Kaheawa Wind Project II
Habitat Conservation Plan
FY 2020 Annual Report

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Incidental Take License ITL-15 / Incidental Take Permit TE27260A-1

EXECUTIVE SUMMARY

This report summarizes work performed by Kaheawa Wind Power II, LLC (KWP II), owner of the Kaheawa Wind Project II (Project), during the State of Hawai‘i fiscal year 2020 (FY 2020; July 1, 2019– June 30, 2020) under the terms of the approved Habitat Conservation Plan (HCP). The original HCP was dated December 2011 and described KWP II's compliance obligations under the Project's state Incidental Take License ITL-15 and federal Incidental Take Permit ITP-TE27260A-1. In 2019, the HCP was amended to address higher than expected take of two species at the Project, and the Project continues to operate under updated versions of the ITL and ITP. Species covered under the amended HCP (hereafter HCP) include four federally and state-listed threatened and endangered species. The 14-turbine Project was constructed in 2011– 2012 and has been operating since July 2, 2012.

Fatality monitoring at the Project in FY 2020 continued within search plots limited to cleared areas within 70-meters of each Wind Turbine Generator (WTG). Canine teams searched within each of the fatality monitoring plots once per week year-round. Bias correction trials were conducted quarterly at the Project 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 canine search team. In FY 2020, probabilities of a carcass persisting until the next search were 0.95 (Hawaiian goose surrogates), 0.86 (bat surrogates), and 0.86 (seabird surrogates). Searcher efficiency was 100 percent each for the Hawaiian goose, bat, and seabird surrogates.

KWP II documented observed take of one Covered Species in FY 2020—the Hawaiian goose. Three Hawaiian goose fatalities were observed: November 27 (1) and December 10, 2019 (2). All three of the fatalities were detected within the designated search area and considered observed take per the U.S. Fish and Wildlife Service Protocol for Incidental Finds. No hoary bat fatalities were detected in FY 2020 and no Covered seabird Species (Hawaiian petrel and Newell's shearwater) have been detected as fatalities at the Project to date. Through FY 2020, the Project's total observed direct take of Covered Species has been 12 Hawaiian geese and four Hawaiian hoary bats. The fatality estimates using the Evidence of Absence estimator at the upper 80 percent credibility level are 21 for the Hawaiian goose and 11 for the Hawaiian hoary bat. Indirect take estimates for the Covered Species are two for the Hawaiian goose and one for the Hawaiian hoary bat. Combining these values, there is an approximately 80 percent chance that cumulative take of Covered Species at the Project from the start of operations through FY 2020 was less than or equal to 23 for the Hawaiian goose and 12 for the Hawaiian hoary bat.

The bat acoustic monitoring program evolved during FY 2020. Initially, KWP II collected data at eight ground-based acoustic detectors distributed among Project WTGs. This number was reduced to two after an October 2019 wildfire destroyed monitoring equipment. Between July 2019 – June 2020, Hawaiian hoary bats were detected on 117 of 1,146 detector-nights (10.2 percent of detector-nights). The seasonal pattern of detection rates was comparable with previous years.

Mitigation commitments to offset the take of Covered Species are ongoing. Current estimated take for the Hawaiian goose is within the Tier 2 limit of the HCP. Mitigation for Tiers 1 and 2 in the form of propagation efforts have been funded. Mitigation is ongoing at the Piʻiholo Ranch and Haleakalā Ranch Hawaiian goose release pens; with funding provided in FY 2020 for use in the FY 2021 breeding season. Efforts to-date have not achieved increases in adult or juvenile survival or productivity to fully mitigate for Tier 1 or Tier 2. In FY 2020, KWP II and DOFAW updated the Statement of Work and signed a Memorandum of Understanding for continuing mitigation at Piʻiholo Ranch. Proposed mitigation credit for fledgling production attributable to the Project is still being discussed among KWP II, DOFAW, and USFWS. For the Hawaiian hoary bat, current estimated take is within the Tier 3 limit of the HCP. Tier 1 and Tier 2 mitigation in the form of habitat management have been funded and are ongoing at Kahikinui State Forest Reserve. Tier 3 mitigation began in FY 2018 through a contract with the U.S. Geological Survey Hawaiian Hoary Bat Research Group to conduct bat ecological research on Hawaiʻi Island. The research study is intended to better inform future bat habitat restoration and conservation. For seabirds, current estimated take is within the Tier 1 limit of the HCP. Tier 1 mitigation is on-going as implementation of a comprehensive plan for seabird colony management at the Makamakaʻole Seabird Mitigation Site. The Maui Nui Seabird Recovery Project is contracted to continue work at Makamakaʻole through the 2020 breeding season. KWP II continues to work with wildlife agencies to assess overall benefits of Project's seabird mitigation project. Makamakaʻole mitigation efforts produced five Newell's shearwater chicks in FY 2020 (the 2019 breeding season) in addition to other benefits.

KWP II communicated actively with USFWS and DOFAW throughout FY 2020. The communication was conducted through in-person meetings, conference calls, submittal of quarterly reports, and e-mail communications related to the Project's HCP. These communications included focused discussions regarding mitigation projects, mitigation funding, and potential adjustments to mitigation strategies.

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1.0 Introduction

The Hawai'i Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW) and U.S. Fish and Wildlife Service (USFWS) approved the Kaheawa Wind Project II (Project) Habitat Conservation Plan (HCP) in 2012. In January 2012, the Project received a federal incidental take permit (ITP; ITP-TE27260A-0) from the USFWS and a state incidental take license (ITL; ITL-15) from DOFAW. In 2019, DOFAW and USFWS approved an HCP Amendment to (hereafter HCP; SWCA 2019) to address the higher than expected take of two species, and the ITP and ITL were reissued (ITP-TE27260A-1 and amended ITL-15). The ITP and ITL cover the incidental take of four federally and state-listed, threatened and endangered species (the Covered Species) over a 20-year permit term.

The Covered Species include:

- Hawaiian goose or nēnē (*Branta sandvicensis*)[1];
- Hawaiian hoary bat or 'ōpe'ape'a (*Lasiurus cinereus semotus*)[1];
- Hawaiian petrel or 'ua'u (*Pterodroma sandwichensis*); and
- Newell's shearwater or 'a'o (*Puffinus newelli*).

The Project was constructed in 2011 and 2012 and was commission on July 2, 2012. TerraForm Power, LLC (TerraForm) acquired Kaheawa Wind Power II, LLC (KWP II) in 2016; the Project continues to be operated by KWP II. Brookfield Renewable Partners, LP acquired a majority stake in TerraForm in 2017.

On behalf of KWP II, Tetra Tech, Inc. (Tetra Tech) has prepared this report to describe the work performed for the Project during the State of Hawai'i 2020 fiscal year (FY 2020; July 1, 2019–June 30, 2020) pursuant to the terms and obligations of the approved HCP, ITL, and ITP. An updated ITP and ITL were issued in September and November 2019, respectively. The Project has previously submitted annual HCP progress reports to DOFAW and USFWS for FY 2013 through FY 2019 (KWP II 2013, KWP II 2014, KWP II 2015, KWP II 2016, KWP II 2017, KWP II 2018, Tetra Tech 2019).

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 July 2012. In consultation with USFWS, DOFAW, and the Endangered Species Recovery Committee (ESRC), fatality search areas have evolved over time from the start of operations through the initiation of the current approach in 2015. The last modifications were in

[1]Among other modifications, increased take and mitigation for impacts to the Hawaiian goose and Hawaiian hoary bat were addressed in the 2019 approved HCP Amendment.

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." Initially, monitoring occurred within the entirety of the 70-meter circular plots centered on each wind turbine generator (WTG). Beginning in July 2015, with agreement from the agencies, the search area was reduced to graded WTG pads and access roads (search plots) that fall within a 70-meter radius circle centered on each of the Project's 14 WTGs (Figure 1).

In FY 2020, all 14 WTGs were searched for fatalities approximately once per week. The FY 2020 mean search interval for all WTGs was 7.14 days (Standard Deviation = 0.95 days). The search plots were searched by a canine search team which included trained detector dog accompanied by a handler. In February 2020, one search period was not completed due to high winds over several days limiting the ability of the canine search team to safely and effectively perform searches at the Project. If search conditions limited the use of a canine (e.g., weather, injury, availability of canine search team, etc.), plots were visually surveyed by Project staff. However, all searches were conducted by canine teams in FY 2020 and no visual searches occurred.

Special precautions have been taken to eliminate any potential canine interactions with wildlife. If Hawaiian geese were present nearby, the canine handler was directed to immediately retrieve the dog and postpone or temporarily skip dog searches in favor of visual searches. Hawaiian geese were observed on September 25, October 23, November 6, 2019, and on January 2, February 26, March 7, and April 8, 2020. In each case, the handler moved the canine to a different search plot and returned to finish the disrupted search later in the day. No canine wildlife interactions were observed.

3.0 Carcass Persistence Trials

Four, 28-day carcass persistence trials were conducted in FY 2020 using large chickens (*Gallus gallus*) for Hawaiian goose surrogates (i.e., large birds), black rats (*Rattus rattus*) for Hawaiian hoary bat surrogates, and wedge-tailed shearwater (*Ardenna pacifica*) carcasses as surrogates for the Hawaiian petrel and Newell's shearwater (i.e., medium birds; Covered Seabird Species). In FY 2020, the probability that a carcass persisted until the next search was 0.95 for large birds (95 percent Confidence Interval [CI] = 0.81, 0.99; N=8), 0.86 for all bat surrogates (95% CI = 0.77, 0.91; N=20), and 0.86 for medium-sized birds (95% CI = 0.67, 0.94; N=8).

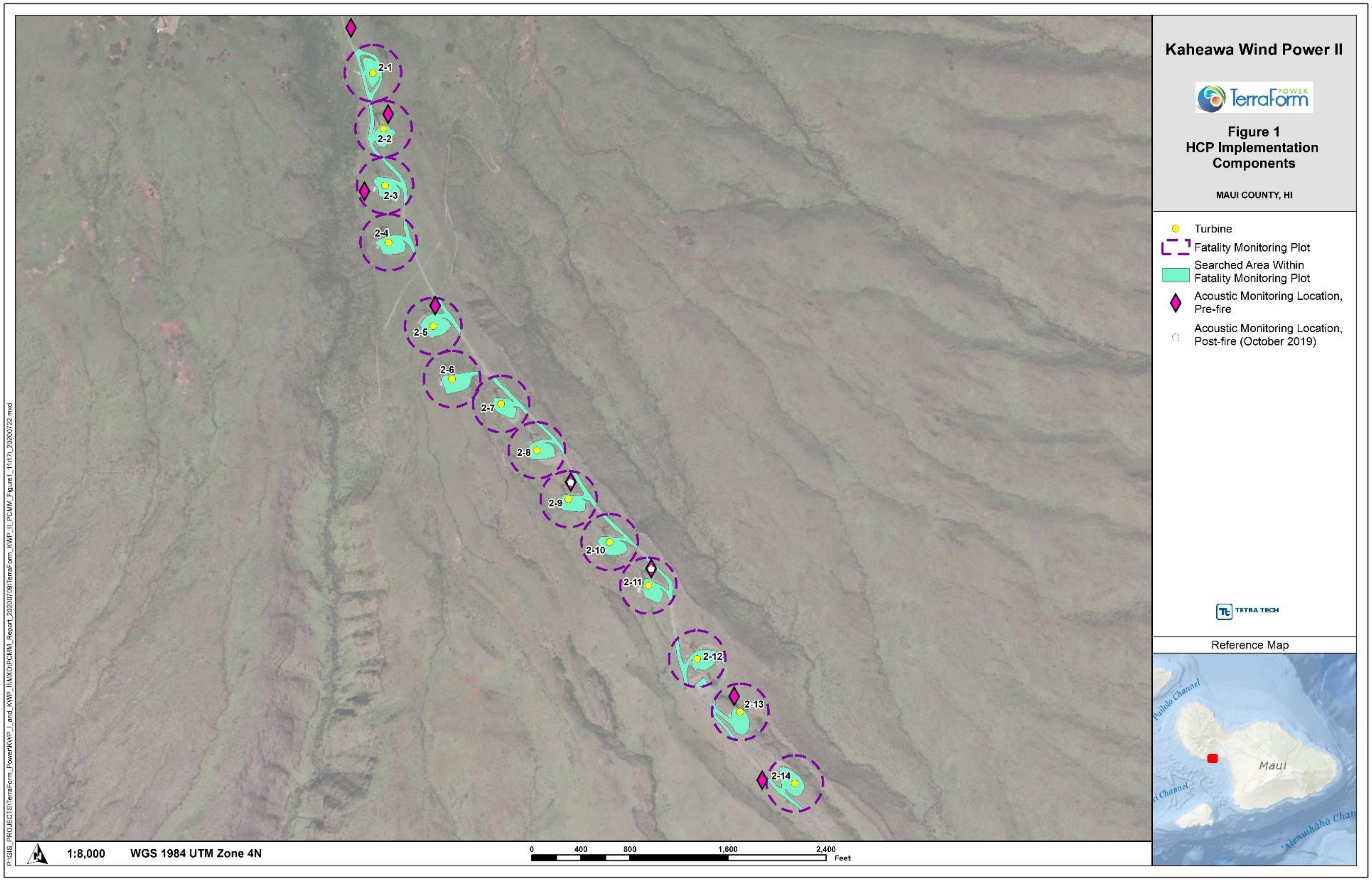

Figure 1. HCP Implementation Components

4.0 Searcher Efficiency Trials

A total of 51 searcher efficiency trials over 19 trial days were administered during FY 2020. Similar to the carcass persistence trials, large chickens were used as surrogates for the Hawaiian goose, black rats as surrogates for bats, and wedge-tailed shearwaters and other medium-sized birds collected under the Project's Special Purpose Utility Permit (MB22096C-0) as surrogates for Covered Seabird Species. Searcher efficiency trials occurred approximately monthly throughout the year; all trials tested canine search teams in FY 2020 (no un-aided human searches occurred in FY 2020). Of the 51 trials placed, five bat surrogates and two wedge-tailed shearwaters were lost to scavenging. All other carcasses were available for detection. For FY 2020, the probability that a canine search team would find a carcass was 100 percent for bat surrogates (95 percent CI = [0.76, 1.00] N=26), 100 percent for medium-sized birds (95 percent CI = [0.71, 1.00]; N=7), and 100 percent for large birds (95 percent CI = [0.80, 1.00]; N=11).

5.0 Vegetation Management

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

- The vegetation management activities within the search plots were initially limited to between April 1 and October 31 to minimize risk during the Hawaiian goose nesting season.
- In November 2016, Stephanie Franklin of DOFAW-Maui verbally approved using hand management tools (spray packs and weed whackers) during the Hawaiian goose nesting season if the 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 was implemented at the Project throughout FY 2020. Quarterly glyphosate-based herbicide treatments using a boom sprayer were applied to search plots, supplemented by weed whacking. In October 2019 (Quarter 2 [Q2]), a wildfire impacted the vegetation surrounding the Project; however, the vegetation management program in place minimized the fire's impact to the search plots. Limited application of herbicide occurred in Q3 by spot treatment with a hand sprayer. On January 22, 2020, nest clearance surveys were conducted in conjunction with DOFAW-Maui prior to the application of herbicide using a boom sprayer to avoid exposing Hawaiian goose nests to the treatment. The regular vegetation management program resumed in Q4.

6.0 Scavenger Trapping

KWP II has implemented periodic scavenger trapping at the Project to extend carcass persistence times and contribute to a high probability of a carcass persisting until the next search. The scavenger trapping program at the Project was implemented during Q1 and Q2 of FY 2020. Due to logistical challenges, scavenger trapping was suspended during Q3 and Q4 of FY 2020. Scavenger trapping resumed in Q1 of FY 2021. Active trapping occurred at 12 WTGs and included nine Doc 250 body grip traps and eight live traps. The scavenger control program documented the removal of 20 mongoose (*Herpestes auropunctatus*), two rats (*Rattus spp.*), one mouse (*Mus musculus*), and four feral cats (*Felis cattus*) in FY 2020. 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 (USFWS and DOFAW 2019). Three Hawaiian goose fatalities were found in FY 2020, as described below. No injured (live) downed wildlife were observed at the Project in FY 2020. No other Covered Species were observed at the Project in FY 2020.

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; therefore, the proportion of the carcass distribution searched has varied. However, no change to the search plots has been made from FY 2016 to FY 2020 (Section 2.0). Thus, the estimate of the proportion of the carcass distribution searched (DWA; Appendix 1) has remained the same as described in the FY 2017 annual report (KWP II 2017).

Cumulative take at an upper credible limit (UCL) of 80 percent was calculated for each Covered 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.

Indirect take calculations are based on the HCP and Agency guidance. Indirect take is estimated based on factors such as the breeding season in which fatalities are observed, 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 (e.g., USFWS 2016 for Hawaiian hoary bats).

Additionally, 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.

7.1 Hawaiian Goose

7.1.1 Estimated Take

A total of 12 adult Hawaiian goose fatalities and one gosling fatality have been observed at the Project since operations began in July 2012. Four of the 12 observed fatalities were classified as incidental observations and the remaining eight were considered ODT. As the gosling (detected in FY 2018) was not capable of flight it was not considered ODT (but see below). The observed Hawaiian goose fatalities by fiscal year are listed in Table 1.

Table 1. Observed Hawaiian Goose Fatalities at KWP II Through FY 2020

Fiscal Year	Hawaiian Goose Observed Direct Take	Hawaiian Goose Incidental Fatality Observations	Total
2013	1	0	1
2014	0	0	0
2015	2	0	2
2016	1	0	1
2017	0	0	0
2018	1	3	4
2019	0	1	1
2020	3	0	3
Total	**8**	**4**	**12**

On November 27, 2019, one fresh adult Hawaiian goose carcass was observed after the completion of the Project's routine search at all WTGs. The carcass was approximately 25 meters from the base of WTG 3, inside of the search area. This fatality was assumed to occur soon after the plot had been searched. Two Hawaiian goose fatalities were detected on December 10, 2020 (not a routine search day) at WTG 7. On this date, a Hawaiian goose wing was observed by Operations staff 21 meters from the base of the WTG. Additionally, a single adult Hawaiian goose carcass was detected on a slightly vegetated slope approximately 38 meters from WTG 7 inside the search area while documenting and recovering the remains of the first Hawaiian goose carcass from which the wing was found. Carcass remains attributable to the first observed December 10 fatality were also detected by the surveyor and canine on the following day during the routine search at the same turbine. All three fatalities were counted as ODT. DOFAW and USFWS were notified and provided reports. The Project's surveyor transported the carcasses to the DOFAW base yard, per request of Stephanie Franklin, on March 12, 2020.

The estimated direct take (ODT + UDT) based on the Hawaiian goose fatalities found between the start of operation (July 2012) and end of FY 2020 (June 30, 2020) is less than or equal to 21 geese (80 percent UCL; Appendix 1). The gosling was added as a single additional juvenile fatality, adjusted to an adult based on estimated survival rates, and added to the estimate of 21 geese at the 80 percent UCL that resulted from the EoA analysis.

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 (SWCA 2011). Indirect take was 1.57 juveniles (0.80 adults, assuming a 0.8 annual survival rate and 3 years from fledging to adult; Appendix 2).

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 drive 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 (SWCA 2011).

DOFAW provided KWP II with Hawaiian goose fledgling data for Project-funded release efforts at the Piʻiholo Ranch and Haleakalā Ranch pens in July 2020. KWP II believes that the current approach to account for mitigation credit undervalues the full extent of benefits the Project's mitigation efforts have provided to the species and is working with USFWS and DOFAW to develop consensus on a modified approach. Accrued lost productivity will be calculated in FY 2021 as more information becomes available.

The UCL for cumulative Project take of the Hawaiian goose at the 80 percent credibility level is 23 geese (rounded up from the sum of 21 [estimated direct take from EoA] + 1 observed gosling fatality*0.512 adults/gosling + 0.80 [estimated adult indirect take]). That is, there is an approximately 80 percent probability that actual take at the Project at the end of FY 2020 is less than or equal to 23 adult geese (Appendix 1).

7.1.2 Projected Take

KWP II projected Hawaiian goose take through the end of the permit term using the fatality monitoring data collected through FY 2020 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). The permitted take limit for the Hawaiian goose is 44. 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 two adult equivalents (approximately four juveniles based on an assumed Hawaiian goose survival rate from juvenile to adult of 0.512 [SWCA 2011]), or 4.5 percent of the permitted take limit in the HCP. Currently, the proportion of total take that is attributable to indirect take is 3.7 percent (0.8 adult geese equivalents estimated from indirect take / 23 geese estimated combining the direct and indirect take) making the assumption of two adult indirect take conservative. Assuming two adult Hawaiian geese equivalents are attributed to the Project as indirect take, the permitted direct take under the HCP would be 42 Hawaiian geese (Take of 44 geese permitted by ITL and ITP – take of 2 geese estimated attributed to indirect take = 42 geese estimated direct take maximum).

Based on the analysis described above and presented in Appendix 3, there is an approximately 25 percent chance that the 80 percent UCL of cumulative take will not be exceeded during the permit term (Appendix 3); EoA calculated a median estimate of 17 years of Project operation without a direct take estimate exceeding 42 geese. KWP II has taken actions to minimize the threats to the Hawaiian goose and continues to work with USFWS, DOFAW, and technical experts to further reduce risk (Section 10.0).

7.2 Hawaiian Hoary Bat

7.2.1 Estimated Take

A total of four Hawaiian hoary bat fatalities have been observed at the Project since operations began in July 2012. Three of the four observed bat fatalities have been found within the searched area and are used to estimate UDT. All bat carcasses were transferred to the U.S. Geological Survey for genetic sexing. Hawaiian hoary bat fatalities by fiscal year are listed in Table 2.

Table 2. Observed Hawaiian Hoary Bat Fatalities at KWP II Through FY 2020

Fiscal Year	Hawaiian Hoary Bat Observed Direct Take	Hawaiian Hoary Bat Incidental Fatality Observations	Total
2013	1	0	1
2014	2	0	2
2015	0	0	0
2016	0	0	0
2017	0	0	0
2018	0	0	0
2019	0	1	1
2020	0	0	0
Total	**3**	**1**	**4**

The estimated direct take (ODT + UDT) for the four Hawaiian hoary bat fatalities found between the start of operation (November 2, 2012) and end of FY 2020 (June 30, 2020) is less than or equal to 11 bats (80 percent UCL; Appendix 1). Because one of the four observed bat fatalities was found outside of the search areas (i.e., was an incidental observation), three fatalities were used in the analysis and considered ODT; the one incidental observation detected in FY 2019 is accounted for in the estimated value of UDT.

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. The timing and sex of all observed fatalities (those observed in fatality monitoring as well as incidental to fatality monitoring) is used in the calculation of indirect take. Indirect take for the Project is calculated using the October 2016 USFWS 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 methodology (2016), the estimate of cumulative indirect take in FY 2020 is calculated as:

- **Total juvenile take calculated from observed female take (April 1 – September 15)**
  - 0 (observed females) * 1.8 (pups per female) = 0 juveniles
- **Total juvenile take calculated from observed unknown sex take (April 1 – September 15)**
  - 0 (observed unknown sex) * 0.5 (assumed sex ratio) * 1.8 (pups per female) = 0 juveniles
- **Total juvenile take calculated from unobserved take**
  - 7 (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) = 1.6 juveniles
- **Total Calculated Juvenile Indirect Take**[2] = 1.6 (0 + 0+ 1.6)
- **Total Adult Equivalent Indirect Take =** 0.3 (juvenile to adult conversion factor) * 1.6 = 0.47

Therefore, the estimated indirect take based on the UCL of Hawaiian hoary bat direct take at the Project is one adult (rounded up from 0.47).

The UCL for Project take of the Hawaiian hoary bat at the 80 percent credibility level is 12 adult bats (11 estimated direct take + one estimated indirect take). That is, there is an approximately 80 percent probability that actual take at the Project at the end of FY 2020 is less than or equal to 12. The current take limit as set forth in the HCP is 38 adult bats, and the Tier 3 limit is 30 bats.

7.2.2 Projected Take

KWP II projected take through the end of the permit term using the fatality monitoring data collected through FY 2020 to evaluate the potential for the Project to exceed the requested take limit at the 80 percent UCL prior to the end of the permit term (Appendix 3). For this analysis, the detection probability for future years is assumed to match the detection probability of FY 2020, and the fatality rate is unaltered for all future years (rho=1). 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 two adult equivalents (approximately 6 juveniles based on assumed Hawaiian hoary bat survival rates [USFWS 2016]), or 5.3 percent of the requested take). Currently, the proportion of total take that is attributable to indirect take is 3.9 percent (0.47 adult bat equivalents estimated from indirect take / 12 bats estimated combining the direct and indirect take), making the assumption of the indirect take of two adult bats reasonable. Assuming two adult bat equivalents are attributed to the Project as indirect take, direct take under the HCP would be 36

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[2] DNA results have identified the sex of all four bat fatalities detected at the Project, confirming that two of the fatalities were female (Pinzari and Bonaccorso 2018, version 4.0 April 13, 2020); however, both female fatalities occurred outside of the window when they would have been caring for dependent young.

bats(Take of 38 bats permitted by ITL and ITP – take of 2 bats estimated attributed to indirect take = 36 bats estimated direct take maximum).

Based on the analysis described above and presented in Appendix 3, there is an 83.4 percent chance that the 80 percent UCL of cumulative take will not be exceeded during the permit term. In addition, the median years of operations without exceeding this direct take threshold is 20. Therefore, the Project is likely to remain below the permitted take limit of Hawaiian hoary bats for the permit term.

7.3 Non-listed Species

In addition to the Covered Species detected as fatalities, two bird species were documented as fatalities at WTGs at the Project site in FY 2020: gray francolin (one fatality; *Francolinus pondicerianus*), and black francolin (one fatality; *Francolinus francolinus*). These species are non-native, introduced birds without Migratory Bird Treaty Act protection. For a complete list of fatalities for FY 2020 see Appendix 4.

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, the 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 and through relevant agency guidance (e.g., USFWS and DOFAW 2019), when 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.

WEOP trainings were provided on November 4 and 5, 2019 and on February 19, 2020 at the Project. 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 downed wildlife while on-site.

9.0 Mitigation

The Project's mitigation requirements are described in Section 6.0 of the HCP (SWCA 2011, SWCA 2019).

9.1 Hawaiian Goose – Maui-based Release Pens

The Project provided funds to DOFAW in FY 2017 to begin predator control at locations with high Hawaiian goose activity or nesting on Maui. The funding provided for the implementation of predator control, fence maintenance, vegetation management and monitoring of a Hawaiian goose release pen at Piʻiholo Ranch in FY 2017, FY 2018, and part of FY 2019. The Project also provided funding for a technician at the Haleakalā Ranch pen from October 2018 through February 2019. Several potential benefits can be accrued based on the effects of these actions including production of fledglings and increases in adult survival rates.

In FY 2019 and FY 2020, KWP II 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 KWP II to meet its mitigation obligations for the Hawaiian goose. Updated Memoranda of Understanding were signed for each release pen; KWP II provided standardized annual reporting forms to capture the annual activities occurring at each pen. In July 2020, DOFAW provided a letter describing proposed mitigation credit for fledgling production attributable to the Project; however, KWP II believes that the proposed accounting approach for mitigation credit undervalues the benefits the Project's mitigation efforts have produced and is working with USFWS and DOFAW to develop consensus. Once consensus is reached, KWP II will assess accrued lost productivity and incorporate that information into an overall assessment of the Hawaiian goose mitigation status for the Project.

9.2 Hawaiian Hoary Bats

9.2.1 Mitigation

Mitigation for Tier 1 and Tier 2 estimated bat take has been completely funded and is ongoing as habitat management at Kahikinui State Forest Reserve (KWP II 2018). Mitigation for Tier 3 estimated take (19 bats within Tier 3, excluding 11 bats mitigated through Tier 1 and Tier 2 mitigation efforts) has been contracted to the U.S. Geological Survey Hawaiian Hoary Bat Research Group. Bat ecological research on Hawaiʻi Island began in FY 2018 and is intended to better inform future bat habitat restoration and conservation. The Project's Tier 3 funding obligation will be completed by the end of 2021. Assuming the current take rate and search conditions remain unchanged through the remainder of the permit term, Tier 4 take mitigation will not be necessary. An annual report on the U.S. Geological Survey's Hawaiian hoary bat ecological research study is provided (Appendix 5).

9.2.2 Acoustic Monitoring at the Project

The HCP commits KWP II to performing acoustic monitoring for bat activity throughout the 20-year permit period. Acoustic monitoring results are based on detection rates (nights with detections per detector -night in which a detector -night represents a night the detector was active). Acoustic monitoring for bat activity has been conducted continuously beginning in 2012. In October 2013 (FY 2014) eight Song Meter SM2BAT+ ultrasonic recorders (SM2) were deployed, replacing the

Anabat SD2 bat detectors (Titley Electronics, Brendale, QLD, Australia). Each SM2 was equipped with one SMX-U1 ultrasonic microphone (Wildlife Acoustics, Maynard, MA, USA) positioned horizontally, facing southwest (away from the prevailing northeast trade winds), 6.5 meters above ground level. Six SM2 units were deployed within 85 meters of the WTGs with the exception of at WTG 1 (125 meters away), and two SM2 units were placed at the gulch edge of WTG-3 and WTG-14 (Figure 1). Because of differences in the equipment used, data collected in FY 2020 is only comparable to data collected between FY 2014 (October 2013) and FY 2019.

In October 2019 (FY 2020) the Pali brush fires burned across most of the Project destroying six SM2 units (WTGs 1, 2, 3, 5, 13 and 14). For the remainder of the FY 2020 (October 2019 to June 2020) two WTG sites were monitored for acoustic bat activity (WTG-9 and WTG-11; Figure 1).

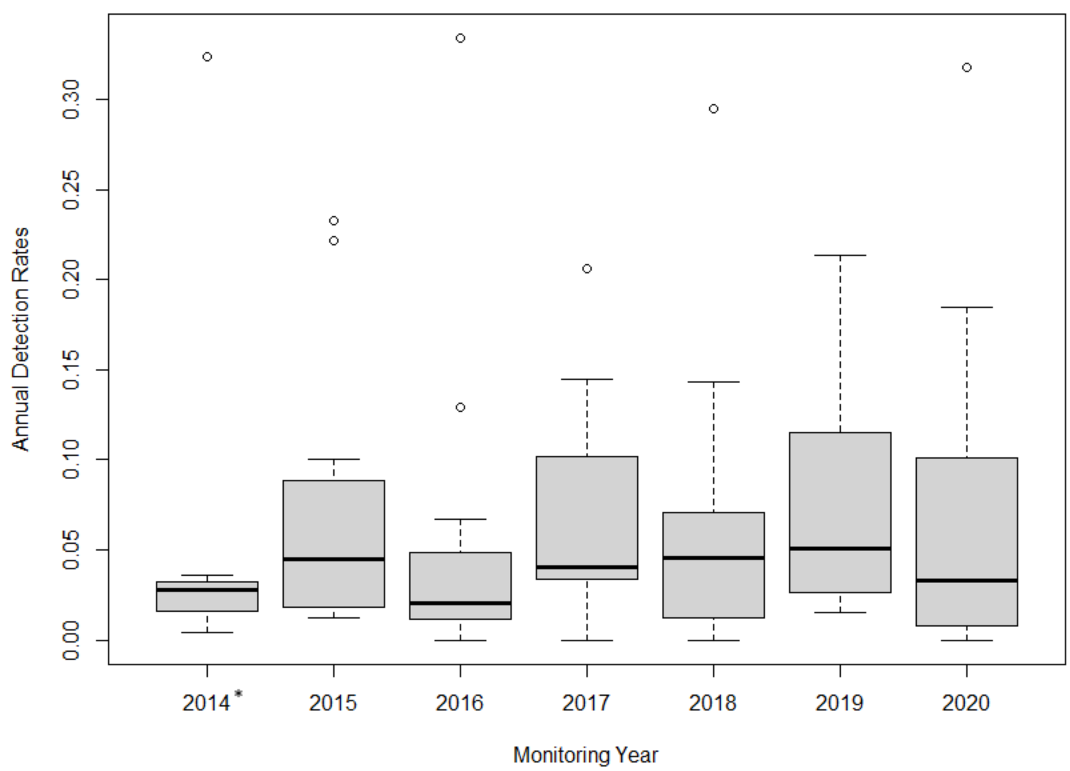
The objective of bat acoustic monitoring is to understand better the annual and seasonal variations in bat activity across WTGs at the Project. Analysis of variance (ANOVA) were used to test for differences in detection rates among FY 2015 and FY 2020. In FY 2020 85 percent (N=100) of all acoustic detections occurred between the months July and September, prior to the Pali brush fires. Therefore, only the months of July through September for each monitoring year were used in the analysis comparing years. Furthermore, FY 2014 was excluded from the interannual analysis because the months of July through August were not sampled during the FY 2014 monitoring year. A linear model (LM) was used to test for a change in detection rates across all sampling years, FY 2015 to FY 2020. All data fit a normal distribution. The distribution of residuals from the LM were examined to check that it did not violate assumptions of the model. All tests were 2-tailed, employed an alpha value of 0.05, and were conducted in R (R Core Team 2017). Separate from the linear regression and to illustrate the variation between years, Figure 2 shows box plots incorporating all months from all years with SongMeter detectors. The characterization of Hawaiian hoary bat seasons corresponds approximately to Starcevich et al. 2019. No significant trend in Hawaiian hoary bat acoustic activity has been detected.

In FY 2020, Hawaiian hoary bats were detected on 117 nights out of 1,146 detector-nights sampled (10.2 percent; annual detection rate; Table 3). Excluding the sampling months after the wildfire, Hawaiian hoary bats were detected on 100 nights out of 624 detector-nights sampled (16.0 percent). Detection rates increased during the lactation reproductive period (July to August), peaking in September and then declining during the remainder of the post-lactation (September to December) reproductive period (Figure 3). Lower detection rates were observed throughout the late post-lactation and pre-pregnancy (January to March) reproductive periods with a second smaller peak in April of the pregnancy (April to June) reproductive period, followed by a decline in May and June (Figure 3). The temporal pattern and scale of the detection rates in FY 2020 was similar to the detection rates observed in previous years (Figure 4). The FY 2020 detection rate (18 percent) during the peak activity period (July to September) is marginally higher than the detection rate for the same sampling period in FY 2019 (12 percent; Tetra Tech 2019).

Table 3. Number of Nights Sampled, Number of Detector-Nights with Bat Detections, and Proportion of Detector-Nights with Bat Detections Between FY 2014 and FY 2020

Dates	No. of Detector-Nights Sampled	No. of Detector-Nights with Detections	Proportion of Detector-Nights with Detection(s)
FY 2014 (October 2013 – June 2014)[1]	2,183	85	0.039
FY 2015 (July 2014 – June 2015)[1]	2,864	204	0.071
FY 2016 (July 2015 – June 2016)[1,2]	2,038	110	0.054
FY 2017 (July 2016 – June 2017)[1]	2,217	166	0.075
FY 2018 (July 2017 – June 2018)[1]	2,103	386	0.183
FY 2019 (July 2018 – June 2019)[1]	2,549	211	0.083
FY 2020 (July 2019 – June 2020)[3]	1,146	117	0.102

1. Number of detectors = 8.
2. Corrected estimates due to observed errors in detection rate calculations for 2016 Annual Report (KWP II, 2016).
3. Detectors reduced from 8 to 2 in October 2019



*data from FY 2014 includes October 2013 through June 2014, missing July-September, which are typically peak activity periods.

Figure 2. Annual Variation (Box Plots: Median, Interquartile Range and Outliers) in Bat Detection Rates at KWP II from FY 2014 to FY 2020

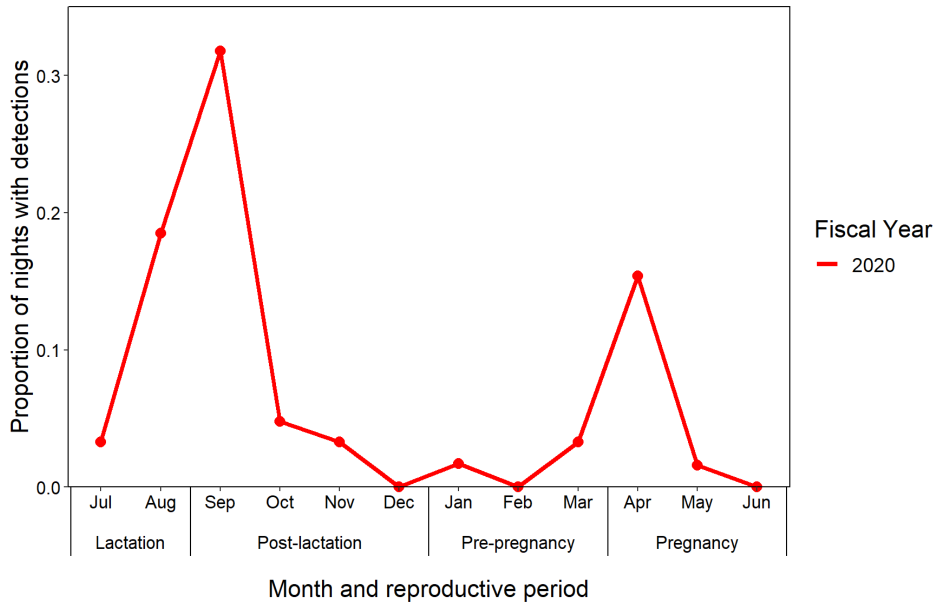


Figure 3. Monthly Detection Rates at Kaheawa II in FY 2020 with Corresponding Reproductive Periods

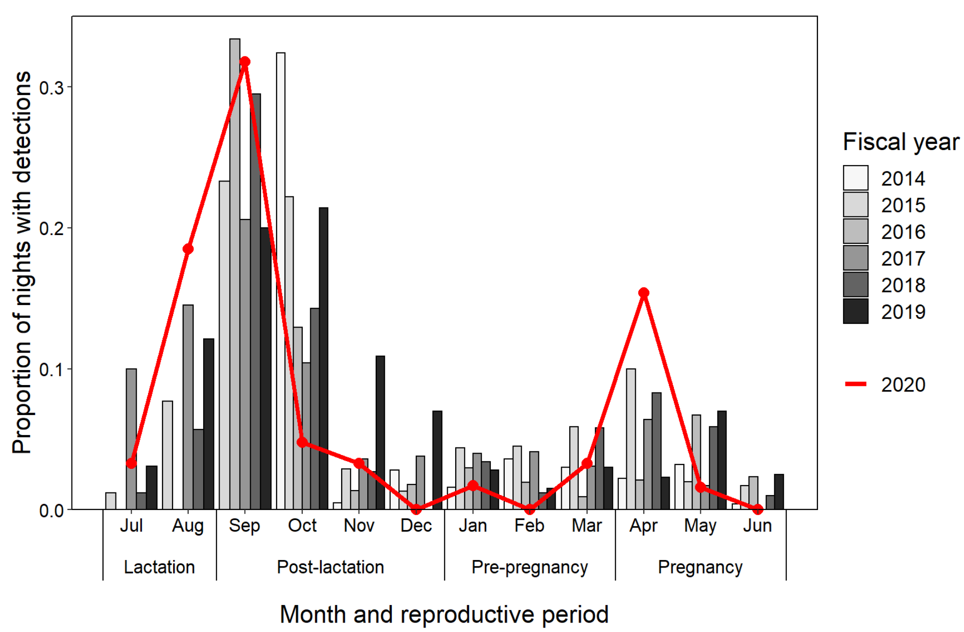


Figure 4. Monthly Bat Detection Rates at Kaheawa II for FY 2014 to FY 2020 with Corresponding Reproductive Periods

Among all monitoring years, annual detection rates were consistently low regardless of variation in the sampling effort (Table 3); with no significant difference in the annual detection rates among years (Figure 4; FY 2015 – FY 2020; ANOVA: $F_{5,18} = 0.14$, $P = 0.981$). Across the FY 2015 to FY 2020 monitoring years there is a slightly increasing trend in the annual detection rate, although not significant (LM: $R^2 = 3.77\%$; $F_{1,18} = 0.38$, $P = 0.545$)

9.3 Seabirds

KWP II is committed to seabird protection and recovery on Maui and within Maui Nui. Although results at the Makamakaʻole Seabird Mitigation Site (Makamaka'ole) suggest the site can support some reproduction of Newell's shearwaters, the Project is not on-track for fulfilling the Project's seabird mitigation needs. Therefore, it is the intent of KWP II to continue to work with DOFAW, USFWS, and seabird experts, to identify suitable alternatives to the Project's ongoing mitigation efforts at Makamaka'ole. KWP II believes adaptive management of this mitigation approach is required to achieve the goals laid out in the HCP.

9.3.1 Hawaiian Petrel and Newell's Shearwater - Makamakaʻole

Mitigation efforts at Makamaka'ole have been ongoing since construction of the two enclosures was completed on September 5, 2013. Mitigation efforts at Makamaka'ole 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. In the 2019 breeding season, which concluded in FY 2020, no Hawaiian petrel breeding was confirmed; however, monitoring results substantiated the production of five Newell's shearwater fledglings (Appendices 6, 7).

In Q2 of FY 2020, continued mitigation efforts at Makamakaʻole were contracted to Maui Nui Seabird Recovery Project (MNSRP) through the 2020 breeding season. Project staff are visiting the enclosures monthly with MNSRP to ensure consistent oversight. MNSRP along with Native Ecosystems Protection and Monitoring staff are working to maintain perimeter fencing. Weekly visits to Enclosures A and B are ongoing, checking burrows and game cameras for activity, completing vegetation management including clearing the outside perimeter and inside pathways, and conducting predator control.

Seabird activity is assessed using game cameras, burrow-scoping, checking for removal or displacement of toothpicks placed at burrow entrances, as well as checks for guano, feathers, and scent presence around the burrows. Data collection for burrow activity began on May 22, 2020. As of July 2020, 18 burrows in Enclosure A have had Newell's shearwater activity for at least one check, with 15 demonstrating consistent activity. In Enclosure B, seven burrows have had a mixture of Newell's shearwater and Bulwer's petrel (*Bulweria bulwerii*) activity with two demonstrating consistent activity.

9.3.2 Newell's Shearwater Survey – East Maui

Surveys of East Maui for potential additional mitigation sites was funded and completed in September 2015 (KWP II 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 HCP, LWSC was implemented from the start of Project operations at wind speeds of up to 5 meters per second at all WTGs for the months of April through November. LWSC is expected to reduce bat take as explained in the HCP. This curtailment period was extended to begin mid-February and continue through December 15, 2014 in response to bat fatalities documented at the Project on March 13, 2013 and February 26, 2014, and at the Kaheawa Wind I Project on December 14, 2013. On June 6, 2014 the Project offered an adaptive management proposal to the USFWS and DOFAW to increase take minimization for bats and on July 29, 2014 the LWSC was raised to 5.5 m/s between February 15 and December 15 from sunset to sunrise. The Project continues site-wide bat activity assessment after the required initial three-year period identified in the original HCP; the approved HCP Amendment commits to monitoring during Project operations (Section 9.2).

The Project has 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, despite a limited duration interruption in FY 2020. KWP II seeks to identify additional practicable actions to minimize the threats to the Hawaiian goose based on current projections of take, and will continue to work with USFWS, DOFAW, and technical experts in FY 2021 to further reduce risk to the species.

11.0 Agency Meetings, Consultations, and Visits

KWP II communicated actively with USFWS and DOFAW throughout FY 2020 through in-person meetings, conference calls, submittal of quarterly reports, and e-mail communications related to the Project's HCP (Table 4). The purpose of these communications included required semi-annual meetings, mitigation funding, adjustments to the acoustic monitoring program, and adjustments to and mitigation credits for the Hawaiian goose and seabird mitigation programs.

Table 4. Summary of Agency Coordination and Communication in FY 2020

Date	Communication	Participants
November 7, 2019	Annual HCP Compliance Review Meeting (in person)	KWP II Tetra Tech, USFWS, DOFAW
November 13, 2019	Submittal of FY2020 Q1 report	Submitted to DOFAW, USFWS by Tetra Tech
December 10, 2019	Submittal of a proposal for a revised bat monitoring program	Submitted to DOFAW, USFWS by Tetra Tech
December 18, 2019	Submittal of the Final KWP II HCP FY 2019 annual report	Submitted to DOFAW, USFWS by Tetra Tech
December 30, 2019	Submittal of Kaheawa Wind Project I and II HCP Makamakaʻole Mitigation and Future Adaptive Management report	Submitted to DOFAW, USFWS by Tetra Tech
January 8, 2020	Seabird mitigation adaptive management discussion	KWP II, Tetra Tech, USFWS, DOFAW
January 15, 2020	Annual HCP implementation review by ESRC	KWP II, Tetra Tech, ESRC
January 30, 2020	Submittal of FY 2020 Q2 report	Submitted to DOFAW, USFWS by Tetra Tech
April 23, 2020	Semi-annual HCP implementation review meeting (via conference call)	KWP II, Tetra Tech, USFWS, DOFAW
April 29, 2020	Submittal of FY 2020 Q3 report	Submitted to DOFAW, USFWS by Tetra Tech
June 8, 2020	Submittal of an addendum to the proposal for a revised bat monitoring program	Submitted to DOFAW, USFWS by Tetra Tech
June 22, 2020	Submittal of Makamaka'ole Seabird Mitigation Site – 2019 Breeding Memo in response to DOFAW request for further data support for fledglings at Makamaka`ole.	Submitted to DOFAW, USFWS by Tetra Tech

12.0 Expenditures

Total HCP-related expenditures for the Project in FY 2020 were $506,800 (Table 5).

Table 5. HCP-related Expenditures at the Project in FY 2020

Category	Amount
Permit Compliance	$65,500
Fatality Monitoring	$50,000
Acoustic Monitoring for Bats	$16,500
Vegetation Management	$11,300
Scavenger Trapping	$5,000
Equipment and Supplies	$3,000

Category	Amount
Staff Labor[1]	-
Makamakaʻole Mitigation Project	$150,000
Tier 3 Bat Research Project	$205,500
Total Cost for FY 2020	**$506,800**
1. Staff labor costs are included in the overall costs for each category	

13.0 Literature Cited

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APPENDIX 1. DALTHORP ET AL. (2017) FATALITY ESTIMATION FOR HAWAIIAN GOOSE AND HAWAIIAN HOARY BAT AT THE PROJECT THROUGH FY 2020

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Appendix 1a. Dalthorp et al. (2017) Fatality Estimation for Hawaiian goose at the Project through FY 2020

Modelling parameter		Modelling Period							
		1	2	3	4	5	6	7	8 (current)
FY		2013	2014	2015	2016	2017	2018	2019	2020
Date Range	Begin	7/1/2012	7/1/2013	7/1/2014	7/1/2015	7/1/2016	7/1/2017	7/1/2018	7/1/2019
	End	6/30/2013	6/30/2014	6/30/2015	6/30/2016	6/30/2017	6/30/2018	6/30/2019	6/30/2020
Period length (days)		364	364	364	365	364	364	364	362
% of Year		1	1	1	1	1	1	1	1
Search Interval (days)		7	7	7	7	7	7	7	7.1
Number of Searches in Modelling period		52	52	52	52	52	52	52	51
Observed fatality (X)		1	0	2	1	0	1	0	3
K		1	1	1	1	1	1	1	1
DWA		0.7	0.7	0.7	0.372[1]	0.372[1]	0.372[1]	0.372[1]	0.372[1]
g	g	0.654	0.653	0.681	0.358	0.361	0.360	0.361	0.347
	min	0.503	0.474	0.583	0.288	0.294	0.285	0.295	0.319
	max	0.791	0.812	0.771	0.431	0.43	0.437	0.429	0.375
B	Ba	26.32	18.94	62.8	61.66	68.06	54.62	70.09	380.2
	Bb	13.91	10.05	29.46	110.5	120.7	97.27	124.2	717.0
M*[2]		3	3	6	9	10	13	13	21

1. Search area reduced to graded portions of and roads within 70 m radius from turbine.
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 1b. Dalthorp et al. (2017) Fatality Estimation for Hawaiian hoary bat at the Project through FY 2020

Modelling Parameter		Modelling Period							
		1	2	3	4	5	6	7	8 (current)
FY		2013	2014	2015	2016	2017	2018	2019	2020
LWSC		5.0 m/s	5.0 m/s	5.5 m/s	5.5 m/s	5.5 m/s	5.5 m/s	5.5 m/s	5.5 m/s
Date Range	Begin	7/1/2012	7/1/2013	7/1/2014	7/1/2015	7/1/2016	7/1/2017	7/1/2018	7/1/2019
	End	6/30/2013	6/30/2014	6/30/2015	6/30/2016	6/30/2017	6/30/2018	6/30/2019	6/30/2020
Period length		364	364	364	364	364	364	364	362
% of Year		1	1	1	1	1	1	1	1
Search Interval (days)		7	7	7	7	7	7	7	7.1
Number of Searches in Modelling period		52	52	52	52	52	52	52	51
Observed fatality (X)		1	2	0	0	0	0	0	0
K		0.7	0.7	0.7	1[1]	1[1]	1[1]	1[1]	1[1]
DWA		1	1	1	0.559[2]	0.559[2]	0.559[2]	0.559[2]	0.559[2]
G	g	0.443	0.359	0.336	0.362	0.442	0.375	0.368	0.476
	min	0.241	0.235	0.187	0.27	0.374	0.287	0.289	0.437
	max	0.656	0.493	0.503	0.46	0.511	0.467	0.45	0.516
B	Ba	9.080	18.50	10.95	35.09	87.96	41.22	50.35	289.1
	Bb	11.41	33.02	21.68	61.84	111.1	68.77	86.64	318.1
M*[3]		5	12	12	12	11	12	12	11

1. Searches performed by canine teams.
2. Search area reduced to graded portions of and roads within 70 m radius from turbine.
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 2. LOST PRODUCTIVITY AND INDIRECT TAKE FOR HAWAIIAN GOOSE AT THE PROJECT IN FY 2020

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Parameter	Description[1]	Fiscal Year								
		2013	2014	2015	2016	2017	2018	2019	2020	Total
A	Observed Take	1	0	2	1	0	4	1	3	12
B	Estimated Take Multiplier (21/12=1.75)	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	
C	Estimated Direct Take (A x B)	1.75	0.00	3.50	1.75	0.00	7.00	1.75	5.25	21.0
D	Observed Indirect Take Multiplier (Season Defined)	0.04	0.00	0.09	0.09	0.00	0.09	0.09	0.09	--
E	Observed Indirect Take (A x D)	0.04	0.00	0.18	0.09	0.00	0.36	0.09	0.27	1.03
F	Unobserved Direct Take (C - A)	0.75	0.00	1.50	0.75	0.00	3.00	0.75	2.25	9.00
G	Unobserved Indirect Take (F x 0.06)	0.05	0.00	0.09	0.05	0.00	0.18	0.05	0.14	0.54
Total Direct Take from Collisions with WTGs (C)										**21**
Total Indirect Take (fledglings; E + G)										**1.57**
Total Indirect Take (adults; [E + G] x 0.512)										**0.80**

1. KWP II is in discussion with DOFAW and USFWS regarding mitigation credit; this table will be amended to include mitigation and lost productivity calculations once consensus is reached.

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APPENDIX 3. HAWAIIAN GOOSE AND HAWAIIAN HOARY BAT 20-YEAR PROJECTED TAKE AT THE PROJECT IN FY 2020

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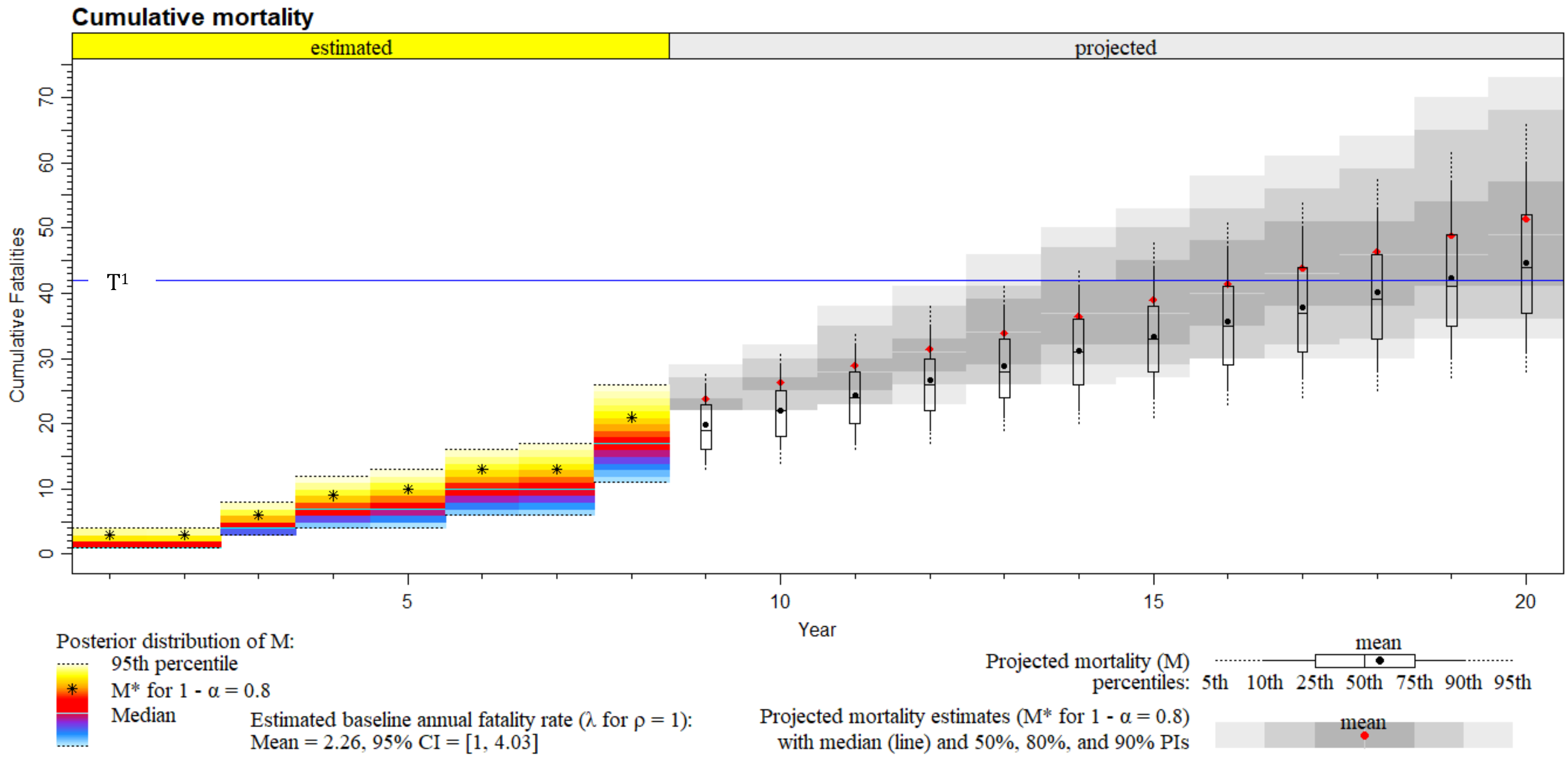
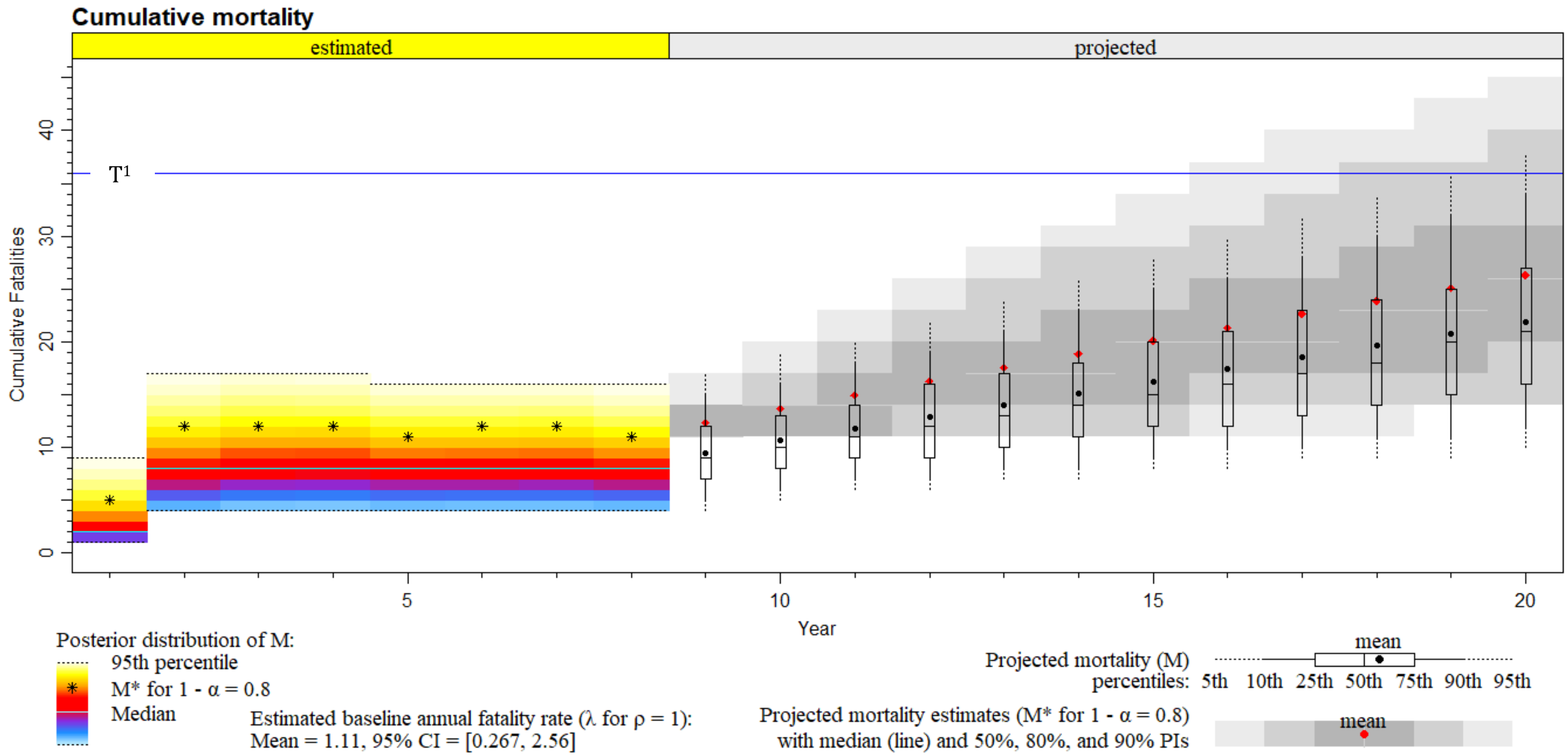
Appendix 3a. Projected Cumulative Mortality for the Hawaiian Goose at the Project



1. Permitted take for the Hawaiian goose at the Project 44; 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 requested authorized Hawaiian goose take (44) minus 2 adult equivalents of indirect take (4.5 percent of the requested authorized limit). Currently, the proportion of total take that is attributable to indirect take is 3.7 percent.

Appendix 3b. Projected Cumulative Mortality for the Hawaiian Hoary Bat at the Project



1. Permitted take for the Hawaiian hoary bat at the Project is 38 under the HCP. Take, however, as calculated from EoA only includes direct take. To account for indirect take in this figure, an approximate take threshold (T) of 33 is shown, representing authorized bat take (38) minus 5 adult equivalents of indirect take (13.2 percent of the requested authorized limit). Currently, the proportion of total take that is attributable to indirect take is 4.3 percent.

APPENDIX 4. DOCUMENTED FATALITIES AT THE PROJECT DURING FY 2020

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Species	Date Documented	WTG	Distance to WTG (meters)	Bearing from WTG (degrees)
Francolinus pondicerianus (Gray Francolin)[1]	7/24/19	12	62	169
Francolinus francolinus (Black Francolin)[1]	9/4/2019	8	3	143
Branta sandvicensis (Hawaiian Goose)[2]	11/27/2019	1	25	262
Branta sandvicensis (Hawaiian Goose)[2]	12/10/2019	7	21	142
Branta sandvicensis (Hawaiian Goose)[2]	12/10/2019	7	38	137

1. Species not protected by MBTA.
2. HCP Covered Species.

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APPENDIX 5. USGS HAWAIʻI ISLAND HAWAIIAN HOARY BAT ECOLOGICAL RESEARCH PROJECT ANNUAL REPORT

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

Agreement # 17WSTAAZB005541

Annual Report

Summary of Research Activities through July 2020

27 July 2020

Prepared by:

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

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 include:

- Roost fidelity and characterization
- Maternal roost ecology and mother-pup behavior
- Habitat use
- Diet analysis using molecular techniques
- Insect prey selection and availability
- Insect prey-host plant associations
- Movements throughout the annual cycle
- 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 Laupahoehoe Hawaii Experimental Tropical Forest. The US Fish and Wildlife Service has granted a special use permit for the Hakalau Forest National Wildlife Refuge. 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 are being 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 are 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.

Effect of Covid-19 pandemic on study

Bat capture efforts were paused mid-March through early June 2020 due to the Covid-19 pandemic. During this time a number of field and lab tasks that could be conducted without the handling of bats and while maintaining social distancing continued relatively uninterrupted and data processing continued. After careful evaluation of conditions on the island of Hawaii, implementation of enhanced sanitation protocols, acquisition of personal protective equipment, and personnel training in the proper use of N95 respirators, bat captures resumed in early June 2020. We will continue to monitor and evaluate conditions and adjust efforts as needed for safety.

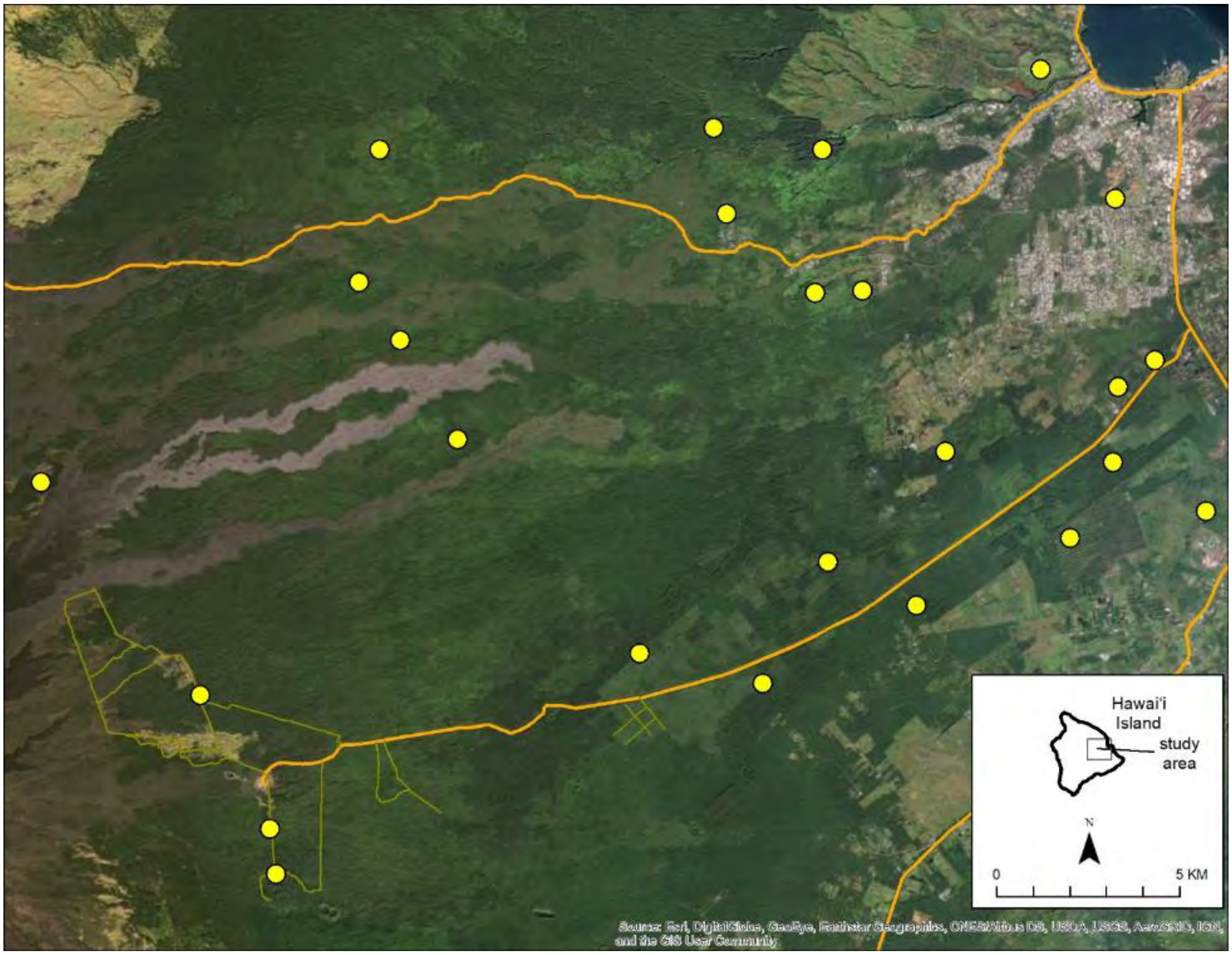

Figure 1. Mist nest sites in the Wailuku watershed of east Hawaii Island. For clarity, map excludes several net sites in the Laupahoehoe Natural Area Reserve (20 km to north).

Capture effort

Bat mist netting was conducted during 155 nights from 14 May 2018 to 24 July 2020 (2018: 36, 2019: 87, 2020: 32); bats were captured on 57 of these nights (Figure 2). Eighty-six 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 81 individuals. Additionally, six individuals were captured twice, four of which were radio-tagged twice.

Figure 2. Mist nest set up to capture Hawaiian hoary bats (left) and captured bat (right).

Roost ecology

Roost ecology studies were a primary focus of field efforts during years one and two 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 3) has been used to date to track a total of 22 bats to a day roost tree; an additional 32 bats have been tracked to the forest stand of their day roost (Figure 4). Three maternity roosts were confirmed in 2019 and three in 2020, and the number of pups is evaluated by repeat observations at each maternity roost (Figure 5). The maternity roosts have been monitored on a weekly basis using acoustic and thermal video recordings to obtain information on roost fidelity, the time of roost emergence/return, the within-night frequency and duration of foraging flights, time to pup fledging, and presence of potential predators (Figure 5). Regular monitoring of select non-maternity roosts is also being conducted to check for returning individuals to document fidelity and identify opportunities for video monitoring (Figure 6). Where possible, roost fidelity of bats with active radio tags is monitored using an automated receiver station near the roost (Figure 3). Data from these systems have been collected and downloaded at 21 tree or stand-level roosts since May 2019, when the system was first used.

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 31 trees. Stand-level characteristics (e.g., stand height, dominant tree, understory, etc.) for an additional 39 locations (72 total) were derived from a combination of satellite and airborne imagery and ground measurements. For the data compiled for the 2018-2019 period of monitoring, trees used by roosting bats were primarily comprised of non-native plantation or invasive species, although native *Metrosideros polymorpha* was also used. Other preliminary tree and stand metric results and metadata are publicly available through the USGS

ScienceBase Catalog, https://doi.org/10.5066/P9R95UYT (Montoya-Aiona et al. 2019). A metadata viewer is available for download: https://github.com/usgs/fort-pymdwizard/releases.

Figure 3. Radio telemetry effort to located day roost tree (left). Automated receiver station used to measure roost fidelity (middle). Thermal imager used for searches for roosting bats (right).

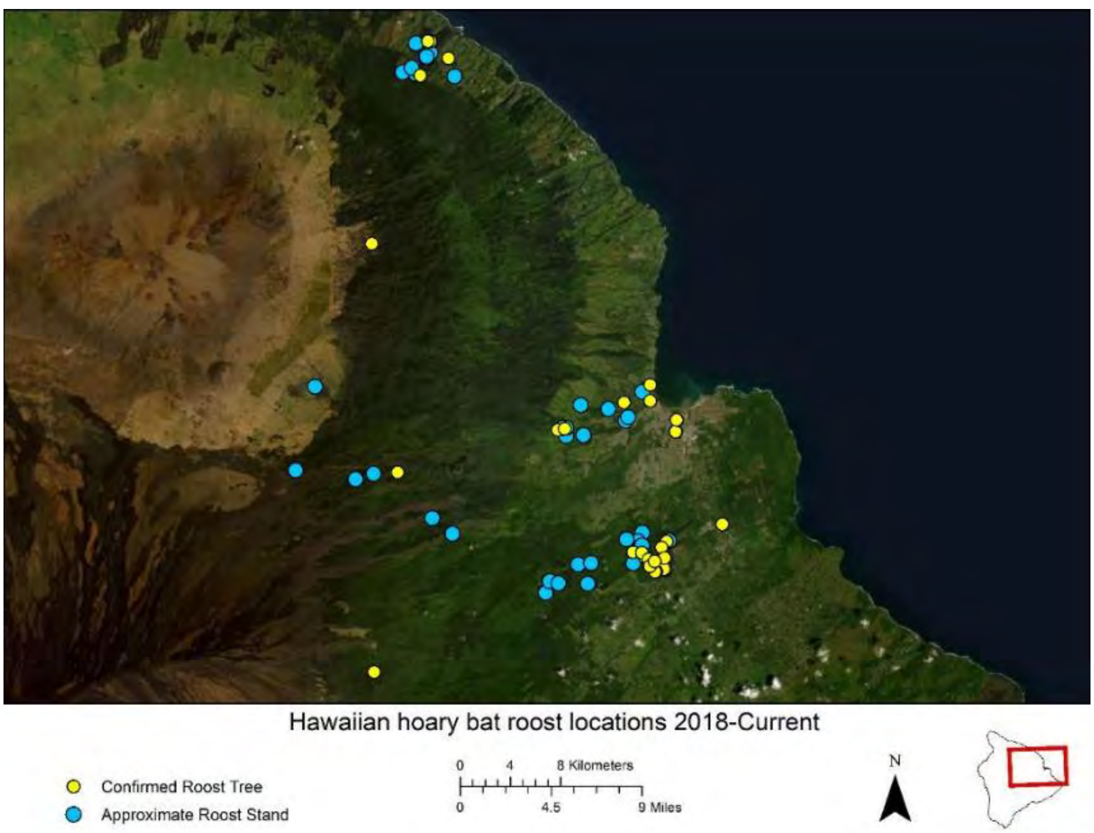

Figure 4. Confirmed and approximate Hawaiian hoary bat roost locations, 2018 – June 2020.

Figure 5. Thermal video camera deployment at maternity roost (left). A mother Hawaiian hoary bat with two pups observed during maternity roost monitoring (right).

Figure 6. Example of a mother-pup Hawaiian hoary bats at roost (left). Adult male Hawaiian hoary bat observed during roost fidelity monitoring (right).

Diet studies

Diet studies were also a focus during years one and two of the study. Studies of diet are focused on three primary lines of research: prey selection (comparison of availability with what is in fecal samples and comparison between sexes), seasonal and elevational comparisons, and host-plant associations with diet species.

Insect collection commenced in February 2019. Nocturnal flying insects are collected using light traps (Figure 7) 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 are categorized by size class and identified to the highest possible taxonomic classification; this lab work is underway (Figure 7). Additionally, DNA extracted from potential prey items have been and will continue to 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 is being conducted, and a bioinformatics approach used to match bat prey items in with the reference library (above) and public databases (see Pinzari et al. 2019). To date, 59 guano samples have been collected. Lab work to begin analysis of these samples commenced in early 2020 and is on-going (Figure 7). Genetic barcoding of potential insect prey commenced in June 2020 and is on-going.

Collection of caterpillars from vegetation at the fixed sampling sites commenced in March 2020 and is on-going (Figure 8). A combination of rearing caterpillars to adult form and genetic meta-barcoding of the caterpillars will be used to link the collections with bat diet. Host plants of bat prey are being identified using these collections and in-depth literature search and cataloging of insect host plants in Hawaii.

Figure 7. Insect collection using UV light trap (left). Potential bat prey collected and identified (middle). Hawaiian hoary bat guano sample being prepared for genetic meta-barcoding (right).

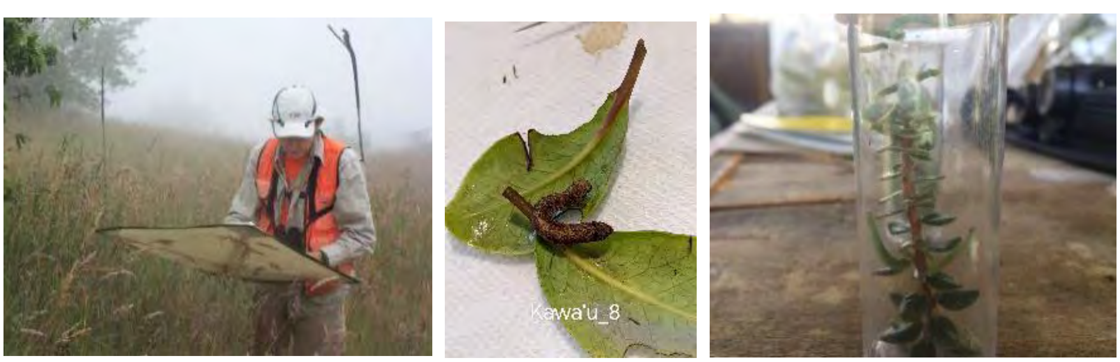

Figure 8. Caterpillar collection from vegetation to identify host plants of potential Hawaiian hoary bat prey (left). Caterpillars collected with host plant material (middle and right).

Movements

Study of Hawaiian hoary bat movements were limited in year one and two of the study; increased effort on this objective is planned in year three. A network of 20-30 ft masts with antennas and radio receivers that function as automated telemetry systems across a broad section of the Hilo watershed is still undergoing testing. Technical issues with the effectiveness of radio receivers for this system have occurred, and extensive testing of receivers continues. Five stations have been installed. 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. By the end of 2020 a determination will be made if efforts to track long distance movements will be shifted to ground-based tracking methods. Additional movement information is documented when possible, including site fidelity and seasonality of re-captured bats (n = 6) and the distance between capture and roost locations (Figure 9).

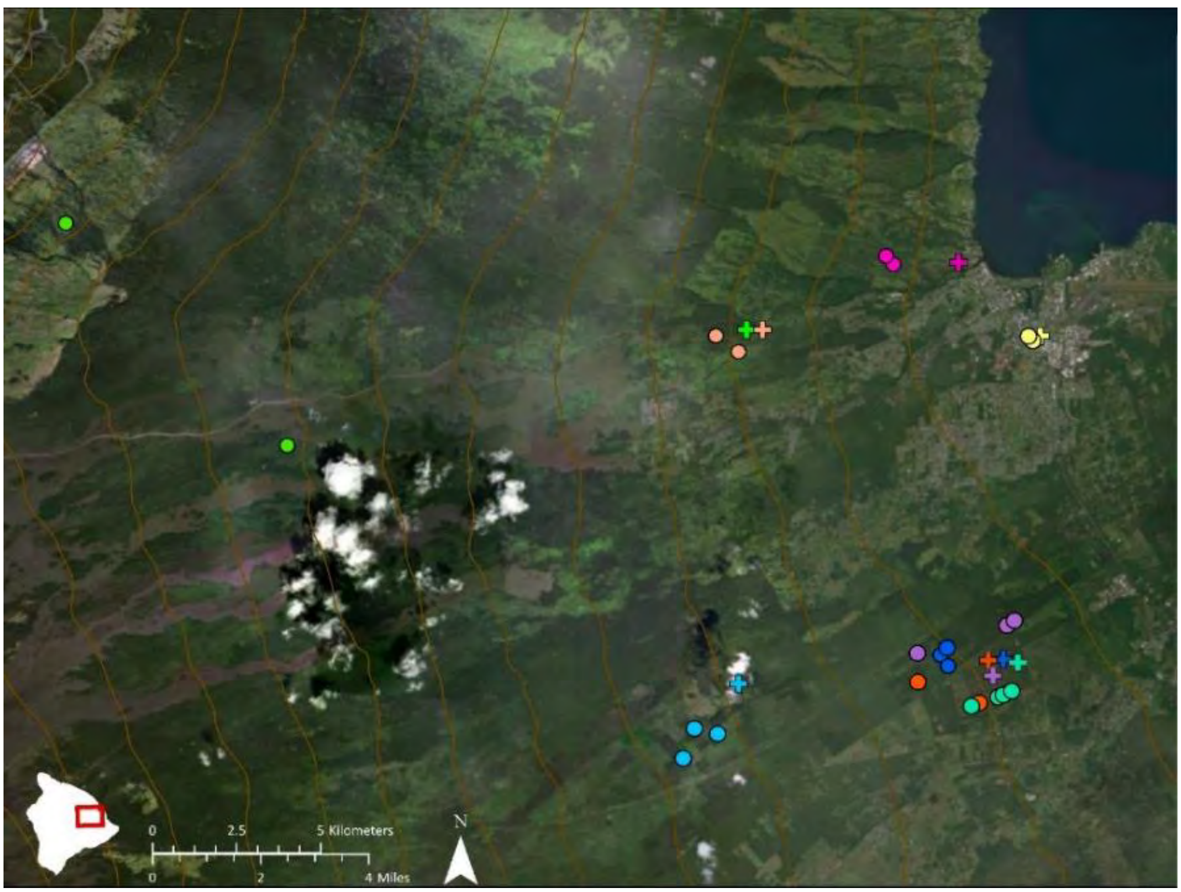

Figure 9. Net sites (cross symbols) relative to roost locations (circles) for captured bat (grouped by color) (data as of March 2020).

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. Diet studies including aerial nocturnal insect collection and caterpillar collection to identify bat prey host plants will also continue to be a focus of field studies through the end of 2020. During late 2020 and early 2021 we expect to increase efforts to track long-distance movements using the automated telemetry system supplemented with ground tracking. Data analysis and report writing is planned for 2021.

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Pinzari, C., T. Zinn, R. W. Peck, D. Gross, K. Montoya-Aiona, K. Brinck, P. M. Gorresen, and F. Bonaccorso. 2019. Hawaiian hoary bat (*Lasiurus cinereus semotus*) activity, diet, and prey availability at the Waihou Mitigation Area, Maui. Hawai`i Cooperative Studies Unit Technical Report HCSU-TR090, University of Hawai'i at Hilo, Hilo, Hawai‘i. Available: http://hdl.handle.net/10790/4638.

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APPENDIX 6. MAKAMAKA'OLE SEABIRD MITIGATION AREA 2019 ANNUAL REPORT

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H. T. HARVEY & ASSOCIATES
Ecological Consultants
50 years of field notes, exploration, and excellence

Makamaka'ole Seabird Mitigation Project
2019 Final Report

Project #3978-02

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January 2020

Executive Summary

The following report contains a summary of the work that H. T. Harvey & Associates performed at the Makamaka'ole Seabird Mitigation Project area during spring-fall 2019, including the seabirds' breeding season, and includes a comprehensive assessment of project performance, success criteria, challenges and future needs. We also present findings and recommendations, for both Newell's shearwaters (*Puffinus newelli)* and Hawaiian petrels *(Pterodroma sandwichensis)*, as they relate to Makamaka'ole and its capacity to provide long-term net conservation benefits by expanding the science and understanding of the ecology, breeding biology, and restorative capacities of both of these ESA-listed species.

Actions being implemented at Makamaka'ole are intended to partially satisfy mitigation obligations for the endangered Hawaiian petrel and threatened Newell's shearwater. Mitigation measures involve the establishment of viable colonies of these species, including predator exclusion fencing, removal and ongoing control of predators, and social attraction to facilitate seabird recruitment and breeding at artificially constructed nesting burrows. The report also includes an assessment of overall project performance to date and presents several scenarios that contemplate next steps and expectations of success going forward. In its sixth year, Makamaka'ole has demonstrated the capacity to provide favorable conditions leading to recruitment and nest site establishment, primarily thus far by Newell's shearwaters. In 2019, following a number of alterations in procedures, nest box use increased from 9-10 in June to 22 nest boxes eventually receiving documented visitation by the end of July. Seventeen of these exhibited consistent visitation by Newell's shearwaters and were monitored through October, while 5 nest boxes were only visited on a few occasions for the first time in 2019. Five of these 17 nests produced chicks that successfully fledged between mid-September and approximately October 15, 2019. These successful fledglings represent the first Newell's shearwater fledglings raised in an artificially constructed nesting colony in Hawaii using social attraction. The project site has also attracted at least one individual, or pair, of dark petrels believed to be Bulwer's petrel *Bulweria bulwerii*. While close fly-bys have occurred, Hawaiian petrels have not been documented landing, prospecting, or attempting to establish nest sites at the mitigation area since 2017.

In general, we conducted management activities on site regularly. Repeated procedures that we employed included: switching camera SD cards weekly; performing fence inspections and vegetation clearing along fencelines and around culverts bi-weekly; monitoring and maintaining the trapping grids and bait stations weekly and monthly, respectively; and barn owl control measures 1-2 nights per week. Vegetation (grass) was trimmed in front of burrows during most camera data card rotations. This was required more frequently depending on the amount of guano deposited at burrow entrances, which resulted in substantial nutrient influx and promoted accelerated growth rate.

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Section 1.0 Introduction

In the fall of 2013, following several years of data collection, feasibility assessment studies, conceptual design and scientific peer review, two approximately 1.8 hectare predator resistant, fenced enclosures were constructed to begin the Makamaka'ole Seabird Mitigation Project. Enclosures were designed to provide nesting habitat largely free of predators for two ESA-listed species: the Newell's shearwater (*Puffinus newelli)* and Hawaiian petrel (*Pterodroma sandwichensis*). In 2013, most of the emphasis was focused on site rejuvenation following fence construction, establishing trapping grids, predator removal, completing the initial installment of roughly 30 artificial burrows inside each enclosure, placing models, and activating the sound playback systems that broadcast calls of Newell's shearwaters (Enclosure A) and Hawaiian petrels (Enclosure B).

By 2015 (Year 2 of project implementation) the number of artificial burrows installed inside each enclosure had reached the initial goal of 50. The sound playback system was managed to attract Newell's shearwaters and Hawaiian petrels in 2015, and both species were documented landing and visiting nest boxes, sometimes concurrently. In 2016, most of the seabird activity observed was limited to Newell's shearwaters and a small dark petrel species, believed to be Bulwer's petrel *Bulweria bulwerii*. It is referred to as such in this report, though by laying an egg in February 2019, it's actual identity was called into question, as the species is supposed to be a summer breeder in Hawaii; Bulwer's petrel activity was almost entirely limited to a cluster of three burrows in Enclosure B. In 2017, Hawaiian petrels, Newell's shearwaters, and Bulwer's petrels were observed visiting nest sites in the aforementioned cluster in Enclosure B and Newell's shearwaters were active at two burrows in Enclosure A. That year, four eggs (three reported to be Newell's shearwaters' and one presumably laid by a Bulwer's petrel) were produced, but did not hatch and were later collected. Newell's shearwater activity increased in 2018 when five nesting sites were visited and occupied for various lengths of time in Enclosure A, and four were visited in Enclosure B (in addition to documented visitation at the naturally excavated burrow cavity referred to as the "uluhe" burrow) (Table 1).

A significant amount of information is contained in previous annual reports detailing management activities associated with the project (Kaheawa Wind Power 2013, 2014, 2015, 2016, 2017, and 2018). We reviewed these reports and developed a timeline for each burrow that exhibited activity, based on previous monitoring, to display the progression of colony establishment and formulate preliminary expectations, in terms of potential breeding performance, in 2019. We also deduced the need for and implemented important refinements to enhance the recruitment capacity of both seabird species, and these actions resulted in a substantial increase in the number of nest sites visited by seabirds. Moreover, five nest sites produced Newell's shearwater chicks that appear to have successfully fledged. This represents the first case in Hawaii in which social attraction has led not just to nesting recruitment, but also successful reproduction among endangered seabirds. The specific actions that were implemented and how these are attributed to the successes observed in 2019 are discussed below

Table 1. Sequence of Nest Site Visitation, Presence of Egg Material, and Newell's Shearwater Chicks Presumed Produced at the Makamaka'ole Seabird Mitigation Site, 2013–2019

Enclosure A				Enclosure B			
Year	Nests Visited	# Eggs	# Chicks	Year	Nests Visited	# Eggs	# Chicks
2013	0	0	0	2013	0	0	0
2014 (1)	0	0	0	2014 (1)	1	0	0
2015 (2)	0	0	0	2015 (2)	1[a]	0	0
2016 (3)	1	0	0	2016 (3)	4	0	0
2017 (4)	3	3	0	2017 (4)	3	1	0
2018 (5)	5	2	0	2018 (5)	5	2	0
2019 (6)	15	3	3	2019 (6)	2	3	2

[a] The single nest visited in Enclosure B in 2015 was a presumed Bulwer's petrel observed in the vicinity of several burrows clustered near one of the speaker horns.

Notes: Numbers in parentheses indicate the project implementation year; Nests visited indicates the number of nest boxes that received visitation that was considered consistent (> 3 weeks); Enclosures A and B were established for Newell's shearwaters and Hawaiian petrels, respectively; # eggs includes intact eggs and egg shell fragments and/or egg membrane material present.

Section 2.0 Work Performed in 2019

2.1 Mitigation Site Inspections and Nest Box Preparation

In anticipation of seabird site use, in February and early March 2019, 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, evaluation of the performance of the audio playback system, and the production of 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 covert IR game cameras to monitor seabird visitation and activities and managed habitat in the vicinity of burrows and active burrow clusters.

We mobilized resources and personnel and initiated fence inspections of Enclosures A and B before the anticipated arrival of shearwaters and petrels to identify any breaches or portions of the fence infrastructure in need of immediate repairs. In early March, H. T. Harvey & Associates ecologists David Ainley, Brad Yuen, Gregory Spencer, and Spencer Engler, formerly a field biologist with TerraForm Power, performed inspections of all nest boxes in both enclosures. We opened each box, examined the contents, and evaluated the condition of each nest box lid. Contents within the nest boxes were carefully inspected to evaluate the presence of feathers and nest material, composition of the nesting substrate, and general conditions inside the nest boxes. We shifted gravel to form nesting "bowls," when one was not evident, to reduce the potential for eggs to be accidentally rolled out of nest chambers during incubation. Moreover, photos and reports from previous years indicated egg breakage in some eggs and to further guard against this, we also removed any large rocks. We also added small amounts of grass to pad the substrate. Finally, we repositioned models so as not to appear to be guarding burrow entrances (and subsequently on occasion moved them to new positions). 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, pulled into the boxes by occupants, and that corroborated records of 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 nest box B-50 (Figure 1). Based on its small size, we concluded that it had been laid by the Bulwer's petrel that has been steadily active at this nest box for most of the entire preceding year, as indicated by game camera photographs.

2.2 Fence Inspections and Repairs

Fence inspections were conducted regularly to guard against intrusion of alien mammals. These inspections consisted of walking and hiking the perimeter and inner edges and inspecting the structural components including mesh and skirt, posts and braces, hood, brackets, overlap sections, and overall structural integrity to identify wear and needed repairs. We also monitored erosion, particularly where terrain is steep, looking for signs of developing rills or new drainage corridors. Eroded gullies might allow predator entrance into the enclosures. We did not identify any significant erosion concerns but recognize the potential for sheeting flow to move through the area, especially during or following periods of heavy rainfall.

Figure 1. Egg Observed at B-50 during Pre-Season Nest Box Inspections in Early March, 2019, and Believed to Belong to Bulwer's Petrel (or Related Species)

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 rust, and while quite a few have been replaced, especially in the lower sections of the enclosures (mostly Enclosure A), many brackets remain in need of replacement. We replaced some brackets based on the severity of rust and corrosion indicating a need for immediate repairs. The mesh on the windward (east) upper side of Enclosure A contains a substantial amount of rusted brackets and there are portions of the mesh that have become severely rusted. High winds in August caused mesh failure on two joining panels and we installed two new 25-foot long sections of mesh over the entire worn portion to ensure that any further disintegration of the original meshing would not result in a breach (Figures 2 and 3). Similarly, we replaced several brackets in this section to reinforce the connection to the adjacent hood.

Although the interim repairs have performed well, another wind event in December 2019 caused one of the upright fence posts to break, resulting in the separation of at least one bracket and damage to the hood (Figure 4). In fact, the damaged section of hood separated from its attachment points and is hanging free of the fence structure, threatening further damage and potential for unwanted breaches. Interim repairs to correct this damage are in progress and recommendations for additional fence repairs needs are outlined below.

Figure 2. Fence Damage Caused by Excessive Rust Detected in August 2019

Figure 3. Fence Repairs Implemented in August 2019

Figure 4. Damaged Section of Fence Detected in December, 2019

2.3 Erosion Management

We did not observe any significant erosion issues in 2019. Soils were saturated in the early weeks of project management, but steadily improved throughout the season. When rainfall was consistent, or surface runoff evident, we examined areas where runoff appeared heaviest and traced adjacent sources of runoff to ensure that new rills were not forming outside of previously installed erosion control features (water bars, flow deflectors). We systematically looked for any evidence of sediment flow and/or slumping of mud or other debris to ensure that there was no accumulation along the fences, especially in the steep and lower sections.

2.4 Culverts

Culverts were installed in 2013 as components of the original fence designs to manage and direct storm water flow at four discharge points along the lower sections of the fenced enclosures. Three are located at Enclosure A and one was installed along the lower margin of Enclosure B. We used hand tools and weed-whackers to regularly clear vegetation from around the culverts and aprons to ensure unimpeded storm water flow downslope, which also enabled culverts to be inspected for wear, needed repairs, and evidence of digging or cracks that might facilitate small mammal ingress, mostly around the grouted margins. We frequently inspected the four culverts and reduced the vegetation around them. We used care in applying spot treatments of Round-

Up to inhibit weed regeneration around the grouted margins of the culverts. We only applied herbicide around the culverts during dry periods when rainfall was absent or forecast to be negligible.

2.5 Vegetation and Invasive Weed Control

The terrain within the enclosures is densely covered by mostly perennial herbaceous vegetation. We did not consider vegetation to present significant issues and did not observe the emergence of any new types of noxious or invasive weeds. By far, the majority of the ground-cover management that we performed in 2019 was intended to open up and maintain a cleared corridor along the fencelines. Facilitated by weed-whackers and hand tools (machete), regular clearing helped to provide easy access along the perimeter inside and outside each fenced enclosure, helped reduce seed dispersal, and enabled the partially buried fence skirt to be inspected for wear, signs of digging by unwanted mammals, or breaches of any kind. In order to properly inspect and repair the margins of the culverts, vegetation control around these features was necessary and was performed routinely. Maintenance of habitat around the burrow groups entailed trimming back grasses and small shrubs, by hand, to enhance the visibility of models, burrow entrances, and the field of view for the covert IR game cameras. We also targeted the removal of particularly unwanted weeds, such as clidemia *Clidemia hirta* and *Tibouchina* spp., and we removed several of these plants at the root, bagged and disposed of these off site. Benefits of this approach were indicated by expansion of uluhe fern *Dicranopteris linearis* and other native plants within the enclosures, thereby contributing to habitat improvements within the management area. Uluhe fern is often associated with nesting areas of the shearwaters and petrels at lower altitudes (i.e. Lanai, Kauai). We also conducted monthly spot treatments of *Clidemia* and *Tibouchina* using Round-Up. Monitoring of vegetation focused on detecting the spread of unwanted species such as molasses grass *Melinis minutiflora* and guava *Psidium* spp, to ensure that early detection would facilitate future actions can be taken to limit encroachment of these unwanted species along the fencelines and other portions of the management area.

Section 3.0 Predator Control

3.1 Rodents and Mongoose

The predator control program implemented at Makamaka'ole specifically targeted the exclusion of predators such as rats *Rattus* spp., cats *Felis catus*, mongoose *Herpestes auropunctatus*, and feral pigs *Sus scrofa*, all of which are known to harm or kill burrowing seabirds. Measures focused on removal and ongoing control of rats and included trapping to intercept any mongoose that might find a way into the fenced enclosures. No mongoose have been documented inside either of the enclosures since the project began in 2013-2014, although many were trapped immediately adjacent to fences outside. Traps were placed to actively dispatch rats and mongoose within a buffer extending several meters outside the fences. DOC-200 traps (New Zealand Department of Conservation) and Victor snap traps were used for mongoose and rats, respectively. These traps were secured within wooden boxes designed to exclude seabirds and non-target species. In 2019, we removed 37 mongoose from outside-the-fence buffer areas, whereas ten rats were trapped inside: nine in Enclosure A and one in Enclosure B; and an additional ten were removed from the buffer (Table 2). Three mice were removed from inside Enclosure A.

Table 2. Rodent and Mongoose Trapping Results in Each Enclosure by Target Species and Location (April 1 to November 22, 2019)

Location	Trap	Enclosure	Mongoose	Rat	Mouse
Outside	DOC	A	19	1	0
		B	17	1	0
	Snap	A	0	5	0
		B	1	3	0
Inside	DOC	A	0	0	0
		B	0	0	0
	Snap	A	0	9	3
		B	0	1	0
Total			**37**	**20**	**3**

In addition to trapping, we provisioned and checked 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 used is mold- and moisture-resistant, it generally needed replacement after a period of six to ten weeks, depending on the weather conditions and placement within the grid. Thus far, all bait replacement was deemed necessary due to molding with no bait bars chewed by rodents by more than approximately 25%. Overall, most bait checked and replaced had not shown evidence of consumption by rats, with the same bait boxes generally showing evidence of consumption from check to check.

3.2 Tracking-Tunnel Surveys

We performed three quarterly tracking-tunnel surveys to sample rodent and mongoose presence. Surveys were conducted 21-25 March, 3-7 June, and September 26-30; Table 3). Each survey consisted of deploying 40 tracking 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). As in previous years, no mongoose activity was detected in either enclosure in 2019, while some amount of rodent activity was detected in both enclosures.

Table 3. Estimates of Rodent and Mongoose Activity Levels in Each Enclosure Using Tracking Tunnel Cards Expressed as Percent Activity (March 1, 2018 to September 30, 2019)

Predator	Month	Enclosure A	Enclosure B
Mongoose	March	0	0
	June	0	0
	September	0	0
Rat/Mouse	March	20	0
	June	10	0
	September	30	60

Note: Activity levels are expressed as percent, averaged among all cards used in the trial for a given treatment period. Trials are performed quarterly; percent activity functions as a proxy index of relative presence.

These results indicate very low to negligible levels of rodents early in the year, and high probability that mongoose remained completely absent inside both enclosures. However, we did note an increase in the presence of rodents, as evidenced by the activity levels seen in September, in both enclosures. An increase in rodent activity on tracking tunnel surveys beginning in late summer and continuing into winter is also consistent with what was observed in previous years and suggests that rodents are probably exhibiting seasonal fluctuation in abundance.

Despite the seasonal increase in rat activity evident in tracking-tunnel surveys, there was little evidence of increased bait consumption at bait stations. Because of this, we also suspect that the current bait station system may not be entirely adequate. When rodents are exposed to poison baits, some individuals consume a lethal quantity, but others consume a sublethal quantity and after surviving the ill-effects, may develop an aversion to the bait (Prakash 1988). In this way, some rats may have developed an aversion to the diphacinone-based bait within the enclosures and are thereby experiencing higher than expected survival. This scenario is supported by information we obtained from the Vector Control Branch (Hawaii Department of Health) and the U.S. Department of Agriculture. These organizations recommended changing the type of toxin used on a rotational basis to reduce the likelihood of aversion and also of tolerance to any one type of control agent.

3.3 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 of Barn owls when we could observe them, and to coordinate on control. We also conducted surveillance for owls while making 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 observed barn owls on at least 5 occasions at Makamaka'ole in 2019. At the preferred hunting area, we attracted individual owls on two separate occasions to recorded call playbacks of distressed small mammals (mice and voles).

H. T. Harvey & Associates obtained a new Wildlife Control Permit with the Division of Forestry and Wildlife, issued at the end of June 2019. Active owl-control efforts began on July 12th. This involved playing a recording associated with a decoy. We hunted actively on three occasions but no owls were shot or removed from the project area in 2019.

Section 4.0 Social Attraction and Nesting Colony Establishment

4.1 Sound Playback System

Three sound playback systems were used at Makamaka'ole in 2019. Each system entails one Xplod 350 watt 2/1 Channel Power Amplifier housed in a weather-resistant case and powered by a 12-volt battery charged by solar panels. Each power amplifier can accommodate up to eight speaker horns under the current configuration. The playback systems at Makamaka'ole, from the original start of the project, were intended to broadcast only Newell's shearwater calls in Enclosure A and only Hawaiian petrel calls in Enclosure B. Early in the season, we were surprised to learn that the recorded playback sequence being broadcast in Enclosure A since 2018 was a mix of Newell's shearwater and Hawaiian petrel. We quickly made a new recording sequence containing only the calls of Newell's shearwaters and this new sequence was used for the duration of the 2019 season. In early July, upon installing additional speakers (see below), and upon testing the revised system, we reevaluated the recording sequence being played in enclosure B and, although this track contained only Hawaiian petrels, we found it to lack clarity and deemed that it needed to be replaced. The re-installed playback sequence for Hawaiian petrels was derived from recordings made on Lanai'hale and was provided by the Cornell Lab of Ornithology (Macaulay Library). These calls generally resemble, in our opinion, those made by petrels at Makamaka'ole. Thus, we considered them to be well suited given the proximity, and shared ecological setting with the petrels breeding on Lanai. There is the possibility that some Makamaka'ole recruits could be from that population. Each of the three systems were configured to play from sundown to sunrise and each had been on this playback regime, non-stop, since the end of the 2018 breeding season. In 2019, we discontinued playbacks at the end of October, which is long past when new potential recruits would have been visiting and calling.

At the beginning of 2019, two large 50 watt speaker horns (TOA Electronics) were being run on each amplifier. In early July, to spread the sound sources, we replaced the horn drivers in the 50 watt horns and added four additional 30 watt speakers to the existing arrays in each enclosure (eight new speaker horns). We chose to increase speaker coverage on the basis of our observation that visited nest boxes where close to existing speaker horns. We concluded that by installing additional horns we might increase the number of active burrows, spread over a wider area.

The Newell's shearwaters, as noted, have been using nest boxes that are closest to the speaker horns (i.e. the source of the broadcast), i.e. within 1-3 meters. Upon adding new speakers, which basically was an informed hunch, we were pleased that within days additional nest boxes began to be visited by seabirds in Enclosure A. This confirmed our suspicion that we could manipulate recruitment through strategic placement of horns. By expanding the sound system, though not in a systematic manner (we were just experimenting) we significantly expanded the distribution and number of active burrows. These adjustments clearly helped to advance the attraction of new recruits to nest at Makamaka'ole, in the process contributing important insights that will prove useful in the future.

4.2 Nest Site Monitoring

In March, we evaluated the distribution and posture of seabird models, considering that prospecting shearwaters and petrels may be sensitive to the position of decoys relative to nest sites. To mitigate the possibility that models were positioned in a way that could be interpreted by recruits to be guarding a respective burrow entrance, we rearranged models in both enclosures, increased the distance between models and burrow entrances. Periodically, we adjusted the postures and orientations of individual models throughout the season.

In the recently completed nesting season, the first Newell's shearwaters began arriving and visiting burrows on about April 8, 2019. Visitation increased gradually thereafter, and apparently reached a stable maximum by June. Shortly after the system upgrades were accomplished in early July, we observed a nearly three-fold increase in the number of active nest sites being visited by Newell's shearwaters, mostly in Enclosure A. Eventually, 22 nest boxes were being visited by shearwaters by the end of July. Seventeen of these exhibited consistent visitation by Newell's shearwaters and were monitored through October, while 5 nest boxes were only visited on a few occasions for the first time in 2019. Five of these 17 nests produced chicks that successfully fledged between mid-September and mid-October (Table 4).

4.3 Camera Deployments and Data Review

We monitored visitation and activities of mostly Newell's shearwaters at all active nest sites using primarily the professional quality Reconyx covert IR game cameras (*HyperFire* and *HyperFire 2*, Reconyx, Inc., Holmen, Wisconsin), as well as some older digital trail cameras having 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 proved to be superior in terms of meeting project performance criteria. Burrows were selected for camera monitoring based on initial indications of toothpick displacement at burrow entrances, as well as the appearance of fresh guano. Grass outside burrows was trimmed by hand and regularly maintained to enhance the quality of the photos and reduce unwanted triggering by wind moving the vegetation (below).

The cameras are designed for securing to a stationary object and can depict areas several meters wide. We made every effort to install one camera at each active nesting burrow at Makamaka'ole in 2019 using a wooden stake in a position that allowed the entrance of the nesting burrow to be under continuous surveillance (Figure 5). In some cases, depending on the amount of activity and number of birds visiting a given site, we repositioned cameras to observe more area in the immediate vicinity of the entrance while, at others, the camera looked 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 the activities recorded. This was done very carefully, especially when birds were suspected of being present inside the nest box during the day, in order to minimize any disturbance. Camera data cards were switched and reviewed at least weekly and slight changes in the position of cameras were sometimes made, as needed.

Table 4. Timeline of Nest Site Visitation and Breeding Parameters Exhibited by Newell's Shearwaters at the Makamaka'ole Seabird Mitigation Project Area in 2019

Burrow	Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
A-11 [a]	NESH										
A-12 [a]	NESH									9/20	
A-13 [a]	NESH						Upgrades installed →			9/20	
A-14 [a]	NESH										10/ 5
A-18 [a]	NESH										
A-20 [a]	NESH										
A-21 [a]	NESH										
A-22 [b, c]	NESH										10/14
A-24 [a]	NESH									9/24	
A-25 [b]	NESH										10/5
A-26 [b, c, d]	NESH										10/5
A-42 [a]	NESH										
A-43 [b, d, e]	NESH										10/14
A-48 [a]	NESH										10/14
A-50 [a]	NESH									9/20	
B-22 [b, d]	NESH									9/5	
B-50 [b, e]	NESH										10/7

[a] Probable non-breeders in 2019.

[b] Downy feathers present in nest box.

[c] Chick presence confirmed visually.

[d] Egg shell fragments and/or membrane present.

[e] Intact egg present; A-43 (intact NESH egg, relay); B-50 (NESH egg roll out, relay).

Notes: NESH = Newell's shearwater ; dates in cells indicate the date birds last seen at burrow and, blue shaded burrows indicate chick produced .

Data obtained with game cameras were entered into a data base, useful in characterizing the activities of seabirds associated with active nesting burrows. Behavioral changes observed over the course of the season were useful indicators of breeding status and the relative likelihood that pairs were involved. Such behaviors can indicate breeding, incubation, and/or chick provisioning, or whether birds visiting specific nest sites may have been simply prospecting or establishing their claim on nest sites that would be used for breeding in subsequent seasons.

Figure 5. Reconyx HyperFire 2 Camera Monitoring an Active Newell's Shearwater Nesting Burrow at Makamaka'ole in 2019

Figure 6. A Pair of Newell's Shearwaters Active at One of the Burrows in Enclosure B; the Camera was Positioned at this Site to Capture a Broader Field of View

Figure 7. Newell's Shearwaters Documented at an Artificial Burrow in Mid-July, 2019 using the Reconyx HyperFire Camera Aimed Directly into the Burrow Passage

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

In the long term, we expect that shearwaters (and petrels) will eventually dig their own burrows, especially once a high proportion of nest boxes become used. Therefore, we performed searches for 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, in addition to nest box use. While on site and working inside the enclosures we frequently moved around in areas containing dense understory habitat that would be suitable for nesting. We carefully examined and searched areas, independently and as a team, coordinating observations, in an effort to achieve consistency in our searches for signs of burrow excavation and nesting.

So far, we have not found any burrows or signs of active prospecting outside of the immediate management areas, defined as the areas where the sound system and artificial burrows are situated, within the exclosures. Outside the fenced enclosures, the modest investigations we have done within ten meters of the fencelines, thus far, have not yielded any active nesting burrows or promising signs of prospecting or excavation, by any seabird species. Nor have we found any carcasses that predators outside the exclosures would have left upon predating prospecting birds. We know of one site in Enclosure B, not a nest box (i.e. the "uluhe" burrow), that was prospected, partially excavated, and was routinely visited by both Newell's shearwaters and Hawaiian petrels in past years. This site is located immediately adjacent to one of the 50 watt horns and less than one meter from

B-22, one of the most active burrows in this enclosure. No substantive activity was documented at the uluhe site in 2019 (see Section 5.2).

In Enclosure A, we discovered that Newell's shearwaters were actively 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 (A-26). We directed considerable attention to monitoring this site, deploying a camera for several weeks, and we regularly searched for additional nest-site prospecting in the surrounding area. We concluded that, although some excavation was occurring, there was no nest established in 2019. Any places that birds may be exploring or beginning to tunnel or excavate are areas that we have inspected carefully. In that way, we can be sure that we are accounting for all nesting activity attributable to our management actions.

While it is important to understand how the project might affect the distribution of nest sites beyond the immediate range of the management area, based on our observations, we have learned that there is a strong spatial correlation between the source of sound playback broadcasts and nest site selection. Concerns expressed about the capacity of the project's social attraction mechanism to result in birds establishing nest sites outside of the enclosures, where they may be exposed to predation, do not appear to be valid at this time. As the colony grows and expands, however, a corresponding increase in the effective radius of calling may eventually result in greater probability that birds will establish nest sites beyond the core management area. Such a development may require the project to expand management actions to ensure the needed protection from threats associated with predation exposure.

Section 5.0 Overall Assessment of Seabird Productivity and Trends in Recruitment Dynamics

5.1 Newell's Shearwaters

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; that number increased to about 22 by mid-July. We attribute the nearly three-fold increase in the number of nesting burrows being visited by Newell's shearwaters, in part, to the modifications we made to the playback system and digital call playback sequences. Re-positioning models may also have been involved. Apparently, there has been a 'surplus' of birds being attracted by the call playbacks, but which owing to the territoriality of nest box occupants, have not been encouraged to land. However, there may be other factors that contributed to this increase. For example, in 2018, a second pulse of activity in both enclosures occurred in roughly mid-August, indicated by disturbed toothpicks and some guano deposits (4 nest boxes in Enclosure A and 3 in Enclosure B). Data and observations gathered since project inception indicate that this new colony has been experiencing a stepwise advancement over time. In fact, eight of the nest boxes visited by Newell's shearwaters in 2019 have been active sites for 1-3 previous seasons and four of these (A-26, A-43, B-50, and B-22) have contained eggs each year since 2017 (B-22 first egg in 2018). By installing several new horns in proximity to unused burrows, we believe that we helped to overcome territoriality by existing nest box occupants, thus helping to facilitate the expansion of prospecting opportunities, indicated by the temporal cascade of visitation and subsequent nest site activity that we observed in 2019.

We continued to monitor the visitation and activities of Newell's shearwaters carefully, noting that visitation remained consistent at most nest sites until the end of August, when activity at some of the sites diminished. The drop off was consistent with the expected departure of non-breeders toward the end of the egg period. Song meters (Wildlife Acoustics) used elsewhere indicate a reduction in calling at that time. However, several nests remained active, indicating to us that some of these nesting burrows may have contained chicks being provisioned by parents. On September 4, we used a burrow scope equipped with an LED lamp rosette to examine the contents of several burrow boxes. The burrow scope, which came with the project, was sub-optimal for this purpose since it was not equipped with IR capacity and was difficult to maneuver inside the passage. We did observe a bird (presumably a chick) in nest A-26, but the bird moved out of the view of the burrow scope lens and we were not able to manipulate the scope to get a clearer view. By September, our analysis of camera-derived data indicated a group of five to eight burrows that likely contained chicks, based on the consistency of visitation and behaviors being exhibited by adults, such as food delivery (Figure 8).

On October 10, when it became evident that game camera data alone would not be sufficient to unequivocally confirm chick presence, we opened and examined the eight nest boxes that most likely contained chicks (plus an additional seven nest boxes that were still very active during much of 2019). Anticipating the presence of chicks at these eight nest sites, we coordinated with the Maui Nui Seabird Recovery Project, which we were informed possessed permits for banding Newell's shearwaters and Hawaiian petrels. Our hope was to band chicks prior to fledging. To our surprise, we found no chicks in the eight nest boxes examined. Unsatisfied, we returned two days later to conduct a more thorough evaluation of the contents of each nesting burrow. We carefully inspected the contents, including the inner surfaces of the nest boxes, nesting materials, and substrate on the floor of the nest boxes. We discovered evidence for the presence of chicks, including downy feathers and down filaments (i.e. filoplume-like), egg shell fragments, egg membrane, and indication that at least two pairs of birds layed a second egg which presumably hatched a chick that fledged (A-43 and B-50). One of the nest boxes (A-22) that we inspected on the second day did in fact contain a chick, which apparently was occupying the nest passageway and not the nest box, and thus was not visible to us on the first inspection (Figure 9). In total, strong evidence indicated that five shearwaters fledged from the site in 2019.

5.2 Hawaiian Petrels

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. In 2016, after it first 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 apparently returned to species-specific calls being broadcast in the two respective enclosures, and indeed Hawaiian petrels were observed on the ground, briefly, in 2017. As our data and observations indicate, the quality and character of the recorded call playback sequences are very important. Prior to July 2019, we thought it problematic to expect both species to establish equally successful nesting colonies intermixed or in close proximity given the more aggressive behavior exhibited by Newell's shearwaters. Newell's shearwaters have responded favorably to audio playback of the species' recorded calls, and as indicated by the camera data, may, at times, fiercely protect a chosen nest site (Figure 10).

Hawaiian petrels and Newell's shearwaters both visited the "uluhe" burrow in 2017, but petrels have not been documented there since. The reasons for their absence are unclear but may relate to several factors including competition with Newell's shearwaters, social attraction response sensitivity, habitat or other variables (including ecological processes at sea). In an effort to better understand factors most influencing the recruitment capacity of Hawaiian petrels and to evaluate whether petrels might exhibit response patterns similar to Newell's shearwaters, we refined the recorded call playback sequence and broadcast the new recordings from 4 additional speaker horns beginning in early July, 2019.

Figure 8. An Adult Newell's Shearwater Delivering Food to a Chick at the Entrance to Burrow A-22 at the Makamaka'ole Seabird Mitigation Area, September 20, 2019

Figure 9. Newell's Shearwater Chick at Rest Shortly before Fledging from Artificial Nest Box A-22 at the Makamaka'ole Seabird Mitigation Area, October 2019

Figure 10. Newell's Shearwater, Possibly a Male, Exhibiting Territoriality

An interesting event cycle occurred in Enclosure B approximately five weeks after the system upgrades were implemented in early July, 2019. On August 14 we discovered that 11 of the burrows in Enclosure B had received visitation, including the "uluhe" burrow, indicated by toothpick displacement and fresh guano. Given that Hawaiian petrels have not been detected landing and exploring burrows in this area since 2017, the observation was a welcome surprise. At that time, we took pictures and inspected the entrances of each burrow where toothpicks had been displaced (indicative of birds passing through the entrance) and then replaced the toothpicks. Two days later, on August 16, three of these burrows were visited again, indicated by toothpick displacement. At the time, all of our covert IR game cameras were in place monitoring other active burrows. Therefore, we determined which of those boxes were least likely to contain active breeding, and redeployed three cameras in Enclosure B in an effort to document the species that was newly exploring the burrows. Unfortunately, the pattern of visitation at burrows in Enclosure B became highly variable and, because we didn't have enough cameras to deploy at each of these newly visited burrows, we were unable to document species. The fact that visitation in Enclosure B rapidly diminished was not a surprise because, based on the breeding season phenology exhibited by Hawaiian petrels, colony attendance by pre-breeding birds would be expected to have already started to decrease for the season (Simons 1985).

The wave of visitation we observed in Enclosure B indicates to us that these birds may have been Hawaiian petrels, for several reasons. First, the system in Enclosure B is only playing Hawaiian petrel calls. The Newell's shearwaters that occupy burrows B-22 and B-50 began establishing these sites in 2015-2016 and are well-stablished. However, there has been no further effort exhibited by Newell's shearwaters to establish nest sites in this enclosure since that time, despite the significant concurrent increases evident in Enclosure A. Second, the response by seabirds in Enclosure B (and Enclosure A) coincided closely with the installation of additional speaker horns, playing species-specific calls. This is important, and encouraging, because the systems in each enclosure are species-specific with the objective being to minimize interspecific competition and maximize reproductive capacity for each species. One of the burrows that was visited in the initial wave of visits in August, the "uluhe" burrow, has a history of visitation beginning with Newell's shearwaters in 2016 and including both species at this site in 2017. All of the nest boxes that showed signs of visitation were adjacent to newly installed speaker horns, consistent with the pattern we observed in Enclosure A.

Notwithstanding the promising recruitment success in Enclosure A with Newell's shearwaters along with the active nest sites at B-22 and B-50, we did not observe nor confirm any new prospecting or nest site establishment by Newell's shearwaters in Enclosure B in 2019. Hawaiian petrels continue to be present based on nighttime observations of birds in flight over the area.

Section 6.0 Conclusions and Recommendations

6.1 2019 Breeding Performance

Based on the monitoring of nest-site visitation and evidence collected at nest sites in 2019, we conclude that five nest sites occupied by Newell's shearwaters produced young, which successfully fledged between mid-September and mid-October. Of the 22 total burrows that received visitation in 2019, 17 of these were visited consistently through September-October, while an additional 5 burrows were visited inconsistently, for periods lasting no more than three weeks, and are presumed to have been early prospectors. By the time the surge in nest site visitation occurred, consistent with the system upgrades (more speakers, recorded call playback refinement, rearrangement of decoys, etc.) in July, with the exception of burrow A-22, it was probably too late in the summer for new eggs to be laid. Seven nests remained active most of the season with visitation extending into early to mid-October. We observed a very small amount of feather material inside A-25 that resembled down. However, based on the criteria we applied in confirming successful fledgling production, we deemed this evidence to be insufficient to confirm a likely fledged chick. The late increase in nest box visitation is expected of subadults seeking to establish nests for use in subsequent seasons.

Although Hawaiian petrels were not directly observed landing and visiting nest sites in 2019, the evidence of late season visitation in Enclosure B indicates to us that at the very least this species may well have exhibited a renewed interest once the improvements we undertook were accomplished.

6.1.1 Recommendations

- Add an additional four 30 watt speaker horns to the sound playback array in Enclosure B in 2020 and begin broadcasting calls of Hawaiian petrels 2-3 weeks before initiating call playbacks of Newell's shearwaters in Enclosure A. This considers the fact that Newell's shearwaters appear to have reached a stage in site recruitment in which they will continue to return to their nest sites even in the absence of artificial social cues, at least initially, and may provide an initial advantage for first time prospecting Hawaiian petrels to initiate nest site establishment ahead of Newell's shearwaters.
- Acquire new sound recordings of Hawaiian petrels at the Makamaka'ole site, Haleakala, and/or the island of Lanai to improve call playback quality and consistency with local call dialects; phase these recordings into the playback sequences by March-April, 2020.
- Obtain a new burrow scope equipped with IR capacity and plan to open and inspect nest boxes in late August, in order to confirm the presence of chicks and ensure that birds are banded well in advance of anticipated fledging dates.

6.2 Nest Box Design

The nest boxes at Makamaka'ole were installed initially in accord to experience with petrels in New Zealand, and with little consideration for possible differences in how Newell's shearwaters and Hawaiian petrels might utilize the structures. There was little reason at the time to believe that design attributes would have any measurable effect on nest site establishment and breeding performance for these two species, given the success of similar efforts in New Zealand (where principal consultant, Steve Sawyer, conducted similar work). However, we observed a significant amount of variability in the behavior of the Hawaiian species at different nest sites, and this became increasingly evident as the season progressed, especially during the chick provisioning period. Some of this variability included how much time birds spent at the entrances, outside the burrows, resting inside the lower portion of the burrow passages, or whether birds quickly entered burrows and did not emerge again until they departed the site. On the other hand, these differences in behavior may have been related to differences in configurations of the burrow structures. For example, the adult birds that occupied A-22 frequently performed many of their exchanges with the chick near the entrance, indicating to us that the chick may have spent considerable time inside the burrow passage rather than inside the nest box. There is also the possibility that the temperature was lower inside the passage, which is insulated by substrate; not every nest box contained an insulated cover in 2019. This is further indicated by the fact that we did not initially observe the chick at A-22 when we opened the box for the first time in October, but discovered its presence two days later. This led to the idea that perhaps Newell's shearwaters may not require nor necessarily prefer as long a passage that existing design offered between the burrow entrance and the nest box chamber. In contrast, burrow A-43 contained a somewhat steeper gradient between the entrance and the nest box chamber and the nest box also was equipped with an insulated cover. This nest box contained copious amounts of feathers and guano, indicating the chick and the adults probably spent considerable time inside the box. We believe that in the near future some modifications of nest boxes in both enclosures may be warranted to understand better the effects of these potential factors.

6.2.1 Recommendations

- Consider modifying the burrow passages on some of the burrows in Enclosure A by shortening the length of the passage and/or adjusting the angle between the entrance and the nest box.
- Construct and install insulated nest box covers to bring temperatures in the nest box chamber in alignment with the temperatures inside the passage, or alternatively, install newly fabricated nest boxes partially below ground level, allowing the nesting chambers to approximate subsurface temperatures.
- Replace worn nest boxes with newly fabricated nest boxes and install these (and any refinements in the burrow passages) well before the first birds are expected to arrive in late March-early April. In this way, the nest site and adjacent ground cover and habitat would have time to recover sufficiently from disturbances to the substrate resulting from these modifications.

6.3 Predator Control

Control of predators needs to remain as an important component for the long term success of the Makamaka'ole project. This is especially true as the seabird populations within the exclosures increase, and become more attractive especially to owls. Adaptive measures should be used whenever changes that might affect success are identified. One of the more apparent examples we observed in 2019 relates to the seasonal variability in rodent activity inside the enclosures. As discussed, we believe there is reason to suspect that, although density of rodents is very low most of the year, there is a seasonal uptick that occurs in late summer through fall. Combined with some degree of habituation or aversion to trap baits (peanut butter, nuts, coconut, etc.) and possibly the development of aversion to Ramik bars containing diphacinone, it may be necessary to explore rotational alternatives to address the latter.

6.3.1 Recommendations

- Explore the use of a secondary formulation of diphacinone or use of an alternative agent if deemed warranted to deal with the potential of aversion in rodents that may reside inside the enclosures and obtain approval by the U.S. Fish and Wildlife Service and the Hawaii Division of Forestry and Wildlife for a change in protocol for the use of a secondary rotational or alternative agent that can be applied within the scope of the management plan to control rodents.
- Remove all caches of materials associated with initial fence construction which remain inside the enclosures, such as bags of sand, lumber, tarps, and any items that may provide shelter for rodents.
- Invite the expertise of two Barn owl control experts with whom we established communication in 2019, to visit the site, and advise on most effective management methods and approach to efficiently address the issue of Barn owl control at Makamaka'ole going forward.

6.4 Fence Maintenance

Both fenced enclosures have been in place for nearly seven years and certain portions are beginning to wear out. The areas affected most at this time are in the upper windward sections, where salt-laden air carried by the prevailing trade winds and rainfall is more frequent and the steepness of the terrain increases. The wear is most apparent in the meshing and bases of wooden uprights, and there are numerous hood brackets that have rusted and should be replaced concurrent with other repairs. Some of the repair work is considered proactive in order to avoid later damage or failures while other actions that are necessary should address immediate repair priorities. Some immediate repairs are being performed on an interim level, while other measures should include replacement and reconstruction of specific structural features in anticipation of the 2020 season.

We will provide a supplemental assessment that will detail and better characterize fence damage observed to date and quantify the fence maintenance and repair needs for both enclosures so that planning for these needed actions can commence. It is likely that mesh needn't be as high as it is currently, and thus could also reduce costs associated with replacement. But that option needs to be considered further before being introduced.

6.5 Important Considerations

The addition of more speaker horns should enhance recruitment capacity of seabirds at Makamaka'ole. Rather than deliver one call sequence for the entire season, we believe there is merit in considering the phasing in of playback sequences that better represent petrel call variability that occurs as the season progresses. Given the present status and trends being observed with Newell's shearwater recruitment in Enclosure A, increasing the attractiveness of Enclosure B for Hawaiian petrels may well demonstrate that petrels are able to become established, without compromising or reducing the overall performance trajectory of Newell's shearwaters. We are looking forward to determining whether this will be true. Meanwhile we expect accelerated growth of Newell's shearwater occupation in Enclosure A.

The number of active Newell's shearwater burrows, and especially the dramatic 2019 increase, is impressive, as after a slow start, these results indicate an acceleration toward meeting mitigation targets, for this species, consistent with the models developed to guide the initial permitting process; such models predicted the likely success of the Makamaka'ole project to achieve its goals (H. T. Harvey & Associates 2011a and 2011b). Given the sudden jump from partial success to a season in which several nests produced young, we believe that the alterations that we introduced were involved. This is one of the only projects anywhere, and certainly in Hawaii, in which demographic models constructed prior to conservation action are being tested in real time. We believe it will be instructive to revisit those demographic models and examine the degree to which the project is on a track, based on theory, toward correctly predicting performance of seabird populations assisted by management actions. The number of active Newell's shearwater burrows at Makamaka'ole, following a dramatic increase in 2019, is now within the rather broad modeled 20-70 active burrow range used to estimate net benefit (number of birds produced) under the reasonable (preferred) starting point scenario (H. T. Harvey & Associates 2011a). Whether the Hawaiian petrels at Makamaka'ole will likewise catch up, following revised management actions, remains to be seen.

Section 7.0 References

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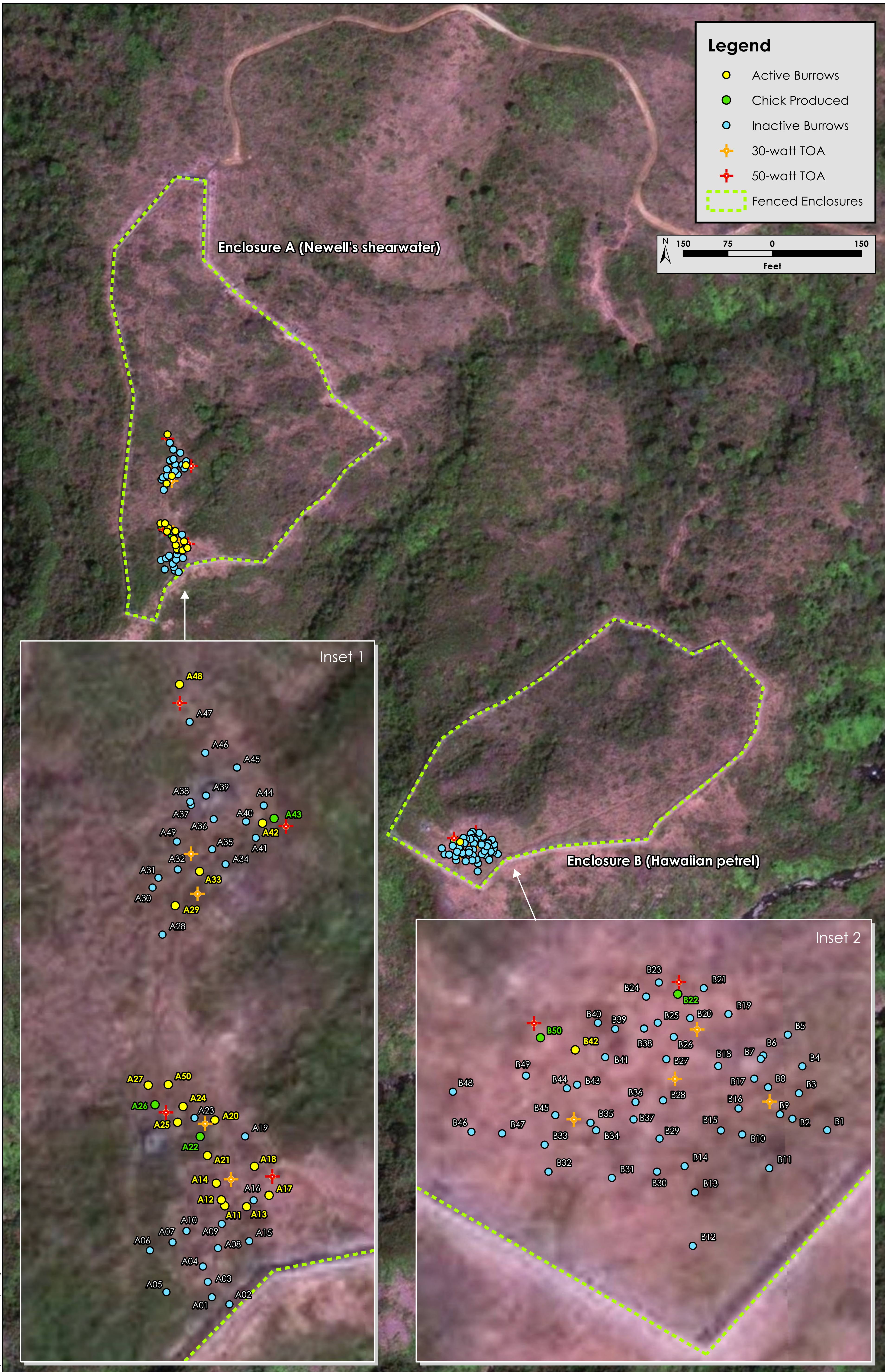
Appendix A. Distribution of Active, Inactive, and Chick Producing Burrows at Makamaka'ole in 2019



H. T. HARVEY & ASSOCIATES
Ecological Consultants

Appendix A. Distribution of Active, Inactive, and Chick Producing Burrows at Makamaka'ole in 2019
Makamaka'ole Seabird Mitigation (3978-02)
January 2020

Appendix B. Summary of Nocturnal Avian Surveillance 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 patterns and timing of arrival.	No owls observed. Very dark, mostly overcast, intermittent drizzle late.
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	One Barn owl detected at about 19:15; approached from lower gulch – flew directly to the lure

Date	Day	Time	Location	Objective	Summary
				lure); observe owl response.	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 structure relative to hunting position; surveillance for owls and seabirds after sundown.	Seabirds active; no owls observed.
7/2/19	Tuesday	Dusk, early evening	Enclosure B deck and road outcropping	Surveillance for owls and seabirds after sundown.	Seabirds active; no owls observed.

Date	Day	Time	Location	Objective	Summary
		(18:45-20:30)			
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.

Appendix C. Nest Box Inspection Photos for Active Burrows in 2019

Nest Box A-11 Contents on October 10, 2019 Consisted of Sparse Nesting Material with Little Evidence of Activity Inside the Nest Box by Shearwaters

Nest Box A-12 Contents on October 10, 2019 Consisted of a Small Amount of Nesting Material, Feathers, and Dried Guano. No Eggshell, Membrane, or Down was Found

Nest box A-13 contents on October 10, 2019 consisted of nesting material and feathers. No eggshell, membrane, or down was found.

Nest Box A-14 Contents on October 10, 2019 Consisted of a Small Amount of Nesting Material and Feathers. No Eggshell, Membrane, or Down was Found

Nest Box A-18 Contents on October 10, 2019 Consisted of a Small Amount of Nesting Material and Feathers. Some Larger Stones were Excavated and Moved to the Center of the Nest by the Birds. No Eggshell, Membrane, or Down was Found

Nest Box A-20 Contents on October 10, 2019 Consisted of Copious Nesting Material and Some Feathers. No Eggshell, Membrane, or Down was Found

Nest Box A-21 Contents on October 10, 2019 Consisted of a Small Amount of Nesting Material, Some Feathers, and Guano. No Eggshell, Membrane, or Down was Found.

Newell's Shearwater Chick was Discovered in Nest Box A-22 on October 14, 2019. The Nest Box also Contained a Small Amount of Nesting Material, Some Feathers, Guano, and Sparse Down. No Eggshell or Membrane was Found

Nest Box A-24 Contents on October 10, 2019 Consisted of Nesting Material and Feathers. No Eggshell, Membrane, or Down was Found

Nest Box A-25 Contents on October 10, 2019 Consisted of Nesting Material, Feathers, and Few Small Down-Like Feathers. No Eggshell or Membrane was Found

Nest Box A-26 Contents on October 14, 2019 Consisted of Nesting Material, Feathers, Down, Eggshell Fragments, and Membrane

Nest Box A-42 Contents on October 10, 2019 Consisted of Nesting Material and Feathers. No Eggshell, Membrane, or Down was Found

Nest Box A-43 Contents on October 10, 2019 Consisted of Copious Nesting Material, Feathers, a Complete Intact Egg, Eggshell Fragments from a Second Egg, and Down Scattered throughout the Nest Bowl

Nest Box A-48 Contents on October 10, 2019 Consisted of Nesting Material and Feathers. No Eggshell, Membrane, or Down was Found

Nest Box B-22 Contents on October 11, 2019 Consisted of Nesting Material, Feathers, Down, and Eggshell Membrane

Nest Box B-50 Contents on October 11, 2019 Consisted of Nesting Material, Feathers, and Down. No Eggshell or Membrane was Found

Nest B-50 Entrance Passageway Margin Inside the Nest Box Encrusted in Down on October 16, 2019

APPENDIX 7. SUPPLEMENTAL MAKAMAKA'OLE 2019 BREEDING SEASON MEMORANDUM

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TETRA TECH

MEMO

To:	Lasha Salbosa, U.S. Fish and Wildlife Service Lauren Taylor, State of Hawai'i Division of Forestry and Wildlife
From:	Tetra Tech, Inc.
Date:	June 2020
Correspondence #:	TTCES-PTLD-2020-081
Subject:	Makamaka'ole Seabird Mitigation Site – 2019 Breeding

1.0 Introduction

TerraForm Power, LLC (TerraForm) owns and operates the Kaheawa Wind Power I, LLC (KWP I) and Kaheawa Wind Power II, LLC (KWP II) facilities at Kaheawa Pastures, West Maui. In accordance with the state- and federally approved Habitat Conservation Plans (HCPs) for both projects, a final mitigation plan was approved in January 2012 to establish seabird nest sites protected by two separate predator-resistant enclosures (KWP I 2006, SWCA 2011). These nest sites are intended to attract Hawaiian petrels (*Pterodroma sandwichensis*) and Newell's shearwaters (*Puffinus newelli*), and to provide a net conservation benefit to mitigate for the estimated take of both species at KWP I and KWP II. Together, the two nest site enclosures are known as the Makamaka`ole Seabird Mitigation Site (Makamaka'ole) and encompass approximately 7.9 acres.

On September 5, 2013, KWPI and KWPII completed construction of the two enclosures at Makamaka'ole. The first documentation of Newell's shearwater and Hawaiian petrel at Makamaka'ole occurred in 2014. Beginning in 2017 and in each year thereafter, Newell's shearwater attempted to nest, producing three or more eggs observed per year. The first Newell's shearwater fledging success at Makamaka'ole was documented in 2019.

During the semiannual HCP implementation meeting with the U.S. Fish and Wildlife Service (USFWS) and the State of Hawai'i Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) (collectively, "the agencies"), DOFAW requested additional documentation of reproductive success beyond that provided in the Makamaka'ole Seabird Mitigation Project 2019 Final Report (H.T. Harvey 2019), an annual report provided to the agencies in April 2020. This memo therefore serves as a supplement to that annual report, clarifies interpretation of results, and provides additional context relevant to the determination of successful fledging.

2.0 Methods

2.1 Statewide Standards for Fledging Success

Evaluation of success for the Makamaka’ole is described in the KWP II HCP (SWCA 2011); however, the HCP did not include descriptions of specific definitions for determining nesting activity and burrow fledging success. The monitoring methods and assessment criteria used at Makamaka’ole in the 2019 season report are consistent with monitoring methods and assessment criteria used throughout the state of Hawaii (Simons 1985, Haleakalā National Park 2019, Tetra Tech 2018, Chen et al. 2019, DOFAW 2020). Since fledging success is determined by monitoring burrow activity, multiple monitoring methods are used at Makamaka’ole to document burrow activity and fledging success and the collective dataset is evaluated to assess burrow activity and fledging success (described below in Section 2.2). Statewide the assessment of fledging success is determined by the number of burrows active during the fledging period of September and October where there are no indications of depredation. Signs of an active burrow include the following:

1. Weekly burrow visitation by adults
    a. Feathers
    b. Scent
    c. Toothpick movement
    d. Droppings
    e. Tracks
    f. Game camera activity
2. Evidence of breeding
    a. Egg or egg fragments
    b. Down feathers
    c. Chick observations
    d. Parental feeding of chicks

Evidence that suggests a burrow did not produce a fledged chick may include one or more of the following:

1. Evidence of chick mortality
    a. Documented predation
    b. Chick remains observed
2. Occupied by non-breeding adults
    a. Absence of signs of nesting as defined above
    b. Infrequent visitation
    c. Early departure from the colony, before September or October

2.2 Site-Specific Considerations for Makamaka’ole

During colony establishment, seabirds are sensitive to disturbance. Disturbance of breeding individuals could have substantial detrimental impacts, prompting outcomes including nest and site abandonment. Therefore, the desire for monitoring to be as comprehensive as possible must be balanced against the disturbance it may cause. At Makamaka'ole, establishment of the colony was and remains the highest priority. This entails minimizing human-made noise and minimizing disturbance such as burrow scoping, opening burrow boxes, and banding until late in the breeding season at the potential expense of additional documentation.

The conclusions reached by the ecologists managing Makamaka'ole (see the Results section below) represent the combined evidence as described above. Any single line of evidence may not be sufficient to determine the outcome of a burrow, but the use of multiple methods provides multiple opportunities to recognize signs of both successful fledging young and failed nesting attempts. Late-season activity is the strongest indicator of breeding activity because non-breeding individuals typically depart the colony prior to the fledging period. In the absence of evidence of chick mortality, the presence of a chick, indicated by observation, egg fragments, down, or daily adult visitation late in the breeding season, are indicative of successful fledging. The uncertainty in monitoring comes as a result of prioritizing colony establishment. The outcome of the burrows may not be known with certainty, but the evaluation of success at Makamaka'ole is consistent with methods and criteria used elsewhere for measuring fledging success of seabirds, including at mitigation sites.

3.0 Results

Observations from the 2019 breeding season indicate that five Newell's shearwaters fledged from the Makamaka'ole. Table 1 describes multiple lines of evidence that support the determination of fledging success from the on-site ecologist. For completeness, we have included data associated with the assessment of Burrow Number A-25 because this burrow showed several lines of evidence suggesting the possible production of young.

Table 1. Evidence of Newell's Shearwater Fledging Success from Burrow Monitoring at the Makamaka'ole Seabird Mitigation Site in 2019

Burrow Number	Active in Previous Season(s)	Weekly Adult Visitation[1]	Chick Observed	Evidence of Breeding	Evidence of Possible Nest Failure	Final Status
A-22	No	July–October 14	Yes	Down, Guano, Nest Material, No Egg	None	Successfully Fledged
A-25	No	April–October 5	No	Possible Down, Guano, Nest Material, No Egg	None	Non-breeder/ Failed
A-26	Yes	April–October 5	Yes	Down, Guano, Nest Material, Egg Fragments	None	Successfully Fledged
A-43	Yes	April–October 14	No	Down, Guano, Nest Material, Egg Fragments	Second egg observed in burrow	Successfully Fledged
B-22	Yes	April–September 5	No	Down, Guano, Nest Material, Egg Fragments	None	Successfully Fledged
B-50	Yes	April–October 7	No	Down, Guano, Nest Material, No Egg	None	Successfully Fledged

1 Documentation of activity is determined by one or more of the following: game camera observations, toothpick activity, scent, guano, feathers, tracks, or other signs of activity.

4.0 Revised Procedures

The lessons learned from prior years of management at Makamaka'ole will improve monitoring and decrease uncertainty in the future. Changes to the field methods and management of data collected as the result of these lessons include:

- Modifications to game camera use:
  - Position game cameras to capture burrow entrances. Through the breeding season, Newell's shearwater chicks did not exit the tunnels; therefore, capturing mid-season activity may necessitate photos capturing tunnel entrances where possible.
  - Monitoring requirements may be different for different times of year, requiring cameras to be moved as appropriate for breeding phenology and project needs. When cameras are placed close to burrows, non-animal triggering of game cameras is reduced, and details such as burrow entrances can be captured; however, seabirds sometimes move rapidly past the cameras, resulting in movements being missed. Moving cameras further from the burrows results in the camera being triggered by grass and shadow movement, but allows for the capture of a larger area.
- Burrow examination:
  - Using a burrow scope to examine the tunnel will provide additional evidence of the presence or absence of a chick since they may remain in the burrow entrance tunnel if boxes are opened.
  - Burrows that produced chicks vary in the type and quantity of evidence (down, egg fragments, or otherwise), and multiple lines of evidence must be used to determine fledging success where single observations do not clearly document success or failure. Adjustments to game camera deployment, the timing of late-season burrow checks, and possible use of burrow scopes should increase the confidence in nesting success assessments.
- Data review:
  - Subcontractor data will be reviewed and compiled monthly to ensure data transfer and that appropriate documentation of nesting success are collected and shared.

5.0 Conclusions

Makamaka'ole has demonstrated the success of predator control and social attraction for the Newell's shearwater. During the 2019 breeding season, five Newell's shearwater nests showed burrow activity patterns consistent with successful fledging based on assessment criteria used to evaluate mitigation success at other sites in Hawai'i. The continued growth of the colony as shown by the increasing number of Newell's shearwaters illustrates that the cautious approach to monitoring has had a negligible impact on nesting seabirds. TerraForm has provided documentation of the evidence used to support these successes and will provide additional documentation from H.T. Harvey, if available. Based on Tetra Tech's review of the standards applied to measure fledging success at other similar projects, the evidence presented in the 2019 Final Report's conclusions (H.T. Harvey 2019), and supplemented in this memo, is consistent with the standards used to measure fledging success throughout the state.

Tetra Tech is working with the Maui Nui Seabird Recovery Project to ensure that the lessons learned from 2019 are applied to work being performed in 2020. TerraForm expects that the application of these lessons will improve the documentation of fledging success in 2020.

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