Kawailoa Wind Project Habitat Conservation Plan
FY 2021 Annual Report

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Incidental Take License ITL-14 Amended/ Incidental Take Permit TE59861A-1

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EXECUTIVE SUMMARY

This report summarizes work performed by Kawailoa Wind, LLC (Kawailoa Wind), owner of Kawailoa Wind Project (Project), during the State of Hawaiʻi fiscal year 2021 (FY 2021; July 1, 2020 – June 30, 2021) under the terms of the approved Habitat Conservation Plan (HCP), dated October 2011, and the approved HCP Amendment, dated September 2019, as well as pursuant to the obligations contained in the Project's state Incidental Take License (ITL; ITL-14 Amended) and federal Incidental Take Permit (ITP; TE-59861A-1). The Project was constructed in 2011 and 2012, and was commissioned to begin operating on November 2, 2012. Species covered under the HCP and HCP Amendment include seven state- and federally listed threatened or endangered species, as well as one state-listed endangered species.

Fatality monitoring at the Project continued throughout FY 2021 at all wind turbine generators (WTG) within the 35-meter radius circular search plots. The mean search interval for WTGs and the two meteorological towers in FY 2021 was 3.5 days and 7.0 days, respectively.

Four 28-day carcass persistence trials were conducted in FY 2021, using 60 bat surrogates and 12 medium-sized bird carcasses. For FY 2021, the probability that a carcass persisted until the next search was 0.87 (95% confidence interval [CI] = [0.80, 0.91]) for all bat surrogate carcasses, and 0.98 (95% CI = [0.94, 1.00]) for medium-sized bird carcasses. No scavenger trapping was conducted at the Project in FY 2021.

Searcher efficiency trials were conducted over 24 trial days with 82 trial carcasses in FY 2021. The overall searcher efficiencies in FY 2021 for bat surrogate (N = 72) and medium-sized bird (N = 10 carcass trials were 0.93 (95% CI = [0.85, 0.97]) and 1.00 (95% CI = [0.78, 1.00]), respectively.

No Covered Species fatalities or fatalities of other federally or state listed species were observed in FY 2021. No Hawaiian hoary bat (*Lasiurus cinereus semotus*) fatalities have been observed since FY 2019. The Project's total observed bat take from November 2012 through FY 2021 is 40 bats. The fatality estimate for non-incidental observed bats using the Evidence of Absence estimator (Dalthorp et al. 2017) at the upper 80 percent credibility level is 88 bats and the total indirect take for this estimate is 9 adult bat equivalents. Combining these values, there is an approximately 80 percent chance that actual take of Hawaiian hoary bats at the Project is less than or equal to 97 adult bats. This estimate falls within the Tier 4 bat take request detailed in the HCP Amendment.

Twenty-seven bird fatalities representing ten non-listed species were found at the Project in FY 2021. This includes two cattle egrets (*Bubulcus ibis*) and one Pacific golden-plover (*Pluvialis fulva*), which are protected by the Migratory Bird Treaty Act.

Mitigation for the Hawaiian hoary bat continued in FY 2021. Four permanent ground-based ultrasonic bat detectors were managed at the Project at WTGs 1, 10, 21, and 25. Hawaiian hoary bats were detected on 298 of 1,437 (20.7 percent) detector-nights sampled throughout the 2021 Bat Sampling Period (June 2020 – May 2021).

The ʻUkoʻa Wetland mitigation program for Tier 1 mitigation continued for waterbirds and bats through FY 2021 including invasive vegetation control, predator control and monitoring, fence monitoring and maintenance, bat lane maintenance, bat acoustic monitoring, and insect sampling. Hawaiian hoary bat research projects conducted by the U.S. Geological Survey and WEST Consultants for Tier 2 and 3 bat mitigation continued in FY 2021. The remainder of Tier 3 bat mitigation was completed in FY 2019 with the acquisition of the Waimea Native Forest. Tier 4 bat mitigation was completed in FY 2019 with the acquisition of the Helemano Wilderness Area.

To mitigate for impacts to the Hawaiian petrel, Kawailoa Wind funded 1 year of monitoring and predator control at the Hanakāpīʻai and Hanakoa seabird colonies within the Hono O Nā Pali Natural Area Reserve on Kauaʻi in 2020. This work completes Kawailoa Wind's Hawaiian petrel mitigation. Tier 1 mitigation for Newell's shearwater or ʻaʻo (*Puffinus newelli*) was completed in FY 2015. Tier 1 pueo or Hawaiian short-eared owl (*Asio flammeus sandwichensis*) mitigation was completed in FY 2017.

Kawailoa Wind and Tetra Tech participated in five meetings with USFWS and DOFAW staff in FY 2021. In addition, Kawailoa Wind and Tetra Tech attended one ESRC meeting, one BLNR meeting, and the ESRC bat workshop during FY 2021.

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1.0 Introduction

The Habitat Conservation Plan (HCP) for the Kawailoa Wind Project (Project) was approved by the Hawaiʻi Division of Forestry and Wildlife (DOFAW) in 2012 (SWCA 2011; 2011 HCP). On December 8, 2011, the U.S. Fish and Wildlife Service (USFWS) issued Kawailoa Wind, LLC (Kawailoa Wind) a federal incidental take permit (ITP) for the Project, and DOFAW issued a state incidental take license (ITL) on January 6, 2012. The original ITP and ITL cover the incidental take of six state- and federally listed threatened or endangered species, as well as one state-listed endangered species (referred to as the Covered Species) over a 20-year permit term. In September 2019, Kawailoa Wind submitted a final HCP Amendment to USFWS and DOFAW to request an increase in the amount of Hawaiian hoary bat take, and add the endangered Hawaiian petrel or ʻuaʻu (*Pterodroma sandwichensis*) as a Covered Species. Kawailoa Wind received an amended ITP from USFWS on September 4, 2019. After a contested case hearing was dismissed in January 2021, the Hawaiʻi Board of Land and Natural Resources (BLNR) unanimously voted for approval of the HCP Amendment on February 26, 2021. The Amended ITL was issued by DOFAW on February 26, 2021, and signed by Kawailoa Wind on March 30, 2021. The Project's Covered Species now include the Hawaiian stilt or aeʻo (*Himantopus mexicanus knudseni*), Hawaiian coot or ʻalae keʻokeʻo (*Fulica alai*), Hawaiian duck or koloa maoli (*Anas wyvilliana*), Hawaiian gallinule or ʻalae ʻula (*Gallinula chloropus sandvicensis*), Newell's shearwater or ʻaʻo (*Puffinus newelli*), Hawaiian petrel or ʻuaʻu (*Pterodroma sandwichensis*), Hawaiian hoary bat or ʻopeʻapeʻa (*Lasiurus cinereus semotus*), and the state-listed Hawaiian short-eared owl or pueo (*Asio flammeus sandwichensis*).

Project construction occurred in 2011 and 2012, and was commissioned to begin operating on November 2, 2012. The Project is owned and operated by Kawailoa Wind, a wholly-owned subsidiary of DESRI IV, LLC, which is an investment fund managed by D.E. Shaw Renewable Investments, LLC.

This report summarizes work performed for the Project during the State of Hawaiʻi 2021 fiscal year (FY 2021; July 1, 2020–June 30, 2021) pursuant to the terms and obligations of the 2011 HCP, and amended ITL and ITP.[1]

2.0 Fatality Monitoring

In FY 2021, all 30 wind turbine generators (WTGs) were searched for fatalities twice per week, and the two meteorological (met) towers were searched once per week. Search plots consisted of a 35-meter radius circular plot centered on each WTG, and 50-meter radius plot centered on the two

[1] Beginning this FY, the time period for analyzing and reporting bat acoustic data (referred to as the Bat Sampling Period) is from June 1–May 31 rather than the FY (July 1–June 30) to allow adequate time for data review and analysis.

unguyed met towers. The FY 2021 mean search interval for WTGs was 3.5 days (standard deviation [SD] = 0.5 days), and the mean search interval for met towers was 7.0 days (SD = 1.8 days).

In FY 2021, the search plots were searched by trained dogs accompanied by their handlers. In previous years when conditions limited the use of dogs (e.g., weather, injury, availability of canine search team, etc.), search plots were visually surveyed by Project staff; however, canine teams conducted 100 percent of the WTG searches in FY 2021.

There are no unsearchable areas or rock-lined swales within the 35-meter radius search plots. Vegetation within the search plots was managed (e.g., mowed) to maximize searcher efficiency (Sections 4.0 and 5.0).

3.0 Bias Correction

3.1 Carcass Persistence Trials

Four 28-day carcass persistence trials were conducted in FY 2021 using bat surrogates (black rat; *Rattus rattus*) and wedge-tailed shearwater (*Ardenna pacifica*) carcasses. Wedge-tailed shearwaters are medium-sized birds that are suitable surrogates for the listed bird species covered in the 2011 HCP and HCP Amendment (see above). For FY 2021, the probability that a carcass persisted until the next search was 0.87 (95% CI = [0.80, 0.91]) for all bat surrogate carcasses (N=60), and was 0.98 (95% CI = [0.94, 1.00]) for medium-sized bird carcasses (N=12).

3.2 Searcher Efficiency Trials

Tetra Tech personnel (non-searchers) administered 82 searcher efficiency trials on 24 trial days during FY 2021. Similar to the carcass persistence trials, wedge-tailed shearwaters were used as surrogates for listed bird species, and black rats were used as surrogates for bats. Searcher efficiency trials occurred throughout the year, and 100 percent were conducted on canine search teams in FY 2021.

Vegetation category (short vs. medium) of the search plot was documented at the time the carcasses were placed and when they were found. The overall searcher efficiency for canine searchers (i.e., combined vegetation classes) in FY 2021 was 0.93 (95% CI = [0.85, 0.97]) for bat surrogates (N = 72) and 1.00 (95% CI = [0.78, 1.00]) for medium-sized bird (N = 10) carcasses. The mean searcher efficiencies in FY 2021 for canine searchers for bat surrogate (N = 60) and medium-sized bird (N = 7) carcass trials in short vegetation were 0.98 (95% CI = [0.93, 1.00]) and 1.00 (95% CI = [0.71, 1.00]), respectively. The mean searcher efficiencies in FY 2021 for canine searchers for bat surrogate (N= 12) and medium-sized bird (N= 3) carcass trials in medium vegetation were 0.67 (95% CI = [0.34, 0.88]) and 1.00 (95% CI = [0.46, 1.00]), respectively.

4.0 Vegetation Management

Vegetation in the search plots consists mainly of Guinea grass (*Megathyrsus maximus*), Bermuda grass (*Cynodon dactylon*), sensitive plant (*Mimosa pudica*), and a mixture of common low-growing weedy plants. All search plots around the WTGs and met towers are mowed regularly to increase visibility during fatality searches. Plots are mowed to a height of 3 to 4 inches, depending on the type of mower used. Plots are mowed roughly every 2 to 4 weeks; the frequency of vegetation management varies depending on rainfall, time of year, type of vegetation cover, and cattle presence.

Cattle grazing has occurred on the Kamehameha Schools lands on which the Project is located since prior to construction. Domestic cattle are rotated periodically throughout portions of the Project, and graze vegetation under several of the turbines. Cattle are consistently present at WTGs 1 – 3 and WTGs 16 – 26. The specific locations and number of cows present throughout the year depends on several factors, including forage, water availability, and landowner operations. A small herd of feral cattle roam throughout WTGs 4 – 15. No cattle are present at WTGs 27 – 30. Because Kawailoa Wind is not the landowner, the Project does not have control over cattle use in the area, but Kawailoa Wind has requested Kamehameha Schools not graze WTGs 4-15 due to concerns raised by USFWS and DOFAW about attracting bats.

5.0 Scavenger Trapping

Trapping is responsive to Project needs and carcass persistence times are monitored quarterly throughout the fiscal year. No trapping was conducted at the Project in FY 2021. Mean carcass persistence times calculated at the end of each quarter exceeded the search interval; as a result, no trapping was conducted. If deemed necessary, trapping will resume in the future.

6.0 Documented Fatalities and Take Estimates

No Hawaiian hoary bat fatalities, or other listed species fatalities were found in FY 2021. All non-listed fatalities observed at the Project during FY 2021 are listed in Appendix 1. All observed, downed wildlife were handled and reported in accordance with the Downed Wildlife Protocol provided by USFWS and DOFAW. No injured (live) downed wildlife were observed at the Project.

6.1 Hawaiian Hoary Bat

As stated above, no Hawaiian hoary bat fatalities were documented during FY 2021 (Table 1, Appendix 1). No bat fatalities have been observed since FY 2019.

The total take estimate for the Hawaiian hoary bat is based on fatality monitoring data and bias correction data from the start of operation in November 2012 through June 2021. An upper credible limit (UCL) of take is estimated from three components: (1) observed direct take (ODT) during protocol (standardized) surveys, (2) unobserved direct take (UDT), and (3) indirect take. The Evidence of Absence software program (EoA; Dalthorp et al. 2017), the agency-approved analysis tool for analyzing direct take, uses results from bias correction trials and ODT to generate UCL of direct take (i.e., ODT + UDT). The USFWS and DOFAW have requested that these calculations be reported at the 80 percent UCL. Values from this analysis can be interpreted as there is an 80 percent probability that actual direct take at the Project over the analysis period was less than or equal to the 80 percent UCL. Associated indirect take is estimated based on observations of the temporal distribution of Covered Species fatalities at the Project and agency guidance regarding life history characteristics of the associated Covered Species.

A total of 40 Hawaiian hoary bat fatalities have been observed at the Project since operations began on November 2, 2012. The highest number of bat fatalities was observed in FY 2014 and 2015. Two of the total 40 observed bats were found outside of fatality search plots and classified as incidental observations. Table 1 also presents the cumulative take estimate (direct take + indirect take) by FY since operations began. Direct take is estimated using the EoA estimator at the 80 percent UCL (Dalthorp et al. 2017). Indirect take is calculated using USFWS (2016) guidance.

Table 1. Hawaiian Hoary Bat Fatalities Observed Since Operations Began and Cumulative Take Estimates

Fiscal Year	Number of Observed Fatalities[1]	Cumulative Take Estimate[2]
2013	4	11
2014	9	26
2015	9	38
2016	4	49
2017	2	60
2018	5	73
2019	5	89
2020	0	94 [3]
2021	0	97 [3]
Total	**38**	**97** [3]

1. Does not include bat fatalities found outside of the search areas (i.e., 2 incidental observations).
2. Cumulative take represents the 80 percent upper credible limit of cumulative direct take estimated from the Evidence of Absence estimator (Dalthorp et al. 2017) plus the associated indirect take calculated using USFWS (USFWS 2016) guidance.
3. The installation of acoustic deterrents represents an inflection point in the bat fatality rate, reducing the risk to bats, and requires the re-evaluation of 2020 – 2021 data with the application of an appropriate rho value. Changes in the rho value require discussions with USFWS and DOFAW on the appropriate statistical approach to account for the change in risk.

The estimated direct take (ODT + UDT) for the 40 Hawaiian hoary bat fatalities found between the start of operation (November 2, 2012) and end of FY 2021 is less than or equal to 88 bats (80 percent UCL; Appendix 2). Because 2 of the 40 observed bat fatalities were found outside of the search areas (i.e., were incidental observations), 38 fatalities were used in the direct take analysis, and the 2 incidental observations are accounted for in the estimated value of UDT. The two incidental observations were found in FY 2013 and FY 2016.

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

- The average number of pups attributed to a female that survive to weaning is assumed to be 1.8.
- The sex ratio of bats taken through UDT is assumed to be 45 percent female based on the 40 bats assessed by USGS from the Project.
- The assessment of indirect take to a modeled UDT accounts for the fact that it is not known when the unobserved fatality may have occurred. The period of time from pregnancy to end of pup dependency for any individual bat is estimated to be 3 months. Thus, the probability of taking a female bat that is pregnant or has dependent young is 25 percent.
- The conversion of juveniles to adults is one juvenile to 0.3 adults.

Based on the USFWS methodology (2016), the estimate of cumulative indirect take in FY 2021 is calculated as:

- **Total juvenile take calculated from observed female take (April 1 – September 15)**
    - 10 (observed females) * 1.8 (pups per female) = 18 juveniles
- **Total juvenile take calculated from observed unknown sex take (April 1 – September 15)**
    - 0 (observed unknown sex) * 0.45 (sex ratio observed at Kawailoa Wind)* 1.8 (pups per female) = 0 juveniles
- **Total juvenile take calculated from unobserved take**
    - 48 (unobserved direct take) * 0.45 (sex ratio observed at Kawailoa Wind) * 0.25 (proportion of calendar year females could be pregnant or have dependent pups) * 1.8 (pups per female) = 9.7 juveniles
- **Total Calculated Juvenile Indirect Take** = 27.7 (18 + 0 + 9.7)
- **Total Adult Equivalent Indirect Take =** 0.3 (juvenile to adult conversion factor) * 27.7 = 8.3

Therefore, the estimated indirect take based on the UCL of Hawaiian hoary bat direct take at the Project is nine adult bats (rounded up from 8.3).

The UCL for Project take of the Hawaiian hoary bat at the 80 percent credibility level is 97 adult bats (88 estimated direct take + 9 estimated indirect take)[2]. That is, there is an approximately 80 percent probability that actual take at the Project at the end of FY 2021 is less than or equal to 97 bats. This estimate falls within the Tier 4 bat take request detailed in the HCP Amendment, which has a total take request of 115 bats. The approved HCP Amendment addressed the exceedance of the previously authorized bat take limit (Tiers 1-3) in the 2011 HCP through the identification of additional avoidance and minimization measures, as well as additional compensatory mitigation for the Hawaiian hoary bat (Tetra Tech 2019).

The minimization measures associated with the HCP Amendment demonstrate a statistically significant reduction in the fatality rate. This reduction warrants the application of an appropriate rho value in the EoA model. A comparison of the fatality rates before and after the application of minimization measures associated with the HCP Amendment shows the fatality rate is reduced from an average of 11.15 bats per year in FY 2013 – 2019 estimated by EoA to an average of 1.45 bats per year in FY 2020 –2021 (Figure 1). A test for misspecification of rho in EoA demonstrates that application of a rho value of 1 in FY 2020 – 2021 is overestimated (p value = 0.0002). Using an annual rho value of 0.25, the test for misspecification exceeds the threshold of 0.05 (p value = 0.054). The estimate of a rho of 0.25 is statistically supported by EoA (95 percent certain) and is conservative (assumes lower deterrent effectiveness than suggested by available data) because of the use of 95 percent confidence level and limited monitoring data (2 years) following the installation of the ultrasonic acoustic deterrent (UAD); the estimated rho value is likely to decrease as additional monitoring data are collected.

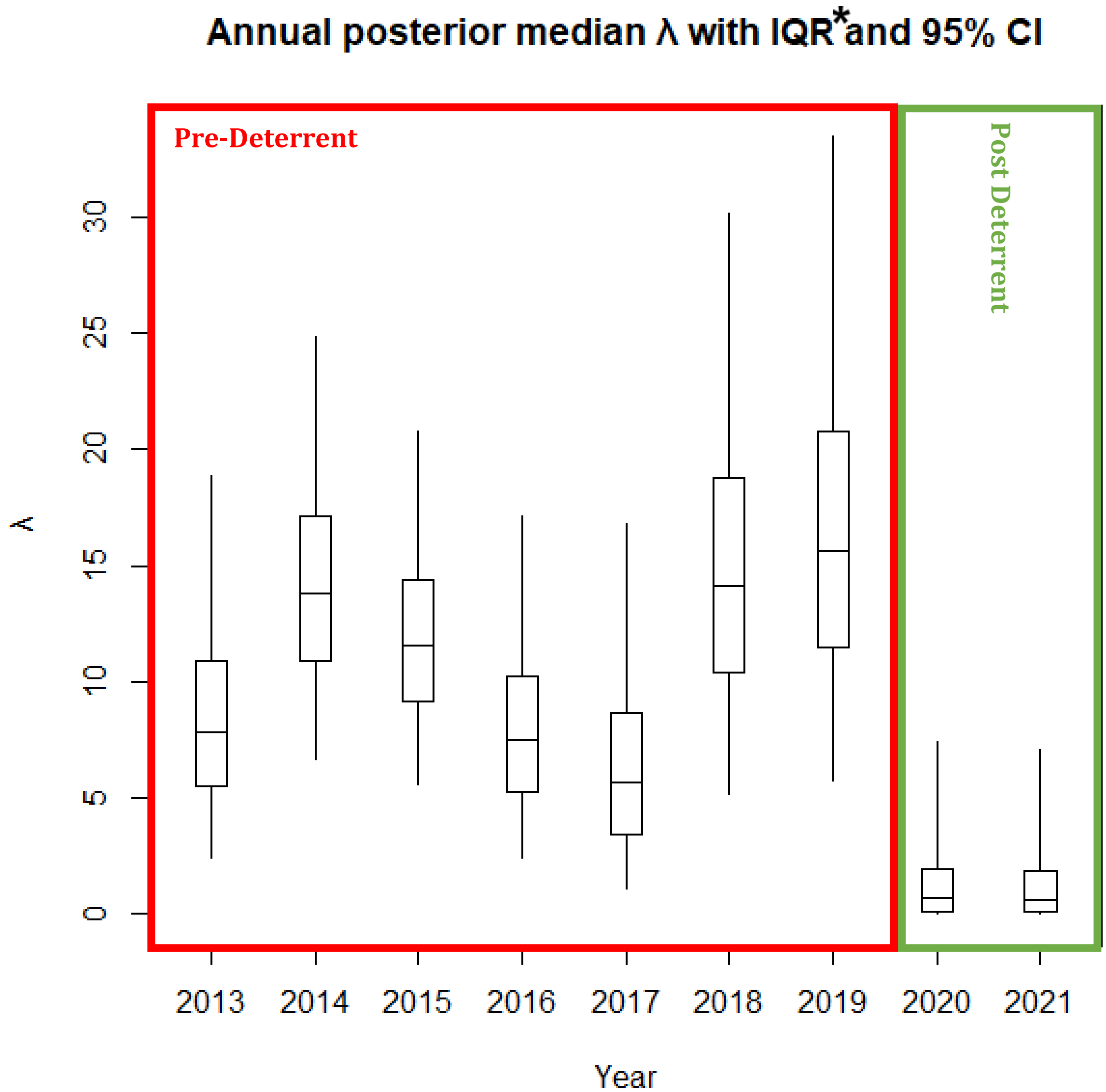
Kawailoa Wind proposed methods for determining an appropriate and conservative rho value in Appendix 3 of the FY 2020 annual report (Tetra Tech 2020) and continues discussions with the agencies to allow incorporation of the modified rho into future analyses. Assessment of rho in the post-UAD installation period will continue to incorporate ongoing fatality monitoring results in the post-UAD period through the approach outlined in the FY 2020 annual report. The inclusion of multiple years will increase statistical rigor to accurately assess changes in rho given the observed inter-annual variability. The rho value applied for periods with the current minimization measures will be re-evaluated annually to adjust for additional information until Kawailoa Wind, USFWS, and DOFAW have sufficient evidence for the reduction in fatalities associated with deterrents. The use of a rho value less than 1 to evaluate compliance with authorized take limits is subject to approval from USFWS and DOFAW, as such this approach has not been used in the current analysis of cumulative take estimates. The details of the rho analysis with data through FY 2021 are provided in Appendix 3.

A take projection can be generated with EoA and with methods outlined in the HCP Amendment to estimate the likelihood of staying within the permitted take within the permit term. The take projection is influenced by the rho value as outlined in the preceding paragraphs. Given the use of a rho value of 0.25, the median take projection in the last year of the permit term (2032) is 115

[2] This total is estimated using a rho value of 1. The assessment of take is subject to change if a rho value less than one is determined to apply.

(Interquartile Range [IQR]: 110, 120). This value would be well below the total take authorization of 220 bats. This method of projection is likely to overestimate project impacts because the take rate prior to deterrent installation heavily impacts the projection despite the application of a rho value less than one (9.4 estimated fatality rate from FY 2013 through FY 2021 * 0.25 rho value = approximately 2.4 bats per year estimated future fatality rate compared to an average calculated rate of 1.4 bats per year post-UAD). The HCP specifies a comparison of the current take estimate and the current take rate to total authorized take over the permit term to determine if adaptive management is warranted. This method can also be used to evaluate take rates on an ongoing basis. EoA estimated the take rate at the Project in FY 2020-2021 is 1.45 bats per year; extrapolating from the current direct take estimate, and the current take rate the Project estimates a direct take total of 103.9 bats (88 bats estimated by EoA in FY 2021 + 1.45 bats per year * 11 years remaining in the permit term).

The Project's current ratio of indirect take to direct take indicates the estimated indirect take is 9.4 percent of the direct take estimate (8.31 adult bat equivalents estimated in FY 2021 / 88 bats estimated from direct take). When an estimate of indirect take of 9.8 adult bat equivalents (9.4 percent * 103.9 bats estimated from direct take) is added to the direct take estimate, the estimated take is 113.7 adult bat equivalents (103.9 bats estimated through direct take + 9.8 bats estimated through indirect take) in year 2032. This indicates the Project may stay below the Tier 4 maximum of 115 bats through the permit term. Both the EoA and HCP methods of generating take projections indicate the Project will stay below the HCP Amendment take estimates through the permit term.



***Interquartile Range**

Figure 1. EoA Estimated Hawaiian Hoary Bat Fatality Rates by Year at the Project

6.2 Non-listed Species

Twenty-seven bird fatalities representing ten species were documented at WTGs at the Project in FY 2021. No fatalities have been observed at either of the two met towers. Two of the species observed in FY 2021 are protected by the Migratory Bird Treaty Act (MBTA): cattle egret (two birds; *Bubulcus ibis*) and Pacific-golden plover (one bird; *Pluvialis fulva*). In addition, twenty-four fatalities of non-native introduced birds without MBTA protection were documented: black francolin (five birds; *Francolinus francolinus*), zebra dove (five birds; *Geopelia striata*), common waxbill (four birds; *Estrilda astrild*), common myna (four birds; *Acridotheres tristis*), spotted dove (two birds; *Spilopelia chinensis*), scaly-breasted munia (two birds; *Lonchura punctulata*), gray francolin (one bird; *Francolinus pondicerianus*) and ring-necked pheasant (one bird; *Phasianus colchicus*). For a complete list of fatalities for FY 2021, see Appendix 1.

7.0 Wildlife Education and Observation Program

Wildlife Education and Observation Program (WEOP) trainings continue to be conducted on an as-needed basis to provide on-site personnel with the information they need to be able to respond appropriately in the event they observe a listed species or encounter a fatality while on site. Nineteen WEOP trainings were conducted in FY 2021.

8.0 Mitigation

The Project's current mitigation requirements are described in Section 7.6 of the 2011 HCP (SWCA 2011) and Section 7 of the HCP Amendment (Tetra Tech 2019).

8.1 Hawaiian Hoary Bats

For the Hawaiian hoary bat, mitigation is required based on where the estimated Project take falls with respect to tiers identified in the 2011 HCP and HCP Amendment. As stated above, the Project is currently in Tier 4 bat take.

During FY 2021, acoustic bat surveys continued at the Project (see Section 8.1.1) and management activities and acoustic bat survey for Tier 1 mitigation continued at ʻUkoʻa Wetland (see Section 8.1.2). USFWS and DOFAW approved bat research projects for Tiers 2/3 mitigation continued in FY 2021 (see Section 8.1.3). In previous fiscal years, Kawailoa Wind contributed funds toward the acquisition of Waimea Native Forest to fulfill remaining obligations for Tier 3 (see Section 8.1.4), and contributed funds toward the purchase and long-term protection of the Helemano Wilderness Area for Tier 4 mitigation (see Section 8.1.5). Despite no bat take being observed in FY 2020 and 2021, Kawailoa Wind is continuing planning for Tier 5 bat mitigation should it be required during the Project's permit term (see Section 8.1.6).

8.1.1 On-site Acoustic Surveys

Following commitments outlined in the 2011 HCP (SWCA 2011), bat activity was intensively monitored at 42 sites (30 WTGs at ground and nacelle, and 12 gulch detectors) across the Project during the first 3 years of systematic fatality monitoring (beginning in August of 2013, FY 2014). Having identified no significant correlation with acoustic bat activity that could inform curtailment during the required intensive acoustic monitoring period (April 2012 to November 2015), Kawailoa Wind reduced the acoustic monitoring effort at the Project in the second quarter of FY 2017 to four permanent ground-based units located at WTGs 1, 10, 21, and 25 (Figure 2). These locations were randomly chosen after eliminating detectors with high or low detection rates. Currently, each monitoring site consists of one song meter SM2BAT+ ultrasonic recorder (SM2) equipped with one SMX-U1 ultrasonic microphone (Wildlife Acoustics, Maynard, MA, USA) positioned 6.5 meters above ground level.

In contrast to previous years, the analysis and reporting period for bat acoustic data for FY 2021 is from June 1, 2020 to May 31, 2021. In this report, all previous sampling years have been adjusted to reflect this same sampling time period (June to May; referred to as the Bat Sampling Period). The change in the bat acoustic data period was made to allow adequate time for data review and analysis.

The objective of this acoustic monitoring is to better understand the annual and seasonal variations in bat activity at the Project. Analysis of variance (ANOVA) and Tukey's honest significance difference (Tukey's HSD) were used to test for differences in detection rates between the 2014 and 2021 Bat Sampling Periods. A linear model (LM) was used to test for a change in detection rates across all monitoring years. Data were normalized using an Ordered Quantile normalization transformation (ORQ). The distribution of residuals from the LM were examined to check for violations of model assumptions. All tests were 2-tailed, employed an alpha value of 0.05, and were conducted in the program R version 4.05 (R Core Team 2017).

Hawaiian hoary bats were detected on 298 of 1,437 (20.7 percent) detector-nights sampled throughout the 2021 Bat Sampling Period (June 2020 – May 2021). The annual detection rate during the 2021 Bat Sampling Period was higher than the annual detection rate in the 2020 Bat Sampling Period (13.3 percent, Table 2), although not significant (Tukey's HSD: $P > 0.531$). Annual detection rates varied between all years (Table 2); however, only differences between 2014 and 2018, 2014 and 2019, and 2014 and 2021 were significant (ANOVA: $F_{7,88} = 2.94$, $P < 0.009$; Tukey's HSD: 2014–2018 $P < 0.049$; 2014–2019 $P < 0.017$; 2014–FY 2021 $P < 0.027$).

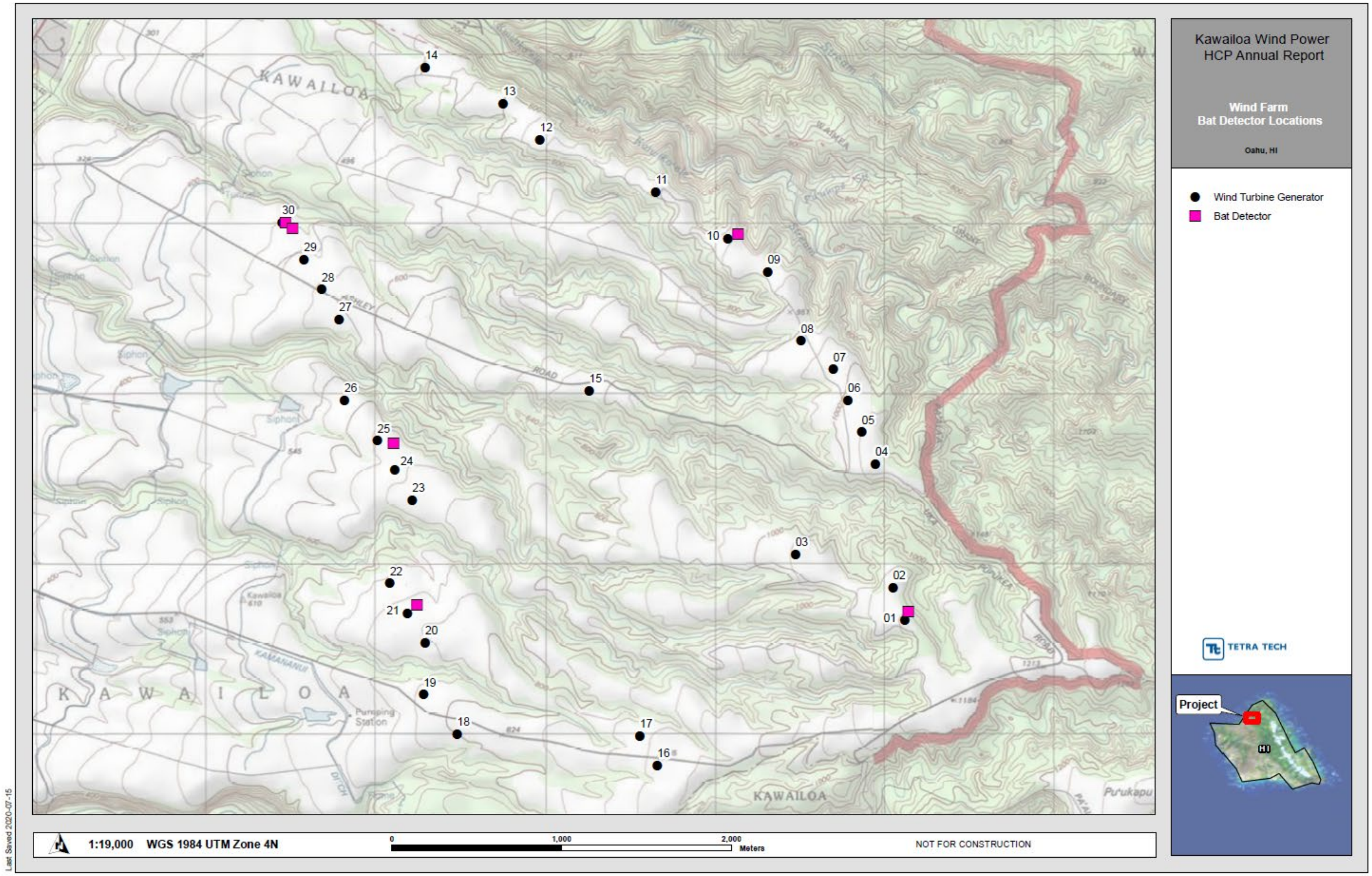

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Table 2. Number of Nights Sampled, Number of Nights with Detections, and Proportion of Nights with Bat Detections at Four Permanent Ground-based Detectors Sampled from June 2013 through May 2021

Bat Sampling Period	No. of Nights Sampled	No. of Nights with Detections	Proportion of Nights with Detections
2014 Sampling Period (June 2013 – May 2014)	1,211	82	0.068
2015 Sampling Period (June 2014 – May 2015)	1,021	144	0.141
2016 Sampling Period (June 2015 – May 2016)	1,321	213	0.161
2017 Sampling Period (June 2016 – May 2017)	1,355	180	0.133
2018 Sampling Period (June 2017 – May 2018)	1,451	280	0.193
2019 Sampling Period (June 2018 – May 2019)	1,249	300	0.240
2020 Sampling Period (June 2019 – May 2020)	1,272	169	0.133
2021 Sampling Period (June 2020 – May 2021)	1,437	298	0.207

Notes:

2013 Sampling Period not included due to minimal number of detector-nights compared to other years.

Beginning FY 2021, the time period for analyzing and reporting bat acoustic data (referred to as the Bat Sampling Period) was changed to June 1–May 31 rather than the FY (July 1–June 30) to allow adequate time for data review and analysis. All previous sampling years have been adjusted to reflect this same sampling time period.

Across all years (2014 to 2021 Bat Sampling Period), there is a significant increasing trend in the annual detection rates (LM: $R^2 = 9.56\%$; $F_{1,94} = 9.94$, $P < 0.003$; Figure 3). If the 2014 Bat Sampling Period is removed, there is still an increasing trend in the annual detection rates, although not significant (LM: $R^2 = 3.18\%$; $F_{1,82} = 2.69$, $P = 0.105$). The low r-squared value of this trend suggests that little of the variation is explained by the linear model (i.e., year). This could be an indication of inherent inter-annual variation or the importance of variables not included in the model.

During the 2021 Bat Sampling Period, elevated detection rates were observed during the lactation (mid-June through August) and early post-lactation (September) reproductive periods[3]. A decline in the detection rates occurred shortly after the transition to the post-lactation (September to mid-December) reproductive period. Lower detection rates were observed from October of the post-lactation reproductive period to January of the pre-pregnancy reproductive period (mid-December

[3] Reproductive periods correspond approximately with reproductive periods as defined by Gorresen et al. (2013).

to mid-March). In February of the pre-pregnancy reproductive period detection rates increased and continued to increase into May of the pregnancy reproductive period (mid-March to mid-June; Figure 4).

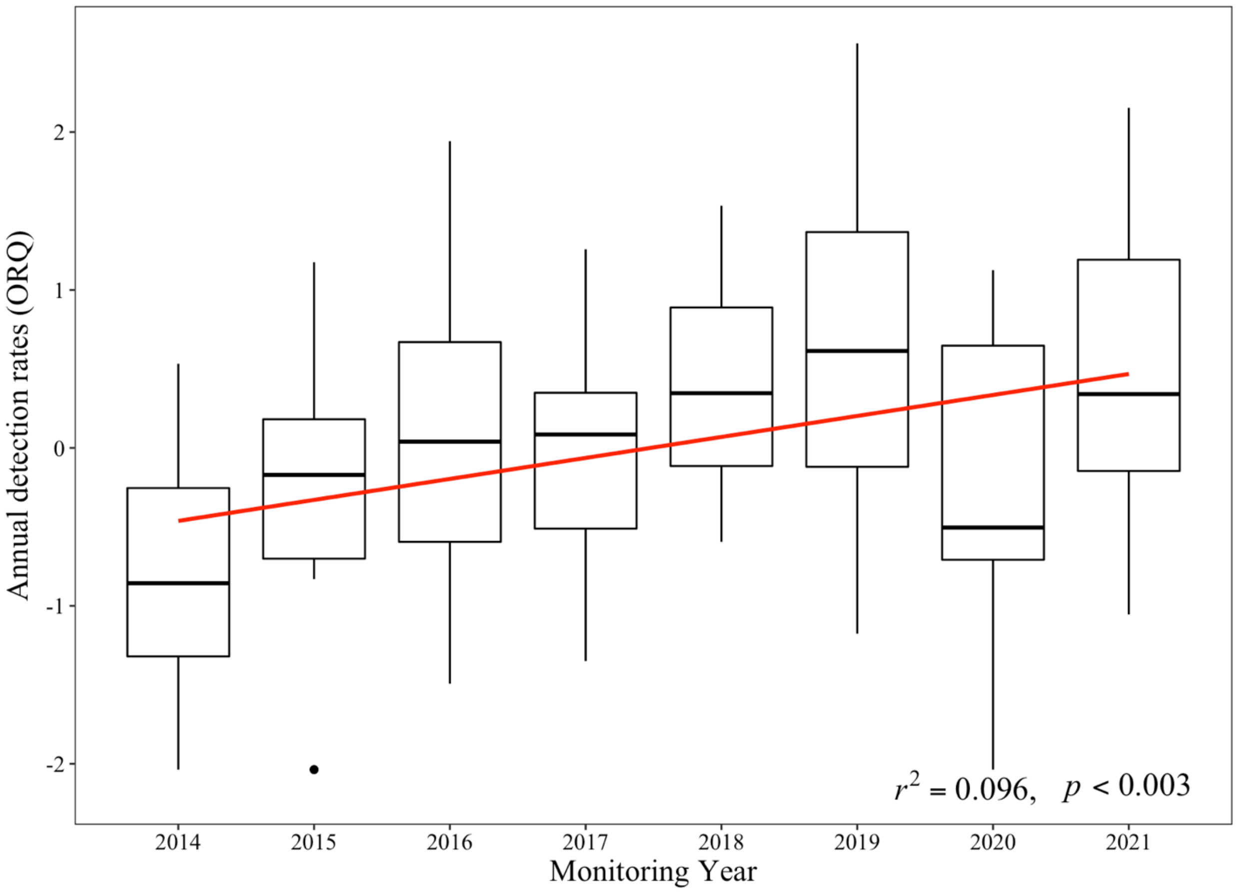

Figure 3. Box-plot Identifying the Median, Lower (Q1), and Upper (Q3) Quartiles, Whiskers (IQR*1.5), and Outliers; Fitted with a Linear Regression Showing the Increasing Trend in the Annual Detection Rates at the Project between the 2014 and 2021 Bat Sampling Periods

Note: Annual Detection Rates were Transformed using an Ordered Quantile Normalization Transformation (ORQ).

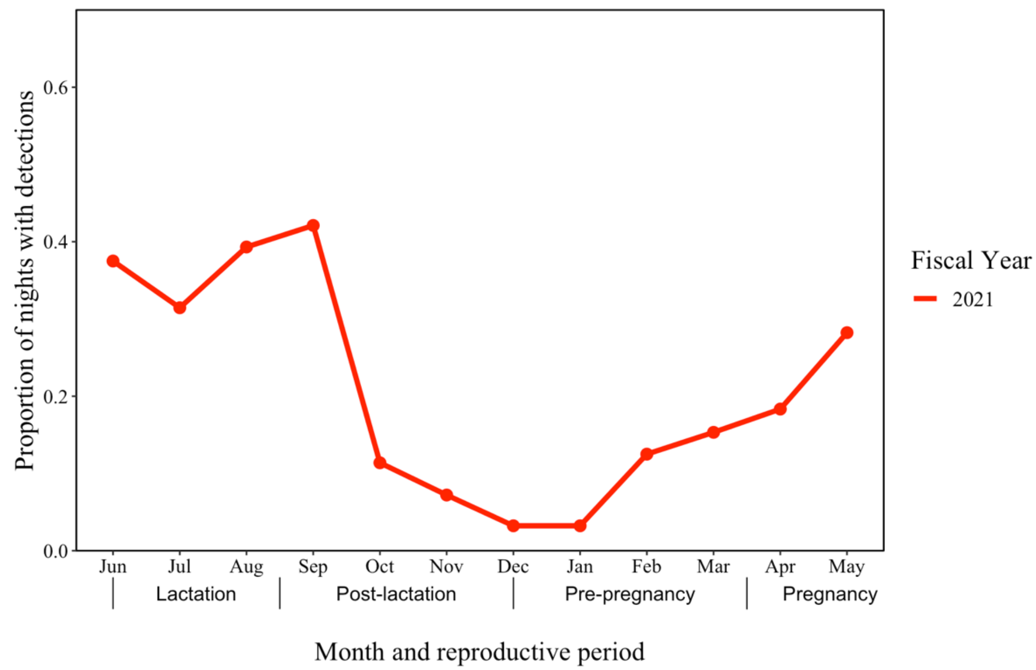

Figure 4. Monthly Bat Detection Rates at Kawailoa during 2021 Bat Sampling Period (June 2020–May 2021) with Corresponding Reproductive Periods

The temporal patterns in the detection rates for the 2021 sampling period were relatively similar to the detection rates observed in previous sampling years (Figure 5). The general temporal pattern in the detection rates observed at the Project has also been reported in Hawaiian hoary bats monitored at other low elevation sites on Oʻahu (Starcevich et al. 2020) and Hawaiʼi Island (Todd 2012).

Detection rates varied among the four sampling locations. During the lactation (July and August) and early post-lactation (September) reproductive periods detection rates were highest at site WTG-25 (Figure 6). Throughout the remainder of the post-lactation (October to December) reproductive period and the beginning of the pre-pregnancy reproductive period, detection rates declined at all sites. Detection rates began steadily increasing in January at sites WTG-25, 21 and in February at site WTG-1 during the pre-pregnancy reproductive period. No detections were observed at site WTG-1 between the months of November and February. All other sites had some level of detection during each of the sampling months throughout the year, with the highest detection rates occurring at site WTG-25 (Figure 6).

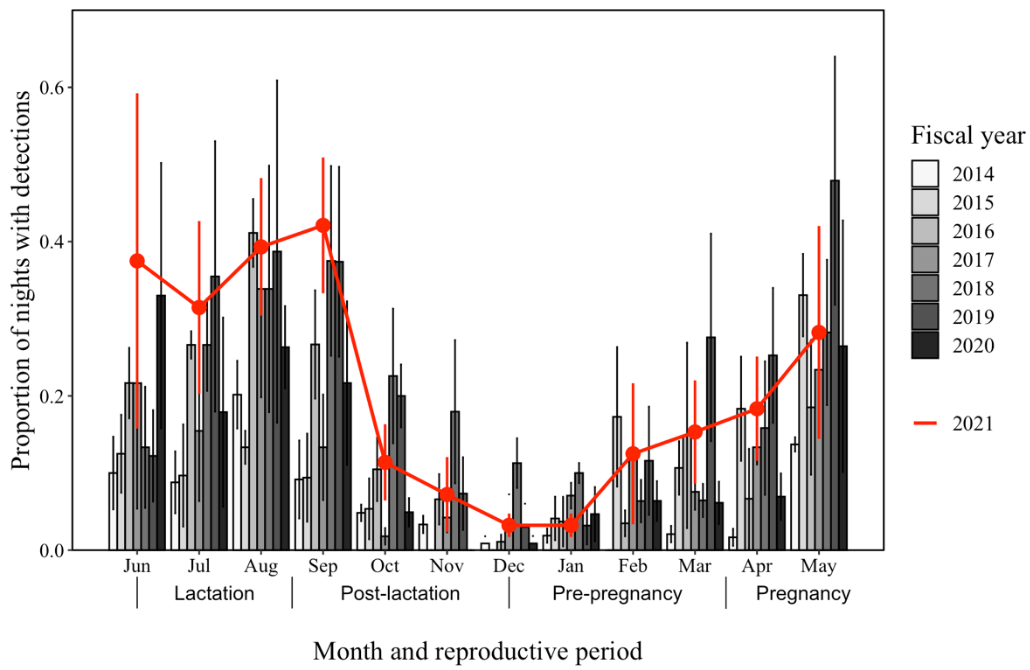

Figure 5. Monthly Bat Detection Rates at Kawailoa for 2014 to 2021 Bat Sampling Periods with Corresponding Reproductive Periods

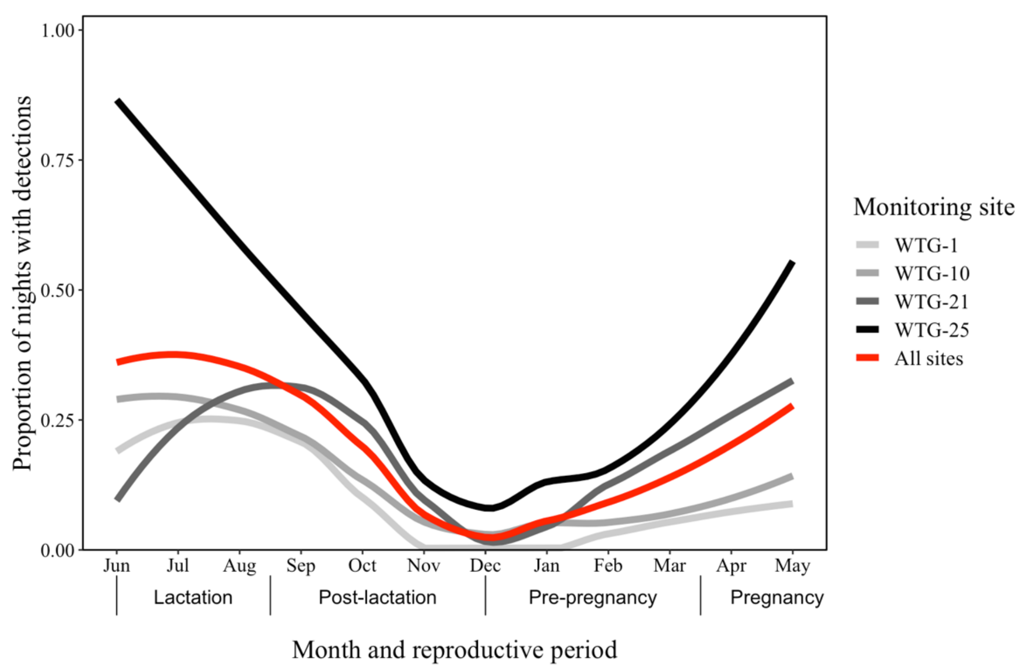

Figure 6. Monthly Site-Specific Variation in Detection Rates for 2021 Bat Sampling Period with Corresponding Reproductive Periods

Note: Trend Lines are fitted with Loess smoothing curve.

8.1.1.1 Acoustic Monitoring at WTG 30

In July 2018, WTG-30 was fitted with an NRG ultrasonic UAD as a "proof of concept" test, and in May and June 2019 all WTGs at Kawailoa Wind were fitted with similar UADs. Two SM2 units were deployed at WTG-30 in September 2018 to monitor bat activity. One SM2 unit (WTG-30H) was deployed approximately 75 meters east-southeast from the turbine at the historical detector location which was monitored in FYs 2014 to 2016. The second SM2 unit (WTG-30N) was deployed approximately 27 meters east of site WTG-30.

At site WTG-30N, Hawaiian hoary bats were detected on 48 nights out of 342 (14.0 percent) detector-nights sampled during the 2021 bat reporting period, which was a slight increase compared to the 2020 and 2019 annual detection rates (9.4 percent and 7.9 percent, respectively). At WTG-30H, Hawaiian hoary bats were detected on 61 nights out of 251 (24.3 percent) detector-nights sampled during the 2021 bat reporting period, which is higher than the 2020 and 2019 annual detection rates (12.9 percent and 8.6 percent, respectively).

8.1.2 'Uko'a Wetland (Tier 1)

Mitigation for bats and waterbirds continued at 'Uko'a Wetland during FY 2021. In FY 2016 (March 2016), USFWS and DOFAW provided written confirmation permitting adaptive management for the original bat and waterbird mitigation proposed at 'Uko'a Wetland. This included the following:

1. Reduction from 40 acres of vegetation removal to assumed open water areas, as outlined in Figure 2 of the approved 'Uko'a Wetland Hawaiian Hoary Bat Mitigation Management Plan (H. T. Harvey and SWCA 2014);
2. Omit replanting of natives with assumption of natural recruitment after invasive plant species are removed;
3. Omit mosquitofish removal component; and
4. Tie success criteria for bats to completion of all other management and monitoring components instead of increased bat activity.

In FY 2021, activities associated with Tier 1 bat mitigation at 'Uko'a Wetland included invasive vegetation removal, predator control, monitoring predator presence, fence monitoring and maintenance, bat lane maintenance, bat acoustic monitoring and insect sampling. Additional details for each are provided below. Based on the approved 'Uko'a Wetland Hawaiian Hoary Bat Mitigation Management Plan (H. T. Harvey and SWCA 2014), bat acoustic monitoring will continue for 3 to 5 years post-restoration. Based on the approved 'Uko'a Wetland Management Plan for Waterbirds 2012–2032 (SWCA 2012), vegetation management, predator and ungulate control, and fence maintenance will continue for the permit term (20 years).

8.1.2.1 Invasive Vegetation Removal

In FY 2021, Hapa Landscaping conducted maintenance visits to remove any areas of water hyacinth (*Eichhornia crassipes*) or other invasive vegetation that regenerated in the previously cleared open water area including water lettuce (*Pistia stratiotes*) and California grass (*Urochloa mutica*). Quarterly scheduled visits were modified as needed to accommodate staff schedules and avoid disturbing Hawaiian common gallinule nests and chicks in the area. Figure 7 shows a representative photograph of this ongoing maintenance.

Figure 7. Open Water Resulting from Ongoing Removal of Invasive Vegetation at ʻUkoʻa Wetland in FY 2021.

Photo Taken in May 2021.

8.1.2.2 Predator Control and Monitoring Predator Presence

The Project contracted Grey Boar Wildlife Services, LLC (Grey Boar) to conduct predator and ungulate removal at ʻUkoʻa Wetland, as well as to monitor and repair the fence. Predator control first began at ʻUkoʻa Wetland in June 2014 (FY 2014). The number and types of predators trapped at ʻUkoʻa Wetland from FY 2014 to FY 2021 is shown in Table 3. In FY 2021, a total of 219 predators were removed from ʻUkoʻa Wetland including 9 pigs, 173 mongoose, 2 cats, and 35 rats (Grey Boar 2020a, 2020b, 2021a, 2021b). The following trap types are used throughout at ʻUkoʻa Wetland in FY 2021: four pig corral and two pig box traps, 100 GoodNature A24s, 12 live cages, and 50 Doc-250s. Pigs continue to move into the fenced area at ʻUkoʻa Wetland due to trespassers cutting the fence.

Table 3. Predators Trapped at ʻUkoʻa Wetland from FY 2014 to FY 2021

Predator	FY 2014[1]	FY 2015[2]	FY 2016[2]	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Rats	26	137	0	22	24	12	25	35
Cats	14	27	0	7	10	2	3	2
Mongoose	215	262	0	131	160	136	168	173
Mice	16	30	0	4	3	0	0	0
Pigs	47	74	37	77	29	42	7	9
Dogs	0	0	0	0	1	0	0	0
Total Predators removed	**318**	**0**	**37**	**241**	**227**	**192**	**203**	**219**

1. In FY 2014, trapping only occurred for 1 month (June 2014).
2. No trapping occurred at ʻUkoʻa Wetland from April 2016 to November 2016.

Tracking tunnels are generally set out quarterly to assess the presence of rodents, mongoose, and cats within the wetland. Overall, tracking tunnel data since 2014 (see Figure 8) shows a general reduction in predator presence, specifically mongoose and rats, since the predator program was initiated.

In FY 2021 tracking tunnels were set out in September 2020, December 2020, March 2021, and June 2021. Twenty-two tracking tunnels were used to detect predator presence in Q1 of FY 2021; twenty-five tracking tunnels were used in all other quarters of FY 2021. The cards were baited with fish paste and collected one day after setting. Tracks were then counted and recorded. Percent activity (number of cards with tracks divided by total number of cards set out) during FY 2021 is shown in Table 4. Rat activity varied between 4.0 percent and 28.0 percent, mongoose activity varied between zero and 22.7 percent, mice activity varied between zero and 9.1 percent, and cat activity varied from zero to 4.6 percent.

Table 4. Percent Predator Activity Based on Tracking Tunnels at ʻUkoʻa Wetland during FY 2021

Date	Rats	Mongoose	Mice	Cats
September 26, 2020	9.1%	22.7%	9.1%	4.6%
December 18, 2020	28.0%	0.0%	0.0%	4.0%
March 26, 2021	4.0%	4.0%	4.0%	0.0%
June 26, 2021	4.0%	0.0%	4.0%	0.0%

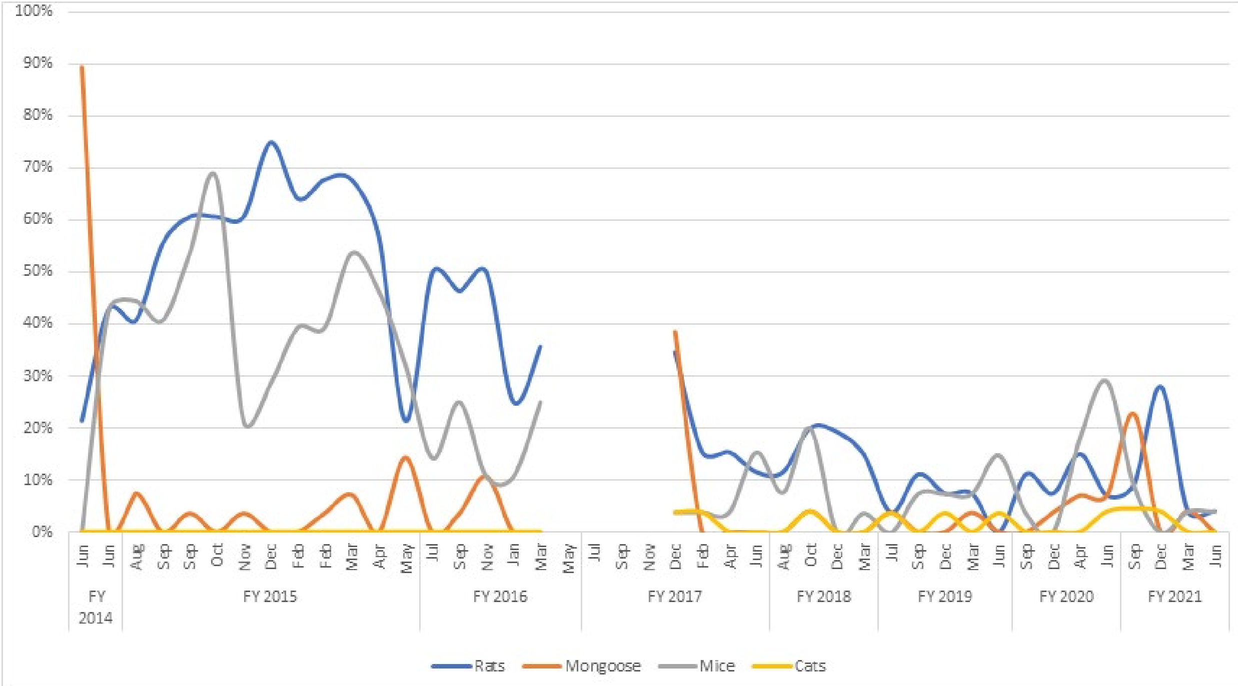

Figure 8. Precent Activity of Tracking Tunnels from FY 2014 to FY 2021

Source: Grey Boar 2021b.

8.1.2.3 Fence Monitoring and Maintenance

Fence inspections were conducted by Grey Boar while checking predator control traps. The fence was visually inspected for any signs of ungulate disturbance, damage, or vandalism. During FY 2021, several sections of fence were repaired. The main cause of fence damage continues to be trespassers.

8.1.2.4 Bat Lanes

Oahu Tree Works, LLC finished bat lane construction in December 2017 (FY 2018). In total, there are 16 bat lanes within 10 zones throughout ʻUkoʻa Wetland (Figure 9). Bat lane maintenance occurred in March 2021. Lane maintenance in FY 2021 consisted of cutting branches and vegetation that regrew within the 5-meter-wide bat lanes. Figure 10 shows one of the bat lanes shortly after lane maintenance in FY 2021.

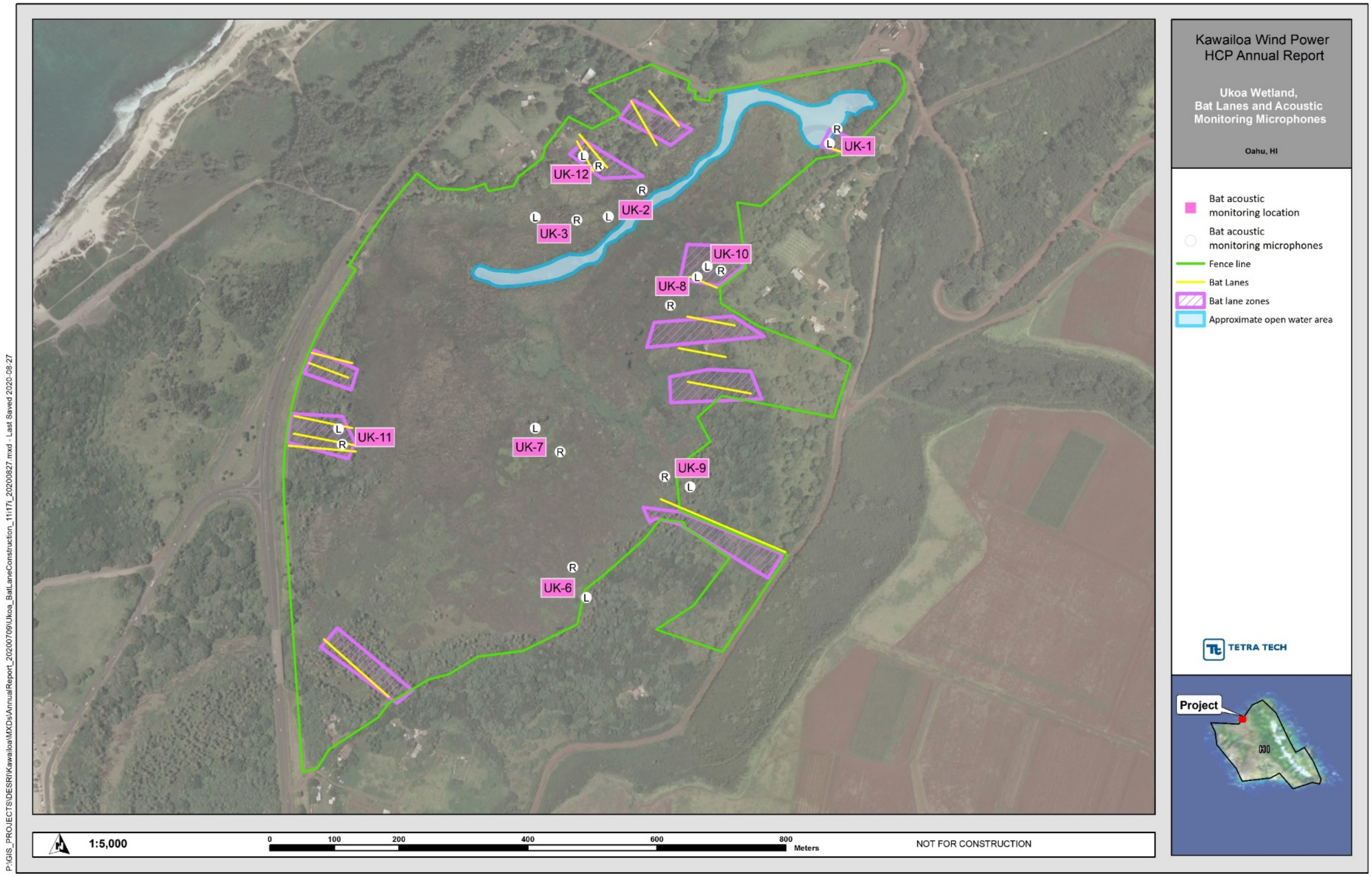

Figure 9. Bat Lanes and Bat Acoustic Detector Microphones at ʻUkoʻa Wetland

Figure 10. Bat Lane at ʻUkoʻa Wetland.

Photo Taken in April 2021.

8.1.2.5 Bat Acoustic Surveys at ʻUko'a

In June 2017, following the removal of invasive vegetation at the open water areas of ʻUko'a Wetland and construction of bat lanes, 10 Song Meter SM2BAT+ acoustic recorders (Wildlife Acoustics, Maynard, MA, USA) (hereafter referred to as SM2) were deployed at locations previously monitored in 2012 through 2015 (see Figure 9). The SM2's deployed in June 2017 are similar to those used in previous sampling years to maintain consistency. Each SM2 is equipped with two SMX-U1 ultrasonic microphones (Wildlife Acoustics, Maynard, MA, USA) positioned between 3 and 6.5 meters above ground level.

The proportion of detector-nights containing a single bat pass (any call file containing two or more bat echolocation pulses; Gannon et al. 2003) was used as a measure to quantify bat activity. The sampling period and methods used to analyze bat acoustic data at 'Uko'a Wetland are the same as those used for acoustic data at the Project (see Section 8.1.1).

During the 2021 Bat Sampling Period (June 2020 – May 2021), Hawaiian hoary bats were detected on 613 nights out of 3,182 (19.3 percent) detector-nights sampled. The annual detection rate in the 2021 Bat Sampling Period was similar to the annual detection rate (19.5 percent) during the previous sampling year (Table 5). As shown in Table 5, annual detection rates have varied, with significant differences (ANOVA: $F_{8,89} = 3.86$, $P < 0.001$) between 2014 and 2016 (Tukey's HSD: $P < 0.029$), 2014 and 2020 (Tukey's HSD: $P < 0.002$), and 2014 and 2021 (Tukey's HSD: $P < 0.009$). Despite this variation, there is a significant increase in the annual detection rates across all years (LM: $R_2 = 16.29\%$; $F_{2,89} = 16.93$, $P < 0.001$; Figure 11). There are some inconsistencies in sampling periods for some of the monitoring years. Sampling in the 2012 and 2016 Bat Sampling Periods only occurred during the pregnancy and lactation reproductive periods, which have higher rates of detections, and sampling in 2015 did not occur during the months of November and December, which typically have lower rates of detection.

Detection rates in the 2021 Bat Sampling Period peaked (0.57) during the lactation reproductive period (August) followed by a decline in the detection rate at the onset of the post-lactation reproductive period (September to December), reaching the lowest detection rate (0.02) in December (Figure 12). Following the low point in December, detection rates steadily increased during the pre-pregnancy reproductive period (January to March) and through the pregnancy reproductive period (June to May) (Figure 12). The temporal patterns in the detection rates for the 2021 sampling period are similar to the detection rates observed at 'Uko'a Wetland in previous sampling years (Figure 13).

Table 5. Number of Nights Sampled, Number of Nights with Detections, and Proportion of Nights with Bat Detections at ‘Uko’a Wetland from April 2012 to May 2021

Bat Sampling Period	Before or After Vegetation Removal	No. of Nights Sampled	No. of Nights with Detections	Proportion of Nights with Detections
2012 Sampling Period (April 2012 — May 2012)	Before	142	18	0.127
2013 Sampling Period (June 2012 —May 2013)	Before	2,036	191	0.094
2014 Sampling Period (June 2013 — May 2014)	Before	2,694	100	0.037
2015 Sampling Period (June 2014 — May 2015)	Before	2,552	175	0.069
2016 Sampling Period (June 2015 — October 2015)	Before	1,211	218	0.180
2018 Sampling Period (June 2017 — May 2018)	After	3,248	444	0.137
2019 Sampling Period (June 2018 — May 2019)	After	3,391	506	0.149
2020 Sampling Period (June 2019 — May 2020)	After	3,339	650	0.195
2021 Sampling Period| (June 2020 — May 2021)	After	3,182	613	0.193

Notes:

2017 Sampling Period not included due to minimal number of detector-nights compared to other years; no detectors were deployed from November 2015 to May 2017.

Beginning FY 2021, the time period for analyzing and reporting bat acoustic data (referred to as the Bat Sampling Period) was changed to June 1–May 31 rather than the FY (July 1–June 30) to allow adequate time for data review and analysis. All previous sampling years have been adjusted to reflect this same sampling time period.

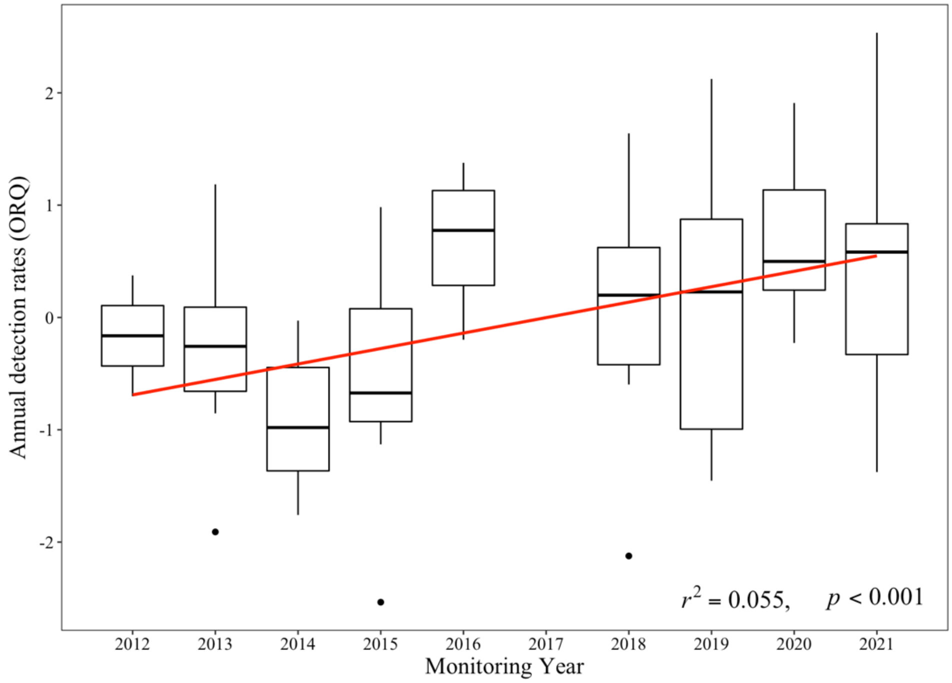

Figure 11. Box-plot Identifying the Median, Lower (Q1) and Upper (Q3) Quartiles, Whiskers (IQR*1.5), and Outliers; Fitted with a Linear Regression Showing the Increasing Trend in the Annual Detection Rates at the Project between 2012 Sampling Period and 2021 Sampling Periods

Note: Annual Detection Rates were Transformed using an Ordered Quantile Normalization Transformation (ORQ).

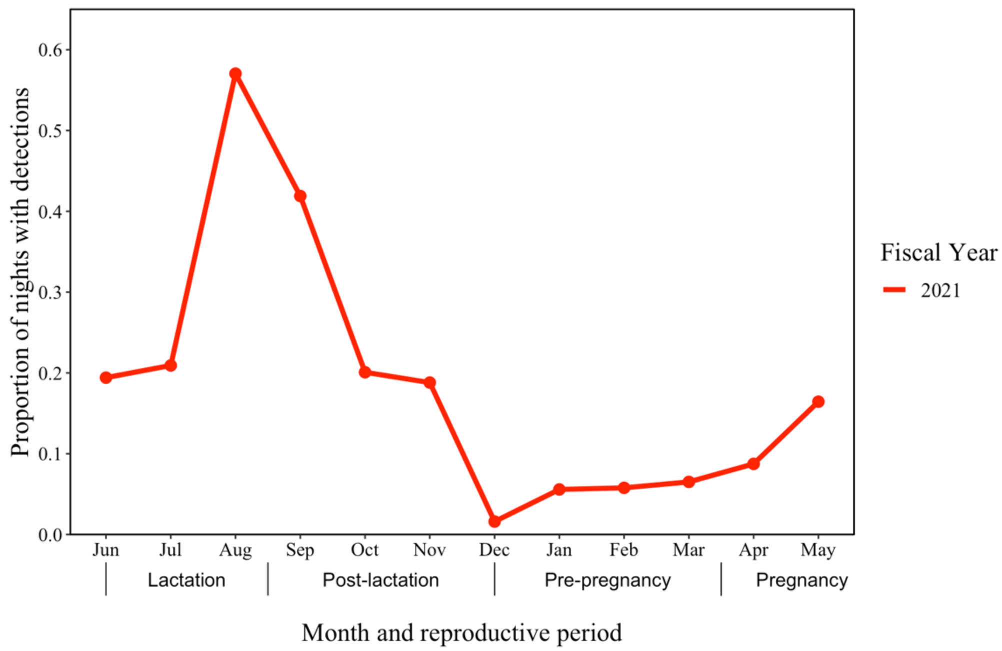

Figure 12. Monthly Bat Detection Rates at ʻUkoʻa Wetland during 2021 Bat Sampling Period (June 2020–May 2021) with Corresponding Reproductive Periods

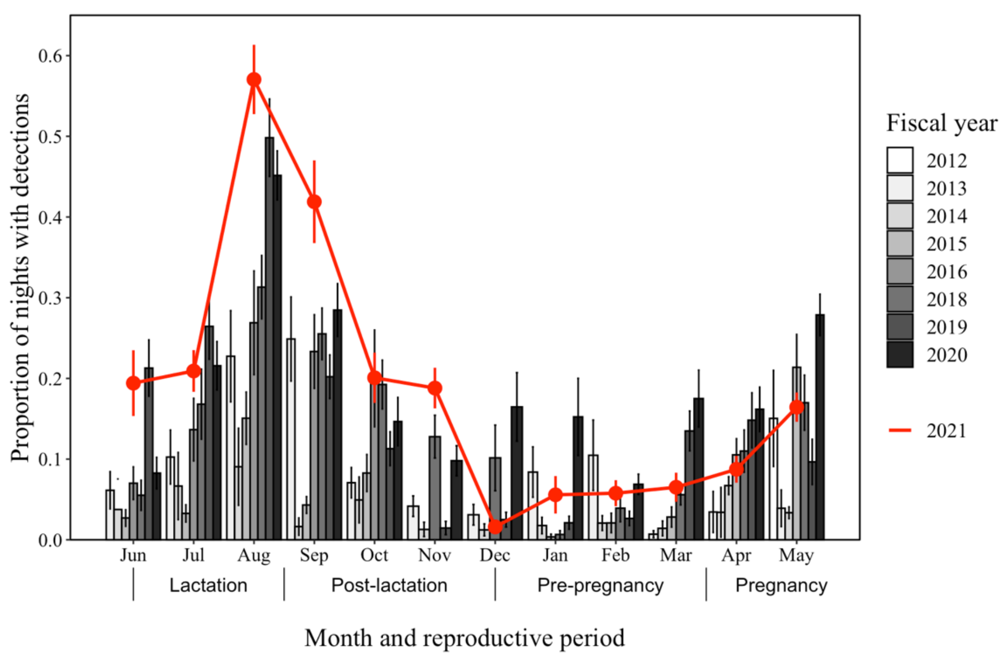

Figure 13. Monthly Bat Detection Rates at ʻUkoʻa Wetland for 2014 to 2021 Bat Sampling Periods with Corresponding Reproductive Periods

Comparison of detection rates for each month before (2012 to 2016 Sampling Period) and after (2018 to 2021 Sampling Period) management was implemented at 'Uko'a Wetland indicate an increase in the detection rates for several of the months throughout the year (Figure 14). In addition to observed increases in monthly detection rates, there was also an observed increase in the mean proportion of nights with feeding buzzes recorded at several of the monitoring sites after management was implemented (Figure 15). A feeding buzz is classified as a burst of pulses at a very high rate with less than 11 milliseconds between pulses (Griffin et al. 1960) and are indicative of foraging behaviors. Monitoring sites UK-1, UK-2, UK-6, UK-11, and UK-12 had the greatest observed increase subsequent to management activities (Figure 15). The observed increases in the detection rates and feeding buzzes are a positive indication for the effects of management but may correlate with factors other than the invasive plant species removal or bat lane installation.

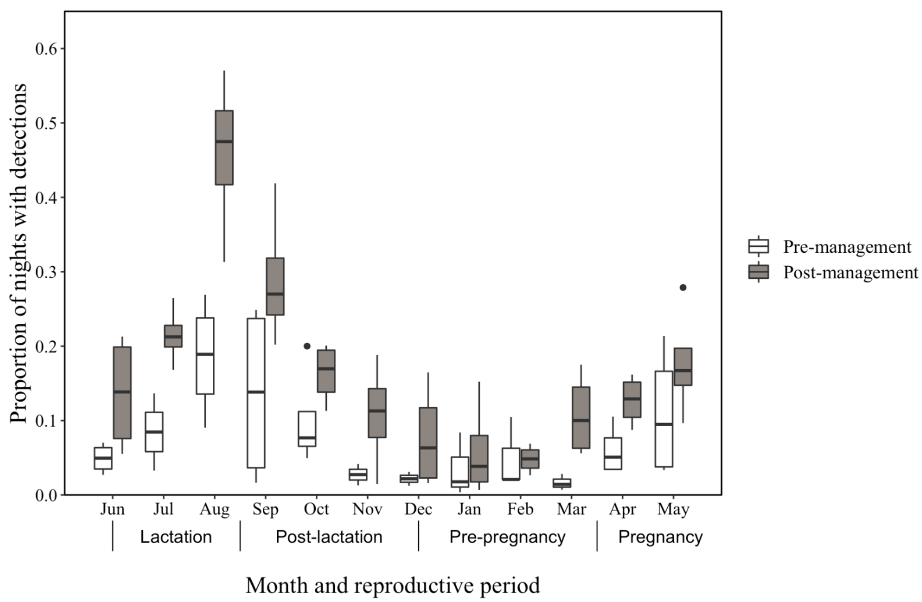

Figure 14. Box-plot Identifying the Median, Lower (Q1) and Upper (Q3) Quartiles, Whiskers (IQR*1.5), and Outliers for Monthly Bat Detection Rates at 'Uko'a Wetland Before (2012 – 2016 Sampling Period) and After (2018– 2021 Sampling Period) Invasive Vegetation Removal and Bat Lane Construction

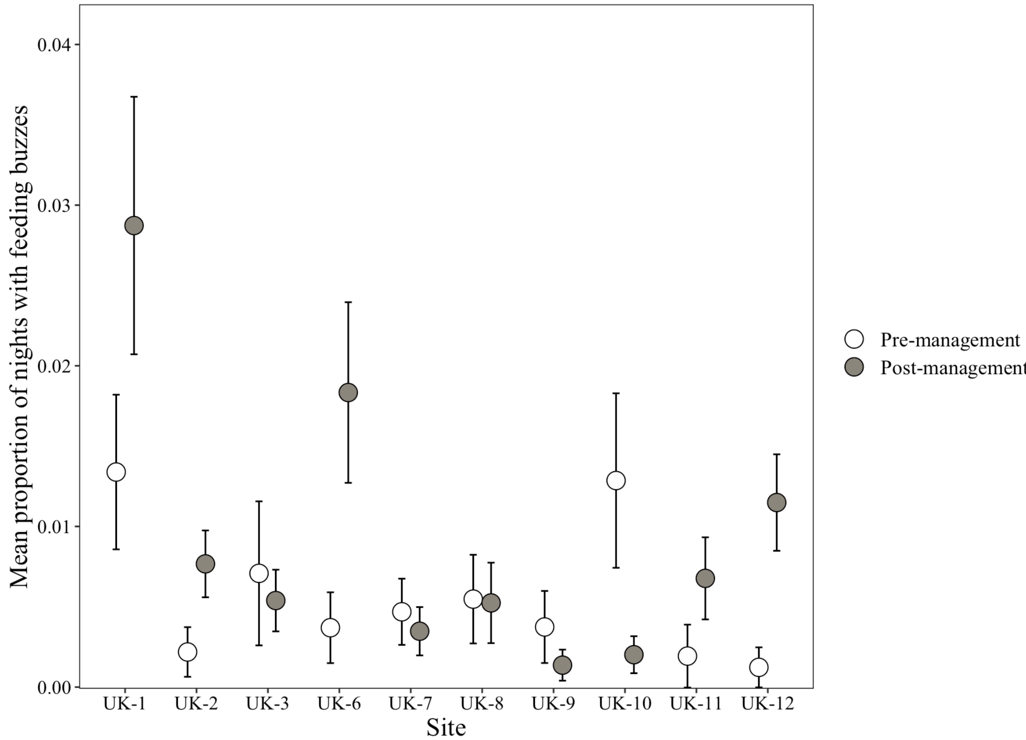

Figure 15. Mean and Standard Error for the Proportion of Feeding Buzzes for each monitoring site at 'Uko'a Wetland Before (2012 – 2016 Sampling Period) and After (2018-2021 Sampling Period) Management

8.1.2.6 Insect Sampling

In 2014 and 2015, First Wind biologists sampled insects at 10 traps throughout 'Uko'a Wetland as part of bat mitigation. Several Endangered Species Recovery Committee (ESRC) members have requested Kawailoa Wind conduct a follow-up insect assessment to compare bat prey availability prior to and after management activities at 'Uko'a Wetland. DOFAW and USFWS approved Kawailoa Wind's methods for conducting a follow-up insect assessment in April and May 2021, respectively. The purpose of the 2021 insect sampling is to evaluate current Hawaiian hoary bat prey availability at 'Uko'a Wetland and compare the results to insect sampling conducted in 2014 and 2015.

Insect sampling was initiated 'Uko'a Wetland in June 2021. Trap locations are shown in Figure 16. Insect sampling will be conducted for 4 months (June to September 2021). All traps will be set out from sunset to sunrise for 3 to 5 consecutive nights each month (similar to 2014 and 2015). Trap types and sampling events are show in Table 6. After all samples are collected, a report will be drafted to include a list of insect taxa collected in 2014, 2015, and 2021. This report will include a size range of each taxa collected and a discussion on the relative abundance of insects sampled in previous years compared to samples collected in 2021.

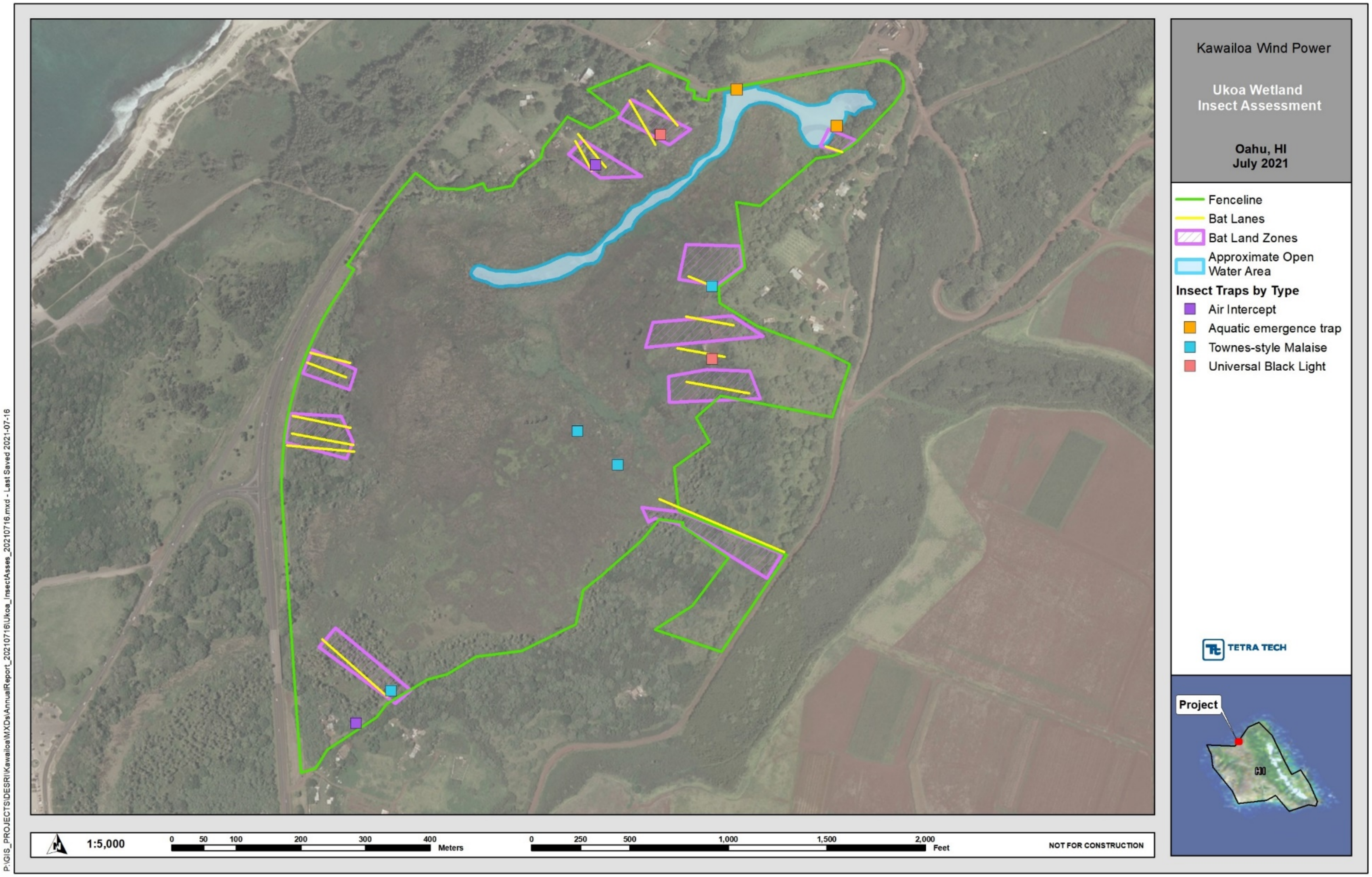

Figure 16. Insect Trap Locations at ‘Uko‘a Wetland

Table 6. Insect Trap Types and Sampling Events per Month

Trap ID	Trap Type	No. Sampling Nights in 2021				Total No. Sampling Nights
		June	July	August	September	
Up 10	Townes-style Malaise trap	5	5	5	5	20
Up DOT	Townes-style Malaise trap	5	5	5	5	20
Wet 1	Townes-style Malaise trap	5	5	5	5	20
Wet 2	Townes-style Malaise trap	5	5	5	5	20
Water Kayak	Aquatic emergent trap	5	5	5	5	20
Water Road	Aquatic emergent trap	5	5	5	5	20
Light 9	Universal black light trap	3	3	3	3	12
Light 12	Universal black light trap	3	3	3	3	12
Air 12	Air intercept trap	5	5	5	5	20
Air DOT	Air intercept trap	5	5	5	5	20

8.1.3 Studies (Tier 2/3)

Kawailoa Wind finalized contracts with WEST Consultants (WEST) and the U.S. Geological Survey (USGS) in FY 2017 to conduct three multi-year studies as Tier 2/3 Hawaiian hoary bat mitigation. These studies were recommended to Kawailoa Wind by USFWS and DOFAW. The total funding for the three projects is over $1.6 million.

One of the USGS research projects (Modeling Foraging Habitat Suitability) was completed in FY 2019 and the research was published in *PLOS ONE* (Gorresen et al. 2018). During FY 2020, Kawailoa Wind continued to fund the WEST project and the second USGS genetics study. A summary of the work completed for these studies during FY 2021 is provided below.

The objectives of USGS' *Hawaiian Hoary Bat Conservation Genetics* study are to improve the understanding of the genetic diversity of the Hawaiian hoary bat, identify bat prey items, and identify the sex of bat carcasses and any sex-specific food habits. Data on these topics will help inform conservation planning and improve host-plant selection for future habitat restoration efforts. In FY 2021 the following work was conducted for this research project:

- Microsatellite genotypic completed for 298 individuals;
- Mitochondrial DNA analyses complete for over 321 individuals across four islands.
- SNP sequencing completed for 10 additional individuals at Virginia Tech.
- Population genetic analysis of mitochondrial DNA and microsatellites completed.

- Reference genome that has been assembled improved by incorporating high coverage sequencing data from six additional bats.
- Manuscript related to inter-island variation, colonization time, and genomic (SNP) diversity published in Genome Biology and Evolution (Pinzari et al. 2020);
- Genetic sex determination for additional Hawaiian hoary bat samples and data release in January 2021, Version 6.0 (Pinzari and Bonaccorso 2018).
- Manuscript including results from mitochondrial and nuclear DNA analyses drafted and submitted for peer review in the USGS review process.
- Produced initial results of four methods to estimate historic and contemporary island-specific effective population sizes and past population trends, based on the completed whole genome sequencing efforts and SNP detection for 32 individuals (Hawaii = 9, Maui = 12, and Oahu = 11).

The goal of WEST's multi-year *Hawaiian Hoary Bat Acoustic Surveys* study was to examine the distribution and seasonal occupancy of the Hawaiian hoary bat on Oʻahu. Occupancy is the modeling of the proportion of an area occupied by a species or fraction of landscape units where the species is present (MacKenzie et al. 2019). The island-wide, randomized block, multi-season monitoring study design of *Hawaiian Hoary Bat Acoustic Surveys* can be used to estimate island-wide trends in occupancy. Throughout FY 2021, WEST continued data downloads and processing from the detectors deployed throughout Oʻahu. The Year 3 Status Report for the study provides analyses based on the cumulative dataset spanning June 2017 to August 2020 (Thompson and Starcevich 2021; Appendix 4). Preliminary study results were also presented to ESRC in January 2021.

8.1.4 Waimea Native Forest (Tier 3)

Funding the above-listed Tier 2/3 studies left an outstanding obligation of $353,702 for Tier 3 bat mitigation. To fulfill the remaining uncommitted funding obligation, Kawailoa Wind provided $353,702 to Trust for Public Land (TPL) in December 2019 (FY 2019) to contribute to the acquisition of the Waimea Native Forest. The acquisition was completed, and ownership of the parcel was transferred to DOFAW in December 2019. This contribution completes the mitigation obligation for Tier 3 Hawaiian hoary bat mitigation.

8.1.5 Helemano Wilderness Area (Tier 4)

As described in the HCP Amendment (Tetra Tech 2019), Tier 4 Hawaiian hoary bat mitigation included contributing $2,750,000 to TPL toward the purchase and long-term protection of the nearly 2,900-acre Helemano Wilderness Area (HWA). Kawailoa Wind proactively provided these funds to TPL in October 2018, to ensure mitigation continued to occur ahead of bat take. Ownership of the HWA was transferred from TPL to DOFAW in 2018. On March 12, 2021, the Governor issued an executive order to designate the area as part of the State of Hawaiʻi's Forest Reserve System; the acquired area is now the "Helemano Section of the ʻEwa Forest Reserve." A Preliminary Draft Management Plan for HWA was completed in June 2021. In addition, DOFAW has conducted biological surveys (forest birds, plants, invertebrates); outplanted native species; performed road maintenance and road repair; vegetation control along road corridors; fence maintenance; and cleaned up and hauled out rubbish from past tenants (L. Johnson/DOFAW, pers. comm, July 2021).

8.1.6 Tier 5 Mitigation

As outlined in the HCP Amendment, Tier 5 bat mitigation consists of implementation of one or a combination of the following: 1) contributing funding to acquire property that will protect bat roosting and foraging habitat in perpetuity, and/or 2) conduct bat habitat management/restoration to improve bat foraging and/or roosting habitat at the Central Koʻolau area, HWA, Waimea Native Forest, or similar site (Tetra Tech 2019). In accordance with the mitigation planning requirements under the HCP Amendment, planning for Tier 5 bat mitigation has begun. In March 2020, Kawailoa and Tetra Tech had a semi-annual HCP meeting with USFWS and DOFAW in which Tier 5 bat mitigation was discussed. A Site-Specific Mitigation Implementation Plan for Tier 5 mitigation was submitted to USFWS and DOFAW on May 1, 2020. During FY 2021, Kawailoa Wind has continued planning for Tier 5 mitigation despite no bat take being observed since FY 2019.

8.2 Waterbirds

As stated above, USFWS and DOFAW provided written confirmation permitting adaptive management for the original bat and waterbird mitigation. Some activities completed for waterbird mitigation at ʻUkoʻa Wetland overlap with bat mitigation requirements and are summarized in Section 8.1.2 above. Tetra Tech conducts waterbird surveys as part of the waterbird mitigation, as described below.

Prior to each vegetation maintenance event, a biologist conducts waterbird surveys to identify if nests or chicks were present in the vicinity of the planned work area. These surveys are required as a Best Management Practice when contractors are working at the site to minimize impacts to endangered Hawaiian waterbirds.

Comprehensive weekly waterbird surveys began at ʻUkoʻa Wetland in January 2017, and continued throughout FY 2021 (Table 7). In FY 2021, waterbird surveys were conducted weekly from July 2020 to September 2020 and December 2020 to June 2021. A total of 40 waterbird surveys were completed in FY 2021. A qualified biologist conducted surveys at nine point count (PC) stations set up in the vicinity of the open water and in areas with previous waterbird sightings (Figure 17). In addition to the PC stations, independent waterbird observations are recorded while walking between stations. The detailed protocols for these surveys were provided in the FY 2017 Annual Report (Tetra Tech 2017). The bird individuals at ʻUkoʻa are not banded; therefore, assessments of changes on an individual basis is not possible. Kawailoa Wind has begun discussions with USFWS and DOFAW regarding adaptive management of waterbird mitigation due to minimal observed breeding events at the site despite years of management.

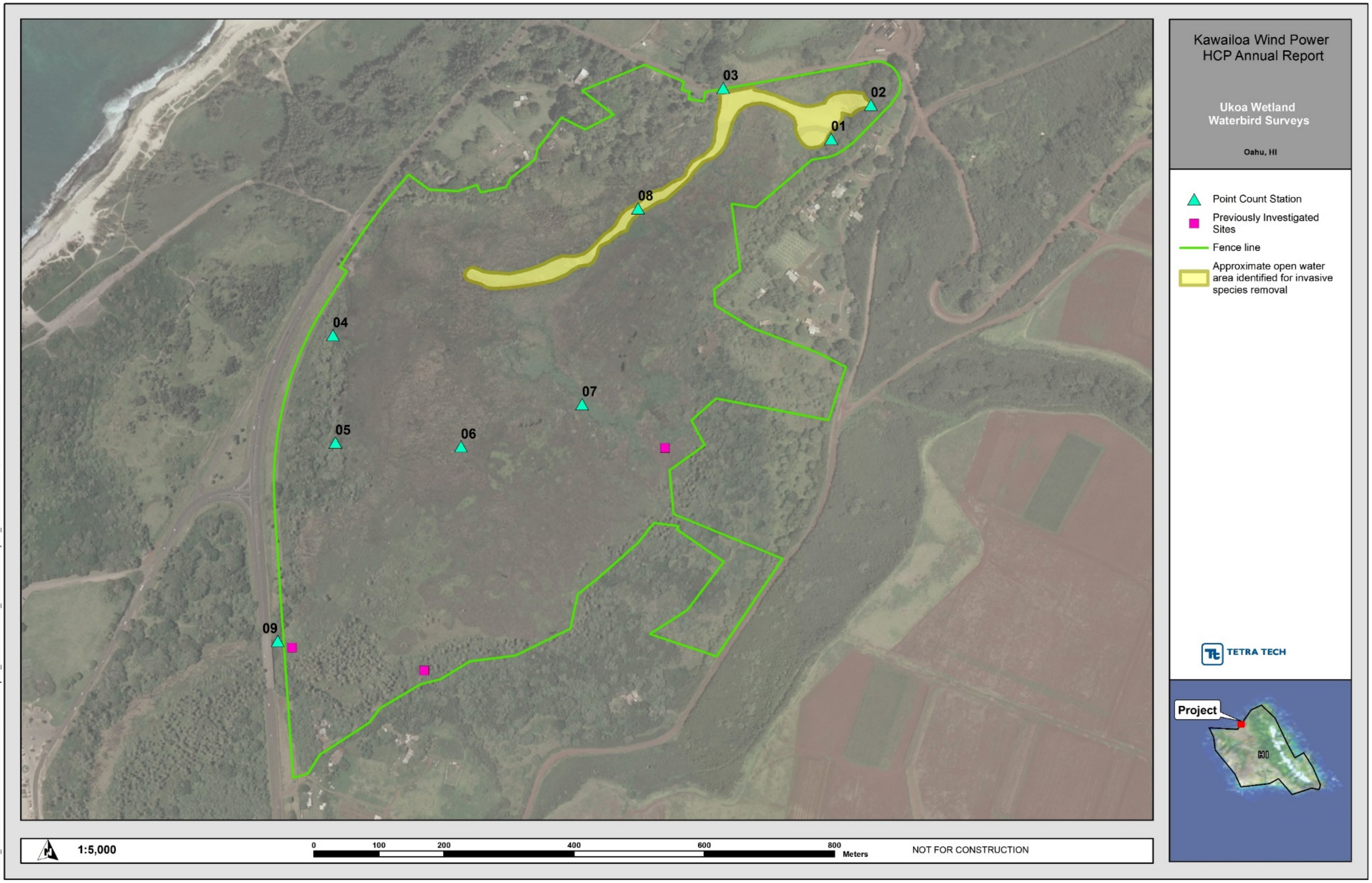

Figure 17. Waterbird Point Count Station Locations at ʻUkoʻa Wetland

8.2.1 Hawaiian Common Gallinule

The Hawaiian common gallinule was the only listed waterbird species detected during weekly surveys. In FY 2021, gallinule were recorded at five out of the nine PC stations (Figure 18). Gallinule (either adults or chicks) were observed on 39 out of 40 survey dates. Average monthly gallinule detections for FY 2021 are shown in Figure 19.

Table 7. Average Number of Hawaiian Common Gallinule Detected per Survey by Fiscal Year

Sampling Period	No. of Surveys	Average No. of Adults Detected per Survey	Average No. of Chicks Detected per Survey	Average No. of Fledglings Detected per Survey
FY 2017 (January 2017–June 2017)	25	5.7	0.8	1.0
FY 2018 (July 2017–June 2018)	38	4.1	0.4	0.0
FY 2019 (July 2018–June 2019)	41	3.0	0.4	0.0
FY 2020 (July 2019–June 2020)	40	1.9	0.1	0.0
FY 2021 (July 2020–June 2021)	40	2.2	0.4	0.1

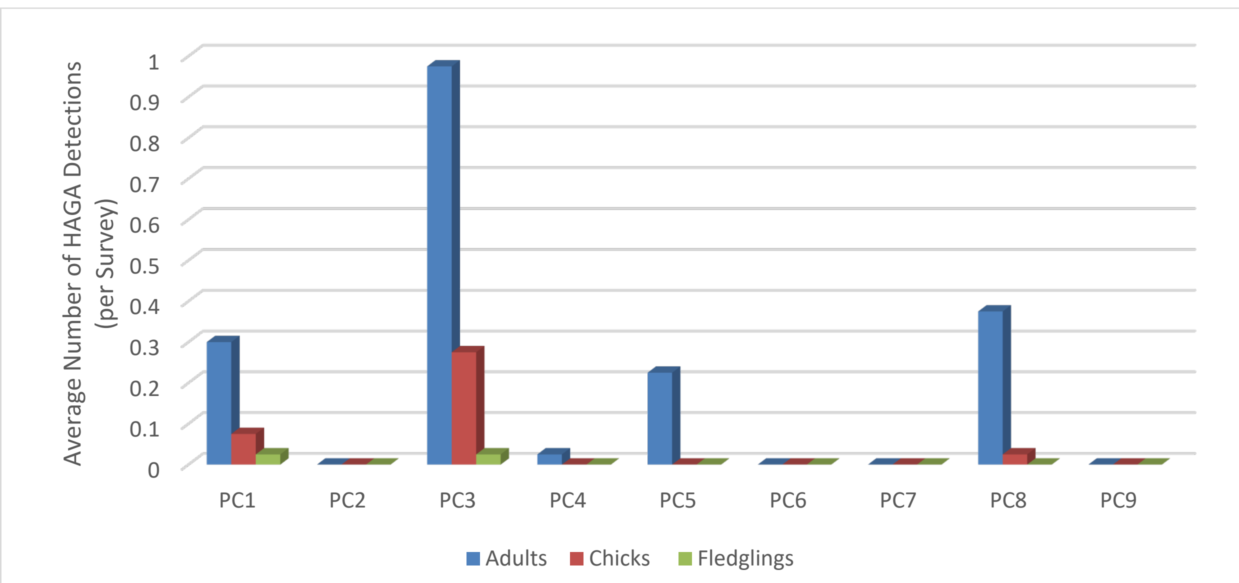

Figure 18. Average Number of Hawaiian Common Gallinule (HAGA) Detections per Survey at Point Count Stations in FY 2021

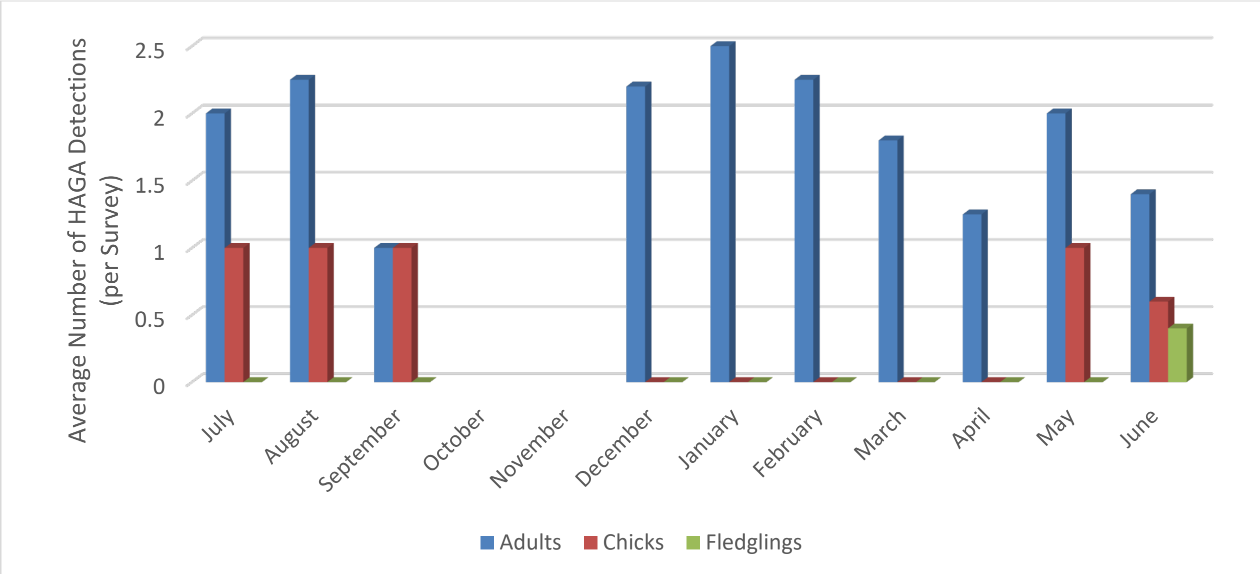

Figure 19. Average Number of Hawaiian Common Gallinule (HAGA) Detections by Month (per Survey) at Point Count Stations in FY 2021

Gallinule breeding activity (e.g., nests or chicks) was observed at PC stations 1, 3, and 8. This consisted of two separate events. The first event occurred in late FY 2020 (June 2020) near PC station 3 and carried into early FY 2021. It is believed that no gallinule chicks successfully fledged from this breeding event; the cause of reproductive failure was not known. The second event was first observed near PC station 8 in May 2021 and resulted in the first fledgling observed at ʻUkoʻa Wetland since February 2017.

Table 7 summarizes gallinule detections since comprehensive waterbird surveys began in January 2017. In general, gallinule detections have decreased over the years, although there was a slight increase in detections in FY 2021 compared to FY 2020. The removal of water hyacinth in the open water area has altered habitat available to gallinule, and the birds may be using areas of the wetland that are not currently surveyed; however, no incidental observations were documented in FY 2021 that would suggest gallinules occur in other locations within ʻUkoʻa Wetland.

8.2.2 Hawaiian Stilt

No Hawaiian stilts were detected in FY 2021. As shown in Table 8, Hawaiian stilt detections have decreased since comprehensive surveys began in January 2017. No Hawaiian stilt nests or chicks have been observed at ʻUkoʻa Wetland since comprehensive surveys began.

Table 8. Average Number of Hawaiian Stilts Detected per Survey and Proportion of Surveys with at Least One Detection by Fiscal Year

Sampling Period	No. of Surveys	Average No. of Adults Detected per Survey	Proportion of Surveys with at Least One Detection
FY 2017 (January 2017–June 2017)	25	0.7	0.24
FY 2018 (July 2017–June 2018)	38	0.7	0.29
FY 2019 (July 2018–June 2019)	41	0.2	0.05
FY 2020 (July 2019–June 2020)	40	0.1	0.07
FY 2021 (July 2020–June 2021)	40	0	0

8.2.3 Hawaiian Coot

Since comprehensive waterbird surveys begin in January 2017, only one Hawaiian coot has been detected during the surveys; a single adult Hawaiian coot was recorded in March 2017.

8.3 Seabirds

8.3.1 Newell's Shearwater

Tier 1 mitigation for Newell's shearwater was completed in FY 2015.

8.3.2 Hawaiian Petrel

As stated in Section 1.0, the Hawaiian petrel was added as a Covered Species in the HCP Amendment (Tetra Tech 2019). To mitigate for impacts to this species, Kawailoa funded 1 year of monitoring and predator control at the Hanakāpīʻai and Hanakoa seabird colonies within the Hono O Nā Pali Natural Area Reserve on Kauaʻi in 2020. Hallux Ecosystem Restoration LLC conducted the predator control and the Kauaʻi Endangered Seabird Recovery Project (KESRP) conducted the burrow monitoring. Final reports from KESRP (Raine et al. 2020) and Hallux Ecosystem Restoration LLC (Dutcher and Pias 2021) are included as Appendix 5 and 6, respectively. The report from KESRP documents the production of at least 139 Hawaiian petrel chicks as a result of mitigation funded by Kawailoa Wind; therefore, Kawailoa Wind's mitigation obligations for Hawaiian petrel (at least 71 Hawaiian petrel chicks) outlined in the HCP Amendment are complete.

8.4 Hawaiian Short-eared Owls or Pueo

Mitigation for the Hawaiian short-eared owl (or pueo) was completed in FY 2017.

9.0 Adaptive Management

Kawailoa Wind is committed to the ongoing implementation of operational avoidance and minimization measures described in the 2011 HCP and HCP Amendment. Kawailoa Wind has been evaluating options to reduce the risk to bats since Project operations began in 2012. Kawailoa Wind implemented multiple adaptive management steps to understand and reduce the risk to the Hawaiian hoary bat in previous fiscal years including modifying the low wind speed curtailment (LWSC) regime, implementing innovative approaches to post-construction mortality monitoring, and supporting development of the latest technologies that could reduce WTG collision risk to bats. Details on the Project's adaptive management are provided in previous annual reports (Tetra Tech 2018) and the HCP Amendment (Tetra Tech 2019).

In FY 2019 (July 25, 2018), Kawailoa Wind extended the rolling average time from 10 to 20 minutes in an attempt to reduce the number of start and stop events. The 20-minute averaging resulted in unanticipated WTG behavior and LWSC averaging was returned to 10 minutes on December 5, 2019. On December 11, 2020 Kawailoa Wind returned to a 20-minute average for LWSC using software updates developed by the turbine manufacturer to address the anomalous WTG behavior previously noted. The system was closely monitored to ensure the performance expected was observed. The system largely performed as anticipated; however, the increased averaging period resulted in slower response times at both startup and shutdown. The delay in shut-down resulted in increased periods where rotor RPM was above 2 while wind speeds were below 5 m/s, which had a significant potential to increase risk to bats. To ensure that Kawailoa Wind minimized risk to the maximum extent practicable, the site returned to LWSC based on the 10-minute rolling average on December 18, 2020. After consultation with USFWS and DOFAW on January 21, 2021 the rolling average was again reverted back to a 20-minute average, despite concerns from Tetra Tech and Kawailoa Wind that this could increase the risk to bats at the Project. Kawailoa Wind provided internal analysis to USFWS and DOFAW on February 12, 2021 supporting a change back to a 10-minute rolling average and discussed the findings with USFWS and DOFAW on March 24, 2021 to determine the appropriate approach to LWSC averaging. Following approval by USFWS, Kawailoa returned to the 10-minute on April 3, 2021.

Kawailoa Wind installed acoustic deterrents at all 30 Project WTGs in May and June 2019. To date, no bat fatalities have been observed at WTGs with operational bat deterrent systems. Deterrent functionality is monitored remotely to ensure the systems are functioning properly. Deterrent units (DU) and deterrent unit controller (DUC) that are identified as underperforming are replaced as soon as possible based on manufacturer recommendations. Each WTG is installed with five DUs, each having overlap in coverage in the deterred airspace. The result of a single DU failure is less than one-fifth of the rotor swept area. If one DU is deficient, a WTG has adequate coverage across the rotor swept area due to redundancy provided by the other four DUs. Kawailoa Wind and NRG work together to install replacements as quickly as feasible. Based on data provided by NRG, the total sitewide deterrent availability for the Project was 97.68 percent in FY 2021. Despite periodic DU and DUC deficiencies, no bat fatalities have been observed since deterrent installation.

10.0 Collection Permits

Annual reports for the Project's federal and state collection permits were submitted in Q2 of FY 2021. The State's Protected Wildlife Permit (Permit No. WL19-33) was renewed on February 10, 2021 (Permit No. WL21-05) and will expire on February 10, 2023. The USFWS special purpose utility permit (MB22099C-0) was issued on April 5, 2019 and expires March 31, 2022.

11.0 Agency Meetings, Consultations, and Visits

Kawailoa Wind and Tetra Tech conducted or participated in five meetings with USFWS and DOFAW staff in FY 2021, as well as one ESRC meeting, one BLNR meeting, and the ESRC bat workshop. Meetings took place on:

- September 21, 2020 – USFWS and DOFAW semi-annual meeting;
- September 30, 2020 – ESRC Draft Hawaiian hoary bat Guidance;
- January 21, 2020 – USFWS and DOFAW discussion regarding low wind speed curtailment averaging;
- January 27, 2021 – ESRC FY 2020 annual report review;
- February 26, 2021 – BLNR approval of the HCP Amendment;
- March 24, 2021 – USFWS and DOFAW discussion regarding low wind speed curtailment averaging;
- April 29, 2021 – USFWS and DOFAW semi-annual meeting; and
- May 13, 2021 – DOFAW discussion regarding waterbird mitigation at ʻUkoʻa Pond.

12.0 Expenditures

Total HCP-related expenditures for the Project in FY 2021 were approximately $1,181,600 (Table 9).

Table 9. Estimated HCP-Related Expenditures at the Project in FY 2021.

Category	Amount
Permit Compliance	$174,400
Facility Vegetation Management	$143,100
Fatality Monitoring	$122,200
ʻUkoʻa Wetland Mitigation Compliance	$115,000
Hawaiian Petrel Mitigation	$246,900
Tier 2/3 Bat Research Projects	$379,500
Tier 5 Bat Mitigation Preparation	$500
Total Cost for FY 2021	**$1,181,600**

13.0 Literature Cited

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

Dutcher, A. and K. Pias. 2021. Hanakāpīʻai – Hanakoa 2020 Final Report. Hallux Ecosystem Restoration LLC. Prepared for Kawailoa Wind, LLC.

Gannon, W. L., R. E. Sherwin, S. Haymond. 2003. On the importance of articulating assumptions when conducting acoustic studies of habitat use by bats. Wildlife Society Bulletin 31:45-61.

Gorresen, P.M., Bonaccorso, F., Pinzari, C., Todd, C., Montoya-Aiona, K. and Brinck, K. 2013. A Five Year Study of Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) Occupancy on the Island of Hawaii. Hawai'i Cooperative Studies Unit. Technical Report HCSU-041.

Gorresen, P.M., K.W. Brinck, M.A. DeLisle, K. Montoya-Aiona, C.A. Pinzari, F.J. Bonaccorso. 2018. Multi-state occupancy models of foraging habitat use by the Hawaiian hoary bat (*Lasiurus cinereus semotus*). PLoS ONE 13(10): e0205150. Available at: https://doi.org/10.1371/journal.pone.0205150.

Grey Boar (Grey Boar Wildlife Services LLC). 2020a. Ukoa Predator Control Program. 3rd Quarter Report 2020. Prepared for Kawailoa Wind LLC.

Grey Boar. 2020b. Ukoa Predator Control Program. 4th Quarter Report 2020. Prepared for Kawailoa Wind LLC.

Grey Boar. 2021a. Ukoa Predator Control Program. 1st Quarter Report 2021. Prepared for Kawailoa Wind LLC.

Grey Boar. 2021b. Ukoa Predator Control Program. 2nd Quarter Report 2021. Prepared for Kawailoa Wind LLC.

Griffin, D.R., F.A. Webster, and C.R. Michael. 1960. The echolocation of flying insects by bats. Animal Behavior 8:141-154.

H. T. Harvey and SWCA (H. T. Harvey and Associates and SWCA Environmental Consultants). 2014. ʻUkoʻa Wetland Hawaiian Hoary Bat Mitigation Management Plan. Prepared for First Wind. Approved by USFWS and DOFAW 2014.

MacKenzie D.I, Nichols, J.D., Royle, J.A., Pollock, K.H., Bailey, L.L., Hines, J.E. 2019. Occupancy Estimation and Modeling (Second Edition), Academic Press, https://doi.org/10.1016/B978-0-12-407197-1.00002-8.

Pinzari, C.A. and F.J. Bonaccorso. 2018. Hawaiian Islands Hawaiian Hoary Bat Genetic Sexing 2009-2020 (ver. 6.0, January 2021): U.S. Geological Survey data release. Available at: https://www.sciencebase.gov/catalog/item/5ba1617ae4b08583a5c42da3.

Pinzari, C. A., L. Kang, P. Michalak, L. S. Jermiin, D. K. Price, and F. J. Bonaccorso. 2020. Analysis of genomic sequence data reveals the origin and evolutionary separation of Hawaiian hoary bat populations. Genome Biology and Evolution 12:1504–1514. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7543519/1.

R Core Team. 2017. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at: https://www.R-project.org/

Raine, A.F. J. Rothe, S. Driskill, and S. Rossiter. 2020. Monitoring of Endangered Seabirds at Hanakāpīʻai and Hanakoa, Annual Report 2020. Kauaʻi Endangered Seabird Recovery Project (KESRP), Pacific Cooperative Studies Unit (PCSU), University of Hawaiʻi and Division of Forestry and Wildlife (DOFAW).

Starcevich, L.A., J. Thompson, T. Rintz, E. Adamczyk, M. Martin, and D. Solick. 2020. Oahu Hawaiian Hoary Bat Occupancy and Distribution Study. Project Update and Second Year Analysis. Dated February 13, 2020. Prepared for: Hawaii Endangered Species Research Committee.

Thompson, J. and L.A. Starcevich. 2021 Oahu Hawaiian Hoary Bat Occupancy and Distribution Study. Project Update and Third Year Analysis. Dated May 2021. Prepared for: Hawaii Endangered Species Research Committee.

SWCA (SWCA Environmental Consultants). 2011. Kawailoa Wind Power Habitat Conservation Plan. Prepared for Kawailoa Wind Power. Dated October 2011.

SWCA. 2012. ʻUkoʻa Wetland Management Plan for Waterbirds 2012 – 2032. Prepared for First Wind. Approved by USFWS and DOFAW 2012.

Tetra Tech. 2017. Kawailoa Wind Power Habitat Conservation Plan, FY 2017 Annual Report.

Tetra Tech. 2018. Kawailoa Wind Power Habitat Conservation Plan, FY 2018 Annual Report.

Tetra Tech. 2019. Kawailoa Wind Power Habitat Conservation Plan Amendment.

Tetra Tech. 2020. Kawailoa Wind Power Habitat Conservation Plan, FY 2020 Annual Report.

Todd, C.M. 2012. Effects of Prey Abundance on Seasonal Movements of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*). ProQuest. Presented to the faculty of the Tropical Conservation Biology and Environmental Science Graduate Program University of Hawaiʻi at Hilo.

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

APPENDIX 1

DOCUMENTED FATALITIES AT THE PROJECT DURING FY 2021

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Species[1]	Date Documented	WTG	Distance to WTG (meters)	Bearing from WTG (degrees)
Lonchura punctulata (Scaly-breasted Munia)	8/11/2020	23	15	340
Lonchura punctulata (Scaly-breasted Munia)	9/1/2020	19	23	167
Geopelia striata (Zebra Dove)	9/21/2020	1	6	90
Bubulcus ibis (Cattle Egret)	10/12/2020	1	9	90
Francolinus francolinus (Black Francolin)	10/19/2020	10	2	180
Francolinus francolinus (Black Francolin)	11/5/2020	5	1	170
Bubulcus ibis (Cattle Egret)	11/6/2020	22	4	90
Acridotheres tristis (Common Myna)	12/8/2020	16	3	90
Acridotheres tristis (Common Myna)	12/10/2020	4	3	90
Pluvialis fulva (Pacific Golden-Plover)	12/10/2020	1	14	170
Francolinus pondicerianus (Gray Francolin)	12/22/2020	26	2	230
Acridotheres tristis (Common Myna)	1/15/2021	16	4	90
Geopelia striata (Zebra Dove)	1/26/2021	24	15	218
Spilopelia chinensis (Spotted Dove)	1/28/2021	4	1	112
Francolinus francolinus (Black Francolin)	1/29/2021	16	1	150
Spilopelia chinensis (Spotted Dove)	2/9/2021	24	2	48
Geopelia striata (Zebra Dove)	2/11/2021	15	2	80
Estrilda astrild (Common Waxbill)	2/16/2021	25	14	134
Estrilda astrild (Common Waxbill)	2/16/2021	30	25	210
Francolinus francolinus (Black Francolin)	2/22/2021	3	1	60
Geopelia striata (Zebra Dove)	4/20/2021	29	1	34
Geopelia striata (Zebra Dove)	4/22/2021	14	1	6
Estrilda astrild (Common Waxbill)	4/27/2021	30	9	1
Francolinus francolinus (Black Francolin)	5/6/2021	2	1	90
Acridotheres tristis (Common Myna)	5/11/2021	26	10	313
Estrilda astrild (Common Waxbill)	5/25/2021	28	1	340
Phasianus colchicus (Ring-Necked Pheasant)	6/15/2021	19	1	120
1. Species protected by the Migratory Bird Treaty Act are highlighted in gray.				

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APPENDIX 2

DALTHORP ET AL. (2017) FATALITY ESTIMATION FOR HAWAIIAN HOARY BATS AT PROJECT THROUGH FY 2021

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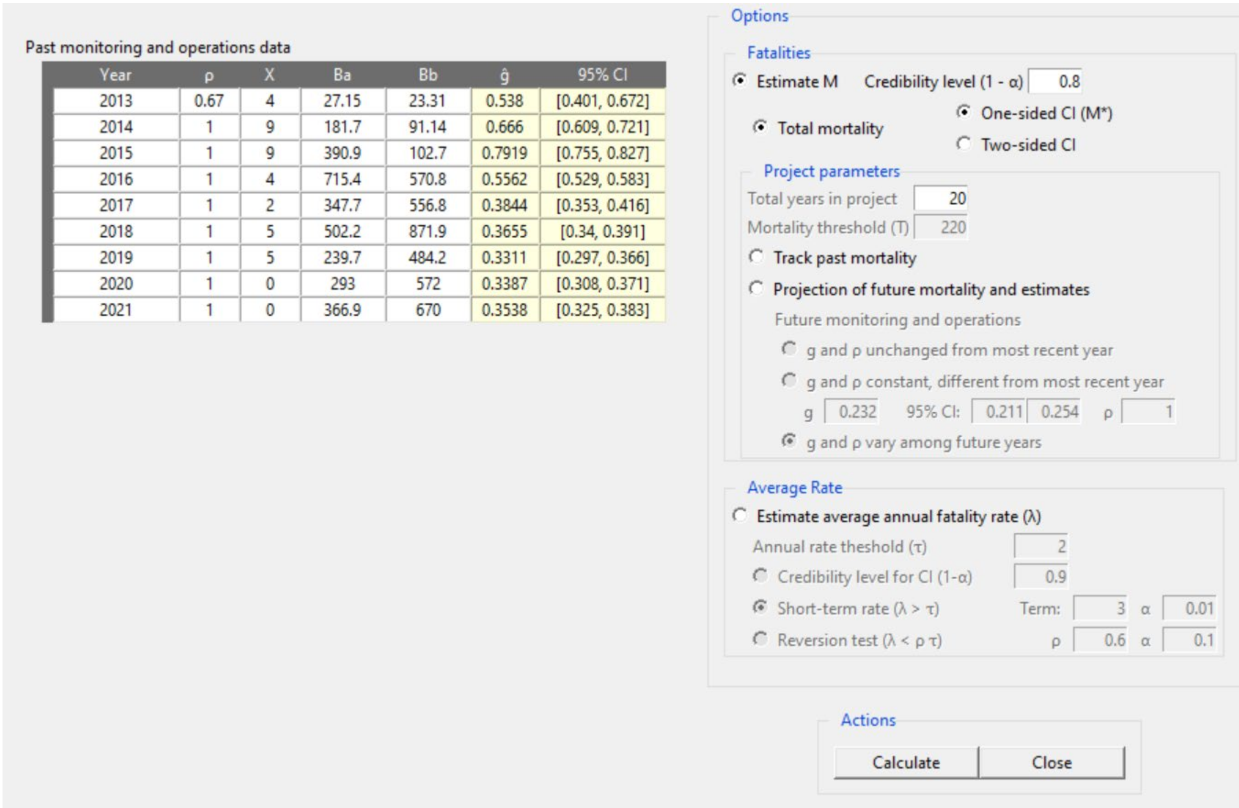
Figure 1. Dalthorp et al. (2017) Fatality Estimation for Hawaiian hoary bats at Project through FY 2021.[4]

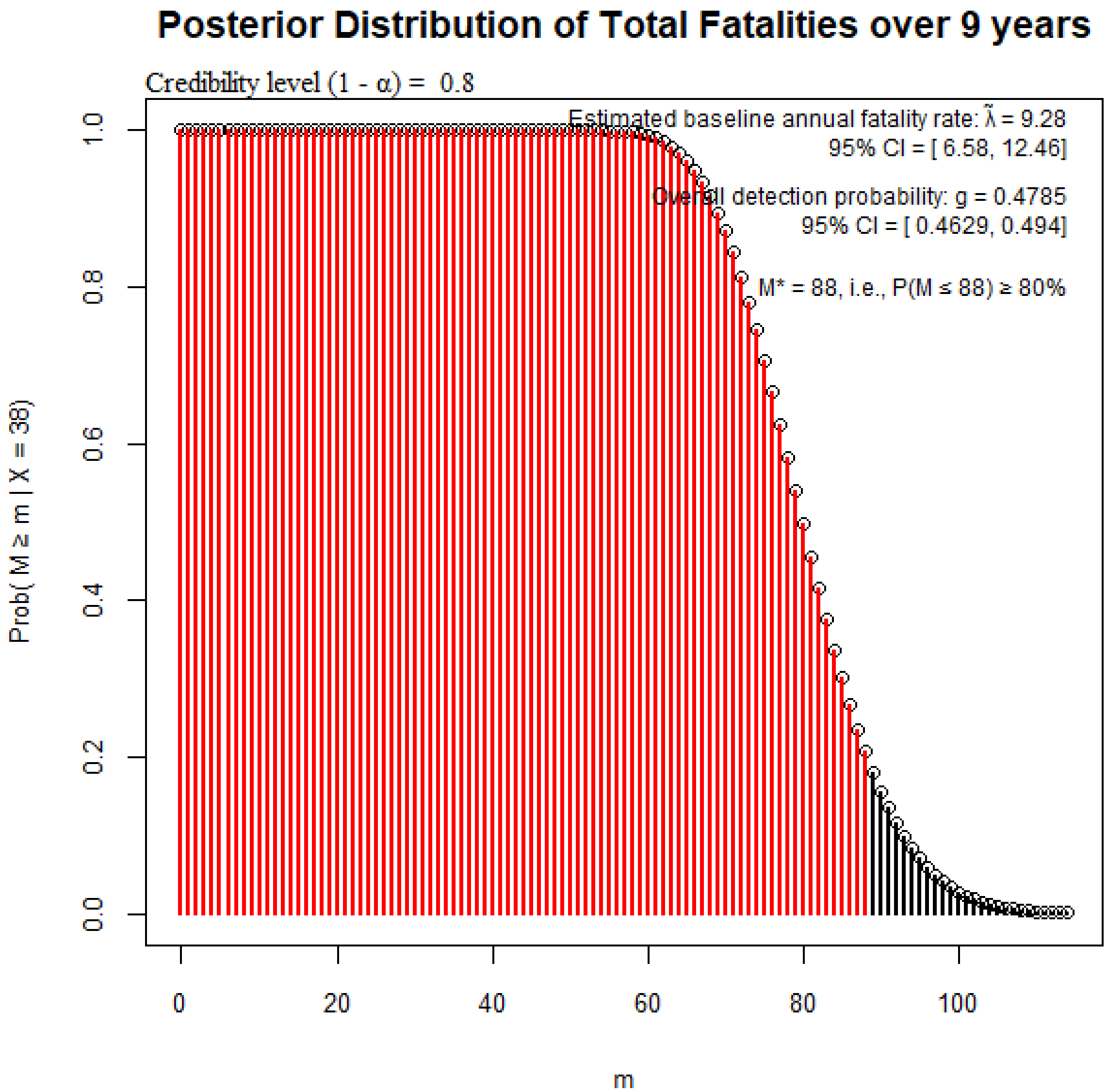


Past monitoring and operations data

Year	ρ	X	Ba	Bb	ĝ	95% CI
2013	0.67	4	27.15	23.31	0.538	[0.401, 0.672]
2014	1	9	181.7	91.14	0.666	[0.609, 0.721]
2015	1	9	390.9	102.7	0.7919	[0.755, 0.827]
2016	1	4	715.4	570.8	0.5562	[0.529, 0.583]
2017	1	2	347.7	556.8	0.3844	[0.353, 0.416]
2018	1	5	502.2	871.9	0.3655	[0.34, 0.391]
2019	1	5	239.7	484.2	0.3311	[0.297, 0.366]
2020	1	0	293	572	0.3387	[0.308, 0.371]
2021	1	0	366.9	670	0.3538	[0.325, 0.383]

[4] Rho represents the portion of a year represented for each line of data. Year 2013 represents a partial year (November 2012 – June 2013) because the Project began operations in November; all remaining years represent a full fiscal year.

Figure 2. Posterior Distribution: Dalthorp et al. (2017) Fatality Estimation for Hawaiian hoary bats at Project for FY 2021



APPENDIX 3

METHODOLOGY FOR DETERMINING AN APPROPRIATE RHO VALUE

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In May and June 2019, Kawailoa Wind, LLC (Kawailoa Wind) installed ultrasonic acoustic deterrents (UAD) at all 30 wind turbine generators (WTG) at the Kawailoa Wind Project (Project). The installation of UADs is correlated with a reduction in fatality rates for mainland hoary bats (Weaver et al. 2019) and is a minimization measure encouraged by the U.S. Fish and Wildlife Service (USFWS) and Hawai'i Division of Forestry and Wildlife (DOFAW) to reduce the risk to Hawaiian hoary bats at the Project.

The effectiveness of UADs on the Hawaiian hoary bat is not known, but evidence from monitoring at the Project suggests the Hawaiian hoary bat fatality rate is reduced at the Project after installation of UADs. The effectiveness of UADs for mainland hoary bats at Los Vientos Wind Farm in Texas was found to be 78.3 percent (95% confidence interval [CI]: 61.5–95.1%) reduced relative to WTGs without UADs active. Differences in site conditions and the species-specific responses led to uncertainty if this reduction will be replicated at the Project. Additionally, the Project has implemented low wind speed curtailment at 5 meters per second (m/s) with a 0.2 m/s hysteresis, further reducing the risk to bats relative to the study at Los Vientos.

The Evidence of Absence (EoA) software program incorporates a parameter called rho (ρ), which adjusts the expected fatality rate. A rho value of 1 is typically used when assessing compliance with authorized take limits. The use of a rho value of 1 assumes the risk is the same from year to year. Rho has also been used to account for the proportion of the year covered by search parameters, such as the partial year of fatality monitoring at the Project's start in fiscal year (FY) 2013 and the change in search areas that occurred in FY 2016. The EoA user's manual (Dalthorp et al. 2017) describes rho as follows:

> The assumed relative mortality rate is ρ. If there are no changes in operations and no reason to suspect mortality rates varied systematically from year to year, then ρ=1 each year. However, if operations or ecological conditions change, the ρ parameter should be adjusted to reflect changes. For example, if a site is expanded by 20% in year 3, then ρ=1 for years 1 and 2 as a baseline and ρ=1.2 in year 3 would be appropriate. Or if minimization measures that are expected to reduce fatalities by 30% are implemented in year 3, then ρ=1 for years 1 and 2, and ρ=0.7 for year 3.

To test if the fatality rate is reduced, Tetra Tech used EoA to compare fatality rates and check for misspecification in rho. In other words, "Does the fatality monitoring data provide evidence that minimization measures have reduced the risk to bats?" To compare the fatality rate in each year, Tetra Tech used the multi-year module of EoA to compare the fatality rates. The fatality rates (lambda[λ]) for each year are shown in Table 1 and Figure 1. These illustrate that the interquartile ranges are non-overlapping, although the 95 percent confidence intervals overlap.

To test if the rho value is appropriately specified before and after installation of UADs, each period was grouped as a single period in the multi-years module of EoA and tested for misspecification of rho using the multi-year module of EoA. For the pre-UAD period, rho = 1 for each full year; the rho for a partial year is calculated as the proportion of the year involved. The rho for the post-UAD period will begin with rho=1 for all years (i.e., after 4 years, rho=4). For multiple years, the rho value for the post-UAD period is represented by the equation: rho * years of monitoring. In practice this would be assumed to be the same for all years. For example, if after year four, the cumulative rho value of 0.5 for the post-UAD period (2020-2024) is indicated by the EoA test for misspecification of rho, the annual rho value would be 0.5/4 years, or 0.125. Similarly, if a rho value of 4 is indicted by the EoA test for misspecification of rho for the same period (2020-2024), the rho value would be 1 for all years (4 rho/4 years = 1 rho/year).

November 2012-June 2019, which correlates with FY 2013-2019, represents the pre-UAD period, and July 2019-June 2021, which correlates with FY 2020-2021, represents the post-UAD installation period. The cumulative detection probability for each period was calculated using EoA to group the years (FY 2013-2019, and FY 2020-2021) and provide a cumulative detection probability. For each period, the observed fatalities were summed to calculate the total observed fatalities for the period. The pre-deterrent period therefore represents the pooled data from FY 2013 to FY 2019 including: rho which represents the years of monitoring from November 2012-June 2019 or 6.67 years, the sum of observed bat fatalities (38 bats), and the cumulative detection probability from November 2012 to June 2019 (0.518). The post-deterrent period represents the pooled data from FY 2020 to FY 2021 including: rho which represents the years of monitoring from July 2019-June 2021 or 2 years, the sum of observed bat fatalities (0 bats), and the cumulative detection probability from July 2019 to June 2021 (0.346). The inputs are provided in Table 2.

Comparing the fatality monitoring data before and after UADs demonstrates that fatality rates are overestimated after installation of UADs if the same rho is used for both periods. At a rho value of 2 (annual rho of 1), the test for misspecification returns a significant result when testing for a p value less than 0.05 (p value =0.0002); the EoA outputs for this trial are shown in Figure 2. The rho value was decreased incrementally by 0.05 until the p value for the test of misspecification of rho exceeded a p value of 0.05. The first rho value with a test of misspecification p value greater than 0.05 (p value= 0.05401) was found when the combined rho FY 2020 – FY 2021 = 0.5 (a 0.25 annual rho) or a 75 percent reduction in the annual fatality rate after installation of UADs; the EoA outputs for this trial are shown in Figure 3. Therefore, Project data suggest 95 percent confidence that Hawaiian hoary bat risk at the Project is reduced by at least 75 percent through the use of UADs.

As shown in Figure 1, fatality rates can vary significantly from year to year. Kawailoa Wind, USFWS, and DOFAW will need to continue to evaluate the results of fatality monitoring to ensure the rho value is appropriately specified. The methods outlined here represent the means by which an appropriate rho value will be determined, and which are consistent with the recommended methodology outlined in the USFWS Programmatic Environmental Impact Statement (USFWS 2019), which states:

> All projects start off with using ρ = 1. If an additional minimization such as raising the cut in speed (see Appendix D) or deterrents are implemented, the rho-value is still kept at 1 until tests on assumed weights indicate that there may be a difference in fatality rates. This may require several years of deploying the minimization action before any difference can be supported by the test on the rho-value. If the tests do confirm a change in the fatality rates between periods beyond a reasonable doubt, a rho-value can be put in place, retroactively, for the periods in which the minimization action was deployed, if approved by the Service.

The tests can be rerun to determine if the rho value continues to be reasonable. Note, however, that the actual rho-value is not calculated by the model and may never be known. The best that can be done is to maintain testing of the rho value being used to see if it is reasonable.

An appropriate rho value needs to be incorporated in the Project EoA assessment to account for the reduced risk to bats from the installation of UADs at the Project. An appropriate rho value will have sufficient years of supporting data for both pre- and post-minimization effectiveness to statistically account for inter-annual variability in the observed take rate. Once a final rho value is determined, the final rho will be applied to all years in which UADs are active.

Table 1. Fatality Rates for Each Year of Project Operation

Year	Observed Fatalities	Detection Probability	Fatality Estimate at the 80% Credible Level	Median Fatality Estimate	Fatality Estimate 95% CI	Lambda	Lambda 95% CI
2013	4	0.538	10	7	[4,14]	8.588	[2.4860, 18.8300]
2014	9	0.666	16	13	[10,20]	14.3	[6.6690, 24.8700]
2015	9	0.792	13	11	[9,15]	12.01	[5.6190, 20.7900]
2016	4	0.556	10	7	[4,12]	8.097	[2.4270, 17.1400]
2017	2	0.384	8	5	[2,12]	6.52	[1.0810, 16.7800]
2018	5	0.365	19	14	[7,26]	15.08	[5.2150, 30.1300]
2019	5	0.331	21	15	[7,28]	16.68	[5.7490, 33.4400]
2020	0	0.339	2	0	[0,4]	1.481	[0.0014, 7.4480]
2021	0	0.354	1	0	[0,4]	1.416	[0.0014, 7.1230]

Table 2. Inputs for the Test of Misspecification of Rho

Year	P (rho)	X (Observed Fatalities)	Ba (Shape)	Bb (Scale)	$\hat{g}$ (Detection Probability)	95% CI
2013-2019	6.67	38	1356	1262	0.518	[0.499, 0.537]
2020-2021	2 or 0.5	0	654.3	1235.3	0.346	[0.325, 0.368]

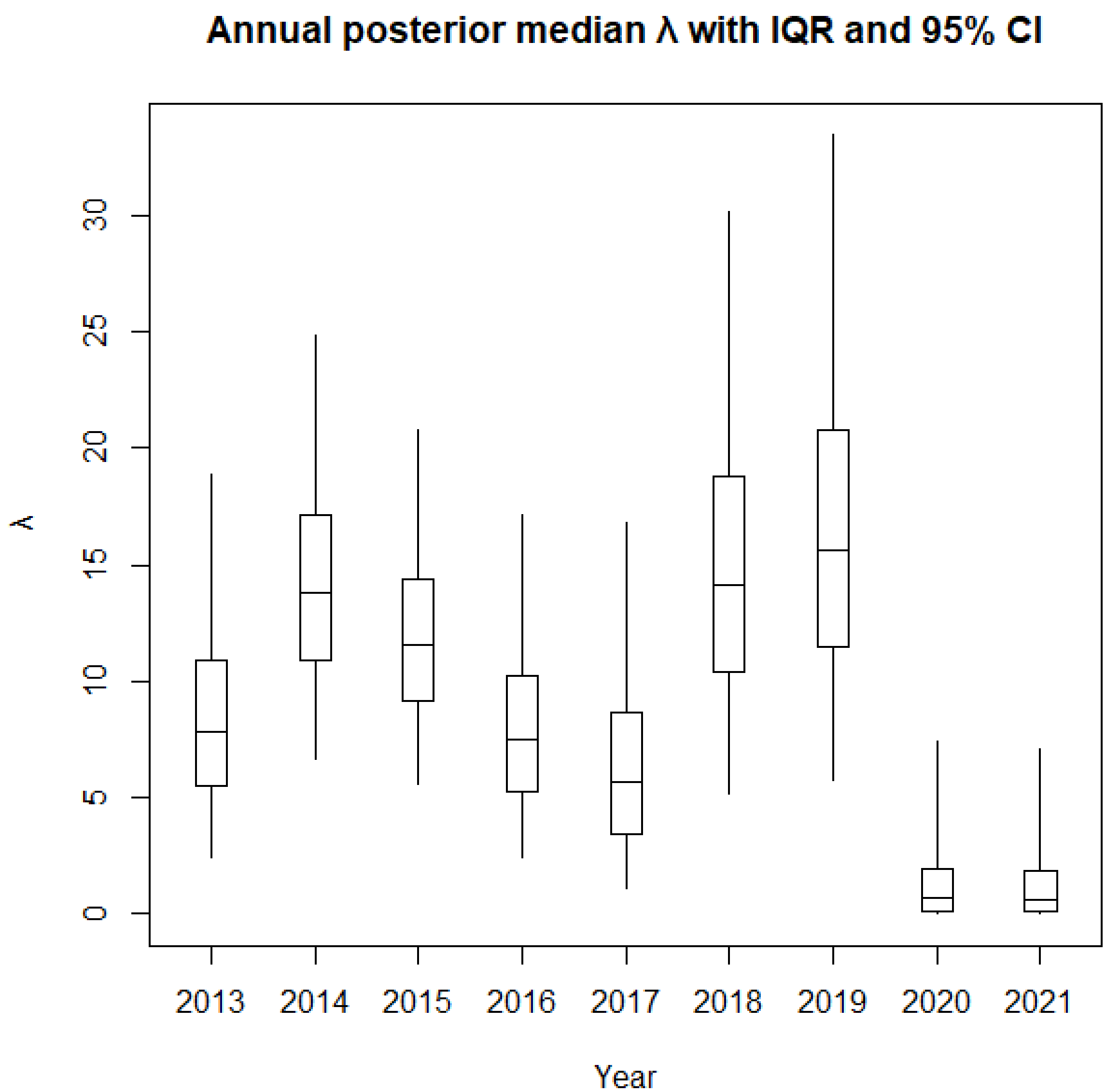

Figure 1. Annual Hawaiian Hoary Bat Fatality Rates Estimated by EoA for the Project at the 80 Percent Credible Level

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Summary statistics for mortality estimates through 2 years
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Results

M* = 88 for 1 - a = 0.8, i.e., P(M <= 88) >= 80%
Estimated overall detection probability: g = 0.478, 95% CI = [0.463, 0.494]
   Ba = 1900.4, Bb = 2072.3
Estimated baseline fatality rate (for rho = 1): lambda = 9.286, 95% CI = [6.58, 12.5]

Cumulative Mortality Estimates
                                                        mean
Year            X     g     M*  median  95% CI  lambda       95% CI
2013-2019      38 0.518    81    73     [59, 91]  74.37   [52.64, 99.84]
2020-2021      38 0.478    88    79     [63, 99]  80.51   [57.02, 108]


Annual Mortality Estimates
                                                        mean
Year            X     g     M*  median  95% CI  lambda       95% CI
2013-2019      38 0.518    81    73     [59, 91] 74.3700   [52.6400, 99.8400]
2020-2021       0 0.346     2     0     [0, 4] 1.4460   [0.0014, 7.2670]


Test of assumed relative weights (rho) and potential bias
              Fitted rho
Assumed rho      95% CI
   6.67     [7.913, 8.670]
      2     [0.000, 0.737]

p = 2e-04 for likelihood ratio test of H0: assumed rho = true rho
Quick test of relative bias: 1.073

=================================================================================
Input
Year (or period)  rho     X    Ba      Bb   ghat    95% CI
2013-2019        6.670   38   1356    1262 0.518 [0.499, 0.537]
2020-2021        2.000    0  654.3    1235 0.346 [0.325, 0.368]
```

Figure 2. Testing for Misspecification of Rho with a Rho Value of 2

```
Summary statistics for mortality estimates through 2 years
------------------------------------
Results

M* = 83 for 1 - a = 0.8, i.e., P(M <= 83) >= 80%
Estimated overall detection probability: g = 0.506, 95% CI = [0.488, 0.524]
   Ba = 1521.8, Bb = 1485.8
Estimated baseline fatality rate (for rho = 1): lambda = 10.62, 95% CI = [7.52, 14.3]

Cumulative Mortality Estimates
                                                   mean
Year           X    g     M*  median  95% CI  lambda       95% CI
2013-2019     38 0.518   81    73     [59, 91]  74.37    [52.64, 99.84]
2020-2021     38 0.506   83    75     [60, 93]  76.12    [53.9, 102.2]


Annual Mortality Estimates
                                                   mean
Year           X    g     M*  median  95% CI  lambda       95% CI
2013-2019     38 0.518   81    73     [59, 91] 74.3700    [52.6400, 99.8400]
2020-2021      0 0.346    2     0     [0, 4] 1.4460   [0.0014, 7.2670]


Test of assumed relative weights (rho) and potential bias
              Fitted rho
Assumed rho     95% CI
   6.67     [6.497, 7.169]
    0.5     [0.001, 0.671]

p = 0.05401 for likelihood ratio test of H0: assumed rho = true rho
Quick test of relative bias: 1.014

================================================================================
Input
Year (or period)  rho    X    Ba     Bb   ghat    95% CI
2013-2019        6.670  38   1356   1262 0.518 [0.499, 0.537]
2020-2021        0.500   0  654.3   1235 0.346 [0.325, 0.368]
```

Figure 3. Testing for Misspecification of Rho with a Rho Value of 0.5 (Annual Rho of 0.25)

Literature Cited:

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

USFWS (U.S. Fish and Wildlife Service). 2019. Final Programmatic Environmental Impact Statement Addressing the Issuance of Incidental Take Permits for Four Wind Energy Projects in Hawaiʻi. U.S. Department of the Interior, Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office. July.

Weaver, S., and I. Castro-Arellano. 2019. Studying Behavior and Testing Strategies to Reduce Impact of Wind Energy on Bats in Texas. Final Performance Report. Prepared for the State Wildlife Grant Program, Texas.

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APPENDIX 4

OAHU HAWAIIAN HOARY BAT OCCUPANCY AND DISTRIBUTION STUDY PROJECT UPDATE AND THIRD YEAR ANALYSIS, DATED MAY 2021 (THOMPSON AND STARCEVICH 2021)

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APPENDIX 5

MONITORING OF ENDANGERED SEABIRDS AT HANAKĀPĪʻAI AND HANAKOA, ANNUAL REPORT 2020 (RAINE ET AL. 2020)

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APPENDIX 6

HANAKĀPĪ‘AI – HANAKOA 2020 FINAL REPORT (DUTCHER AND PIAS 2021)

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