Kaheawa Wind Power
Habitat Conservation Plan
FY 2022 Annual Report

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

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Executive Summary

This report summarizes work performed by Kaheawa Wind Power, LLC (KWP I), owner of the Kaheawa Wind Power I Project (Project), during the State of Hawaiʻi fiscal year (FY) 2022 (July 1, 2021 – June 30, 2022) under the terms of the approved Habitat Conservation Plan (HCP). The HCP was approved in January 2006 and describes KWP I's compliance obligations under Project's state Incidental Take License (ITL-08) and federal Incidental Take Permit (TE118901-0). Species covered under the HCP include four federally and state-listed threatened and endangered species (Covered Species). The 20-turbine Project was constructed in 2005 and 2006 and has been operating since June 22, 2006.

Wildlife fatality monitoring in FY 2022 continued within search plots limited to cleared areas within 70-meters of each Wind Turbine Generator (WTG). Canine-handler teams searched each of the fatality monitoring search 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 (carcass persistence) and the probability that an available carcass would be found (searcher efficiency) by a canine search team. In FY 2022, mean probabilities of a carcass persisting until the next search were 0.84 (bat surrogates), 1.00 (Hawaiian goose surrogates), and 0.99 (seabird surrogates); searcher efficiency was 1.00 for surrogates of each of the three species.

Of Covered Species, one Hawaiian goose fatality was detected in FY 2022. This fatality was detected within the search plots over two dates: January 25 and February 1, 2022 and determined to be different parts of a single individual. Since the commencement of operations, the Project's total observed direct take of Covered Species has been 12 Hawaiian hoary bats, 31 Hawaiian geese, and eight Hawaiian petrels. The fatality estimates using the Evidence of Absence estimator at the upper 80 percent credibility level are 26 (Hawaiian hoary bat), 49 (Hawaiian goose), and 17 (Hawaiian petrel). Rounded up indirect take estimates for the Covered Species are four (Hawaiian hoary bat), two (Hawaiian goose), and four (Hawaiian petrel). Combining these values, there is an approximately 80 percent chance that cumulative take of Covered Species at the Project since the beginning of operations through FY 2022 was less than or equal to 30 Hawaiian hoary bats, 51 Hawaiian geese, and 21 Hawaiian petrels.

The bat acoustic monitoring program captured bat activity across the Project at five detector locations throughout FY 2022. Between July 2021 and June 2022, Hawaiian hoary bats were detected on 167 nights out of 1,756 (9.5 percent) detector-nights sampled. The seasonal pattern of detection rates was similar to previous years, except in January and February where an abnormal peak was detected. While the cause of this peak is unknown, similar increases in January and February were observed at other monitoring sites on Oʻahu in the FY 2022 monitoring year.

Mitigation commitments are ongoing. Baseline (Tier 1) mitigation obligations for the Hawaiian hoary bat were met prior to this fiscal year and current estimated take remains within Higher levels of take (Tier 2). Tier 2 mitigation funding was provided to USGS in FY 2022 for ecological research on Hawaiʻi Island. The Project's Hawaiian goose current estimate of take remains within Tier 1. Tier

1 mitigation has been funded and is ongoing as propagation efforts at the Haleakalā Ranch Hawaiian goose release pen. Current estimated take of Covered Species that are seabirds remains within Tier 1. 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. For the 2022 breeding season, the Maui Nui Seabird Recovery Project is contracted to perform work at Makamakaʻole; Pūlama Lānaʻi is contracted to perform predator control efforts on Lānaʻi. KWP I continues to work with wildlife agencies to assess overall benefits of KWP I's seabird mitigation projects.

KWP I 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. The purpose of these communications included required semi-annual HCP implementation meetings and focused discussions of mitigation funding and strategies.

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1.0 Introduction

The Hawaii Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW) and U.S. Fish and Wildlife Service (USFWS) approved the Kaheawa Wind Project I (Project) Habitat Conservation Plan (HCP) in 2006. Kaheawa Wind Power, LLC was issued a federal Incidental Take Permit (ITP; ITP- TE118901-0) from the U.S. Fish and Wildlife Service (USFWS) and a state Incidental Take License (ITL; ITL-08) from the Hawaii Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW) for the Project in January of 2006. The ITP and ITL cover the incidental take of four federally and state-listed threatened and endangered species (referred to as the Covered Species) over a 20-year permit term.

The Covered Species include the:

- Hawaiian hoary bat or ʻōpeʻapeʻa (*Lasiurus cinereus semotus*);
- Hawaiian goose or nēnē (*Branta sandvicensis*);
- Hawaiian petrel or ʻuaʻu (*Pterodroma sandwichensis*); and
- Newell's shearwater or ʻaʻo (*Puffinus newelli*).

The HCP frames take levels and mitigation as "Baseline Take" and "Higher Take." Hereafter, this document refers to Baseline Take as Tier 1 and Higher Take as Tier 2.

The Project was constructed in 2005 and 2006 and was commissioned to begin operating on June 22, 2006. Brookfield Renewable Partners, LP acquired the Project's LLC through acquisition of a controlling interest TerraForm, LLC in 2017; the Project continues to be operated by KWP I.

On behalf of KWP I, Tetra Tech, Inc. (Tetra Tech) prepared this report to describe the work performed for the Project during the State of Hawaiʻi 2022 fiscal year (FY 2022; July 1, 2021 – June 30, 2022) pursuant to the terms and obligations of the approved HCP, ITL, and ITP. KWP I has previously submitted annual HCP progress reports for FY 2007 through FY 2021 to the USFWS and DOFAW (KWP I 2007, KWP I 2008, KWP I 2009, KWP I 2010, KWP I 2011, KWP I 2012, KWP I 2013, KWP I 2014, KWP I 2015, KWP I 2016, KWP I 2017, KWP I 2018, Tetra Tech 2019, Tetra Tech 2020, Tetra Tech 2022).

2.0 Fatality Monitoring

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

- In June 2006, search plots were 180-meter by 200-meter rectangles centered on each of the Project's 20 wind turbine generators (WTG).
- On October 1, 2010, search plots were reduced to 73-meter radius circular plots centered on each WTG, except where steep slopes prohibited visual searching.
- Since April 2015, search plots were reduced to the graded WTG pads and access roads that fall within a 70-meter radius circle centered on each of the Project's 20 WTGs (Figure 1). This search area continues to be used for monitoring in FY 2022.

In FY 2022, all 20 WTGs were searched for fatalities once per week. Due to WTG maintenance, a total of 14 search days were excluded in FY 2022, one day at WTG 11 and 13 days at WTG 16. When maintenance is being conducted turbines are not accessible for fatality searches to ensure the safety of search teams; turbines were non-operational during these times. When accounting for search days lost to maintenance, the total number of search days across all WTGs in FY2022 was 1,026. The FY 2022 mean search interval for all WTGs was 7.0 days (Standard Deviation = 0.2 days). The search plots were searched by a canine search team which included a trained detector dog accompanied by a handler. Should search conditions prevent the use of dogs (e.g., weather, injury, availability of canine search team, etc.), search plots would be visually surveyed by Project staff. In FY 2022, all searches were conducted by canine teams and no visual searches occurred.

One Covered Species, Hawaiian goose, was detected during fatality searches in FY 2022 (see Section 7.2.1). No fatalities of other Covered species were observed at the Project in FY 2022; fatalities of other species are reported in Section 7.4.

Precautions have been taken to prevent potential canine interactions with wildlife, particularly the Hawaiian goose. If Hawaiian geese were present in the search area, the canine handler immediately retrieved and restrained the dog, avoided disturbing the birds, postponed searching in the vicinity of the birds, worked on leash away from wildlife and/or temporarily skipped canine searches in the proximity of the Hawaiian goose. Hawaiian geese were observed at the Project over 53 days in FY 2022 and in every month of the year except for September. In each case, the canine handler moved the dog to a different WTG search area away from the Hawaiian geese and returned to finish the search later in the day. No canine searcher-wildlife interactions occurred in FY 2022.

3.0 Carcass Persistence Trials

One 28-day carcass persistence trial (including 10 individual carcasses) was conducted in each quarter of FY 2022, for a total of four trials and 40 carcasses. 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). For FY

2022, the probability that a carcass persisted until the next search was 0.84 for all bat surrogate carcasses (95 percent Confidence Interval [CI] = 0.72, 0.93; N=20), 1.00 for Hawaiian goose surrogates (95 percent CI = 0.97, 1.00; N=10), and 0.99 for seabird surrogates (95 percent CI = 0.88, 1.00; N=10).

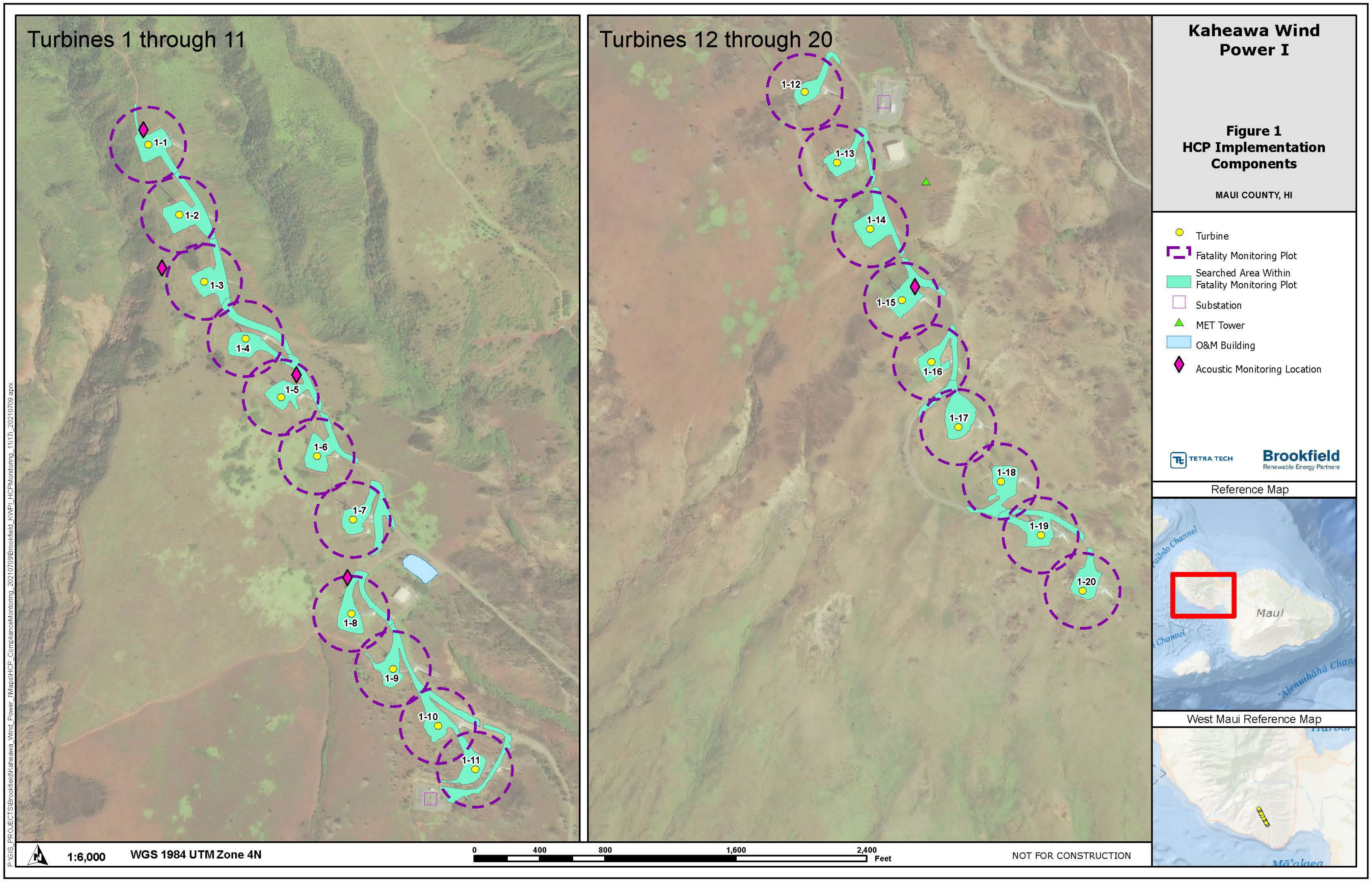

Figure 1. HCP Implementation Components

4.0 Searcher Efficiency Trials

A total of 76 searcher efficiency trial carcasses were placed over 20 trial days during FY 2022. Similar to the carcass persistence trials, black rats were used as surrogates for bats, chickens were used as surrogates for Hawaiian goose, and wedge-tailed shearwaters and other medium-sized birds collected under the Project's Special Purpose Utility Permit (MB22096C-0) were used as surrogates for Covered Seabird Species. Searcher efficiency trials occurred throughout the year; 100 percent were conducted with canine search teams in FY 2022. Of the 76 trial carcasses placed, three bat surrogates were lost to scavenging. All other carcasses were 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 = 0.94, 1.00; N=43), 1.00 for Hawaiian goose surrogates (95 percent CI = 0.87, 1.00; N=17), and 1.00 for Hawaiian petrel surrogates (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 I 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. Additional woody vegetation removal was approved to occur within a one-meter buffer of select turbine access roads with all work 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, 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 I anticipates removal of woody vegetation in proximity to select turbines in FY 2023.

6.0 Scavenger Trapping

KWP I 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 twelve live traps placed throughout the Project. In Q3 FY 2022, the number of traps in use for each effort was increased to address declining probabilities of carcasses persisting the next search and provide additional protections to the Hawaiian goose. An addition of 15 DOC250 and six cage traps were added for a total programmatic effort of 24 DOC250 and 18 cage traps. In FY 2022, the scavenger trapping program removed 30 mongooses (*Herpestes auropunctatus*), and five 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

A single fatality of a Covered Species was detected in FY 2022. One Hawaiian goose fatality was detected in January 2022 (Section 7.1.1). 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.

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 search 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 search plot 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. As no changes to search plot dimensions have been made since FY 2016, the estimate of the density weighted proportion (DWP) of the carcass distribution searched (Appendix 1) has remained the same as described in the FY 2017 annual report (KWP I 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. Estimated Unobserved direct take (UDT); and
3. Estimated Indirect take.

The Evidence of Absence software program (EoA; Dalthorp et al. 2017), the agency-approved analysis tool for estimating direct take, uses results from bias correction trials and ODT to generate a UCL of direct take (i.e., ODT + UDT). Direct take values from this analysis can be interpreted as: there is an 80 percent probability that actual direct take at the Project over the analysis period was less than or equal to the 80 percent UCL. Indirect take calculations are based on the HCP (KWP I 2006) 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 for Hawaiian hoary bats (e.g., USFWS [2016] for Hawaiian hoary bats).

Additionally, EoA includes a module that allows users to project future estimates of mortality based on results of past fatality monitoring. Due to the inherent uncertainty of these projections (including the potential future contribution of indirect take) and the amplification of this uncertainty resulting from the use of the 80 percent UCL as the estimate of take for regulatory compliance, long term projections may 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 12 Hawaiian hoary bat fatalities have been observed at the Project since monitoring began in June 2006. Of the 12 observed, nine were found inside of fatality search plots and are used to estimate UDT. Three bat fatalities were classified as incidental observations. All bat carcasses were transferred to the U.S. Geological Survey for genetic sexing. Genetic sexing is used to estimate indirect take. The observed Hawaiian hoary bat fatalities by fiscal year are listed in Table 1.

Table 1. Observed Hawaiian Hoary Bat Fatalities at KWP I Through FY 2022

Fiscal Year	Hawaiian Hoary Bat Observed Direct Take	Hawaiian Hoary Bat Incidental Fatality Observations	Total
2007	0	0	0
2008	0	0	0
2009	0	1	1
2010	0	0	0
2011	0	1	1
2012	0	0	0
2013	2	0	2

Fiscal Year	Hawaiian Hoary Bat Observed Direct Take	Hawaiian Hoary Bat Incidental Fatality Observations	Total
2014	4	0	4
2015	0	0	0
2016	0	0	0
2017	1	1	2
2018	1	0	1
2019	1	0	1
2020	0	0	0
2021	0	0	0
2022	0	0	0
Total	**9**	**3**	**12**

The estimated direct take (ODT + UDT) for the 12 Hawaiian hoary bat fatalities found between the start of fatality monitoring in June 2006 and end of FY 2022 (June 30, 2022) is less than or equal to 26 bats (80 percent UCL; Appendix 1a).

Indirect take is estimated to account for the potential loss of individuals (offspring) that may occur indirectly as the result of the loss of an adult (breeding) female through direct take during the period that females may be pregnant or supporting dependent young. The seasonal timing and sex of all observed fatalities (those observed in fatality monitoring as well as incidental to fatality monitoring) is used in the estimate of indirect take. Cumulative indirect take is calculated as 3.11 adults (Appendix 2a).

The UCL for cumulative Project take of the Hawaiian hoary bat at the 80 percent credibility level is 30 adult bats (26 [estimated direct take] + 4 [estimated indirect take, rounded up from 3.11]). That is, there is an approximately 80 percent probability that cumulative take at the Project at the end of FY 2022 is less than or equal to 30 bats (Appendix 1a).

7.1.2 Projected Take

KWP I projected Hawaiian hoary bat take through the end of the permit term using the fatality monitoring data collected through FY 2022. The objective of this analysis was to evaluate the potential for the Project to exceed the permitted take limit at the 80 percent UCL prior to the end of the permit term (Appendix 3). For this analysis, the carcass detection probability for future years is assumed to match the estimated overall detection probability of FY 2022, 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. Based on historical Project data, Tetra Tech assumed total indirect take for the Project over the permit term would be a maximum of six adult equivalents (approximately 20 juveniles based on assumed Hawaiian hoary bat survival rates; USFWS 2016), or 12 percent of the permitted take. Currently, the proportion of total take that is attributable to indirect take is roughly 10.7 percent (3.11 adult bat equivalents estimated from indirect take / 29.11 bats estimated combining the direct and indirect take), making the assumption of indirect take of six adult bats to be conservative. Assuming six adult bat equivalents are attributed to the Project as indirect take, the permitted direct take under the Project's ITP and ITL would be 44 bats (take of 50 bats permitted by ITL and ITP minus take of six bats estimated as attributed to indirect take = 44 bats estimated direct take maximum).

Based on the analysis, there is an approximately 98.6 percent probability that the 80 percent UCL of cumulative take at the Project *will not* exceed permitted Tier 2 take during the permit term (Appendix 3). EoA projected a median estimate of 20 years of Project operation without a direct take estimate exceeding 44 bats. Therefore, based on these projections the Project is likely to remain below the permitted take limit of 50 Hawaiian hoary bats for the permit term.

7.2 Hawaiian Goose

7.2.1 Estimated Take

A total of 31 Hawaiian goose fatalities attributable to the Project have been observed at the Project since monitoring began in June 2006. Twenty-six of the 31 geese were found inside of fatality search plots and are used to estimate direct take, while five were considered incidental detections. The observed Hawaiian goose fatalities by fiscal year are listed in Table 2.

Table 2. Observed Hawaiian Goose Fatalities at KWP I Through FY2022

Fiscal Year	Hawaiian Goose Observed Direct Take	Hawaiian Goose Incidental Fatality Observations	Total
2007	0	0	0
2008	2	1	3
2009	1	0	1
2010	1	0	1
2011	5	0	5
2012	1	0	1
2013	4	0	4
2014	3	0	3
2015	4	0	4
2016	1	0	1
2017	0	1	1
2018	1	1	2
2019	2	0	2
2020	0	0	0
2021	0	2[1]	2

Fiscal Year	Hawaiian Goose Observed Direct Take	Hawaiian Goose Incidental Fatality Observations	Total
2022	1	0	1
Total	**26**	**5**	**31**
1. Includes one juvenile fatality found outside of search area. Based on estimated age and carcass condition at discovery, it is unknown if carcass was attributed to Project operations or other circumstances.			

On January 25, 2022, one adult Hawaiian goose carcass (in three parts) was observed during a scheduled search 10 meters from Turbine 20. On February 1, 2022, a thigh and leg portion of an adult Hawaiian goose carcass was found 40 meters from Turbine 20. The location, decomposition characteristics, size, and structure of the leg were all consistent with carcass parts found on January 25, 2022, providing definitive evidence that all body parts belong to the same single adult Hawaiian goose fatality attributed to the January 25 detection date.

The estimated direct take (ODT + UDT) for the 26 Hawaiian goose fatalities (within the search area) found between the start of operation (June 5, 2006) and end of FY 2022 (June 30, 2022) is less than or equal to 49 geese (80 percent UCL; Appendix 1b).

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 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. Cumulative indirect take was 3.21 juveniles (1.65 adults, assuming a 0.8 annual survival rate and 3 years from fledging to adult; Appendix 2b).[1]

The UCL for cumulative Project take of the Hawaiian goose at the 80 percent credibility level is 51 geese (49 [estimated direct take] + 2 [estimated indirect take, rounded up from 1.65]). That is, there is an approximately 80 percent probability that cumulative take at the Project at the end of FY 2022 is less than or equal to 51 adult geese.

KWP I, USFWS, and DOFAW reached consensus on mitigation credits attributable to the Project in FY 2022. Through FY 2021, the total reported mitigation credits sum to 49.69 fledglings and 2.65 adults and are distributed annually as indicated in rows K and L of Appendix 2b.[2] 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 (KWP 2006). Accrued lost productivity is presented in Appendix 2b. USFWS and DOFAW have agreed that

[1] No indirect take was attributed to the observed juvenile fatality observed in FY 2021, as a juvenile could not have dependent young.

[2] DOFAW has not yet reported the number of breeding birds in FY 2022 to allow for the calculation of the associated increased adult survival nor fledglings and number of breeding birds in FY 2022.

the Project will not accrue lost productivity for Hawaiian goose take that occurred prior to calendar year 2011, the year the release pen was constructed. Six Hawaiian goose fatalities were documented at the Project prior to January 1, 2011.

7.2.2 Projected Take

KWP I projected Hawaiian goose take through the end of the permit term using the fatality monitoring data collected through FY 2022. The objective of this analysis was to evaluate the potential for the Project to exceed the Tier 1 take limit (described as Baseline Take in the Project's HCP) at the 80 percent UCL prior to the end of the permit term (Appendix 3). For this analysis, the detection probability for future years is assumed to match the estimated overall detection probability of FY 2022, 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. Based on historical Project data, Tetra Tech 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; KWP I 2006), or 3.3 percent of the Tier 1 take. Currently, the proportion of total take that is attributable to indirect take is 3.3 percent (1.65 adult goose equivalents estimated from indirect take/ 50.65 adult geese estimated, combining the direct and indirect take), making the assumption of two indirect take on par with the data. Assuming two adult Hawaiian geese are attributed to the Project as indirect take, the permitted direct take under Tier 1 of the Project's ITP and ITL would be 58 Hawaiian geese (take of 60 geese permitted by ITL and ITP for Tier 1 minus take of two geese estimated attributed to indirect take = 58 geese estimated direct take maximum).

Based on the analysis described above, there is a 28.56 percent chance that the 80 percent UCL of cumulative take *will not* exceed the Tier 1 take limit during the permit term. Specifically, the estimated direct take threshold of 58 exceeds 28 percent of the projected mortality estimates (Appendix 3). EoA projected a median estimate of 20 years of Project operation without a direct take estimate exceeding 58 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 I has consulted with agencies regarding adjustments to the mitigation program needed to meet obligations. As described within the HCP, the Tier 2 level of take (described as Higher Take) provides for 100 Hawaiian geese. Finally, KWP I has taken actions to minimize the threats to the Hawaiian goose and anticipates working with USFWS, DOFAW, and technical experts to further reduce risks of take (Sections 5.0, 10.0).

7.3 Hawaiian Petrel

7.3.1 Estimated Take

A total of eight Hawaiian petrel fatalities have been observed at the Project since monitoring began in June 2006. Seven of the eight petrels were found inside of fatality search plots and were used to estimate UDT. The FY 2013 fatality was found outside of the designated search areas and is treated as an incidental observation. The observed Hawaiian petrel fatalities by fiscal year are listed in Table 3.

Table 3. Observed Hawaiian Petrel Fatalities at KWP I Through FY 2022

Fiscal Year	Hawaiian Petrel Observed Direct Take	Hawaiian Petrel Incidental Fatality Observations	Total
2007	0	0	0
2008	1	0	1
2009	0	0	0
2010	0	0	0
2011	0	0	0
2012	2	0	2
2013	0	1	1
2014	1	0	1
2015	2	0	2
2016	0	0	0
2017	0	0	0
2018	0	0	0
2019	1	0	1
2020	0	0	0
2021	0	0	0
2022	0	0	0
Total	**7**	**1**	**8**

The estimated direct take (ODT + UDT) for the seven Hawaiian petrel fatalities found between the start of operation (June 5, 2006) and end of FY 2022 (June 30, 2022) is less than or equal to 17 petrels (80 percent UCL; Appendix 1c).

Indirect take is estimated to account for the potential loss of individuals that may occur as the result of the loss their parents. Both parents for the Hawaiian petrel care for their young until fledging. The point during the breeding season when an adult is taken determines to what extent offspring may be affected. Cumulative indirect take was calculated at 12.84 juveniles (3.85 adults assuming a 0.3 survival rate from fledging to adult; Appendix 2c).

The Project may cause a net loss in productivity if take outpaces the number of individuals produced from mitigation efforts. The life history lag between production of Hawaiian petrels through mitigation efforts and the take of petrels at the Project drives the estimates of lost productivity. Accrued lost productivity at a given point in time is calculated as the cumulative take less the number of individuals generated from mitigation efforts to date, and then adjusted by a factor of 0.15 to account for the probability that those unmitigated petrels would have produced young (KWP I 2006). Each year's lost productivity is accumulated until mitigation occurs for the estimated adult take. The timing of the mitigation benefits is a key factor in the calculation of lost productivity. Therefore, lost productivity cannot be quantified until mitigation benefits are allocated.

KWP I is working with DOFAW and USFWS to quantify the benefits accrued through mitigation efforts at the Makamakaʻole Seabird Mitigation Site (Makamakaʻole) and on Lānaʻi. Reporting from the 2018 Hawaiian petrel breeding season on Lānaʻi (see FY 2019 annual report [Tetra Tech 2019]) and expected additional petrel mitigation benefits from Makamaka'ole and from the 2021 breeding season on Lānaʻi should allow for an understanding of any remaining petrel mitigation needs prior to the 2023 breeding season.

The UCL for cumulative Project take of the Hawaiian petrel at the 80 percent credibility level is 21 petrels (17 [estimated direct take] + 4 [estimated indirect take, rounded up from 3.85]). That is, there is an approximately 80 percent probability that cumulative take at the Project at the end of FY 2022 is less than or equal to 21 petrels.

7.3.2 Projected Take

KWP I projected Hawaiian petrel take through the end of the permit term using the fatality monitoring data collected through FY 2022. The objective of this analysis was to evaluate the potential for the Project to exceed the permitted take limit at the 80 percent UCL prior to the end of the permit term (Appendix 3). For this analysis, the detection probability for future years is assumed to match the estimated overall detection probability of FY 2022, 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. Based on historical Project data, Tetra Tech assumed total indirect take for the Project over the permit term would be a maximum of eight adult equivalents (approximately 27 juveniles based on an assumed Hawaiian petrel survival rate of 0.3 from fledging to adult; KWP I 2006), or 21.1 percent of the permitted take. Currently, the proportion of total take that is attributable to indirect take is 15.5 percent (3.85 adult petrel equivalents estimated from indirect take/ 20.85 adult petrel estimated combining the direct and indirect take), making the assumption of eight indirect take upwardly conservative.

Assuming eight adult Hawaiian petrel equivalents are attributed to the Project as indirect take, the permitted direct take under the Project's ITP and ITL would be 30 petrels (take of 38 petrels permitted by ITL and ITP minus the take of eight petrels estimated to be attributed to indirect take = 30 Hawaiian petrel estimated direct take maximum).

Based on the analysis described above and presented in Appendix 3, there is a 99.47 percent chance that the 80 percent UCL of cumulative take *will not* be exceeded during the permit term. Specifically, the estimated direct take threshold of 30 exceeds more than 99 percent of the projected mortality estimates (Appendix 3). EoA projected a median estimate of 20 years of Project operation without a direct take estimate exceeding 30 petrels. Therefore, the Project is likely to remain below the permitted take limit of 38 Hawaiian petrels for the permit term.

7.4 Non-listed Species

In addition to the single Hawaiian goose fatality, seven non-listed bird fatalities representing four species were documented at WTGs at the Project in FY 2022. One of the four species observed in FY 2022 is protected by the Migratory Bird Treaty Act (MBTA): the white-tailed tropicbird (*Phaethon lepturus;* two individuals). Fatalities of three non-native (introduced) species without MBTA protection were also detected: the black francolin (*Francolinus francolinus*; two individuals), gray francolin (*Francolinus pondicerianus;* one individual), and African silverbill (*Euodice cantans*; two individuals). For a complete list of 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 total of 38 people. WEOP trainings will continue to be conducted on an as-needed basis to provide on-site personnel with the information 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 5.0 of the approved HCP (KWP I 2006).

9.1 Hawaiian Hoary Bats

9.1.1 Mitigation

Mitigation for Tier 1 take of 20 bats was funded in 2006 and completed. An HCP minor amendment approved by USFWS in October 2015 and DOFAW in January 2016 authorized take of up to an additional 30 Hawaiian hoary bats under Tier 2. A mitigation project that accounts for 15 of the authorized additional take of 30 bats began May 2017 and was completed in FY 2020 (KWP I 2017, Tetra Tech 2020). This mitigation project consists of Hawaiian hoary bat ecological research in East Maui, contracted to H.T. Harvey Ecological Consultants. The contract total cost was $750,000.

Mitigation funding for Tier 2 take of 50 bats was provided to the U.S. Geological Survey Hawaiian Hoary Bat Research Group starting in FY 2018 to conduct bat ecological research on Hawai'i Island to better inform future bat habitat restoration and conservation (Appendix 5). In FY 2022, funding of $167,500 was provided. This research project provided mitigation benefits to account for the remaining 15 bats of Tier 2, and 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 II Wind Project (KWP II) had a total funding obligation of $1.7M to allocate to portions of each Project's mitigation requirement. KWP I exceeded this funding obligation by $131,500, for a total expenditure of $1,831,500.

9.1.2 Acoustic Monitoring at the Project

As a voluntary measure (not required in the HCP), acoustic monitoring for bat activity at the Project has been conducted continuously since August 2008. In October 2013 (FY 2014) nine Song Meter SM2BAT+ ultrasonic recorders (SM2) were deployed, replacing the previously used Anabat SD2 bat detectors (Titley Electronics, Brendale, QLD, Australia). Each SM2 was equipped with one SMX-U1 ultrasonic microphone (Wildlife Acoustics, Maynard, MA, USA) positioned horizontally, facing southwest (away from the prevailing northeast trade winds), 6.5 meters above ground level. In October 2019 (FY 2020), the Pali brush fires burned across most of the Project destroying four SM2 units. In order to continue with the objectives of the monitoring program and address gaps in the spatial coverage of SM2's introduced by the brush fire; the monitoring regime was redesigned in July 2020 with the deployment of five SM2 units (WTGs 1, 5, 13, 15, and 20; Figure 1). This type of unit has been continuously used since October 2013. 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 and FY 2021.

The objective of bat acoustic monitoring is to better understand the annual and seasonal variation in bat activity at the Project. Analysis of variance (ANOVA) and a Tukey's Honest Significant Difference (HSD) were used to test for interannual differences in detection rates between sampling years. A linear model (LM) was constructed 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 two-tailed, employed an alpha value of 0.05, and were conducted in R version 4.1.2 (R Core Team 2018). The characterization of Hawaiian hoary bat seasons corresponds approximately to Gorresen et al. (2013).

In FY 2022, the seasonal fluctuation in detection rates were atypical to the seasonal trends observed in previous monitoring years. Over the course of the FY 2022 monitoring period (July

2021 to June 2022), Hawaiian hoary bats were detected on 167 nights out of 1,756 detector-nights sampled (9.5 percent). The proportion of detector nights with detections increased during the lactation reproductive period and peaked (0.22) in September of the post-lactation reproductive period (Figure 2). Following the initial peak in September, detection rates fluctuated monthly (between 0.06 and 0.20) throughout the post-lactation and pre-pregnancy reproductive periods (October to February), before reaching a low (0.01) in March of the pre-pregnancy reproductive period (Figure 2). Detections rates slightly increased in April and May (0.08 and 0.07), at the beginning of the pregnancy reproductive period, followed by subsequent decline in June (Figure 2). The monthly detection rates observed in FY 2022 are within the ranges of detection rates observed during similar months from previous years, with the exception of January and February (Figure 3). However, the overall annual trend in detection rates observed in FY 2022 is inconsistent with trends observed in previous years. Typically, the annual trend in detection rates follows a bimodal distribution, increasing throughout the lactation reproductive period and reaching a peak in the early or middle (September and October) post-lactation reproductive period. Following the peak, detection rates decline and remain low throughout the second half of the post-lactation and pre-pregnancy reproductive periods, with a second smaller peak in detection rates occurring at the beginning of the pregnancy reproductive period (Figure 3). The cause for the differences observed in the seasonal trend during the FY 2022 monitoring period, most notably January and February, is unknown. Potential correlations may include weather patterns, as similar increases in January and February were observed at other monitoring sites on Oʻahu in the FY 2022 monitoring year.

Throughout the FY 2015 – FY 2022 dataset of the Project's monitoring program, there were only marginal fluctuations in the interannual detection rates (Table 4). Across analyzed monitoring years, there is an increasing trend in the annual detection rates. Although the annual detection rates in FY 2022 were lower than FY 2021 (by 3.9 percent), they were not significantly different than that year's annual detection rate (ANOVA: $F_{7,88} = 2.26$, $P < 0.037$; Tukey's HSD: $P > 0.973$;13.4 percent). Furthermore, a conservative Tukey's HSD post-hoc analysis, which accounts for accumulated type I errors in the ANOVA (Tian et al. 2018), found no significant differences in annual detection rates between FY 2015 and FY 2022. Overall, across analyzed monitoring years (FY 2015 – FY 2022), there is a significant increasing trend in the annual detection rates (LM: R^2 = 7.4 percent; $F_{1,94}$ = 8.58, $P < 0.005$; Figure 4).

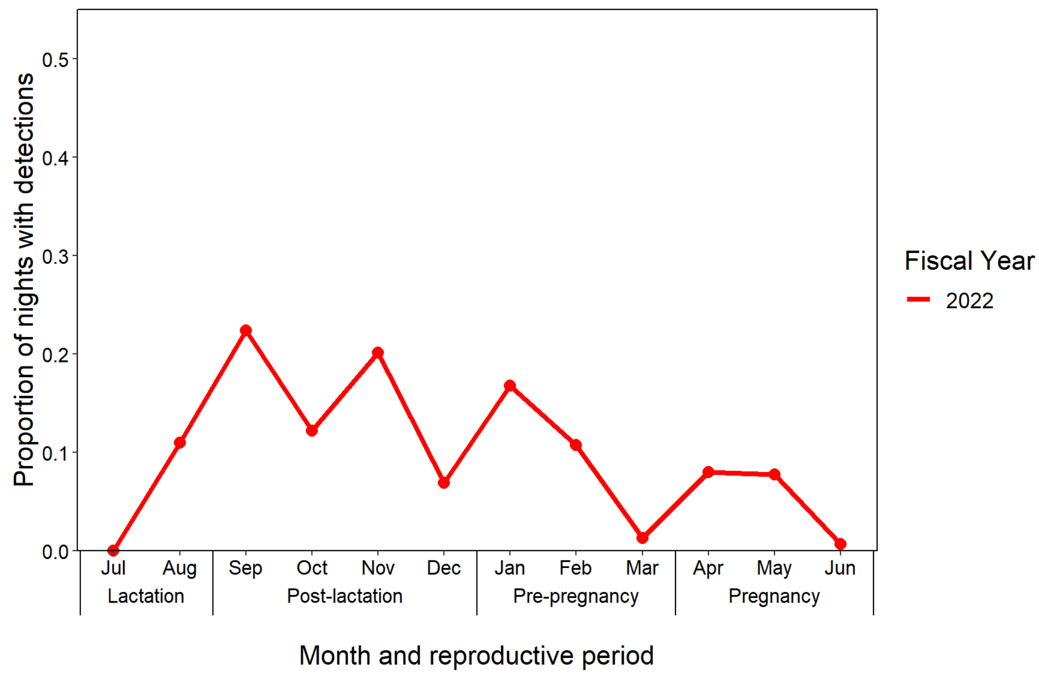

Figure 2. Monthly Detection Rates at the Project in FY 2022 with Corresponding Reproductive Periods

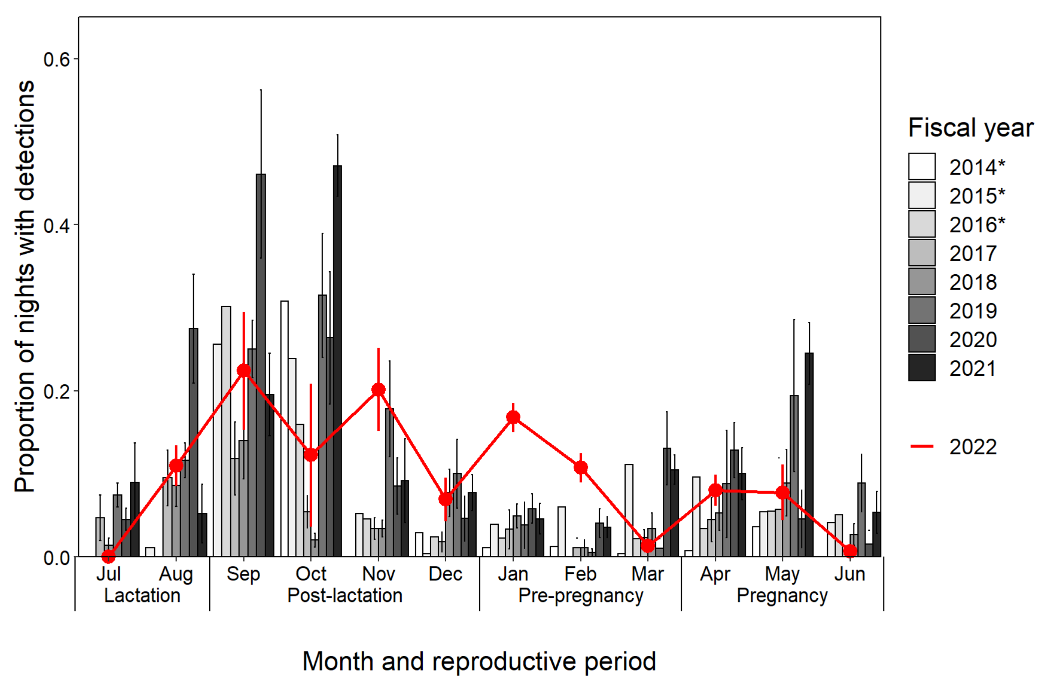

Figure 3. Monthly Bat Detection Rates at the Project for FY 2014 to FY 2022 with Corresponding Reproductive Periods

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

Table 4. 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 (October 2013 – June 2014)[1]	2,700	101	0.037
FY 2015[1]	3,203	249	0.078
FY 2016[1]	2,426	175	0.072
FY 2017[1]	2,827	129	0.045
FY 2018[1]	2,989	162	0.054
FY 2019[1]	2,906	372	0.128
FY 2020[2]	1,853	280	0.151
FY 2021[2]	1,680	225	0.134
FY 2022[2]	1,756	167	0.095

1. Number of detectors = 9.

2. Detectors reduced from 9 to 5 in November 2019 due to fire.

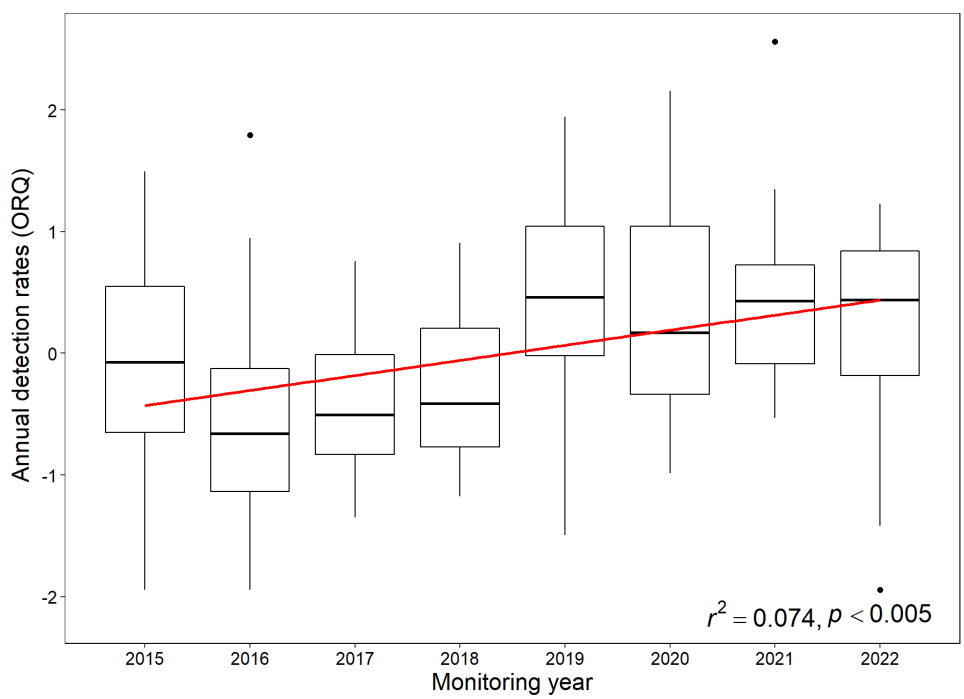

Figure 4. Box-plot with Linear Regression Showing the Increasing Trend in the Annual Detection Rate at the Project Between FY 2015 and FY 2022

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

9.2 Hawaiian Goose – Haleakalā Ranch Release Pen

As part of Project Hawaiian goose mitigation, the Project provided $140,852 to DOFAW to fund construction and management of the Haleakalā Ranch Hawaiian goose release pen in 2008. DOFAW completed construction of the release pen three years later. Subsequent funding has been used by DOFAW to perform fence maintenance, predator control, vegetation management, and monitoring at the Haleakalā Ranch pen over the nine years since construction. In FY 2022, DOFAW utilized funds remaining from FY 2021 to conduct the work. Hawaiian geese have been translocated from Kauaʻi to the Haleakalā Ranch pen since 2011, and several potential benefits have accrued based on the effects of these actions including production of fledglings and increases adult survival rates. The outcome of the 2021 – 2022 breeding season included 10 fledglings (Appendix 6). Through 2022, DOFAW has reported 76 fledglings produced in the pen from the translocated birds (see Appendix 2b for quantification of mitigation credits associated with the Project).

KWP I is working with DOFAW and USFWS to adaptively manage the Hawaiian goose mitigation program. Cumulatively, the increases in adult and juvenile survival and productivity achieved by KWP I's mitigation project have not been sufficient to fully offset the mitigation obligations of Tier 1. KWP I is exploring opportunities for additional mitigation projects in order to address lagging credits. In FY 2022, KWP I met with DOFAW to better understand DOFAW's request that KWP I assume Haleakalā Ranch release pen's management tasks in conjunction with the KWP II Wind Project in lieu of providing direct funding to DOFAW. In FY 2023, KWP I will update their current MOU with DOFAW (KWP I FY 2021) and assume release pen management.

9.3 Seabirds

KWP I is committed to seabird protection and recovery on Maui and within Maui Nui. Results at the Makamakaʻole Seabird Mitigation Site (Makamakaʻole) demonstrate that the site can support reproduction of Newell's shearwaters, however the mitigation project is not on track for fulfilling the KWP I's Hawaiian petrel mitigation needs. KWP I is actively working with USFWS and DOFAW to adaptively manage 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 additional mitigation sites was funded and completed in September 2015 (KWP I 2016). These surveys evaluated potential colony locations, estimated the numbers of birds present, assessed predator activity, and provided for management feasibility assessment.

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 Makamakaʻole involve predator monitoring and trapping, artificial burrow checks and monitoring using game cameras, seabird social attraction using decoys and sound systems, and ongoing maintenance of both enclosures.

USFWS and DOFAW reviewed an updated management protocol prior to the 2021 breeding season (Tetra Tech 2021). This protocol was then implemented at the site in FY 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 7).

In March 2022, DOFAW provided a letter attributing a total mitigation credit of 6.418 adult equivalents to Makamaka'ole. DOFAW interpreted the KWP I and KWP II HCPs as the Projects 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 its mitigation obligation. The USFWS concurred with DOFAW's assessment in May 2022.

In FY 2022, continued mitigation efforts at Makamaka'ole were contracted to Maui Nui Seabird Recovery Project (MNSRP) through the 2022 breeding season. MNSRP staff continue to update and maintain perimeter fencing. Approximately bi-weekly visits to Enclosures A and B are ongoing, checking burrows and game cameras for activity and performing vegetation management. Project staff visit the enclosures with MNSRP to ensure consistent oversight.

During the semi-annual meeting on June 1, 2022, KWP I summarized historical activity data at the site and the associated agency assessment of mitigation credits to ensure that USFWS and DOFAW understand that KWP I 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 with the condition that KWP I's mitigation obligation is met. 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 I 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. 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 8) were removed from the area during the 2021 breeding season. Using a robust 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 I is currently in discussion with the USFWS on this outcome assessment.

KWP I 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 2022 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, the Project began implementing LWSC at all WTGs up to wind speeds of 5 meters per second (m/s) on July 29, 2014. LWSC is expected to reduce bat take (Section 7.12). LWSC was increased to 5.5 m/s on August 4, 2014 in response to bat take occurring at the Project and at the Kaheawa Wind Power II Project on March 13, 2013 and February 26, 2014. Curtailment at 5.5 m/s was in effect from sunset to sunrise, annually, from February 15 through December 15. The Project continues site-wide bat activity assessment via acoustic monitoring after the initial HCP-required monitoring period (Section 9.1.1).

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. KWP I has identified additional practicable actions to minimize the threats to the Hawaiian goose based on current projections of take. In FY 2023, KWP I will implement 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 I 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 I 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, and 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 follows in Table 5.

Table 5. Summary of Agency Coordination and Communication in FY 2022

Date	Communication	Participants
August 17, 2021	Nene mitigation program meeting	KWP I, Tetra Tech, DOFAW
October 19, 2021	Annual HCP implementation review meeting	KWP I, Tetra Tech, USFWS, DOFAW
October 28, 2021	Submittal of FY 2021 Q1 report	Submitted to DOFAW, USFWS by Tetra Tech
December 14, 2021	KWP Lānai'i Hawaiian petrel mitigation 2021 review/discussion of 2022 Hawaiian petrel mitigation opportunities on Lānai'i meeting	KWP I, Tetra Tech, USFWS, DOFAW, Pūlama Lānai'i
December 15, 2022	KWPs Makamaka'ole Mitigation Program 2021 review meeting	KWP I, USFWS, DOFAW, MNSBRP
January 6, 2022	Submittal of the final KWP I HCP FY 2022 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 I, 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 I, ESRC

Date	Communication	Participants
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
March 3, 2022	Haleakala Ranch nēnē release pen management discussion	KWP I, 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 I
March 23, 2022	Submittal of Nene 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	Haleakala Ranch nēnē release pen management meeting	KWP I, Tetra Tech, DOFAW, Haleakala Ranch
June 1, 2022	Semi-annual HCP implementation review meeting	KWP I, 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 $621,300 (Table 6).

Table 6. HCP-related Expenditures at the Project in FY 2022

Category[1]	Amount
Permit Compliance	$53,000
Fatality Monitoring	$75,000
Acoustic Monitoring for Bats	$10,500
Vegetation Management and Scavenger Trapping	$40,500
Equipment and Supplies	$2,000
Makamakaʻole Mitigation Project	$146,500[2]
Lānaʻi Hawaiian Petrel Protection Project	$118,300[2]
Haleakala Release Pen	$8,000[3]
Tier 2 Bat Research Projects	$167,500
Total Cost for FY 2022	**$621,300**

1. Staff labor costs are included in the overall costs for each category except for Equipment and Supplies.
2. Makamaka'ole and the Lānaʻi petrel mitigation project are co-funded by KWP I and KWP II.
3. Hawaiian goose mitigation funding included planning efforts at Haleakalā Ranch.

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

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Appendix 1a. Dalthorp et al. (2017) Fatality Estimation for Hawaiian Hoary Bats at Project Through FY 2022

Modeling Period	FY	Dates		Period Length (days)	% Year	LWSC	Search Interval (days)	Number of Searches in Modeling Period	Observed Fatalities (X)	K[1]	Canine Searches	DWP[2]	g			B		M*[3]
		Begin	Ending										g	95% LCI	95% UCI	Ba	Bb	
1	2007	6/22/2006	6/30/2007	373	1.02	no	9	41	0	0.7	No	1	0.445	0.261	0.638	11.21	13.96	1
2	2008	7/1/2007	6/30/2008	365	1	no	9	41	0	0.7	No	1	0.442	0.258	0.636	11.06	13.94	1
3	2009	7/1/2008	6/30/2009	364	1	no	7	52	0	0.7	No	1	0.501	0.312	0.69	12.70	12.64	1
4	2010	7/1/2009	6/30/2010	364	1	no	7	52	0	0.7	No	1	0.45	0.272	0.634	12.37	15.14	1
5	2011	7/1/2010	6/30/2011	364	1	no	7	52	0	0.7	No	1	0.505	0.257	0.752	7.145	7.007	1
6	2012	7/1/2011	6/30/2012	365	1	no	7	52	0	0.7	No	1	0.345	0.149	0.574	6.089	11.56	1
7	2013	7/1/2012	6/30/2013	364	1	no	7	52	2	0.7	No	1	0.414	0.183	0.669	5.894	8.335	7
8	2014	7/1/2013	6/30/2014	364	1	no	7	52	4	0.7	No	1	0.484	0.332	0.638	19.23	20.47	18
9	2015	7/1/2014	6/30/2015	364	1	5.5 m/s	7	52	0	0.7	No	1	0.217	0.128	0.321	14.76	53.30	19
10	2016	7/1/2015	6/30/2016	365	1	5.5 m/s	7	52	0	1	Yes	0.4922	0.44	0.408	0.472	407.9	520.1	19
11	2017	7/1/2016	6/30/2017	364	1	5.5 m/s	7	52	1	1	Yes	0.4922 or 0.573	0.524	0.499	0.549	816.1	741.0	21
12	2018	7/1/2017	6/30/2018	364	1	5.5 m/s	7	52	1	1	Yes	0.573	0.459	0.386	0.533	80.67	95.13	23
13	2019	7/1/2018	6/30/2019	364	1	5.5 m/s	7	52	1	1	Yes	0.573	0.368	0.289	0.45	50.35	86.64	26
14	2020	7/1/2019	6/30/2020	365	1	5.5 m/s	7	53	0	1	Yes	0.573	0.466	0.405	0.529	115.3	132.0	26
15	2021	7/1/2020	6/30/2021	364	1	5.5 m/s	7	52	0	1	Yes	0.573	0.437	0.351	0.522	58.18	75.11	26
16 (current)	2022	7/1/2021	6/30/2022	364	1	5.5 m/s	7	52	0	1	Yes	0.573	0.477	0.414	0.54	115.1	126.2	26

1. Searches performed by canine teams increases the probability that a missed carcass will be detected on the next search.
2. Where two values are represented, the searched area changed within the modeled period. Detection probability represents the cumulative detection for the year. See annual reports for details.
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 the Hawaiian Goose at Project Through FY 2022

Modeling Period	FY	Dates		Period Length (days)	% Year	LWSC	Search Interval (days)	Number of Searches in Modeling Period	Observed Fatalities (X)	K	Canine Searches	DWP[1]	g			B		M*[2]
		Begin	Ending										g	95% LCI	95% UCI	Ba	Bb	
1	2007	6/22/2006	6/30/2007	373	1.02	no	9	41	0	1	No	0.95	0.923	0.871	0.962	120.8	10.14	0
2	2008	7/1/2007	6/30/2008	365	1	no	9	41	2	1	No	0.95	0.923	0.871	0.962	120.8	10.14	2
3	2009	7/1/2008	6/30/2009	364	1	no	7	52	1	1	No	0.95	0.928	0.886	0.961	162.5	12.60	4
4	2010	7/1/2009	6/30/2010	364	1	no	7	52	1	1	No	0.95	0.928	0.886	0.961	162.5	12.60	5
5	2011	7/1/2010	6/30/2011	364	1	no	7	52	5	1	No	0.95 or 0.7	0.773	0.748	0.797	889.3	261.5	11
6	2012	7/1/2011	6/30/2012	365	1	no	7	52	1	1	No	0.7	0.678	0.633	0.72	299.4	142.5	13
7	2013	7/1/2012	6/30/2013	364	1	no	7	52	4	1	No	0.7	0.666	0.58	0.748	79.75	39.93	18
8	2014	7/1/2013	6/30/2014	364	1	no	7	52	3	1	No	0.7	0.683	0.626	0.737	183.9	85.39	23
9	2015	7/1/2014	6/30/2015	364	1	5.5 m/s	7	52	4	1	No	0.7	0.691	0.658	0.722	548.7	245.9	28
10	2016	7/1/2015	6/30/2016	365	1	5.5 m/s	7	52	1	1	Yes	0.29	0.284	0.265	0.302	661.2	1671	32
11	2017	7/1/2016	6/30/2017	364	1	5.5 m/s	7	52	0	1	Yes	0.29 or 0.35	0.327	0.314	0.341	1474.3	3031	34
12	2018	7/1/2017	6/30/2018	364	1	5.5 m/s	7	52	1	1	Yes	0.35	0.344	0.336	0.352	4420	8438	37
13	2019	7/1/2018	6/30/2019	364	1	5.5 m/s	7	52	2	1	Yes	0.35	0.339	0.282	0.399	84.70	165.3	42
14	2020	7/1/2019	6/30/2020	365	1	5.5 m/s	7	53	0	1	Yes	0.35	0.33	0.301	0.359	337.8	686.5	43
15	2021	7/1/2020	6/30/2021	365	1	5.5 m/s	7	52	0	1	Yes	0.35	0.336	0.315	0.357	674.4	1280	45
16 (current)	2022	7/1/2021	6/30/2022	364	1	5.5 m/s	7	52	1	1	Yes	0.35	0.345	0.315	0.375	327.5	622.8	49

1. Where two values are represented, the searched area changed within the modeled period. Detection probability represents the cumulative detection for the year. See annual reports for details.
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 1c. Dalthorp et al. (2017) Fatality Estimation for Hawaiian Petrel at Project Through FY 2022

Modeling Period	FY	Dates		Period Length (days)	% Year	Search Interval (days)	Number of Searches in Modeling Period	Observed Fatalities (X)[1]	K	Canine Searches	DWP[2]	g			B		M*[3]
		Begin	Ending									g	95% LCI	95% UCI	Ba	Bb	
1	2007	6/22/2006	6/30/2007	545	1.02	9	61	0	0.9	No	1	0.807	0.602	0.948	14.64	3.512	0
2	2008	7/1/2007	6/30/2008	365	1	9	41	1	0.9	No	1	0.786	0.593	0.928	16.78	4.58	2
3	2009	7/1/2008	6/30/2009	364	1	7	52	0	0.9	No	1	0.847	0.717	0.942	31.55	5.682	2
4	2010	7/1/2009	6/30/2010	364	1	7	52	0	0.9	No	1	0.861	0.706	0.963	22.06	3.566	2
5	2011	7/1/2010	6/30/2011	364	1	7	52	0	0.9	No	1 or 0.75	0.798	0.752	0.841	244.5	61.78	2
6	2012	7/1/2011	6/30/2012	365	1	7	52	2	0.9	No	0.75	0.581	0.431	0.724	24.57	17.7	5
7	2013	7/1/2012	6/30/2013	364	1	7	52	0	0.9	No	0.75	0.646	0.511	0.77	32.73	17.93	5
8	2014	7/1/2013	6/30/2014	364	1	7	52	1	0.9	No	0.75	0.714	0.668	0.758	281.2	112.6	6
9	2015	7/1/2014	6/30/2015	364	1	7	52	2	0.9	No	0.75	0.65	0.555	0.74	65.57	35.3	10
10	2016	7/1/2015	6/30/2016	365	1	7	52	0	1	Yes	0.204	0.197	0.18	0.214	414.2	1690	10
11	2017	7/1/2016	6/30/2017	364	1	7	52	0	1	Yes	0.204 or 0.246	0.232	0.221	0.243	1272	4216	11
12	2018	7/1/2017	6/30/2018	364	1	7	52	0	1	Yes	0.246	0.24	0.203	0.28	114.8	362.8	12
13	2019	7/1/2018	6/30/2019	364	1	7	52	1	1	Yes	0.246	0.239	0.196	0.284	85.2	272	14
14	2020	7/1/2019	6/30/2020	365	1	7	53	0	1	Yes	0.246	0.218	0.192	0.244	210.7	757.7	15
15	2021	7/1/2020	6/30/2021	365	1	7	52	0	1	Yes	0.246	0.2096	0.12	0.316	13.62	51.37	16
16 (current)	2022	7/1/2021	6/30/2022	364	1	7	52	0	1	Yes	0.246	0.24	0.224	0.25	808.5	756.0	17

1. FY 2013 fatality was mistakenly included in previous analyses. Based on the contemporaneous fatality report, the carcass was recovered outside of the designated search plots.
2. Where two values are represented, the searched area changed within the modeled period. Detection probability represents the cumulative detection for the year. See annual reports for details.
3. Cumulative value representing estimate of total direct take from the start of operations through the identified monitoring period at the 80 percent UCL.

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Appendix 2. Indirect Take for the Hawaiian Hoary Bat, Hawaiian Goose, and Hawaiian Petrel 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																
		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
A	Observed Breeding Female Take	0	0	0	0	1	0	0	2	0	0	0	1	0	0	0	0	**4**
B	Indirect Take from Observed Breeding Female Take (A x 1.8)	0	0	0	0	1.8	0	0	3.6	0	0	0	1.8	0	0	0	0	**7.2**
C	Observed Breeding Unknown Sex Take	0	0	0	0	0	0	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	0	0	0	0	0	**0**
E	All Observed Take (Search and Incidental)	0	0	1	0	1	0	2	4	0	0	2	1	1	0	0	0	**12**
F	Estimated Take Multiplier (26/12=2.17)	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	
G	Estimated Direct Take (E x F)	0	0	2.17	0	2.17	0	4.33	8.67	0	0	4.33	2.17	2.17	0	0	0	**26**
H	Unobserved Direct Take (G - E)	0	0	1.17	0	1.17	0	2.33	4.67	0	0	2.33	1.17	1.17	0	0	0	**14**
I	Indirect Take Calculated from Unobserved Take (H * 0.5 * 0.25 * 1.8)	0	0	0.26	0	0.26	0	0.53	1.05	0	0	0.53	0.26	0.26	0	0	0	**3.15**
Total Indirect Take (B + D + I; juveniles)																		**10.35**
Total Indirect Take (B + D + I)*0.3 (adults)																		**3.11**

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

Parameter	Description	Fiscal Year																			
		2007	2008	2009	2010	2011		2012	2013	2014		2015		2016	2017	2018	2019	2020	2021	2022	Total
A1	Observed Adult Take	0	3	1	1	3	2	1	4	2	1	3	1	1	1	2	2	0	1	1	**30**
A2	Observed Juvenile Take	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	**1**
B	Estimated Take Multiplier (49/30=1.63)	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	
C	Estimated Adult Direct Take (A1 x B)	0.00	4.90	1.63	1.63	4.90	3.27	1.63	6.53	3.27	1.63	4.90	1.63	1.63	1.63	3.27	3.27	0.00	1.63	1.63	**49.00**
D	Observed Indirect Take Multiplier (Season Defined)	0	0.09	0	0	0.09	0	0.09	0.09	0.09	0	0.09	0.04	0.09	0.04	0.09	0.09	0	0.09	0.09	
E	Observed Indirect Take (C x A1)	0.00	0.27	0.00	0.00	0.27	0.00	0.09	0.36	0.18	0.00	0.27	0.04	0.09	0.04	0.18	0.18	0.00	0.09	0.09	**2.15**
F	Unobserved Direct Take (C – A1)	0.00	1.90	0.63	0.63	1.90	1.27	0.63	2.53	1.27	0.63	1.90	0.63	0.63	0.63	1.27	1.27	0.00	0.63	0.63	
G	Unobserved Indirect Take (F x 0.06)	0.00	0.107	0.036	0.036	0.107	0.071	0.036	0.143	0.071	0.036	0.107	0.036	0.036	0.036	0.071	0.071	0.00	0.036	0.036	**1.07**
H	Accrued Adult Take ([Previous Year's Accrued C]- N - L) (beginning 1/1/2011)							3.17	4.90	11.27		15.50		20.18	20.14	20.89	22.15	22.14	22.69	24.27	
I	Lost Productivity from accrued adult take (Current year's H x 0.1) (fledglings)							0.32	0.49	1.13		1.55		2.02	2.01	2.09	2.21	2.21	2.27	2.43	**18.73**

Parameter	Description	Fiscal Year																
		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
J	(Indirect Take) + Lost Productivity ([E + G]+ I +A3), for fledglings						0.44	0.99	1.41	2.00	2.14	2.09	2.34	2.47	2.21	2.43	2.65	
K	Mitigation fledglings (fledglings)						1.61	4.29	4.29	3.22	5.90	7.50	0.54	1.36	10.00	1.00	10.00	**49.69**
L	Mitigation adult survival (adults)						0.10	0.10	0.17	0.07	0.17	0.20	0.27	0.08	0.50	0.37	0.62	**2.65**
M	Net fledglings remain (Current Year K - J)					0.00	1.17	3.30	2.87	1.22	3.75	5.42	-1.80	-1.11	7.79	-1.39	7.45	
N	Net adults 3 yrs. later (3 Years' Previous M*0.512)						0.00	0.00	0.00	0.60	1.69	1.47	0.62	1.92	2.77	-0.92	-0.57	
Total Direct Take from Collisions with WTGs (adults; C)																		**49.00**
Total Indirect Take (fledglings; E + G)																		**3.21**
Total Indirect Take (adults; [E + G] x 0.512)																		**1.65**
Total Lost Productivity (fledglings; I)																		**18.73**
Total Lost Productivity (adults; I x 0.512)																		**9.59**

Appendix 2c. Indirect Take for the Hawaiian Petrel at the Project in FY 2022

Parameter	Description	Fiscal Year																		
		2007	2008	2009	2010	2011	2012		2013	2014	2015		2016	2017	2018	2019	2020	2021	2022	Total
A	Observed Take	0	1	0	0	0	1	1	1	1	1	1	0	0	0	1	0	0	0	**8**
B	Estimated Take Multiplier (16/8=2)	0	2.13	0	0	0	2.13	2.13	2.13	2.13	2.13	2.13	0	0	0	2.13	0	0	0	
C	Estimated Direct Take (A x B)	0	2.13	0	0	0	2.13	2.13	2.13	2.13	2.13	2.13	0	0	0	2.13	0	0	0	**17**
D	Observed Indirect Take Multiplier (Season defined)	0	0.66	0	0	0	0.66	0.5	0.89	0.89	0.89	0.66	0	0	0	0.89	0	0	0	
E	Observed Indirect Take (A x D)	0	0.66	0	0	0	0.66	0.5	0.89	0.89	0.89	0.66	0	0	0	0.89	0	0	0	**6.04**
F	Unobserved Direct Take (C - A)	0	1.13	0	0	0	1.13	1.13	1.13	1.13	1.13	1.13	0	0	0	1.13	0	0	0	**9**
G	Unobserved Indirect Take (D x F)	0	0.74	0	0	0	0.74	0.56	1	1	1	0.74	0	0	0	1	0	0	0	**6.80**
Total Indirect Take (E + G) chicks/eggs																				**12.84**
Total Indirect Take (E + G) x 0.3 adults																				**3.85**

1. Productivity information for FY 2019 and FY 2020 is not yet available; values will be updated when data becomes available.

Appendix 3. Hawaiian hoary bat, Hawaiian Goose and Hawaiian Petrel 20-year Projected Take at the Project in FY 2022

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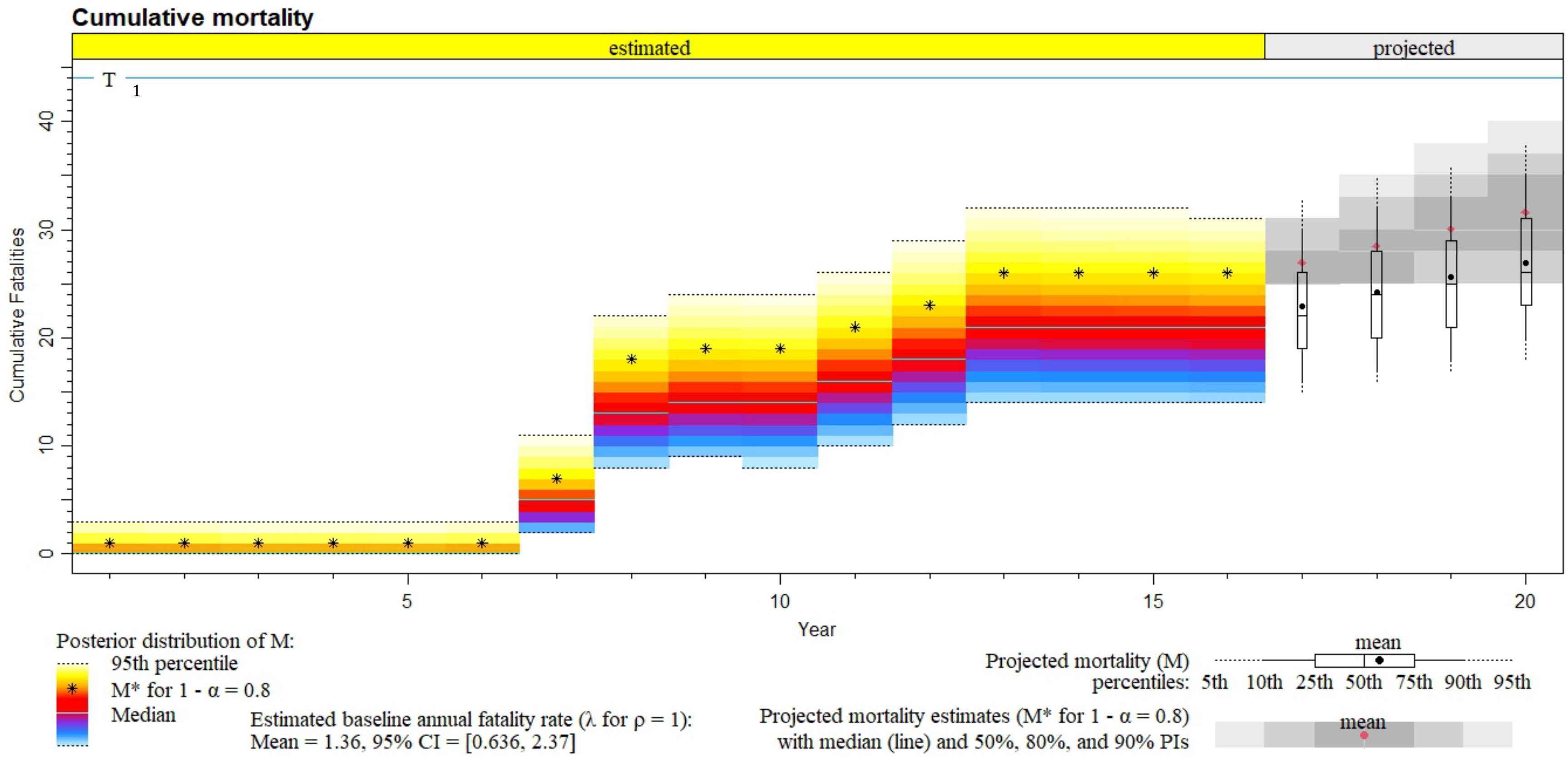
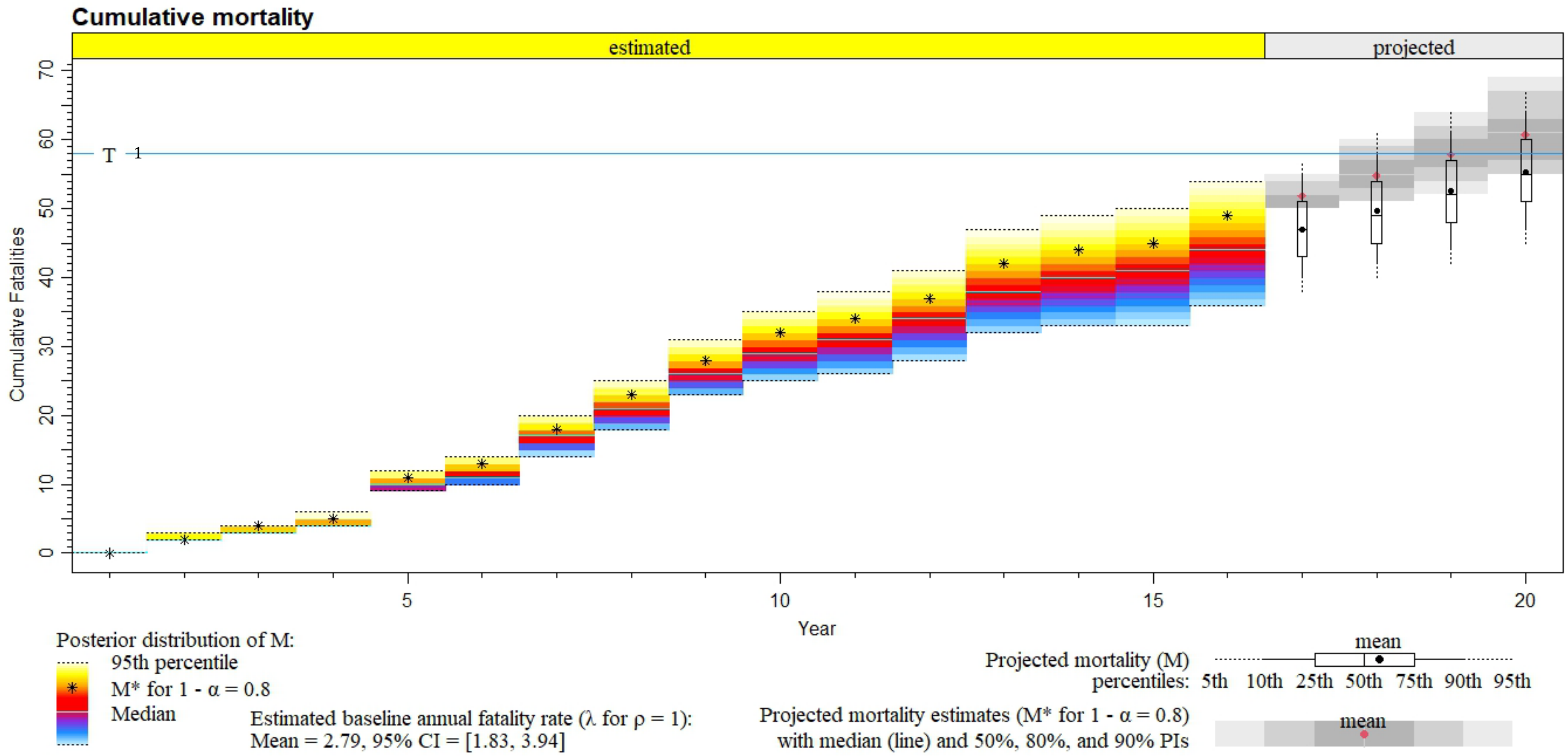
Appendix 3a. Projected Cumulative Mortality for the Hawaiian Hoary Bat at the Project



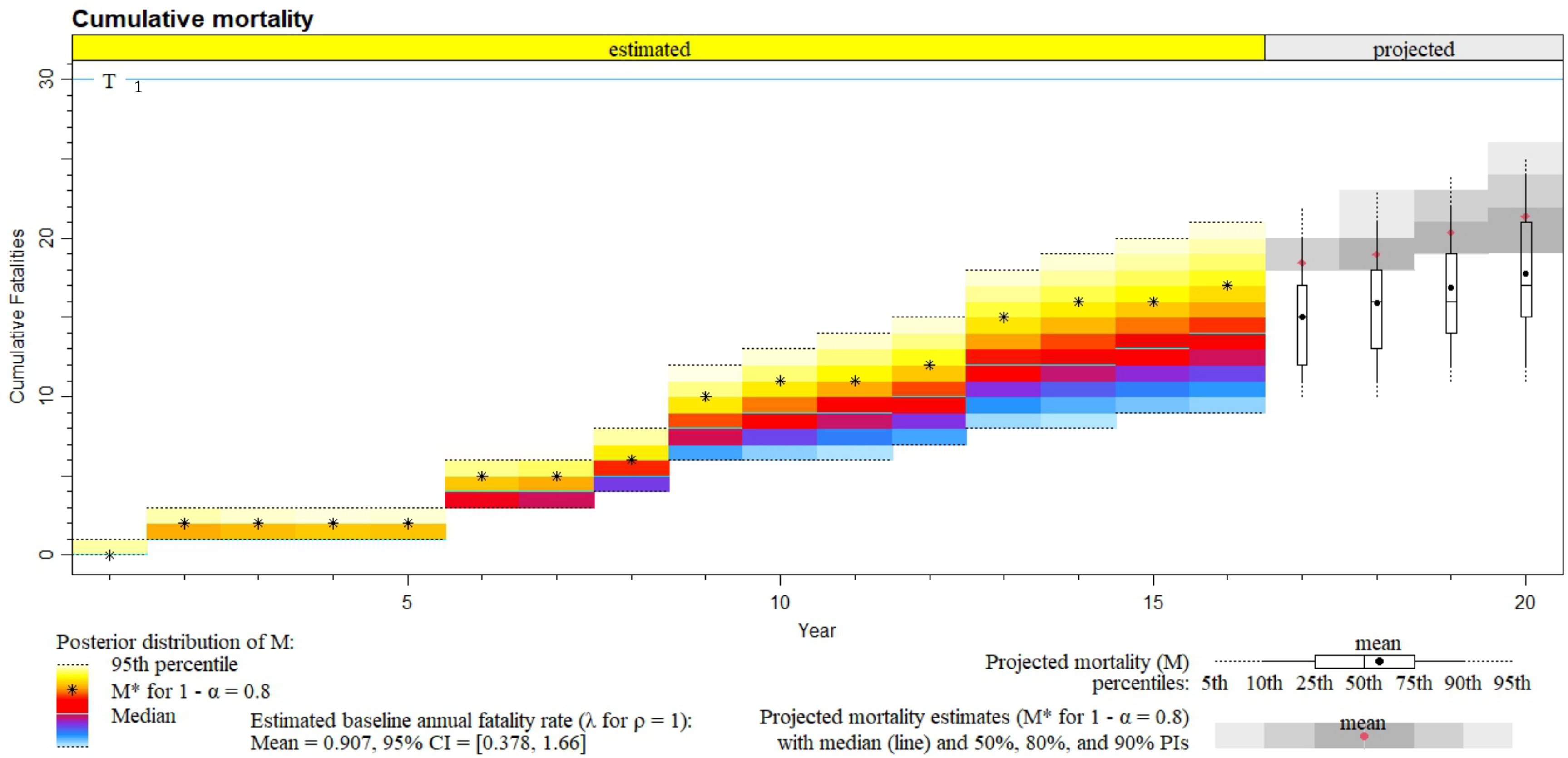
1. Permitted take for the Hawaiian hoary bat at the Project is 50; however, take as calculated from EoA only includes direct take. To account for indirect take in this figure, an approximate take threshold (T) of 44 is shown, representing authorized bat take (50) minus 6 adult equivalents of indirect take (12.0 percent of the authorized limit). Currently, the proportion of total take that is attributable to indirect take is 10.7 percent.

Appendix 3b. Projected Cumulative Mortality for the Hawaiian Goose at the Project with Tier 1 Threshold



1. Permitted take for Tier 1 of the Hawaiian goose at the Project is 60; however, take as calculated from EoA only includes direct take. To account for indirect take in this figure, an approximate take threshold (T) of 58 is shown, representing permitted Hawaiian goose take (60) minus 2 adult equivalents of indirect take (3.3 percent of the requested authorized limit). Currently, the proportion of total take that is attributable to indirect take is 3.3 percent.

Appendix 3c. Projected Cumulative Mortality for the Hawaiian Petrel at the Project



1. Permitted take for the Hawaiian petrel at the Project is 38; however, take as calculated from EoA only includes direct take. To account for indirect take in this figure, an approximate take threshold (T) of 30 is shown, representing authorized petrel take (38) minus 8 adult equivalents of indirect take (21.1 percent of the authorized limit). Currently, the proportion of total take that is attributable to indirect take is 15.5 percent.

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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)
Phaethon lepturus (White-tailed tropicbird or Koa'e Kea)[1]	07/06/2021	7	30	277
Francolinus pondicerianus (Gray francolin)	08/17/2021	10	1	24
Francolinus francolinus (Black francolin)	01/18/2022	6	1	37
Branta sandvicensis (Hawaiian goose or nēnē)[2]	01/25/2022	20	10	77
Phaethon lepturus (White-tailed tropicbird or Koa'e Kea)[1]	03/01/2022	10	24	200
Francolinus francolinus (Black francolin)	03/01/2022	8	1	66
Euodice cantans (African Silverbill)	05/10/2022	12	35	70
Euodice cantans (African Silverbill)	06/21/2022	18	10	190

1. MBTA-protected species.
2. Covered Species.

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

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

Agreement # 17WSTAAZB005541
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 ʻōpeʻapeʻa (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.

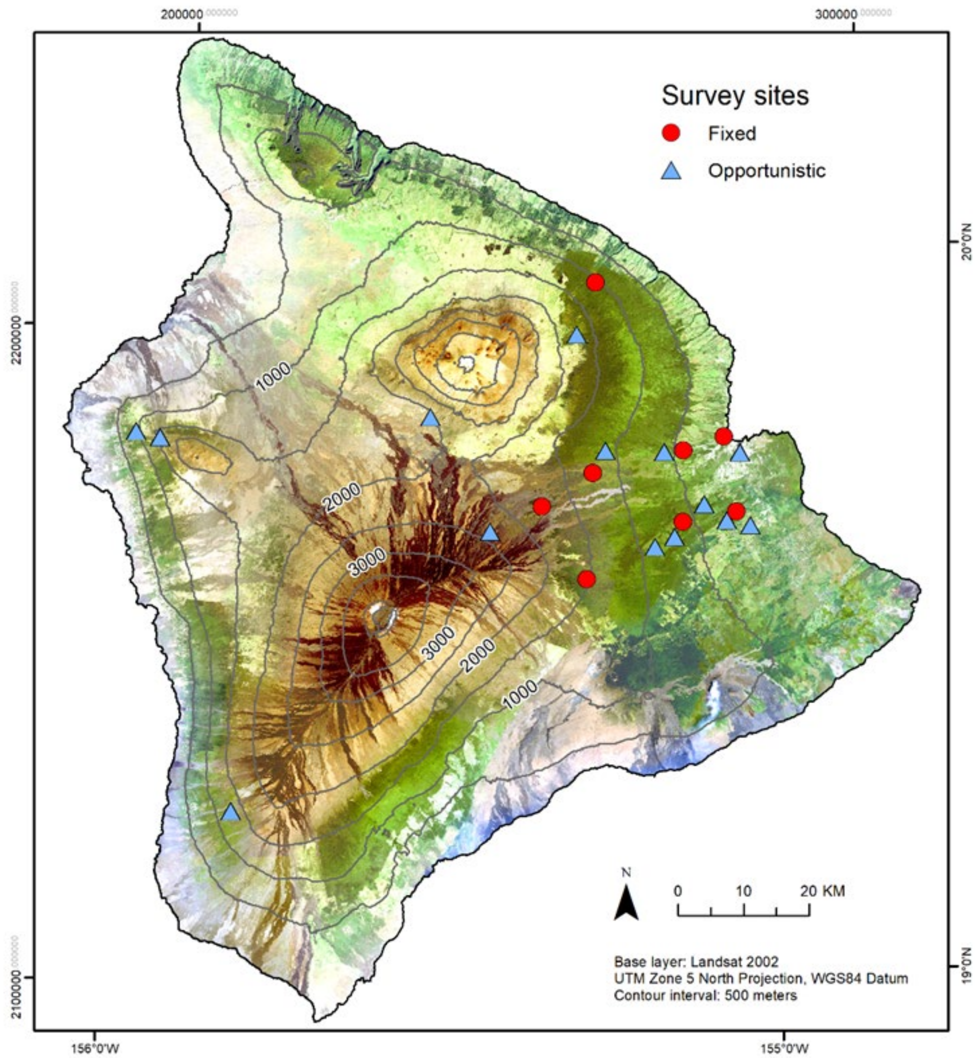

Figure 1. Mist net sites surveyed from May 2018 to August 2021 on Hawai'i Island with fixed sites (circles) surveyed at regular intervals and opportunistic surveys added at fixed sites or opportunistic sites (triangles).

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 ʻōpeʼapeʼa

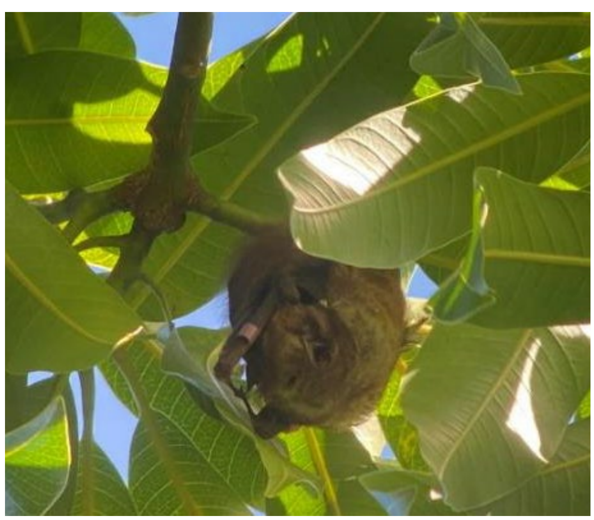

Figure 3. ʻŌpeʻapeʻa with unique color arm band combination at roost

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.

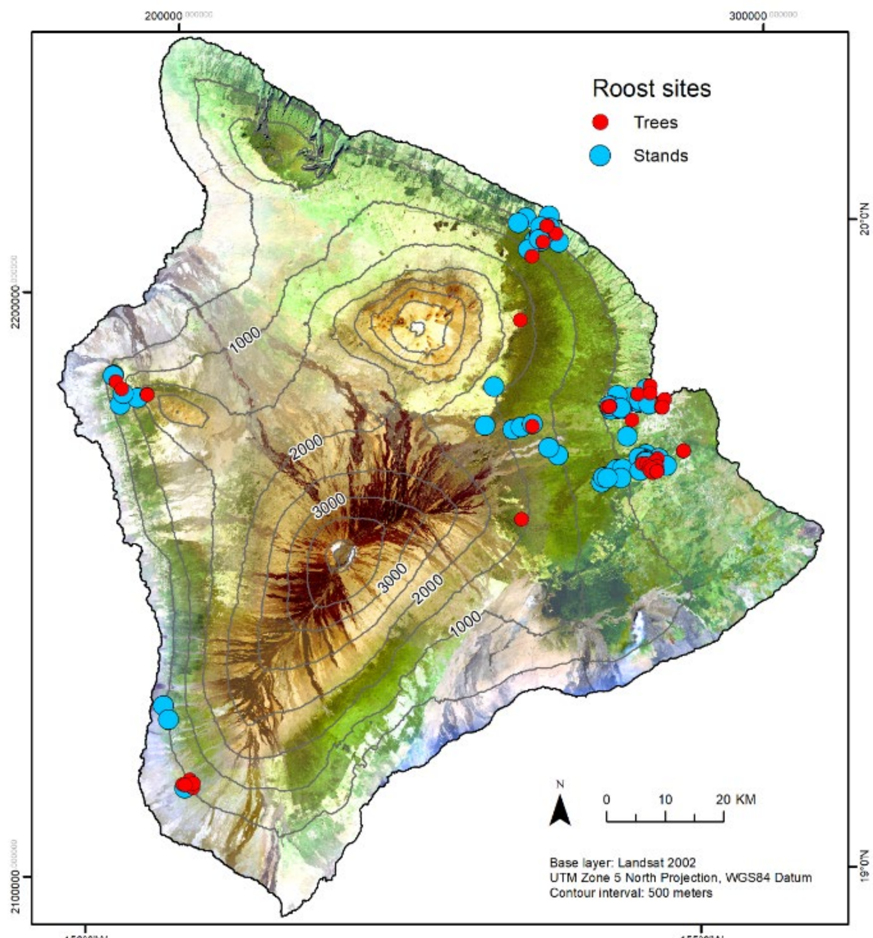

Figure 4. Locations of forest stands and trees identified as ‘ōpe’ape’a as day-roosts, May 2018 – August 2021.

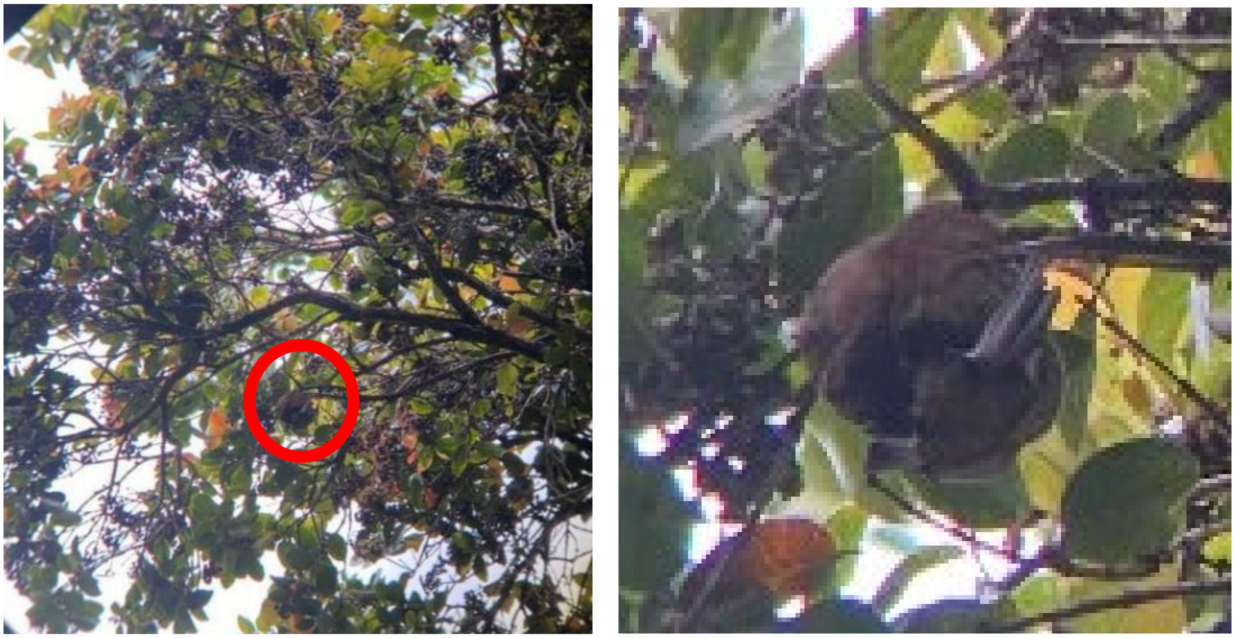

Figure 5. Family group at ʻōpeʼapeʼa maternity roost in an ʻōhiʻa (red circle, left), enlarged (right) to show three bats in the family group including a radio-tagged juvenile male seen on the left side of the group.

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.

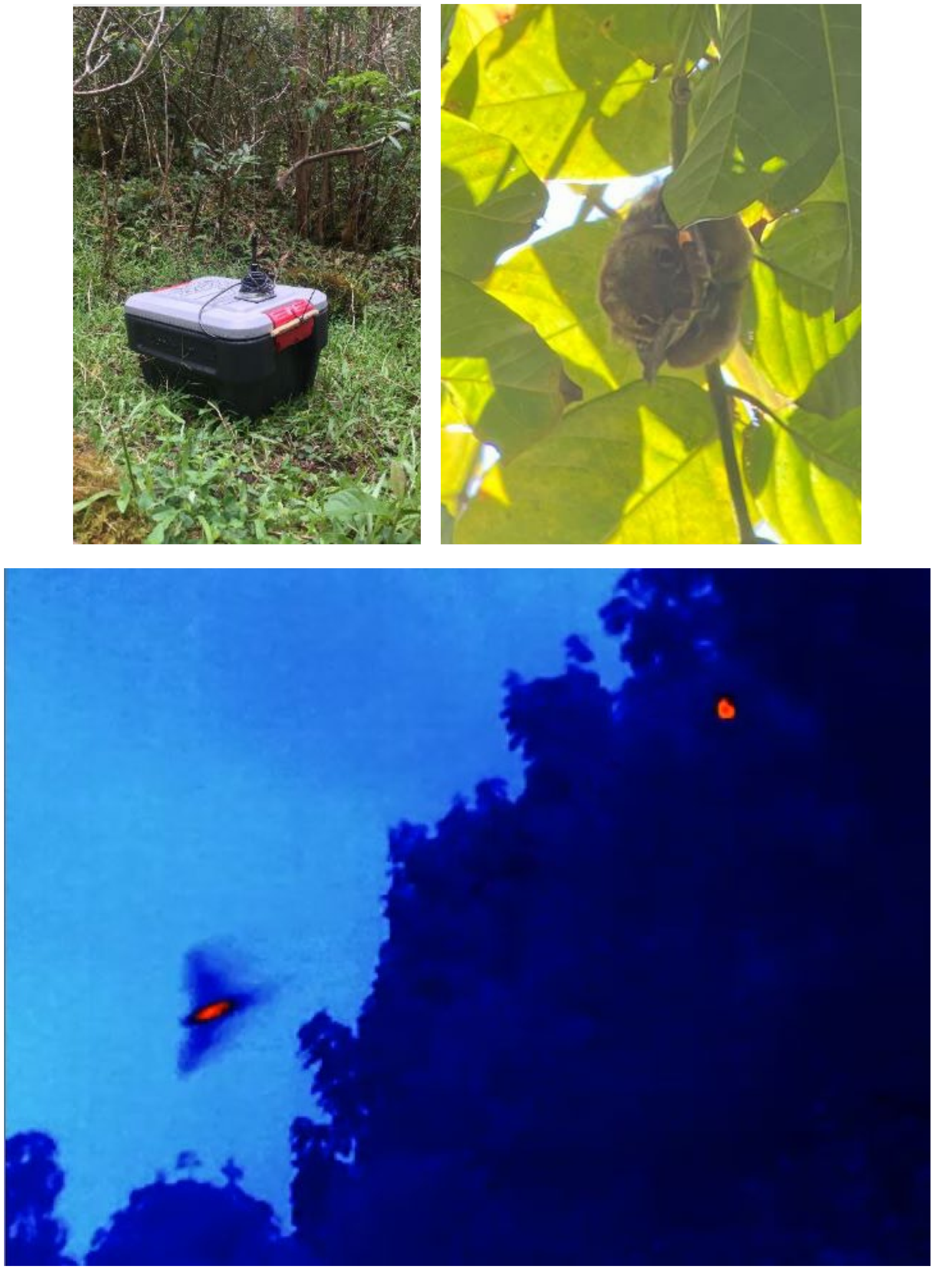

Figure 6. Automated receiver station used to measure roost fidelity (top left). A banded mother Hawaiian hoary bat with two pups observed during maternity roost monitoring (top right). Thermal video monitoring of bat roost behavior (bottom).

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, Hawai‘i. Available: http://hdl.handle.net/10790/4638.

Appendix 6. Nēnē Monitoring and Predator Control Management at Haleakalā Ranch, Maui Annual Report

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NĒNĒ MONITORING AND PREDATOR CONTROL MANAGEMENT AT HALEAKALĀ RANCH, MAUI

ANNUAL REPORT

FY 2022 (JULY 1, 2021 through JUNE 30, 2022)

1.0 Introduction

Since May 2011, the Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW), funded by the Kaheawa Wind Power projects, is managing a Nēnē Monitoring and Predator Control Management Program (Program) at Haleakalā Ranch (Ranch), Maui. The purpose of this Program is to establish a population of the endangered Nēnē, or Hawaiian goose (*Branta sandvicensis*) at the Ranch. The Program contributes to the mitigation requirements for the Nēnē as identified in the Kaheawa Pastures Wind Energy Generation Facility (KWP I) and Kaheawa Wind Power II (KWP II) Habitat Conservation Plans (KWP I 2006, SWCA 2011).

This report summarizes the population establishment efforts for FY 2022. This report and the activities described herein are in compliance with the Haleakalā Ranch SHA (Haleakalā Ranch et al. 2019).

2.0 Mitigation Actions

2.1 Road Improvement

The road to the pen was maintained periodically, as needed, by moving rocks and backfilling holes with dirt and rocks. Approximately, twenty (20) feet of road was repaired this year.

2.2 Nēnē Monitoring

2.2.1 Sightings

Weekly observations and monitoring were conducted throughout the year on the Ranch. Observations of banded and unbanded birds were recorded at the Ranch to monitor movements, distribution, and survival of Nēnē. In FY2022, thirty-one (31) banded birds were sighted at the Ranch. Twenty-nine (29) were wild Maui Nēnē and two (2) were from the Kauai translocation. An island-wide annual Nēnē survey was conducted on September 27, 2012. During this survey, four (4) birds were seen at the Ranch.

2.2.2 Nesting

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

Ten (10) nests were located at the Ranch this year, nine (9) inside the Ranch's open-top release pen and one (1) outside the pen in the water unit. Five (5) of these nests were successful in producing twelve (12) goslings. Ten (10) Nēnē fledged from the Ranch open-top release pen this season.

Table 1. Nēnē Nesting Summary for 2021-2022 Breeding Season at Haleakalā Ranch, Maui

Total Number of Nests	
Located at the Ranch	**10**
Located in open-top pen	**9**
Successful	**6**
Abandoned	**1**
Depredated	**0**
Failed (unknown reason)	**3**
Renests	**0**
Total Number of Eggs	
Known	**27**
Depredated	**0**
Abandoned (later scavenged)	**1**
Salvaged	**0**
Outcome unknown	**14**
Hatched	**12**
Total Number of Goslings/Fledglings	
Known goslings	**12**
Goslings died (impact injuries)	**2**
Fledglings fledged from pen (credited for mitigation)	**10**

2.3 Banding

Fourteen (14) birds were banded this year, ten (10) fledglings and four (4) adults.

2.4 Pen Maintenance

The open-top pen's fence line was continuously checked and maintained throughout the year with holes being patched as needed. A total of five (5) feet of fence was repaired along the pen. The entire fence line was weedeated monthly, as needed, for a total of four and a half (4.5) acres for the year. The water unit was checked monthly, and the pond and automatic waterers were cleaned and maintained monthly. The door on the water until was replaced, and the rain gutter and gutter screens were replaced.

2.5 Habitat Management

Short grass habitat was maintained at the open-top release pen. A total of twenty-eight and a quarter (28.25) acres was mowed this year to maintain Nēnē short grass habitat. Twelve and a quarter (12.25) acres of alien vegetation, including lantana, guava, tomato, fireweed, and bur, were also removed.

2.6 Predator Control

Predator traps were used to control rats, mongoose, feral cats, and dogs that may pose a threat to Nēnē and their nesting sites. Traplines using thirty (30) Tomahawk live traps, thirty (30), and ten (10) A24s were baited and checked at the Ranch throughout the year.

This year at the Ranch, eight (8) mongoose were removed through predator trapping. No avian predators were controlled this season on the Ranch. No cats or cat sign were seen at the pen. Rats may likely be more abundant. Wild dogs have been seen on the ranch, but not specifically near the pen.

Table 2. Traps Deployed and Predators Removed during 2021-2022 at Haleakalā Ranch, Maui

Predator Type Removed	Trap Type		
	Tomahawk Live Trap (30)	Sherman Trap (30)	A24 Traps (10)
Cats	**0**	**0**	**0**
Dogs	**0**	**0**	**0**
Mongoose	**8**	**0**	**0**
Rats	**0**	**0**	**0**
Mice	**0**	**0**	**0**

Table 3. Avian Predator Control during 2021-2022 at Haleakalā Ranch, Maui

Predator Type Removed	Control Effort		
	(Describe Type 1) (Quantify level of effort)	(Describe Type 2) (Quantify level of effort)	(Describe Type 3) (Quantify level of effort)
Barn owls	**0**	**0**	**0**
Cattle egrets	**0**	**0**	**0**

2.7 Relocations

No relocations or releases were done this year.

2.8 Injury, Fatalities, Disease

One (1) adult nene was found at the pen with a broken right wing. It was taken to the vet and later euthanized due to the severity of the injury. Two (2) goslings that died from impact injuries (one (1) to the head and one (1) to the wing) were found during the nesting season.

2.9 Adaptive Management Actions

N/A

3.0 Literature Cited

Haleakalā Ranch Company, DLNR, USFWS. 2019. Safe Harbor Agreement for Nēnē at Haleakalā Ranch, Island of Maui.

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

SWCA (SWCA Environmental Consultants). 2011. Kaheawa Wind Power II Wind Energy Generation Facility Habitat Conservation Plan. Prepared for Kaheawa Wind Power II, LLC. December 2011.

Appendix 7. Makamakaʻole Threatened and Endangered Seabird Mitigation Project: Exclosures and Artificial Burrows Annual Summary 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**

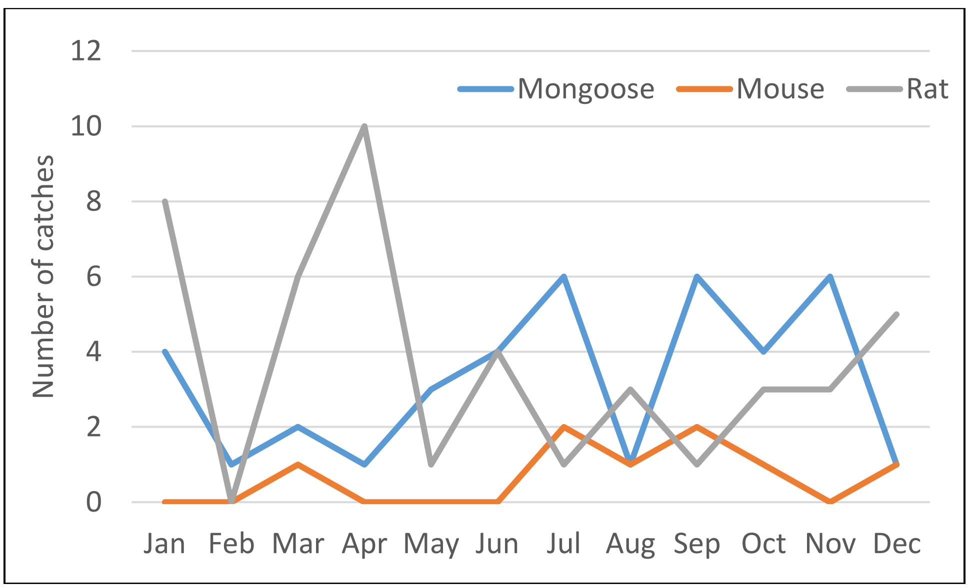


Figure 2. Number of catches by species per month (2021).

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).

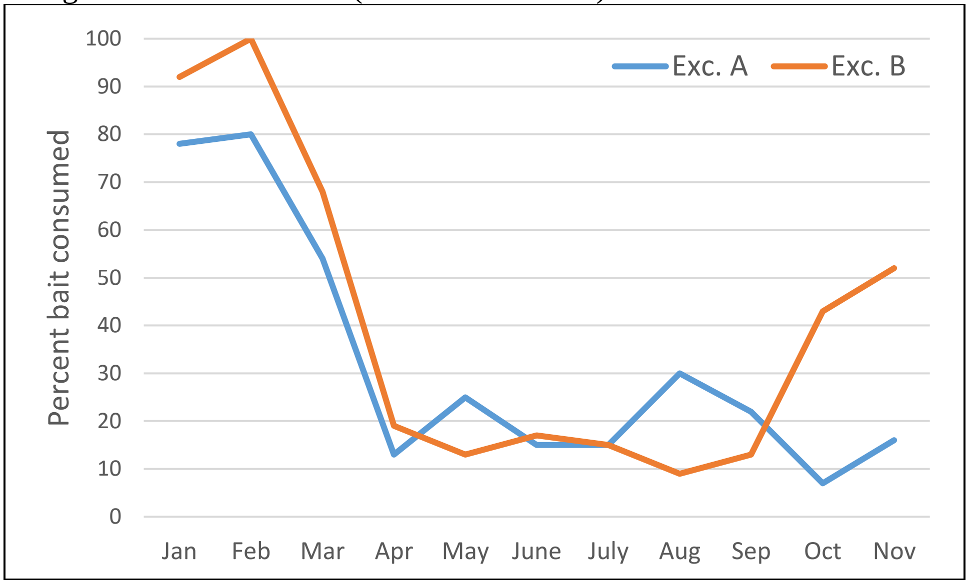


Figure 3. Average amount of Ramik green bait consumed by month in each exclosure (2021).

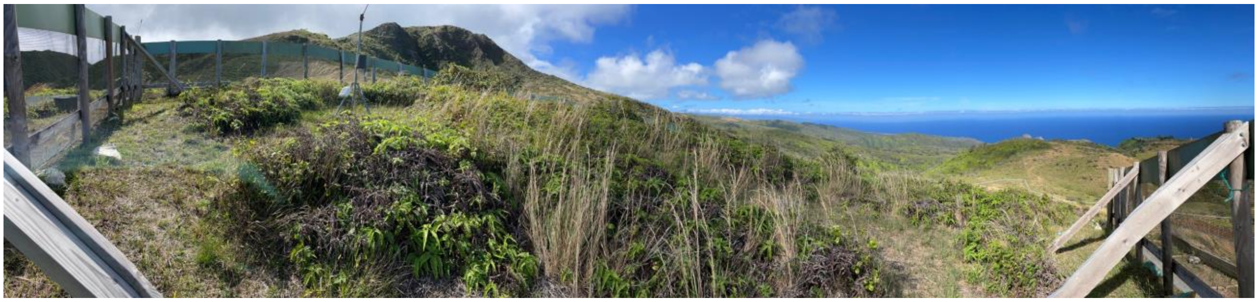
Predator Tracking: Tracking cards baited with peanut butter were used to assess rodent and mongoose activity within the exclosures (10 each in A and B). Tracking cards are deployed for 24 hours and checked for rodent activity, new cards are deployed then checked again after 72 hours for mongooses. In 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

Makamakaʻole 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

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Appendix 8. 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.

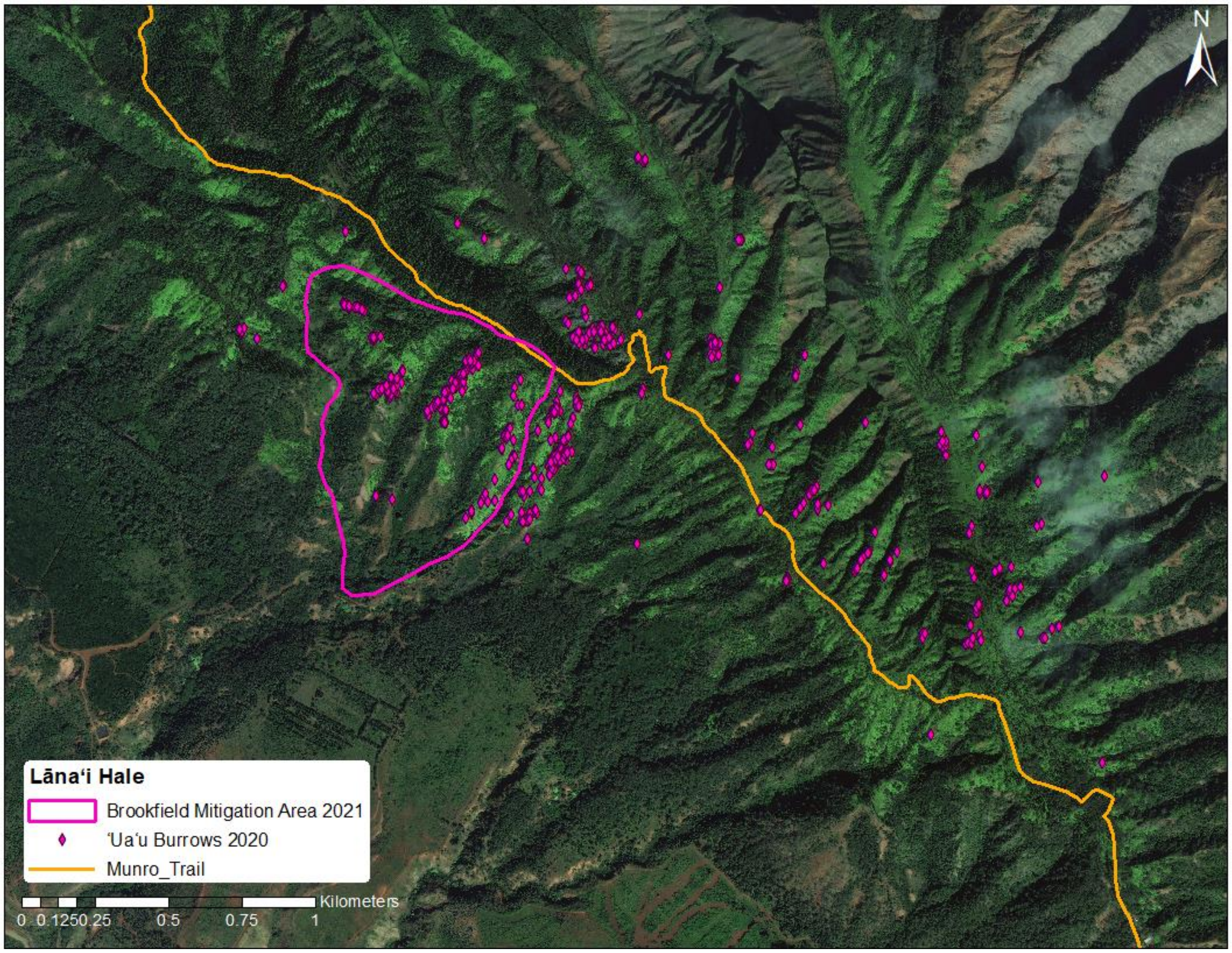

Figure 1. Map of area supported by Brookfield Renewable Partners mitigation funding for 2021, relative to the known Hawaiian petrel burrows on Lānaʻi Hale. The area is approximately 150 acres, and encompasses over 30% of the known Hawaiian petrel burrows on Lānaʻi.

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.

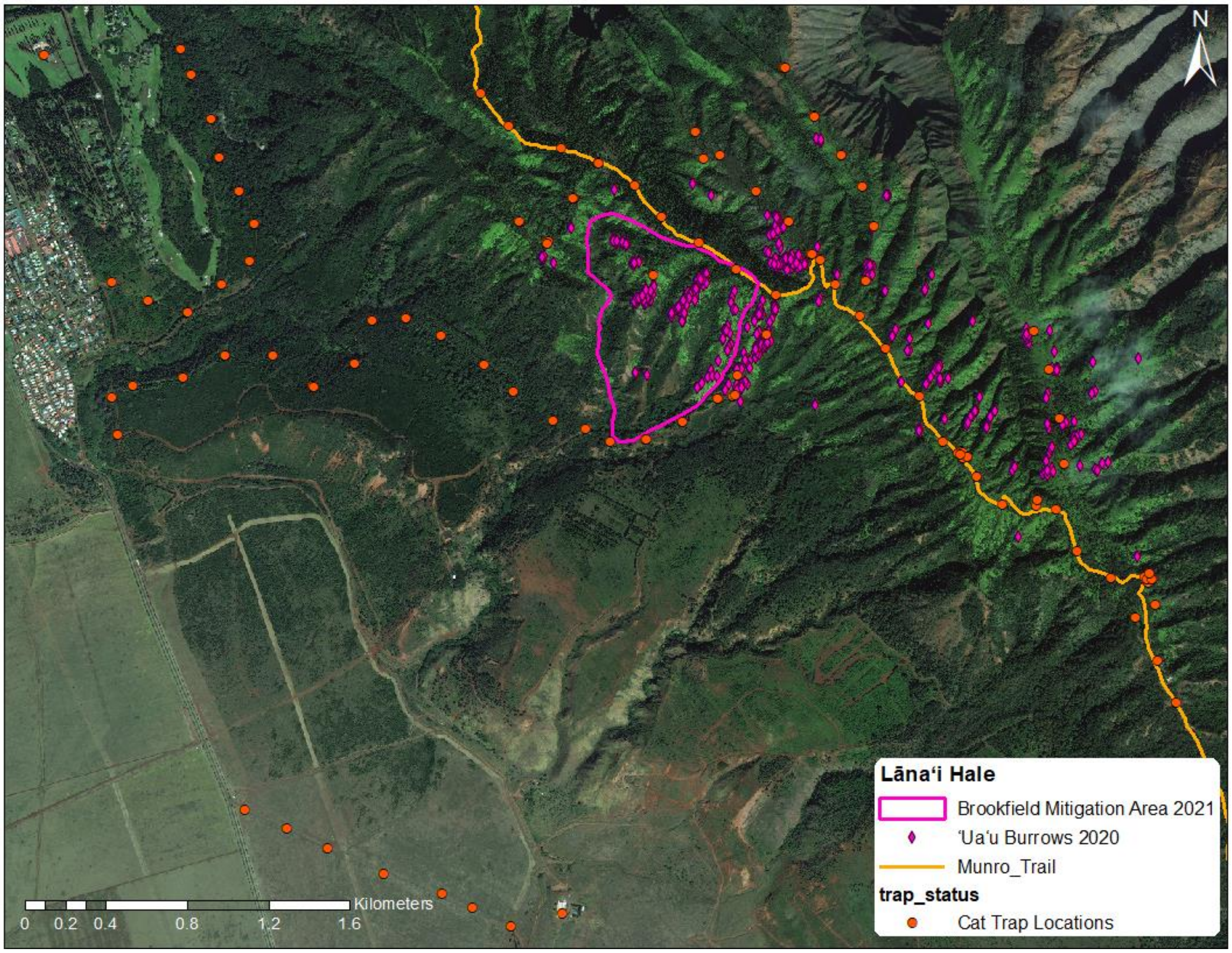

Figure 2. Locations of the landscape-level cat trap stations in the grid protecting the Hawaiian petrel colony on Lānaʻi Hale.

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.

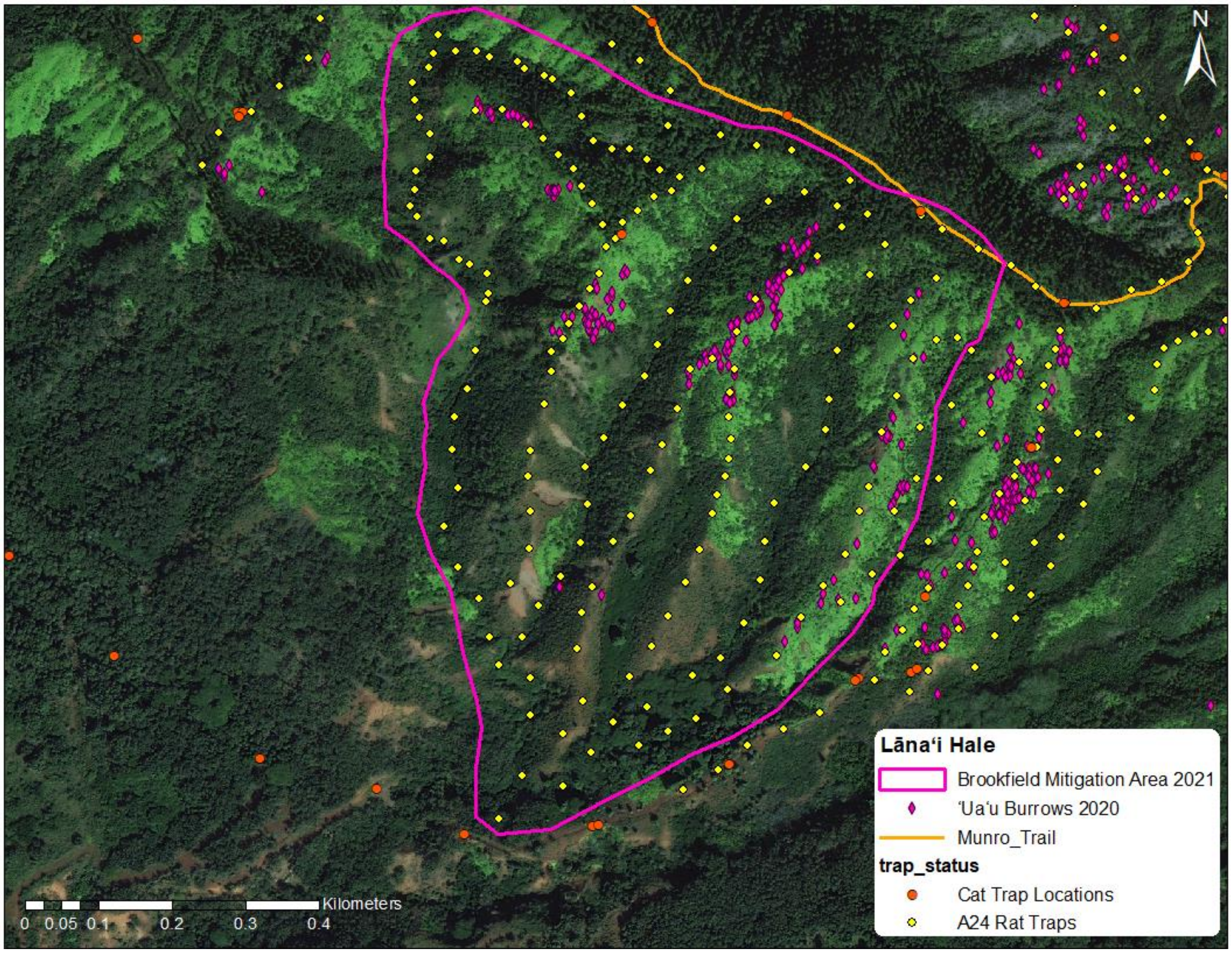

Figure 3. Locations of A24 self-resetting rat traps in the area supported by Brookfield Renewable Partners mitigation funding.

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.