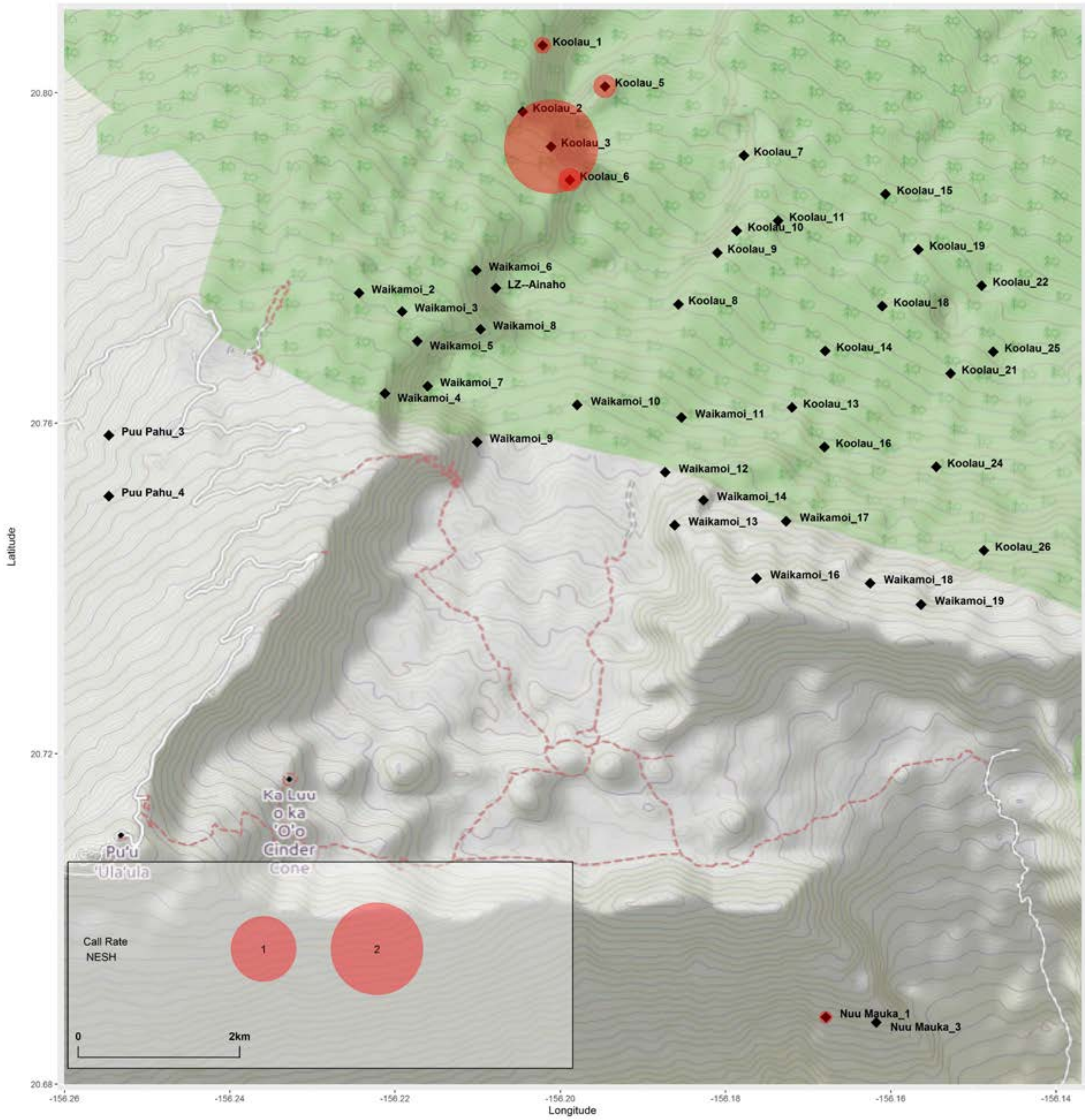


**Figure 12: Map showing average Newell's Shearwater detections per survey night.**

## Barn Owl

Barn Owl calls were detected at 12 sites in Waikamoi, 7 sites in Ko'olau, and one site in Puu Pahu (Figure 12, Figure 16), with the highest call rates at Waikamoi_5 and Waikamoi_9 (Figure 12). Owls exhibited no temporal trends in activity, whether over the course of a night (Figure 12) or over the course of the survey season (Figure 13, Figure 14).

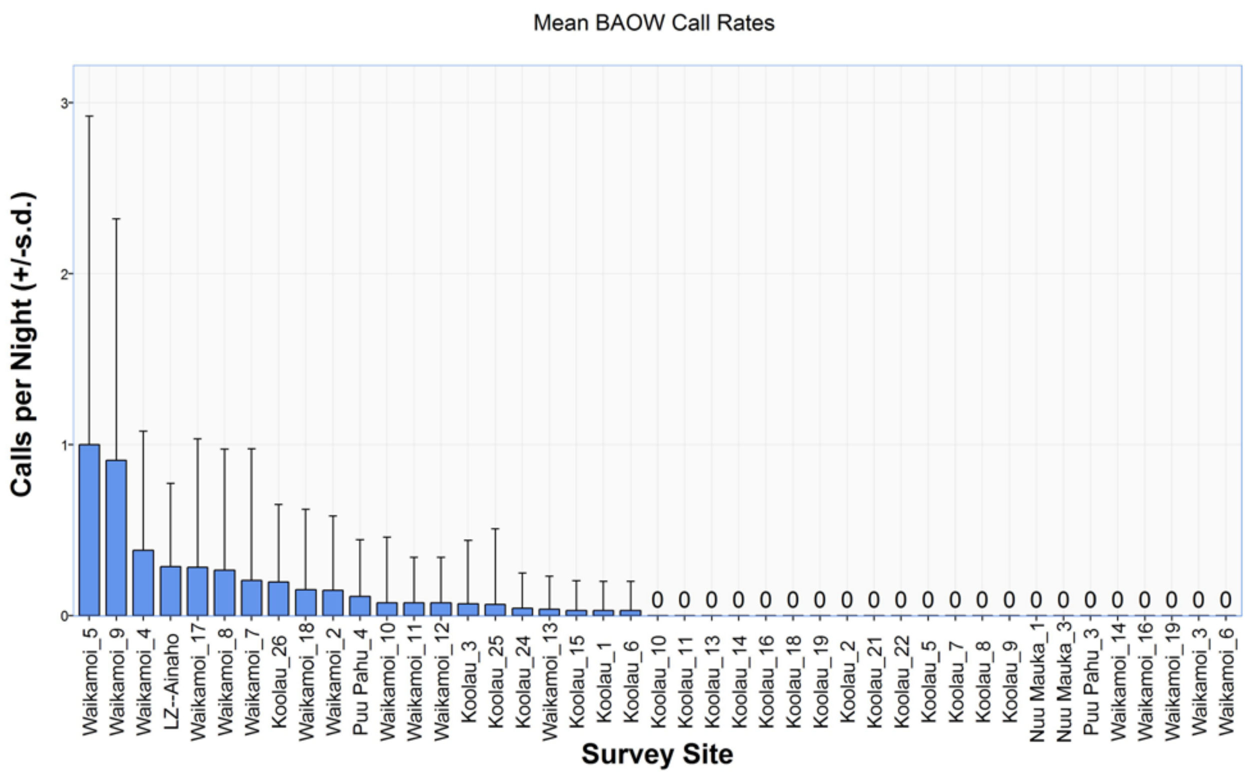


**Figure 13: Mean Barn Owl calls per night at all sites across entire survey duration**

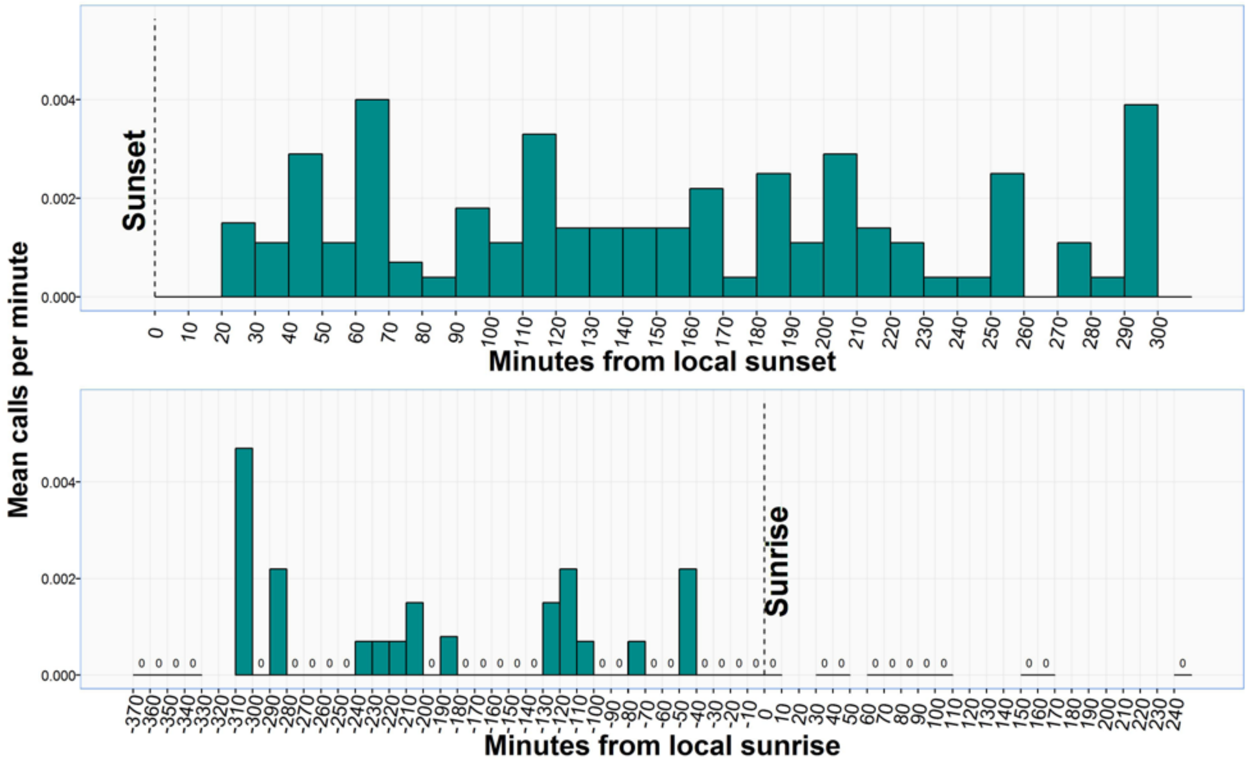


**Figure 14: Barn Owl call rates as a function of time from sunset and sunrise, across all sites during the entire survey duration.**

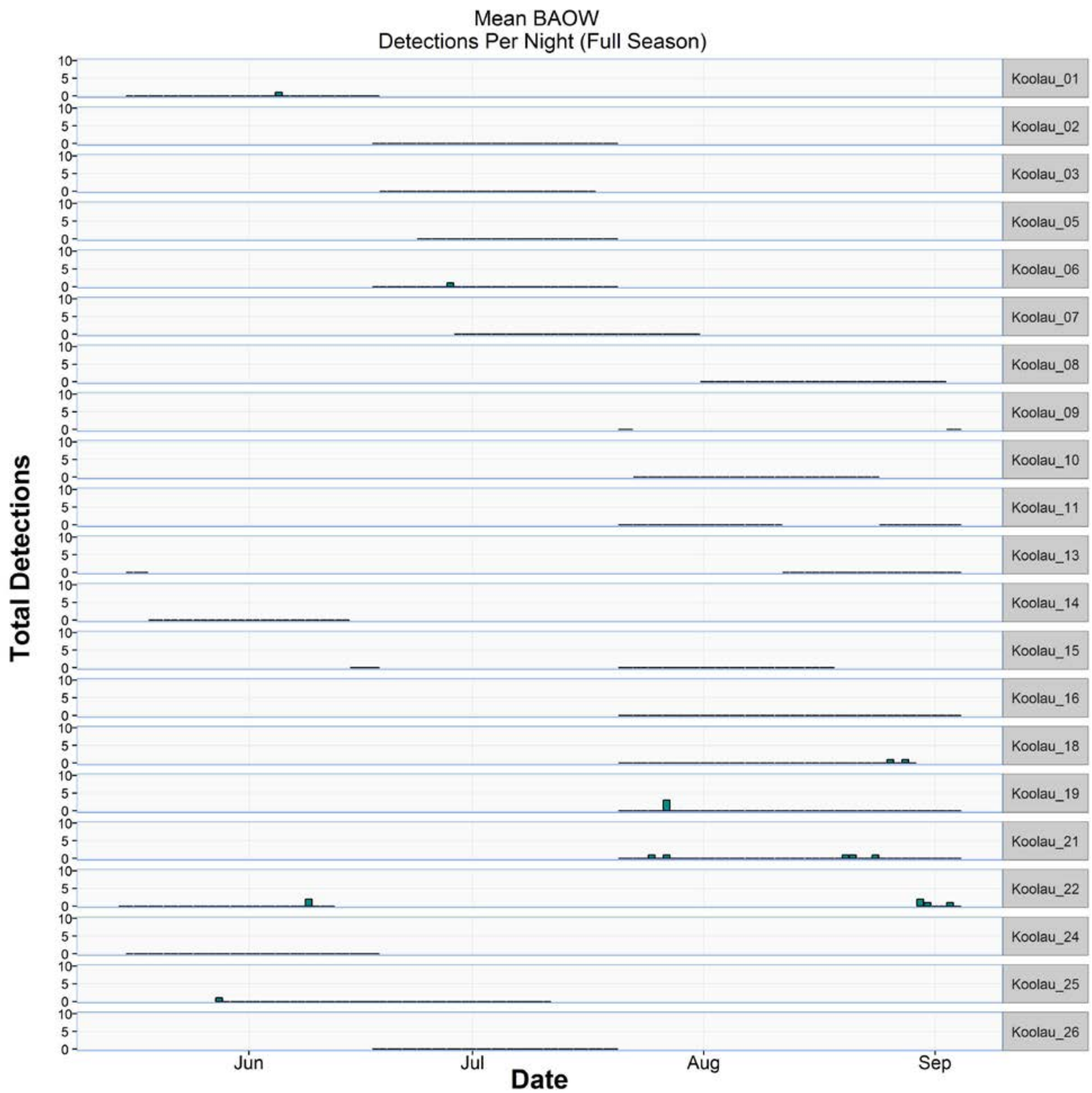


**Figure 15: Total Barn Owl detections by day at Ko'olau sites.**

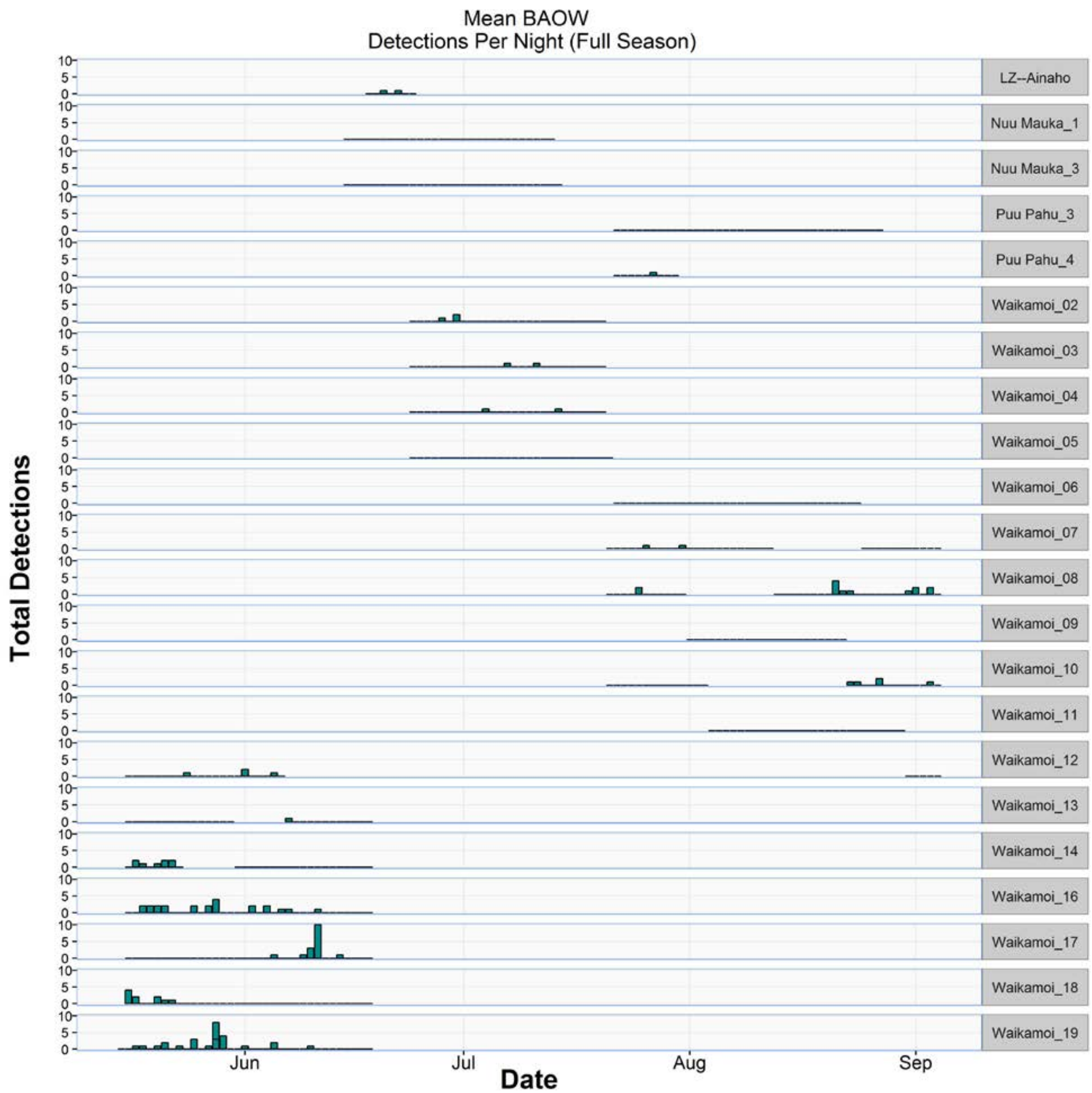


**Figure 16: Total Barn Owl detections by day at non-Ko'olau sites.**

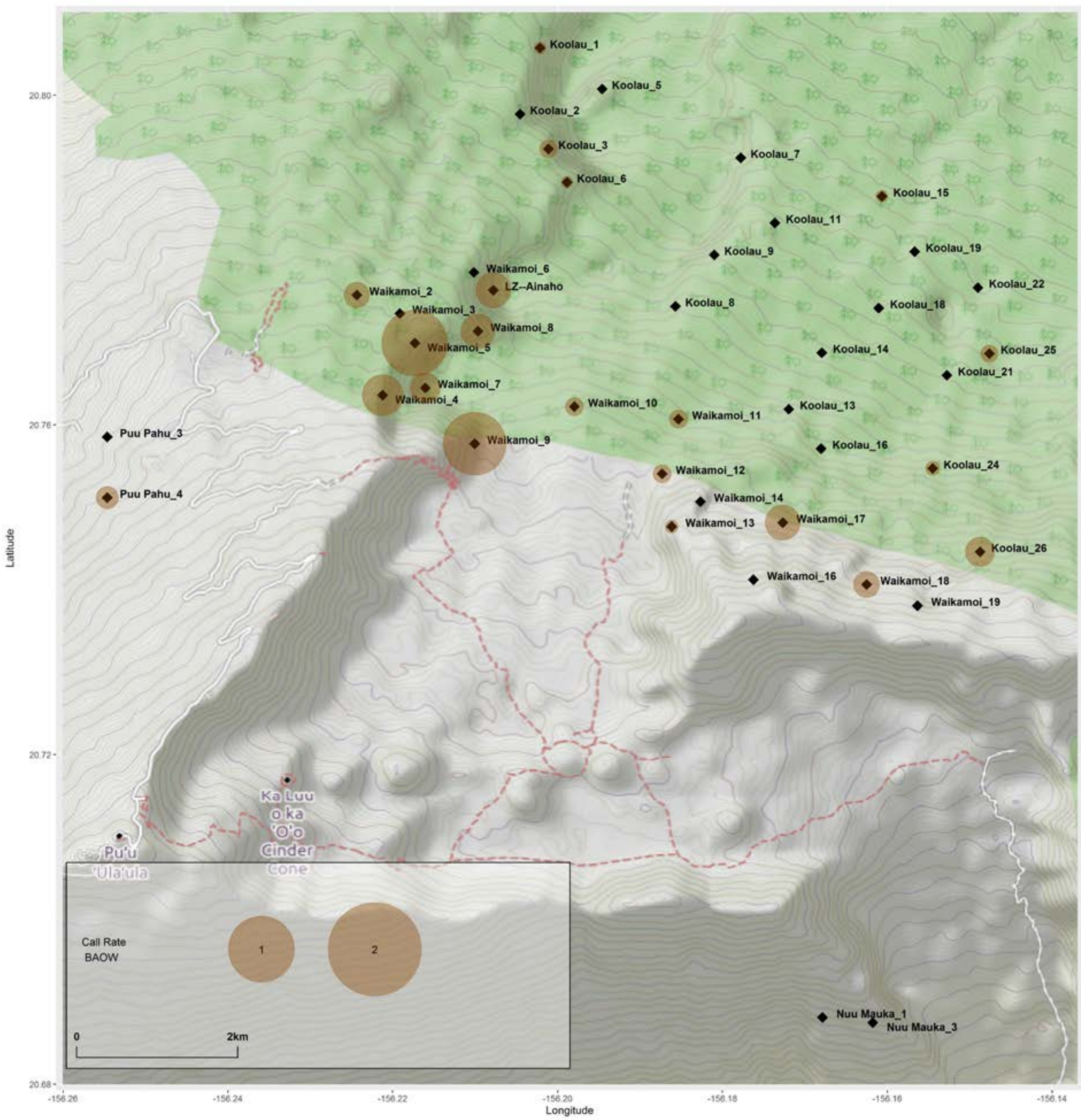


**Figure 17: Map of average Barn Owl detections per night, across entire survey duration**

## Discussion

The 2015 helicopter deployed acoustic surveys in East Maui detected the vocalizations of target species at a number of exploratory sites. Specifically, Hawaiian Petrel vocal activity was detected at many points across the survey area. Newell's Shearwater activity was limited to 4 or fewer detections at all but one site - Koolau_3.

Barn Owl detections were widespread but intermittent, which matches with the results of previous Barn Owl acoustic surveys at other locations in the Hawaiian Islands (McKown unpublished reports).

Whether the activity detected is related to new breeding aggregations, or to birds flying up to the large Hawaiian Petrel breeding colony on Haleakalā remains to be determined.

Future acoustic surveys should duplicate previously-successful survey designs, combining some season-long deployments at single locations with helicopter deployment of shorter-survey 'Rover' units to detect novel sites. This approach would allow for improved observation of phenology and better establishment of baseline activity for long-term trend monitoring.

Finally, it is interesting to note that the observed Hawaiian Petrel peak activity period was 30 minutes earlier than the peak of activity in survey effort from 2014 in Kahikinui Forest Reserve on the western side of Haleakalā, just under 10km away. Whether this is related to flight paths or some other explanation remains to be seen.

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**Appendix 12. Makamaka’ole night survey summary data.**

| Date | Time | Species | Count | Flight Direction | Notes |
|---|---|---|---|---|---|
| 30-Mar-16 | 18:15 | BANO | 1 | | |
| 30-Mar-16 | 18:20 | BANO | 1 | | |
| 30-Mar-16 | 19:40 | HAPE | 1 | | Maybe two |
| 20-Apr-16 | 19:20 | HAPE | 1 | S | |
| 20-Apr-16 | 19:25 | HAPE | 1 | S | |
| 20-Apr-16 | 19:30 | HAPE | 1 | S | |
| 20-Apr-16 | 19:35 | HAPE | 1 | S | |
| 20-Apr-16 | 19:40 | HAPE | 1 | S | |
| 20-Apr-16 | 19:45 | HAPE | 1 | S | |
| 20-Apr-16 | 19:50 | HAPE | 1 | S | |
| 20-Apr-16 | 19:55 | NESH | 1 | S | |
| 16-May-16 | 19:20 | NESH | 1 | S | |
| 16-May-16 | 19:27 | NESH | 2 | NE | Clear view |
| 16-May-16 | 19:30 | NESH | 2 | | Hear calls, cloud cover low |
| 16-May-16 | 19:38 | NESH | 2 | | Calls overhead |
| 16-May-16 | 19:41 | NESH | 4 | | Circling in Makamaka'ole |
| 16-May-16 | 19:46 | NESH | 1 | N | Flies directly above burrows |
| 16-May-16 | 19:49 | NESH | 3 | | Observed directly overhead |
| 16-May-16 | 19:52 | HAPE | 2 | | Fly within 5m of observation point |
| 16-May-16 | 19:52 | NESH | 1 | | Fly within 5m of observation point |
| 16-May-16 | 19:54 | NESH | 1 | | Calls from Stream |
| 16-May-16 | 20:05 | NESH | 1 | S | |
| 20-Jun-16 | 19:41 | NESH | 1 | SW | |
| 20-Jun-16 | 19:46 | NESH | 1 | | |
| 20-Jun-16 | 19:50 | NESH | 1 | | |
| 20-Jun-16 | 19:53 | NESH | 2 | | |
| 20-Jun-16 | 19:55 | NESH | 2 | | |
| 20-Jun-16 | 19:56 | NESH | 1 | | |
| 20-Jun-16 | 19:59 | NESH | 2 | | 1953-2030 NESH Calling back to sound system and circling burrow area aggressively |
| 20-Jun-16 | 20:30 | BANO | 1 | NW | Barn owl flushed from roost on fence post inside of enclosure B as we were packing out. |

## Appendix 13.

### Burrow Temperature Monitoring

Maintaining burrow temperatures within specified tolerances by experimenting with burrowing box insulation concepts was done during the non-breeding months within both enclosures. Studies conducted by Lyons (1979), Simons (1985, Figure 1), and Howell and Bartholomew (1961) suggest that high temperatures, exceeding 30 C and high variation in temperature, exceeding 5 C could discourage HAPE and NESH from the use of artificial burrows and that long term exposure to high temperatures could be detrimental. Six different designs were drawn up and constructed to insulate the exposed burrow boxes from direct sun and high temperatures (Figure 2). The 6 designs included 2 sizes of plywood covers, with and without insulation material (for a total of 4), one with a shade cloth cover, and one with burlap and sandbags. Each experimental method was measured with a LogTag Temperature Data Logger. Temperature loggers were set inside the burrow box, on the ground adjacent to the entrance for each burrow. Temperatures were recorded every 30 minutes from Dec 4, 2015 to Jan 8, 2016 (Figure 3).

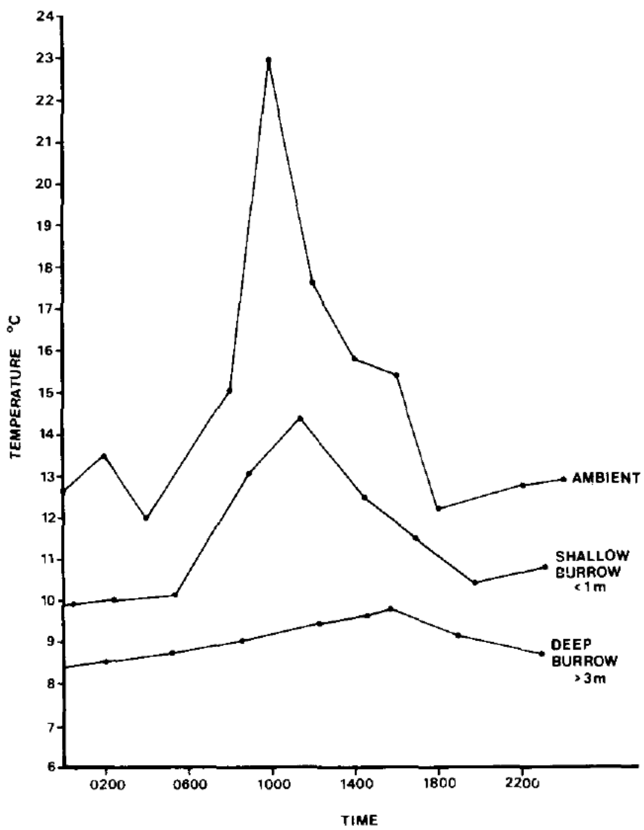


Figure 1. Simons (1985) Burrow temperatures from the summit of Haleakala

Figure 2. Each of the experimental insulation designs tested. Left top: Small unvented. Right top: Shade cloth. Mid left: Small vented. Mid right: Large insulated. Bottom: sand bag and burlap burrow covered left and exposed right.

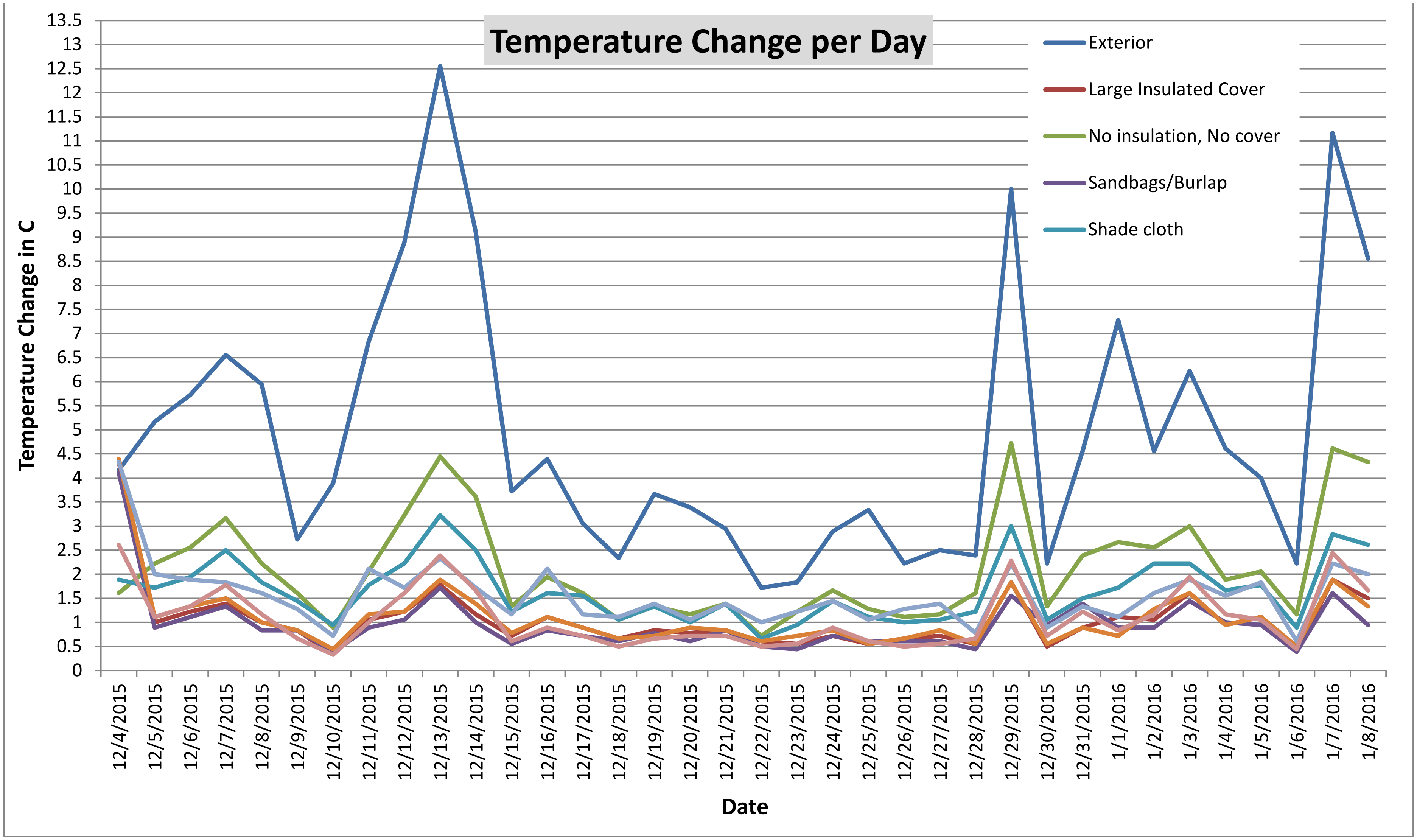


Figure 3. This graph shows the difference between the maximum and minimum daily temperatures.

All of the experimental methods reduced the mean and range of internal burrow temperature well below the 30° C threshold. It appears that the sandbag/burlap has the highest mitigating impact in terms of temperature regulation. Each of the "insulated" boxes maintained the maximum temperature swing below 2.5° C and none of the temperatures approached 30° C. With these results in mind, as well as the DLNR NARs staff concerns of maintaining minimal visual impact, minimal site disturbance, and ease of access to nest boxes, a final insulation design was created (Figure 4). It is a slightly modified version of the small uninsulated box which provides more airflow/airspace between the insulating box and the burrow box (Figure 5). It has no added insulation, requires no excavation, and provides easy access to check inside the burrows. A wooden cover with an air insulation buffer also provides added protection to the burrow boxes, which should increase the longevity of the boxes and decrease the frequency which disturbance would be necessary to replace decaying boxes.

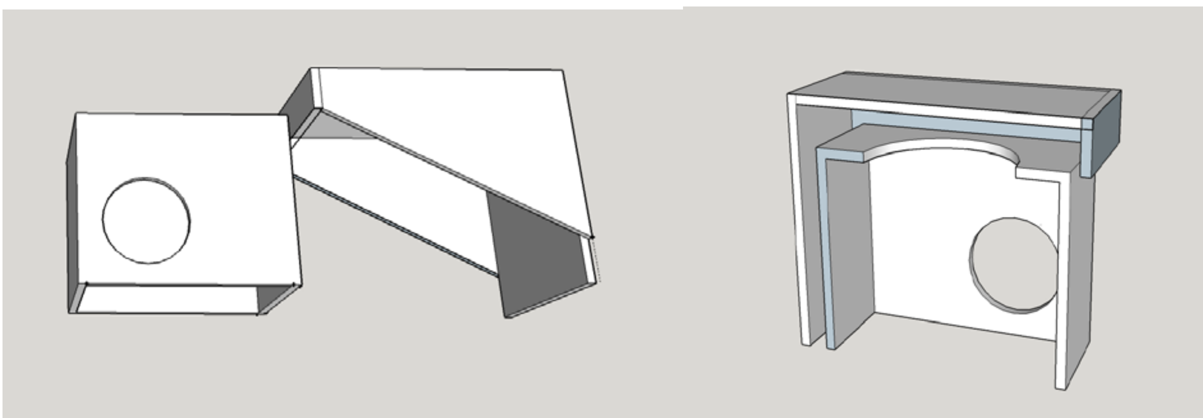

Figure 4. Detailed plan view of the final design, relative to the burrow boxes.

Figure 5. An insulation box prior to assembly

Figure 6. Final insulation box design in place over a burrow.

Additional temperature readings were collected inside 8 burrow boxes with the final insulations design installed within enclosure B using the same methods as the previous trials (Figure 6). Temperatures were collected between the dates of March $3^{rd}$ 2016 through June $26^{th}$ 2016 (Figure 7). Ambient temperature was collected at 10 minute intervals by a weather nearby weather station.

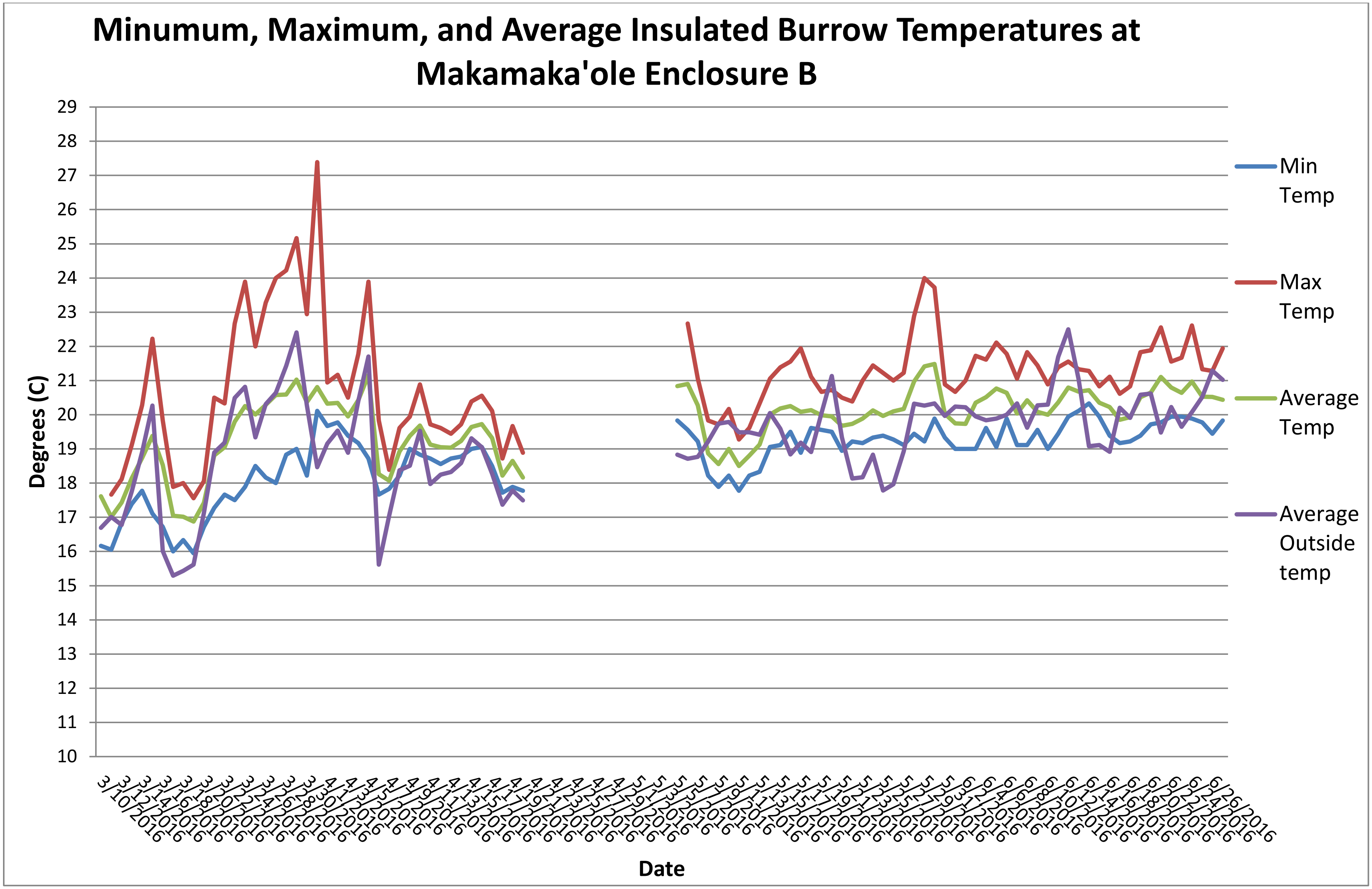


Figure 7. Graph showing minimum, maximum, and average burrow temperatures Inside enclosure B burrows with the final insulation design.

## Appendix 14. KWPI expenditures for FY 2016.

| KWPI | Cost |
|---|---|
| Permit Compliance | $83 |
| Seabird Management | $223,369 |
| Vegetative Management | $28,447 |
| Fatality Monitoring | $46,734 |
| Equipment and Supplies | $8,237 |
| Staff Labor | $102,999 |
| **Total Cost for FY 2016** | **$409,869** |