Kaheawa Wind Power I Project
Habitat Conservation Plan
FY 2019 Annual Report

Prepared for:

TerraForm Power, LLC
3000 Honoapi`ilani Highway
Wailuku, Hawai`i 96768

Prepared by:

Tetra Tech, Inc.
1750 SW Harbor Way., Suite 400
Honolulu, Hawaiʻi 96813

August 2019

Incidental Take License ITL-08/ Incidental Take Permit TE118901-0

This page intentionally left blank

EXECUTIVE SUMMARY

This report summarizes work performed by TerraForm Power, LLC (TerraForm), operator of the 20-turbine Kaheawa Wind Power I Project (Project), during the State of Hawaiʻi fiscal year (FY) 2019 (July 1, 2018 – June 30, 2019) under the terms of the approved Habitat Conservation Plan (HCP). The HCP was approved in January 2006 and describes TerraForm's compliance obligations under Project's state Incidental Take License (ITL-08) and federal Incidental Take Permit (TE118901-0). Species covered under the HCP include four federally-listed threatened and endangered species (Covered Species). The Project was constructed in 2005 and 2006 and has been operating since June 22, 2006.

Fatality monitoring at the Project continued throughout FY 2019 within search plots consisting of the graded roads and wind turbine generator (WTG) pads found within a 70-meter radius circle centered on each WTG. Plots were searched by canine teams once per week year-round. Bias correction trials were conducted at the Project in FY 2019 to measure the probability that a carcass would persist until the next search and the probability that an available carcass would be found by a searcher. The results of these trials were consistent with previous years, with searcher efficiency exceeding 91 percent for surrogates for bats and avian Covered Species.

Fatalities of three Covered Species were found in FY 2019: Hawaiian hoary bat (1), Hawaiian goose (2), and Hawaiian petrel (1). Through FY 2019, the Project's total observed direct take of Covered Species has been 12 Hawaiian hoary bats, 26 Hawaiian geese, and eight Hawaiian petrels. The fatality estimates using the Evidence of Absence estimator at the upper 80 percent credibility level are 26 (Hawaiian hoary bat), 42 (Hawaiian goose), and 16 (Hawaiian petrel). Indirect take estimates for the Covered Species are four (Hawaiian hoary bat), two (Hawaiian goose), and four (Hawaiian petrel). Combining these values, there is an approximately 80 percent chance that actual take of Covered Species at the Project through FY 2019 was less than or equal to 30 for the Hawaiian hoary bat, 44 for the Hawaiian goose, and 20 for the Hawaiian petrel.

During FY 2019, nine ground-based acoustic detectors were deployed at Project WTGs. Between July 2018-June 2019, Hawaiian hoary bats were detected on 372 nights of 2,906 detector-nights (12.8 percent of detector-nights). Seasonal patterns of detection rate were comparable with previous years.

Tier 1 mitigation obligations for the Hawaiian hoary bat were met prior to FY 2019, and TerraForm began funding ecological research studies on East Maui and Hawai'i Island in FY 2019 to mitigate for Tier 2 Hawaiian hoary bat take. The Project's Hawaiian goose mitigation project consists of funding construction and operation of a Hawaiian goose release pen on Haleakalā Ranch. Hawaiian geese have been translocated from Kaua`i to the Haleakalā Ranch pen since 2011. Through FY 2018, 47 fledglings have been credited to the Project (FY 2019 results are not yet available). The Project's seabird Covered Species mitigation efforts are focused on the continued maintenance, predator control, and social attraction work at the Makamakaʻole seabird colony. In FY 2019, observations at this site have included Newell's shearwaters, but no Hawaiian petrels have been documented.

TerraForm communicated actively with USFWS and DOFAW throughout FY 2019. The communication was conducted through in-person meetings, conference calls, submittal of quarterly reports, and e-mail communications related to the Project's HCP. The purpose of these communications varied, and included required semi-annual meetings, and discussions regarding mitigation funding and potential adjustments to mitigation strategies.

Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 Introduction

The Habitat Conservation Plan (HCP) for the Kaheawa Wind Power I Project (Project) was approved by the Hawaiʻi Division of Forestry and Wildlife (DOFAW) in 2006. Kaheawa Wind Power, LLC was issued a federal incidental take permit (ITP; ITP- TE118901-0) from the U.S. Fish and Wildlife Service (USFWS) and a state incidental take license (ITL; ITL-08) from the Hawaiʻi Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW) for the Project in January of 2006. The ITP and ITL cover the incidental take of four federally-listed threatened and endangered species (referred to as the Covered Species) over a 20-year permit term. The Covered Species include: the Hawaiian petrel or ʻuaʻu (*Pterodroma sandwichensis*), Newell's shearwater or ʻaʻo (*Puffinus newelli*), Hawaiian goose or nēnē (*Branta sandvicensis*), and Hawaiian hoary bat or ʻōpeʻapeʻa (*Lasiurus cinereus semotus*).

The Project was constructed in 2005 and 2006 and was commissioned to begin operating on June 22, 2006. TerraForm Power, LLC (TerraForm) now operates the Project. Brookfield Renewable Partners, LP acquired a majority stake in Terraform in 2017.

The Project has previously submitted annual HCP progress reports for FY 2007 through FY 2018 to the USFWS and DOFAW (KWP I 2007, KWP I 2008, KWP I 2009, KWP I 2010, KWP I 2011, KWP I 2012, KWP I 2013, KWP I 2014, KWP I 2015, KWP I 2016, KWP I 2017 and KWP I 2018). This report summarizes work performed for the Project during the State of Hawaiʻi 2019 fiscal year (FY 2019; July 1, 2018-June 30, 2019) pursuant to the terms and obligations of the approved HCP, ITL, and ITP.

2.0 Fatality Monitoring

The Project has implemented a year-round intensive monitoring program to document downed (i.e., injured or dead) wildlife incidents involving Covered Species and other species at the Project since operations began in June 2006. In consultation with USFWS, DOFAW, and the ESRC, fatality search areas have evolved over time from the start of operations in 2006 through the initiation of the current approach in April 2015. Recent modifications were in response to the March 31, 2015 ESRC meeting wherein members agreed to "encourage the applicant to work with the statistical experts and researchers to develop an alternative more efficient and focused monitoring strategy which still meets the committees expressed preference for continuation of annual monitoring".

- In June 2006, fatality monitoring plots were 180-meter by 200-meter rectangular plots centered on each of the Project's 20 wind turbine generators (WTG).
- In October 1, 2010, fatality monitoring plots were reduced to 73-meter radius circular plots centered on each WTG, except where steep slopes prohibited visual searching.
- In April 2015, the search area was reduced to the graded roads and WTG pads found within a 70-meter radius circle centered on each WTG (Figure 1).

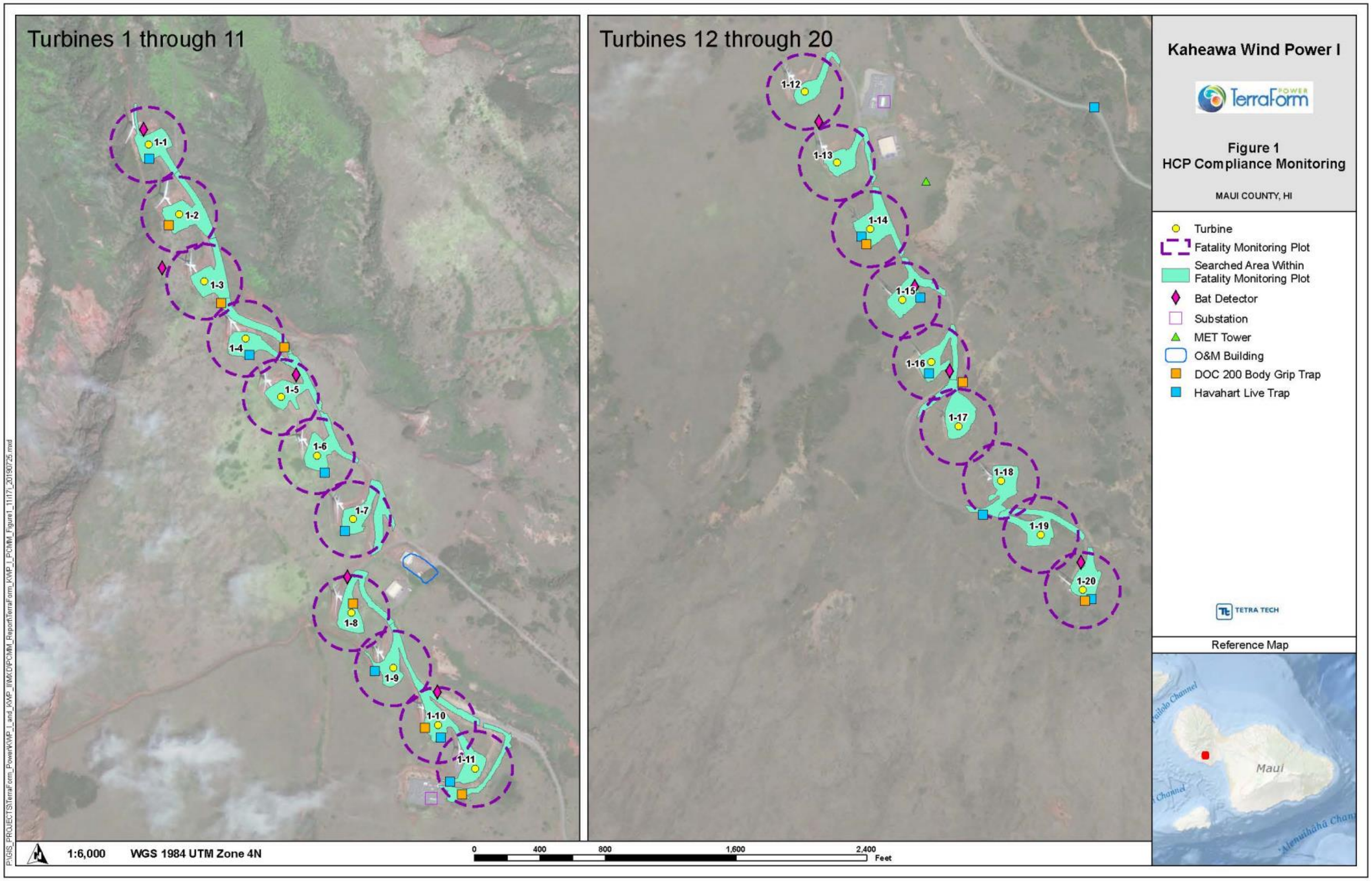


Figure 1. HCP Compliance Monitoring

In FY 2019, all 20 WTGs were searched for fatalities once per week. The FY 2019 mean search interval for WTGs was 7.0 days (Standard Deviation = 0.2 days). The search plots were searched by trained dogs accompanied by their handlers. If search conditions limited the use of dogs (e.g., weather, injury, availability of canine search team, etc.), search plots were visually surveyed by Project staff. However, no visual searches were required in FY 2019; 100 percent of searches were conducted by canine teams. Special precautions have been taken to eliminate any potential canine interactions with wildlife. The handler was directed to immediately retrieve the dog and postpone or temporarily skip dog searches in favor of visual searches if nearby Hawaiian geese were present. No Hawaiian goose were observed during the searches and no WTG searches were halted in FY 2019. Furthermore, no canine wildlife interactions were observed.

3.0 Carcass Persistence Trials

Four 28-day carcass persistence trials were conducted in FY 2019, once per quarter, using bat surrogates (rats), Hawaiian petrel surrogates (wedge-tailed shearwaters) and Hawaiian goose surrogates (chickens). For FY 2019, the mean probability that a carcass persisted until the next search was 0.68 for all bat surrogate carcasses (N=34; 95 percent Confidence Interval [CI] = [0.53, 0.80), 1.0 (95 percent CI = 0.93, 1.0) for Hawaiian petrel surrogates (N=11), and 1.0 (95 percent CI = 0.93, 1.0) for Hawaiian goose surrogates (N=10).

4.0 Searcher Efficiency Trials

A total of 65 searcher efficiency trials on 22 trial days were administered during FY 2019. Similar to the carcass persistence trials, rats were used as surrogates for bats and wedge-tailed shearwaters, and large chickens were used as surrogates for listed bird species. Searcher efficiency trials occurred throughout the year; 100 percent were conducted with canine search teams in FY 2019. Of the 65 trials placed, seven bat surrogates were lost to predation. All other carcasses were available for detection. Searcher efficiency in FY 2019 was 91.9 percent for bat surrogates (N=37; 95 percent CI = 0.80, 0.98), 100 percent for Hawaiian petrel surrogates (N=11; 95 percent CI = 0.8, 1.0), and 100 percent for Hawaiian goose surrogates (N=10; 95 percent CI = 0.78, 1.0).

5.0 Vegetation Management

In order to maximize monitoring efficiency and minimize impacts to native plants without compromising soil stability, TerraForm performed vegetation management at the Project. Vegetation management activities have evolved over time, and account for Hawaiian goose nesting season restrictions:

- An overall site vegetation management plan was approved by DOFAW in 2010. No vegetation management was authorized Prior to 2010.

- The vegetation management activities within the search plots are limited to between April 1 and October 31.
- In November 2016, Stephanie Franklin of DOFAW-Maui verbally approved using hand management tools (spray packs and weed whackers) during nesting season if activity was within the current search area and did not disturb wildlife.
- In March 2017, Stephanie Franklin of DOFAW-Maui verbally approved the removal of Christmas berry (*Schinus terebinthifolius*) within 70 meters of the WTGs to reduce potential Hawaiian goose nesting habitat in the vicinity.

Vegetation management has not occurred at the Project since September 2018. TerraForm will resume vegetation management in FY 2020.

6.0 Scavenger Trapping

Beginning in January 2018 trapping was suspended to determine if decreasing carcass persistence times for rat carcasses were resulting from the constant availability of scavenger food sources. Trapping efforts were resumed in November 2018 due to observations of reduced carcass persistence times. Trapping was suspended again beginning January 1, 2019, but again scavenging appeared to begin having a negative impact on carcass persistence times. Trapping efforts resumed March 26, 2019 and continued through the end of FY 2019.

Traps covered the same general area where traps were deployed at the end of FY 2018 (KWP I 2018). Nine DOC200 body grip kill traps and 12 Havahart live traps were deployed within or adjacent to the fatality monitoring plots in FY 2019, and an additional Havahart live trap was deployed along a service road adjacent to a gulch that runs along the Project and the Kaheawa Wind Power II Project (Figure 1). The trapping program documented the removal of 25 mongoose, five cats and one rat in FY 2019. No non-target animals were trapped.

7.0 Documented Fatalities and Take Estimates

All observed downed wildlife were handled and reported in accordance with the Downed Wildlife Protocol provided by USFWS and DOFAW. Four fatalities of Covered Species were found in FY 2019: one Hawaiian hoary bat fatality, two Hawaiian goose fatalities, and one Hawaiian petrel fatality (Appendix 1). The Hawaiian petrel was found during a carcass persistence trial but was included in modelling following the USFWS 2016 guidelines. No injured (live) downed wildlife were observed at the Project in FY 2019. No other Covered Species were observed at the Project in FY 2019.

To calculate take estimates, the number of observed fatalities is scaled to account for fatalities that are not detected, or unobserved. Unobserved fatalities are the result of three primary factors:

- Carcasses may be scavenged before searchers can find them;
- Carcasses may be present, but not detected by searchers; and

- Carcasses may fall outside of the searched area.

Carcass persistence and searcher efficiency (bias correction; see Sections 3.0 and 4.0) measure the effect of the first two factors. The third factor, the number of carcasses that fall outside of the searched area, is dependent upon the proportion of the carcass distribution that is actually searched. The search area for fatalities at the Project has evolved over time, and therefore the proportion of the carcass distribution searched has varied; however, no change to the search area was made from FY 2018 to FY 2019. Thus, the estimate of the density weighted proportion of the carcass distribution searched (DWA; Appendix 2) has remained the same as that described in the FY 2018 annual report (KWP I 2018).

Cumulative take at an upper credible limit (UCL) of 80 percent was calculated for each species for which documented fatalities have occurred, per request of USFWS and DOFAW. The UCL is estimated from three components:

1. Observed direct take (ODT) during protocol (standardized) fatality monitoring;
2. Unobserved direct take (UDT); and
3. Indirect take.

The Evidence of Absence software program (EoA; Dalthorp et al. 2017), the agency-approved analysis tool for analyzing direct take, uses results from bias correction trials and ODT to generate a UCL of direct take (i.e., ODT + UDT). Direct take values from this analysis can be interpreted as: there is an 80 percent probability that actual direct take at the Project over the analysis period was less than or equal to the 80 percent UCL. Associated indirect take is estimated based on factors such as the sex and age characteristics of Covered Species fatalities found at the Project, their associated life history characteristics as described in the Project's approved HCP, and current agency guidance (when available; e.g., USFWS 2016 for Hawaiian hoary bats).

7.1 Hawaiian Hoary Bat

7.1.1 Estimated Take

A total of 12 Hawaiian hoary bat fatalities have been observed at the Project since monitoring began in June 2006. One Hawaiian hoary bat fatality was detected in FY 2019 and was observed on November 8, 2018. All bat carcasses were transferred to the U.S. Geological Survey for genetic testing. Nine of the 12 bats were found inside of fatality search plots; three bat detections were excluded from inputs to EoA and are accounted for in the estimated take generated; the timing and sex of incidental take observations was used in the calculation of indirect take.

The estimated direct take (ODT + UDT) for the 12 Hawaiian hoary bat fatalities found between the start of fatality monitoring in June 2006 and end of FY 2019 (June 30, 2019) is less than or equal to 26 bats (80 percent UCL; Appendix 2). Therefore, 14 unobserved take were estimated in addition to the 12 observed take.

Indirect take is estimated to account for the potential loss of individuals that may occur indirectly as the result of the loss of an adult female through direct take during the period that females may be pregnant or supporting dependent young. Indirect take for the Project is calculated using the USFWS (2016) guidance as follows:

- The average number of pups attributed to a female that survive to weaning is assumed to be 1.8.
- The sex ratio of bats taken through UDT is assumed to be 50 percent female, unless there is substantial evidence (10 or more bats) to indicate a different sex ratio.
- The assessment of indirect take to a modeled UDT accounts for the fact that it is not known when the unobserved fatality may have occurred. The period of time from pregnancy to end of pup dependency for any individual bat is estimated to be 3 months. Thus, the probability of taking a female bat that is pregnant or has dependent young is 25 percent.
- The conversion of juveniles to adults is one juvenile to 0.3 adults.

Based on the USFWS guidance (USFWS 2016), the estimate of cumulative indirect take in FY 2019 is calculated as:

- **Total juvenile take calculated from observed female take (April 1 – September 15)**
  - 3 (observed females) * 1.8 (pups per female) = 5.4 juveniles[1]
- **Total juvenile take calculated from observed unknown sex take (April 1 – September 15)**
  - 2 (observed unknown sex) * 0.5 (assumed sex ratio) * 1.8 (pups per female) = 1.8 juveniles
- **Total juvenile take calculated from unobserved take**
  - 14 (unobserved direct take) * 0.5 (assumed sex ratio) * 0.25 (proportion of calendar year females could be pregnant or have dependent pups) * 1.8 (pups per female) = 3.2 juveniles
- **Total Calculated Juvenile Indirect Take** = 10.4 (5.4 + 1.8 + 3.2)
- **Total Adult Equivalent Indirect Take =** 0.3 (juvenile to adult conversion factor) * 10.4 = 3.1 (rounded up to 4)

Therefore, the estimated indirect take based on the UCL of Hawaiian hoary bat direct take at the Project is three adults.

The UCL for Project take of the Hawaiian hoary bat at the 80 percent credibility level is 30 adult bats (26 [estimated direct take] + 4 [estimated indirect take]). That is, there is an approximately 80

[1] DNA results have identified the sex of eight of the 12 bat fatalities detected at the Project, confirming that four of the fatalities were female (Pinzari and Bonaccorso 2018). Three of these were detected between April 1 and September 15.

percent probability that actual take at the Project at the end of FY 2019 is less than or equal to 30 bats.

7.1.2 Projected Take

EoA includes a module that allows users to project future estimates of mortality based on results of past fatality monitoring. Due to the inherent uncertainty of these projections (including the potential future contribution of indirect take) and the amplification of this uncertainty resulting from the use of the 80 percent UCL as the estimate of take for regulatory compliance, long term projections have limited utility. Nevertheless, they do help gauge the likelihood of permitted take exceedance, and may help operators in their mitigation planning, assuming future management and monitoring conditions can be reasonably estimated.

TerraForm projected Hawaiian hoary bat take through the end of the permit term using the fatality monitoring data collected through FY 2019. The objective of this analysis was to evaluate the potential for the Project to exceed the permitted take limit at the 80 percent UCL prior to the end of the permit term (Appendix 3). For this analysis, the proportion of risk in the model was adjusted to reflect the assumption that the risk to bats was reduced by 50 percent on an annual basis under each of the various Low Wind Speed Curtailment (LWSC) regimes implemented at the Project (Section 9.0), and that LWSC would continue to be used for the remainder of the Project's permit term. This estimate of the benefit of LWSC is conservatively low, based on estimates of the reduction in fatalities on bats from large studies at industrial scale wind projects in North America (Arnett et al. 2011, Good et al. 2011, Hein et al. 2014). Because future indirect take is unknown and will potentially vary based on the timing of ODT, we assumed total indirect take for the Project over the permit term would be a maximum of eight adult equivalents (27 juveniles based on assumed Hawaiian hoary bat survival rates [USFWS 2016]), or 16 percent of the permitted take. Currently, the proportion of total take that is attributable to indirect take is 13.3 percent, making the assumption of indirect take of eight adult bats to be upwardly conservative. Assuming eight adult bat equivalents are attributed to the Project as indirect take, the permitted direct take under the Project's ITP and ITL would be 42 bats.

Based on the analysis described above and presented in Appendix 3, there is more than a 90 percent chance that the 80 percent UCL of cumulative take will not be exceeded during the permit term. Specifically, the permitted direct take value of 42 exceeded more than 90 percent of the projected mortality estimates (Appendix 3). Therefore, the Project is likely to remain below the permitted take limit of Hawaiian hoary bats for the permit term.

7.2 Hawaiian Goose

7.2.1 Estimated Take

A total of 26 Hawaiian goose fatalities attributable to the Project have been observed at the Project since monitoring began in June 2006. Two Hawaiian goose fatalities were detected in FY 2019, the most recent of which was observed on January 22, 2019. Twenty-five of the 26 geese were found inside of fatality search plots.

The estimated direct take (ODT + UDT) for the 25 Hawaiian goose fatalities (within the search area) found between the start of operation (June 5, 2006) and end of FY 2019 (June 30, 2019) is less than or equal to 42 geese (80 percent UCL; Appendix 2).

Indirect take is estimated to account for the potential loss of individuals that may occur as the result of the loss their parents. Both parents for the Hawaiian goose exhibit responsibility for care of young until fledging. The point during the breeding season when an adult is taken determines to what extent offspring may be affected. Indirect take was 3.85 juveniles (2.0 adults assuming a 0.8 annual survival rate and 3 years from fledging to adult; Appendix 4).

The Project may cause a net loss in productivity in the event that take outpaces the number of individuals produced from mitigation efforts. The lag between production of geese through mitigation efforts and the take of geese at the Project drives the estimates of lost productivity. Accrued lost productivity at a given point in time is calculated as the cumulative take less the number of individuals generated from mitigation efforts to date, and then adjusted by a factor of 0.1 to account for the probability that those unmitigated birds would have produced young (KWP I 2006). USFWS and DOFAW have agreed that the Project will not accrue lost productivity for Hawaiian goose take that occurred prior to calendar year 2011, when the pen was constructed. Six Hawaiian goose fatalities were documented at the Project prior to January 1, 2011.

Lost productivity was 9.62 for the Hawaiian goose to date and is presented in Appendix 4. The number of fledglings produced through FY 2019 is not available for lost productivity calculations in this annual report. Lost productivity will be recalculated and presented cumulatively in the FY 2020 Annual Report once fledgling numbers are finalized.

The UCL for cumulative Project take of the Hawaiian goose at the 80 percent credibility level is 44 geese (42 [estimated direct take] + 2 [estimated indirect take]). That is, there is an approximately 80 percent probability that actual take at the Project at the end of FY 2019 is less than or equal to 44 geese.

7.2.2 Projected Take

TerraForm projected Hawaiian goose take through the end of the permit term using the fatality monitoring data collected through FY 2019. The objective of this analysis was to evaluate the potential for the Project to exceed the Tier 1 take limit (described as Baseline Take in the Project's HCP) at the 80 percent UCL prior to the end of the permit term (Appendix 3). As future indirect take is unknown and will potentially vary based on the timing of ODT, we assumed total indirect take for the Project over the permit term would be a maximum of three adult equivalents (six juveniles based on an assumed Hawaiian goose survival rates from juvenile to adult of 0.512 [KWP I 2006]), or 5 percent of the Tier 1 take. Currently, the proportion of total take that is attributable to indirect take is 4.5 percent, making the assumption of three indirect take upwardly conservative. Assuming three adult Hawaiian geese are attributed to the Project as indirect take, the permitted direct take under Tier 1 of the Project's ITP and ITL would be 57 Hawaiian geese.

Based on the analysis described above and presented in Appendix 3, there is more than approximately a 90 percent chance that the 80 percent UCL of cumulative take will exceed the Tier 1 take limit during the permit term. Specifically, approximately 90 percent of the projected mortality estimate exceeded the Tier 1 permitted direct take value of 57 (Appendix 3). Although the Project may exceed the Tier 1 permitted take limit within the permit term if no additional avoidance and minimization measures can be identified and implemented, the Tier 2 take (described as Higher Take in the Project's HCP) limit is 100. There is a very low probability that Project take will exceed this value (Appendix 3). Specifically, a permitted direct take value of 95[2] exceeds more than 95 percent of the projected mortality estimates (Appendix 3). TerraForm has taken actions to minimize the threats to the Hawaiian goose and anticipates working with USFWS, DOFAW, and technical experts to further reduce risk (Section 10.0).

7.3 Hawaiian Petrel

7.3.1 Estimated Take

A total of eight Hawaiian petrel fatalities have been observed at the Project since monitoring began on June 5, 2006. In FY 2019, one Hawaiian petrel was detected, observed on June 6, 2019. Each of the eight petrels were found inside of fatality search plots; the Hawaiian petrel found during a FY 2019 carcass persistence trial was included in the modelling following the USFWS 2018 guidelines.

The estimated direct take (ODT + UDT) for the eight Hawaiian petrel fatalities found between the start of operation (June 5, 2006) and end of FY 2019 (June 30, 2019) is less than or equal to 16 petrels (80 percent UCL; Appendix 2). Appendix 2 presents the cumulative Hawaiian petrel direct take estimate based on results from the FY 2019 multi-year analysis from EoA.

Indirect take is estimated to account for the potential loss of individuals that may occur as the result of the loss their parents. Both parents for the Hawaiian petrel exhibit responsibility for care of young until fledging. The point during the breeding season when an adult is taken determines to what extent offspring may be affected. Indirect take was 11.77 juveniles (3.5 adults assuming a 0.3 survival rate from fledging to adult; Appendix 4).

The Project may cause a net loss in productivity if take outpaces the number of individuals produced from mitigation efforts. The lag between production of Hawaiian petrels through mitigation efforts and the take of petrels at the Project drives the estimates of lost productivity. Accrued lost productivity at a given point in time is calculated as the cumulative take less the number of individuals generated from mitigation efforts to date, and then adjusted by a factor of 0.15 to account for the probability that those unmitigated petrels would have produced young

---

[2] As with Tier 1 take, assuming 5 percent of the Tier 2 take limit is attributable to indirect take, authorized direct take under Tier 2 would be 100 - 0.05*100 = 95 Hawaiian geese.

(KWP I 2006). Each year's lost productivity is accumulated until mitigation occurs for the estimated adult take.

Based on preliminary results, no Hawaiian petrels appear to have nested at the Makamaka'ole seabird mitigation site in FY 2019, although the breeding season is not yet complete. Results from mitigation efforts on Lāna'i in 2018 indicate that 36 Hawaiian petrel fledglings were produced (Sprague 2019; Appendix 5). Assuming no petrels successfully breed in FY 2019 at Makamaka'ole, accrued combined mitigation efforts have already more than mitigated for accrued lost productivity for the Hawaiian petrel (Appendix 4). Mitigation efforts have produced 22.1 fledglings beyond those required to mitigate for lost productivity. Assuming a 0.3 survival rate from fledgling to adult, mitigation efforts equate to 6.6 adult Hawaiian petrel equivalents.

The UCL for cumulative Project take of the Hawaiian petrel at the 80 percent credibility level is 20 petrels (16 [estimated direct take] + 4 [estimated indirect take]). That is, there is an approximately 80 percent probability that actual take at the Project at the end of FY 2019 is less than or equal to 20 petrels.

7.3.2 Projected Take

TerraForm projected Hawaiian petrel take through the end of the permit term using the fatality monitoring data collected through FY 2019. The objective of this analysis was to evaluate the potential for the Project to exceed the permitted take limit at the 80 percent UCL prior to the end of the permit term (Appendix 3). Because future indirect take is unknown and will potentially vary based on the timing of ODT, we assumed total indirect take for the Project over the permit term would be a maximum of nine adult equivalents (30 juveniles based on an assumed Hawaiian petrel survival rate of 0.3 from fledging to adult [KWP I 2006]), or 23.6 percent of the permitted take. Currently, the proportion of total take that is attributable to indirect take is 20 percent, making the assumption of nine indirect take upwardly conservative. Assuming nine adult Hawaiian petrel equivalents are attributed to the Project as indirect take, the permitted direct take under the Project's ITP and ITL would be 29 petrels.

Based on the analysis described above and presented in Appendix 3, there is more than a 90 percent chance that the 80 percent UCL of cumulative take will not be exceeded during the permit term. Specifically, the permitted direct take value of 29 exceeds more than 90 percent of the projected mortality estimates (Appendix 3). Therefore, the Project is likely to remain below the permitted take limit of Hawaiian petrels for the permit term.

7.4 Non-listed Species

Eight bird fatalities representing three species and one undetermined species (an upland gamebird fledgling) were documented at WTGs at the Project in FY 2019. One of the three species observed in FY 2019 are protected by the Migratory Bird Treaty Act (MBTA): white-tailed tropicbird (three birds; *Phaethon lepturus*). There were also fatalities of two non-native introduced birds without MBTA protection: Gray francolin (two birds; *Francolinus pondicerianus*), and black francolin (2 birds; *Francolinus francolinus*). The upland gamebird fledgling would not have been capable of flight and therefore this fatality is not attributed to Project operations. For a complete list of fatalities for FY 2019 see Appendix 1.

8.0 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, Conditional Use Permit, land use agreements and applicable laws. Personnel are trained to identify Covered Species and other 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 are also made aware of driving conditions and receive instruction on how to drive and act around wildlife. 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.

No WEOP trainings were provided in 2019, but WEOP trainings will continue to be conducted on an as-needed basis to provide on-site personnel with the information they need to be able to respond appropriately in the event they observe a Covered Species or encounter a fatality while on-site.

9.0 Mitigation

The Project's mitigation requirements are described in Section 5.0 of the approved HCP (KWP I 2006).

9.1 Hawaiian Hoary Bats

Mitigation for Tier 1 take of 20 bats was funded in 2006 and completed. An HCP minor amendment approved by USFWS in October 2015 and DOFAW in January 2016 authorized take of up to an additional 30 Hawaiian hoary bats. A mitigation project that will account for take of 15 of the authorized additional take of 30 bats began May 2017 (KWP I 2017). This mitigation project consists of Hawaiian hoary bat ecological research in East Maui, contracted to H.T. Harvey Ecological Consultants. TerraForm is working with HT Harvey to finalize the reporting of this research. Because reporting is not yet finalized, the research results will be included with the FY 2020 HCP annual report. The contract total cost is $750,000, and funding was completed with a payment of $172,000 in FY 2019. The Project is also partially funding another Hawaiian hoary bat ecological research project on Hawaiʻi Island contracted to the U.S. Geological Survey Hawaiian Hoary Bat Research Group that began in FY 2018 (Appendix 6). The Project contribution to this contract will be $750,000 by mid-2021 and accounts for take of the remaining 15 bats of the amended total.

Acoustic monitoring of bat activity has been performed since 2008, but changes in the technology used for monitoring over that time period limit the comparability of earlier data to current data.

Therefore, FY 2019 data is only able to be directly compared to historical data from October 2013 onward. Nine Wildlife Acoustics SM2BAT+ ultrasonic bat detectors with one SMX-U1 microphone each have been used since October 2013 to acoustically monitor bat activity throughout the Project. The objective of the monitoring is to better understand variations in bat activity specifically near the ground close to the WTGs. The detector microphones are mounted at 6.5 meters in height. Eight are placed near the WTGs and one is placed near a gulch edge (WTG 3; Figure 1); each microphone is positioned horizontally, pointing SW (away from the prevailing NE trade winds). Prior to October 2013, (between 2008 and September 2013), Titley AnaBat detectors were deployed around the site near WTGs (KWP I 2013).

In FY 2019, detectors recorded bat activity at all nine ground locations during 12.8 percent of detector nights (372 of 2,906) with the highest rate at WTG 3 (23 percent; Table 1). Spatially, the bat activity was variably distributed across WTGs with detection rates ranging from 4 percent to 23 percent (Table 1). Temporal patterns of ground-based detection rates in FY 2019 (Figure 2) were comparable to previous years (Figure 3), with elevated activity levels in the post-lactation period (roughly September through November) compared to the remainder of the year (KWP I 2013, KWP I 2014, KWP I 2015, KWP I 2016, KWP I 2017, KWP I 2018).

9.2 Hawaiian Goose – Haleakalā Ranch Release Pen

As part of Project Hawaiian goose mitigation, the Haleakalā Ranch Hawaiian goose release pen was paid for in 2008 by the Project and constructed three years later by DOFAW. Hawaiian geese have been translocated from Kaua`i to the Haleakalā Ranch pen since 2011. Through FY 2018, 47 fledglings produced in the pen from these translocated birds have been credited to the Project.

Hawaiian goose fledgling production attributable to the Project in FY 2019 has not yet been determined; however, overall production at the Haleakalā Ranch pen is reported in the state Hawaiian goose release pens Safe Harbor Agreements FY 2019 report (Appendix 7). Credit attributable to Project-funded Hawaiian goose mitigation actions in FY 2019 will be provided in the FY 2020 HCP annual report.

In FY 2019, TerraForm met with USFWS and DOFAW to better understand the past management of the Hawaiian goose release pen, improve accountability, and identify an approach to allow TerraForm to meet its mitigation obligations for the Hawaiian goose. These discussions will continue in FY 2020, and TerraForm intends to have resolution on a path forward during FY 2020.

Table 1. Hawaiian Hoary Bats at each Turbine Location Sampled Between July 2018 and June 2019 (FY 2019)

WTG	No. of Nights Sampled	No. of Nights with Detections	Proportion of Nights with Detections
1	359	65	0.18
3	356	83	0.23
5	282	56	0.20
8	357	44	0.12
10	309	11	0.04
13	333	40	0.12
15	267	38	0.14
16	319	16	0.05
20	324	19	0.06
Total	**2,906**	**372**	**0.128**

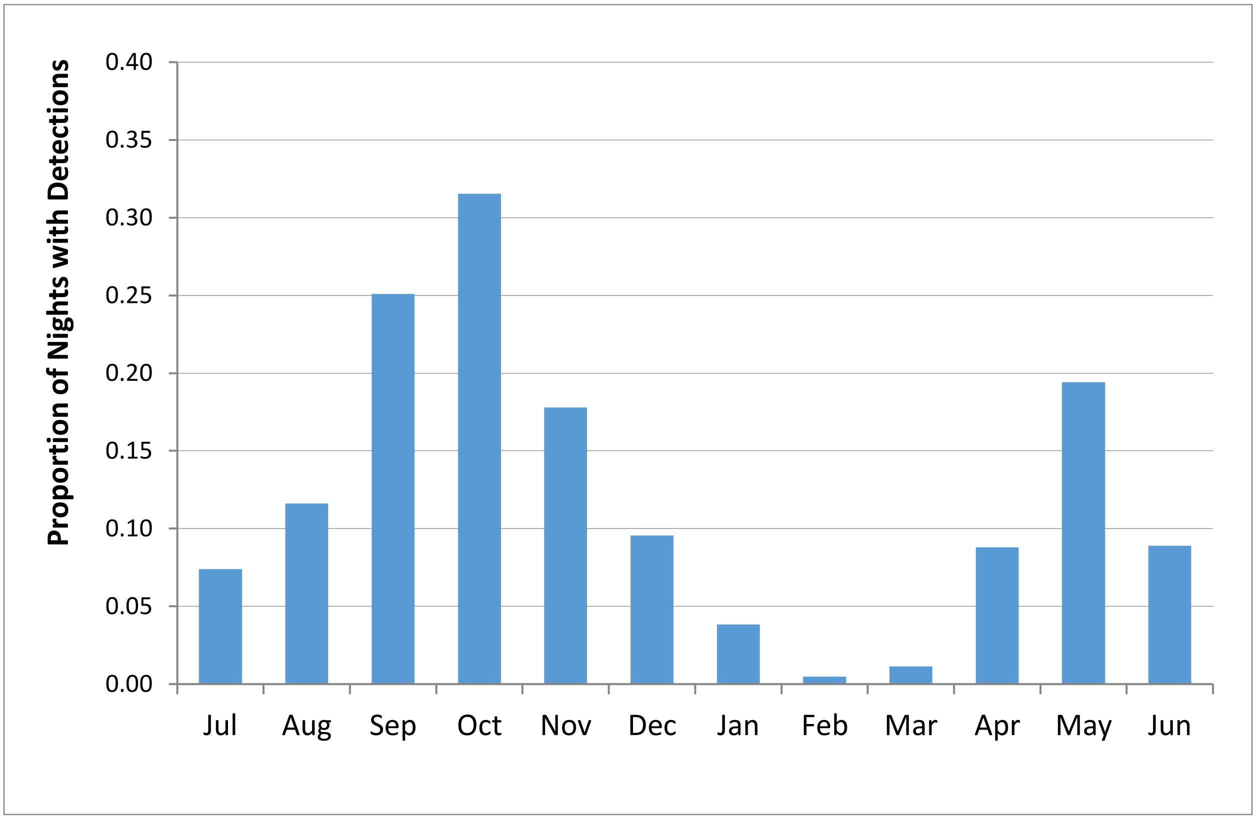


Figure 2. Bat Acoustic Activity at Nine Detectors Sampled During FY 2019

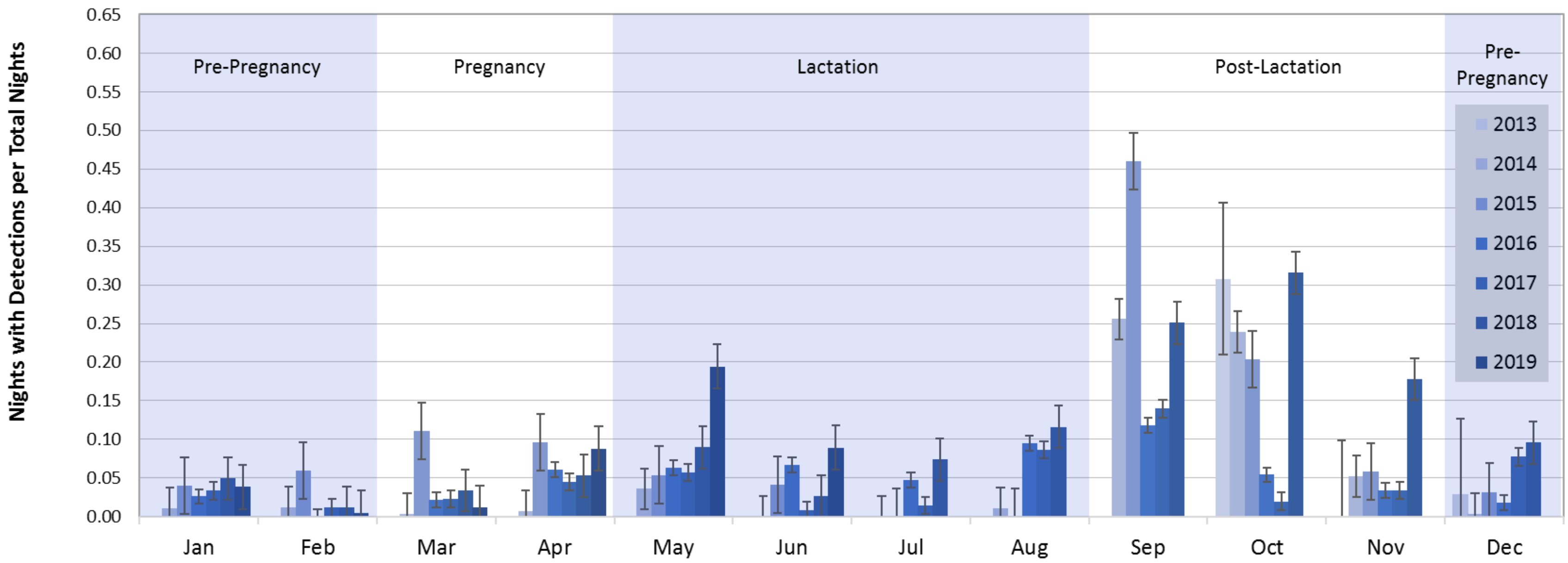


Figure 3. Bat Acoustic Activity with Standard Error Across Reproductive Periods at Nine Detectors for FY 2013 through FY 2019

9.3 Seabirds

TerraForm is committed to seabird protection and recovery on Maui Nui. Although results at Makamakaʻole have suggested the potential for the site to support some reproduction of Newell's shearwaters, the Project is not fulfilling the Project's mitigation needs. Therefore, it is the intent of TerraForm to work with DOFAW, USFWS, and seabird experts, to identify suitable alternatives to the Project's ongoing mitigation efforts at Makamakaʻole.

9.3.1 Hawaiian Petrel and Newell's Shearwater- Makamakaʻole

Mitigation efforts at the Makamakaʻole Seabird Mitigation Site (Makamakaʻole; Figure 4) have been ongoing since construction of the two enclosures was completed on September 5, 2013. Mitigation efforts at Makamakaʻole involve predator monitoring and trapping, artificial burrow checks and monitoring using game cameras, seabird social attraction using decoys and sound systems, and ongoing maintenance of both enclosures. Breeding has not been confirmed for Hawaiian petrels. Breeding is suspected for Newell's shearwaters (eggs and fragments of eggs present at burrows visited by Newell's Shearwaters during the 2017 and 2018 breeding seasons), but no fledglings have been confirmed to date. An annual report will be available and provided in mid-August (Appendix 8).

Currently, mitigation efforts at Makamakaʻole are under contract with H.T. Harvey and Associates. Monitoring checklists recorded via IForm have been created to ensure consistent oversight. These checklists include sound system battery checks, game camera operation and data download, burrow checks for erosion damage, signs of bird activity (visual, scent, and game camera) and ongoing perimeter checks of fences and culverts.

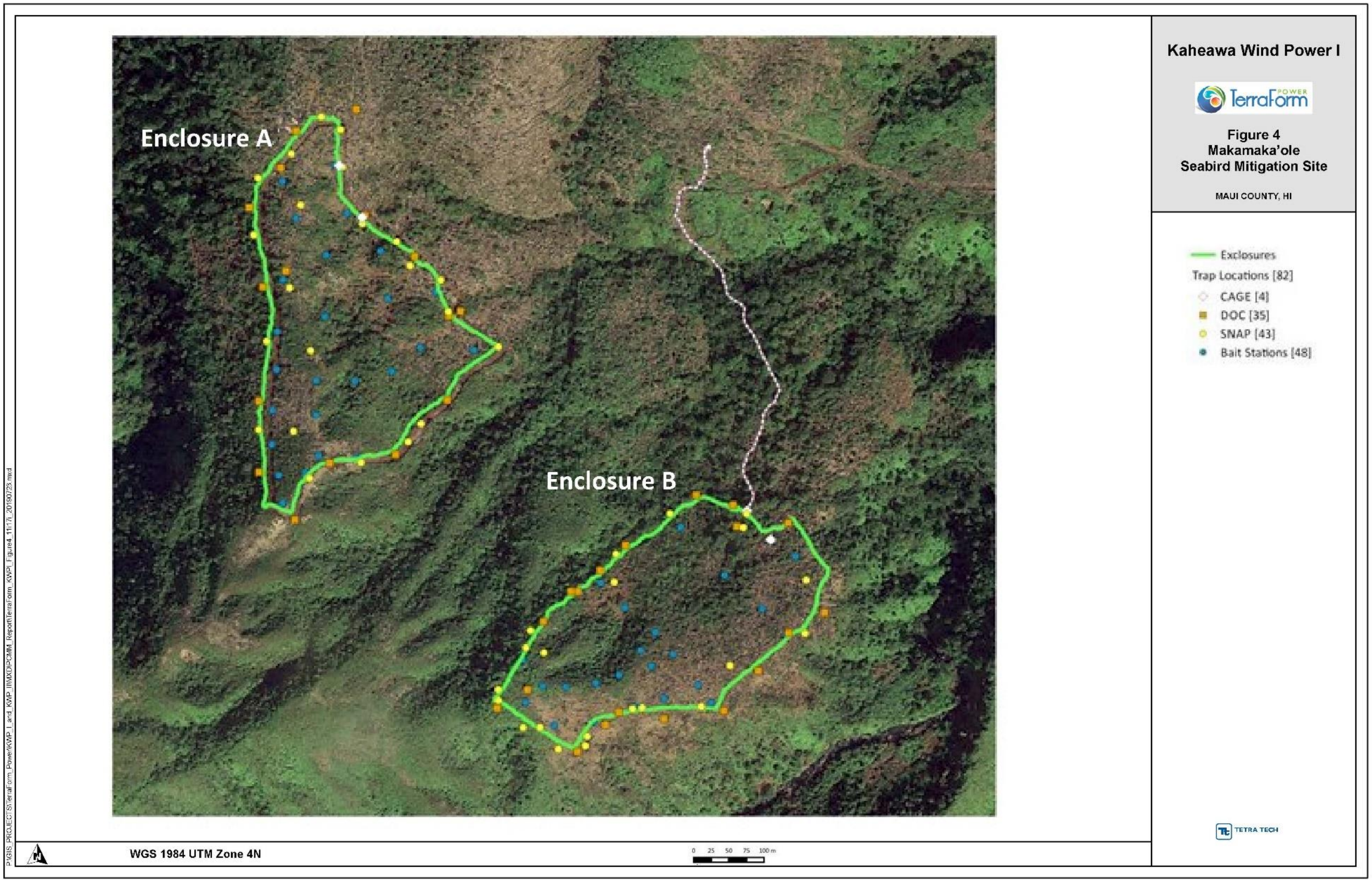


Figure 4. Makamakaʻole Seabird Mitigation Site

9.3.1.1 Predator Monitoring and Trapping

A total of 82 traps were deployed Makamakaʻole in FY 2019 (Figure 4). A total of 57 mongooses, 50 rats and 5 mice were captured in FY 2019 (Table 1). All of the mongooses were captured outside the enclosures.

Table 2. Makamakaʻole trapping results for FY 2019

Trap Location	Trap Type	Quantity Deployed	Number Caught
Outside A	Cage	1	0
	Victor Rat Snap	13	26 rats, 1 mongoose
	DOC 200 Body Grip	13	2 rats, 31 mongooses
Inside A	Cage	1	0
	Victor Rat Snap	10	4 rats, 5 mice
	DOC 200 Body Grip	4	0
Outside B	Cage	1	0
	Victor Rat Snap	10	12 rats
	DOC 200 Body Grip	13	2 rats, 25 mongooses
Inside B	Cage	1	0
	Victor Rat Snap	10	3 rats
	DOC 200 Body Grip	5	1 rat

To assess the presence or absence of small mammal activity inside each enclosure, ten tracking tunnels inside each enclosure were inked and baited in August, October, March, and June. Since January 24, 2014 no mongoose have been detected or trapped inside either enclosure. On January 7, 2015, the protocol was approved to continue using Diphacinone bait blocks (KWP I 2015). 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.

Barn owls (*Tyto alba*) also pose a predation threat to seabirds. TerraForm continues to renew its USFWS depredation permit (MB 19697C-0) and has obtained a DOFAW wildlife control permit to continue barn owl control. Control work for the 2019 calendar year has been contracted to H.T. Harvey and Associates. To understand the magnitude of the threat presented by barn owls in the area 25 surveys were conducted in FY 2019. Two owls were confirmed hit with shotgun loads; however, removal was unconfirmed.

9.3.1.2 Burrow Monitoring

Three species of seabirds, Hawaiian petrel, Newell's Shearwater, and Bulwer's petrel or ʻou (*Bulweria bulwerii*), have frequented burrows within both enclosures between the months of March and October since June 22, 2015. Cameras have been in place at 11 nest boxes known to be visited. Only Newell's Shearwater and Bulwer's petrel nesting activity has been observed during the 2019 breeding season to date; no Hawaiian petrels have been observed in either enclosure. Out of the

100 total nest boxes (50 in each enclosure), there are currently 11 active nest boxes; eight in enclosure A, and three in enclosure B. June 2019 has shown a significant increase in overall activity of birds, mostly Newell's shearwaters, within the enclosures. Two birds have been seen at B22, A25, A26, and A48. Behaviors being exhibited indicate that birds are engaged in a combination of territoriality, pair establishment, and breeding (Appendix 8).

Searches have been conducted regularly for active nests and signs of burrowing and prospecting by both Newell's shearwaters and Hawaiian petrels inside and outside of both enclosures. No burrows or signs of active prospecting outside of enclosures, and no indications of nesting activity have been observed during infrared night surveillance of both sides of the fenced terrain. Additionally, searches within 10 meters of the fence line have not yielded any active nesting burrows of any seabird species.

9.3.1.3 Seabird Acoustic Attraction

Three sound playback systems are currently in use at Makamakaʻole. Two are deployed in enclosure A and one in enclosure B. Acoustic attraction systems broadcast social calls year-round at night. Newell's shearwater calls are broadcast only in enclosure A, and Hawaiian petrel calls are broadcast only in enclosure B. Periodic night surveys to monitor bird activity in the area and ensure the sound systems are working correctly are ongoing. Observations suggest that the Newell's shearwaters attracted to the sites are selecting nest boxes that are closest to the source of the broadcast (distance, proximity, and direction to the speakers).

9.3.1.4 Vegetation and Erosion Management

Erosion inside and outside of enclosures continues to be monitored closely. Specially fabricated hydrologic flumes are attached to the outflow sections of two culverts at enclosure A. The flumes direct water away from the enclosure, preventing erosion directly outside of the culvert tube and at the fence line. ʻUki (*Machaerina augustifolia*), propagated by Maui Native Nursery were planted around the approved irrigation ditches dug in December 2017 to stabilize soil in the disturbed areas. As specified by the NARS permit, regular herbiciding and weeding without motorized tools occurred each quarter. Target species for removal were *Clidemia hirta*, *Tibouchina spp*., *Melinus minutiflora* and *Psidium spp.*

9.3.2 Lāna'i Hawaiian Petrel Protection Project

For the 2018 – 2019 Hawaiian petrel breeding seasons, as Hawaiian petrel mitigation at Makamakaʻole was not on track to meet Project mitigation requirements, Kaheawa Wind Power I worked with USFWS and DOFAW to adaptively manage Hawaiian petrel mitigation efforts in an interim fashion. As a result of this adaptive management, Kaheawa Wind Power I funded Pūlama Lānaʻi to supplement Hawaiian petrel breeding colony protection efforts on Lāna'i.

Overall, Kaheawa Wind Power I funded the expansion of predator control for cats and rats into some extremely dense petrel nesting areas on the island of Lānaʻi and improved monitoring in those areas to better understand the effects of predator control. Activities and results are reported in the 2018 annual report; results from 2019 are not yet available. In 2018, activities resulted in a net increase of 36 Hawaiian petrel fledglings over the calculated baseline (Sprague 2019; Appendix 5).

9.3.3 Newell's Shearwater Survey - East Maui

Surveys of East Maui for potential additional mitigation sites was funded and completed in September 2015 (KWP I 2016). These surveys evaluated potential colony locations, estimated the numbers of birds present, assessed predator activity, and provided for management feasibility assessment.

10.0 Adaptive Management

In accordance with the Project HCP, the Project began implementing LWSC at all WTGs up to wind speeds of 5.0 m/s on July 29, 2014. LWSC is expected to reduce bat take (Section 7.1). LWSC was increased to 5.5 m/s on August 4, 2014 in response to take occurring at the Project and at the Kaheawa Wind Power II Project. Curtailment at 5.5 m/s was in effect from sunset to sunrise, annually, from February 15 through December 15. The Project continues site-wide bat activity assessment after the initial HCP-required three-year period.

The Project has also implemented a variety of actions to minimize risk to the Hawaiian goose. Safety measures to avoid interactions between Hawaiian goose and canine search teams have been identified and are implemented as needed. Additionally, scavenger trapping efforts implemented at the Project to improve persistence of carcasses during fatality monitoring have likely reduced the risk of predation of the Hawaiian goose. TerraForm seeks to identify additional practicable actions to minimize the threats to the Hawaiian goose based on current projections of take, and anticipates working with USFWS, DOFAW, and technical experts in FY 2020 to further reduce risk.

11.0 Agency Meetings, Consultations, and Visits

TerraForm communicated actively with USFWS and DOFAW throughout FY 2019 through in-person meetings, conference calls, submittal of quarterly reports, and e-mail communications related to the Project's HCP. The purpose of these communications varied, and included required semi-annual meetings, mitigation funding, and potential adjustments to the Hawaiian goose and seabird mitigation strategies.

A summary of agency coordination follows:

- October 2018—Submittal of FY 2019 Q1 report;
- October 5, 2018—Semi-annual, in-person meeting with DOFAW, USFWS, and TerraForm regarding Project mitigation for the Hawaiian goose and seabirds;

- December 2018—e-mail communication among DOFAW, USFWS, and TerraForm regarding status of funding and success for on-going mitigation efforts for the Hawaiian goose, Hawaiian hoary bat, and seabirds;
- January 2019—Submittal of FY 2019 Q2 report;
- February 2019—e-mail communication between USFWS and TerraForm regarding mitigation funding and bat research as mitigation;
- March 7, 2019—TerraForm presented findings from FY 2018 HCP annual report to the ESRC; and
- April 2019—Submittal of FY 2019 Q3 report.

12.0 Expenditures

Total HCP-related expenditures for the Project in FY 2019 were $439,600 (Table 3).

Table 3. HCP-related Expenditures at the Project in FY 2019

Category	Amount
Permit Compliance	$25,000
Fatality Monitoring	$45,000
Equipment and Supplies	$5,000
Staff Labor	$40,000
Makamakaʻole Mitigation Project	$152,600
Tier 2/3 Bat Research Projects	$172,000
Total Cost for FY 2019	**$439,600**

13.0 Literature Cited

Arnett, E., M. Huso, M. Schirmacher, and J. Hayes. 2011. Altering turbine speed reduces bat mortality at wind-energy facilities. Ecol. Environ. 9(4) pp 209-214.

Dalthorp, D., M. Huso, and D. Dail. 2017. Evidence of absence (v2.0) software user guide: U.S. Geological Survey Data Series 1055, 109 p., https://doi.org/10.3133/ds1055.

Good. R. E., W. Erickson, A. Merrill, S. Simon, K. L. Murray, K. Bay, and Chris Fritchman. 2011. Bat monitoring studies at the Fowler Ridge Wind Energy Facility Benton County, Indiana, April 13 – October 15, 2010. Prepared for Fowler Ridge Wind Farm, Fowler, Indiana. Prepared by Western EcoSystems Technology, Inc. Cheyenne WY.

Hein, C. D., A. Prichard, T. Mabee, and M. R. Schirmacher. 2014. Efficacy of an operational minimization experiment to reduce bat fatalities at the Pinnacle Wind Farm, Mineral

County, West Virginia, 2013. An annual report submitted to Edison Mission Energy and the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, TX, USA.

KWP I (Kaheawa Wind Power, LLC). 2006. Kaheawa Pastures Wind Energy Generation Facility Habitat Conservation Plan. January 2006.

KWP I. 2007. Kaheawa Pastures Wind Energy Generation Facility Habitat Conservation Plan (2006) Annual Report. UPC Wind Management, LLC, Environmental Affairs, Newton, MA. 25 pp. + apps.

KWP I. 2008. Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan: Year 2 HCP Implementation July 2007-June 2, 2008. First Wind Energy LLC, Environmental Affairs, Newton, MA. 26 pp. + apps.

KWP I. 2009. Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan FY09 Annual Report: Year 3 HCP Implementation. First Wind Environmental Affairs, Portland, MA. 39 pp. +apps.

KWP I. 2010. Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan: FY10 Annual Report: Year 4 HCP Implementation. First Wind Environmental Affairs, Portland, MA. 35 pp. +apps.

KWP I. 2011. Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan FY-2011 Annual Report: Year 5 HCP Implementation. First Wind Environmental Affairs, Portland, MA. 34 pp.+ apps.

KWP I. 2012. Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan FY-2012 Annual Report: Year 6 HCP Implementation. First Wind Environmental Affairs, Portland, MA. 25 pp. +apps.

KWP I. 2013. Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan FY-2013 Annual Report: Year 7 HCP Implementation. First Wind Energy, LLC, Wailuku, HI 96793. 21 pp. + apps.

KWP I. 2014. Kaheawa I Habitat Conservation Plan FY-2014 Annual Report. First Wind Energy, LLC, Wailuku, HI 96793. 34 pp. + apps.

KWP I. 2015. Kaheawa I Habitat Conservation Plan Annual Report: FY-2015. SunEdison, LLC, Wailuku, HI 96793. 25 pp. + apps.

KWP I. 2016. Kaheawa Wind Power I Habitat Conservation Plan Annual Report: FY 2016. TerraForm Power, LLC, Wailuku, HI 96793. 31 pp. + apps.

KWP I. 2017. Kaheawa Wind Power I Habitat Conservation Plan Annual Report: FY 2017. TerraForm Power, LLC, Wailuku, HI 96793. 20 pp. + apps.

KWP I. 2018. Kaheawa Wind Power I Habitat Conservation Plan Annual Report: FY 2018. TerraForm Power, LLC, Wailuku, HI 96793. 26 pp. + apps.

Pinzari, C.A. and Bonaccorso, F.J., 2018. Hawaiian Islands Hawaiian Hoary Bat Genetic Sexing 2009-2018 (ver. 2.0, November 2018): U.S. Geological Survey data release, https://doi.org/10.5066/P9R7L1NS.

Sprague, R. 2019. Lānaʻi Hawaiian Petrel Protection Project Final Report – 2018. Prepared by Pūlama Lānaʻi for Kaheawa Wind Power I.

USFWS (U.S. Fish and Wildlife Service). 2016. Wildlife agency guidance for calculation of Hawaiian hoary bat indirect take. USFWS Pacific Islands Field Office. Honolulu, HI. October 2016.

USFWS. 2018. Wildlife agency standardized protocols for wildlife fatalities found outside the designated search area or discovered incidentally outside of a routine search. USFWS Pacific Islands Field Office. Honolulu, HI. March 2018.

APPENDIX 1. DOCUMENTED FATALITIES AT THE PROJECT DURING FY 2019

This page intentionally left blank

Species	Date Documented	WTG	Distance to WTG (meters)	Bearing from WTG (degrees)
Francolinus francolinus (Black Francolin)[1]	07/24/18	10	1	353
Phaethon lepturus (White-tailed Tropicbird)	07/24/18	16	16	260
Phaethon lepturus (White-tailed Tropicbird)	08/14/18	5	19	208
Lasiurus cinereus semotus (Hawaiian Hoary Bat)[2]	11/08/18	11	31	154
Francolinus pondicerianus (Gray Francolin)[1]	11/20/18	10	2	240
Francolinus pondicerianus (Gray Francolin)[1]	12/26/18	16	1	341
Branta sandvicensis (Hawaiian Goose)[2]	01/15/19	19	13	52
Branta sandvicensis (Hawaiian Goose)[2]	01/22/19	14	10	290
Phaethon lepturus (White-tailed Tropicbird)	03/08/19	7	11	-
Unknown Juvenile Bird[1]	04/23/19	8	44	-
Francolinus francolinus (Black Francolin)[1]	05/28/19	4	1	30
Pterodroma sandwichensis (Hawaiian Petrel)[2, 3]	06/05/19	18	46	165

1. Species not protected by the MTBA.
2. Covered Species.
3. The Hawaiian Petrel was found during a carcass persistence trial, but was included in modelling following the USFWS 2018 guidelines.

This page intentionally left blank

APPENDIX 2. DALTHORP ET AL. (2017) FATALITY ESTIMATION FOR HAWAIIAN HOARY BATS, HAWAIIAN GEESE AND HAWAIIAN PETRELS AT PROJECT THROUGH FY 2019

This page intentionally left blank

Appendix 2a. Dalthorp et al. (2017) Fatality Estimation for Hawaiian Hoary Bats at Project Through FY 2019

Modelling Parameter		Modelling Period													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14 (current)
FY		7	8	9	10	11	12	13	14	15	16	17:Q1	17:Q2- Q4	18	19
Dates	Begin	6/1/2006	7/1/2007	7/1/2008	7/1/2009	7/1/2010	7/1/2011	7/1/2012	7/1/2013	7/1/2014	7/1/2015	7/1/2016	10/1/2016	7/1/2017	7/1/2018
	End	6/30/2007	6/30/2008	6/30/2009	6/30/2010	6/30/2011	6/30/2012	6/30/2013	6/30/2014	6/30/2015	6/30/2016	9/30/2016	6/30/2017	6/30/2018	7/1/2019
Period Length (days)		394	365	365	365	365	365	365	365	365	365	91	272	365	365
% Year		1.08	1	1	1	1	1	1	1	1	1	0.25	0.75	1	1
LWSC		no	no	no	no	no	no	no	no	5.5 m/s	5.5 m/s	5.5 m/s	5.5 m/s	5.5 m/s	5.5 m/s
Search Interval (days)		9	9	7	7	7	7	7	7	7	7	7	7	7	7
Number of Searches in Modelling Period		43	41	52	52	52	52	52	52	52	52	14	38	52	52
Observed Fatalities (X)		0	0	0	0	0	0	2	4	0	0	1	0	1	1
K		0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	1[1]	1[1]	1[1]	1[1]	1[1]
DWA		1	1	1	1	1	1	1	1	1	0.492[2]	0.492[2]	0.573[2]	0.573[2]	0.573[2]
g	g	0.445	0.443	0.501	0.45	0.505	0.345	0.414	0.484	0.217	0.44	0.45	0.549	0.459	0.368
	95% LCI	0.261	0.258	0.312	0.272	0.257	0.149	0.183	0.332	0.128	0.408	0.401	0.52	0.386	0.289
	95% UCI	0.638	0.636	0.69	0.634	0.752	0.574	0.669	0.638	0.321	0.472	0.499	0.578	0.533	0.450
B	Ba	11.208	11.064	12.697	12.367	7.145	6.089	5.894	19.227	14.757	407.897	177.743	631.103	80.673	28.7865
	Bb	13.955	13.936	12.644	15.14	7.007	11.555	8.335	20.472	53.295	520.143	217.5	518.616	95.133	16.0924
M*[3]		1	1	1	1	1	1	7	18	19	19	21	21	23	26

1. Searches performed by canine.
2. Reduced search area (See FY2018 Annual Report for detailed analysis).
3. Cumulative value representing estimate of total direct take from the start of operations through the identified monitoring period at the 80 percent UCL.

Appendix 2b. Dalthorp et al. (2017) Fatality Estimation for Hawaiian Goose at Project Through FY 2019

Modelling Parameter		Modelling Period											
		1	2	3	4	5	6	7	8	9	10	11	12 (current)
FY		06-08	09, 10, 11a	11b	12	13	14	15	16	17: Q1	17: Q2-4	18	19
Dates	Begin	1/1/2006	7/1/2008	11/16/2010	7/1/2011	7/1/2012	7/1/2013	7/1/2014	7/1/2015	7/1/2016	10/1/2016	7/1/2017	7/1/2018
	End	7/1/2008	11/15/2010	7/1/2011	7/1/2012	6/30/2013	6/30/2014	6/30/2015	6/30/2016	9/30/2016	6/30/2017	6/30/2018	6/30/2019
Period Length (days)		912	867	227	366	365	365	365	365	91	272	365	365
% Year		2.50	2.38	0.62	1	1	1	1	1	0.25	0.75	1	1
Search Interval (days)		9	7	7	7	7	7	7	7	7	7	7	7
Number of Searches in Modelling Period		101	124	32	52	52	52	52	52	13	39	52	52
Observed Fatalities		2	2	5	1	4	3	4	1	0	0	1	2
K		1	1	1	1	1	1	1	1	1	1	1	1
DWA		0.95	0.95	0.70[1]	0.70[1]	0.70[1]	0.70[1]	0.70[1]	0.29[1]	0.29[1]	0.35[1]	0.35[1]	0.35[1]
g	g	0.923	0.928	0.678	0.678	0.666	0.683	0.691	0.284	0.285	0.341	0.344	0.339
	95% LCI	0.871	0.885	0.646	0.633	0.580	0.626	0.658	0.265	0.272	0.324	0.336	0.282
	95% UCI	0.962	0.961	0.708	0.720	0.748	0.737	0.722	0.302	0.297	0.359	0.352	0.399
B	Ba	120.759	162.466	581.813	299.380	79.751	183.925	548.693	661.221	1437.106	931.839	4419.702	84.7
	Bb	10.138	12.600	276.801	142.504	39.926	85.392	245.857	1670.615	3613.457	1797.232	8438.369	165.3
M*[2]		2	5	11	13	18	23	28	32	32	34	37	42

1. Reduced search area (See FY2018 Annual Report for detailed analysis).
2. Cumulative value representing estimate of total direct take from the start of operations through the identified monitoring period at the 80 percent UCL.

Appendix 2c. Dalthorp et al. (2017) Fatality Estimation for Hawaiian Petrel at Project Through FY 2019

Modelling Parameter		Modelling Period														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15 (current)
FY		06-07	08	09	10	11a	11b	12	13	14	15	16	17: Q1	17: Q2-4	18	19
Dates	Begin	1/1/2006	7/1/2007	7/1/2008	7/1/2009	7/1/2010	11/16/2010	7/1/2011	7/1/2012	7/1/2013	7/1/2014	7/1/2015	7/1/2016	10/1/2016	7/1/2017	7/1/2018
	End	6/30/2007	6/30/2008	6/30/2009	6/30/2010	11/15/2010	6/30/2011	6/30/2012	6/30/2013	6/30/2014	6/30/2015	6/30/2016	9/30/2016	6/30/2017	6/30/2018	6/60/2019
Period Length (days)		545	365	365	365	137	226	365	365	365	365	365	91	272	365	365
% Year		1.50	1	1	1	0.38	0.62	1	1	1	1	1	0.25	0.75	1	1
Search Interval (days)		9	9	7	7	7	7	7	7	7	7	7	7	7	7	7
Number of Searches in Modelling Period		60	40	52	52	19	31	52	52	52	52	52	12	38	52	52
Observed Fatalities		0	1	0	0	0	0	2	1	1	2	0	0	0	0	1
K		0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1[1]	1[1]	1[1]	1[1]	1*	1[1]
DWA		1	1	1	1	1	0.75[2]	0.75[2]	0.75[2]	0.75[2]	0.75[2]	0.204[2]	0.204[2]	0.246[2]	0.246[2]	0.246[2]
g	G	0.807	0.786	0.847	0.861	0.939	0.712	0.581	0.646	0.714	0.650	0.197	0.198	0.239	0.241	0.239
	95% LCI	0.602	0.593	0.717	0.706	0.848	0.654	0.431	0.511	0.668	0.555	0.18	0.183	0.225	0.203	0.196
	95% UCI	0.948	0.928	0.942	0.963	0.99	0.767	0.724	0.77	0.758	0.74	0.214	0.212	0.253	0.28	0.284
B	Ba	14.64	16.780	31.552	22.061	37.522	173.48	24.567	32.733	281.195	65.572	414.190	587.750	864.440	114.850	85.197
	Bb	3.512	4.580	5.682	3.566	2.438	70.173	17.703	17.929	112.620	35.296	1689.740	2386.760	2690.800	362.767	271.994
M*[3]		0	2	2	2	2	2	5	6	8	11	12	12	13	14	16

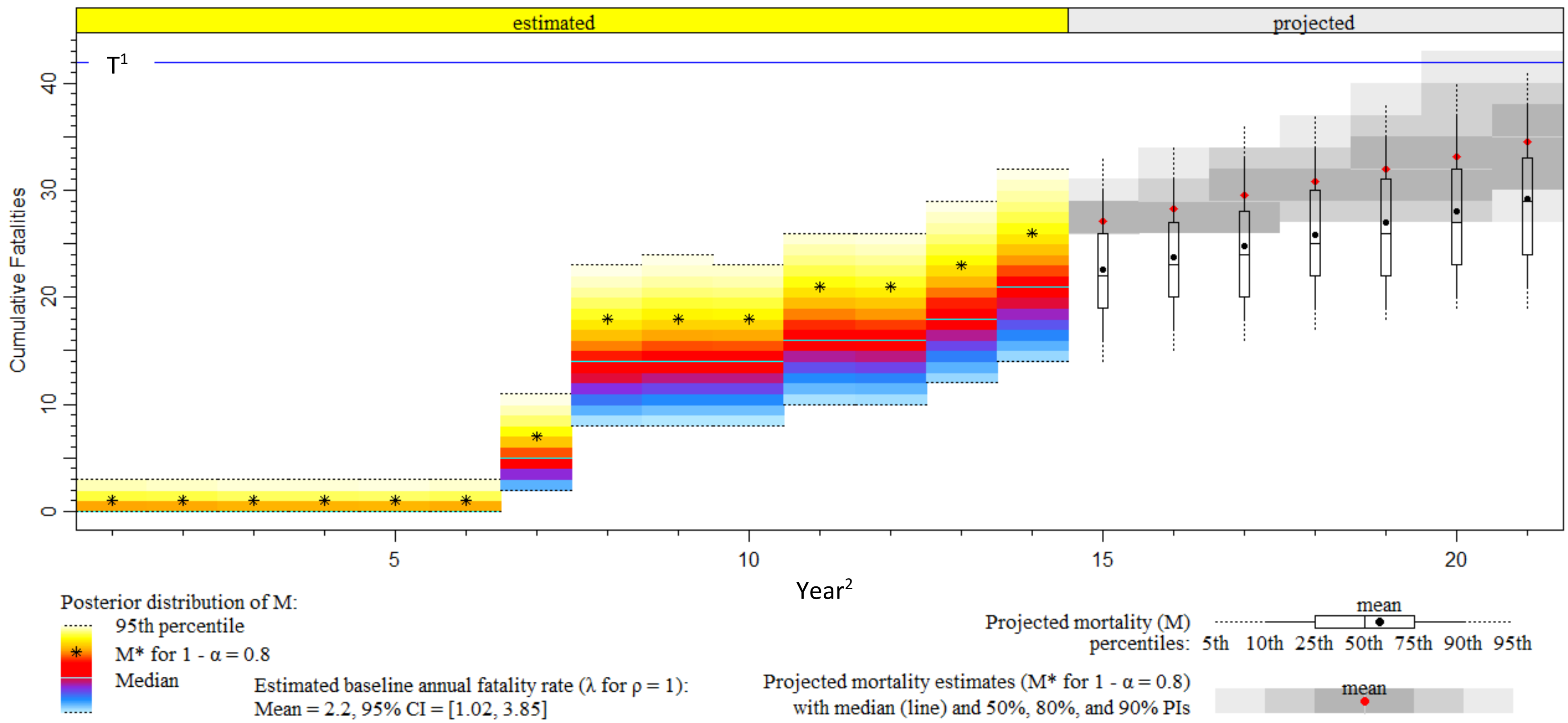
1. Searches performed by canine.
2. Reduced search area (See FY2018 Annual Report for detailed analysis).
3. Cumulative value representing estimate of total direct take from the start of operations through the identified monitoring period at the 80 percent UCL.

This page intentionally left blank

APPENDIX 3. HAWAIIAN HOARY BAT, HAWAIIAN GOOSE AND HAWAIIAN PETREL 20-YEAR PROJECTED TAKE AT PROJECT IN FY 2019

This page intentionally left blank

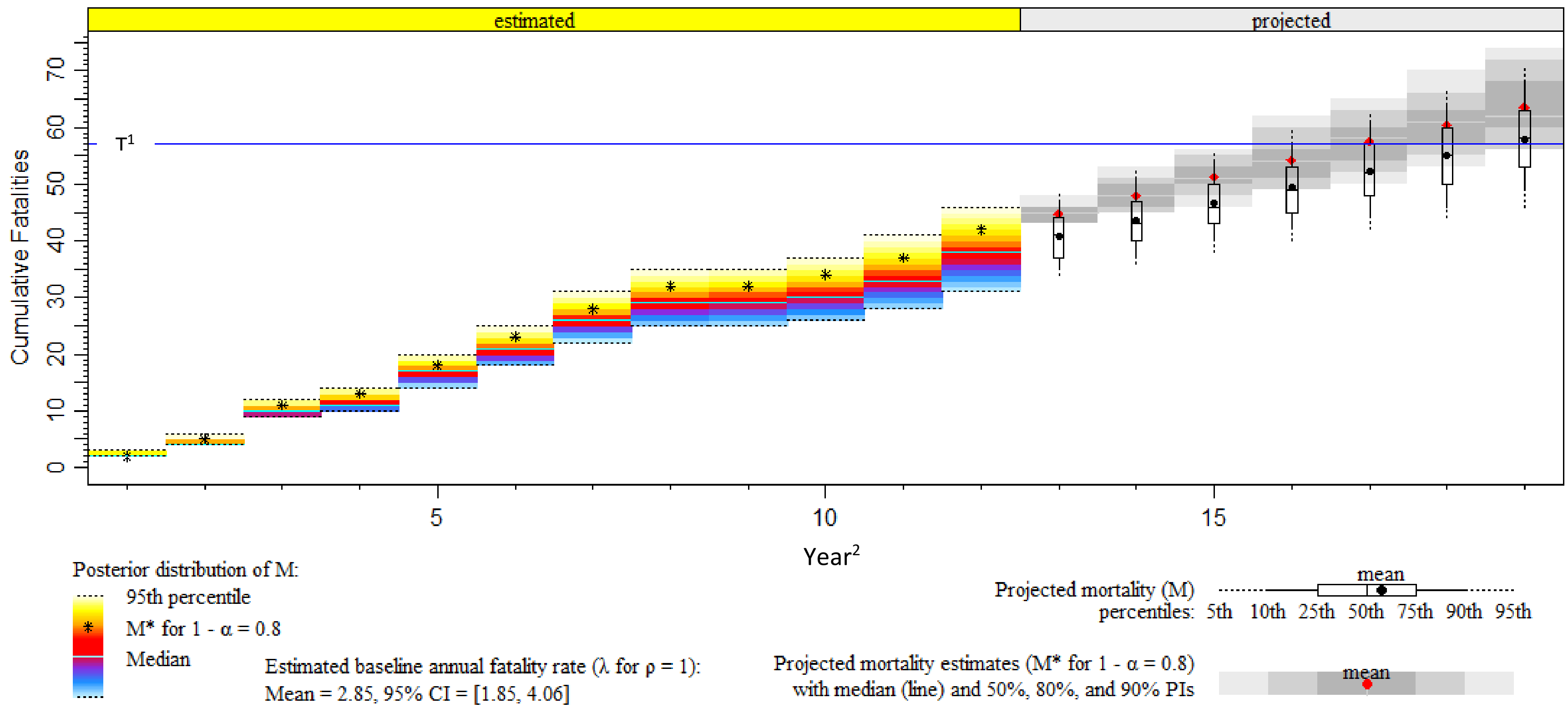
Appendix 3a. Cumulative mortality for Hawaiian hoary bat



[1]Permitted take for the Hawaiian hoary bat at the Project is 50; however, take as calculated from EoA only includes direct take. To account for indirect take in this figure, an approximate take threshold (T) of 42 is shown, representing authorized bat take (50) minus 8 adult equivalents of indirect take (16.0 percent of the authorized limit). Currently, the proportion of total take that is attributable to indirect take is 14.6 percent.

[2]Year represents monitoring periods rather than full years (see Appendix 2 for time periods covered under each monitoring period).

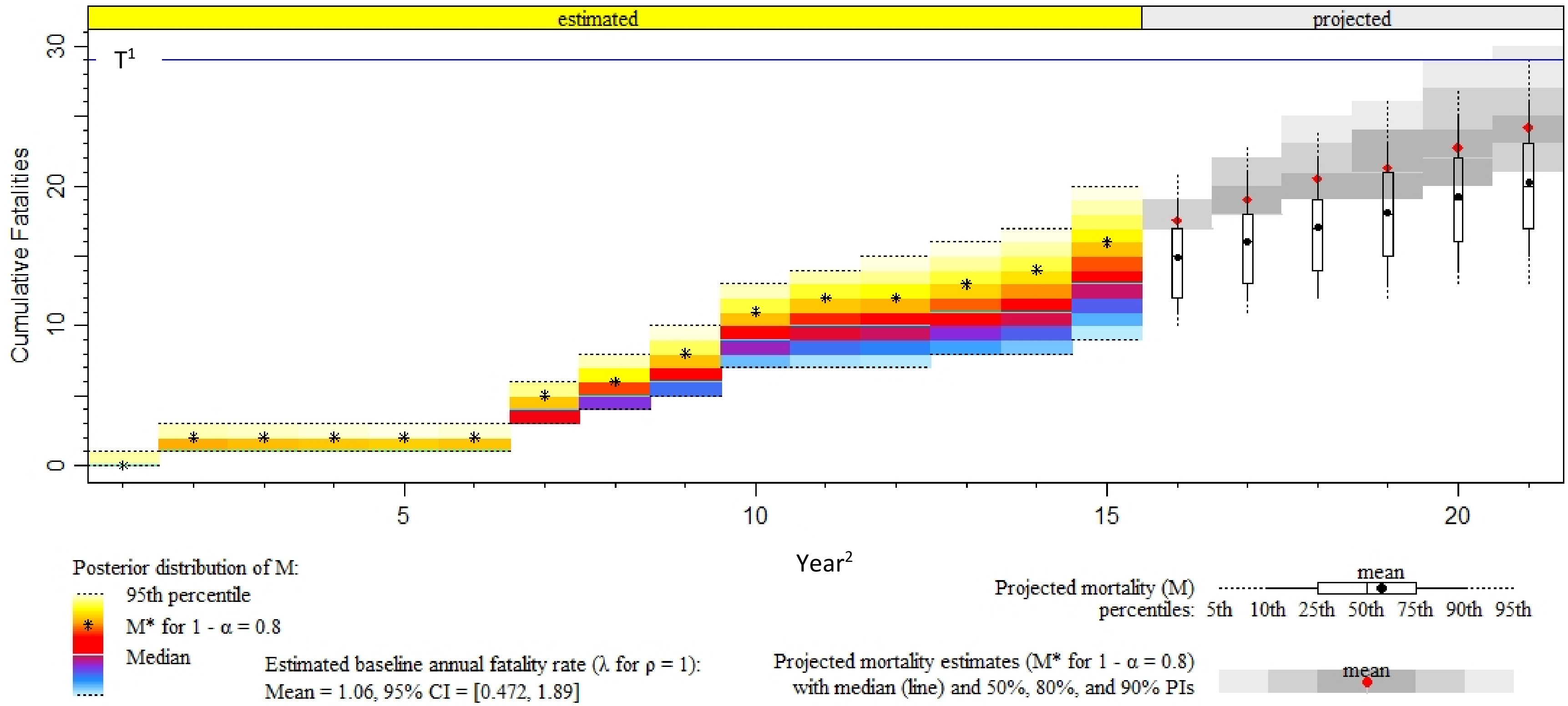
Appendix 3b. Cumulative mortality for the Hawaiian goose



[1] Tier 1 permitted take for the Hawaiian goose at the Project is 60; however, take as calculated from EoA only includes direct take. To account for indirect take in this figure, an approximate take threshold (T) of 57 is shown, representing Tier 1 Hawaiian goose take (60) minus 3 adult equivalents of indirect take (5.0 percent of the requested authorized limit). Currently, the proportion of total take that is attributable to indirect take is 4.5 percent. Total authorized take under Tier 2 (Higher Take) is 100.

[2] Year represents monitoring periods rather than full years (see Appendix 2 for time periods covered under each monitoring period).

Appendix 3c. Cumulative mortality for Hawaiian petrel



[1]Permitted take for the Hawaiian petrel at the Project is 38; however, take as calculated from EoA only includes direct take. To account for indirect take in this figure, an approximate take threshold (T) of 29 is shown, representing authorized petrel take (38) minus 9 adult equivalents of indirect take (23.6 percent of the authorized limit). Currently, the proportion of total take that is attributable to indirect take is 17.7 percent.

[2]Year represents monitoring periods rather than full years (see Appendix 2 for time periods covered under each monitoring period).

This page intentionally left blank

APPENDIX 4. LOST PRODUCTIVITY AND INDIRECT TAKE FOR THE HAWAIIAN GOOSE AND HAWAIIAN PETREL AT PROJECT IN FY 2019

This page intentionally left blank

Appendix 4a. Lost Productivity and Indirect Take for the Hawaiian Goose at the Project in FY 2019

Parameter	Description	Fiscal Year																
		2007	2008	2009	2010	2011		2012	2013	2014		2015		2016	2017	2018	2019	Total
A	Observed Take	0	2	1	1	3	2	1	4	2	1	3	1	1	1	1	2	26
B	Estimated Take Multiplier (42/26=1.62)	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	--
C	Estimated Direct Take (A x B)	0.00	3.23	1.62	1.62	4.85	3.23	1.62	6.46	3.23	1.62	4.85	1.62	1.62	1.62	1.62	3.23	42.00
D	Observed Indirect Take Multiplier (Season Defined)	0.00	0.09	0.00	0.00	0.09	0.00	0.09	0.09	0.09	0.00	0.09	0.04	0.09	0.04	0.09	0.09	--
E	Observed Indirect Take (C x D)	0.00	0.29	0.00	0.00	0.44	0.00	0.15	0.58	0.29	0.00	0.44	0.06	0.15	0.06	0.15	0.29	2.89
F	Unobserved Direct Take (C - A)	0.00	1.23	0.62	0.62	1.85	1.23	0.62	2.46	1.23	0.62	1.85	0.62	0.62	0.62	0.62	1.23	--
G	Unobserved Indirect Take (F x 0.06)	0.00	0.07	0.04	0.04	0.11	0.07	0.04	0.15	0.07	0.04	0.11	0.04	0.04	0.04	0.04	0.07	0.96
H	Accrued Adult Take (Previous Year's Accrued C - M) (beginning 1/1/2011)	--	--	--	--	--		3.36	4.99	11.69		16.76		22.47	20.61	19.38	18.43	--
I	Lost Productivity from accrued adult take (Current year's H x 0.1) Fledglings	--	--	--	--	--		0.34	0.50	0.35		0.35		2.25	2.06	1.94	1.84	9.62
J	Indirect Take + Lost Productivity (E + G + I)-Total Current Fledglings	--	--	--	--	--		0.52	1.23	0.75		1.00		2.43	2.16	2.12	2.21	*12.41*
K[1]	Mitigation fledglings produced	--	--	--	--	--		2	8	8		6		8	14	1	0	47
L[2]	Net fledglings remain (Current Year K - J))	--	-0.25	-0.04	-0.04	-0.45		1.48	6.77	7.25		5.00		5.57	11.84	-1.12	-2.21	--
M	Net adults 3 yrs. later (Three year's previous L x 0.512)	--	--	--	--	-0.13		-0.02	-0.02	-0.23		0.76		3.47	2.85	2.56	2.85	12.09
												Total Lost Productivity (I)						9.62
												Total Indirect Take (E + G)						3.85

1. Productivity information for FY 2019 is not yet available; values will be updated when data becomes available.
2. 1 Prior to 1/1/2011 Indirect Take (E+G) is converted to adult take 2 years later (M) and added to current Accrued Adult Take (H)

Appendix 4b. Lost Productivity and Indirect Take for the Hawaiian Petrel at the Project in FY 2019

Parameter	Description	Fiscal Year															
		2007	2008	2009	2010	2011	2012		2013	2014	2015		2016	2017	2018	2019	Total
A	Observed Take	0	1	0	0	0	1	1	0	1	1	1	0	0	0	1	7
B	Estimated Take Multiplier (16/7 = 2.29)	--	2.29	--	--	--	2.29	2.29	--	2.29	2.29	2.29	--	--	--	2.29	--
C	Estimated Direct Take (A x B)	0.00	2.29	0.00	0.00	0.00	2.29	2.29	0.00	2.29	2.29	2.29	0.00	0.00	0.00	2.29	16.00
D	Observed Indirect Take Multiplier (Season defined)	--	0.66	--	--	--	0.66	0.50	--	0.89	0.89	0.66	--	--	--	0.89	--
E	Observed Indirect Take (A x D)	0.00	0.66	0.00	0.00	0.00	0.66	0.50	0.00	0.89	0.89	0.66	0.00	0.00	0.00	0.89	5.15
F	Unobserved Direct Take (C - A)	0.00	1.29	0.00	0.00	0.00	1.29	1.29	0.00	1.29	1.29	1.29	0.00	0.00	0.00	1.29	9.00
G	Unobserved Indirect Take (D x F)	0.00	0.85	0.00	0.00	0.00	0.85	0.64	0.00	1.14	1.14	0.85	0.00	0.00	0.00	1.14	6.62
H	Accrued Adult Take (Sum all previous year's C)	--	--	2.29	2.29	2.29	2.29		6.87	6.87	9.16		13.74	13.74	13.74	13.74	--
I[1]	Fledglings Produced	0	0	0	0	0	0		0	0	0		0	0	36	0	36
J	Accrued Adult Take Lost Productivity (H x 0.15)-I	0.00	0.00	0.34	0.34	0.34	0.34		1.03	1.03	1.37		2.06	2.06	-22.97	-22.97	-22.97
K	Second Generation Adults: Indirect Take Survive to Adult Accumulated and Unmitigated (fifth year previous IDT (E + G) *0.3)	--	--	--	--	--	--		0.45	0.45	0.45		0.45	1.25	1.25	1.86	--
L	Second Generation Adult Lost Productivity (K x 0.15)	--	--	--	--	--	--	--	0.07	0.07	0.07		0.07	0.19	0.19	0.28	0.92
											Total Lost Productivity (J + L)						**-22.05**
											Total Indirect Take (E + G)						**11.77**

1. Productivity information for FY 2019 is not yet available; values will be updated when data becomes available.

APPENDIX 5. LĀNA’I HAWAIIAN PETREL PROTECTION PROJECT 2018 ANNUAL REPORT

This page intentionally left blank

Kaheawa Wind Power Mitigation
Lāna'i Hawaiian Petrel Protection Project
Final Report – 2018

Prepared by:
Dr. Rachel Sprague
Director of Conservation

Pūlama Lāna'i
Preservation. Progress. Sustainability.

April 2019

Executive Summary

This report outlines the results of predator control efforts and monitoring conducted by Pūlama Lānaʻi to protect Hawaiian petrels as mitigation for the Kaheawa Wind Power I Project. Overall, this project supported the expansion of predator control for cats and rats into some extremely dense petrel nesting areas on the island of Lānaʻi, Greater Hiʻi and Upper Hauola, and improved monitoring in those areas to better understand the effects of predator control.

Predator Control: Cat control was expanded to add 32 live Tomahawk traps across (and below) Lānaʻi Hale, focusing on protection for Greater Hiʻi and Upper Hauola areas. Ninety-six cats were captured in 2018. Even though most captures occurred outside of the petrel colonies, we saw the number of cat visits to petrel burrows decrease significantly: there was only one cat visit to a burrow (on Kūnoa Ridge) and it did not investigate or depredate the burrows. A total of 283 Good Nature A24 rat traps were added to provide ecosystem-level reduction of rat numbers over Greater Hiʻi and Upper Hauola. New trap lines with 184 A24s were installed following the ridges and gulches around Greater Hiʻi (50 m spacing) and along the Munro Trail (25 m spacing). We also added 8 trap lines with 13 A24 traps at 25m spacing down the Upper Hauola ridges, and increased the density of traps on the North Hauola ridge and adjacent trap line (which already had traps at 50m), adding another 39 traps.

Hawaiian Petrel Monitoring: Over the course of 2018, many burrows were found across the Greater Hiʻi Ridges, bringing the total in this area to 121 burrows, 117 of which had activity, and 83 of which had confirmed breeding and a known outcome. By the end of 2018, there were 32 known burrows in the Upper Hauola area, 31 of which had activity, and 19 of which had confirmed breeding and a known outcome. We monitored all known Hawaiian petrel burrows in the areas monthly, during daytime hours only, with a physical check to see if a bird is visible and detect any evidence of predation outside or in the entrance to the burrow. We also monitored a subset of the active burrows with 79 Reconyx cameras (fully-covert IR model). Breeding and eventual end-of-year outcome were confirmed for 84.8% of the burrows that were monitored with cameras, and 68.9% of the total number of active burrows in the mitigation areas.

Reproductive Success: A total of 79 burrows were monitored with cameras across the mitigation project areas. Of those, 67 were confirmed to have breeding and had a known outcome, and 52 of those nests fledged chicks on camera, leading to a reproductive success rate of 77.6%. **Assuming that the reproductive success baseline would have been 38.2% for the camera-monitored nests, this represents a net increase of 26.4 Hawaiian petrel fledglings over the calculated baseline.** We did monitor all 153 burrows, confirming breeding and determining a known outcome for 102 of those burrows using observations and evidence of sign at different breeding stages. Overall, using this close monitoring and review of the data by KESRP, we determined that the reproductive success at the Greater Hiʻi and Upper Hauola areas was 71% (59 fledglings from 83 burrows) and 84% (16 fledglings from 19 burrows), respectively. **This success rate represents a net increase of 36 Hawaiian petrel fledglings over the calculated baseline.**

Table of Contents

Introduction

This report outlines the results of predator control efforts and monitoring conducted by Pūlama Lānaʻi to protect Hawaiian petrels as part of the mitigation for the Kaheawa Wind Power I Project. Overall, this project supported the expansion of predator control for cats and rats into some extremely dense petrel nesting areas on the island of Lānaʻi, and improved monitoring in those areas to better understand the effects of the predator control.

Goal

Expand ecosystem-level Hawaiian petrel (*Pterodroma sandwichensis*) colony management on the island of Lānaʻi (Figure 1) to improve reproductive success in areas that are currently under-protected from mammalian predators.

Objective

Improve reproductive success to produce at least 22 chicks over the estimated baseline reproductive success levels – to meet regulatory requirements of Kaheawa Wind Power's (KWP) state/federal Habitat Conservation Plan (HCP).

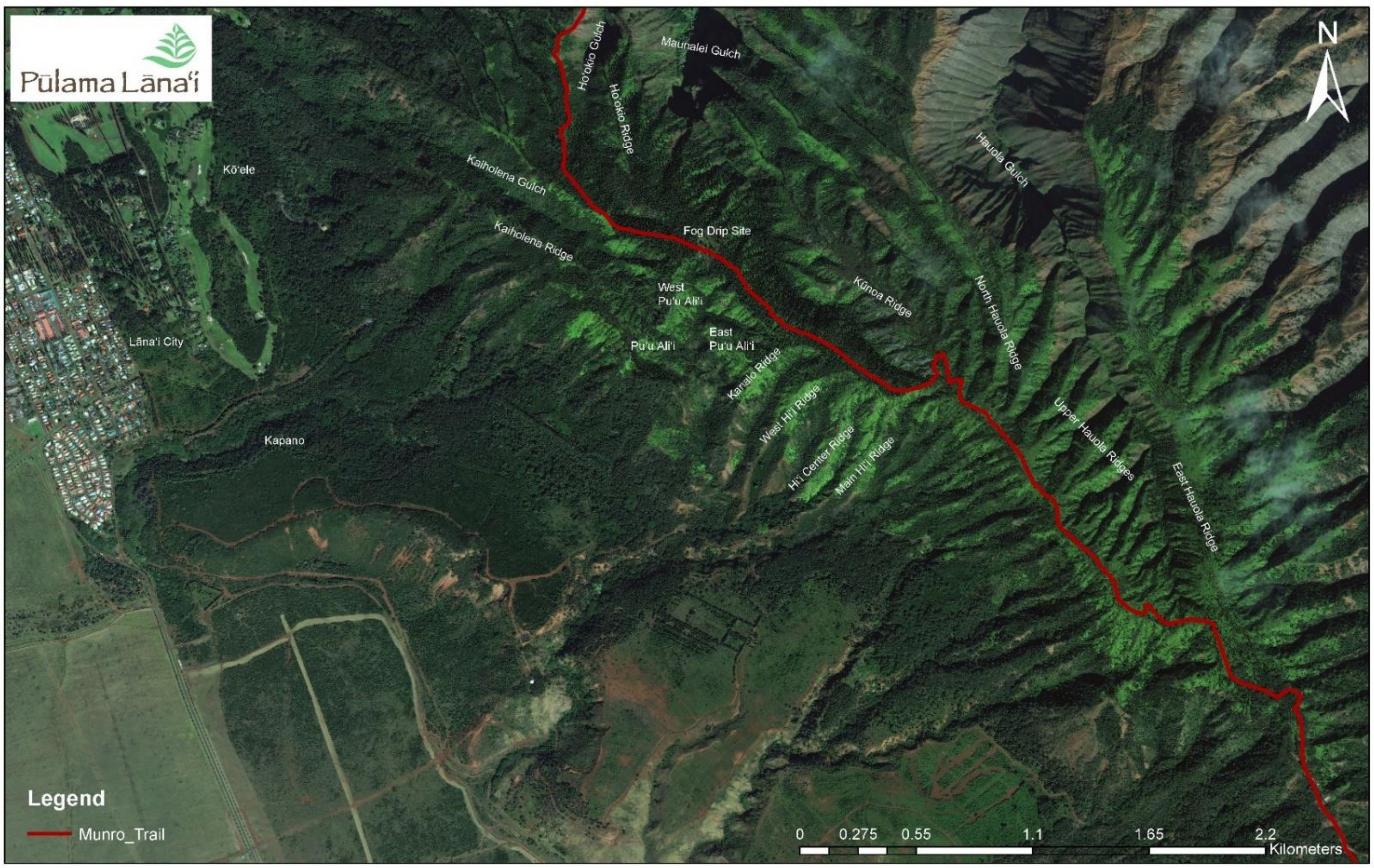


Figure 1. Map of central Lānaʻi with locations for Hawaiian petrel monitoring and predator control areas labeled.

Project Area Overview

Greater Hiʻi

This area extends to the west of Hiʻi Ridge, which currently has the highest density of burrows known on Lānaʻi. The Greater Hiʻi area consists of several large ridges to the west of the main Hiʻi Ridge: (from east to west) Hiʻi Center Ridge, West Hiʻi Ridge, Kanalo Ridge, and West Puʻu Alii.

In late June 2017, 59 burrows were found on West Hiʻi, Kanalo, and East Puʻu Aliʻi ridges, and the observed activity at night was commensurate with the core of the Main Hiʻi Ridge colony, so the density of birds in this area was known to also be extremely high. Burrows in this area were monitored for part of 2017, but with few burrow visits, the outcome of many nests was unknown. Prior to the start of this mitigation project, the Hiʻi Center Ridge was on the edge of the previously existing predator-control grid, meaning that for the purposes of this project, the protection efforts changed the status of the Center Ridge from the edge into the core of the predator-protected area. This greater protection likely provided significant benefits to the birds in that area.

Over the course of 2018, many more burrows were found across the Greater Hiʻi Ridges, bringing the total in this area to 121 burrows, 117 of which had activity, and 83 of which had confirmed breeding and a known outcome (Table 1).

Upper Hauola

This area consists of short ridges that drop into Upper Hauola Canyon between the North and East Hauola petrel colonies. Songmeter monitoring in 2017 showed extremely high levels of petrel activity. In 2017, 17 burrows were found on three of the Upper Hauola Ridges in 2017 while deploying songmeters. These burrows were not monitored beyond the initial discovery, so success in the area was not known. There was cat control along the Munro Trail (the top of these ridges), but no rodent control in the vicinity of the known burrows. By the end of 2018, there were 32 known burrows, 31 of which had activity, and 19 of which had confirmed breeding and a known outcome (Table 1).

Table 1. Hawaiian petrel burrows monitored across the island of Lānaʻi, broken down by the total number of burrows, burrows determined to be active, those with confirmed breeding and known outcome, the number of fledglings, and the reproductive success rate at each site.

	KWP Mitigation Areas						Other Pulama-Managed Areas					
Location:	Hii Center Ridge	West Hii	Kanalo	East Puu Alii	Upper Hauola Ridges	**Subtotal Mitigation Areas**	Kunoa	East Hauola	North Hauola	Main Hii Ridge	**Subtotal Other Managed Areas**	**Total**
# Monitored burrows	28	37	35	21	32	**153**	58	22	22	88	**190**	**343**
# Active burrows	26	37	33	21	31	**148**	57	21	22	77	**177**	**325**
# Confirmed breed & known outcome	15	28	28	12	19	**102**	31	12	17	56	**116**	**218**
Total # Fledged	13	22	20	4	16	**75**	21	9	14	42	**86**	**161**
Reproductive Success	0.867	0.786	0.714	0.333	0.842	**0.735**	0.677	0.750	0.824	0.750	**0.741**	**0.739**

Mitigation Actions

Predator Control

Cat Trapping: Cat control was expanded to add 32 live Tomahawk traps across (and below) Lānaʻi Hale, focusing on protection for Greater Hiʻi and Upper Hauola areas (Figure 2). This was achieved by decrease the spacing between traps on the Munro Trail (increasing the density of traps), extend the ends of the Munro Trail trap line, and new traps along the top of Kaiholena Ridge, and add traps below Lānaʻi Hale in the Palawai Basin. While we had originally planned to extend traps all the way down Kaiholena Ridge, weather delays and then staffing shortages meant that the full Kaiholena line will not be operational until early 2019.

Ninety-six cats were captured in 2018 (Figure 3). Even though most captures occurred outside of the petrel colonies, we saw the number of cat visits to petrel burrows decrease significantly (Figure 4): there was only one cat visit to a burrow (on Kūnoa Ridge) and it did not investigate or depredate the burrows. This pattern reinforces the strategy of landscape-level trapping for meso-predators being potentially more effective than trapping only in the immediate vicinity of known burrows.

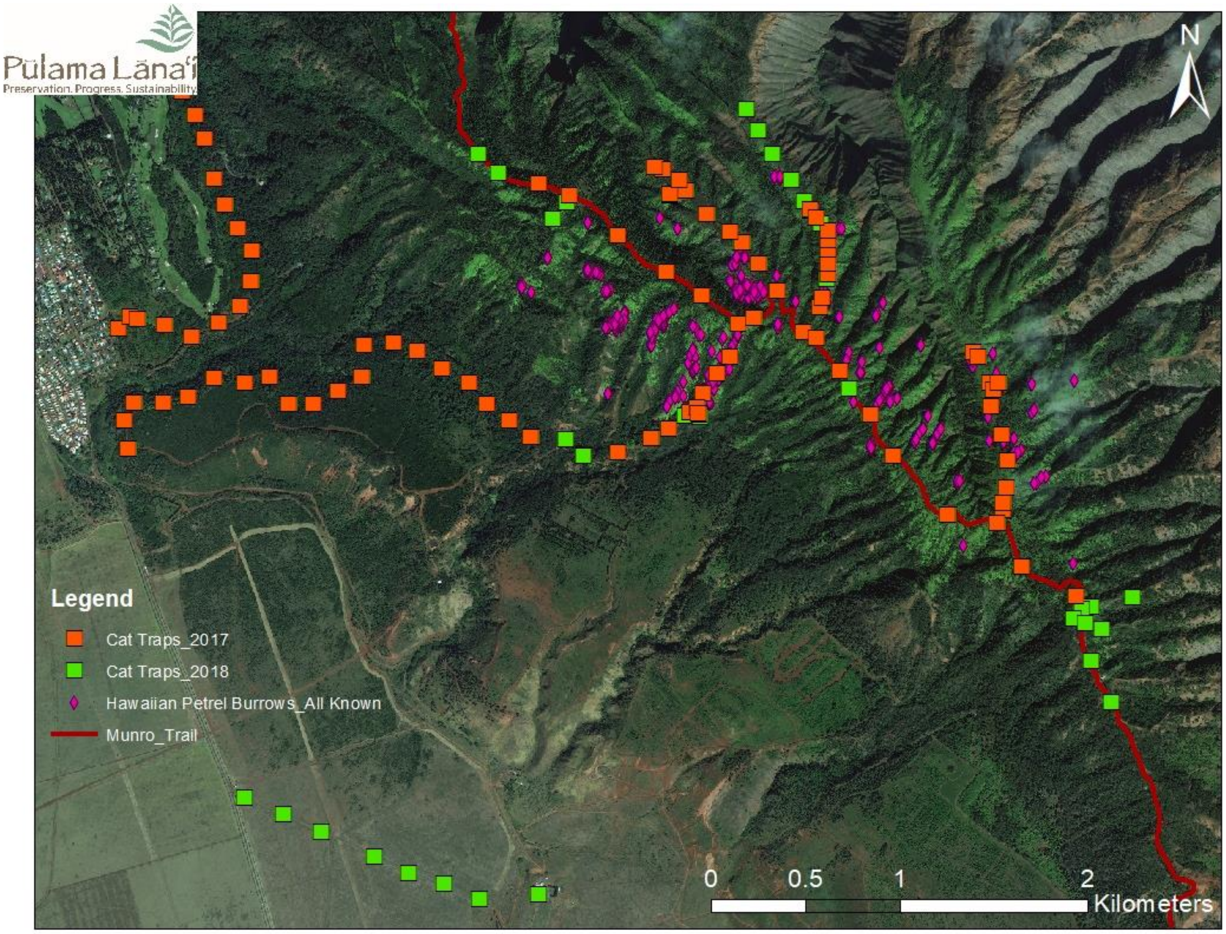


Figure 2. Existing cat traps in 2017, with the mitigation project cat trap expansion, and currently monitored Hawaiian petrel burrows.

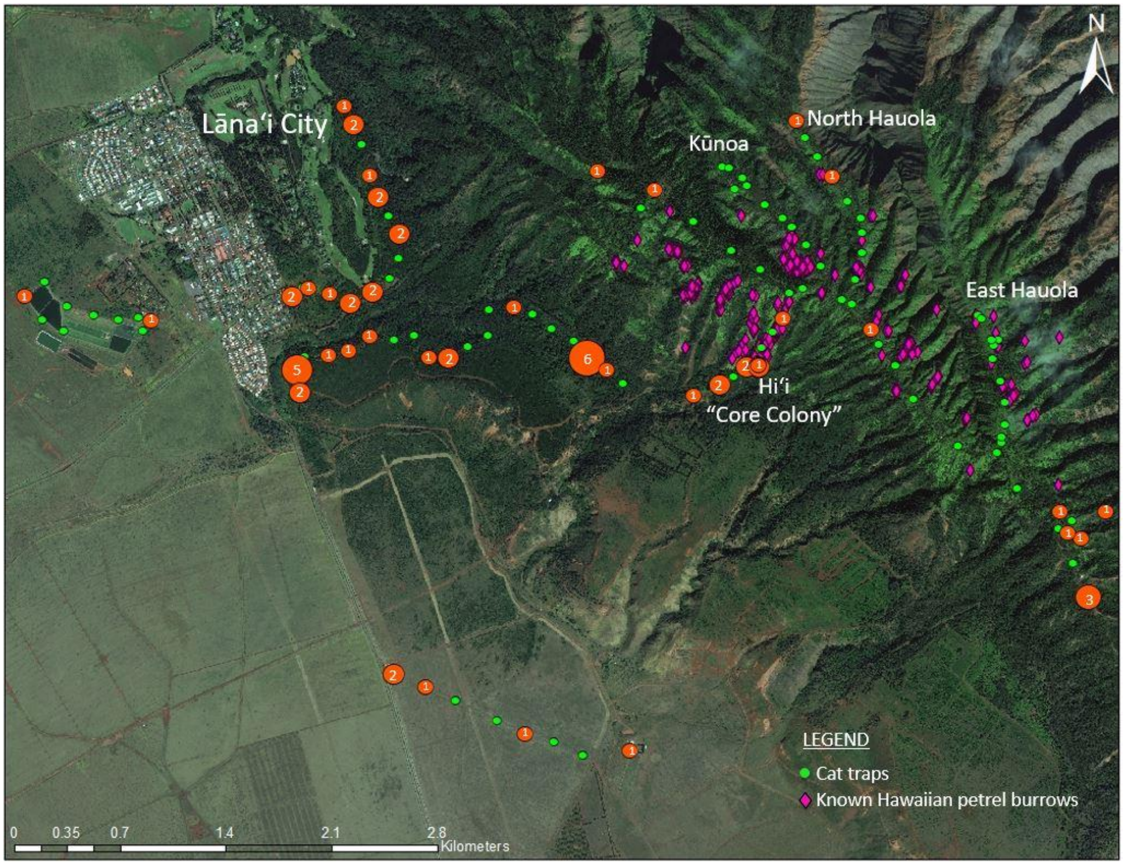


Figure 3. Locations of cat traps (in green) and cat captures in 2018. Numbers in the orange circles indicate the number of cats captured at that trap. Ninety-six cats were captured overall in 2018.

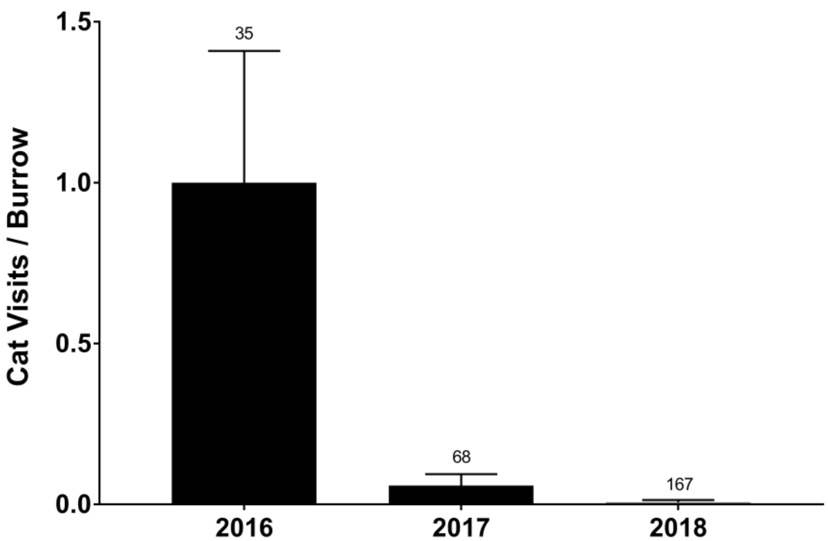


Figure 4. Number of cat visits per burrow monitored with infrared cameras in 2016, 2017, and 2018. N = number of burrows monitored with cameras. 2018 had only one cat visit to a camera-monitored burrows, and it was not a depredation event.

Rat Trapping: We added trap lines with 283 Good Nature A24 rat traps to provide ecosystem-level reduction of rat numbers over Greater Hiʻi and Upper Hauola (Figure 5). The terrain on Lānaʻi Hale around the Hawaiian petrel colonies prevents designing a traditional grid layout. After consultation and site visits with Darren Peters (the predator control officer for the New Zealand Department of Conservation), we decided that following ridgelines and gulches in the Greater Hiʻi area, and ridgelines only in the even steeper Upper Hauola area would provide coverage that is likely to be effective at controlling rats in those areas, while minimizing disturbance to Hawaiian petrel habitat, and keeping staff safe in the field. We added trap lines with 184 A24s following the ridges and gulches around Greater Hiʻi (50 m spacing) and along the Munro Trail (25 m spacing). We also added 8 trap lines with 13 A24 traps at 25m spacing down the Upper Hauola ridges, and increased the density of traps on the North Hauola ridge and adjacent trap line (which already had traps at 50m), adding another 39 traps.

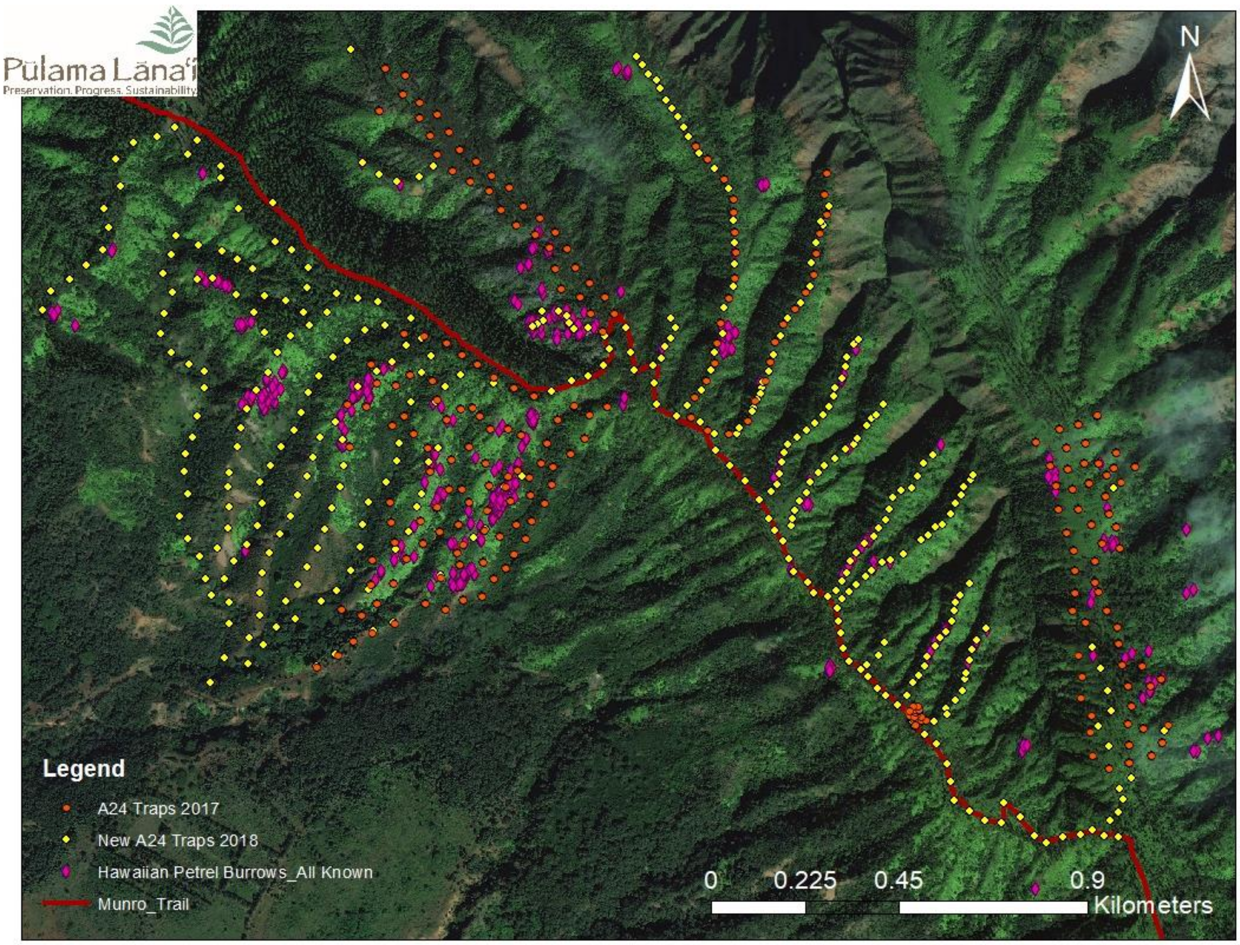


Figure 5. Locations of Good Nature A24 automatic rat traps existing in 2017 (orange), traps that were added as part of the mitigation project A24 expansion (yellow), and currently monitored Hawaiian petrel burrows (purple).

Rat trap spacing notes – Optimal spacing of A24 rat traps depends on many factors, including terrain, rodent density, type of resource needing protection, and desired conservation goals. In the end, the design of trap networks ends up being based on best practices and principles, but there is also an element of art to adapt those principles to different situations on the ground. Based on the Good Nature A24 manual, large-scale (~50+ ha) rat networks should consist of trapping lines 100m apart with A24s spaced at 50m along those trapping lines. Black rat (*Rattus rattus*) home ranges in Hawaiʻi and New Zealand forests tend to be about 50-100m in radius, depending on the forest type. For large-sized networks, 2 traps per hectare is NZ Department of Conservation (DOC) best practices for rat control.

Pūlama Lānaʻi specifically consulted with Darren Peters, the predator control officer for DOC, on this project expansion strategy. From a spatial standpoint, the Greater Hiʻi area would be a realtively simple and contiguous expansion of the existing Hiʻi A24 trapping grid. So while ridges and gulches would be used for the traplines in the new area to avoid excessive damage to habitat (and for safety reasons), the resulting trap network would effectively conform to the recommended 100m x 50m trap spacing. For the Upper Hauola area, it was not possible for field personnel to safely enter and traverse the gulches for traplines. D. Peters discussed alternatives: when areas needing protection are inaccessible for various reasons, NZ has had success using higher densities of traps in the adjacent accessible areas. He observed that these Upper Hauola ridges are extremely close together (~75 m as the petrel flies) and that the desired rodent control could likely be achieved by restricting the traplines to the ridges, but increasing the density of traps on each line from 50 m to 25 m.

Monitoring/Evaluation

Hawaiian Petrel Burrow Monitoring

We monitored all known Hawaiian petrel burrows in the areas monthly, during daytime hours only, with a physical check to see if a bird is visible and detect any evidence of predation outside or in the entrance to the burrow. We also monitored a subset of the active burrows with 79 Reconyx cameras (fully-covert IR model). Reconyx cameras provide an additional level of certainty in burrow monitoring and additional information on rates of predator interactions for failed burrows. Cameras were placed prior to the breeding season (or as early in the breeding season as possible) and remained in place until after chicks fledge (or nests fail, or nest appears to be inactive) (Figure 6). Some cameras from failed nests were moved to other active burrows in order to use them to confirm fledging. A full description of the burrow monitoring protocol and definitions of breeding status and outcome can be found in Appendix A.

Figure 6. Photo of a Hawaiian petrel nest on Lāna‘i with a Reconyx infrared motion-sensor camera monitoring the entrance.

Outcomes

Petrel Reproductive Success Monitoring

There are currently 153 monitored burrows in Greater Hi‘i and Upper Hauola (Table 1). Even with monthly burrow checks, it is generally not possible to confirm breeding (e.g., see an egg, see Appendix A for other definitions of "confirmed breeding") and determe the outcome (e.g., fledging success, or cause of nest failure) for every active burrow. We were able to confirm breeding and eventual end-of-year outcome of 84.8% of the burrows that were monitored with cameras, and 68.9% of the total number of active burrows in the mitigation areas. This is on par with the rest of the Lāna‘i Hawaiian petrel colony, for which we could confirm breeding and determine a known outcome for 65.5% of active burrows.

Calculation of Baseline Reproductive Success

In 2016, the monitored petrel ridges on Lāna‘i had no rat control, and while there were some cat traps across Lāna‘i Hale, they were not being set or rebaited in an effective way, so capture rate was extremely low. By July 2016, the invasive species program had been "re-booted": cat traps were starting to be set more carefully, a more effective (and long-lasting) bait was being used, and a trap line was added down a ridge where many adult petrels had been found killed by cats. The capture rate of cats did slowly increase over the season, however, overall success rate of the petrels in 2016 was 26.7% (range = 0-60%) in the monitored colonies – largely due to predation by rats and cats (Raine et al. 2018a). This baseline rate is notably lower than known unprotected sites on Kauaʻi in similar montane/uluhe habitat. However, fragmentation of native habitat with invasive species on Lānaʻi (in comparison to relatively intact habitats on Kauaʻi) may be expected to facilitate increased predator activity and ingress into the colonies.

We do not have true baseline "unmanaged" reproductive success rates for the Greater Hiʻi and Upper Hauola areas. By the time most burrows were found in those areas in 2017, Pūlama Lānaʻi had already improved and expanded cat trapping on Lānaʻi Hale. There were not specifically traplines through the Greater Hiʻi and Upper Hauola areas, but the trapping grid extended around both areas, so they were within the area of influence for cat control. The predation rates appeared to reflect that, with a limited number of monitored burrows in the Greater Hiʻi area having pre-management reproductive success of 59.1% in 2017 – a bit higher than the other pre-management Lānaʻi colonies. Active burrows were found in 2017 in the Upper Hauola area, but they were not visited after their discovery, so all were unknown outcome. Greater Hiʻi and Upper Hauola did NOT have any burrows identified or monitored in 2016, but those areas were adjacent to the monitored colony areas.

The baseline reproductive success calculated for this project used the available baseline reproductive success information for Hawaiian petrels on Lānaʻi and took into account the pre-existing predator control efforts that this mitigation project will build upon: we calculated a combined average of the reproductive success in Greater Hiʻi in 2017 and the rest of the managed colonies pre-predator control (in 2016), which resulted in a **baseline success rate of 38.2%**. Applying this rate to the 102 burrows with confirmed breeding and known outcome in 2018 results in a baseline fledgling production of 39 chicks (Table 2).

Change from Baseline

Prior to this mitigation project, significant cat and rat control was implemented in other parts of Lānaʻi's Hawaiian petrel colony in 2017, leading to an increase in reproductive success from 26.7% to 69.4% overall, and 79.3% at Hiʻi, the site with the highest level of protection (range = 53.6-100%. Hawaiian petrel nesting sites on Kauaʻi similarly rose to 76.1-84.1% after high levels of predator control were implemented (Raine et al. 2018b, Raine et al. 2018c). A similar increase in reproductive success was seen in the Greater Hiʻi and Upper Hauola areas in response to this mitigation project implementation.

Camera-monitored burrows only: A total of 79 burrows were monitored with cameras across the mitigation project areas. Of those, 67 were confirmed to have breeding and had a known outcome, and 52 of those nests fledged chicks on camera, leading to a reproductive success rate of 77.6%. **Assuming that the reproductive success baseline would have been 38.2% for**

those nests, this represents a net increase of 26.4 Hawaiian petrel fledglings over the calculated baseline (Table 2).

All mitigation area burrows: We did monitor all 153 burrows, confirming breeding and determining a known outcome for 102 of those burrows using observations and evidence of sign at different breeding stages. Even without camera surveillance, close monthly monitoring allows us to determine if, for instance, we find large eggshell pieces with membrane attached and no chick is ever seen (indicating depredation of the egg by rats), or light amounts of down in the substrate outside the burrow late in the season with no large feathers or evidence of depredation (indicating a successful chick fledging). When KESRP was here on island, they did also check burrow interiors using handheld cameras and recorded if they saw an incubating adult or chick present. Overall, using this close monitoring and review of the data by KESRP, we determined that the reproductive success at the Greater Hiʻi and Upper Hauola areas was 71% (59 fledglings from 83 burrows) and 84% (16 fledglings from 19 burrows), respectively. **This success rate represents a net increase of 36 Hawaiian petrel fledglings over the calculated baseline (Table 2).** It should be noted that these reproductive success percentages are slightly lower than the success rates determined with cameras. This may be explained by the fact that it is usually easier to observe evidence of a failure or depredation (and there are more types of sign of depredations that tend to persist in the environment longer) than evidence to confirm that a chick fledged – so using physical monitoring alone can tend to push the success rate results lower, and these overall numbers should be considered a conservative or low-end success rate estimate.

Table 2. Calculation of baseline reproductive success and net increase in the number of fledglings due to the enhanced predator control from this mitigation project. The upper part of the table shows the rates and numbers of fledglings for all burrows monitored in the mitigation areas, while the lower part of the table shows the calculations for only the burrows that were monitored with cameras.

ALL Burrows	# 2018 Burrows w/Confirmed Breeding and Known Outcome	Calculated Baseline Fledglings (38.2%)	# Fledglings 2018	Reproductive Success Rate 2018	Net increase over baseline (# fledglings)
Greater Hiʻi	83	31.7	59	0.710	27
Upper Hauola	19	7.3	16	0.842	9
Total	**102**	**39.0**	**75**	**0.735**	**36**
ONLY Burrows monitored with cameras					
Greater Hiʻi	50	19.1	37	0.740	17.9
Upper Hauola	17	6.5	15	0.882	8.5
Total	**67**	**25.6**	**52**	**0.776**	**26.4**

Budget

Most of the budget was implemented as expected. The purchase of equipment (cat and rat traps, petrel monitoring cameras, and associated supplies) was all completed and ended up totaling $7,867 less than budgeted. The only items in the original budget not fully executed (or requested for reimbursement) are the salary for the Wildlife Specialist, and the contract rebaiting support for the A24 rat traps. The budget still has $79,167.08 remaining for these items.

We did hire a Wildlife Specialist (Grazel Caceres, promoted from within our team) in August 2018, but have not yet requested reimbursement for her time to date (approx. $25,300 for Aug-Dec 2018). We also plan to schedule contract support for A24 rebaiting in early August. We rebaited traps with Pūlama staff in April 2019 (aiming to get fresh bait into traps before petrel eggs are laid in late May), but will likely be limited in our personnel availability in August to complete the next rebaiting. This is the most critical time for having fresh bait in the rat traps as young chicks left alone in burrows in mid-August is arguably the most vulnerable time for rat depredation.

Assuming contract support for rebaiting traps, and continued support for the Wildlife Specialist (hourly rate + 35% benefits/fringe), we estimate that the original funding will support continued predator control protection for the petrel colony through the end of September 2019.

Item	**Budgeted**	**Actual**	**Variance**
Good Nature A24 rat traps and accessories - (350) traps and (700) auto-lure pumps (ALPs) and CO2	$ 56,665.00	$ 53,386.84	$ 3,278.16
Contract support for A24 line/trap installation and servicing	$ 5,000.00	$ 3,124.98	$ 1,875.02
Contract rebaiting support	$ 9,000.00		$ 9,000.00
Tomahawk w/covers & shipping - (45) traps	$ 6,800.00	$ 6,176.60	$ 623.40
Various Supplies (cat food, flagging, tags, jars, etc.)	$ 500.00	$ 221.70	$ 278.30
Covert infrared burrow monitoring cameras and mounts (w/shipping) - (70) Reconyx HP2X cameras	$ 35,211.40	$ 33,474.40	$ 1,737.00
AA Lithium Batteries for burrow monitoring cameras - 2520 batteries)	$ 3,477.60	$ 3,200.40	$ 277.20
Memory cards for burrow monitoring cameras - (170) SD cards	$ 880.00	$ 1,032.00	$ (152.00)
IS/Wildlife Specialist (salary + fringe)	$ 62,250.00		$ 62,250.00
Total	$ 179,784.00	$ 100,616.92	
Remaining Funding		$ 79,167.08	

References

Raine, A.F., M. Vynne, S. Driskill, K. Stoner, and E. Pickett. 2018a. Monitoring of Endangered Seabirds on Lānaʻi, Annual Report 2017. Kauaʻi Endangered Seabird Recovery Project (KESRP), Pacific Cooperative Studies Unit (PCSU), University of Hawaiʻi and Division of Forestry and Wildife, State of Hawaiʻi Department of Land and Natural Resources, Hawaiʻi, USA. 73 pp.

Raine, A.F., M. Vynne, S. Driskill, and E. Pickett. 2018b. Monitoring of Endangered Seabirds in Hono o Nā Pali Natural Area Reserve IV: Hanakāpīʻai, Annual Report 2017. Kauaʻi Endangered Seabird Recovery Project (KESRP), Pacific Cooperative Studies Unit (PCSU), University of Hawaiʻi and Division of Forestry and Wildife, State of Hawaiʻi Department of Land and Natural Resources, Hawaiʻi, USA. 49 pp.

Raine, A.F., M. Vynne, S. Driskill, J. Kuwahara-Hu, and K. Stoner. 2018c. Monitoring of Endangered Seabirds in Hono o Nā Pali Natural Area Reserve V: Hanakoa, Annual Report 2017. Kauaʻi Endangered Seabird Recovery Project (KESRP), Pacific Cooperative Studies Unit (PCSU), University of Hawaiʻi and Division of Forestry and Wildife, State of Hawaiʻi Department of Land and Natural Resources, Hawaiʻi, USA. 45 pp.

Shiels, A.B. 2010. Ecology and impacts of introduced rodents (*Rattus spp.* and *Mus musculus*) in the Hawaiian Islands. PhD dissertation, University of Hawaiʻi at Mānoa, Honolulu, Hawaiʻi, USA.

This page intentionally left blank

APPENDIX 6. HAWAI’I ISLAND HAWAIIAN HOARY BAT ECOLOGICAL RESEARCH PROJECT ANNUAL REPORT

This page intentionally left blank

Hawaiian Hoary Bat Conservation Biology: Movements, Roosting Behavior, and Diet

Summary Report of Research 2018-July 2019

Agreement # 17WSTAAZB005541

Prepared by:

Karen N. Courtot[1] and P. Marcos Goressen[2]

29 July 2019

[1]USGS-Pacific Island Ecosystems Research Center, Kilauea Field Station, P.O. Box 44, Hawaii National Park, HI 96718

[2]Hawaii Cooperative Studies Unit, University of Hawaii at Hilo, P.O. Box 44, Hawaii National Park, HI 96718

The Hawaiian Hoary Bat Conservation Biology project is designed to advance understanding of key aspects of endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) ecology and population biology. Key components of the study will include:

- Movements throughout the annual cycle
- Habitat use
- Roost fidelity and characterization
- Maternal roost ecology and mother-pup behavior
- Diet analysis using molecular techniques
- Insect prey selection and availability
- Insect prey-host plant associations
- Banking of tissue and fur collection for genetic and pesticide studies (outside scope of this study)

Study preparation and design

This USGS-led study is being conducted in collaboration with several researchers with the University of Hawaii at Hilo – Hawaii Cooperative Studies Unit.

Significant permitting and land access requirements were addressed during the initial phase of the project. State of Hawaii Department of Land and Natural Resources – Division of Forestry and Wildlife (HI DLNR-DOFAW) has granted permits for access and special use in several Forest Reserves and Natural Area Reserves and the Laupahoehoe Hawaii Experimental Tropical Forest. A native invertebrate collection permit has been granted by HI DLNR-DOFAW. Additionally, State and Federal permits for the capture, handling, and sampling of Hawaiian hoary bats have been renewed. The USDA Forest Service - Institute for Pacific Islands Forestry and the University of Hawaii College of Tropical Agriculture and Human Services have granted permission to station automated telemetry receiver stations on their properties. All permits will be renewed annually.

The study area spans much of the east side of Hawaii Island (Figure 1). Eight fixed sampling sites have been selected for regularly scheduled bat mist netting and insect collections; these sites will be sampled three times per year (approximately 4-month interval between visits). Four fixed sites are located at high elevation (above 1000 m asl) and four at low elevation (below 600 m asl). The fixed sample sites include native and exotic forests, orchards, pastures, and mixed habitats. Sampling cycles are divided by breeding cycle phase: non-reproductive (December-March), pregnancy/pupping (April-July), post-lactation/fledging (August-November). Additional bat mist netting efforts are conducted at a variety of sites that span a range of habitat types in east Hawaii.

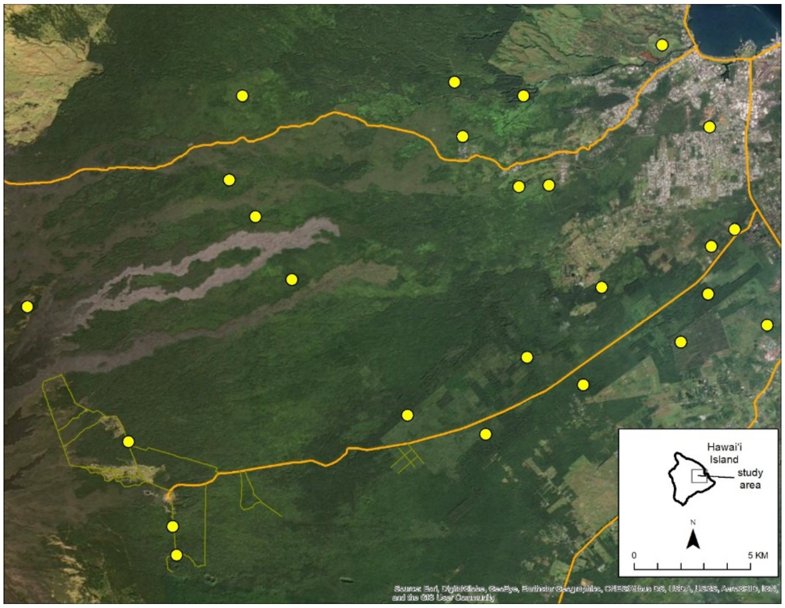


Figure 1. Mist nest sites in the Wailuku watershed of east Hawaii Island. For clarity, map excludes several net sites in the Laupahoehoe Natural Area Reserve (20 km to north).

Capture effort

Ninety-six nights of bat mist netting effort were conducted 14 May 2018 – 24 July 2019; bats were captured on thirty-four of these nights (Figure 2). Forty-five individuals were captured and from all individuals tissue and hair samples were collected and morphometric measurements and reproductive status recorded. All bats were marked with unique color-coded bands. Radio-telemetry tags were affixed to 41 individuals. Additionally, three individuals were captured twice, two of which were radio-tagged twice.

Figure 2. Mist nest set to capture Hawaiian hoary bats (left) and bat with color-coded wing band (right).

Movements

Study of Hawaiian hoary bat movements were limited in year one of the study; increased effort on this objective is planned through years two and three. A network of 20-30 ft masts with antennas and radio receivers (Figure 3) that will function as automated telemetry systems across a broad section of the Hilo watershed is undergoing testing. Technical issues with the effectiveness of radio receivers for this system have occurred. Extensive testing of receivers has occurred and continues. Full field trials will begin in August 2019. Five of the seven to eight stations have been installed (Figure 3). Once operational, the receiver systems should allow for a better understanding of the distances traveled and elevational migrations made by bats within a night and within the approximately two- to three-week period that a radio tag is active. Additional movement information is documented when possible, including site fidelity and seasonality of re-captured bats (*n* = 3) and the distance between capture and roost locations (see below).

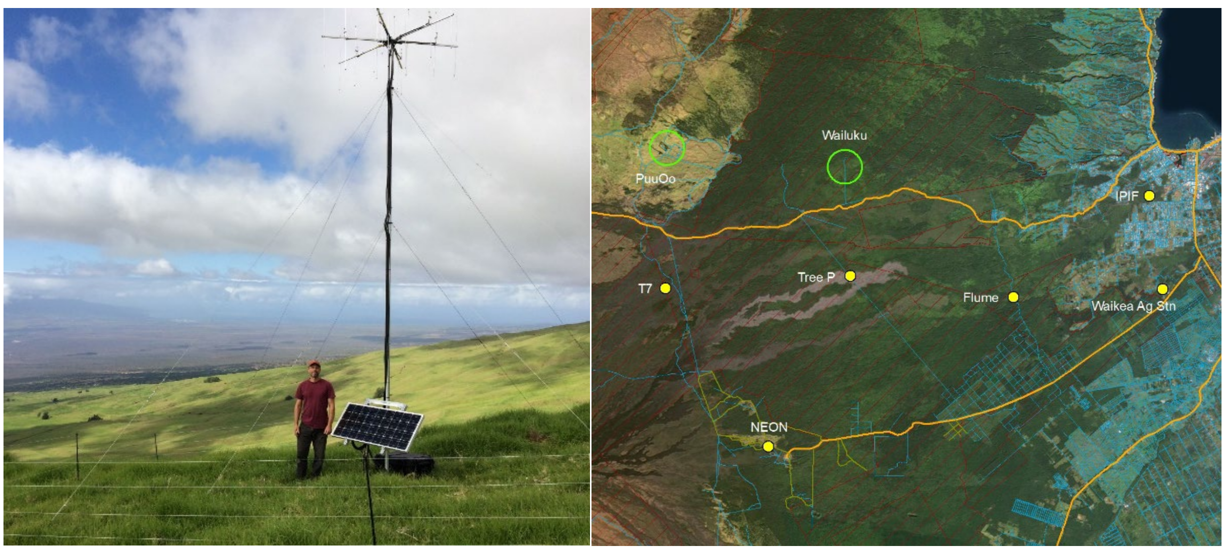


Figure 3. Automated telemetry system station (left). Map of locations of automated telemetry system stations (right), yellow dots are permitted and established stations, green circles are proposed additional locations.

Roost ecology

Roost ecology studies were a primary focus of field efforts during year one of the project. Once individuals are captured and radio-tagged, efforts to track the individual to a day roost tree commence within one day. Dense forest vegetation and a limited road network creates extremely difficult conditions for tracking individuals to their day roost resulting in significant effort devoted to this work. Radio telemetry (Figure 4) has been used to track 13 bats to a day roost tree, an additional 19 bats have been tracked to the forest stand of their day roost.

Roost trees are identified to species and characteristics are measured (e.g., height, dbh, percent canopy cover, etc.). To date, roost tree metrics have been collected at 11 trees. Stand-level characteristics (e.g., stand height, dominant tree, understory, etc.) will be derived from a combination of satellite and airborne imagery and ground measurements.

Where possible, roost fidelity of bats with active radio tags is monitored using an automated receiver station near the roost (Figure 4). Data from these systems have been collected and downloaded at four roosts since May 2019, when the system was first used. We expect data collection using this system to be more frequent in the coming year. The automated system is augmented by manual searches using thermal imaging scanners and binoculars (Figure 4) at known roost sites where bats are not radio-tagged (or no longer tagged).

Video monitoring of a maternal roost to assess behavior was conducted during the summer of 2018. Two known maternal roosts were monitored for returning females during April-July 2019 (ongoing). The first mother with pups was observed in late July; regular monitoring of this site will commence.

Figure 4. Radio telemetry effort to located day roost tree (left). Automated receiver station for measure roost fidelity (middle). Manual search for roosting bat at a historical roost site (right).

Diet studies

Studies of diet are focused on three primary lines of research: prey selection (comparison of availability with what is in fecal samples), seasonal and elevational comparisons, host-plant associations with diet species.

Insect collection commenced in February 2019. Nocturnal flying insects are collected using light traps (Figure 5) run at each fixed collection site concurrently with mist netting. Insect collection is conducted during two nights in each sampling cycle (i.e., 16 nights per cycle). Insects will be categorized by size class and identified to the highest possible taxonomic classification; this lab work is underway. Additionally, samples will be submitted for genetic meta-barcoding to establish a reference library of potential bat prey items.

To identify bat prey, genetic meta-barcoding of guano samples will be conducted, and a bioinformatics approach will be used to match bat prey items in with the reference library (above) and public databases (see Pinzari et al. 2019). To date, 28 guano samples have been collected. Lab work to begin analysis of these samples will commence in early 2020.

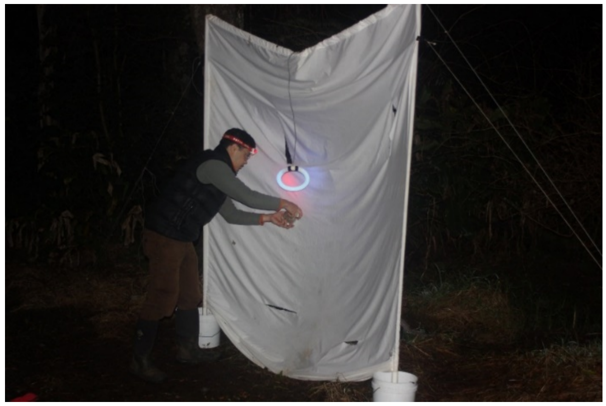


Figure 5. Insect collection using UV light trap.

Future research efforts

We plan to continue field work and data collection across east Hawaii through mid-year 2021 including regular efforts to capture, collect samples, and radio-tag bats. Tracking individuals to roost trees and data collection at roost trees will continue to be a focus of field efforts during 2020. Additionally, during 2020 we expect to increase efforts to track long-distance movements using the automated telemetry system supplemented with ground tracking. Diet studies including aerial nocturnal insect collection and fecal sample collection will also continue into 2020. Work to associate host plants with bat insect prey will commence during 2020. Fecal samples collected to date will be submitted for lab analysis in early 2020. Data analysis and report writing is planned for 2021.

APPENDIX 7. HAWAIIAN GOOSE RELEASE PENS SAFE HARBOR AGREEMENTS FY 2019 ANNUAL REPORT

This page intentionally left blank

PUʻU O HOKU RANCH / PIʻIHOLO RANCH / HALEAKALĀ RANCH
SAFE HARBOR AGREEMENT
ANNUAL REPORT

JULY 1, 2018 – JUNE 30, 2019

MOLOKAʻI:

PUʻU O HOKU RANCH:

SIGHTINGS:

Weekly observations and monitoring were accomplished by state personnel throughout the year on Puʻu O Hoku Ranch. This past year a total of twenty-six (26) banded birds and one (1) unbanded bird were sighted throughout the eastern section of Molokaʻi. Of the twenty-seven (27) birds, twenty-five (25) were recognized as Molokaʻi birds, one (1) was an original released bird, and one (1) was a previous bird that fledged before being banded. An island-wide nēnē survey was conducted on September 5, 2018, during which twenty-one (21) banded birds were recorded. Calculations from banded birds observed and recorded produced an estimated population of twenty-seven (27) birds at Puʻu O Hoku Ranch.

NESTING:

Two (2) nests were located in the open-top release pen at Puʻu O Hoku Ranch. Both nests were successful with each producing two (2) goslings resulting in four (4) birds fledging.

BANDING:

Four (4) goslings were successfully banded in the Puʻu O Hoku Ranch open-top release pen before fledging.

PEN MAINTENANCE:

The fences and watering units were checked and maintained monthly. All wire on the corners of the iron roofing was replaced because of rotting. A new solar panel box was installed, and electrical clamps and wires were replaced. Waterlines and water troughs were checked weekly. Two (2) broken waterlines were replaced, and one (1) trough was changed.

HABITAT MANAGEMENT:

Five (5) acres of alien vegetation (Christmas berry, haole koa, and sour grass) was removed from the pen. Fifty-nine and a half (59.5) acres were mowed this year by DOFAW staff. Ranch personnel mowed an additional nine hundred (900) acres within the ranch. Additionally, six (6) acres along the fenceline was mowed and maintained.

TRAPPING:
Predator trapping using 16 live traps occurred monthly this year except for November when there were cattle in the pasture. A total of thirty-eight (38) mongoose and one (1) cat were removed through predator trapping.

DEATHS:
There were no deaths this season.

MAUI:

<u>PIʻIHOLO RANCH:</u>

SIGHTINGS:
Observations of banded and unbanded birds were recorded at Piʻiholo Ranch to monitor movements, distribution, and survival of nēnē. This year thirty-seven (37) banded birds were sighted at the ranch. Thirty-four (34) were wild Maui nēnē and three (3) were from the original Olinda released birds. An island-wide annual nēnē survey was conducted on September 19, 2018. During this survey, eighteen (18) birds were seen at Piʻiholo Ranch.

NESTING:
During nesting season, records were kept on mated pairs and the gravid levels of females found at the ranch. Nests found on the ranch were marked using GPS and checked weekly to determine their status. Nesting activities, nest outcomes, hatching, and fledgling success were recorded for the nesting season.

Seventeen (17) nests or nesting attempts were located within the Piʻiholo Ranch open-top release pen this year. Seven (7) of these nests were successful. Fifteen (15) nēnē fledged from Piʻiholo Ranch open-top release pen this season.

BANDING:
Staff attempted to band as many unringed nēnē as possible found at Piʻiholo Ranch. Banding information is recorded and a database is kept for bird bands sighted at the ranch.

This year fourteen (14) nēnē were banded at the open-top release pen. This included thirteen (13) fledglings and one (1) adult. Two (2) birds fledged before being banded.

PEN MAINTENANCE:
The open-top pen's fence line was continuously checked and maintained throughout the year. The fenceline was sprayed with herbicide for weed control and trees were trimmed along the exterior boundary. The pond was cleaned and flushed twice a month, and the automatic waters were cleaned and maintained weekly. The water shutoff valve was replaced after it was leaking.

HABITAT MANAGMENT:
Short grass habitat was maintained at the open-top release pen. The one (1) acre open-top pen was mowed once a week and the area around the outside of the pen was maintained as needed. A total of twenty-five and a half (25.5) acres was mowed this year to maintain nēnē short grass habitat. In addition, a quarter (0.25) acre of weeds was removed from the pen. One (1) pilo plant was planted inside the pen.

TRAPPING:
Predator traps are used to control rats, mongoose, feral cats, and dogs that may pose a threat to nēnē and their nesting sites. Year-round traplines were baited and checked at Piʻiholo Ranch using 30 Tomahawk live traps, 30 Sherman traps, and 10 A24s.

This year at Piʻiholo Ranch, forty-eight (48) mongoose, three (3) rats, and twelve (12) mice were removed through predator trapping. No avian predators were controlled this season on the ranch.

DEATHS:

The only nēnē deaths that occurred this season at Piʻiholo Ranch were those of goslings due to failed/unsuccessful nests. A total of five (5) gosling deaths were attributed to abandonment and inclement weather factors.

HALEAKALĀ RANCH:

SIGHTINGS:
Haleakalā Ranch was continuously surveyed and birds observed were recorded. Forty-seven (47) banded birds were recorded this season at the pen. Of these, thirty-six (36) were wild Maui birds, one (1) was an original Olinda released bird, and ten (10) were translocated birds. During the September 2018 survey, twenty-five (25) nēnē where seen, which included twenty-two (22) banded birds and three (3) unbanded birds.

NESTING:
Seven (7) nests were found in the open-top release pens this season. Two (2) nests were successful this season. Two (2) goslings successfully fledged from each nest, producing a total of four (4) fledglings from Haleakalā Ranch open-top release pen.

BANDING:
Four (4) fledglings were banded at Haleakalā Ranch this year.

PEN MAINTENANCE:
The fenceline and electric fence were checked monthly and repaired as needed. A half (0.5) acre of fence line was sprayed with herbicide every three (3) months. The water unit was checked and maintained monthly.

HABITAT MANAGEMENT:
Twenty-six (26) acres were mowed in and around the pen to maintain short grass habitat. An additional seven and a quarter (7.25) acres of alien vegetation, including lantana, guava, Sacramento bur, abutilon, baconia, and glycine, was removed from the pen.

TRAPPING:
Predator trapping occurs year-round at Haleakalā Ranch open-top release pen. Thirty-four (34) Tomahawk live traps and seven (7) A24s traps are checked throughout each week. Two (2) mongoose, three (3) rats, and one (1) mouse were removed from the pen through predator trapping this year.

RELOCATIONS:
Three (3) nēnē were relocated to Haleakalā Ranch open-top release pen. All were injured birds that were captured, treated, and relocated to the pen. None of the birds bred at the pen.

DEATHS:
Four (4) nēnē died this year at the pen. This included three (3) adults and one (1) gosling. One (1) of the adults died from a wing injury. The other two (2) adults were found dead of unknown causes. The gosling was found dead tangled in the vegetation.

TABLES:

NĒNĒ NESTING SUMMARY FOR 2018 - 2019 BREEDING SEASON AT PU‘U O HOKU RANCH - MOLOKA‘I

Total Number of Nests Located in Open-top pen	=	2
Total Number of Nests Successful	=	2
Total Number of Nests Abandoned	=	0
Total Number of Nests Depredated	=	0
Total Number of Renests	=	0
Total Number of Known Eggs	=	5
Total Number of Eggs Salvaged	=	1
Total Number of Eggs Depredated	=	0
Total Number of Eggs Hatched	=	4
Total Number of Goslings	=	4
Total Number of Goslings Died Before Fledged	=	0
Number of Fledglings Fledged from Pen	=	4

NĒNĒ NESTING SUMMARY FOR 2018 – 2019 BREEDING SEASON AT PI‘IHOLO RANCH – MAUI

Total Number of Nests located in Open-top Pen	=	17
Total Number of Nests Successful	=	7
Total Number of Nests Abandoned	=	8
Total Number of Nests Depredated	=	1
Total Number of Nests Failed due to weather	=	1
Total Number of Renests	=	5

Total Number of Known Eggs	=	45
Total Number of Known Eggs Salvaged	=	22
Total Number of Eggs Destroyed Naturally	=	1
Total Number of Known Eggs Depredated	=	2
Total Number of Known Eggs Hatched	=	20

Total Number of Known Goslings	=	20
Total Number of Goslings Died from Weather	=	4
Total Number of Goslings Died from Abandonment	=	1

Number of Nēnē Fledged from Pi‘iholo pen	=	15

NĒNĒ NESTING SUMMARY FOR 2018 – 2019 BREEDING SEASON AT HALEAKALĀ RANCH

Total Number of Nests Located in Open-top Pen	= 7
Total Number of Nests Successful	= 2
Total Number of Nests Abandoned	= 0
Total Number of Nests Depredated	= 3
Total Number of Nests Hatched but Unsuccessful	= 2
Total Number of Renests	= 3

Total Number of Known Eggs	= 18
Total Number of Known Eggs Depredated	= 7
Total Number of Eggs Salvaged	= 3
Total Number of Eggs Hatched	= 8

Total Number of Goslings	= 8
Total Number of Goslings Depredated	= 3
Total Number of Goslings Died in Vegetation	= 1
Number of Fledglings Fledged from Pen	= 4

APPENDIX 8. MAKAMAKA‘OLE SEABIRD MITIGATION AREA 2019 ANNUAL REPORT

This page intentionally left blank

H. T. HARVEY & ASSOCIATES
Ecological Consultants

Makamaka'ole Seabird Mitigation Project
2019 Annual Report

Project No. 3978-02

August 15, 2019

To: **Lily Henning, Senior Manager, Environmental Affairs and Permitting, TerraForm Power**

From: **Gregory Spencer and David Ainley, H. T. Harvey & Associates**

Subject: **Makamaka'ole Seabird Mitigation Project, Kaheawa Wind Power I and IIz Habitat Conservation Plans: 2019 Annual Report**

Summary

The following report contains a summary of the work that H. T. Harvey & Associates has performed in continuance of the seabird mitigation initiatives set forth in the Kaheawa Wind Power I and II Habitat Conservation Plans (HCPs) and at the Makamaka'ole Seabird Mitigation Project area during the 2019 breeding season. Actions being implemented at Makamaka'ole are intended to partially satisfy mitigation obligations for the endangered Hawaiian petrel Pterodroma sandwichensis and threatened Newell's shearwater Puffinus newelli. Mitigation measures involve the establishment of viable colonies of these species, including predator exclusion fencing, removal and ongoing control of predators, and broadcasting attractive calls to facilitate recruitment and breeding at artificially constructed nesting burrows. Recorded calls are broadcast through weather-resistant horns (speakers) in an effort to attract birds to nest boxes that have been installed inside two protective fenced enclosures, each 4-5 acres in area. Predators are controlled inside and outside of each using a combination of bait stations containing diphacinone targeting rodents and specially designed traps that target rats and mongoose. Attention is paid to owls and control measures have been ramping up since July.

In its sixth year, Makamaka'ole has demonstrated the capacity to provide favorable conditions for recruitment and nest site establishment by Newell's shearwaters. The project site has also attracted at least one individual, or pair, of dark petrels believed to be Bulwer's petrel *Bulweria bulwerii.* Hawaiian petrels have not been documented landing, prospecting, or attempting to establish nest sites at the mitigation area since 2017. In anticipation of seabird site use during the 2019 breeding season, we conducted pre-season field site assessments, nesting box inspections and preparations, fence inspections, inventory and provisioning of project components such as traps and bait-stations, evaluated performance of the audio playback system, and produced new and enhanced call playback sequences in an effort to achieve more effective representations of both species. Once

birds began arriving and visiting nest sites, we installed high performance game cameras and managed habitat in the vicinity of burrows and active burrow clusters.

Work Performed

Mitigation Site Inspections and Nest Box Preparation

Initial fence line inspections of enclosures A and B started in late February 2019 and continued into early March. We evaluated the condition of both fenced areas to identify any damage or severely worn sections for which immediate repair might be needed. In early March, David Ainley, Brad Yuen, Gregory Spencer, and Spencer Engler performed inspections of all nest boxes in both enclosures. The effort included removing the lid from each box and examining the contents and evaluating the condition of each nest box lid. Contents within the nest boxes were carefully inspected to identify the presence of feathers and nest material, physical conditions inside the nest boxes, and composition of the nesting substrate (Figure 1). Photos gathered during inspections at the end of the 2018 season showed at least one egg found outside of a nest box (Kaheawa Wind Power 2018). We shifted gravel to make nesting "bowls," when one was not evident, to reduce the potential for eggs to be accidentally rolled out of nest chambers during incubation. We also added small amounts of grass to pad the substrate, as photos from previous years also indicated egg breakage. During our initial nest box inspections at enclosure A in early March, we encountered four nest boxes that contained feathers and eight that contained pieces of grass, twigs, and tips of grassy vegetation that suggested past visitation. In enclosure B, we observed feathers in five nest boxes. One small egg was discovered intact inside a well-prepared nest bowl in B50 (Figure 2). Based on its small size, we concluded that it had been laid by the small dark petrel species that has been steadily active at this nest box for most of the entire preceding year. In our reporting, we refer to this species as Bulwer's petrel *Bulweria bulwerii* until a more definitive species determination is made (see discussion below).

Figure 1. Nest box contents during site inspections and preparations in spring, 2019.

Figure 2. An egg observed at B-50 believed to belong to Bulwer's Petrel.

Fence Inspections and Repairs

Fence inspections consist of walking the perimeter and inner edges and inspecting the structural components including mesh and skirt, posts and braces, hood, brackets, overlap sections, and all components to identify wear and needed repairs. We also look closely for signs of erosion, particularly where terrain is steep, which may signal further close attention. We have not been seeing any significant erosion but recognize the potential, especially during or following periods of heavy rainfall. Until early August 2019, most interim repairs were limited to patching and plugging small holes, cracks, or crevices that sometimes form around the margins of the culverts. Numerous older brackets contain some rust, and while quite a few have been replaced, especially in the lower sections of the enclosures, they appear to be holding up well. We intend to continue replacing brackets based on the severity of rust and corrosion observed. Severely rusted brackets, which may begin to separate from the adjacent hood, require prompt replacement. The mesh on the windward (east) upper side of enclosure A contains a substantial amount of rusted brackets and includes portions of mesh. We observed failure of the mesh on two joining panels during an episode of high winds in early August 2019 (Figure 3). Our response entailed placing a new 25-foot long section of mesh over the entire worn section to ensure that any further disintegration of the meshing will not result in a breach (Figure 4). Based on what we are observing with respect to failure of rusted mesh sections and bracket replacement needs, we are taking a proactive approach and implementing needed interim repairs before failure occurs, by installing new mesh panels and brackets where the need is greatest.

Figure 3. Fence damage caused by excessive rust detected in August 2019

Figure 4. Fence repairs in August 2019

Erosion Management

There have not been significant erosion issues encountered at the mitigation site since monitoring began in early March 2019. Conditions were saturated in the early weeks but have steadily improved throughout the summer. When rainfall is consistent or surface runoff is evident, we examine areas that contain standing water and trace sources of runoff to ensure new rills aren't forming outside of previously installed erosion control features (water bars, flow deflectors). We systematically look for any evidence of sediment flow and/or slumping of mud or other debris to ensure that there is no accumulation along the fences, especially in the steep and lower sections.

Vegetation and Invasive Weed Control

Vegetation has not presented significant issues and has been managed so far by placing a high priority on maintaining a cleared corridor along the fencelines. Facilitated by mechanized and hand tools (weed-whackers, machete), regular clearing helps provide a condition that allows easy access along the perimeter (inside and outside each fenced enclosure), helps reduce seed dispersal, and enables the partially buried fence skirt to be inspected for wear, signs of digging by unwanted mammals, or breaches of any kind. Much of our vegetation management activities that include weed control, have occurred in the course of maintaining the cleared areas around the fences and culverts and in the maintenance of habitat around the burrow groups. The latter consists of trimming back grasses and small shrubs, by hand, to enhance the visibility of decoys, burrow entrances, and the field of view for each camera. This is not an exhaustive exercise, but enables us to target the removal of some particularly unwanted weeds, such as clidemia *Clidemia hirta* and *Tibouchina* spp., by removing individual plants at the root from the management area and disposing of these off site. There are benefits in this approach, indicated by expansion of uluhe fern *Dicranopteris linearis* and other native plants within the enclosures, and thereby contributing to habitat improvements within the management area. We also conducted spot treatments of clidemia and tibouchina in late July 2019 using Round-Up and will expand these treatments, as needed and at least quarterly, to include other unwanted species such as molasses grass and guava, and continue to control the proliferation of these and other weed species along the fencelines and other access areas.

Culverts

We have used hand tools and weed whacker to completely clear all of the culverts of thick weeds and have successfully closed off several holes that appeared capable of allowing small mammal ingress, mostly around the grouted margins. We frequently inspect the four culverts (three at enclosure A, one at enclosure B) and manage the weeds and vegetation around these features to near ground level so that we are able to monitor the integrity of all margins, status of interim repairs, and ensure unimpeded flow through the culverts during heavy rains. We use care in applying spot treatments of Round-Up to inhibit weed regeneration around the grouted margins of the culverts. We only apply herbicide around the culverts during dry periods when rainfall is absent or forecast to be negligible.

Predator Control

Rodents and Mongoose

The predator control program being implemented at Makamaka'ole specifically targets the removal and ongoing control of rats, mice, and mongoose inside the two enclosures and Barn owls *Tyto alba* in the general vicinity of the management area using lethal dispatch. DOC-200 traps (New Zealand Department of Conservation) and Victor snap traps are used for mongoose and rats, respectively. These traps are secured within a wooden box designed to exclude seabirds and non-target species. There have been no mongoose captured inside either enclosure (Table 1).

Table 1. Trapping Success by Target Species and Location (July 1, 2018 to August 2, 2019).

Location	Trap	Enclosure	Mongoose	Rat	Mouse
Outside	DOC	A	34	3	0
		B	27	2	0
	Snap	A	1	27	0
		B	1	12	0
Inside	DOC	A	0	1	0
		B	0	0	0
	Snap	A	0	4	5
		B	0	3	0
	Total		**63**	**52**	**5**

We provision and check bait stations (24 per enclosure in an approximate grid) loaded with Ramik Mini-Bars (active ingredient 0.005% diphacinone) every two weeks for signs of consumption by rats and to ensure bait freshness. Although the bait is mold- and moisture-resistant, it generally needs replacement after a period of six to ten weeks, depending on the weather conditions and placement within the grid. Thus far, all bait replacement has been done due to molding with no bait bars chewed by rats by more than approximately 25%. Overall, most bait checked and replaced has not shown evidence of consumption by rats, with the same bait boxes generally showing evidence of consumption from check to check. This suggests that density of bait boxes may need to be increased to target areas with more evidence of rat consumption.

Barn Owls

Our initial work on managing the threat presented by Barn owls was limited to observations in the vicinity of the hunting zone, to learn about presence, activity and habits when we could observe them, and to coordinate on control. We also conduct surveillance for owls while we make observations of seabirds at night, mostly from the stable, elevated platform in the uppermost corner of enclosure B, and along the road near the preferred hunting area. We have not observed many barn owls at Makamaka'ole in 2019, which is encouraging.

H. T. Harvey & Associates processed a new Wildlife Control Permit with the Division of Forestry and Wildlife, which was issued at the end of June 2019. Active owl-control efforts began on July 12th. We have hunted actively on three occasions since the permit was issued and anticipate much more effort to be directed at this activity for the remainder of the breeding season, which is now in the chick-provisioning period. No owls have been shot at or removed from the project area as of this reporting.

One owl was seen flying into our lure and playback calls on April 4th, during efforts to attract them; and another owl was heard calling in the vicinity on May 16th. Table 2 provides a summary of observations in which surveillance was conducted at night, using IR-enhanced visual aids, to evaluate the response of owls to playback and visual cues, detect them flying anywhere at night near the project area, and includes observations of seabird activity.

Table 2. Summary of Avian Surveillance and Barn Owl Control Activities at the Makamaka'ole Seabird Mitigation Project through July 2019.

Date	Day	Time	Location	Objective	Summary
2/21/19	Thursday	Dusk, early evening (18:30-20:45)	Enclosure B deck.	Observe the airspace for barn owls; evaluate for hunting and general reconnaissance.	Broad area can be seen including much of adjacent Maka valley and enclosure B; not preferred for hunting owls due to immediate proximity to encl. No owls observed.
2/22/19	Friday	Dusk, early evening (18:30-20:10)	Along the road near the enclosure B trail spur.	Surveillance scanning for owls moving through the upper gulches, approaching from lower pastures, or other movement patterns and timing of arrival.	No owls observed; mostly overcast, light rain late.
3/20/19	Wednesday	Late afternoon through early evening (17:30-20:00)	Enclosure B deck; casual observations from points along the access road.	Surveillance scans to detect owls – first arrivals and movement and early season seabird arrivals.	No owls observed. Few HAPE. Broken clouds, no precip.
3/21/19	Thursday	Dusk, early evening (18:00-20:00)	Along the road near the enclosure B trail spur; adjacent to established hunting site.	Surveillance scanning for owls moving through the upper gulches, approaching from lower pastures, or other movement patterns and timing of arrival.	On site discussion of hunting procedures; surveillance in 5-10 minute segments from road, overlook, and across adjacent forested pastures. No Barn owls observed.
4/3/19	Wednesday	Dusk, early evening (18:30-20:00)	Along the road near the enclosure B trail spur.	Surveillance scanning for owls moving through the upper gulches, approaching from lower pastures, or other movement	No owls observed. Very dark, mostly overcast, intermittent drizzle late.

Date	Day	Time	Location	Objective	Summary
				patterns and timing of arrival.	
4/4/19	Thursday	Dusk, early evening (18:30-20:00)	Hunting location below enclosure B spur.	Deploy audio and visual attraction cues (small rodent distress calls, battery-operated lure); observe owl response.	One Barn owl detected at about 19:15; approached from lower gulch – flew directly to the lure and sound playback source; departed quickly in response to observers; no further observations. Very dark conditions, overcast, no precip.
4/18/19	Thursday	Dusk, early evening (18:30-20:00)	Enclosure B deck; casual observations from points along the access road.	Mostly observe activity of seabirds; secondary surveillance for presence of Barn owls.	HAPE and few NESH; no owls. Weather mostly fair, light wind, no precip.
4/19/19	Friday	Dusk, early evening (18:30-20:00)	Enclosure B deck; casual observations from points along the access road.	Mostly observe activity of seabirds; secondary surveillance for presence of Barn owls.	HAPE and few NESH; no owls. Light wind, occasional gusts, no precip.
4/23/19	Tuesday	Dusk, early evening (18:30-20:30)	Enclosure B deck.	Mostly observe activity of seabirds and effort to observe any birds landing near nest boxes or adjacent areas; secondary surveillance for presence of Barn owls.	HAPE and several NESH; no owls. Light wind, occasional gusts, and light precip late.
4/26/19	Friday	Dusk, early evening (18:30-20:30)	Enclosure B deck; casual observations from points along the access road.	Mostly observe activity of seabirds; secondary surveillance for presence of Barn owls.	HAPE and several NESH; no owls. Light wind, 50% overcast.
5/16/19	Thursday	Dusk, early evening (18:30-20:30)	Hunting location below enclosure B spur and well below road.	Deployed audio attraction cues (two separate types of small rodent distress calls).	Set up audio playback in two separate locations (snag and road berm) to widen broadcast; one owl call heard; no owls observed.
5/30/19	Thursday	Dusk, early evening (18:30-20:30)	Enclosure B deck	Comprehensive assessment from high point in the management area to evaluate landscape	Seabirds active; no owls observed.

Date	Day	Time	Location	Objective	Summary
				structure relative to hunting position; surveillance for owls and seabirds after sundown.	
7/2/19	Tuesday	Dusk, early evening (18:45-20:30)	Enclosure B deck and road outcropping	Surveillance for owls and seabirds after sundown.	Seabirds active; no owls observed.
7/12/19	Friday	Early evening	Hunting location below enclosure B spur and well below road.	Set up attractive lure, sound playback (distressed vole and mouse).	No owls approached or observed; seabirds present and calling during flyovers.
7/15/19	Monday	Early evening	Hunting location below enclosure B spur and well below road.	Set up attractive lure, sound playback (distressed vole and mouse).	No owls approached or observed; seabirds present and calling during flyovers.
7/19/19	Friday	Early evening	Hunting location below enclosure B spur and well below road.	Set up attractive lure, sound playback (distressed vole and mouse).	No owls approached or observed; seabirds present and calling during flyovers.
7/20/19	Saturday	Early evening (18:45-20:00)	Along the road above Makamaka'ole Stream	General seabird and owl reconnaissance	Several petrels and Newell's — several Newell's heard above the sound playback near A.

Tracking-Tunnel Surveys

Tracking-tunnel surveys are performed quarterly. Surveys are designed to sample rodent and mongoose presence by deploying forty track tunnels and cards in each enclosure over a 96 hour exposure period (n=20 per treatment, 2 treatments; treatment exposure time = 24 hours for rodents, 72 hours for mongoose). We conducted two tracking-tunnel surveys for rodents and mongoose inside both enclosures between 21 and 25 March, then again between 3 and 6 June 2019. During the first survey in March we did not detect the presence of small rodents (rat or mouse, 24-hour exposure time) or mongoose (72-hour exposure) on any of the track cards deployed in enclosure B; nine cards contained evidence of rodent activity inside enclosure A (average 0.25 activity level for rats and mice combined, range: rats 0.5-0.6, mouse 0.1-0.3). The June survey resulted in no tracks of rodents (mice or rats) or mongoose on ten cards placed at tunnel stations in each enclosure. Table 3 summarizes the results of all tracking tunnel surveys performed July 1 to August 2, 2018-19.

Table 3. Percentage of Tracking Tunnel Cards with Activity by Month (July 1, 2018 to August 2, 2019) at the Makamaka'ole Seabird Mitigation Area, Fiscal Year 2019.

Predator	Month	Enclosure A	Enclosure B
Mongoose	August	0	0
	October	0	0
	March	0	0
	June	0	0
Rat/Mouse	August	10	10
	October	60	20
	March	20	0
	June	10	0

These results suggest very low to negligible levels of rodents, and high probability that mongoose remain completely absent inside both enclosures. We remain somewhat skeptical that these results are a true estimation of the level of rodent presence and activity. Therefore, we will be exploring a modified approach that may be used outside of the quarterly sampling regime in a separate independent assessment capacity.

Social Attraction and Nesting Colony Establishment

Sound Playback System

Three sound playback systems are currently in use at Makamaka'ole. Two of these are deployed in enclosure A and one is set up in enclosure B. Prior to initiating the system upgrades described below, each amplifier and playback system broadcasted sound through two weather resistant 50-watt speakers, or horns (TOA Electronics). The systems in enclosure A broadcasts only Newell's shearwater calls while the system in enclosure B only broadcasts Hawaiian petrel calls. Each of the three systems are solar-powered and each is configured to play from sundown to sunrise.

Our observations, substantiated by what we have expected based on similar work with closely related species elsewhere and consistent with nest site visitation patterns in past years, suggest there is a strong positive relationship between the number and distribution of horns and the number and distribution of burrows receiving visitation. The Newell's shearwaters we are attracting to the site are selecting nest boxes that are closest in terms of distance, proximity, and direction to the horns (i.e. the source of the broadcast). In our evaluation of this relationship, we concluded that it made sense to select additional locations where horns can be placed to increase the probability that more active burrows spread over a wider area will be visited and to reduce the amount of competition for prime nest sites.

We added four new 30-watt horns to the playback systems in each enclosure in early July (for a total of eight new horns). Prior to adding the new horns, we made some adjustments in the directional orientation of the existing 50-watt TOAs, to evaluate whether this would affect the recruitment of birds visiting nesting burrows.

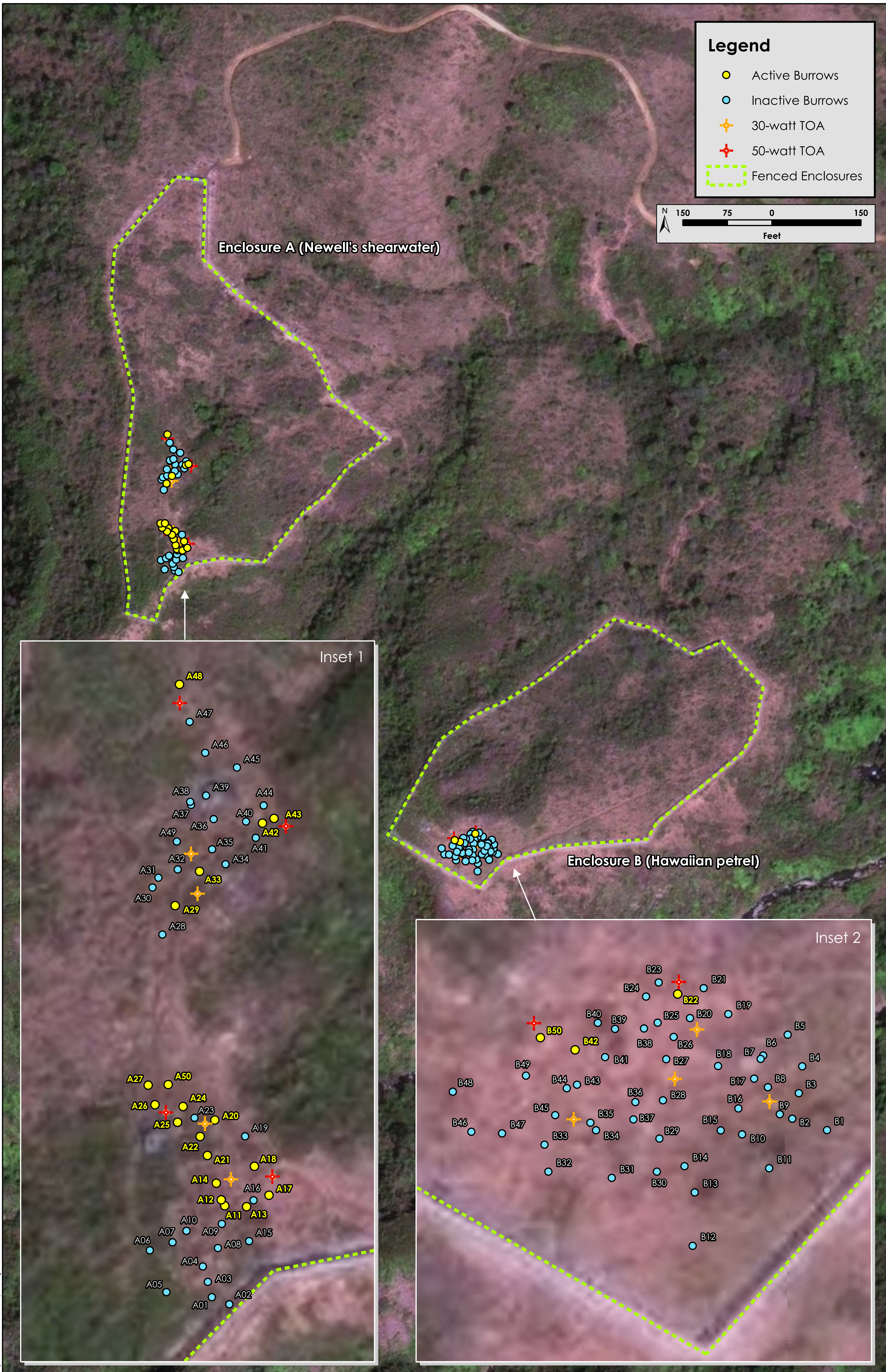
The response by seabirds was characterized by new visitation documented at burrows near the 50-watt horns (within 1-3 meters), within days, essentially confirming that depending on the proximity of horns to burrows, we could begin to manipulate recruitment by selecting the placement of additional horns relative to the locations of burrows. By expanding the sound system, we essentially expanded the distribution and number of active burrows. We believe these adjustments have greatly facilitated the process of attracting new birds to nest at Makamaka'ole and are providing important insights that will continue to inform success and enhance project performance.

At the beginning of the season, we evaluated the call playback sequences being used in each enclosure and were surprised to learn that the sequence being played from the systems in enclosure A was still a mix of Newell's shearwater and Hawaiian petrel. We quickly made a new recording sequence that contains only the calls of Newell's shearwaters and this sequence has been in use from late February through the present. Similarly, we went to work on evaluating the recording sequence being played in enclosure B and, although this track contained only Hawaiian petrels, the sequence needed refinement. The vast majority of the sequence we produced for Hawaiian petrels is derived from recordings made on Lanai'hale and provided by the Cornell Lab of Ornithology (Macaulay Library). These were chosen because of their general resemblance to the types of calls petrels seem to produce at Makamaka'ole in addition to geographic proximity to petrels breeding on Lanai.

Nest Site Monitoring

In March, we placed 4-6 toothpicks upright in the ground across the entrance to each nesting box in both enclosures to document when and where specific burrows would begin to receive visitation by shearwaters and petrels. We also evaluated the distribution and posture of decoys, considering that prospecting shearwaters and petrels may exhibit guarding behavior, and thereby be sensitive to the position of decoys relative to nest sites. We elected to rearrange decoys in both enclosures, increase the distance between decoys and burrow entrances, and adjust the postures and orientations of individual decoys. We also compared our preliminary observations with patterns of visitation documented in past years (Kaheawa Wind Power 2015-2018) to help us anticipate the distribution of nesting activity in 2019.

We began documenting nest site visitation by Newell's shearwaters on about April 8, 2019. Since that time, we have seen a gradual and sometimes marked increase in the number of nest sites being visited by Newell's shearwaters, mostly in enclosure A; the steady rate of visitation suggests increasing site tenacity of this species (Figure 5). At the time of this reporting there are a total of 19 active nest sites receiving regular visitation by Newell's shearwaters within enclosure A; there are 3 active nests in enclosure B, originally designed for Hawaiian petrel, and are occupied at this time by Newell's shearwater and Bulwer's petrel (Table 4).



N:\Projects3900\3978-01\02\Reports\Fig 1 Distribution of Active and Inactive Burrows.mxd

Figure 5. Distribution of Active and Inactive Burrows at Makamaka'ole

Makamaka'ole Seabird Mitigation (3978-02)

August 2019

H. T. HARVEY & ASSOCIATES

Ecological Consultants

Table 4. Timeline of Visitation and Nesting Burrow Establishment at Makamaka'ole in 2019.

Burrow	Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
A-11	NESH								
A-12	NESH								
A-13	NESH								
A-14	NESH								
A-17	NESH								
A-18	NESH								
A-20	NESH								
A-21	NESH								
A-22	NESH								
A-24	NESH								
A-25	NESH								
A-26	NESH								
A-27	NESH								
A-29	NESH								
A-33	NESH								
A-42	NESH								
A-43	NESH								
A-48	NESH								
A-50	NESH								
B-22	NESH								
B-42 [1]	BUPE								
B-50 [2]	NESH and BUPE						Egg		

[1] Bulwer's Petrel began occupying this burrow as soon as Newell's shearwater arrived.

[2] On approximately April 20, 2019 Newell's shearwater began to cohabitate B-50 with Bulwer's petrel; Bulwer's relocated to neighboring B-42 where it has remained active.

Notes: NESH = Newell's shearwater; BUPE = Bulwer's petrel; Egg = Fractured egg observed at entrance June 21, 2019; visitation continued, possible relay.

Camera Deployments and Review

We have been monitoring visitation and activities of mostly Newell's shearwaters at all of the active nest sites using primarily the professional quality Reconyx covert IR game cameras (*HyperFire* and *HyperFire 2*, Reconyx, Inc., Holmen, Wisconsin) and also some older digital trail cameras with similar IR-illumination capacity manufactured by Moultrie. These cameras are motion triggered, capturing high quality digital monochrome photos using a nighttime infrared illuminator and are custom programmed to function according to a specific set of operational parameters that maximize data acquisition and quality. Although both types of cameras perform these functions, the Reconyx is superior in terms of meeting project performance criteria. Burrows are selected for camera monitoring based on initial indications of toothpick displacement and the appearance of fresh guano at burrow entrances. Grass outside burrows is trimmed by hand and regularly maintained to enhance the quality of the photos and reduce unwanted triggering.

The cameras are designed for securing to a stationary object and are capable of surveying areas up to several meters from the target of interest. We install one camera at each active nesting burrow at Makamaka'ole using a wooden stake in a position that allows the entrance of the nesting burrow to be under continuous surveillance. In some cases, depending on the amount of activity and number of birds present at a given site, we have positioned cameras to observe more area in the immediate vicinity of the entrance while, at others, the camera looks directly at the entrance itself (Figures 6 and 7). Reducing unwanted triggering by trimming weeds and grass in the foreground is important and also helps to enhance the quality of the images and our interpretation of activities being observed. This is done very carefully, especially when birds are suspected of being present inside the nest box during the day, in order to minimize any disturbance. Camera data cards are switched and reviewed at least weekly and slight changes in the position of cameras are sometimes made, as needed.

Figure 6. Reconyx HyperFire 2 camera Monitoring Active Nesting Burrow at Makamaka'ole, 2019

Figure 7. Newell's Shearwaters Activity Documented at the Entrance to an Artificial

Burrow using the Reconyx HyperFire Camera.

Data obtained with game cameras is being used to develop a data base in order to characterize the activities of seabirds associated with active nesting burrows. Changes we have observed over the course of the season are useful indicators of the relative likelihood that pairs are engaged in breeding, incubation, and/or chick provisioning, or simply pioneering new sites prior to breeding in subsequent seasons.

Searches for Active Nesting Burrows, Inside and Outside of the Protective Enclosures

We continue to search for and investigate the presence of active nests and signs of burrowing and prospecting by both Newell's shearwaters and Hawaiian petrels inside and outside of both enclosures. While we are on site and working inside the enclosures we frequently move into areas containing dense understory habitat that could be suitable for nesting. We examine and search areas, independently and as a team, coordinate and discuss observations, to achieve consistency in our searches.

So far, we have not found any burrows or signs of active prospecting outside of the immediate management areas within the exclosures (i.e. outside the fences). The modest investigations we have done within 10 meters of the fencelines, thus far, have not yielded any active nesting burrows of any seabird species. What we have learned is that Newell's shearwaters have started prospecting at least one site in close proximity to one of the large 50-watt horns, a few meters behind one of the more active burrows in this portion of the new colony. We have directed considerable attention at this site – deploying a camera for several weeks, in addition to surrounding areas, and regularly investigate short trails we know are used by birds because guano is evident.

Any places that birds may be exploring or beginning to tunnel or excavate are areas that we look for in order to maintain our understanding of where naturally established burrows might be set up.

As we broaden our searches and define the area within which Newell's shearwaters and/or Hawaiian petrels are prospecting or attempting to establish nest sites independent of those provisioned by the project, we will include search profiles and description of habitat. These will be represented in subsequent maps showing nest distribution, prospecting or independent nest site establishment, and how these variables may change over time, within the context of our overall assessment this breeding season.

Preliminary Assessment of Seabird Productivity and Trends in Recruitment Dynamics at Makamaka'ole in 2019

The first Newell's shearwaters arrived at Makamaka'ole and began entering burrows on approximately April 8 2019. By the end of June there were eight nest sites being visited by Newell's shearwaters; that number increased to twenty-one by mid-July. We attribute the three-fold increase in the number of nesting burrows receiving visitation by Newell's shearwaters to the modifications we made to the playback system and digital call playback sequences. By installing several new horns in proximity to unused burrows, we facilitated the expansion of prospecting opportunities, as indicated by the cascade of visitation and subsequent activity we are now observing.

There is good reason to suspect that at the time of this writing there are likely to be young chicks and perhaps a few eggs being incubated in some, if not several, of the Newell's shearwater nests we are monitoring. We are planning to evaluate the status of each of the active nest boxes over a period of several days in mid-August using a fiber-optic burrow scope designed to be maneuvered through the burrow passage to the nest box. The contents and/or occupants can be viewed in situ; a video feeds via a phone app. The burrow scope is fitted through a tennis ball so that noise or disturbances can be avoided or minimized and to stabilize the lens.

Hawaiian petrels have not been observed actively visiting any burrows at Makamaka'ole since 2017, when there were one or more birds associated with the "uluhe" burrow and B-22, both in enclosure B. The Hawaiian petrels that were visiting these sites appear to have been displaced by Newell's shearwaters toward the end of 2017, as indicated by the camera data gathered at the time. In 2016 the call playback sequences were modified, and for a period of several months, a mix of Hawaiian petrel and Newell's shearwater calls were broadcast. We have learned that Newell's shearwaters can be extremely responsive to audio playback of the species' recorded calls, and that during nest site establishment they may fiercely, at times, protect a chosen nest site (Figure 8).

In 2016, after it appeared that Hawaiian petrels had stopped landing to prospect and visit potential nesting burrows during the period when the mixed recorded sequences were playing, the call playback sequence was supposed to have been returned to species specific calls being broadcast from the playback systems in the two species respective enclosures. This is not consistent with the mixed recording that was being broadcast from the systems in enclosure A at the beginning of 2019. The quality and character of the recorded call playback sequences are very important. Our preliminary assessment suggests that it may be problematic to expect both species to establish equally successful nesting colonies in close association due to what appears to be the more aggressive behavior exhibited by Newell's shearwaters. Further refinement in the sound delivery system may alter that assessment. Options may exist to dilute the Newell's shearwater playback, reducing intensity of the sound output, while ramping up the Hawaiian petrel output to surpass the calls being broadcast in enclosure A. Given the present status of Newell's shearwater recruitment, aiming more attention on the attractiveness of enclosure B for Hawaiian petrels may reveal the species capacity to use the site for breeding in a manner resembling what we have seen thus far for Newell's shearwaters, without compromising the performance trajectory of the latter.

Figure 8. Newell's shearwater, possibly a male, exhibiting territoriality.

Discussion

Developing a better understanding of the most important factors affecting Hawaiian petrel prospecting and nest site visitation and establishment capacity at Makamaka'ole will remain an important component of our work this season. We are currently in the chick-rearing period when we should see a marked reduction in the presence of pre-breeders and non-breeding birds that may be using Makamaka'ole this year for prospecting and developing site specific pair bonds. Our current priorities include examining the status of each active nesting burrow to determine reproductive status using the burrow scope, and to ensure needed interim repairs to the fence(s) when needed. We have repositioned some traps and been providing continuous fresh bait to all DOCs and Victor snap traps in their respective boxes inside the enclosures and regularly outside. Barn owl control is a primary focus through November.

The number of active Newell's shearwater burrows is impressive and is likely to accelerate the project toward meeting its mitigation targets consistent with the models that were developed to examine success factors and probabilities for both species at Makamaka'ole (H. T. Harvey & Associates 2011).

Our final report at the conclusion of the 2019 season will provide 1) a comprehensive assessment and analysis of the project performance, success criteria, challenges and future needs, 2) a detailed set of findings and recommendations, for both Hawaiian petrels and Newell's shearwaters. The latter relates to Makamaka'ole and its capacity to continue providing a net conservation benefit, and which might arguably exceed the ordinary threshold for this criterion, by expanding the science and understanding of the ecology, breeding biology, and restorative capacities of both these covered species.

References

H. T. Harvey & Associates in association with PRBO Conservation Science. 2017. Newell's Shearwater Population Modeling. Prepared for Kaheawa Wind Power, 3000 Honoapi'ilani Highway, Wailuku, HI.

Kaheawa Wind Power, LLC. 2018. Habitat Conservation Plan, 2018 Annual Report. 183 pp.

Kaheawa Wind Power, LLC. 2017. Habitat Conservation Plan, 2017 Annual Report. 52 pp.