Kaheawa Wind Project II
Habitat Conservation Plan
FY 2022 Annual Report

Prepared for:

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

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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 Hawaiʻi fiscal year 2022 (FY 2022; July 1, 2021– June 30, 2022) 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 (Hawaiian hoary bat and Hawaiian goose) 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; Covered Species) 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 2022 continued within search plots limited to cleared areas within 70 meters of each Wind Turbine Generator. Canine teams searched 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 2022, probabilities of a carcass persisting until the next search were 0.64 (bat surrogates), 1.00 (Hawaiian goose surrogates), and 1.00 (seabird surrogates). Searcher efficiency was 0.94 for bat surrogates, and 1.00 for the Hawaiian goose and seabird surrogates.

Two fatalities of Covered Species were found at KWP II during FY 2022: two Hawaiian geese were detected in September 2021 and January 2022. Through FY 2022 and excluding incidental detections, the Project's total observed direct take of Covered Species has been three Hawaiian hoary bats and nine Hawaiian geese. No Covered seabird Species (Hawaiian petrel and Newell's shearwater) have been detected as fatalities at the Project to date. The fatality estimates using the Evidence of Absence estimator at the upper 80 percent credibility level are 11 for the Hawaiian hoary bat and 25 for the Hawaiian goose (plus one gosling fatality attributable to Project operation, but not related to the effects of wind turbine operation analyzed using the Evidence of Absence estimator). Indirect take estimates for the Covered Species are one adult equivalent for the Hawaiian hoary bat and one adult equivalent for the Hawaiian goose. Combining direct and indirect take estimate values, there is an approximately 80 percent chance that cumulative take of Covered Species at the Project from the start of operations through FY 2022 was less than or equal to 12 Hawaiian hoary bats and 27 Hawaiian geese (includes one gosling).

The bat acoustic monitoring program data captured bat activity across the Project at five detector locations throughout FY 2022. Hawaiian hoary bats were detected on 163 of 1,780 detector-nights (9.2 percent of detector-nights). The seasonal pattern of detection rates demonstrated an increase in January which was unique when compared with previous years.

Mitigation commitments to offset the take of Covered Species are ongoing. Current estimated take for the Hawaiian hoary bat is within the Tier 3 limit of the HCP. Tier 3 mitigation has been fully

funded and began in FY 2018 through a contract with the U.S. Geological Survey's Hawaiian Hoary Bat Research Group to conduct bat ecological research on Hawaiʻi Island. This project is expected to be complete in FY 2023. Current estimated take for the Hawaiian goose is within the Tier 2 limit of the HCP. KWP II is currently working with DOFAW and USFWS on a plan to transfer mitigation activities to the Haleakalā Ranch release pen from the Piʻiholo Ranch release pen. This action would include taking on management of the mitigation program at the Haleakalā Ranch release pen in lieu of funding DOFAW to perform the work. No mitigation was carried out for the project in FY 2022 due to a change in ownership at the former mitigation site (Piʻiholo Ranch). KWP II is actively working with DOFAW and USFWS to adaptively manage the Hawaiian goose mitigation program. In FY 2022, KWP II, DOFAW, and USFWS reached consensus on mitigation credits attributable to the Project. No observed take has occurred for Covered Seabird Species, with both species 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 as well as implementation of predator control efforts at a Hawaiian petrel breeding colony on Lānaʻi. KWP II continues to work with wildlife agencies to assess overall benefits of KWP II's seabird mitigation projects.

KWP II communicated actively with USFWS and DOFAW throughout FY 2022. The communication was conducted through conference calls, submittal of quarterly reports, and email communications related to the Project's HCP. No in-person meetings were conducted in FY 2022 due to ongoing COVID-related restrictions. Communications content included focused discussions regarding mitigation projects, mitigation funding, Hawaiian goose minimization measures, and the evaluation of mitigation benefits.

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1.0 Introduction

The Hawai'i Department of Land and Natural Resources, 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; September 2019 and amended ITL-15; November 2019). 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 hoary bat or ʻōpeʻapeʻa (*Lasiurus cinereus semotus*)[1];
- Hawaiian goose or nēnē (*Branta sandvicensis*)[1];
- Hawaiian petrel or ʻuaʻu (*Pterodroma sandwichensis*); and
- Newell's shearwater or ʻaʻo (*Puffinus newelli*).

The Project was constructed in 2011 and 2012 and was commissioned on July 2, 2012. Brookfield Renewable Partners, LP acquired the Project's LLC through acquisition of a controlling interest in TerraForm, LLC in 2017; the Project continues to be operated by Kaheawa Wind Power II, LLC (KWP II).

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 2022 fiscal year (FY 2022; July 1, 2021–June 30, 2022) pursuant to the terms and obligations of the approved HCP, ITL, and ITP. The Project has previously submitted annual HCP progress reports to DOFAW and USFWS for FY 2013 through FY 2021 (KWP II 2013, KWP II 2014, KWP II 2015, KWP II 2016, KWP II 2017, KWP II 2018, Tetra Tech 2019, Tetra Tech 2020, Tetra Tech 2022).

2.0 Fatality Monitoring

Since operations began in July 2012, 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. 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 70-meter radius 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). This search area continued to be used for monitoring in FY 2022.

In FY 2022, all 14 WTGs were searched for fatalities once per week. The FY 2022 mean search interval for all WTGs was 7 days (Standard Deviation = 0.2 days); no search dates were missed; one date was adjusted due to extreme weather. All search plots were searched by a canine search team which included a trained detector dog accompanied by a handler; no visual-only searches occurred in FY 2022.

Special precautions have been taken to eliminate any potential canine interactions with wildlife, with a focus on the Hawaiian goose. If Hawaiian geese were present nearby by, the canine handler immediately retrieved and restrained the dog to avoid disturbing the bird(s), and either postponed searching in the vicinity of the bird(s), worked on leash away from any geese, or temporarily skipped canine searches in the vicinity. A total of 94 individual Hawaiian geese were observed over 40 days in FY 2022 (single individuals may have been observed over multiple dates). Hawaiian geese were observed by the canine handler in each month, with the exception of October, May, and June. In each case, the handler moved the canine to a different WTG search area and returned to finish the disrupted search later in the day. No canine-wildlife interactions were observed.

3.0 Carcass Persistence Trials

One 28-day carcass persistence trial (including 10 individual carcasses of each size class) was conducted in each quarter of FY 2022, for a total of four trials. Trials used black rats (*Rattus rattus*) for Hawaiian hoary bat surrogates, large chickens (*Gallus gallus*) for Hawaiian goose surrogates (i.e., large birds), 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 2022, the probability that a carcass persisted until the next search was 0.64 for all bat surrogates (95 percent Confidence Interval [CI] = 0.47, 0.79; N=20), 1.00 for large birds (95 percent CI = 0.97, 1.00; N=10), and 0.99 for medium-sized birds (95 percent CI = 0.88, 0.99; N=10).

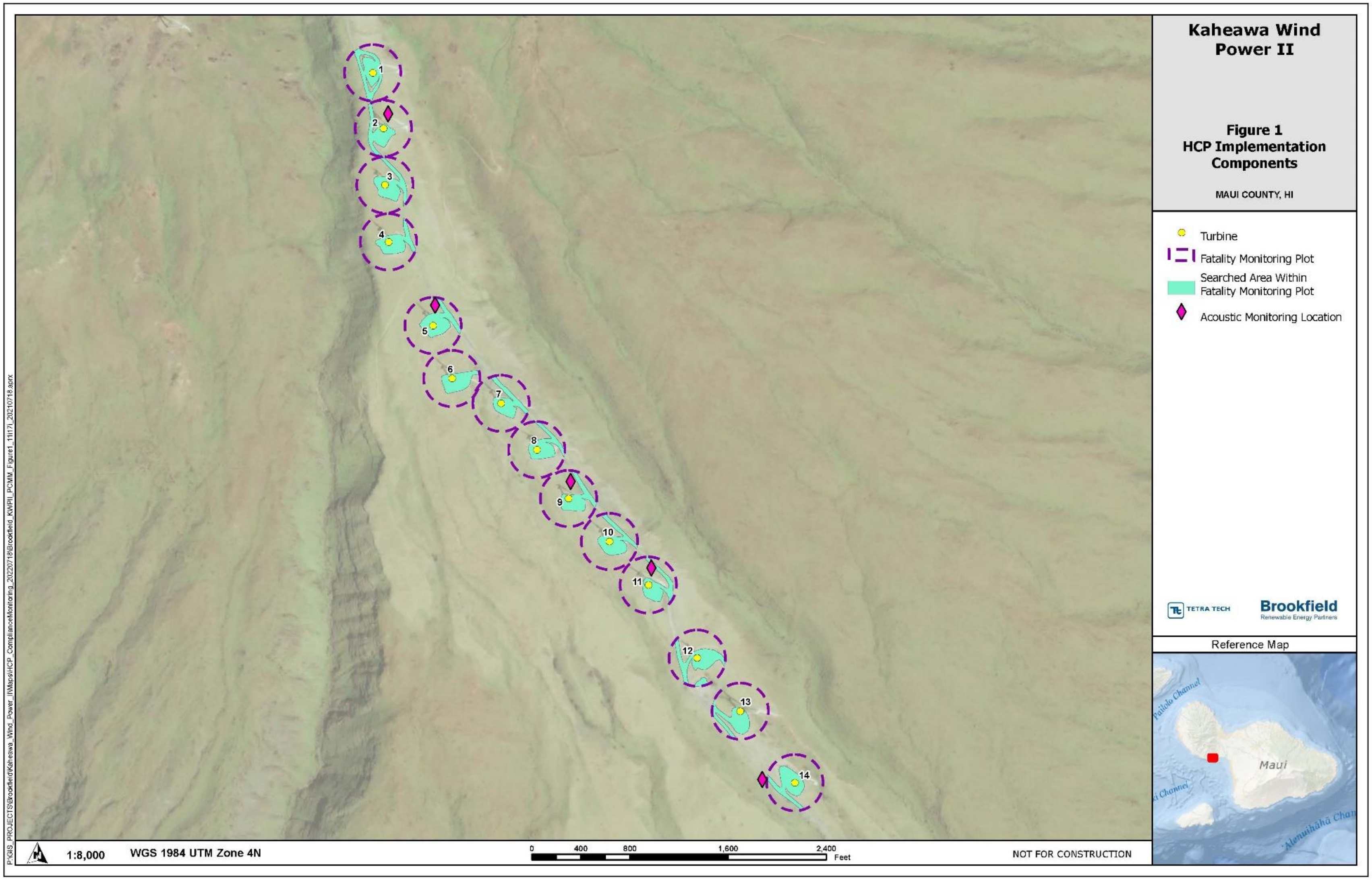

Figure 1. HCP Implementation Components

4.0 Searcher Efficiency Trials

A total of 71 individual searcher efficiency carcasses (trial carcasses) over 21 trial dates were administered during FY 2022. Similar to the carcass persistence trials, black rats were used as surrogates for bats, large chickens were used as surrogates for the Hawaiian goose, and wedge-tailed shearwaters and other medium-sized birds collected or procured under the Project's Special Purpose Utility Permit (MB22096C-0) were used as surrogates for Covered Seabird Species. Searcher efficiency trials occurred approximately twice monthly throughout the year; all trials tested canine search teams in FY 2022 (no visual only searches occurred in FY 2022). Of the 71 trial carcasses placed, six bat surrogates and one wedge-tailed shearwater were not available for detection.

For FY 2022, the probability that a canine search team would find a carcass was 1.00 for bat surrogates (95 percent CI = [0.93, 1.00]; N=38), 1.00 for large birds (95 percent CI = [0.83, 1.00]; N=13), and 1.00 for medium-sized birds (95 percent CI = [0.83, 1.00]; N=13).

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 management activity restrictions during the Hawaiian goose nesting season. The evolution of activity includes:

- Initial vegetation management activities within the search plots were 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.
- In September 2021, Stephanie Franklin of DOFAW-Maui verbally approved the continuation of the quarterly management program and woody vegetation removal using hand and power tools, and manual application of herbicide on cut stumps as necessary, in proximity to select turbines. Verbal approval was also given for additional woody vegetation removal within a 1-meter buffer of select turbine access roads. All work must be completed between April 1 and October 31 and in conjunction with a biological monitor.

In FY 2022, vegetation management was implemented at the Project in Q1, Q3, and Q4. During these quarters, a glyphosate-based herbicide treatments using a boom sprayer were applied to the cleared areas within each search plot, supplemented by weed whacking to maintain consistency of the extent of the cleared area within 70 meters of each WTG. In Q3 and Q4, application of herbicide occurred after the areas were deemed clear of Hawaiian goose activity by a biological monitor. KWP II anticipates removal of woody vegetation in proximity to select turbines in FY 2023.

6.0 Scavenger Trapping

KWP II implements 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 program includes a once-quarterly intensive trapping effort followed by ongoing biweekly (every other week) trapping effort. In FY 2022, trapping initially included the use of nine DOC250 body grip traps and six live traps placed throughout the Project. In Q3 FY 2022, KWP II increased the number of traps in use for each effort to address reduced probabilities of carcasses persisting the next search and provide additional protections to the Hawaiian goose. An addition of eight DOC250 and six cage traps were added for a total programmatic effort of 17 DOC250 and 14 cage traps. In FY 2022, the scavenger trapping program removed 16 mongooses (*Herpestes auropunctatus*), and 10 feral cats (*Felis cattus*). No non-target animals were trapped. This program also benefits the resident wildlife by reducing the potential for predation.

7.0 Documented Fatalities and Take Estimates

Take of two HCP Covered Species was documented in FY 2022: two Hawaiian geese (see Section 7.2). All observed downed wildlife were handled and reported in accordance with the Downed Wildlife Protocol provided by USFWS and DOFAW (USFWS and DOFAW 2020). No injured (live) downed wildlife was observed at the Project in FY 2022. One Hawaiian goose egg was discovered on December 15, 2021 on bare gravel at the base of a steep slope in proximity to WTG12 without damage to its shell. The egg was collected by DOFAW. Stephanie Franklin (DOFAW-Maui) concluded the egg was likely laid by an immature bird still progressing towards reproductive maturity. The egg discovery and collection were documented on an Endangered Species Collection form provided to DOFAW on December 16, 2021.

To calculate take estimates, the number of observed fatalities is scaled to account for fatalities that are not detected (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 searched. The search area for fatalities at the Project has evolved over time (Section 2.0); therefore, the proportion of the carcass distribution searched has varied historically. However, no change to the search plots has been made since FY 2016 (Section 2.0). Thus, the estimate of the proportion of the carcass distribution searched (DWP; 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 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, it is important to note that 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 Hoary Bat

7.1.1 Estimated Take

A total of four Hawaiian hoary bat fatalities have been observed at the Project since operations began in July 2012, with no take observed in FY 2022. Three observed bat fatalities have been found within the search area and are used to estimate UDT. One of the fatalities was classified as an incidental observation. All bat carcasses were transferred to the U.S. Geological Survey for genetic sexing (Pinzari and Bonaccorso 2018). Hawaiian hoary bat fatalities by fiscal year are listed in Table 1.

Table 1. Observed Hawaiian Hoary Bat Fatalities at KWP II through FY 2022

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
2021	0	0	0
2022	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 2022 (June 30, 2022) is less than or equal to 11 bats (80 percent UCL; Appendix 1a). Because one of the four observed bat fatalities was found outside of the search areas (i.e., incidental observation), three fatalities were used in the analysis; 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. Cumulative indirect take through FY 2022 remained the same as in FY 2021 at 0.47 adults (Appendix 2a).

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, rounded up from 0.47). That is, there is an approximately 80 percent probability that actual take at the Project at the end of FY 2022 is less than or equal to 12 bats (Appendix 1a).

7.1.2 Projected Take

KWP II projected take through the end of the permit term using the fatality monitoring data collected through FY 2022 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 3a). For this analysis, the detection probability for future years is assumed to match the detection probability of FY 2022 (Appendix 1a), and the fatality rate is unaltered for all future years (rho=1). Future indirect take is unknown and will potentially vary based on the timing of ODT. Therefore, based on historical Project data, we assumed total indirect take for the Project over the permit term would be a maximum of two adult equivalents (approximately six 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 4.1 percent (0.47 adult bat equivalents estimated from indirect take / 11.47 bats estimated combining the direct and indirect take), making the assumption of the indirect take of two adult bats conservative. Assuming two adult bat equivalents are attributed to the Project as indirect take, direct take allowable under the HCP would be 36 bats (permitted take of 38 bats – estimated take of two bats attributed to indirect take = 36 bats estimated direct take maximum).

Based on the analysis described above and presented in Appendix 3a, there is a 96.74 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, suggesting that even with an indirect take contribution of two adult equivalents, the Project is unlikely to exceed a cumulative take estimate of either 36 (permitted take – estimated indirect take) or 30 (Tier 3 threshold). Therefore, the Project is likely to remain below both the Tier 3 of Hawaiian hoary bat take threshold of 30 bats *and* the permitted take limit (38) for the permit term.

7.2 Hawaiian Goose

7.2.1 Estimated Take

A total of 14 adult Hawaiian goose fatalities and one gosling fatality have been observed at the Project since operations began in July 2012. Nine of the 14 observed fatalities have been found within the search area and are used to estimate UDT. Five of the 14 observed fatalities were classified as incidental observations. One gosling was detected in FY 2018; as the gosling was not capable of flight, it is not considered ODT. The observed Hawaiian goose fatalities by fiscal year are listed in Table 2.

Table 2. Observed Hawaiian Goose Fatalities at KWP II through FY 2022

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 [1]	4
2019	0	1	1
2020	3	0	3

Fiscal Year	Hawaiian Goose Observed Direct Take	Hawaiian Goose Incidental Fatality Observations	Total
2021	0	0	0
2022	1	1	2
Total	**9**	**5**	**14[1]**
1. Excludes one gosling detected in FY 2018 attributable to wind farm operations other than turbines.			

Two Hawaiian goose fatalities were detected at the Project in FY 2022. On September 1, 2021, one adult carcass was observed during a routine search approximately 1 meter from the base of WTG 7. This carcass was counted as ODT. On January 19, 2022, one adult carcass was observed outside of the delineated search area during a routine search. The carcass was 36 meters to the northwest from the base of WTG 4 in a vegetated area and detected in the later stages of decomposition. This carcass was counted as an incidental find based on its location; although this fatality is treated as attributable to the Project, wind direction data and carcass location suggest cause of fatality is inconclusive. DOFAW and USFWS were notified and provided downed wildlife reports for both carcasses, and both carcasses were ultimately collected from the Project by DOFAW.

The estimated direct take (ODT + UDT) based on the Hawaiian goose fatalities found between the start of operation (July 2012) and end of FY 2022 is less than or equal to 25 geese (80 percent UCL; Appendix 1b).

The gosling was then added as a single additional juvenile fatality, adjusted to an adult based on estimated survival rates ($1*0.8^3$); the gosling fatality translates to 0.512 adult equivalents. The gosling was added to the estimate of 25 geese at the 80 percent UCL that resulted from the EoA analysis for a total estimated direct take of 25.512.

Indirect take is estimated to account for the potential loss of individuals that may occur as the result of the loss of their parents. Both parents for the Hawaiian goose care for young well after post-fledging (Banko et al. 2020). The point during the breeding season when an adult is taken determines to what extent offspring may be affected (SWCA 2011). Cumulative indirect take through FY 2022 was 1.59 fledglings (0.82 adult equivalents, assuming a 0.8 annual survival rate and 3 years from fledging to adult; Appendix 2b).

Thus, the UCL for cumulative Project take of the Hawaiian goose at the 80 percent credibility level is 27 geese (25 [estimated direct take from EoA] + 1 observed gosling fatality*0.512 adults/gosling + 0.82 [estimated adult equivalent indirect take], rounded up). That is, there is an approximately 80 percent probability that actual take at the Project at the end of FY 2022 is less than or equal to 27 adult geese.

KWP II, USFWS, and DOFAW reached consensus on mitigation credits attributable to the Project in FY 2022. The total mitigation credits sum to 14.56 fledglings and 1.63 adults and are distributed annually as indicated in rows H and I of Appendix 2b. Per the HCP, 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). Accrued lost productivity is presented in Appendix 2b.

7.2.2 Projected Take

KWP II projected Hawaiian goose take through the end of the permit term using the fatality monitoring data collected through FY 2022 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. Future indirect take is unknown and will potentially vary based on the timing of ODT. Based on historical Project data, 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 4.54 percent of the permitted take limit in the HCP. Currently, the proportion of total take that is attributable to indirect take is 3.11 percent (0.82 adult geese equivalents estimated from indirect take / 26.33 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 (permitted take of 44 geese – take of 2 geese estimated attributed to indirect take = 42 geese estimated direct take maximum).

Based on the analysis, there is approximately 30 percent probability that the 80 percent UCL of cumulative take at the Project *will not* exceed the permitted amount during the permit term (Appendix 3); EoA calculated a median estimate of 18 years of Project operation without a direct take estimate exceeding 42 geese. Estimated take at the 80 percent UCL at the Project has surpassed 75 percent of allowable take in the current tier take. As a result, KWP II has consulted with agencies regarding adjustments to the mitigation program to meet Tier 3 obligations. KWP II has also taken actions to minimize the threats to the Hawaiian goose at the Project and continues to work with USFWS, DOFAW, and technical experts to address mitigation and further reduce risk (Section 10.0).

7.3 Non-listed Species

In addition to the two Covered Species detected as fatalities, two bird species were documented as WTG-related fatalities at the Project site in FY 2022: black francolin (*Francolinus francolinus*; three fatalities), and African silverbill (*Euodice cantans*; one fatality). These species are non-native, introduced birds. For details of these fatalities for FY 2022, 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 2020), 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 over 17 dates in FY 2022 training a total of 38 people. WEOP trainings will continue to be conducted on an as-needed basis to provide on-site personnel with the information necessary 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 Hoary Bats

9.1.1 Mitigation

Mitigation for Tier 1 and Tier 2 estimated bat take has been completely funded at Kahikinui State Forest Reserve (KWP II 2018). The habitat management program founded through Project mitigation funding continues under DOFAW management (DOFAW 2021). Mitigation for Tier 3 estimated take (19 bats within Tier 3) is contracted to the U.S. Geological Survey Hawaiian Hoary Bat Research Group (Appendix 5). Bat ecological research on Hawaiʻi Island began in FY 2018 and is intended to better inform future bat habitat restoration and conservation. KWP II fulfilled is full contribution to the contract in FY 2021 (Tetra Tech 2022). The research project is expected to be completed in FY 2023 with completion of the final publications, technical results and data releases. The Project in combination with Brookfield's Kaheawa I Wind Project (KWP I) had a total funding obligation of $1.7M to allocate to portions of each Project's mitigation requirement. KWP II exceeded this funding obligation by $131,500, for a total commitment of $1,831,500.

Assuming the current take rate and search conditions remain unchanged through the remainder of the permit term, Tier 4 mitigation will not be necessary.

9.1.2 *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 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 Anabat SD2 bat detectors. Each SM2 unit is equipped with one SMX-U1 ultrasonic microphone (Wildlife Acoustics, Maynard, MA, USA) positioned horizontally, facing southwest (away from the prevailing NE trade winds), 6.5 meters above ground level. In October 2019 (FY 2020) the Pali brush fires burned across most of the Project destroying six SM2 units. For the remainder of the FY 2020 (October 2019 to June 2020) only two sites (WTGs 9 and 11) were monitored for acoustic bat activity. In order to continue with the objectives of the monitoring program and address gaps in the spatial coverage of SM2 units resulting from the brush fire, the monitoring regime was redesigned in July 2020 with the deployment of five SM2 units (WTGs 2, 5, 9, 11, and 14; Figure 1). Additionally, because of differences in the equipment used prior to FY 2014, data collected in FY 2022 is only comparable to data collected between FY 2014 (October 2013) and FY 2021.

The objective of bat acoustic monitoring is to understand better the annual and seasonal variations in bat activity at the Project. Analysis of variance (ANOVA) was used to test for differences in interannual detection rates between sampling years. A linear model (LM) was used to test for a change in detection rates across all sampling years. FY 2014 was removed from the analysis because it did not represent a full sampling year and excluded months known to have high detection rates (July, August, and September). All data were normalized with an Ordered Quantile Normalization transformation using the “bestNormalize” package in R (Peterson 2021). The distribution of residuals from the LM were examined to check for violations of model assumptions. All tests were 2-tailed, employed an alpha value of 0.05, and were conducted in the R version 4.1.2 (R Core Team 2018). Additionally, the characterization of Hawaiian hoary bat seasons corresponds approximately to Gorresen et al. (2013).

In FY 2022, Hawaiian hoary bats were detected on 163 nights out of 1,780 detector-nights sampled (9.2 percent; Table 3). Detection rates increased during the lactation and post-lactation reproductive periods, reaching a peak in November (0.17) and then declined in December (Figure 2). In January, at the beginning of the pre-pregnancy reproductive period, detection rates increased to the highest peak (0.21) and quickly declined again in February and March. A third smaller peak in activity (0.08) occurred in April at the beginning of the pregnancy reproductive period, followed by a decline in May and June (Figure 2). The annual trend in detection rates observed in FY 2022 differs from the bimodal trend frequently observed among previous monitoring years, excluding FY 2021 (Figure 3). Detection rates during the lactation and first half of the post-lactation reproductive periods were lower on average, although within range of previous monitoring years. The first peak in activity, typically observed in September and October, did not occur until November (Figure 3). Furthermore, and uniquely to FY 2022, the highest peak in activity occurred in January. The cause for the differences observed in the seasonal trend during the FY 2022 monitoring period, most notably January and February, are unknown. Potential correlations may include weather patterns, as similar increases in January and February were observed at other monitored sites on Oʻahu in the FY 2022 monitoring year.

Table 3. Number of Nights Sampled, Number of Nights with Detections and Proportion of Nights with Bat Detections Between FY 2014 and FY 2022

Dates	No. of Nights Sampled	No. of Nights with Detections	Proportion of Nights with Detection(s)
FY 2014[1]	2,183	85	0.039
FY 2015[1]	2,864	204	0.071
FY 2016[1]	2,038	110	0.054
FY 2017[1]	2,217	166	0.075
FY 2018[1]	2,103	386	0.183
FY 2019[1]	2,549	211	0.083
FY 2020[2]	1,146	117	0.102
FY 2021[3]	1,671	232	0.139
FY 2022 [3]	1,780	163	0.092

1. Number of detectors = 8.

2. Detectors reduced from 8 to 2 in October 2019 due to Pali brush fires.

3. Number of detectors = 5.

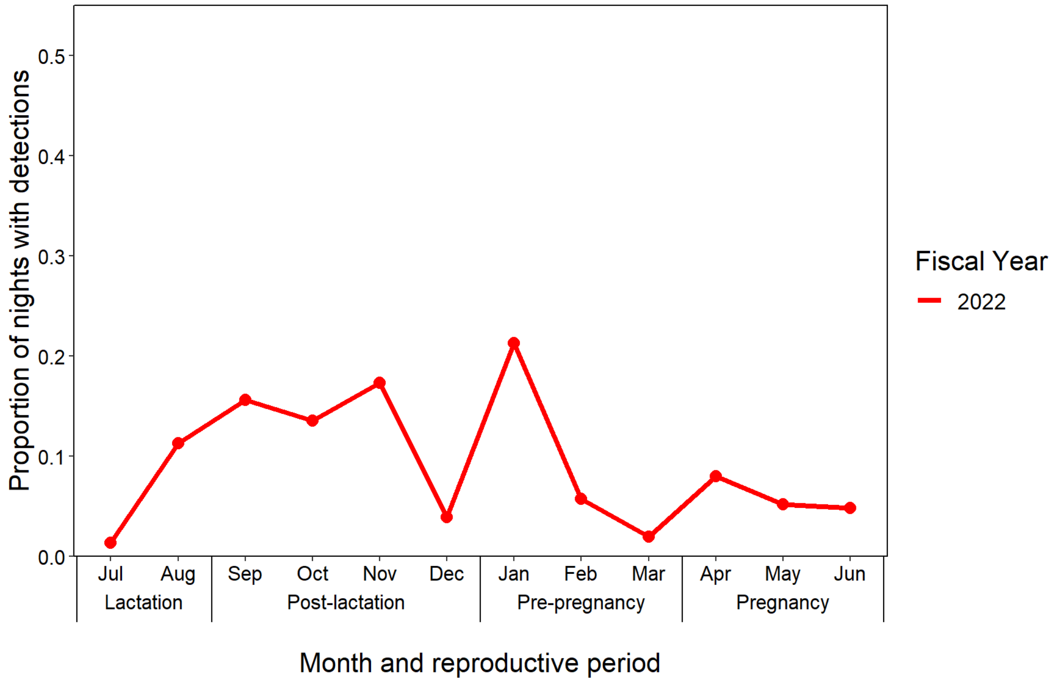

Figure 2. Monthly Detection Rates at KWP II in FY 2022 with Corresponding Reproductive Periods

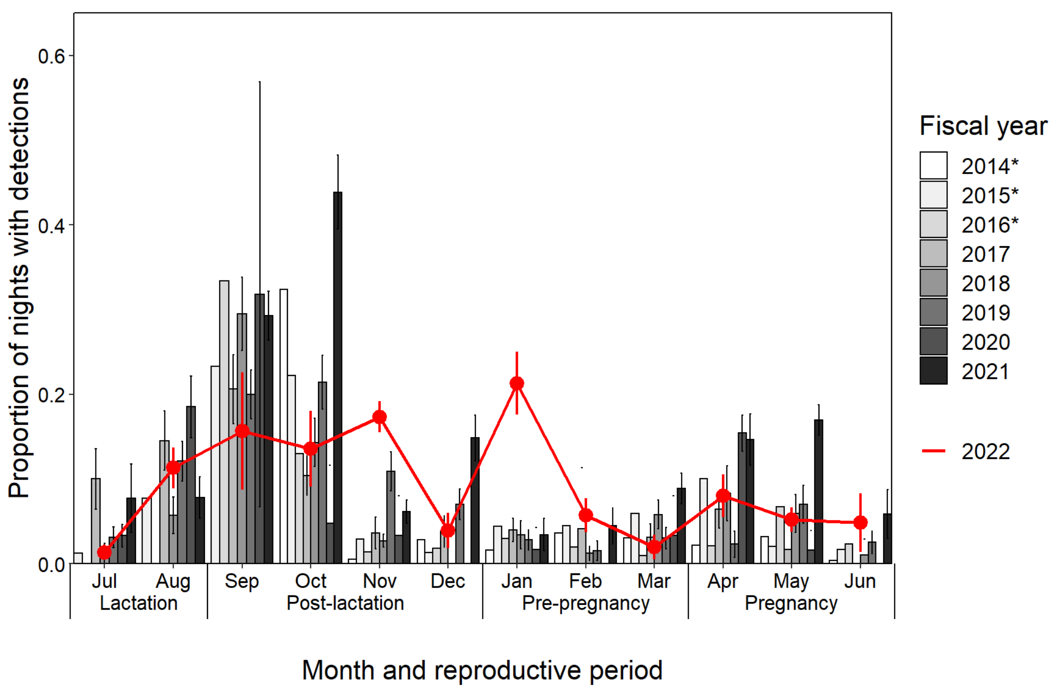

Figure 3. Monthly Bat Detection Rates at KWP II for FY 2014 to FY 2022 with Corresponding Reproductive Periods

*Note: Error bars (*SE*) not available for fiscal years 2014, 2015, and 2016.

The annual detection rate in FY 2022 (9.2 percent) was marginally lower than the annual detection rate in FY 2021 (13.9). Annual detection rates varied between all monitoring years (Table 3) but were not significantly different (ANOVA: $F_{7,88} = 2.01$, $P = 0.062$). Across all monitoring years (FY 2015 to FY 2022) there is a significant increasing trend in the annual detection rate (LM: $R^2 = 3.7$ percent; $F_{1,94} = 4.65$, $P < 0.034$, Figure 4).

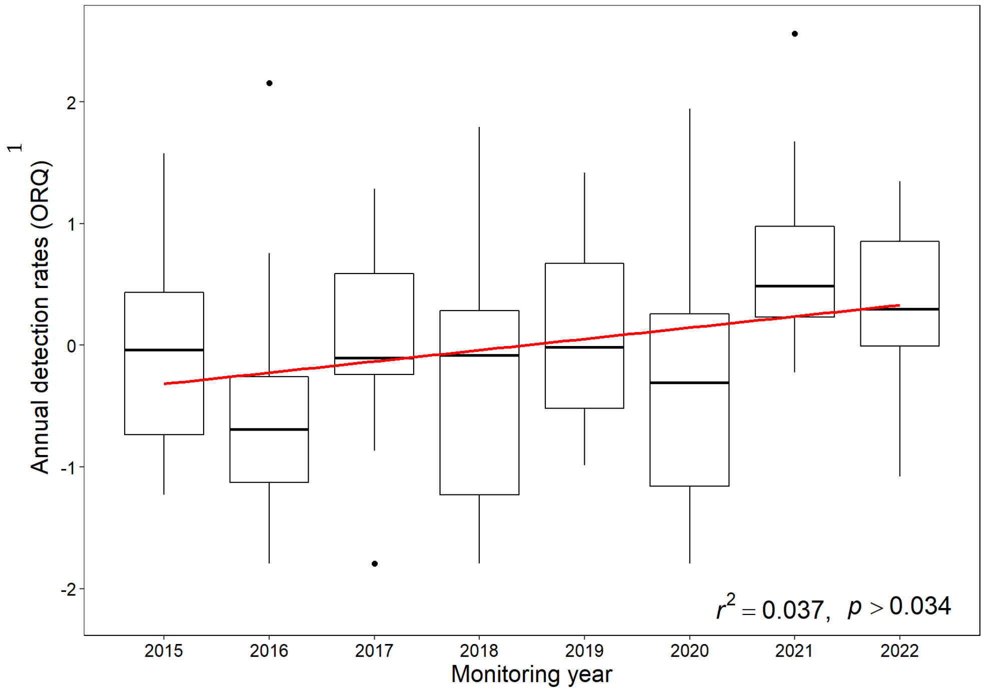

Figure 4. Box-plot with Linear Regression Showing the Increasing Trend in the Annual Detection Rates at KWP II between FY 2015 and FY 2022

1. Ordered Quantile normalization transformation (ORQ). All data were normalized using this transformation.

9.2 Hawaiian Goose

The Project provided funds to DOFAW in FY 2017 to begin predator control at Maui-based release pens locations with high Hawaiian goose activity or nesting. The funding provided for the implementation of predator control, fence maintenance, vegetation management and monitoring of a Hawaiian goose release pen at Pi‘iholo 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. In May 2020, the Project provided $112,682 to fund Hawaiian goose mitigation activities performed by DOFAW at the Pi‘iholo Ranch release pen. DOFAW was unable to process these funds due to internal limitations and the funding was returned to KWP II. In 2021 the Pi‘iholo Ranch was sold and the release pen was no longer available for mitigation. Thus, no mitigation benefits were accrued in either FY 2021 or FY 2022. Additionally, the cumulative increases in adult and juvenile survival and productivity achieved by KWP II's mitigation projects have not been sufficient to fully offset the mitigation obligations of Tier 1 or Tier 2. KWP II is working with DOFAW and USFWS to adaptively manage the Hawaiian goose mitigation program to the Haleakalā Ranch pen by assuming the release pen's management tasks in FY 2023 in conjunction with the KWP I Wind Project.

The agencies and KWP II have reached consensus on a framework for mitigation credits (see Section 7.2.1 and Appendix 2b).

9.3 Seabirds

KWP II is committed to seabird protection and recovery on Maui and within Maui Nui. Results at the Makamakaʻole Seabird Mitigation Site (Makamaka'ole) demonstrate that the site can support reproduction of Newell's shearwaters. Makamaka'ole is not on track for fulfilling the Project's Hawaiian petrel mitigation obligation. In conjunction with agency approval, KWP II is adaptively managing the Hawaiian petrel mitigation by funding Hawaiian petrel mitigation on Lānaʻi to achieve the goals laid out in the HCP.

9.3.1 Newell's Shearwater Survey – East Maui

Surveys of East Maui for potential mitigation sites in addition to Makamaka'ole 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.

9.3.2 Hawaiian Petrel and Newell's Shearwater – Makamakaʻole

Mitigation efforts at Makamaka'ole have been ongoing since construction of the two breeding site enclosures (predator fence exclosures) 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.

USFWS and DOFAW reviewed an updated management protocol prior to the 2021 breeding season (Tetra Tech 2021). This protocol was implemented at the site in 2021. Seabird breeding activity is assessed using game cameras, burrow scoping, checking for removal or displacement of toothpicks placed at burrow entrances, as well as checks for evidence of visitation including guano, feathers, and scent presence around burrows. During the 2021 breeding season, 24 burrows in Enclosure A showed evidence of activity over the monitoring period with 22 burrows showing consistent occupancy (exceeding two months) with Newell's shearwater activity. In Enclosure B, 6 burrows had primarily Newell's shearwater and limited Bulwer's petrel (*Bulweria bulwerii*) activity with three burrows demonstrating consistent Newell's shearwater breeding activity. A total of 11 burrows had reproductive activity, producing a total of 17 eggs and one chick (Appendix 6).

In March 2022, DOFAW provided a letter attributing a total mitigation credit of 6.418 adult equivalents. DOFAW also interpreted the KWP I and KWP II HCPs that the Projects together must achieve a total of 6.358 credits plus one additional fledgling (i.e., 6.681 credits total) or one adult equivalent (i.e., 7.358 credits total) in order to fully meet their mitigation obligations. The USFWS concurred with DOFAW's assessment in May 2022.

In 2022, continued mitigation efforts at Makamakaʻole were contracted to Maui Nui Seabird Recovery Project (MNSRP) through the 2022 breeding season. Project staff visit the enclosures with MNSRP to ensure consistent oversight. MNSRP staff continue to update and maintain perimeter fencing and visit Enclosures A and B approximately bi-weekly. During these visits, burrows and game cameras are checked for activity and vegetation management is performed.

During the semi-annual meeting on June 1, 2022, KWP II summarized historical activity data at the site and the associated agency assessment of mitigation credits to ensure that USFWS and DOFAW understand that KWP II is fully expected to have met the full Newell's shearwater mitigation obligation at the end of the 2022 breeding season. Both agencies acknowledged that this is their expectation. DOFAW provided verbal confirmation that it is DOFAW's intent to assume management of the site after the 2022 breeding season is complete conditioned upon KWP II meeting the full mitigation obligation. Although Makamaka'ole has been managed to benefit the Hawaiian petrel, as well as Newell's shearwater, no Hawaiian petrel activity has been detected at burrows within the enclosures since 2017. Thus, this site is not a viable location for Hawaiian petrel mitigation.

9.3.3 Lānaʻi Hawaiian Petrel Protection Project

Hawaiian petrels have not been observed occupying the Makamaka'ole mitigation site since 2017. Therefore, KWP II has worked with USFWS an DOFAW to adaptively manage mitigation efforts for this species to ensure that its mitigation obligations are met.

For the 2018 Hawaiian petrel breeding season, the KWP I worked with USFWS and DOFAW to adaptively manage Hawaiian petrel mitigation efforts in an interim fashion. As a result of this adaptive management, KWP I provided funding to Pūlama Lānaʻi to supplement Hawaiian petrel breeding colony protection efforts on Lānaʻi. The success of this program and on-going difficulties in attracting petrels to Makamaka'ole suggested that both KWP projects could benefit the Hawaiian petrel and make progress on mitigation obligations by continuing support for the Lānaʻi petrel breeding program.

In FY 2021, the two KWP projects with concurrence from USFWS and DOFAW, adaptively managed their seabird mitigation programs by providing funding to Pūlama Lānaʻi. (Appendix 7). This effort included predator control as well as burrow monitoring and evaluation in the densely occupied Hawaiian petrel nesting area composed of the four distinct ridges of East Puʻu Aliʻi, Kanalo, West Hiʻi, and Hiʻi Center Ridge (known as the Greater Hiʻi area) totaling approximately 150 acres.

Based on mitigation, a total of 21 cats and a minimum of 354 rodents (understood to be an extreme underestimate; Appendix 7) were removed from the area during the 2021 breeding season. Using a standardized sampling design across the colony, developed from a power analysis and assessment completed in partnership with biologists and statisticians with the Zoological Society of San Diego (Schuetz et al. 2020), the number of fledglings produced in the area was estimated. This estimation used the proportions of inactive, prospecting, and breeding status burrows, along with reproductive success rates of a given area to determine an estimated proportion of burrows with breeding attempts. This information was used to estimate the number of fledglings produced. In the 2021 breeding season, 196 known burrows yielded an outcome of 70 Hawaiian petrel chicks above baseline. KWP II is currently in discussion with the USFWS on this outcome assessment.

KWP II is currently in discussion with agencies on the assessment of mitigation credit for the Hawaiian petrel. In FY 2022, the two KWP projects with concurrence from USFWS and DOFAW, again adaptively managed their seabird mitigation programs by providing funding to Pūlama Lānaʻi in the amount of $118,300 for the 2022 breeding season. This effort is similar to what was included in the 2021 breeding season effort. Results from the 2022 breeding season will be reported in the FY 2023 annual report.

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 in response to bat fatalities documented at the Project on March 13, 2013 and February 26, 2014, and at the KWP I Project on December 14, 2013. On June 6, 2014, the Project proposed an additional adaptive management measure to the USFWS and DOFAW, increasing the LWSC cut-in speed. 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 its 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.

The Project has previously implemented a variety of actions to minimize risk to the Hawaiian goose, which continued in FY 2022. Safety measures to avoid interactions between Hawaiian goose and canine search teams have been identified and are implemented as needed. 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. In response to the current projections of potential take of the Hawaiian goose at the Project, KWP II has also identified additional practicable actions to minimize the threats to the Hawaiian goose. In FY 2022, KWP II is implementing a vegetation management plan developed with concurrence from the agencies (Section 5.0) to reduce the amount of woody vegetation on site and therefore minimize the attraction of onsite habitat to the Hawaiian goose. KWP II will continue to work with USFWS, DOFAW, and technical experts in FY 2023 to further reduce risk to the species.

11.0 Agency Meetings, Consultations, and Visits

KWP II communicated actively with USFWS and DOFAW throughout FY 2022 through conference calls, submittal of quarterly reports, and e-mail communications related to the Project's HCP. The purpose of these communications included required semi-annual HCP implementation meetings and focused discussions regarding mitigation funding, adjustments to all current mitigation programs, and mitigation credits for the Hawaiian goose and seabird mitigation programs. All meetings in FY 2022 were via teleconference. A summary of agency coordination is presented in Table 4.

Table 4. Summary of Agency Coordination and Communication in FY 2022

Date	Communication	Participants
August 17, 2021	Nēnē mitigation program meeting	KWP II, Tetra Tech, DOFAW
September 13, 2021	Hawaiian goose minimization measures meeting	KWP II, Tetra Tech, DOFAW-Maui
October 19, 2021	Annual HCP implementation review meeting	KWP II, Tetra Tech, USFWS, DOFAW
October 25, 2021	KWP vegetation management memo	Submitted to DOFAW-Maui by Tetra Tech
October 28, 2021	Submittal of FY2021 Q1 report	Submitted to DOFAW, USFWS by Tetra Tech
December 14, 2021	KWP Lāna'i Hawaiian petrel mitigation 2021 review/discussion of 2022 Hawaiian petrel mitigation opportunities on Lānai'i meeting	KWP II, Tetra Tech, USFWS, DOFAW, Pūlama Lānai'i
December 15, 2022	KWPs Makamaka'ole mitigation program 2021 review meeting	KWP II, USFWS, DOFAW, MNSBRP
January 6, 2022	Submittal of the final KWP I HCP FY 2021 annual report	Submitted to DOFAW, USFWS by Tetra Tech
January 10, 2022	Submittal of KWPs Hawaiian petrel mitigation credit and planning memo	Submitted to DOFAW, USFWS by Tetra Tech
January 14, 2022	KWPs seabird mitigation credit and 2022 planning discussion meeting	KWP II, Tetra Tech, USFWS, DOFAW
January 19, 2022	Submittal of Makamaka'ole Threatened and Endangered Seabird Mitigation Project: Exclosures and Artificial Burrows Annual Summary Report (2021)	Submitted to DOFAW, USFWS by Tetra Tech
January 27, 2022	Submittal of FY 2022 Q2 report	Submitted to DOFAW, USFWS by Tetra Tech
February 3, 2022	Annual HCP implementation review by ESRC	Tetra Tech, KWP II, ESRC
February 8, 2022	Status of Hawaiian petrel mitigation meeting	KWP I, Tetra Tech, USFWS, DOFAW
February 24, 2022	Submittal of supplemental data files for Newell's shearwater activity at Makamaka'ole	Submitted to DOFAW from Tetra Tech

Date	Communication	Participants
March 3, 2022	Haleakalā Ranch nēnē release pen management discussion	KWP II, Tetra Tech, DOFAW
March 21, 2022	Makamaka'ole 2022 management and monitoring intent for 2022 (email)	Sent to USFWS. DOFAW from Tetra Tech on behalf of KWP II
March 23, 2022	Submittal of nēnē mitigation counter proposal, memo update	Submitted to USFWS by Tetra Tech
April 20, 2022	Submittal of Lānaʻi Hawaiian Petrel Mitigation Final Report – 2021	Submitted to USFWS by Tetra Tech
April 27, 2022	Submittal of FY 2022 Q3 report	Submitted to DOFAW, USFWS by Tetra Tech
May 3, 2022	Haleakalā Ranch nēnē release pen management meeting	KWP II, Tetra Tech, DOFAW, Haleakalā Ranch
June 1, 2022	Semi-annual HCP implementation review meeting	KWP II, Tetra Tech, USFWS, DOFAW
June 6, 2022	Submitted documents to seek clarification on take limit authorized for Hawaiian goose on ITL	Submitted to DOFAW, USFWS by Tetra Tech

12.0 Expenditures

Total HCP-related expenditures for the Project in FY 2022 were $404,000 (Table 5).

Table 5. HCP-related Expenditures at the Project in FY 2022

Category[1]	Amount
Permit Compliance	$40,000
Fatality Monitoring	$57,000
Acoustic Monitoring for Bats	$10,500
Vegetation Management and Scavenger Trapping	$23,000
Equipment and Supplies	$1,700
Makamakaʻole Mitigation Project	$145,500[2]
Lānaʻi Hawaiian Petrel Mitigation Project	$118,300[2]
Haleakalā Ranch Release Pen Project	$8,000[3]
Total Cost for FY 2022	**$404,000**

1. Staff labor costs are included in the overall costs for each category.
2. Makamaka'ole and the Lānaʻi petrel mitigation project are co-funded by KWP I and KWP II.
3. Hawaiian goose mitigation funding was limited to planning efforts at Haleakalā Ranch, due to the sale of Piʻiholo Ranch.

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Appendix 1. Dalthorp et al. (2017) Fatality Estimation for Hawaiian Hoary Bat and Hawaiian Goose at the Project through FY 2022

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Appendix 1a. Dalthorp et al. (2017) Fatality Estimation for Hawaiian Hoary Bat at the Project through FY 2022

Modelling Parameter		Modelling Period									
		1	2	3	4	5	6	7	8	9	10 (current)
FY		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	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	7/1/2020	7/1/2021
	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	6/30/2021	6/30/2022
Period length (span)		364	364	364	364	364	364	364	362	364	364
% of Year (rho)		1	1	1	1	1	1	1	1	1	1
Search Interval (days)		7	7	7	7	7	7	7	7.1	7	7
Number of Searches in Modelling period		52	52	52	52	52	52	52	51	52	52
Observed fatality (X)		1	2	0	0	0	0	0	0	0	0
K		0.7	0.7	0.7	1[1]	1[1]	1[1]	1[1]	1[1]	1[1]	1[1]
DWP		1	1	1	0.562	0.562	0.562	0.56	0.56	0.56	0.56
G	G	0.443	0.359	0.336	0.362	0.442	0.375	0.372	0.476	0.409	0.354
	min	0.241	0.235	0.187	0.27	0.374	0.287	0.304	0.437	0.333	0.271
	max	0.656	0.493	0.503	0.46	0.511	0.467	0.440	0.516	0.486	0.441
B	Ba	9.08	18.5	10.95	35.09	87.96	41.22	74.23	289.1	63.53	42.51
	Bb	11.41	33.02	21.68	61.84	111.1	68.77	125.3	318.1	92	77.67
M*[3]		5	12	12	12	11	12	12	11	11	11

1. Searches performed by canine teams increases the probability that a missed carcass will be detected on the next search.

2. Search area reduced to graded and cleared 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 1b. Dalthorp et al. (2017) Fatality Estimation for Hawaiian Goose at the Project through FY 2022

Modelling parameter		Modelling Period									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10 (current)**
FY		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	7/1/2020	7/1/2021
	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	6/30/2021	6/30/2022
Period length (days)		364	364	364	365	364	364	364	362	364	364
% of Year		1	1	1	1	1	1	1	1	1	1
Search Interval (days)		7	7	7	7	7	7	7	7.1	7	7
Number of Searches in Modelling period		52	52	52	52	52	52	52	51	52	52
Observed fatality (X)		1	0	2	1	0	1	0	3	0	1
K		1	1	1	1	1	1	1	1	1	1
DWP		0.7	0.7	0.7	0.3721	0.3721	0.3721	0.3721	0.3721	0.3721	0.3721
g	**g**	0.654	0.653	0.681	0.358	0.361	0.36	0.361	0.347	0.361	0.368
	min	0.503	0.474	0.583	0.288	0.294	0.285	0.295	0.319	0.338	0.355
	max	0.791	0.812	0.771	0.431	0.43	0.437	0.429	0.375	0.384	0.381
B	**Ba**	26.32	18.94	62.8	61.66	68.06	54.62	70.09	380.2	633.1	1811
	Bb	13.91	10.05	29.46	110.5	120.7	97.27	124.2	717	1120	3110
M*2		3	3	6	9	10	13	13	21	22	25

1. Search area reduced to graded and cleared 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 2. Indirect Take for the Hawaiian Hoary Bat and Hawaiian Goose at the Project in FY 2022

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Appendix 2a. Indirect Take for the Hawaiian Hoary Bat at the Project in FY 2022

Parameter	Description	Fiscal Year										
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
A	Observed Breeding Female Take	0	0	0	0	0	0	0	0	0	0	**0**
B	Indirect Take from Observed Breeding Female Take (A x 1.8)	0	0	0	0	0	0	0	0	0	0	**0**
C	Observed Breeding Unknown Sex Take	0	0	0	0	0	0	0	0	0	0	**0**
D	Indirect Take from Observed Breeding Unknown Sex Take (C * 0.5 * 1.8)	0	0	0	0	0	0	0	0	0	0	**0**
E	All Observed Take (Search and Incidental)	1	2	0	0	0	0	1	0	0	0	**4**
F	Estimated Take Multiplier (11/4=2.75)	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	–
G	Estimated Direct Take (E x F)	2.75	5.5	0	0	0	0	2.75	0	0	0	**11**
H	Unobserved Direct Take (G - E)	1.75	3.5	0	0	0	0	1.75	0	0	0	**7**
I	Indirect Take Calculated from Unobserved Take (H * 0.5 * 0.25 * 1.8)	0.39	0.79	0	0	0	0	0.39	0	0	0	**1.58**
Total Indirect Take (B + D + I; juveniles)												**1.58**
Total Indirect Take (B + D + I)*0.3 (adults)												**0.47**

Appendix 2b. Indirect Take and Lost Productivity for the Hawaiian Goose at the Project in FY 2022

Parameter	Description	Fiscal Year												
		2013	2014	2015	2016	2017	2018		2019	2020	2021	2022		Total
A	Observed Take	1	0	2	1	0	2	2	1	3	0	1	1	14
A1	Observed Take (Goslings) Not Attributable to Wind Farm Operation	0	0	0	0	0	0	1	0	0	0	0	0	1
B	Estimated Take Multiplier (25/14=1.79)	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	–
C	Estimated Direct Take (A x B)	1.79	0	3.57	1.79	0	3.57	3.57	1.79	5.36	0	1.79	1.79	25.00
D	Observed Indirect Take Multiplier (Season Defined)	0.04	0	0.09	0.09	0	0	0.09	0.09	0.09	0	0.04	0.09	–
E	Observed Indirect Take (A x D)	0.04	0	0.18	0.09	0	0	0.36	0.09	0.27	0	0.04	0.09	0.98
F	Unobserved Direct Take (C - A)	0.79	0	1.57	0.79	0	1.57	1.57	0.79	2.36	0	0.79	0.79	11.00
G	Unobserved Indirect Take (F x 0.06)	0.04	0	0.09	0.04	0	0.09	0.09	0.04	0.13	0	0.04	0.04	0.62
H	Accrued Adult Take (Previous Year's Accrued C + J2 - L)	0.00	1.79	1.85	5.57	7.39	7.26		15.48	17.27	23.99	25.71		–
I	Lost Productivity from accrued adult take (Current year's H x 0.1) (fledglings)	0.00	0.18	0.19	0.56	0.74	0.73		1.55	1.73	2.40	2.57		10.63
J	Indirect Take + Lost Productivity (E + G + I + A1)(fledglings)	0.08	0.18	0.45	0.69	0.74	2.08		1.68	2.13	2.40	2.79		13.22
J2	Indirect Take + Lost Productivity as Adult (2 year's previous J x 0.9^2) (annual survival rate is 0.9	–	–	0.07	0.14	0.337	0.56		1.69	0.00	1.36	1.72		–
K	Mitigation fledglings produced (fledglings)	0.00	0.00	0.00	0.00	0.00	3.00		11.56	0.00	0.00	0.00		14.56
L	Mitigation adult survival (adults)	0.00	0.00	0.00	0.00	0.33	0.69		0.61	0.00	0.00	0.00		1.63
Total Direct Take from Collisions with WTGs (adults; C)														**25**
Total Direct Take from Non-Collision Causes (adults; A1 x 0.512)														**0.51**
Total Indirect Take (fledglings; E + G)														**1.59**
Total Indirect Take (adults; [E + G] x 0.512)														**0.82**
Total Lost Productivity (fledglings; I)														**10.63**
Total Lost Productivity (adults; I x 0.512)														**5.44**

Appendix 3. FY 2022 Hawaiian Hoary Bat and Hawaiian Goose 20-year Projected Cumulative Mortality at the Project

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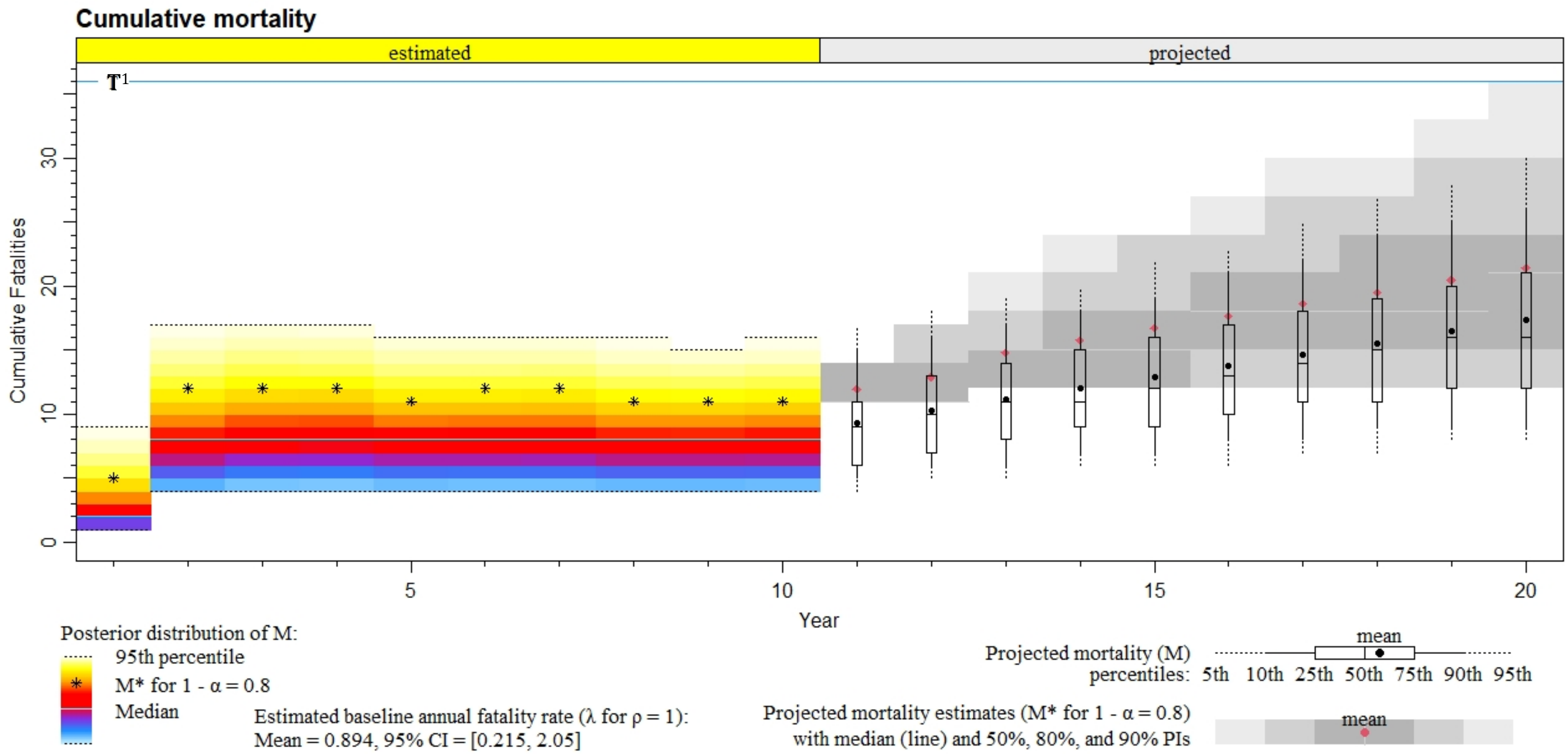
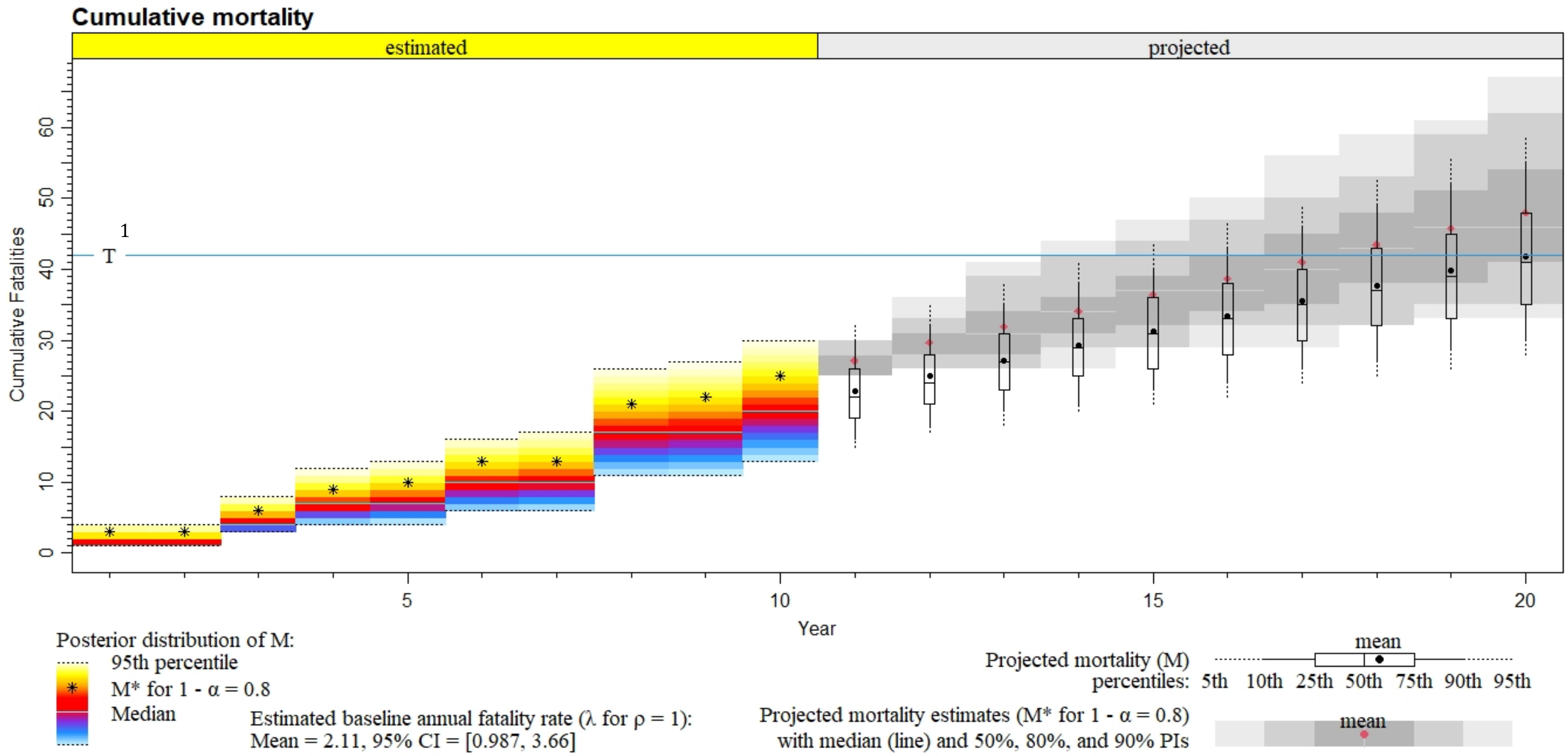
Appendix 3a. Projected Cumulative Mortality for the Hawaiian Hoary Bat at the Project



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 36 is shown, representing authorized bat take (38) minus 2 adult equivalents of indirect take (5.3 percent of the requested authorized limit). Currently, the proportion of total take that is attributable to indirect take is 4.1 percent.

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



1. Permitted take for the Hawaiian goose at the Project is 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 3.1 percent.

Appendix 4. Documented Fatalities at the Project during FY 2022

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Species	Date Documented	WTG	Distance to WTG (meters)	Bearing from WTG (degrees)
Branta sandvicensis (Hawaiian goose or nēnē)[1]	09/01/21	7	1	110
Francolinus francolinus (black francolin)	10/13/21	5	45	136
Branta sandvicensis (Hawaiian goose or nēnē)[1,2]	01/19/22	4	36	307
Francolinus francolinus (black francolin)	02/23/22	1	1	66
Euodice cantans (African silverbill)	04/13/22	3	12	180
Francolinus francolinus (black francolin)	05/25/22	9	1	130

1. HCP Covered Species.
2. Incidental detection.

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Appendix 5. USGS Hawai‘i Island Hawaiian Hoary Bat Ecological Research Project Annual Report (FY 2022)

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

Agreement # 17WSTAAZB005541
with Kaheawa Wind Power, LLC and Kaheawa Wind Power II, LLC

Annual Report

Summary of Research Activities through July 2022

25 July 2022

Prepared by:

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

Hawaiʻi Cooperative Studies Unit, University of Hawaiʻi at Hilo, P.O. Box 44, Hawaiʻi National Park, HI 96718

The Hawaiian Hoary Bat Conservation Biology project is designed to advance understanding of key aspects of endangered ʻōpeʼapeʼa (Hawaiian hoary bat; *Lasiurus 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 (for genetic and pesticide studies outside the scope of this agreement)

Study preparation and design

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

Land and special use access permits were granted by: Hawaiʻi DLNR Division of Forestry and Wildlife - Forest Reserve System, Natural Area Reserve System, and Land Division; USDA Forest Service – Hawaiʻi Experimental Tropical Forest; The Nature Conservancy; USFWS – Hakalau Forest National Wildlife Refuge; Department of Hawaiian Home Lands. Additionally, numerous private landowners have provided access to properties. Sampling permits were granted for bat handling and sampling and for insect collections: USFWS Recovery Permit (TE003483-33); Hawaiʻi Protected Wildlife Permit (WL18-13, WL191-19, WL19-52); Hawaiʻi Native Invertebrate Research Permit (I1211, I2444); University of Hawaiʻi System IACUC (04-039). The USDA Forest Service - Institute for Pacific Islands Forestry and the University of Hawaiʻi College of Tropical Agriculture and Human Services granted permission to station automated telemetry receiver stations on their properties.

Field data collection commenced in May 2018 and was completed in November 2021. We surveyed 22 sites spanning much of Hawaiʻi Island, with a subset of eight sites on the east side of Hawaiʻi Island established as fixed sites for sampling at repeated intervals between January 2019 and January 2021 (Figure 1). Each fixed site was sampled at least once per four-month period (December–March, April–July, August–November), with a survey comprising one to three nights of netting depending on capture success, weather, and available personnel. Netting at fixed sites was paired with insect sampling conducted using ultraviolet lights to attract night-flying insects that may be bat prey. Four fixed sites were located at high elevation (above 1,000 m asl) and four at low elevation (below 600 m asl). The fixed sample sites included native and exotic forests, orchards, and mixed habitats.

Intermittently throughout the study, but particularly after the fixed sampling period, we opportunistically netted to survey a broader geographic area and target reproductive females. During February–August 2021 mist netting efforts were focused in (1) native-dominant forest habitats, (2) leeward forest habitat, and (3) sites where reproductive females had been captured in previous years.

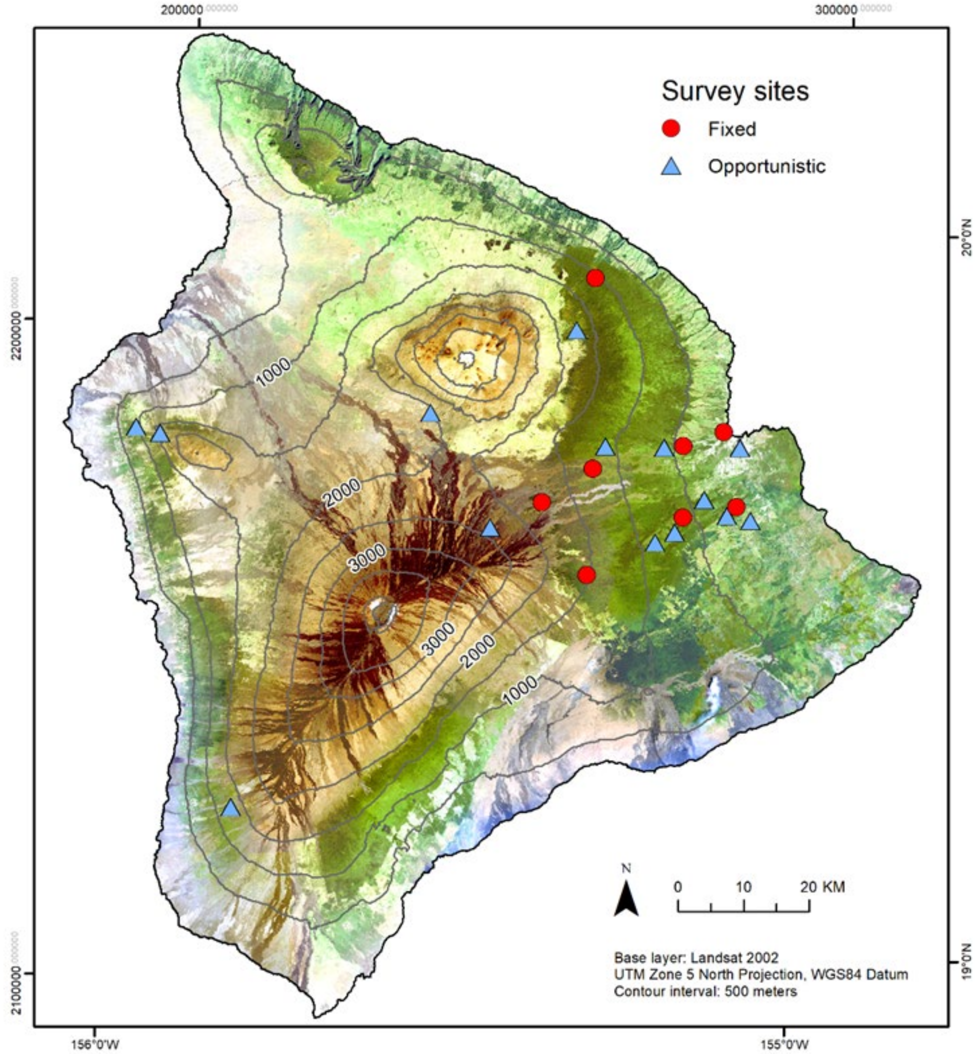

Figure 1. Mist net sites surveyed from May 2018 to August 2021 on Hawai'i Island with fixed sites (circles) surveyed at regular intervals and opportunistic surveys added at fixed sites or opportunistic sites (triangles).

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 field and lab tasks that could be conducted without the handling of bats. Bat captures resumed in early June 2020 after careful evaluation of conditions on Hawai'i Island, implementation of enhanced Covid-19 sanitation protocols, acquisition of personal protective equipment, and personnel training in the proper use of N95 respirators. As work continued, we limited personnel and adjusted work duties within the research team to accommodate enhanced safety measures and changing work conditions.

Capture effort

Mist nets were suspended between poles or from ropes over tree limbs and situated across likely bat flight paths (e.g., roadways, forest edge and gaps; Figure 2). For each netting occasion (i.e., nightly sample), we set an average of three nets (range 1–5). We typically opened nets within 30 min of sunset and checked every 10 min until 3–5 hours after sunset. After removing captured bats from mist nets, we secured them in cloth holding bags for up to 10 min to collect guano samples. Tissue and hair samples were collected, and morphometric measurements and reproductive status was recorded for all individuals. Prior to bat release, each bat received a unique color combination of plastic split ring bands one on the left and/or right forearm, so individuals could be identified if recaptured or observed at day-roosts (Figure 3). After trimming a patch of dorsal fur, we attached very high frequency (VHF) radio transmitters to a subset of individuals using surgical glue.

Bat mist netting was conducted during 224 occasions from 14 May 2018 to 5 August 2021 (2018: 38, 2019: 84, 2020: 61, 2021: 41). 138 unique individuals were captured, of which 10 of were recaptured.

Figure 2. Mist nest being set up to capture ‘ōpe’ape’a

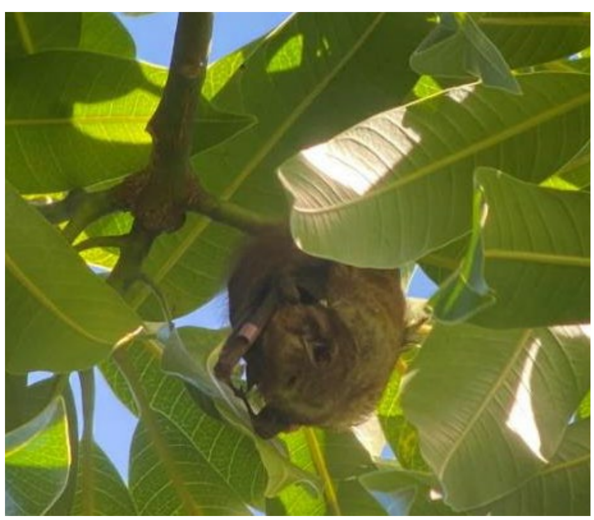

Figure 3. ʻŌpeʻapeʻa with unique color arm band combination at roost

Roost ecology

Roost ecology studies were a primary focus during the three years of field data collection. After bat release, we attempted to track bats to day-roosts using radio telemetry conducted from vehicles and on foot. Dense forest vegetation and a limited road network made for extremely difficult conditions for tracking individuals to their day roost, particularly at higher elevations where the road networks are sparse, and significant effort was needed to conduct this component of the project.

We attempted to track 130 bats to their roosting location using radio telemetry. In cases when we located a telemetry signal, locations and bearings were used to approximate the roost location within a forest stand and in a subset of cases bats could be tracked to a specific tree.

We identified 123 day-roost forest stands using radio telemetry (Figure 4). Using radio telemetry, visual searches, and handheld thermal imagers, 56 day-roost trees were identified (Figure 4). Three maternity roost trees were confirmed in 2019, five in 2020, and five in 2021 (Figure 5). All known historical maternity roosts were visited weekly during the maternity season to monitor for activity and inter-annual fidelity.

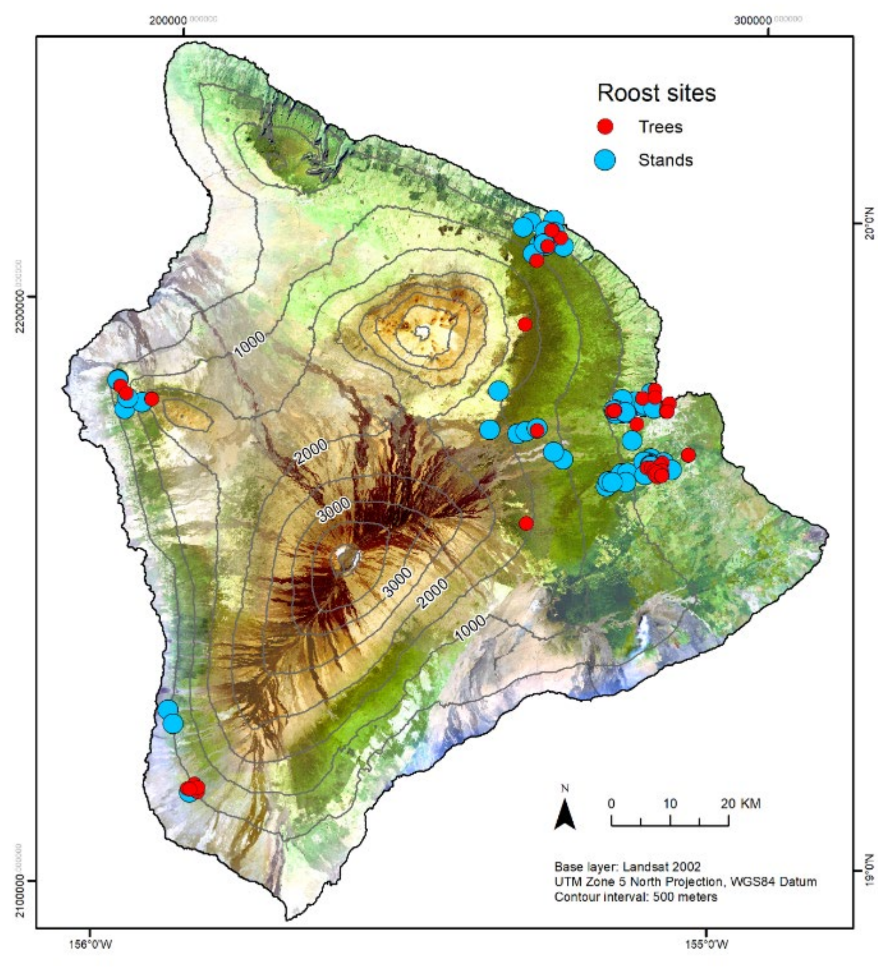

Figure 4. Locations of forest stands and trees identified as ‘ōpe’ape’a as day-roosts, May 2018 – August 2021.

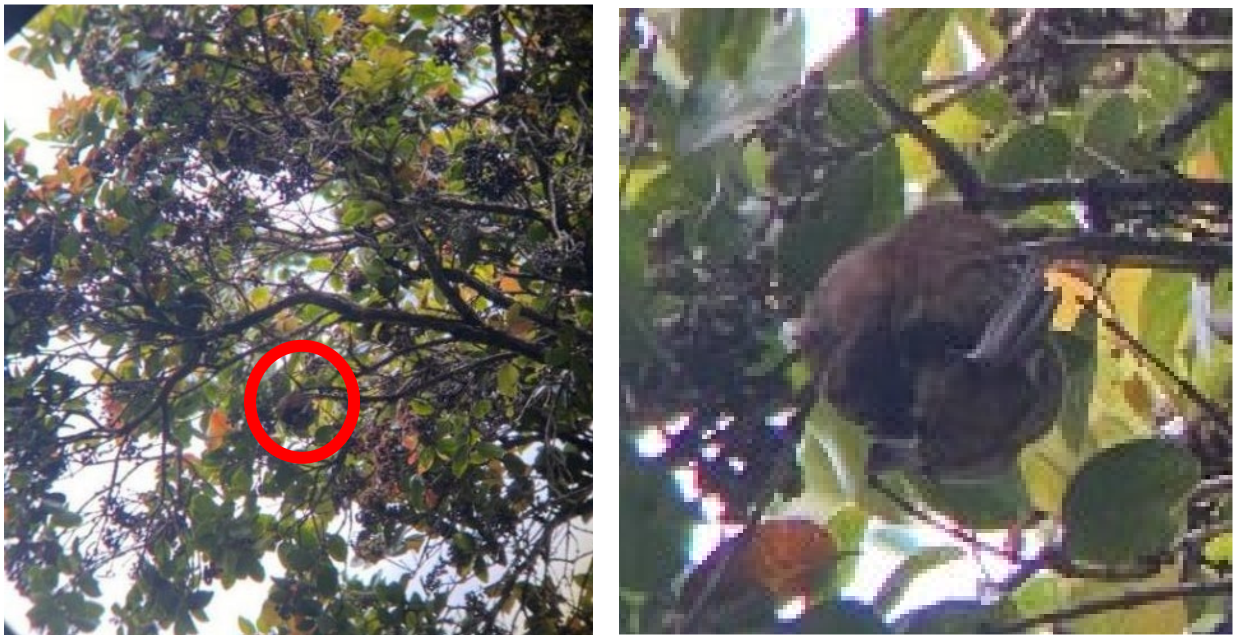

Figure 5. Family group at ʻōpeʼapeʼa maternity roost in an ʻōhiʻa (red circle, left), enlarged (right) to show three bats in the family group including a radio-tagged juvenile male seen on the left side of the group.

Where possible, active maternity and select non-maternity roosts were monitored with thermal video recordings, automated telemetry receiver stations, acoustic recorders, and/or visual checks (Figure 6). More than 363 roost-nights of video, 552 roost-nights of automated receiver data, 50 days and nights of acoustic data were collected. Additionally, more than 1,000 visual checks of roost perches were conducted. Data processing is complete and analyses are underway to quantify time-budget of bat activity, roost attendance and fidelity, maternity phenology, and activity and potential predation by rats and owls.

All identified roost trees were classified to species and tree characteristics were measured (e.g., height, dbh, percent canopy cover, etc.). If a bat was spotted at its perch in the roost tree, additional characteristics of the perch were measured (e.g., aspect, height, canopy cover). For all identified day-roost stands, forest stand-level characteristics (e.g., stand height, dominant tree, understory, etc.) were derived from a combination of satellite and airborne imagery and ground measurements. Trees used by roosting bats were comprised of 18 species including non-native plantation species, invasive species, and native *Metrosideros polymorpha* and *Diospyros sandwicensis*. Characterization of roost habitat and analyses of roost habitat selection have been completed.

Preliminary tree and stand metric results collected through 2019 and associated 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.

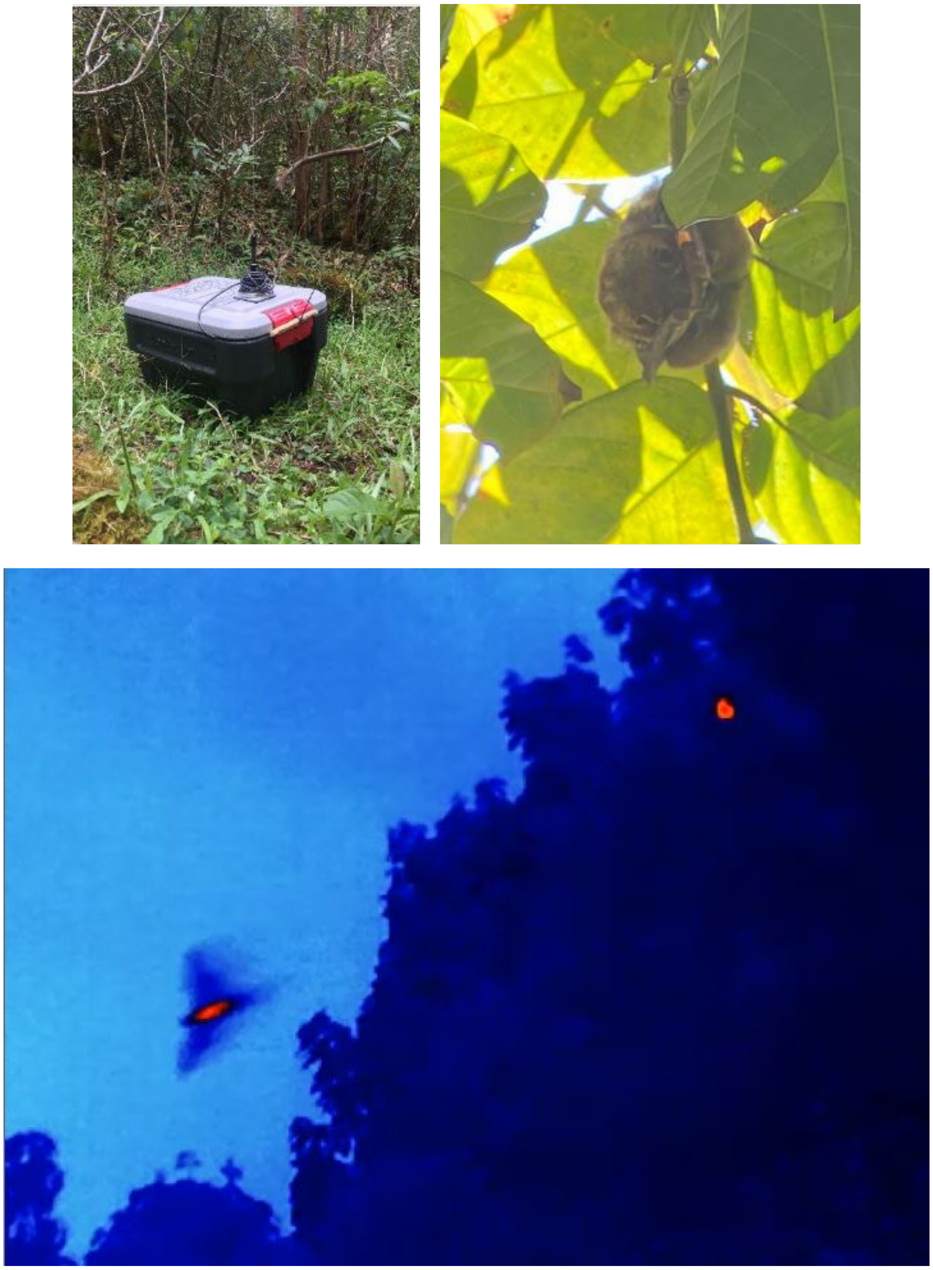

Figure 6. Automated receiver station used to measure roost fidelity (top left). A banded mother Hawaiian hoary bat with two pups observed during maternity roost monitoring (top right). Thermal video monitoring of bat roost behavior (bottom).

Diet studies

Insect sampling using ultraviolet lights to attract night-flying insects that may be bat prey was conducted for two years, February 2019–2021 (Figure 7). Two nights of sampling were conducted at each fixed site during each of the four-month sampling periods; in most cases insect sampling was conducted concurrently with mist netting. Collected insects have been categorized by size class and identified to the highest possible taxonomic classification (Figure 7). Analyses of prey availability are underway.

DNA extracted from potential prey items were submitted for genetic barcoding to establish a reference library of potential bat prey items. All insect genetic barcoding data have been uploaded to the Barcode of Life Data System (BOLD) and the data library will be made publicly available.

To identify bat prey, genetic meta-barcoding of guano samples was conducted, and a bioinformatics approach used to match bat prey items with the reference library (above) and public databases (see Pinzari *et al*. 2019) is underway. A total of 118 guano samples, collected from captured and roosting bats during this project, yielded useable data. All samples were processed and submitted for genetic sequencing and results have been received. For analyses of diet diversity, genetic metabarcoding data from additional guano samples collected from a variety of sources and published sources will be analyzed together with the project samples. Analyses of diet diversity are underway.

Collection of caterpillars from vegetation at the fixed sampling sites was conducted March–May 2020. A combination of rearing caterpillars to adult form and genetic 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 are examined further with in-depth literature searches and the cataloging of insect host plants in Hawaiʻi.

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).

Movements

An automated telemetry system did not serve to provide data on bat movements on the landscape (see Technical issues section below). However, additional movement information has been derived when possible, including site fidelity and seasonality of re-captured bats (n = 10), the distance between multiple roosts used by individual bats (n = 10), and the distance between capture and roost locations (n = 118). Additionally, the activity budget (i.e., flight bout duration and frequency) of individual bats at roosts monitored by thermal video as part of the current study and bat telemetry location data obtained between 2004 and 2010 is being examined for its use in inferring the spatial extent of nightly movements.

Technical issues

A. An automated telemetry system comprised of a network of six stations was established across a broad section of the Wailuku watershed. Each station consisted of a 20 to 30 ft mast with six radially arranged antennas and a radio receiver with cellular connectivity allowing for real-time coverage with live data feeds. However, technical issues with the system precluded its use in recording telemetered bat movement. The issues primarily entailed the high levels of ambient electromagnetic noise present in the region from which transmitter (i.e., radio-tag) signals could not be reliably discerned, persistent software bugs and power failure problems related to overheating of the receiver components. Bat flight behavior, specifically low altitude and within-forest movement, may also have contributed to limiting the reception range of transmitters in many parts of the landscape.

Given the technical difficulties collecting movement data with the automated system, there was a need to adaptively manage the research project to maximize the benefits of this project to the management of Hawaiian hoary bats. The following adjustments were proposed and implemented during 2021:

> 1) Expanded sampling area for roost and diet studies into additional habitat/forest types that represent a broader range of the landscape in Hawaiʻi to improve inference for planning restoration and mitigation areas on other islands. The study area described in the Statement of Work was limited to the east side of Hawaiʻi Island dominated by rain forests and wet shrublands; we expanded sampling areas into mesic and dry forests with a broader range of dominant tree and shrub species.
>
> 2) Focused efforts to collect roost and diet (guano collection) sampling at higher elevation and native dominated forest sites where samples were underrepresented due to the difficulty of obtaining samples in these areas.
>
> 3) Continued sustained high intensity monitoring at roosts, including maternity roosts. In lieu of shifting efforts to facilitate tracking work, we maintained and expanded roost research efforts that yielded quality datasets (e.g., video monitoring, visual checks).
>
> 4) Analysis of hand-held and automated telemetry data collected to find and monitor roosts to better understand Hawaiian hoary bat movements on the landscape. From continued high intensity roost searching efforts and expansion of these efforts into additional habitats, we expanded datasets to calculate distances and elevational differences between capture locations and roost sites and analyze time spent away from the roost.

B. Temperature sensitive tags were tested in the field through deployment on a limited number of bats (n = 3) and with standard range tests at known distances. These field tests indicated that the range at which the temperature tags could be detected was less than that of the standard radio tags that we have been using. Because the road networks are limited in many of the areas that the study was conducted, we did not have confidence that we would be able to track bats to their roost trees as effectively as we had with the standard tags. Additionally, reliable temperature data was not recorded by our receivers. As such, we discontinued deploying temperature sensitive tags and instead collected data on temperature at roost with the use of a handheld thermal imager.

Ongoing work

All data collection is complete. Analyses, manuscript writing and revision, and preparation of data for public release is underway. Manuscripts will be made available as journal publications or technical reports; data will be made available through the USGS ScienceBase catalog and, where appropriate, repositories for genetic data. Peer review of all science products is required per USGS Fundamental Science Practices policy. Manuscripts and data are expected to become publicly available from late 2022 through 2023.

References

Montoya-Aiona, K. M., F. A. Calderon, S. P. Casler, K. N. Courtot, P. M. Gorresen, and J. P. S. Hoeh. 2020. Hawaii Island, Hawaiian hoary bat roosting ecology and detection 2018-2019. U.S. Geological Survey data release, https://doi.org/10.5066/P9R95UYT.

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, Hawaiʻi. Available: http://hdl.handle.net/10790/4638.

Appendix 6. Makamakaʻole Seabird Mitigation Area 2021 Annual Report

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Makamakaʻole Threatened and Endangered Seabird Mitigation Project: Exclosures and Artificial Burrows Annual Summary Report

Reporting Period: January 1, 2021 – December 6, 2021
Monitored and Reported by Maui Nui Seabird Recovery Project for Brookfield Renewables and Tetra Tech

Overall Summary: The Makamakaʻole seabird mitigation site consists of 2 predator-proof exclosures, each housing 50 artificial seabird burrows with nest boxes. Since 2016, social attraction mechanisms including seabird decoys and nighttime auditory playback have been in place to attract Newell's shearwaters (*Puffinus newelli*, NESH) in exclosure A, and Hawaiian petrels (*Pterodroma sandwichensis,* HAPE) in exclosure B (NESH auditory playback inactive in 2021). MNSRP began monitoring in May 2020 and continued standardized methodology through the 2021 breeding season. This year we report a total of 16 eggs produced at 11 burrows, 1 of which hatched a successfully fledged chick. Twenty-five burrows were determined consistently active, an increase of three over 22 last season. Bulwer's petrels continue to attempt to breed in one burrow in exclosure B. No HAPE were detected inside the exclosures.

Trapping and baiting of bait stations to remove predators is consistent and ongoing. All trap boxes were replaced this season, as old boxes were rotted and collapsing. Mongooses were captured only outside the exclosures, but rats and mice were removed from inside and outside the exclosures. Poison bait consumption decreased during the summer months, as did presence of predators on tracking cards. It is critical that trapping continues year-round.

Maintenance and refurbishment of the exclosure fences and other infrastructure continues as time and resources allow.

Vegetation Control:
Removal of overgrown grasses and other vegetation by weed-whacking and hand pulling/trimming took several days at the start of the season in February. Vegetation is cleared and regularly maintained throughout the season around the inside and outside of the exclosure fences, around burrow boxes and burrow entrances, around traps and bait stations, and along interior pathways and between exclosures. Keeping these areas clear is critical for allowing fence inspection, burrow entrance and egress by the birds, and staff access to critical areas during monitoring activities. Because of the rapid rate of growth of the dominant grass species (*Paspalum dilatatum* & *Melinda minutiflora*), hand trimming and pulling occurs around the burrows during every visit, and weed-whacking occurs about once per month.

Exclosure Fence – Status and Activities:
MNSRP staff developed a method for patching sections of the fence hood where the brackets had rusted through the hood material, preventing the attachment of new brackets. The method involves cutting intact pieces of hood "patch" from damaged and previously removed hood sections. The patches are then bolted into the target hood in place, and the new brackets are bolted into the patch (see Figure 1). Using this method, bracket replacement is complete for approximately half of the windward side of exclosure A, and about ¾ of the windward side of B.

After the completion of the priority sections on the windward sides, bracket replacement will continue along the leeward sections.

Figure 1. Example of a hood patch used to secure new bracket.

Using staff and volunteer assistance, rusted sections of the fence mesh were treated with Corroseal, primed, and painted. Some heavily rusted sections of the mesh were replaced; however, new mesh is needed to finish fence repair. Mesh has proved difficult to acquire, and new material is currently on delivery from the mainland.

Sound Playback System – Status and Activities:

The sound playback system in exclosure B was activated on March 4. The HAPE recording that was acquired from Andre Raine, along with recordings made by Jay Penniman on Lānaʻi, were remastered to create a new file. The new recording was initiated as playback on March 16. The NESH playback system in exclosure A was tested and found operational but will remain off. Natural NESH activity is considered sufficient to attract NESH to the area.

The solar panel platforms in exclosure B were re-built this year.

Artificial Burrow Checks:

Sand was added as the substrate to the burrow boxes prior to the start of the breeding season (2/16/21 – 3/02/21). If boxes had signs of activity upon opening (feathers, toothpicks and/or nesting materials), the material was carefully removed and held in a clean Ziploc bag. For all boxes, the gravel and river rock was removed to a depth of ~ 2”. Sand was then added into the box up to the bottom of the tunnel entrance. Any nesting materials or feathers were then replaced to ensure the unique scent signature of the particular burrow would remain. Images were captured of the interior of all boxes (note- pictures were not taken of some *inactive* nest boxes with only sand after refurbishment). Nest box 50B was not refurbished, because upon opening, a single egg was discovered in the nest cup inside. The egg appeared sometime after Nov. 20, 2020. Based on the calendar and on the size of the egg, it is suspected to be BUPE.

Seabird activity is assessed at each burrow every other week by checking for removal or displacement of toothpicks erected at the entrance, searching for guano and feathers, and by noting bird scent. Motion-activated game cameras are deployed at all burrows suspected as active (n = 25 in 2021). NESH activity for the 2021 season was first noted during monitoring on 3/23/21. NESH first appeared on game camera on 3/31/21 at 22B. Bird sign and game camera activity continued consistently throughout the season until the single NESH chick fledged on 10/11/21. A total of 24 burrows in A (including one natural burrow – 51A) and 6 burrows in B had bird sign in 2021. Out of those, 22 in A and 3 in B are considered consistently active. A burrow is considered consistently active if it produced a chick or an egg, or if NESH appeared entering on camera two or more times, or if there was bird sign in combination with evidence inside the burrow box at the end of the season (see Table 1). Two out of the 3 natural sites discovered in 2020 showed no activity in 2021. No new natural sites were discovered this season.

On July 30, all active burrows were opened to check for reproductive status. Three burrows had egg shell or membrane, burrow 32A had one egg, 50B had one NESH egg, and burrows 20A, 24A, 26A, and 22B had 2 eggs. A single chick was present in 25A. Including an egg previously rolled out at 32A and one found at the natural burrow (51A), 11 burrows had reproductive activity, producing a total of 17 eggs and 1 chick (see Table 2). The chick was banded on Sep. 8, 2021, along with two previously unbanded adults. Recaptured NESH in burrows 14A, 20A and 26A were in the same burrows in which they were banded in 2020.

All nest boxes were opened on November 10, 2021 to check for bird activity, and to assess the condition of the boxes. The sand substrate held up well over the season. When compared to the contents present at the start of the season, burrow box contents did not indicate that there was any activity unaccounted for by regular monitoring.

Game camera data show a consistent level of adult NESH activity late into the breeding season, with adults active at several burrows in early October. Camera data also reveal that 3 adults frequented burrows 14A and 25A, and that those birds and several other pairs of birds often displayed apparently aggressive behaviors. These patterns, in addition to the occurrence of multiple eggs in some burrows, suggest that the adult NESH establishing at Makamaka‘ole are young and predominately female birds responding to the auditory playback that was used.

Table 1. 2021 activity summary for all nest boxes.

A	**Bird Sign in March 2021 during sand addition**	**Bird Sign at opening post season (11/10/2021)**	**Activity over the season**	**B**	**Bird Sign in March 2021 during sand addition**	**Bird Sign at opening post season (11/10/2021)**	**Activity over the season**
1	No sign	No sign	No sign	1	No sign	No sign	No sign
2	No sign	No sign	No sign	2	No sign	No sign	No sign
3	No sign	No sign	No sign	3	No sign	No sign	No sign
4	No sign	No sign	Entered twice	4	No sign	No sign	No sign
5	No sign	No sign	No sign	5	No sign	No sign	No sign
6	No sign	Some grass	No sign	6	No sign	No sign	No sign
7	No sign	No sign	No sign	7	No sign	No sign	No sign

A	Bird Sign in March 2021 during sand addition	Bird Sign at opening post season (11/10/2021)	Activity over the season	B	Bird Sign in March 2021 during sand addition	Bird Sign at opening post season (11/10/2021)	Activity over the season
8	No sign	Many feathers, TP, nest material, nest cup	Entered, guano, feathers, odor	8	No sign	No sign	No sign
9	No sign	Many feathers, a few TP, some nest material	Entered, guano, feathers, odor	9	No sign	No sign	No sign
10	No sign	A few feathers and a few pieces of grass	Entered consistently, odor	10	No sign	No sign	No sign
11	No sign	A few feathers and a few pieces of grass	Entered, guano, feathers, odor	11	No sign	No sign	No sign
12	Many feathers, TPs, nesting material	Many feathers, TPs, nesting material	Entered, guano, feathers, odor	12	No sign	No sign	No sign
13	Feathers, some grass	A couple feathers, 1 TP, some grass	Entered, guano, feathers, odor	13	No sign	No sign	No sign
14	Nesting material, some TP, feathers	Many feathers, TP, a few nest materials	Entered, guano, feathers, odor	14	No sign	No sign	No sign
15	Grasses	Pieces of grass	No sign	15	1 feather, grass	1 feather	No sign
16	No sign	10+ pieces of grass (but probably blown in)	No sign	16	No sign	No sign	No sign
17	One feather	One tiny feather	No sign	17	No sign	No sign	No sign
18	No sign	5 feathers, 4 TPs	Entered twice	18	No sign	Bed of grass	No sign
19	No sign	No sign	No sign	19	Grasses	3 feathers	No sign
20	Feathers, nesting material	Many feathers, TPs, nest cup	Entered, guano, feathers, odor	20	3 feathers	3 feathers	No sign
21	Feathers, nesting material	Many feathers, nest material, nest cup	Entered, guano, feathers, odor	21	No sign	Bed of grass, several feathers	No sign
22	Feathers, nesting material	Copious feathers and nest material, nest cup	Entered, guano, feathers, odor	22	Nest cup, feathers.	Nest cup filled with grass and feathers.	Entered, guano, feathers, odor
23	No sign	Less than 10 feathers	Entered, guano, feathers.	23	No sign	11 feathers	Entered, feathers
24	Nesting material, some TP, feathers	Feathers, TPs, nest material, cup, eggshell	Entered, guano, feathers, odor	24	No sign	6 feathers	No sign
25	Feathers, nesting material	A few feathers, down, nest cup, nest material	Entered, guano, feathers, odor	25	4 feathers and grass	4 feathers and grass	No sign
26	Grasses only	Many feathers, nest material, large nest cup	Entered, guano, feathers, odor	26	1 feather	1 feather	No sign
27	No sign	No sign	No sign	27	2 feathers, grass	1 feather, grass	No sign
28	Grasses only	A few pieces of grass	No sign	28	No sign	No sign	No sign

A	Bird Sign in March 2021 during sand addition	Bird Sign at opening post season (11/10/2021)	Activity over the season	B	Bird Sign in March 2021 during sand addition	Bird Sign at opening post season (11/10/2021)	Activity over the season
29	Feathers, nesting material	A few feathers, TPs, some nesting material	Entered, guano, feathers.	29	3 small feathers. Grass, TP and paint chips.	3 small feathers. grass, TPs, and paint chips	No sign
30	No sign	No sign	Entered 3 times	30	1 feather, grass	No sign	No sign
31	No sign	No sign	No sign	31	No sign	No sign	No sign
32	Nesting material, some TP, feathers	Many feathers, nest material, TPs, nest cup	Entered, guano, feathers.	32	No sign	No sign	No sign
33	Nesting material, some TP, feathers	Nesting material, a couple TPs, one feather	Entered consistently.	33	No sign	No sign	No sign
34	No sign	Nesting material, shallow nest cup	Entered, guano, feathers.	34	No sign	No sign	No sign
35	No sign	No sign	No sign	35	2 feathers, grass	No sign	No sign
36	No sign	No sign	No sign	36	No sign	No sign	No sign
37	No sign	No sign	No sign	37	No sign	No sign	No sign
38	No sign	No sign	No sign	38	No sign	No sign	No sign
39	No sign	No sign	No sign	39	No sign	No sign	Entered 3 times
40	No sign	2 feathers	No sign	40	No sign	No sign	No sign
41	3 feathers	1 feather, a few pieces of grass	No sign	41	1 feather	1 feather	No sign
42	Feathers, nesting material	10 feathers, nesting material (undisturbed)	No sign	42	Grass bed with ohia leaves	Grass bed with ohia leaves	No sign
43	Nesting material, TP, feathers	Many feathers, TPs, nest material, nest cup	Entered, guano, feathers, odor	43	4 feathers and duff	4 feathers and some mystery materials	No sign
44	No sign	No sign	No sign	44	No sign	No sign	No sign
45	No sign	No sign	No sign	45	1 feather, grass	A few bits of grass and one feather	No sign
46	No sign	No sign	No sign	46	No sign	No sign	No sign
47	No sign	1 piece of grass	No sign	47	No sign	No sign	No sign
48	Nesting material, TP, feathers	8 feathers, nest cup, nesting material, TPs	Entered, guano, feathers, odor	48	No sign	No sign	No sign
49	No sign	No sign	No sign	49	No sign	No sign	No sign
50	No sign	No sign	No sign	50	Egg in nest cup	TP, veg, a broken eggshell, feathers	Entered, guano, feathers, odor
51		Egg collected	Entered, guano, feathers.				

Table 2. 2021 Summary of visitation and production of consistently active burrow boxes.

Burrow	Active dates at burrow checks	NESH on camera	Game cam deploy dates	Eggs
8A	5/11/21-10/4/21	Pair	5/19/21-current	
9A	4/27/21-9/21/21	Pair	5/19/21-current	
10A	4/27/21-8/11/21	Single	5/19/21-current	
11A	4/27/21-7/30/21	Single	4/2/21-10/13/21	
12A	4/27-5/11/21; 9/8/21	Single	5/19/21-10/4/21	
13A	5/11/21-9/21/21	Single	5/19/21-10/13/21	
14A	4/12/21-10/4/21	Pair +1	4/29/21-current	1
18A	7/13/21; 10/4/21	None	5/4/21-9/21/21	
20A	4/6/21-10/4/21	Pair	4/12/21-current	2
21A	4/27/21-10/4/21	Pair	2/10/21-current	
22A	4/6/21-10/4/21	Pair	2/10/21-current	1
23A	5/11/21; 7/30/21	None		
24A	4/12/21-10/4/21	Single	2/10/21-current	2
25A	4/6/21-10/4/21	Pair +1	4/27/21-current	1 (fledged)
26A	4/6/21-10/4/21	Pair	4/27/21-current	2
29A	4/6/21-8/26/21	None	4/27/21-10/13/21	
32A	4/6/21-11/2/21	Single	5/19/21-current	2
33A	4/6/21-9/21/21	Single	5/26/21-9/27/21	
34A	3/23/21-10/4/21	Single	5/26/21-current	
43A	4/12/21-10/4/21	Pair	2/10/21-current	
48A	4/6/21-10/4/21	Pair	4/8/21-current	1
51A	5/11/21-10/4/21	Pair	5/4/21-current	1
22B	4/6/21-10/4/21	Single	2/10/21-current	2
23B	9/21/21-10/4/21	None	9/27/21-current	
50B	4/6/21-11/2/21	Single	2/10/21-current	1(NESH) 1(BUPE)

Seabird Monitoring:

Acoustic and visual night surveys reveal HAPE activity in and over the gulches adjacent to the exclosures. On April 6 during a survey, 43 distinct HAPE calls were detected between 175° and 215°. One bird was seen flying directly overhead, and another was spotted flying over Makamakaʻole gulch. After the survey, HAPE calls were heard from exclosure A, originating from the nearby peak above the exclosure. NESH calls were only heard from within exclosure A. On May 10, HAPE calls were heard from exclosure B, and HAPE were viewed flying into the valley. In exclosure A only NESH calls were heard, and NESH were seen at the burrows and flying overhead. One barn owl was seen outside the exclosures between the surveys. On August 4, HAPE calls averaged 4.2/min. NESH were detected by calls and by sight on 3 occasions during the survey. A visual survey was conducted on August 5 using near-infrared illumination (NIR) and night vision. The survey revealed that HAPE are numerous in active flight above the gulch to the south of the exclosures. While one individual was behaving as if looking to land, no bird was detected making ground contact.

Predator Removal: DOC200 traps (10 inside and 22 outside) and snap traps (20 inside and 20 outside) are deployed at the exclosures. Baits typically used are eggs for DOC200s and peanut butter for snap traps. One Have-a-heart feral cat trap is left intermittently outside exclosure A near the parking area. One feral cat was removed on 9/27/21. Total catches this year to date are; 39 mongooses outside, 31 rats outside, 14 rats inside, 3 mice outside, and 5 mice inside. The overall catch rate for the year was 0.004 (catches/trap night). Catch rate was higher at exclosure B compared to A (0.005 vs. 0.003) and higher outside of the exclosures compared to inside (0.005 vs. 0.002). Doc200 traps were twice as successful at removing predators than snap traps. The number of predators removed varied by month (Fig. 2). See Table 3 for a summary of trapping.

Table 3. Summary of trap nights and catches, inside and outside exclosures by trap type (Jan. 1 – Dec 6, 2021).

Exclosure	Placement	Trap Type	Trap Nights	Mongoose catch	Rat catch	Mouse catch
A	Outside	DOC200	3544	**16**	**10**	0
		Snap Trap	3315	0	**4**	**1**
	Inside	DOC200	1660	0	**2**	0
		Snap Trap	3320	0	0	**2**
B	Outside	DOC200	3509	**21**	**11**	**1**
		Snap Trap	3285	**2**	**6**	**1**
	Inside	DOC200	1665	0	**1**	0
		Snap Trap	3270	0	**11**	**3**

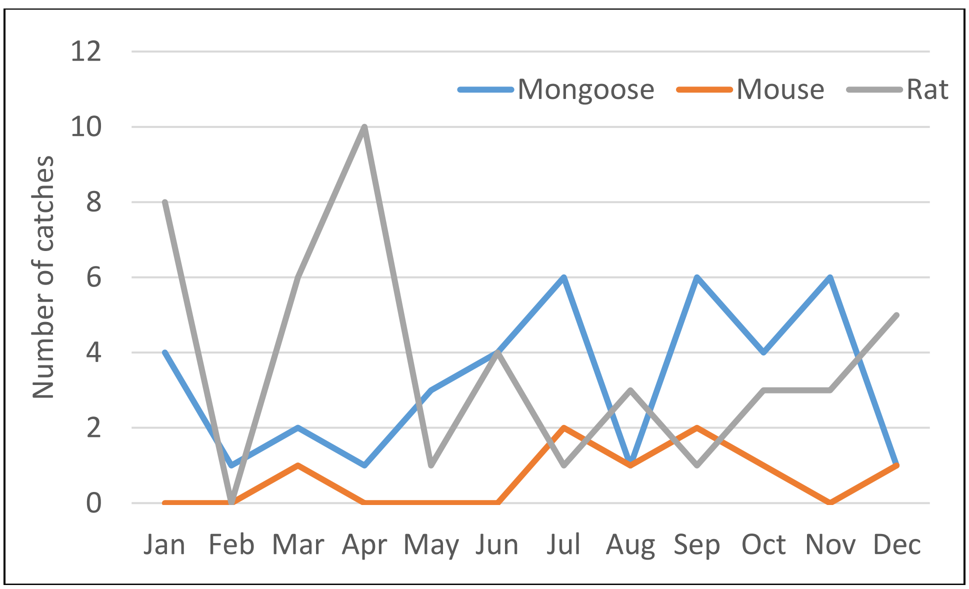


Figure 2. Number of catches by species per month (2021).

Bait stations targeting rodents are deployed throughout both exclosures (24 in A, 22 in B). They are checked monthly and re-baited as needed with Ramik green bait bars. The average amount of bait consumed in both exclosures was near 100% in January and February, but dropped significantly in April and through the summer months. Bait consumption started to increase in exclosure B at the end of the year (see Figure 3). The average percent of bait consumed in 2021 was greater in exclosure B (37% vs. 30% in A).

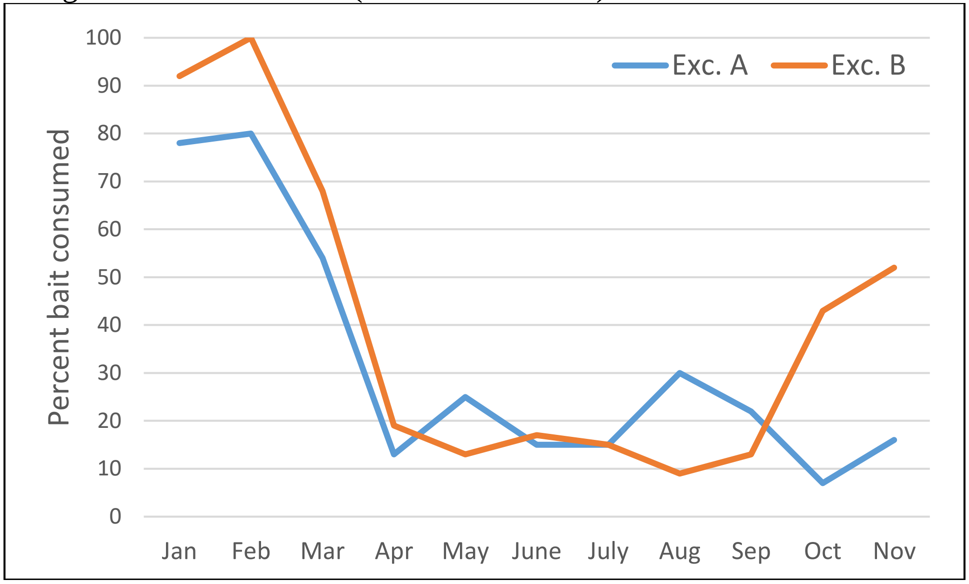


Figure 3. Average amount of Ramik green bait consumed by month in each exclosure (2021).

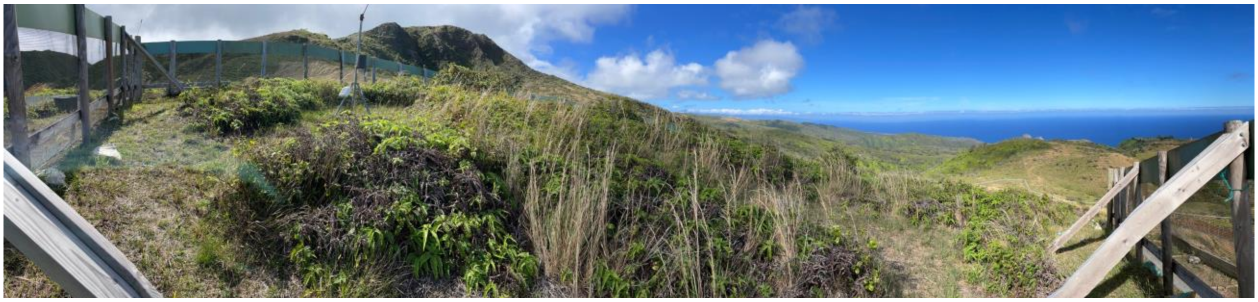
Predator Tracking: Tracking cards baited with peanut butter were used to assess rodent and mongoose activity within the exclosures (10 each in A and B). Tracking cards are deployed for 24 hours and checked for rodent activity, new cards are deployed then checked again after 72 hours for mongooses. In 2021, predator tracking cards were deployed in January, April, August, and November. No mongooses were detected on tracking cards. Rat tracks were seen more frequently in exclosure B than in A. Rodent presence decreases throughout the summer, as suggested by bait consumption (see Table 4).

Table 4. Predator tracking results by month. Results of mouse detection as the percent of cards with mouse tracks. Rat results list specific rat detection locations.

	Percent cards with mice		Cards with rats
	A	B	
January	100%	67%	B9, B10
April	10%	0%	B9
August	60%	20%	A6
November	100%	20%	B2, B3, B9, B10

Makamaka'ole exclosure photo point panoramas:

Exclosure A, entrance, photo point makai west



Exclosure A, photo point mauka west

Exclosure A, photo point makai east


Exclosure B, entrance, photo point makai east


Exclosure B, photo point mauka east


Exclosure B, platform, photo point mauka west

Exclosure B, photo point makai west

Supplemental data files available for agency review:

1. *Burrow monitoring protocols*
    a. General MNSRP burrow monitoring (JKL): SOP Seabird burrow monitoring.docx
    b. Makamakaole detailed monitoring (CEF): 2021_05_17_MKMK_Burrow Monitoring_SOP.docx
2. *iForm data files*
    a. Makamakaole burrow checks: 2021_11_12_MKMK_Burrows2021final.xlsx
3. Burrow status and observations notes summary: 2021_11_12_Burrow_activity_summary
4. Game camera image analysis master data: 2021_12_09_MKMK_Game_Cam_Image_Analysis
5. *Images*
    a. Reconyx game camera images all burrows: https://drive.google.com/drive/folders/1zEuawgpASN0NZKw6KcSmU6SRTZjfuH-K?usp=sharing
    b. Box contents: https://drive.google.com/drive/folders/1vm3mTKv1tU5-YvnICVg0pm2m2i_aXd6L?usp=sharing

Appendix 7. Lānaʻi Hawaiian Petrel Mitigation; Final Report - 2021

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Lānaʻi Hawaiian Petrel Mitigation
Final Report - 2021

Prepared for Brookfield Renewable Partners

Dr. Rachel Sprague
Director of Conservation

Pūlama Lānaʻi
Preservation. Progress. Sustainability.

April 2022

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Objective

The goal of this mitigation work was to improve reproductive success of Hawaiian petrels (*Pterodroma sandwichensis*) in a high-priority colony area on Lānaʻi, where maintenance of previous mitigation work is at risk. Support from this mitigation effort provided nesting petrels protection from predator pressure and resulted in reproductive success well above baseline levels within the project area.

Project Background

In 2018, Brookfield Renewable Partners provided support to Pūlama Lānaʻi to partially meet the regulatory requirements of Kaheawa Wind Power's Habitat Conservation Plan (HCP). With that mitigation project, predator control and monitoring were extended to protect the endangered Hawaiian petrel colony beyond the scope of the work the Pūlama Lānaʻi Conservation Department was conducting at the time.

In 2019, Pūlama Lānaʻi was able to maintain the predator control and monitoring with internal funding. In 2020, the COVID-19 pandemic caused the Pūlama Lānaʻi Conservation Department to constrict and focus on triage of priority activities. Some cat control was continued, and rodent traps were rebaited in January 2021, but the Conservation Department struggled to complete the work with fewer staff, and the department's other endangered species efforts were completely sidelined during that time.

For 2021, mitigation funding support from Brookfield Renewable Partners supported efforts on Lānaʻi to maintain the 2018 level of predator control and Hawaiian petrel monitoring that was at risk due to post-COVID impacts.

Mitigation Actions

The mitigation project area consists of 4 distinct ridges, East Puʻu Aliʻi, Kanalo, West Hiʻi, and Hiʻi Center Ridge, totaling approximately 150 acres (~60 ha). The density of birds in this area is also extremely high, and more than 190 burrows have since been found across these ridges (Figure 1), out of nearly 600 burrows known across Lānaʻi Hale.

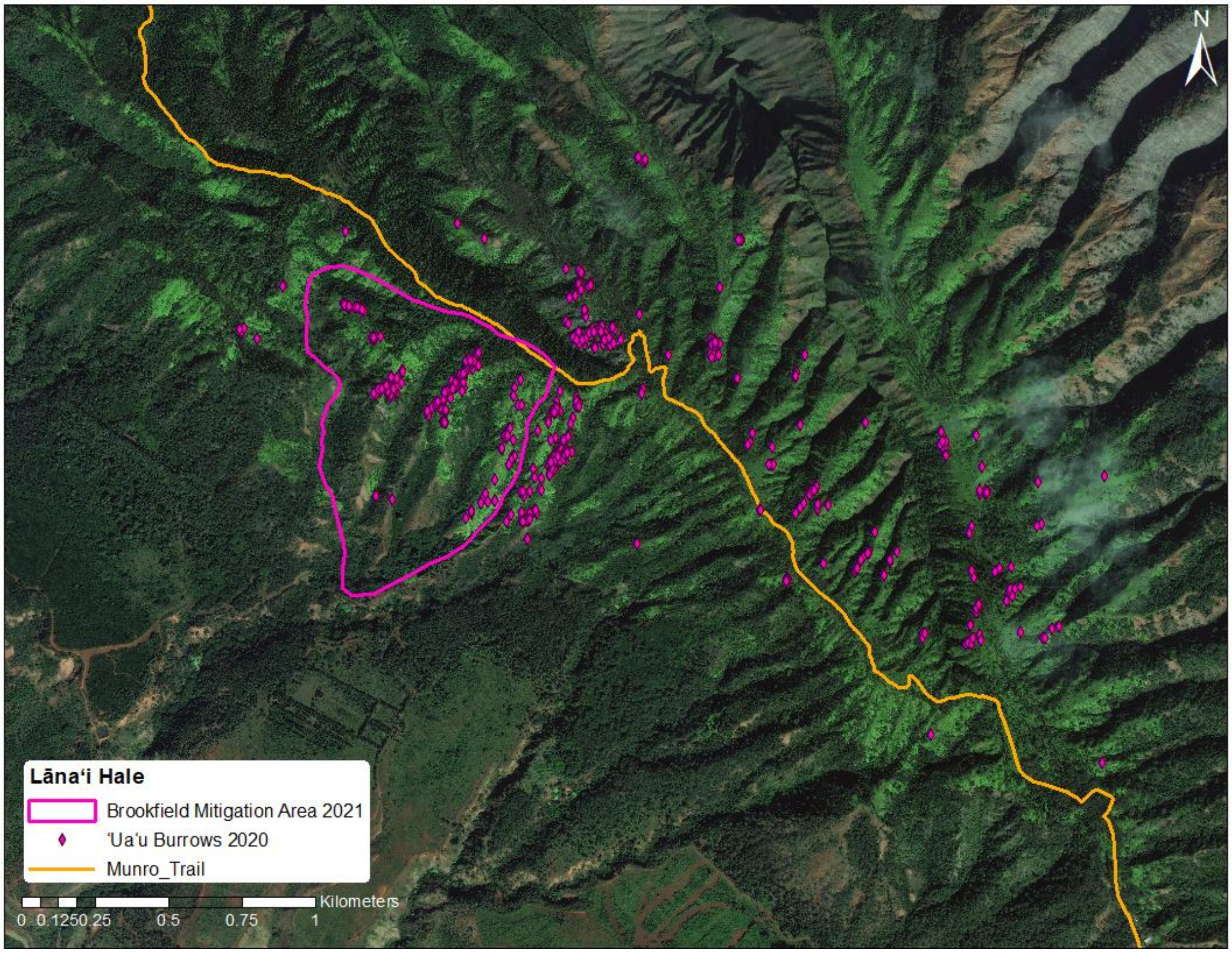

Figure 1. Map of area supported by Brookfield Renewable Partners mitigation funding for 2021, relative to the known Hawaiian petrel burrows on Lānaʻi Hale. The area is approximately 150 acres, and encompasses over 30% of the known Hawaiian petrel burrows on Lānaʻi.

Predator Control

Predator control for cats (*Felis catus*) and rats (*Rattus spp.*) was expanded within and around this area in 2018 as part of the mitigation for Kaheawa Wind Power I (Brookfield Renewable Partners). Today, those cat trap locations remain above these ridges on the Munro Trail and below on the lower Kapano and Kōʻele trap lines, which lie behind Lānaʻi City (Figure 2). During 2021, we captured 21 cats within ½ mile of the mitigation area.

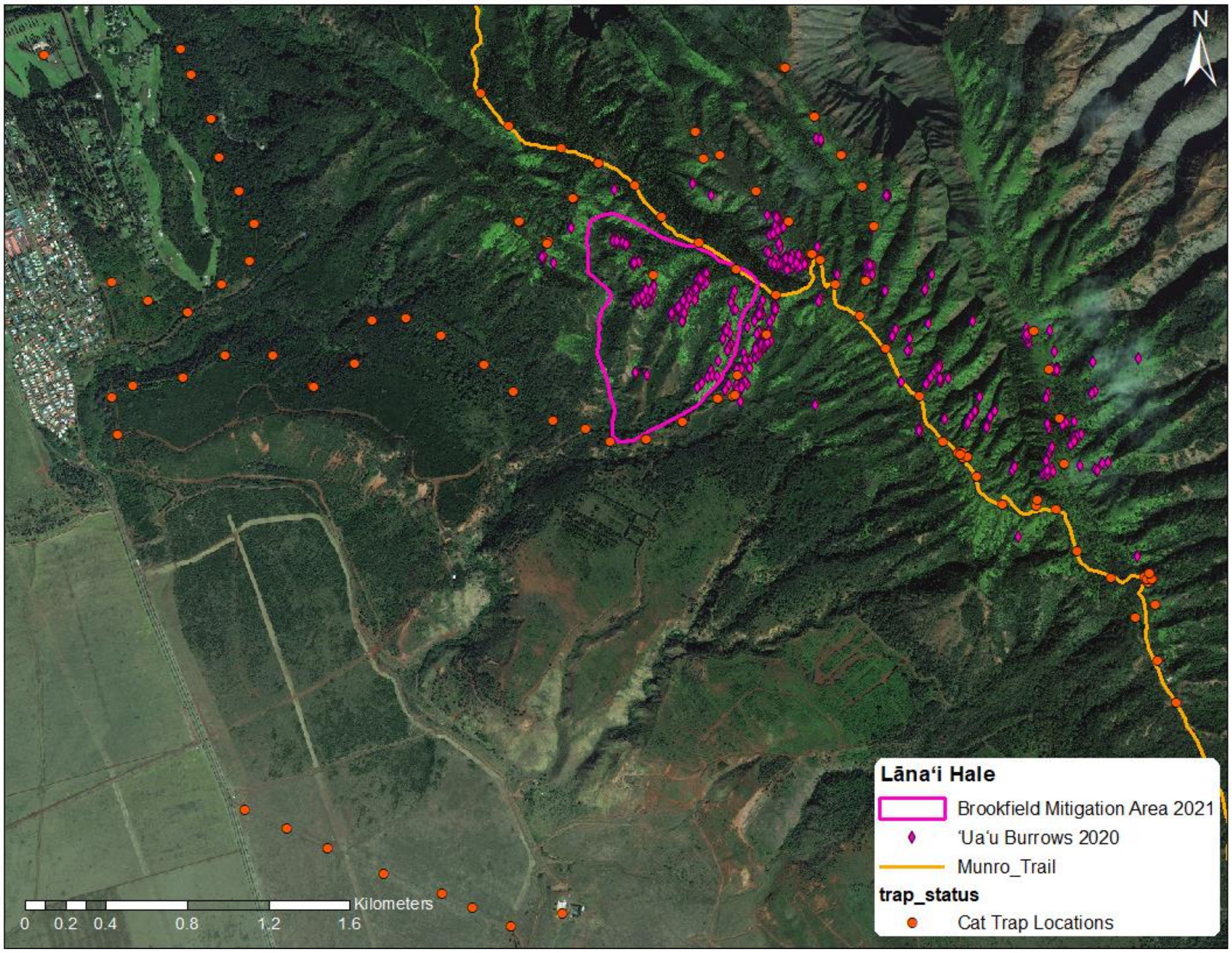

Figure 2. Locations of the landscape-level cat trap stations in the grid protecting the Hawaiian petrel colony on Lānaʻi Hale.

Throughout the 2021 season, 190 self-resetting rat traps (A24s) were active across the 150-acre native habitat area encompassing the burrows. These rat trap lines run down the ridges and through challenging canyon drainages (Figure 3). Mitigation funding provided by Brookfield supported rebaiting and maintenance of the A24 traps in the Greater Hiʻi area – this area is fully 25% of the nearly 800-trap A24 grid on Lānaʻi Hale and is the most technical terrain to traverse.

The Pūlama Lānaʻi Conservation team checked and rebaited the A24 automatic traps twice during the 2021 seabird breeding season, utilizing long-lasting automatic lure pumps (ALPs). During this time, we removed a minimum of 354 rodents,which is understood to be an extreme *under*estimate. This estimation is derived from incidental counts of skulls or carcasses found in the immediate vicinity of the A24 traps at the time of rebaiting.

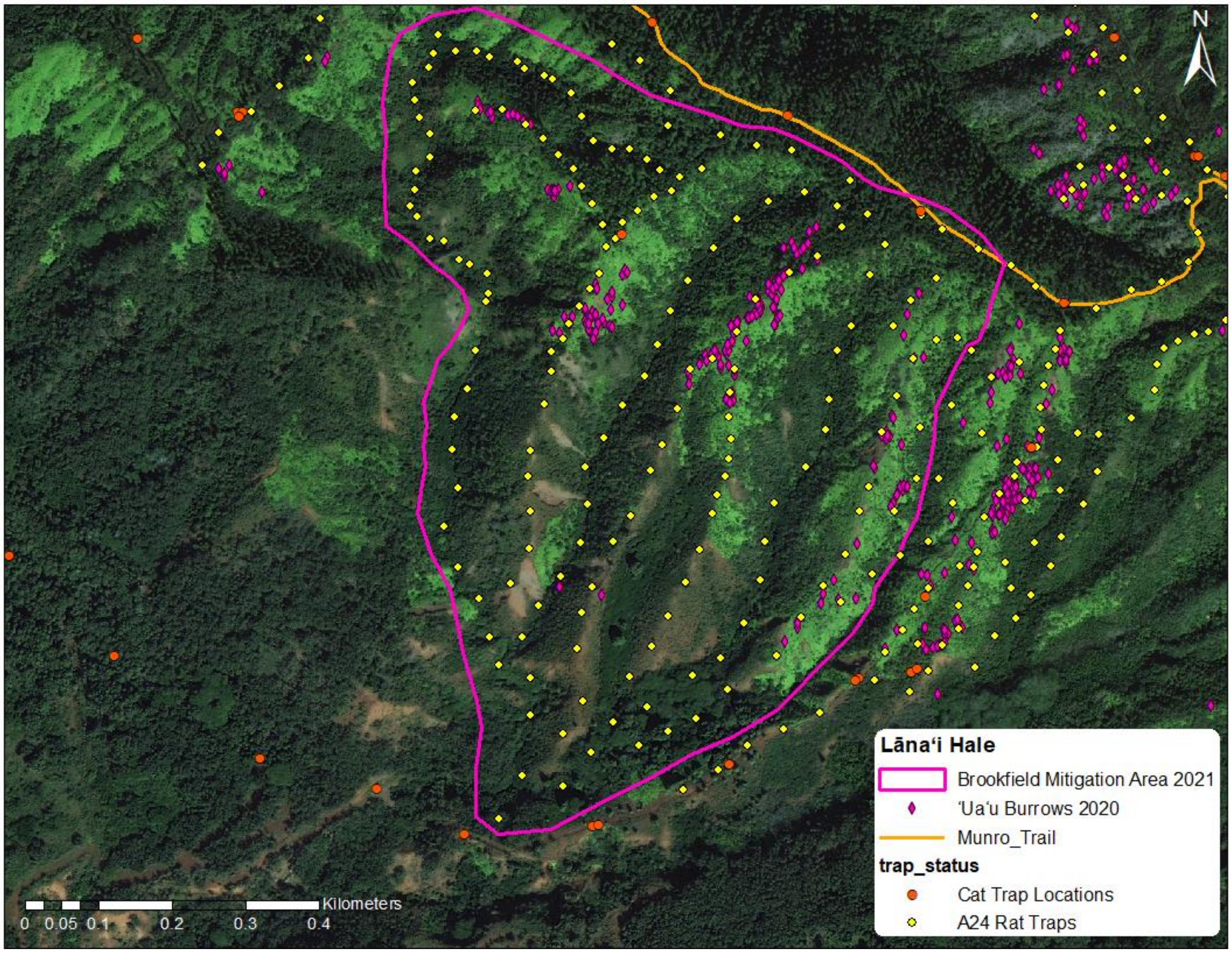

Figure 3. Locations of A24 self-resetting rat traps in the area supported by Brookfield Renewable Partners mitigation funding.

Monitoring/Evaluation

We used 64 motion-activated cameras to monitor a subset of burrows within the project area. Burrows were selected from 2 panels, a set that remains relatively constant over time (static) and a set that changes every year (rotating). All selected burrows were consistently camera monitored, from before the start of the season until after fledging or failure. This sample of monitored burrows was then used to determine apparent reproductive success and relative proportions of inactive burrows, new prospecting pairs, non-breeding pairs, etc. for all known Hawaiian petrel burrows in the monitoring area (Table 1). Any new burrows found were added to the pool of burrows to be potentially selected for monitoring the following year.

Table 1. Number of known burrows and monitoring outcomes in the Greater Hiʻi area from 2017 to 2021.

	2017	2018	2019	2020	2021
Known Burrows	59	124	189	193	196
Monitored Burrows	59	121	176	50	64
*Monitored with Cameras**	18	56	52	50	64
Monitored without Cameras	41	65	124	0	0
Inactive	2	3	2	3	3
Active, unknown status	14	17	33	4	5
Active, non-breeding	7	14	13	4	1
Active, breeding confirmed	36	87	129	39	55
unknown outcome	*14*	*4*	*10*	*0*	*0*
fledged	*13*	*59*	*110*	*32*	*44*
failed	*9*	*24*	*18*	*7*	*11*
Chicks produced per pair (w/known outcome)	**0.59**	**0.71**	**0.86**	**0.82**	**0.80**
Proportion of monitored burrows with known status and outcome	0.53	0.83	0.81	0.92	0.92
Proportion of monitored burrows with breeding and outcome confirmed	0.37	0.69	0.73	0.78	0.86

**Note that from 2017-2019, cameras were moved around between burrows during the season, and burrows with likely breeding or activity were prioritized, so they were not unbiased, random samples.*

Baseline Reproductive Success

The baseline success rate without predator control on Lānaʻi was calculated at 38.2% in communication with USFWS and Hawaiʻi DOFAW. In short, we averaged the 2016 and 2017 reproductive success estimates in colony areas with limited or no predator control.

Impact of Mitigation Project

Burrow Monitoring – Reproductive Success

As of December 31, 2021, there were 196 known burrows on the 4 ridges in the Greater Hiʻi area (East Puʻu Aliʻi, Kanalo, West Hiʻi and Hiʻi Center Ridge), and 64 burrows were monitored on those ridges as part of our 2021 monitoring plan (Figure 1). We confidently determined the breeding status and outcome of 92% of the monitored burrows, and 86% of the monitored burrows had confirmed breeding attempts (Table 1).

Of the burrows with breeding attempts, 80% successfully fledged a chick (n = 55). Causes of nest failure included 3 abandoned eggs, 5 failures at the egg stage for unknown cause (no depredation detected), 2 chick mortalities from rat predation, and 1 chick mortality of unknown cause (no depredation detected). Review of photos from the 64 burrow monitoring cameras (~1.7 million photos) did not detect any feral cat visits to burrows.

Net Fledgling Outcomes

Our monitoring program uses a standardized random selection of Hawaiian petrel burrows to monitor, allowing for application of the proportions of inactive, prospecting, breeding, status burrows and reproductive success rates to be applied to all known burrows in a given area. Calculation of the net benefit uses the monitored set of burrows in 2021 to determine 1) the proportion of burrows that have confirmed breeding (i.e., estimated active nests), and 2) the apparent reproductive success rate for burrows in the Greater Hiʻi area. The estimated number of fledglings produced from the known burrows minus the calculated baseline determines the net fledglings produced as a result of the mitigation actions:

*(# known burrows * proportion with confirmed breeding * 2021 success rate)*

– *(# known burrows * proportion with confirmed breeding * baseline success rate)*

= *net fledglings produced*

In 2021, the calculated benefit of predator control in the Greater Hiʻi area was 70 Hawaiian petrel chicks above baseline, given the currently known number of burrows (Table 2).

Table 2. Calculated increase in 2021 Hawaiian petrel fledgling production in response to predator control in the proposed mitigation area.

	2021
# Known Burrows	196
Estimated proportion of burrows w/breeding attempts *(based on 0.86 proportion of burrows monitored with breeding attempts; Table 1)*	168
Apparent Reproductive Success Rate	0.80
Benefit of predator control above 0.382 baseline (net fledglings produced)	70

Conclusion

Support from this mitigation effort provided nesting petrels protection from predator pressure and resulted in reproductive success well above baseline levels within the project area.