Kawailoa Wind Project Habitat Conservation Plan
FY 2025 Annual Report

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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 2025 (FY 2025; July 1, 2024 to June 30, 2025) under the terms of the approved Habitat Conservation Plan (HCP) dated October 2011 and the approved HCP Amendment dated September 2019, and pursuant to the obligations 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 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 2025 at all wind turbine generators (WTG). In FY 2025, search areas consisted of 55-meter-radius circles centered on each turbine and roads out to 75 meters from each turbine. For the two unguyed meteorological towers, the search area consisted of a 50-meter-radius circle centered on each tower. The mean search interval for both turbines and the meteorological towers in FY 2025 was 7.0 days.

Four 28-day carcass persistence trials were conducted in FY 2025 using 60 bat surrogates and 12 medium-sized bird carcasses. For FY 2025, the probability and 95 percent confidence interval that a bat surrogate carcass persisted until the next search was 0.74 (0.66 to 0.81). The probability that a medium-size bird carcass persisted until the next search was 0.89 (0.49 to 0.99).

Searcher efficiency trials were conducted over 24 trial days with 74 trial carcasses in FY 2025. The overall searcher efficiency in FY 2025 for bat surrogates (N = 62) was 0.95 (0.88 to 0.99). For medium-sized birds (N = 12) searcher efficiency was 1.00 (0.82 to 1.00).

No HCP Covered Species fatalities were observed in FY 2025. The Project's total observed Hawaiian hoary bat take from operations through FY 2025 is 43 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 87 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 96 adult bats, using the approved adjusted rho value. The current estimate falls within the Tier 4 bat take request (which is up to 115 bats). Mitigation for Tier 4 take was completed in 2018.

Fifteen fatalities representing 8 non-listed bird species were found at the Project in FY 2025. This includes the following birds that are protected by the Migratory Bird Treaty Act: two great frigatebirds/ʻiwa (*Fregata minor*) and three Western cattle-egrets (*Ardea ibis*).

Tier 1 mitigation for the Hawaiian hoary bat continued in FY 2025. 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 337 of 1,392 (24.2 percent) detector-nights sampled throughout the 2025 Bat Sampling Period. The ʻUkoʻa Wetland mitigation program for Tier 1 mitigation continued for waterbirds and bats through FY 2025 including invasive vegetation control, predator control and monitoring, fence monitoring and maintenance, and bat lane maintenance.

Bat mitigation for Tiers 2 through 4 is complete. Kawailoa Wind continues to plan for Tier 5 bat mitigation, should it be needed; however, current results and projections suggest the Project is likely to remain within Tier 4 for the permit term.

Mitigation for listed waterbirds continued at ʻUkoʻa Wetland, despite no observed take of these species at the facility. In total, 17 Hawaiian common gallinule/ʻalae ʻula (*Gallinula galeata sandvicensis*) fledglings have been recorded at ʻUkoʻa Wetland since monitoring began (FY 2017 to FY 2025). No gallinule breeding events were observed in FY 2025. One juvenile Hawaiian stilt/aeʻo (*Himantopus mexicanus knudseni*) was documented at ʻUkoʻa Wetland in August 2024; this bird is believed to have fledged from ʻUkoʻa, making this the first Hawaiian stilt documented to fledge from the site. The first breeding activity for Hawaiian coots/ʻalae keʻokeʻo (*Fulica alai*) was documented at ʻUkoʻa Wetland since surveys began in 2017; a coot pair with a nest was documented in May 2025 and by the end of the FY, two coot chicks remain at ʻUkoʻa Wetland.

No Hawaiian petrel/ʻuaʻu (*Pterodroma sandwichensis*) fatalities were observed in FY 2025. The estimated cumulative Project take is below the authorized take limit. Mitigation for the take of Hawaiian petrel was completed in FY 2021. Pacific Rim Conservation's research related to Hawaiian petrels on Oʻahu continued in FY 2025 using funds provided by Kawailoa Wind.

Mitigation for Newell's shearwater/aʻo (*Puffinus newelli*) was completed in FY 2015. Hawaiian short-eared owl/pueo (*Asio flammeus sandwichensis*) mitigation was completed in FY 2017.

Table of Contents

List of Tables

List of Figures

List of Appendices

Acronyms and Abbreviations

ANOVA	analysis of variance
CPT	carcass persistence trials
DOFAW	Division of Forestry and Wildlife
DU	deterrent unit
DUC	deterrent unit controller
EoA	Evidence of Absence
ESRC	Endangered Species Recovery Committee
FY	fiscal year
HCP	Habitat Conservation Plan
HWA	Helemano Wilderness Area
IQR	Interquartile Range
ITL	Incidental Take License
ITP	Incidental Take Permit
LM	linear model
LWSC	low wind speed curtailment
MBTA	Migratory Bird Treaty Act
met	meteorological
ODT	observed direct take
ORQ	ordered quantile normalization transformation
PC	point-count
SD	standard deviation
SEEF	searcher efficiency
TPL	Trust for Public Land
UAD	ultrasonic acoustic deterrents
UCL	upper credible limit
UDT	unobserved direct take
USFWS	U. S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WEOP	Wildlife Education and Observation Program
WEST	Western EcoSystems Technology, Inc.
WTG	wind turbine generator

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; the 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 (collectively 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/ʻōpeʻapeʻa (*Lasiurus semotus*) take and to add the state and federally listed endangered Hawaiian petrel/ʻuaʻu (*Pterodroma sandwichensis*) as a Covered Species (Tetra Tech 2019). Kawailoa Wind received an amended ITP from USFWS on September 4, 2019. An amended ITL was issued by DOFAW on February 26, 2021, and signed by Kawailoa Wind on March 30, 2021. The Project's Covered Species are listed in Table 1.

Table 1. Covered Species

Common Name	Hawaiian Name	Scientific Name	Listing Status[1]
Hawaiian coot	ʻalae keʻokeʻo	*Fulica alai*	FE/SE
Hawaiian duck	koloa maoli	*Anas wyvilliana*	FE/SE
Hawaiian common gallinule	ʻalae ʻula	*Gallinula galeata sandvicensis*	FE/SE
Hawaiian stilt	aeʻo	*Himantopus mexicanus knudseni*	FE/SE
Hawaiian petrel	ʻuaʻu	*Pterodroma sandwichensis*	FE/SE
Newell's shearwater	ʻaʻo	*Puffinus newelli*	FT/ST
Hawaiian hoary bat	ʻōpeʻapeʻa	*Lasiurus semotus*	FE/SE
Hawaiian short-eared owl	pueo	*Asio flammeus sandwichensis*	SE
1. FE = Federally endangered; SE = State endangered; FT = Federally threatened; ST = State threatened.			

The Project was constructed in 2011 and 2012 and was commissioned to begin operating in November 2012. The Project is owned and operated by Kawailoa Wind, a wholly owned subsidiary of DESRI IV, LLC.

This report summarizes work performed for the Project during the State of Hawaiʻi 2025 fiscal year (FY 2025; July 1, 2024 to June 30, 2025) pursuant to the terms and obligations of the 2011 HCP (SWCA 2011), HCP Amendment (Tetra Tech 2019), and amended ITL and ITP.

2.0 Fatality Monitoring

All 30 wind turbine generators (WTGs) and the two meteorological (met) towers were searched for fatalities once per week throughout FY 2025. Search plots for each WTG in FY 2025 consisted of a 55-meter-radius circle centered on the WTG and roads surrounding the WTG out to 75 meters (Figure 1). Search plots for each unguyed met tower were 50-meter-radius circles centered on the met towers. The FY 2025 mean search interval for WTGs was 7.0 days (standard deviation [SD] = 0.3 days). The mean search interval for unguyed met towers in FY 2025 was 7.0 days (SD = 1.6 days).

Small portions of the 55-meter-radius search plots at 13 of the turbines have unsearchable areas. This is primarily due to steep, heavily vegetated slopes that could not be managed or searched safely or efficiently. Combined, the inability to search these areas reduces the proportion of the carcass distribution searched by 0.012 for birds and 0.035 for bats compared to 55-meter-radius search plots without these constraints. There were no unsearchable areas within the unguyed met tower search plots.

In FY 2025, the search areas 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 teams), search plots were visually surveyed by Project staff; however, canine teams conducted 100 percent of the WTG searches in FY 2025. Vegetation within the search areas is managed to maximize searcher efficiency (SEEF) (see Section 4.0).

3.0 Bias Correction

3.1 Carcass Persistence Trials

Four 28-day carcass persistence trials (CPT) were conducted in FY 2025 using black rat (*Rattus rattus*) carcasses as bat surrogates and wedge-tailed shearwater (*Ardenna pacifica*) carcasses as surrogates for the bird Covered Species. Trial results for FY 2025 are provided in Table 2, including results by vegetation class.

3.2 Searcher Efficiency Trials

Tetra Tech personnel (non-searchers) administered 74 SEEF trials on 24 trial days during FY 2025. Similar to the carcass persistence trials, wedge-tailed shearwaters were used as surrogates for the bird Covered Species, and black rats were used as surrogates for the Hawaiian hoary bat. SEEF trials occurred throughout FY 2025. Vegetation class (short vs. medium height) within each search plot was documented at the time the carcasses were placed. Results for the FY 2025 SEEF trials are provided in Table 2, including results by vegetation class.

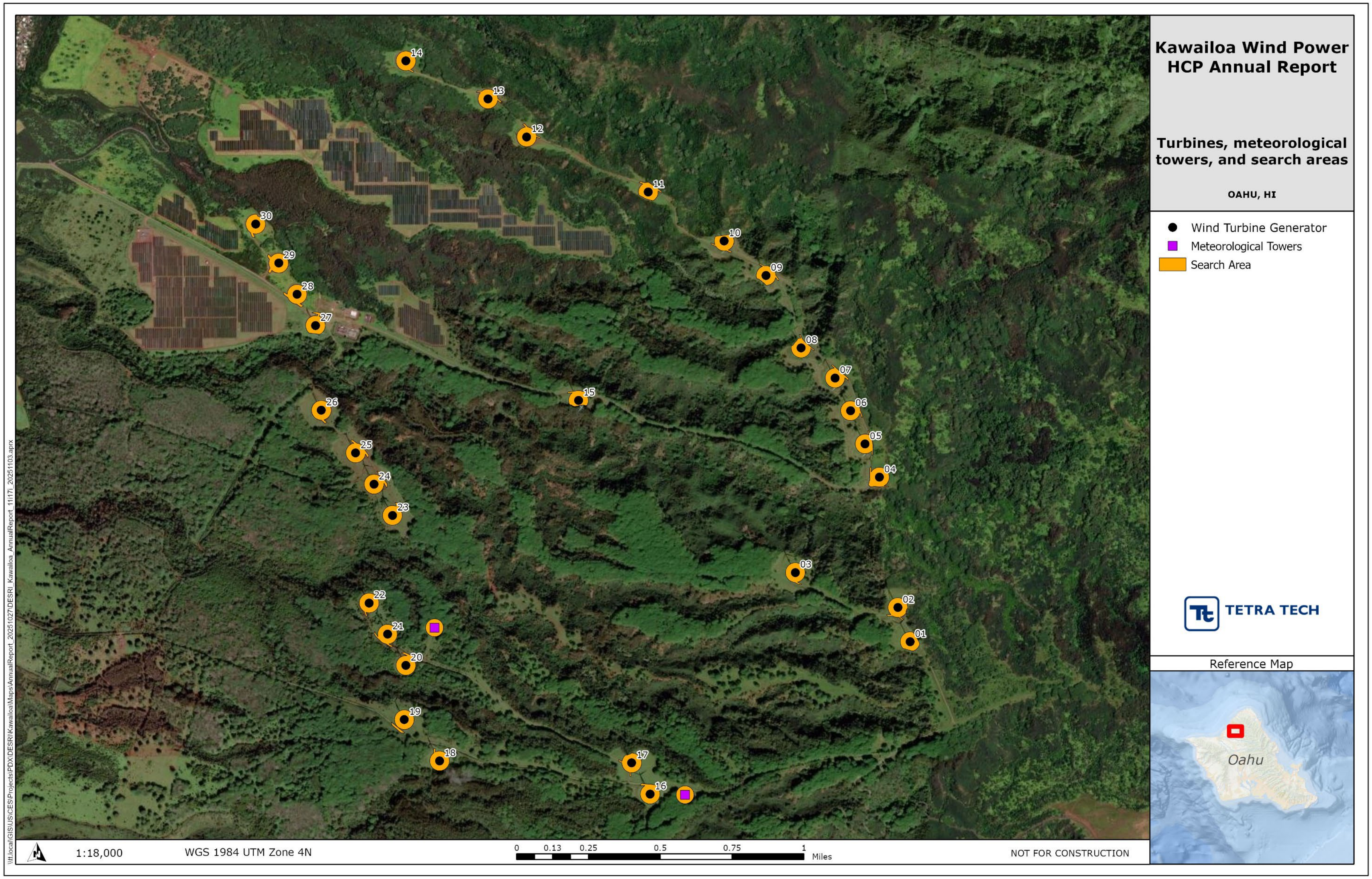

Figure 1. Turbines, meteorological towers, and search areas at the Project

Table 2. Carcass Persistence and Searcher Efficiency Trial Results in FY 2025

Size	Vegetation Class	Total Trials		Mean (95% Confidence Interval)	
		SEEF[1]	CPT[1]	SEEF (Proportion Detected)[2]	Probability of Persistence to the Next Search (*r*)[2, 3]
Rat Surrogate	Short	43	44	0.95 (0.86 – 0.99)	0.73 (0.63 – 0.82)
	Medium	19	16	0.95 (0.78 – 0.99)	0.76 (0.58 – 0.89)
	Combined	62	60	0.95 (0.88 – 0.99)	0.74 (0.66 – 0.81)
Medium Bird	Short	7	9	1.00 (0.71 – 1.00)	0.86 (0.43 – 0.99)
	Medium	5	3	1.00 (0.62 – 1.00)	0.99 (0.91 – 1.00)
	Combined	12	12	1.00 (0.82 – 1.00)	0.89 (0.49 – 0.99)

1. SEEF = Searcher efficiency; CPT = Carcass Persistence Trials.
2. Estimates and confidence interval calculated using Dalthorp et al. (2017) single-year module.
3. The estimate of r is reported in lieu of carcass persistence time, as r provides a more informative portrayal of the effect of carcass persistence on fatality estimates than carcass persistence time, incorporating information from the carcass persistence distribution and the search interval in a single variable. Estimates and confidence interval for r were calculated using Dalthorp et al. (2017) single-year module.

4.0 Vegetation Management

Vegetation in the search plots consists mainly of Guinea grass (*Megathyrsus maximus*), Bermuda grass (*Cynodon dactylon*), and a mixture of common, low-growing weedy plants. All search plots around the WTGs and unguyed 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. Herbicides were also used in FY 2025 to control vegetation in some portions of the search areas. The frequency of vegetation management varies depending on rainfall, time of year, type of vegetation cover, and cattle presence.

The landowner, Kamehameha Schools, has managed cattle on their property since before the Project was constructed. Domestic cattle are rotated periodically throughout portions of the Project and graze vegetation under several of the turbines. Cattle periodically graze 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 and water availability, and landowner operations. No cattle were present at WTGs 4 – 15 and 27 – 30 in FY 2025. Because Kawailoa Wind is not the landowner, the Project does not have control over cattle use in the area.

5.0 Scavenger Trapping

Scavenger trapping is a management action designed to limit removal of carcasses and thus support carcass retention at the Project. Scavenger trapping is responsive to Project needs, and carcass persistence and detection probability are monitored quarterly throughout the fiscal year. Scavenger trapping occurred throughout FY 2025. Mongoose and cats were targeted using 30 DOC-250 series traps and 10 Timms lethal traps. Twenty-five DOC-250 traps were deployed between July 2024 and February 2025, and an additional five DOC-250s were deployed in March 2025 resulting in one DOC-250 trap at each turbine. The scavenger control program documented the trapping of 203 animals in FY 2025, including 196 mongooses (*Herpestes auropunctatus*), 6 rats (*Rattus* spp.), and 1 cat (*Felis catus*).

6.0 Documented Fatalities and Take Estimates

No Hawaiian hoary bat fatalities were observed in FY 2025. The last fatality was documented in May 2024. Only three Hawaiian hoary bat fatalities have been observed at the Project since ultrasonic acoustic deterrents (UAD) were installed in May and June 2019 (see Section 10).

No other listed species fatalities were observed in FY 2025. All observed, downed wildlife were handled and reported in accordance with the most recent (2020) Downed Wildlife Protocol. All non-listed fatalities observed at the Project during FY 2025 are listed in Appendix 1. No injured (live) downed wildlife were observed.

6.1 Hawaiian Hoary Bat

As mentioned above, no Hawaiian hoary bat fatalities were documented during FY 2025 (Appendix 1). The total take estimate for the Hawaiian hoary bat is based on fatality monitoring data and bias correction data from the start of Project operation (November 2012) through the end of FY 2025 (June 30, 2025). 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), which is the agency-approved analysis tool for analyzing direct take, uses results from bias correction trials and ODT to generate an 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 meaning 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 43 Hawaiian hoary bat fatalities have been observed at the Project since operations began on November 2, 2012. The highest number of annual bat fatalities (nine) was observed in FY 2014 and FY 2015 (Table 3). Two of the total 43 observed bats were found outside of fatality search plots and classified as incidental observations. Table 3 presents the cumulative take estimates (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 3. Hawaiian Hoary Bat Fatalities by Fiscal Year 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	89[3]
2021	0	91[3]
2022	2	95[3]
2023	0	95[3]
2024	1	97[3]
2025	0	96[3]
Total	**41**	96[3]

1. Does not include bat fatalities found outside of the search areas (i.e., two incidental observations).
2. Cumulative take represents the 80 percent UCL 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 at the Project. Based on results from 6 years of monitoring, USFWS approved the use of an unbiased estimate of deterrent effectiveness in June 2024. Monitoring data through FY 2025 suggests that the unbiased estimate of deterrent effectiveness at the Project reduces the risk to bats by 89.9 percent (rho = 0.101). Therefore, these values have been updated for these years in this annual report using a modified rho value in the EoA model.

Table 4 summarizes the total estimated Hawaiian hoary bat take through FY 2025. Input values for the multi-year analysis are provided in Table 5. Inputs and outputs from EoA are also provided in Appendix 2.

Table 4. Eighty Percent Upper Credible Limit (UCL) Estimate of Cumulative Hawaiian Hoary Bat Take through FY 2025

A: Observed Direct Take[1]	B: Incidental Observed Take[2]	C: 80% UCL of Estimated Direct Take[3]	D: UDT (C – A – B)	E: Estimated Indirect Take [4]
41	2	87	44	9

1. Observed direct take used in EoA analysis based on FY 2013 to FY 2025 data.
2. Fatalities occurred outside of the defined search area and were not used in EoA analysis.
3. Multi-year EoA analysis (Dalthorp et al. 2017) based on FY 2013 to FY 2025 data.
4. Overall indirect take for the Project was calculated using parameters in the updated USFWS methodology (USFWS 2016).

Table 5. Input Values for Multi-Year Analysis of Hawaiian Hoary Bat Take through FY 2025

Year[1]	Weight	Search Fatalities	Ba	Bb	$\hat{g}$	$\hat{g}$ 95% Confidence Interval
FY 2013	0.67	4	27.15	23.31	0.538	0.401 – 0.672
FY 2014	1	9	181.7	91.14	0.666	0.609 – 0.721
FY 2015	1	9	390.9	102.7	0.792	0.755 – 0.827
FY 2016	1	4	715.4	570.8	0.556	0.529 – 0.583
FY 2017	1	2	347.7	556.8	0.384	0.353 – 0.416
FY 2018	1	5	502.2	871.9	0.365	0.340 – 0.391
FY 2019	1	5	239.7	484.3	0.311	0.297 – 0.366
FY 2020[1]	0.101	0	293.0	572.0	0.339	0.308 – 0.371
FY 2021[1]	0.101	0	366.9	670.0	0.354	0.325 – 0.383
FY 2022[1]	0.101	2	213.2	292.6	0.422	0.379 – 0.465
FY 2023[1]	0.101	0	111.1	85.49	0.565	0.495 – 0.634
FY 2024[1]	0.101	1	140.6	98.74	0.587	0.525 – 0.649
FY 2025[1]	0.101	0	115.9	80.17	0.591	0.522 – 0.591

1. UAD at the Project have shown significant reductions in observed fatalities over 6 years. USFWS approved the use of an unbiased estimate of deterrent effectiveness in June 2024. Monitoring data through FY 2025 suggests that the unbiased estimate of deterrent effectiveness at the Project reduces the risk to bats by 89.9 percent (rho = 0.101). Therefore, rho values have been updated for deterrent years using the adjusted rho value in the EoA model. This rho value will be re-evaluated annually and adjusted accordingly.

Based on USFWS' approval of a modified rho value to account for the benefit of deterrents, estimated take now incorporates this estimate for years of deterrent operation (FY 2020 – FY 2025; see details below); as a result, reported results for those years differ from values reported in the previous annual reports. The estimated direct take (ODT + UDT) for the 43 Hawaiian hoary bat fatalities found between the start of operation (November 2, 2012) and end of FY 2025 is less than or equal to 87 bats (80 percent UCL; Appendix 2). Because two of the 43 observed bat fatalities were found outside of the search areas (i.e., were incidental observations), 41 fatalities were used in the direct take analysis, and the two incidental observations are accounted for in the estimated value of UDT. The two incidental observations were found in FY 2013 and FY 2016. UDT is estimated at 44 fatalities (87 bats; 80 percent UCL, 43 bats ODT).

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 survives to weaning is assumed to be 1.8.

- The sex ratio of bats taken through UDT is assumed to be 44 percent female based on the 43 bats assessed from the Project site by U.S. Geological Survey (USGS) and Bishop Museum data (Pinzari and Bonaccorso 2018; M. Hagemann/Bernice Pauahi Bishop Museum, pers. comm., December 2024).
- 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 (USFWS 2016), the estimate of cumulative indirect take in FY 2025 is calculated as:

- **Total juvenile take calculated from observed female take (April 1 to September 15)**
  - 10 (observed females) * 1.8 (pups per female) = 18 juveniles
- **Total juvenile take calculated from observed unknown sex take (April 1 to September 15)**
  - 0 (observed unknown sex) * 0.44 (sex ratio from USGS and Bishop Museum data from Kawailoa Wind) * 1.8 (pups per female) = 0 juveniles
- **Total juvenile take calculated from unobserved take**
  - 44 (unobserved direct take) * 0.44 (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) = 8.7 juveniles
- **Total Calculated Juvenile Indirect Take** = 26.7 (18 + 0 + 8.7)
- **Total Adult Equivalent Indirect Take =** 0.3 (juvenile to adult conversion factor) * 26.7 = 8.01

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 8.01).

The UCL for Project take of the Hawaiian hoary bat at the 80 percent credibility level is 96 adult bats (87 estimated direct take + 9 estimated indirect take)[1]. That is, there is an approximately 80 percent probability that actual take at the end of FY 2025 is less than or equal to 96 bats. This estimate falls within the Tier 4 bat take authorization detailed in the HCP Amendment (Tetra Tech 2019), which has a total take request of 115 bats.

[1] This total is estimated using a rho value of 0.101 for years when deterrents were operational.

6.1.1 *Estimating Deterrent Effectiveness*

The EoA software program incorporates a parameter called rho (ρ), which adjusts the expected fatality rate (lambda: λ). Methods for determining an estimate of a conservative rho value is described in the FY 2020 to 2024 annual reports (Tetra Tech 2020, Tetra Tech 2021, Tetra Tech 2022, Tetra Tech 2023, Tetra Tech 2024). The minimization measures associated with the HCP Amendment demonstrate a statistically significant reduction in the bat 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 11.14 bats per year from FY 2013 to 2019, estimated by EoA, to an average of 1.23 bats per year in FY 2020 to 2025 (Figure 2). This demonstration of deterrent effectiveness was measurable in the first year of deployment in FY 2020 (Tetra Tech 2020), has been sustained for over 6 years, and is robust enough to demonstrate benefits despite the observation of two bat fatalities in FY 2022 and a single bat fatality in FY 2024. Based on the strength and resilience of these measured benefits, the use of an adjusted rho is appropriate. In FY 2023, Kawailoa Wind hired DAPPER Stats to develop a statistical analysis to produce an unbiased estimate of the benefit of the deterrents (DAPPER Stats 2023). Kawailoa Wind worked with USFWS and DOFAW to ensure that the measurable benefits from deployment of these minimization measures are appropriately accounted for in the take analyses. In June 2024, USFWS agreed that the proposed methodology could be applied to estimate the effectiveness of the deterrents at reducing risk to the Hawaiian hoary bat (D. Gary/USFWS, pers. comm., June 2024).

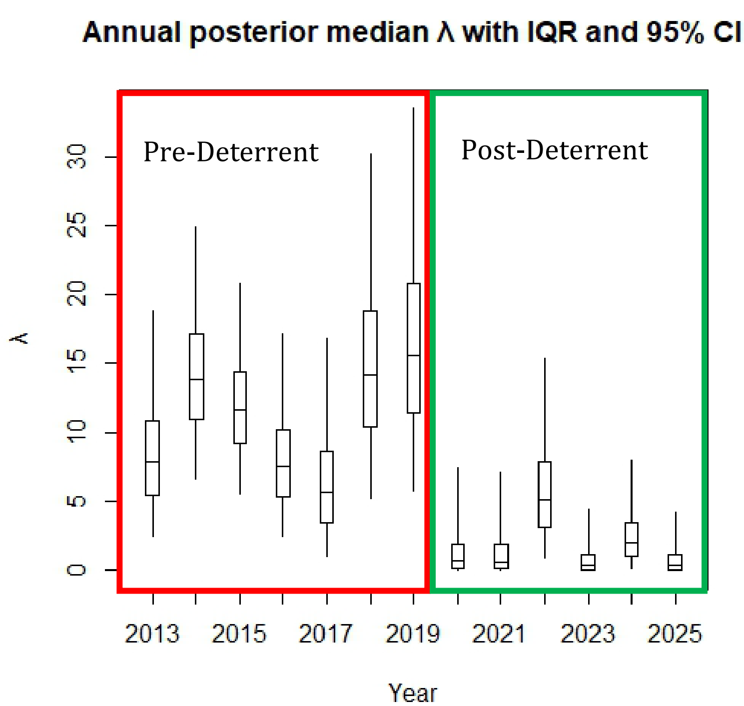

Figure 2. EoA Estimated Hawaiian Hoary Bat Fatality Rates by Year at the Project

The details of the rho analysis estimating the effectiveness of deterrents with data through FY 2025 are provided in Appendix 3. These results indicate the unbiased estimate of rho to account for deterrent effectiveness from FY 2020 to 2025 is 0.101 (0.026 – 0.268), an 89.9 percent reduction of risk. One condition of USFWS' approval of a modified rho value was that each year's detection probability meets or exceeds the FY 2023 detection probability (0.565), and FY 2025 exceeded that detection probability (0.591; Table 5). Ultimately, the assessment of rho in the post-UAD installation period is expected to incorporate ongoing fatality monitoring results and an unbiased estimate of the deterrent benefit. The inclusion of additional years will continue to increase statistical rigor to accurately assess changes in rho. The rho value applied for periods with the current minimization measures will be re-evaluated annually to incorporate new data (i.e., the rho value will likely change annually based on new data). The most current analysis and prior years' rho updates are included in Appendix 3.

6.1.2 Take Projection

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. Given the use of an unbiased estimate of the rho value of 0.101 post-UAD for FY 2020 – 2025, the median take projection at the end of the ITP term (December 2031) is 94 bats (Interquartile Range [IQR]: 92, 98). Alternatively, using EoA with a selected estimate of relative risk of post-UAD versus pre-UAD periods, the HCP Amendment 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 between FY 2020 and FY 2025 as 1.23 bats per year; extrapolating from the current direct take estimate (using a rho of 0.101) and the current take rate, the Project estimates a direct take total of 95.0 bats at the end of the ITP term (87 bats estimated by EoA as direct take through FY 2025 + 1.23 bats per year * 6.5 years remaining in the permit term). This value falls within the IQR generated by EoA that was previously described.

The Project's current ratio of indirect take to direct take indicates the estimated indirect take is 9.2 percent of the direct take estimate (8.01 adult bat equivalents estimated through FY 2025/87 bats estimated from direct take). When an estimate of indirect take of 8.7 adult bat equivalents (9.2 percent * 95.0 bats estimated from direct take) is added to the direct take estimate, the estimated take is 103.7 adult bat equivalents (95.0 bats estimated through direct take + 8.7 bats estimated through indirect take) in December 2031. This indicates that while the Project is likely to stay below the Tier 4 maximum of 115 bats through the permit term, it is also possible that it could surpass this value. However, EoA indicates that there currently is a 98.3 percent chance that the Project will remain within Tier 4 given the current rate of take. Nevertheless, both the EoA and HCP methods of generating take projections indicate the Project will stay below the total HCP Amendment take estimates (up to Tier 6) through the permit term.

6.2 Hawaiian Petrel

Although no Hawaiian petrel fatalities were observed in FY 2025, this is the only other HCP Covered Species previously observed as a fatality at the Project; thus, a take estimate is calculated. The Hawaiian petrel was added as an HCP Covered Species through an amendment to the HCP and issuance of amended permits in 2019 (ITP in September 2019 and ITL in February 2021).[2] Therefore, there is a distinction between the Project estimated take and the level of take occurring under the authorized permits and the amended HCP. To address this issue, estimated take over the period of Project operations was analyzed first. Following this analysis, a ratio was applied of the portion of the Project's operations under which the Hawaiian petrel was an HCP Covered Species to identify the estimated take for the purposes of tracking take with respect to the applicable regulatory permits.

Table 6 summarizes the total estimated Hawaiian petrel take through FY 2025. Input values for the multi-year analysis are provided in Table 7. Inputs and output from EoA are provided in Appendix 4.

Table 6. Eighty Percent Upper Credible Limit (UCL) Estimate of Cumulative Hawaiian Petrel Take through FY 2025

A: Observed Direct Take[1]	B: Incidental Observed Take[2]	C: 80% UCL of Estimated Direct Take[3]	D: UDT (C – A – B)	E: Estimated Indirect Take (Chicks/Eggs)[4]
0	2	1	NA	2

1. Observed direct take used in EoA analysis based on FY 2013 to FY 2025 data.
2. Fatalities occurred outside of the defined search area and were not used in EoA analysis.
3. Multi-year EoA analysis (Dalthorp et al. 2017) based on FY 2013 to FY 2025 data.
4. Overall indirect take for the Project is calculated based on parameters described in Appendix 16 of the HCP Amendment and rounded up to the nearest integer (Tetra Tech 2019).

[2] Based on input from the agencies and species experts, take of the Hawaiian petrel was not anticipated during the development of the original HCP.

Table 7. Input Values for Multi-Year Analysis of Hawaiian Petrel Take through FY 2025

Year[1]	Weight	Search Fatalities[2]	Ba	Bb	$\hat{g}$	$\hat{g}$ 95% Confidence Interval
FY 2013	0.67	0	347.5	34.45	0.910	0.879 – 0.936
FY 2014	1	0	126.3	23.51	0.843	0.781 – 0.897
FY 2015	1	0	398.7	221.4	0.643	0.605 – 0.680
FY 2016a	0.33	0	393.4	209.6	0.652	0.614 – 0.690
FY 2016b	0.67	0	1437	4968	0.224	0.214 – 0.235
FY 2017	1	0	496.6	1734	0.223	0.206 – 0.240
FY 2018	1	0	5.721	22.19	0.205	0.080 – 0.370
FY 2019	1	0	140.0	426.5	0.247	0.213 – 0.283
FY 2020	1	0	978.7	3056	0.243	0.229 – 0.256
FY 2021	1	0	1698	5298	0.243	0.233 – 0.253
FY 2022	1	0	201.2	448.2	0.310	0.275 – 0.346
FY 2023	1	0	775.1	1029	0.430	0.407 – 0.453
FY 2024	1	0	4.322	8.056	0.349	0.122 – 0.622
FY 2025	1	0	36.02	59.14	0.379	0.284 – 0.478

1. Year data for FY 2013 to 2017 are taken from Appendix 16 in the HCP Amendment (Tetra Tech 2019).

2. Two Hawaiian petrel fatalities have been found at the Project (July 21, 2017, and August 20, 2018), both occurred outside of the systematic search areas and therefore were not included in the EoA analysis.

Based on biological parameters presented in Appendix 16 of the HCP Amendment (Tetra Tech 2019), the estimate of cumulative indirect take through FY 2025 is calculated as follows:

- **Estimate of direct adult take:**
  - Greater of observed adult direct take (2) and estimated direct take using EoA (1) = **2 adults**
- **Proportion of adults that breed:**
  - Both observed fatalities occurred from May to August. The estimate of the percent of adults breeding in the colony = **0.89**
- **Parental contribution:**
  - Breeding adults produce 1 chick/pair and are dependent on both adults during May through August = **100 percent**
- **Reproductive success:**
  - Average reproductive success = **0.63**
- **Total chick/egg indirect take**
  - Calculated as (2 * 0.89 * 1.00 * 0.63) **= 1.12**

Therefore, the estimated indirect take based on the estimate of Hawaiian petrel direct take at the Project is **2 chicks/eggs** (rounded up from 1.12). The UCL for cumulative Project take of the Hawaiian petrel over the period of Project operations is **2 adults and 2 chicks/eggs**.

As noted above, from a regulatory perspective, take of the Hawaiian petrel has only been permitted for a portion of the Project's operations. To measure take against the authorized take limit, a proportion of the time the Project has operated with permits authorizing incidental take of the Hawaiian petrel is applied to the estimate for the entire period of Project operation. For FY 2025, the Project has operated from November 2012 through June 2025 (12.67 years) and the Project has authorized incidental take of the Hawaiian petrel from September 2019 to June 2025 (5.82 years).

- **Estimated adult Hawaiian petrel take** under permit = (5.82/12.67) * 2 = **0.92**
- **Estimated chick/fledging Hawaiian petrel take** under permit = (5.82/12.67) * 1.12 = **0.51**

Rounding up, the cumulative Project take of Hawaiian petrels as measured against the authorized take limit is <u>**1 adult and 1 chick/egg**</u>. This estimate is below the authorized take limit of 19 adults and 5 chicks/eggs.

6.3 Non-listed Species

Fifteen bird fatalities representing 8 different non-listed species were documented at WTGs at the Project in FY 2025 (see Table 8). No fatalities have been observed at either of the two met towers. Two of the bird species observed in FY 2025 are protected by the Migratory Bird Treaty Act (MBTA). Appendix 1 provides a complete list of fatalities for FY 2025.

Table 8. Non-listed Bird Fatalities Documented at the Project in FY 2025

Species	Common/ Hawaiian Names	No. of Observed Fatalities in FY 2025
Acridotheres tristis	Common myna	1
Ardea ibis[1]	Western cattle-egret	3
Estrilda astrild	Common waxbill	1
Francolinus francolinus	Black francolin	4
Fregata minor[1]	Great frigatebird; ʻiwa	2
Paroaria coronata	Red-crested cardinal	1
Pycnonotus cafer	Red-vented bulbul	1
Spilopelia chinensis	Spotted dove	2
1. Species protected by the MBTA.		

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 and visitors with the information they need to be able to respond appropriately in the event they observe a listed species or encounter downed wildlife while on site. Fourteen individual WEOP trainings were conducted in FY 2025.

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 HCP and HCP Amendment. As stated above, the Project is currently in the Tier 4 take level.

During FY 2025, acoustic bat surveys continued at the Project (see Section 8.1.1) and management activities for Tier 1 mitigation continued at ʻUkoʻa Wetland (see Section 8.1.2). Mitigation for Tiers 2 through 4 is complete. Bat research projects for Tiers 2/3 mitigation were completed in FY 2022 (see Section 8.1.3), and funds were previously provided toward the acquisition of Waimea Native Forest to fulfill remaining obligations for Tier 3 (see Section 8.1.4). Tier 4 mitigation was completed in FY 2019 with the acquisition and long-term protection of Helemano Wilderness Area (see Section 8.1.5). 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 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 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 3). 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 (hereafter referred to as SM2) equipped with one SMX-U1 ultrasonic microphone (Wildlife Acoustics, Maynard, MA, USA) positioned 6.5 meters above ground level.

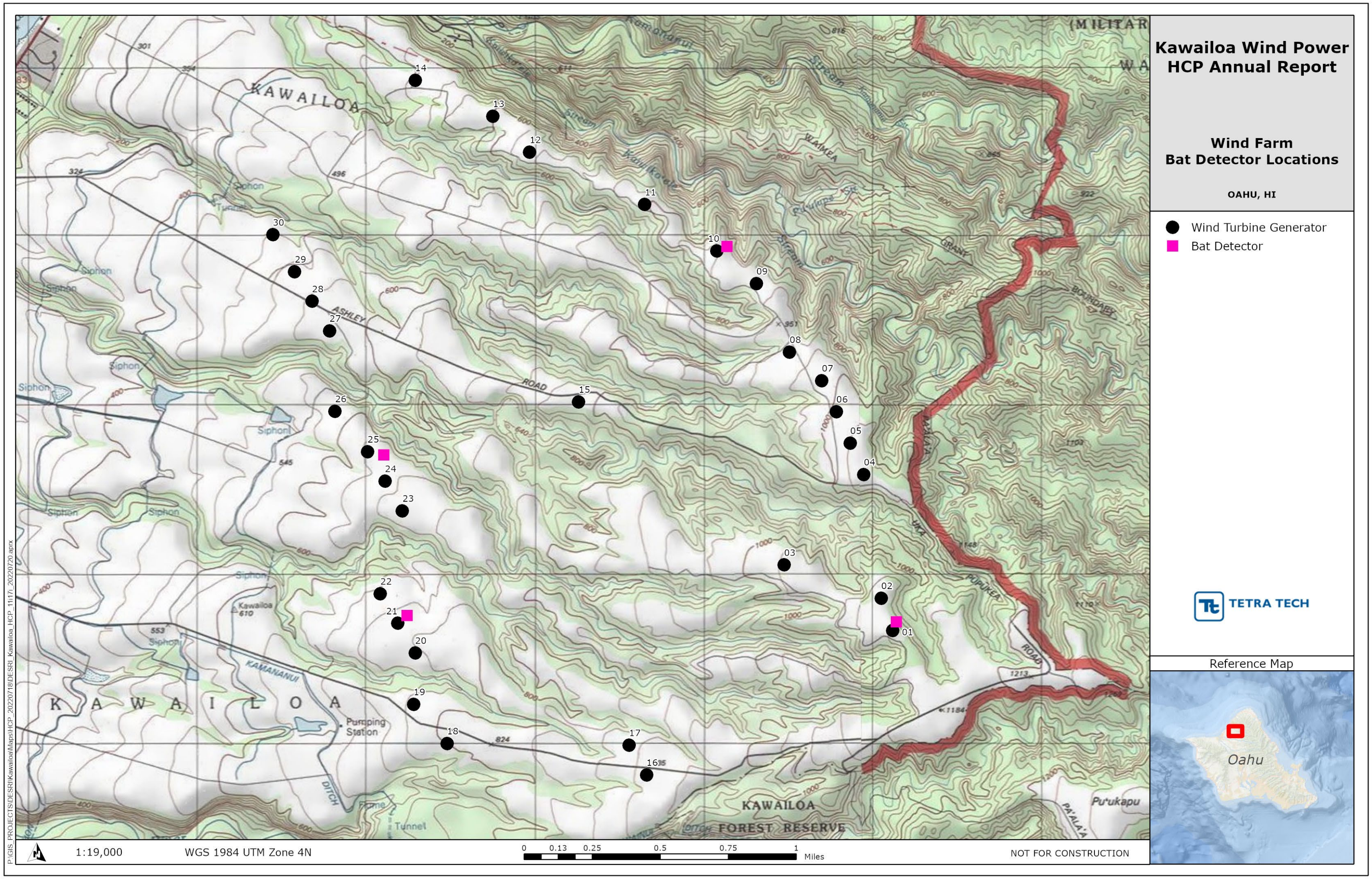

Figure 3. Four Permanent Bat Acoustic Detector Locations at the Project in FY 2025

The objective of 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 2025 Bat Sampling Periods and between monitoring sites. A linear model (LM) was used to test for a change in detection rates across all monitoring years. 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 4.4.2 (R Core Team 2024). The characterization of Hawaiian hoary bat seasons corresponds approximately to Gorresen et al. (2013).

Hawaiian hoary bats were detected on 337 of 1,392 detector-nights during the 2025 Bat Sampling Period (June 2024 – May 2025), corresponding to a 24.2 percent detection rate (Table 9). Although this was slightly lower than the 2024 Bat Sampling Period detection rate (25.3 percent), the difference was not statistically significant (Tukey's HSD: $P = 1.000$). Annual detection rates recorded during post-construction monitoring periods (2014 –2025 Bat Sampling Periods) showed variation among years. Significant differences were observed specifically between 2014 and 2019 ($P < 0.027$), 2014 and 2021 ($P < 0.048$), 2014 and 2022 ($P < 0.034$), and 2014 and 2024 ($P < 0.007$) (ANOVA: $F_{11, 130} = 2.93$, $P < 0.002$).

Table 9. Number of Nights Sampled, Number of Nights with Detections, and Proportion of Nights with Bat Detections at Permanent Detectors from June 2013 through May 2025

Bat Sampling Period	No. of Nights Sampled	No. of Nights with Detections	Proportion of Nights with Detections
FY 2014 (June 2013 — May 2014)	1,211	82	0.068
FY 2015 (June 2014 — May 2015)	1,021	144	0.141
FY 2016 (June 2015 — May 2016)	1,321	213	0.161
FY 2017 (June 2016 — May 2017)	1,355	180	0.133
FY 2018 (June 2017 — May 2018)	1,451	280	0.193
FY 2019 (June 2018 — May 2019)	1,249	300	0.240
FY 2020 (June 2019 — May 2020)	1,272	169	0.133
FY 2021 (June 2020 — May 2021)	1,437	298	0.207
FY 2022 (June 2021 — May 2022)	1,217	266	0.219
FY 2023 (June 2022 — May 2023)	1,451	248	0.171
FY 2024 (June 2023 - May 2024)	1,285	325	0.253
FY 2025 (June 2024 - May 2025)	1,392	337	0.242
Note: FY 2013 not included due to minimal number of detector-nights compared to other years.			

Across all monitoring years, there is a significant increasing trend in the annual detection rates (LM: R^2 = 12.44 percent; $F_{1,140}$ = 19.89, P < 0.001; Figure 4). Even if the 2014 Bat Sampling Period is excluded, the trend remained significant (R^2 = 6.28 percent; $F_{1,128}$ = 8.58, P < 0.004), indicating that bat activity has increased over time, although much of the variation remains unexplained by year alone.

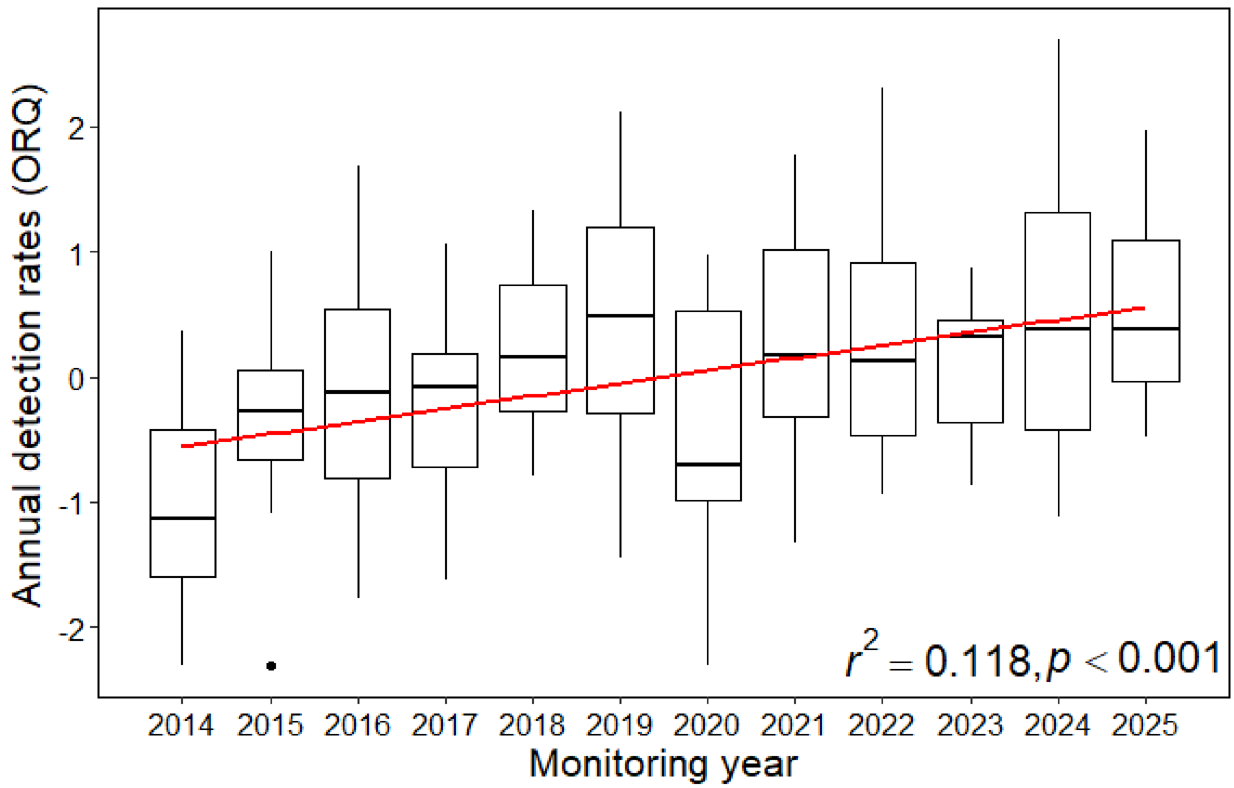

Figure 4. Box-plot Fitted with a Linear Regression Showing the Increasing Trend in the Annual Detection Rate at the Project between 2014 and 2025 Bat Sampling Periods

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

Monthly detection rates during the 2025 Bat Sampling Period were characterized by a peak in activity during the mid lactation reproductive period (July), followed by a decline through the late lactation and post-lactation reproductive periods (August to November). Detection rates reached their lowest in November during the post-lactation reproductive period and then increased at the cusp of the post-lactation and pre-pregnancy reproductive periods (mid-December). A smaller peak observed in February during the pre-pregnancy reproductive period, and then detections increased in April and May of the pregnancy reproductive period (Figure 5).

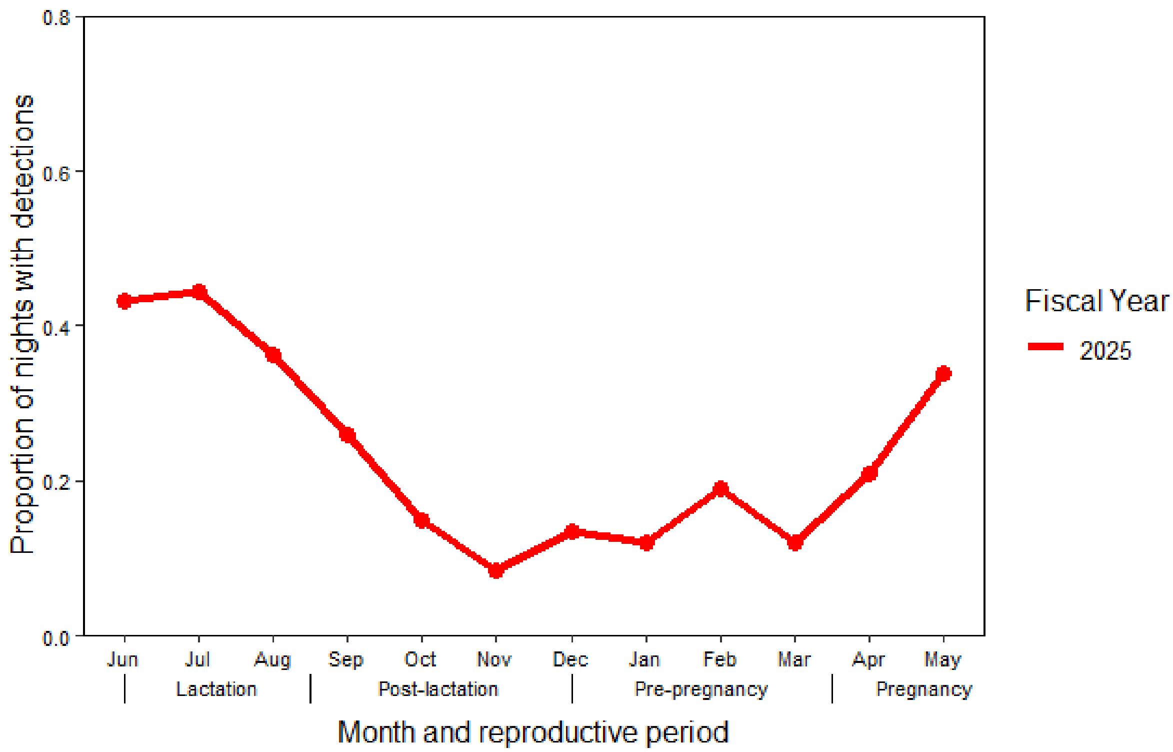

Figure 5. Monthly Detection Rates at Kawailoa in 2025 Bat Sampling Period with Corresponding Reproductive Periods

The seasonal patterns in detection rates during the 2025 Bat Sampling Period were relatively similar to detection rates observed in previous years (Figure 6), suggesting relatively stable seasonal dynamics in bat activity at the Project site. Similar patterns have been documented at other low elevation acoustic monitoring sites on O‘ahu (Thompson and Starcevich 2022) and Hawai‘i Island (Todd 2012).

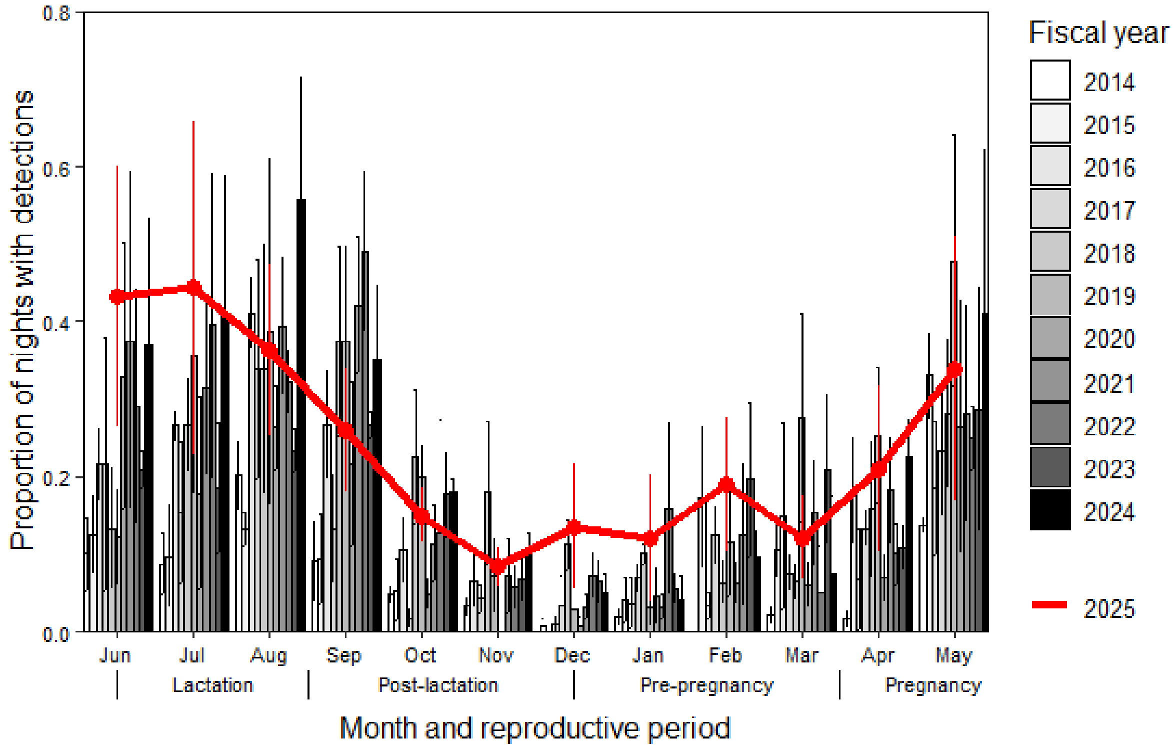

Figure 6. Monthly Bat Detection Rates at Kawailoa for 2014 to 2025 Sampling Periods with Corresponding Reproductive Periods

Across all monitoring years, the seasonal pattern in mean detection rates were relatively similar among the four permanent monitoring sites (Figure 7). A pairwise comparison (Tukey's HSD) indicated detection rates were significantly higher at WTG-25 (ANOVA: $F_{3,505} = 11.78$, $P < 0.001$). In June, WTG-25 had significantly higher detection rates than WTG-1 ($P < 0.001$), WTG-10 ($P < 0.005$), and WTG-21 ($P < 0.001$). In July, detection rates were significantly greater at WTG-25 compared to WTG-1 ($P < 0.048$) and WTG-21 ($P < 0.027$). In August ($P < 0.051$), November ($P < 0.049$), and again in May ($P < 0.003$) detection rates were higher at WTG-25 than WTG-1. These site-specific differences in mean detection rates may reflect variation in local habitat features, bat movement patterns, or resource availability across the four monitoring locations.

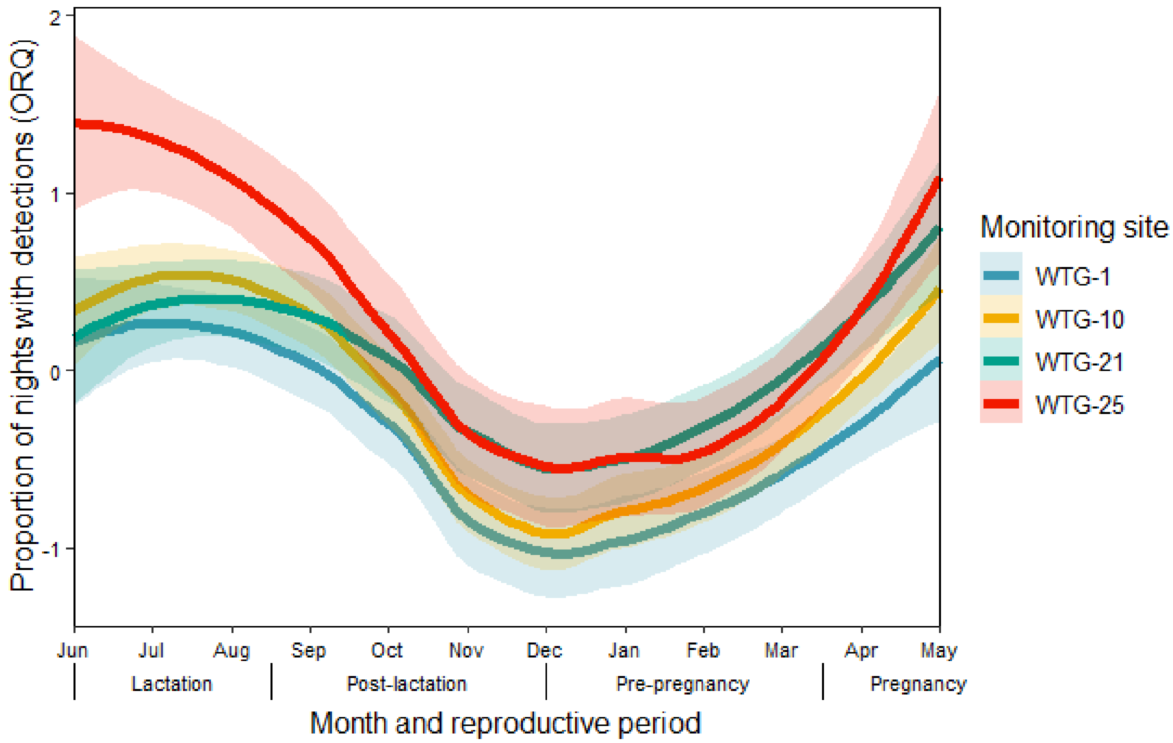

Figure 7. Site-Specific Variation in Mean Detection Rates for Each Month with Corresponding Reproductive Periods.

Note: Trend Lines are fitted with Loess smoothing curve; see Figure 3 for spatial context.

8.1.2 ʻUkoʻa Wetland (Tier 1)

Mitigation for bats and waterbirds continued at ʻUkoʻa Wetland during FY 2025. In FY 2016 (March 2016), USFWS and DOFAW provided written confirmation permitting adaptive management for the original bat and waterbird mitigation proposed at ʻUkoʻa 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 ʻUkoʻa 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 2025, activities associated with Tier 1 bat mitigation at ʻUkoʻa Wetland included invasive vegetation removal, predator control, monitoring predator presence, fence monitoring and maintenance, and bat lane maintenance. Additional details for each are provided below.

8.1.2.1 Invasive Vegetation Removal

In FY 2025, quarterly maintenance was conducted to remove invasive vegetation within the previously cleared, open water area of ʻUkoʻa Wetland. Plant species controlled include water hyacinth (*Eichhornia crassipes*), California grass (*Urochloa mutica*), ʻakaʻakai or bulrush (*Schoenoplectus* spp.), and broadleaf cattail (*Typha latifolia*). This work was conducted by either Hapa Landscaping or Kuahiwi Fencing and Wildlife Services in FY 2025. Quarterly scheduled visits were modified as needed to accommodate staff schedules and avoid disturbing Hawaiian common gallinule/ʻalae ʻula (*Gallinula galeata sandvicensis*) and Hawaiian coot/ ʻalae keʻokeʻo (*Fulica alai*) nests or chicks in the area. Figure 8 shows a representative photograph of the open water that resulted from this ongoing maintenance.

Figure 8. Open Water Resulting from Ongoing Removal of Invasive Vegetation at ʻUkoʻa Wetland in FY 2025.

Note: Photo Taken in May 2025.

8.1.2.2 Predator Control and Monitoring Predator Presence

The Project contracts 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 following trap types are used throughout ʻUkoʻa Wetland in FY 2025: pig corrals, pig box traps, and Doc-250s. The number and type of predators trapped at ʻUkoʻa Wetland from FY 2014 to FY 2025 is shown in Table 10. In FY 2025, a total of 171 predators were removed from ʻUkoʻa Wetland including 40 pigs, 105 mongoose, and 26 rats (Grey Boar 2024a, Grey Boar 2024b, Grey Boar 2025a, Grey Boar 2025b).

Tracking tunnels are generally set out quarterly to assess the presence of rodents, mongoose, and cats within the wetland. In FY 2025, tracking tunnels were set out in July, September, and December 2024 and in March and June 2025, with 24 to 25 tracking tunnels placed during each event. The cards were baited with peanut butter 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 2025 is shown in Table 11. Overall, tracking tunnel data since 2014 (see Figure 9) shows a general reduction in predator presence since the predator program was initiated.

Table 10. Predators Trapped at ʻUkoʻa Wetland from FY 2014 to FY 2025

Fiscal Year	Predator						
	Rats	Cats	Mongoose	Mice	Pigs	Dogs	Total Removed
FY 2014[1]	30	15	224	21	51	0	**341**
FY 2015	92	22	190	23	56	0	**383**
FY 2016[2]	77	7	204	6	20	0	**314**
FY 2017[2]	18	2	96	1	103	0	**220**
FY 2018	24	10	160	3	29	1	**227**
FY 2019	12	2	136	0	42	0	**192**
FY 2020	25	3	168	0	7	0	**203**
FY 2021	35	2	173	0	9	0	**219**
FY 2022	23	0	105	0	48	0	**176**
FY 2023	16	1	79	0	23	0	**119**
FY 2024	16	0	95	0	27	0	**138**
FY 2025	26	0	105	0	40	0	**171**

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.

Table 11. Percent Predator Activity Based on Tracking Tunnels at ʻUkoʻa Wetland during FY 2025

Date	Rats	Mongoose	Mice	Cats
July 14, 2024	14.8%	0.0%	9.0%	0.0%
September 28, 2024	11.1%	4.0%	4.0%	0.0%
December 15, 2024	16.7%	0.0%	4.2%	0.0%
March 16, 2025	25.0%	0.0%	12.5%	0.0%
June 15, 2025	8.3%	0.0%	8.3%	0.0%

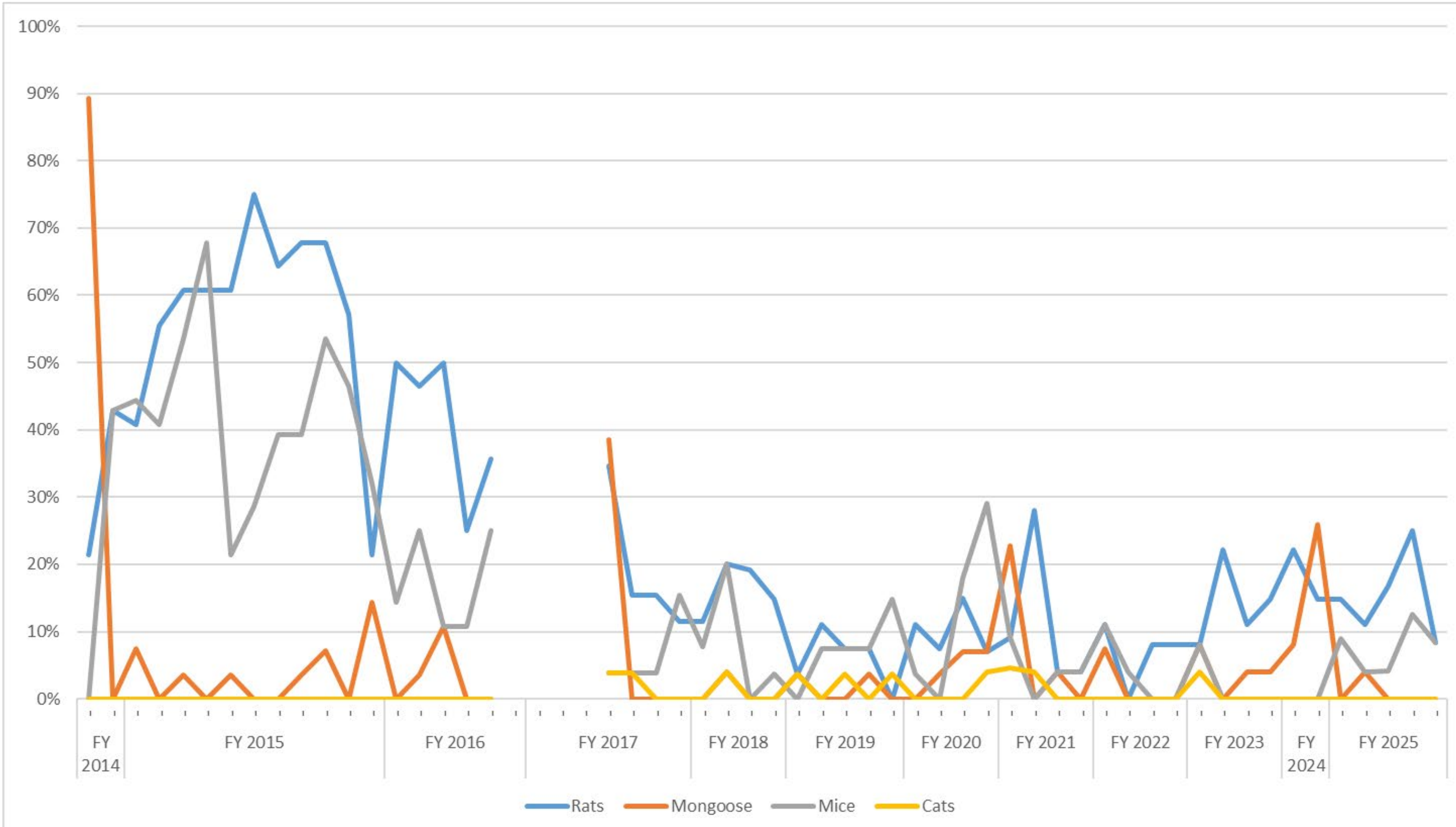

Figure 9. Percent Activity of Tracking Tunnels from FY 2014 to FY 2025

Source: Grey Boar 2025b.

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 2025, no sections of fence of the fence were in need of repair.

8.1.2.4 Bat Lanes

Bat lane construction was completed in December 2017 (FY 2018). During FY 2025, bat lane maintenance occurred on six lanes in November and December 2024. Figure 10 shows an example of a bat lane following the maintenance visits in FY 2025. In total, there are 16 bat lanes within 10 zones throughout ʻUkoʻa Wetland (Figure 11). No maintenance occurred on the other 10 bat lanes in FY 2025 since they were last trimmed in May 2024 and no additional maintenance was needed.

Figure 10. Bat Lane at ʻUkoʻa Wetland

Note: Photo taken in November 2024.

Figure 11. Bat Lane Locations at ʻUkoʻa Wetland

8.1.2.5 Bat Acoustic Surveys

Per the HCP, assessing bat activity at the mitigation site is required for three years post-restoration, and at subsequent five-year intervals. The Project has nearly 7 years of post-restoration bat acoustic data at ʻUkoʻa Wetland (June 2017 to May 2024). Acoustic monitoring was suspended at ʻUkoʻa Wetland on June 1, 2024, and is planned to resume in 2029.

8.1.3 Studies (Tier 2/3)

In FY 2017, Kawailoa Wind contracted USGS and Western EcoSystems Technology, Inc. (WEST) 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 was over $1.6 million. All three agency-approved research projects have been completed. Several publications, data releases, presentations have been made available from the USGS projects (Gorresen et al. 2018, Pinzari et al. 2023) and WEST project (Thompson and Starcevich 2022). Kawailoa also provided an additional $10,000 to WEST in FY 2023 to support continued monitoring of a subset of the deployed detectors during a fifth year of their *Oahu Hawaiian Hoary Bat Occupancy and Distribution Study*. This funding was outside the Tier 2/3 mitigation obligations, which were complete in FY 2022.

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 the Trust for Public Land (TPL) in 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; therefore, Tier 3 Hawaiian hoary bat mitigation is complete.

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 provided these funds to TPL in October 2018, and ownership of the HWA was transferred from TPL to DOFAW in 2018. The area became the Helemano Section of the ʻEwa Forest Reserve in March 2021, and a draft management plan was completed; therefore, Tier 4 Hawaiian hoary bat mitigation is complete. In FY 2025, DOFAW conducted the following: performed road maintenance and road repair; controlled vegetation along road corridors; fence maintenance; maintained five acres in the koa (*Acacia koa*) wilt-resistant koa seed orchard; cleared 5 acres of invasive species to prepare for native planting; and continued to work with contractors and the community to write a Forest Management Plan (Ryan Peralta/DOFAW, pers. comm., June 2025).

8.1.6 Tier 5 Mitigation

As outlined in the HCP Amendment, Tier 5 bat mitigation will consist 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 in the Central Koʻolau area, HWA, Waimea Native Forest, or similar sites (Tetra Tech 2019). In accordance with the mitigation planning requirements under the HCP Amendment, a Site-Specific Mitigation Implementation Plan for Tier 5 mitigation was submitted to USFWS and DOFAW on May 1, 2020; however, current results and projections suggest the Project is likely to remain within Tier 4 for the permit term (see Section 6.1). If Tier 4 take limit is exceeded, take is expected to stay well below the Tier 5 maximum. Therefore, Kawailoa Wind is considering the potential need to adjust the Tier 5 limit to accommodate the observed reduction in take rate. Kawailoa Wind is also currently working to identify potential acquisition options or land management sites based on recent agency requirements in the event Tier 5 bat mitigation should be required during the Project's permit term.

8.2 Waterbirds

As stated above, USFWS and DOFAW provided written confirmation permitting adaptive management for the original waterbird mitigation. Some activities completed for waterbird mitigation at ʻUkoʻa Wetland (e.g., invasive vegetation removal, predator control, fence maintenance) overlap with bat mitigation requirements and are summarized in Section 8.1.2 above.

Tetra Tech conducts waterbird surveys at ʻUkoʻa Wetland as part of the required mitigation. Comprehensive weekly waterbird surveys began at ʻUkoʻa Wetland in January 2017 following invasive vegetation removal in the open water area and have continued annually throughout FY 2025. In FY 2025, waterbird surveys were conducted weekly from July 2024 through August 2024, and then again from December 2024 through June 2025. A total of 40 waterbird surveys were completed in FY 2025. 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 12). Independent waterbird observations are also recorded while walking between stations. The detailed protocols for these surveys are provided in the FY 2017 Annual Report (Tetra Tech 2017).

In addition to the weekly surveys, a biologist conducts waterbird surveys prior to any invasive vegetation control (see Section 8.1.2.1). The purpose of these surveys is to identify if listed waterbird nests or chicks are present in the vicinity of the planned work area. If present, work is modified to avoid and minimize impacts to endangered Hawaiian waterbirds.

Results of the waterbird monitoring are detailed in the sections below. Waterbirds at ʻUkoʻa Wetland are not banded; therefore, assessments of changes on an individual basis are not possible. During FY 2025, Tetra Tech recorded the first documented breeding events for Hawaiian stilt/aeʻo (*Himantopus mexicanus knudseni*) and Hawaiian coot/ʻalae keʻokeʻo (*Fulica alai*) at ʻUkoʻa Wetland. Although Kawailoa Wind has been in discussion with USFWS and DOFAW regarding adaptive management of waterbird mitigation (including switching mitigation sites), these new events are promising and Kawailoa is planning to continue monitoring and managing for waterbirds at ʻUkoʻa Wetland for the remainder of the calendar year. However, considering no waterbird take has been recorded at Kawailoa to date, the Project is still considering reducing the take authorization for waterbirds and is currently in discussions with USFWS and DOFAW. The total number of fledglings produced at ʻUkoʻa, and the total number of fledglings required per the HCP are summarized in Table 12.

Table 12. Number of Listed Waterbirds Fledged at ʻUkoʻa Wetland

Species	Total No. Fledged at ʻUkoʻa	ITP/ITL Fledgling Replacement Requirement
Hawaiian common gallinule; ʻalae ʻula	17	20
Hawaiian coot; ʻalae keʻokeʻo	0[1]	24
Hawaiian stilt; aeʻo	1	20
1. The final outcome of the Hawaiian coot chicks had not been determined at the end of FY 2025.		

8.2.1 Hawaiian Common Gallinule

In FY 2025, Hawaiian gallinules (either adults, chicks, or fledglings) were observed on every survey date and were recorded at all nine PC stations (see Figure 12). Average monthly gallinule detections for FY 2025 are summarized in Table 13 and shown in Figure 13 and Figure 14.

Gallinule detections began to increase in FY 2022 compared to the low detections in FY 2020 and FY 2021. Detections in FY 2025 were similar to those observed in FY 2022 through FY 2024 (Table 13). Table 13 also summarizes the number of observed gallinule breeding efforts since FY 2017. No gallinule breeding events were observed in FY 2025. The outcome of the second breeding event in FY 2024, observed in early June 2024, was determined to be a failure in FY 2025. All gallinule breeding observed during the last 6 years has been along the open water areas (PC 01, 03, 08). In total, 17 Hawaiian gallinule fledglings have been recorded since surveys began in FY 2017. Although no waterbird take has been recorded at Kawailoa to date, the Project is required to replace 20 gallinule fledglings.

Figure 12. Waterbird Point-Count Station Locations at 'Uko'a Wetland

Table 13. Summary of Hawaiian Common Gallinule Detections and Breeding Events 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	No. of Breeding Efforts Observed	No. of Failed Breeding Efforts Observed	Total No. Fledged
FY 2017 (Aug 2016 – Dec 2016)[1]	N/A	N/A	N/A	N/A	3	0	5
FY 2017 (Jan 2017 – June 2017)	25	5.7	0.8	1.0	4	2	3
FY 2018 (July 2017 – June 2018)	38	4.1	0.4	0.0	6	6	0
FY 2019 (July 2018 – June 2019)	41	3.0	0.4	0.0	4	4	0
FY 2020 (July 2019 – June 2020)	40	1.9	0.1	0.0	3	3	0
FY 2021 (July 2020 – June 2021)	40	1.9	0.4	0.1	1	0	1
FY 2022 (July 2021 – June 2022)	38	3.0	0.4	0.3	2	0	4
FY 2023 (July 2022 – June 2023)	39	5.3	0.5	0.3	2	0	2
FY 2024 (July 2023 – June 2024)	39	4.3	0.3	0.2	2	1	2
FY 2025 (July 2024 – June 2025)	40	4.8	0	0.2	0	N/A	0
Total No. Hawaiian Common Gallinule Fledglings							**17**

1. FY 2017 is divided into 2 parts because comprehensive waterbird surveys at PC stations began in January 2017 and detections in late 2016 were incidental to other monitoring that occurred during vegetation removal in the open water areas.

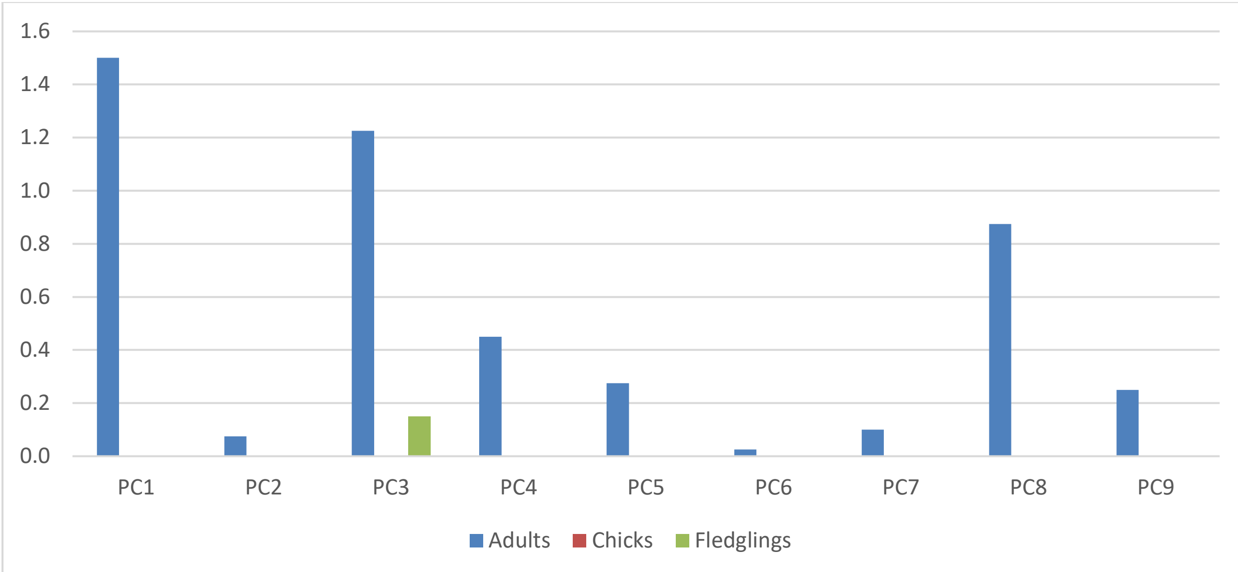

Figure 13. Average Number of Hawaiian Common Gallinule Detections per Survey at Point-Count Stations in FY 2025

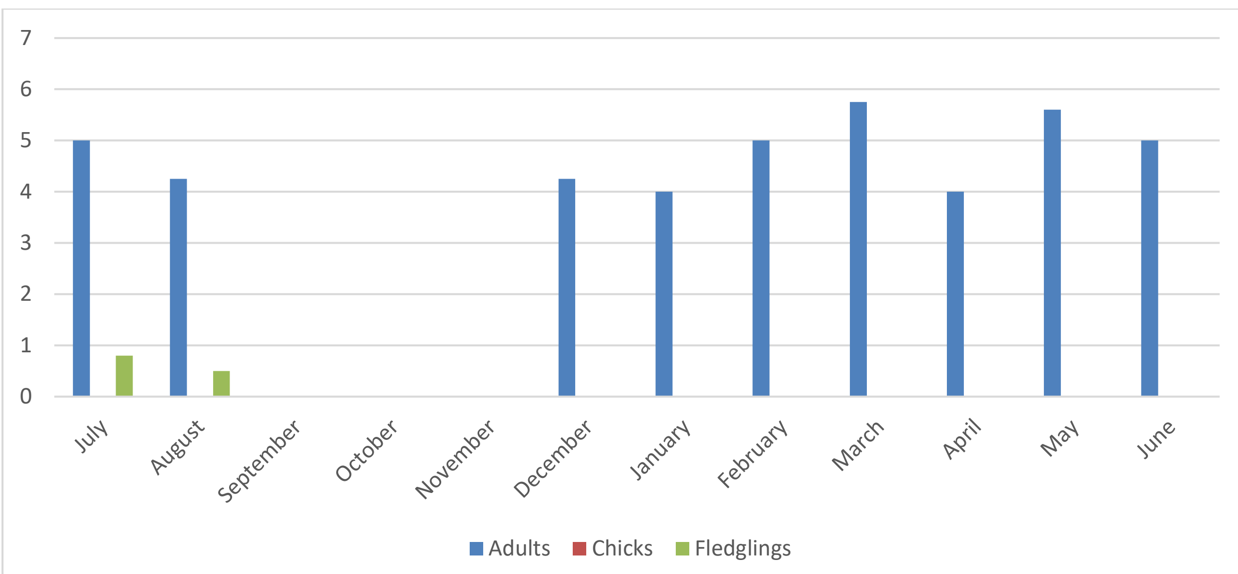

Figure 14. Average Number of Hawaiian Common Gallinule Detections per Survey by Month in FY 2025

Note: Weekly surveys are not conducted in September, October, and November.

8.2.2 *Hawaiian Stilt*

In FY 2025, Hawaiian stilts were observed on 23 of the 40 survey dates, with the majority of the observations being recorded at PC stations 4 and 5 (see Figure 12). Average monthly stilt detections for FY 2025 are summarized in Figure 15. As shown in Table 14, Hawaiian stilt detections began to increase starting in FY 2023 in comparison to the previous four fiscal years. Although the number of Hawaiian stilt individuals recorded continues to be low, the average number of adults detected per survey and proportion with at least one detection was relatively high in FY 2024 and 2025 compared to previous years.

Although no stilt nests were seen at ʻUkoʻa Wetland, a juvenile stilt (between 5 to 8 weeks old) was observed near PC 4 on August 8, 2024. This is the first juvenile Hawaiian stilt observed at ʻUkoʻa Wetland since surveys began in January 2017. Based on the age of the bird, the habitat present, and the consistent territorial behavior demonstrated by the adult pair of Hawaiian stilt for the two months prior, it is believed that this juvenile fledged from ʻUkoʻa Wetland. No take of Hawaiian stilts has been recorded at Kawailoa to date; however, the Project is required to replace 24 stilt fledglings.

Table 14. Summary of Hawaiian Stilt Detections and Breeding Events by Fiscal Year

Sampling Period	No. of Surveys	Average No. of Adults Detected per Survey	Proportion of Surveys with at Least One Detection	No. of Breeding Efforts Observed	Total No. Fledged
FY 2017 (January 2017 – June 2017)	25	0.68	0.24	0	0
FY 2018 (July 2017 – June 2018)	38	0.71	0.29	0	0
FY 2019 (July 2018 – June 2019)	41	0.15	0.05	0	0
FY 2020 (July 2019 – June 2020)	40	0.13	0.07	0	0
FY 2021 (July 2020 – June 2021)	40	0.00	0.00	0	0
FY 2022 (July 2021 – June 2022)	38	0.05	0.03	0	0
FY 2023 (July 2022 – June 2023)	39	0.85	0.33	0	0
FY 2024 (July 2023 – June 2024)	39	1.67	0.80	0	0
FY 2025 (July 2024 – June 2025)	40	1.20	0.58	0	1

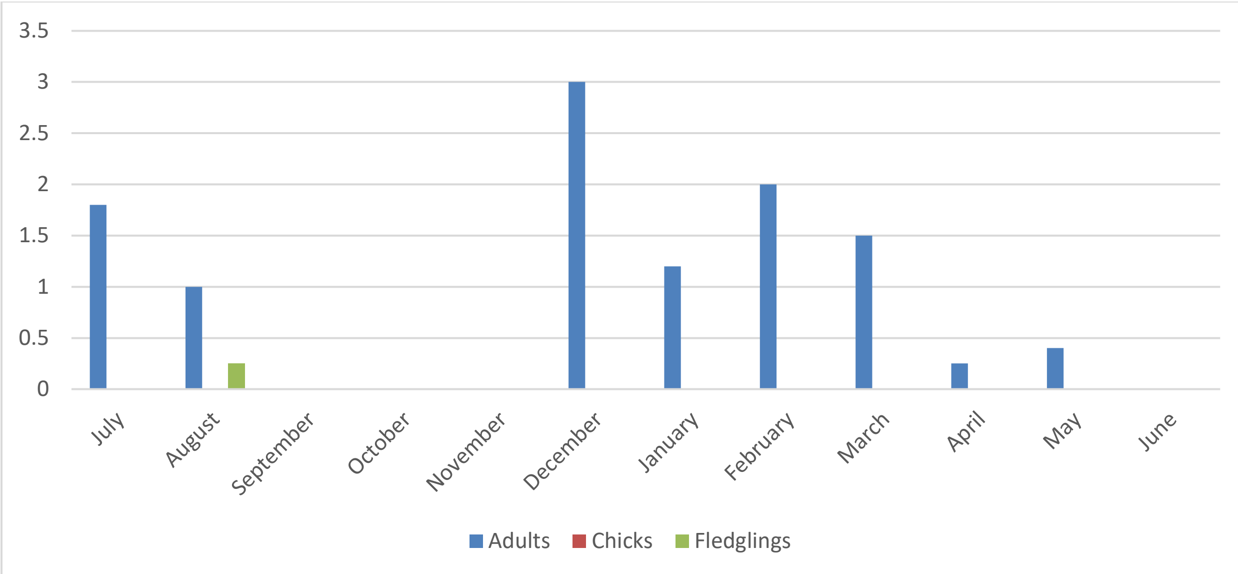

Figure 15. Average Number of Hawaiian Stilt Detections per Survey by Month in FY 2025

Note: Surveys are not conducted in September, October, and November.

8.2.3 Hawaiian Coot

During FY 2025, Hawaiian coots were observed at ʻUkoʻa Wetland for the first time since 2017. Hawaiian coots were observed on 27 of the 40 survey dates with all observations recorded in the open water areas near PC stations 1, 3, and 8 (see Figure 12). A single Hawaiian coot was first observed in August 2024 and then again from December 2024 through March 2025. A second Hawaiian coot was observed at ʻUkoʻa Wetland in April 2025. A Hawaiian coot nest was observed near PC 3 in bulrush (*Schoenoplectus* sp.) on May 29, 2025. On June 9, 2025, 3 eggs and 2 coot chicks were observed in the nest, and three chicks were observed on June 17, 2025. At the end of FY 2025, two Hawaiian coot chicks remained with their parents at ʻUkoʻa Wetland. The final outcome of this breeding effort will be monitored weekly until the chicks fledge or it is determined the chicks did not survive. Although no waterbird take has been recorded at Kawailoa to date, the Project is required to replace 20 coot fledglings.

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 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. Final reports from Kauaʻi Endangered Seabird Recovery Project (Raine et al. 2020) and Hallux Ecosystem Restoration LLC (Dutcher and Pias 2021) for this mitigation project were included in the FY 2021 Annual Report. The reports confirmed Kawailoa Wind's mitigation obligations for the Hawaiian petrel are complete.

8.4 Hawaiian Short-eared Owls or Pueo

Mitigation for the Hawaiian short-eared owl/pueo was completed in FY 2017.

9.0 Other Compliance Items

In response to a contested case settlement, Kawailoa Wind provided $250,000 to Pacific Rim Conservation in FY 2022 to carry out research related to Hawaiian petrels on Oʻahu. The goal of this research project is to determine whether Hawaiian petrels detected in previous surveys are prospecting or breeding on Oʻahu. Pacific Rim Conservation is conducting ground searches and auditory surveys, as well as deploying automated acoustic recording units, to accomplish this goal. The funds from Kawailoa Wind were used for the 2024 breeding season and will also be used for the 2025 breeding season.[3] No Hawaiian petrel vocalizations or nests were found on Oʻahu during the 2024 breeding season (Pacific Rim Conservation 2025).

10.0 Adaptive Management

Kawailoa Wind is committed to the ongoing implementation of operational avoidance and minimization measures described in the 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 actions 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, supporting development of the latest technologies that could reduce WTG collision risk to bats, and installing acoustic deterrents. Details on the Project's adaptive management actions are provided in previous annual reports (Tetra Tech 2018, Tetra Tech 2019, Tetra Tech 2020, Tetra Tech 2021, Tetra Tech 2022, Tetra Tech 2023, Tetra Tech 2024) and the HCP Amendment (Tetra Tech 2019).

[3] Pacific Rim has stated that the funds provided by Kawailoa Wind in October 2021 were applied to the 2021 season, and 2025 is the last year of this 5-year monitoring project (E. VanderWerf, pers. comm., March 2025).

As outlined in the FY 2021 Kawailoa Annual Report (Tetra Tech 2021), Kawailoa Wind returned to a 10-minute rolling average on April 3, 2021. The Project continued to operate under the 10-minute rolling average LWSC regime for all of FY 2025.

Kawailoa Wind was the first wind facility in Hawaiʻi to install acoustic deterrents. Ultrasonic acoustic deterrents (UAD), designed by NRG Systems, were installed at all 30 Project WTGs in May and June 2019. Each bat deterrent system consists of five deterrent units (DU) installed in a star shaped pattern around the nacelle of the WTG, and a single deterrent unit controller (DUC). Each DU consists of six subarray speakers that emit sound at different frequencies and decibel levels. The DU are connected via cables to the DUC which powers, sets schedules, and communicates the status of the system. Each DUC performs comprehensive built-in tests that provide an indication of DU and DUC health including tests of DUC to DU connectivity and communications, the health of each DU subarray, and the status and potential fault information for the DUC and all connected DU. Deterrent functionality is monitored remotely to ensure the systems are operating properly. Deterrent system components that are identified as underperforming are replaced as soon as possible based on manufacturer recommendations. Since each WTG is installed with five DUs, there is an 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 Systems work together to install replacements as quickly as feasible. Based on data provided by NRG Systems, the total sitewide deterrent availability for the Project was 93.3 percent in FY 2025. Additional information on NRG's bat deterrent system is provided on their website (NRG Systems 2025).

11.0 Collection Permits

Annual reports for the Project's federal and state collection permits were submitted in Q2 of FY 2025. The USFWS special purpose utility permit (MB22099C) expired March 31, 2025, and a renewal application was submitted on February 27, 2025. As of the end of FY 2025, the renewal application for the special purpose utility permit was still under review by USFWS. The State's Protected Wildlife Permit (Permit No. WL23-15) expired on February 10, 2025, and a renewal application was submitted on November 4, 2024. A renewed Protected Wildlife Permit was issued by DOFAW on June 26, 2025.

12.0 Agency Meetings, Consultations, and Visits

Kawailoa Wind and Tetra Tech participated in several meetings with USFWS and DOFAW staff in FY 2025, as well as one Endangered Species Recovery Committee (ESRC) meeting. This included the following:

- July 25, 2024 – Rho value working group with USFWS and DOFAW.
- October 23, 2024 – USFWS and DOFAW semi-annual meeting.
- March 3-4, 2025 – Informal meetings with DOFAW regarding potential alternative waterbird mitigating sites.
- March 6, 2025 – ESRC FY 2024 annual report review meeting.
- April 30, 2025 – USFWS and DOFAW semi-annual meeting.
- May 21, 2025 – Informal meeting with DOFAW regarding ESRC update on waterbirds.

13.0 Expenditures

Total HCP-related expenditures for the Project in FY 2025 were approximately **$578,680** (Table 15).

Table 15. Estimated HCP-Related Expenditures at the Project in FY 2025

Category	Amount
Permit Compliance	$144,400
Facility Vegetation Management	$185,000
Fatality Monitoring	$130,000
‘Uko‘a Wetland Mitigation Compliance	$117,685
Pacific Rim Seabird Research Coordination	$485
Tier 5 Bat Mitigation Preparation	$1,100
Total Cost for FY 2025	**$578,680**

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Appendix 1. Documented Fatalities at the Project during FY 2025

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Species[1]	Date Documented	WTG	Distance to WTG (meters)	Bearing from WTG (degrees)
Spilopelia chinensis (Spotted Dove)	7/9/2024	14	1	52
Estrilda astrild (Common Waxbill)	7/30/2024	8	1	30
Paroaria coronata (Red-Crested Cardinal)	8/1/2024	18	1	316
Pycnonotus cafer (Red-vented Bulbul)	8/15/2024	22	1	95
Fregata minor (Great Frigatebird)	8/19/2024	4	35	238
Ardea ibis (Western Cattle-Egret)	10/10/2024	17	4	45
Fregata minor (Great Frigatebird)	10/17/2024	20	39	305
Francolinus francolinus (Black Francolin)	2/4/2025	10	1	130
Ardea ibis (Western Cattle-Egret)	2/27/2025	22	5	90
Ardea ibis (Western Cattle-Egret)	3/7/2025	30	18	308
Spilopelia chinensis (Spotted Dove)	3/20/2025	16	1	280
Francolinus francolinus (Black Francolin)	4/24/2025	18	3	265
Francolinus francolinus (Black Francolin)	4/29/2025	13	32	300
Acridotheres tristis (Common Myna)	5/29/2025	20	66	65
Francolinus francolinus (Black Francolin)	6/10/25	14	1	280
1. Species protected by the MBTA are highlighted in gray. Species protected by the Endangered Species Act are highlighted in yellow (N/A in FY 2025).				

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Appendix 2.
Dalthorp et al. (2017) Fatality Estimation for Hawaiian Hoary Bats at the Project through FY 2025

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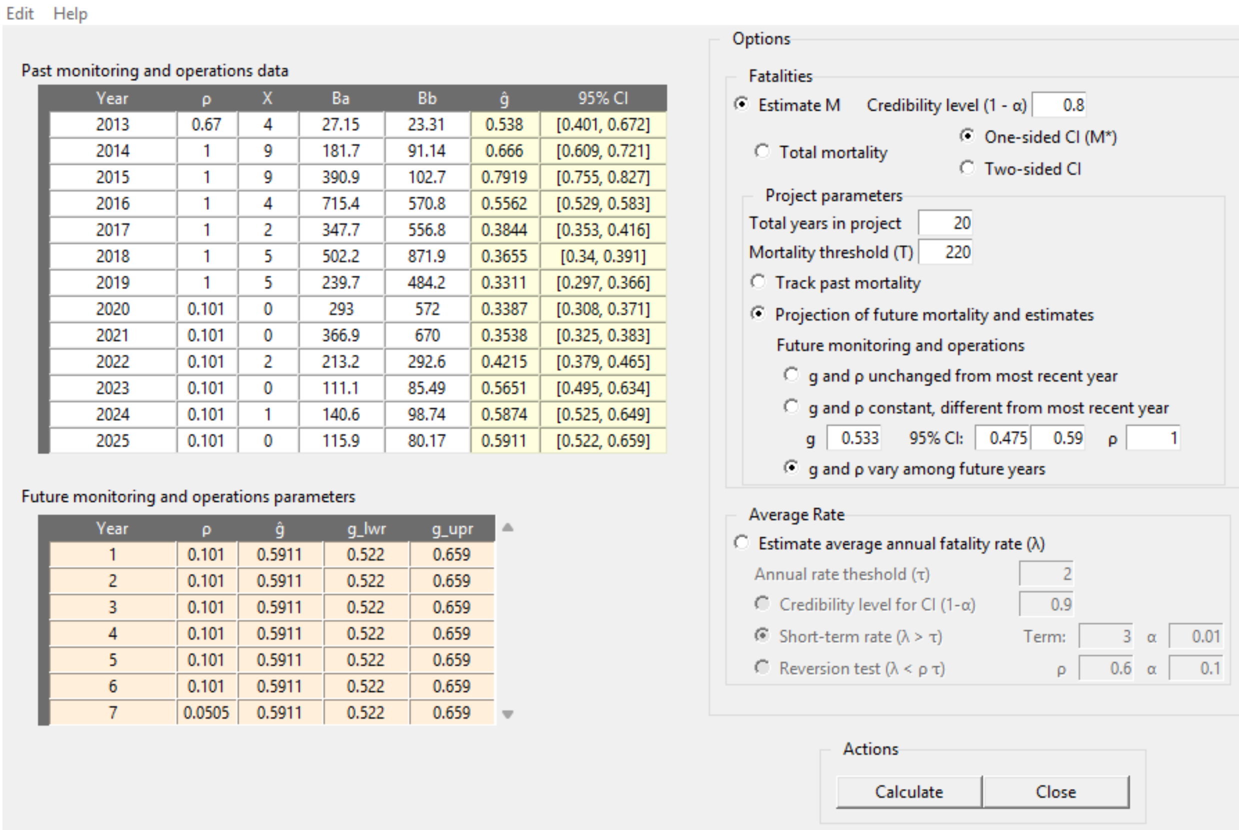

Past monitoring and operations data

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	0.101	0	293	572	0.3387	[0.308, 0.371]
2021	0.101	0	366.9	670	0.3538	[0.325, 0.383]
2022	0.101	2	213.2	292.6	0.4215	[0.379, 0.465]
2023	0.101	0	111.1	85.49	0.5651	[0.495, 0.634]
2024	0.101	1	140.6	98.74	0.5874	[0.525, 0.649]
2025	0.101	0	115.9	80.17	0.5911	[0.522, 0.659]

Future monitoring and operations parameters

Year	ρ	ĝ	g_lwr	g_upr
1	0.101	0.5911	0.522	0.659
2	0.101	0.5911	0.522	0.659
3	0.101	0.5911	0.522	0.659
4	0.101	0.5911	0.522	0.659
5	0.101	0.5911	0.522	0.659
6	0.101	0.5911	0.522	0.659
7	0.0505	0.5911	0.522	0.659

Figure 2-1. Dalthorp et al. (2017) Fatality Estimation for Hawaiian Hoary Bats at Project through FY 2025 with Rho Adjustment

Note: The methodology and calculation of the adjusted rho value is provided in Appendix 3 to the FY 2025 Annual Report.

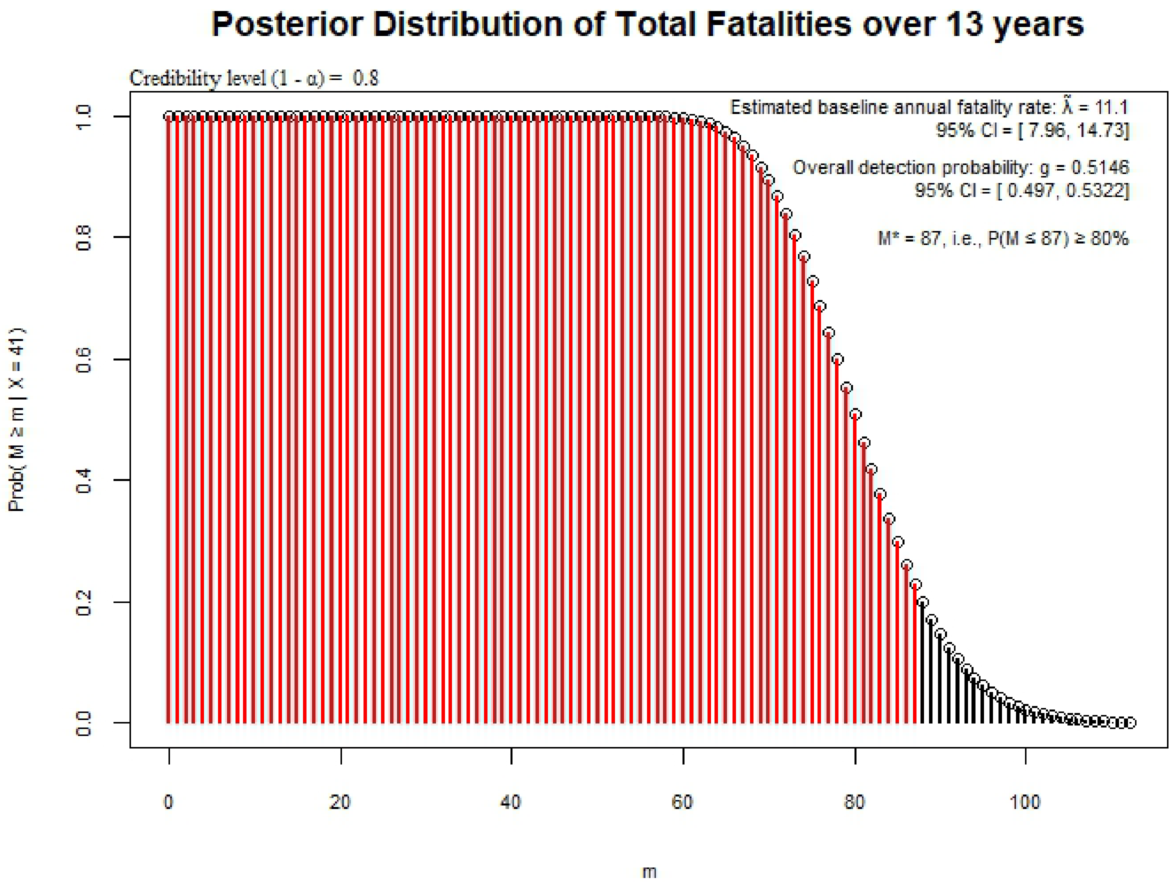

Figure 2-2. Posterior Distribution: Dalthorp et al. (2017) Fatality Estimation for Hawaiian Hoary Bats at Project for FY 2025 with Rho Adjustment

Note: The methodology and calculation of the adjusted rho value is provided in Appendix 3 to the FY 2025 Annual Report.

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Appendix 3.
Methodology for Demonstrating Bat Deterrent Effectiveness

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Appendix 3.
Methodology for Demonstrating Bat Deterrent Effectiveness

Prepared for the Kawailoa Wind Project Habitat Conservation Plan
FY 2025 Annual Report

Prepared by:
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July 2025

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Table of Contents

List of Tables

List of Figures

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1.0 Introduction

1.1 Background

In May and June 2019, Kawailoa Wind, LLC (Kawailoa Wind) installed ultrasonic acoustic deterrents (UADs) at all 30 wind turbine generators (WTGs) at the Kawailoa Wind Project (Project). The installation of UADs is correlated with a reduction in fatality rates for some mainland hoary bat species (Weaver et al. 2020) and was a minimization measure encouraged by U. S. Fish and Wildlife Service (USFWS) and Hawaiʻi Division of Forestry and Wildlife (DOFAW) to reduce the risk to Hawaiian hoary bats/ʻōpeʻapeʻa (*Lasiurus semotus*) at the Project. November 2012 to June 2019, which correlates with FY 2013 to 2019, represents the pre-UAD period at Kawailoa, and July 2019 to June 2025, which correlates with FY 2020 to 2025, represents the post-UAD installation period.

The effectiveness of UADs on the Hawaiian hoary bat is not yet known, but evidence from monitoring at the Project has indicated since FY 2020 that the Hawaiian hoary bat fatality rate is reduced at the Project after installation of UADs. In addition to UAD implementation, the Project implements low wind speed curtailment (LWSC) year-round at 5 meters per second (m/s) with a 0.2 m/s hysteresis to further reduce the risk to bats. The Project has operated under this LWSC regime since June 2018 (i.e., prior to installation of UADs).

The analysis presented in Section 2.0 uses six years of post-construction mortality monitoring data to confirm the Hawaiian hoary bat fatality rate is reduced at the Project after installation of UADs. In FY 2023, Kawailoa Wind hired DAPPER Stats to develop a statistical method to estimate the effectiveness of the deterrents (DAPPER Stats 2023). In June 2024, the USFWS agreed that the methodology could be applied to estimate the effectiveness of the deterrents at reducing risk to the Hawaiian hoary bat at the Project (Deena Gary/USFWS, pers. comm., June 2024).

1.2 Relevance to Fatality Estimation

The Evidence of Absence (EoA) software program incorporates a parameter called rho (ρ), which adjusts the expected fatality rate (lambda: λ). 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.[1] 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*

[1] Acknowledges risk is present for the Hawaiian hoary bat throughout the year without precisely estimating the relative risk (compared to a full year) during partial years of analysis.

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.

Tetra Tech initially used EoA to compare fatality rates and check for misspecification in rho. The fatality rates for each year are shown in Figure 1. To test if the rho value is appropriately specified before and after installation of UADs, pre-UAD years and post-UAD years were grouped as a single period in the multi-year module of EoA. 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.

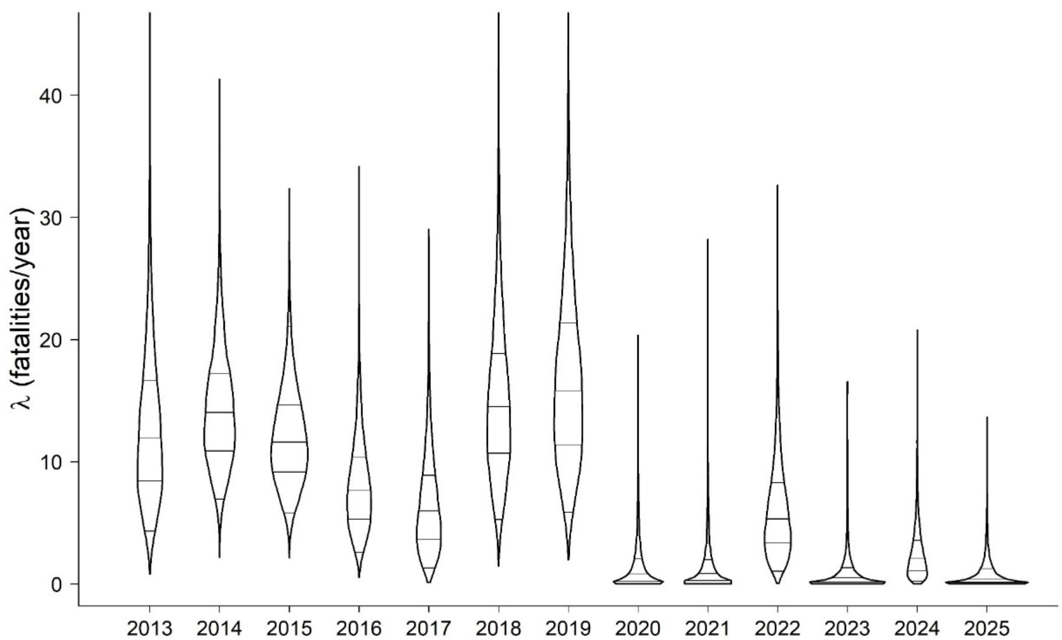

Figure 1. Year-based Distributions of Annual Fatality Rates (λ)

The methods outlined here represent the means by which the efficacy of the minimization measure can be confirmed, 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.

Following the determination that the minimization measure has been effective, 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, represent an unbiased estimate, and be updated annually to ensure new data are incorporated.

In March 2023, Kawailoa Wind provided the DAPPER Stats memo (DAPPER Stats 2023) and associated code in R v4.0.5 (R Core Team 2021) to the USFWS and Hawaiʻi DOFAW for review and recommended the incorporation of use of the greater of two potential measures for the impact of deterrents on annual fatality rates, or rho. The two estimates represent two distinct methodologies described in Section 2.0. The first approach is the composite approach in which all data for years of operations with UADs are combined and compared to the combined data for years of operations without UADs (analgous to the misspecification of rho test described earlier and demonstrating the benefit of the deterrents). The second approach (single year approach) compares individual years, thus accounting for among-year variance.

2.0 Methods for Estimating Rho for Deterrent Years

The following section describes the Bayesian approach used by DAPPER Stats (DAPPER Stats 2023) to estimate the effectiveness of bat deterrents at Kawailoa Wind Project in 2023. These methods have subsequently been applied each fiscal year to supplement the annual report and test for changes in rho each year. To distinguish between the EoA implementation of rho (ρ) and the Bayesian estimate of rho for this analysis, rho will henceforth be represented by δ. Both of these parameters (ρ and δ) measure the relative impact of bat deterrence on annual fatality rates (λ), but ρ will only be considered specifically in the context of EoA software.

The methods used to fit the EoA model framework are Bayesian and leverage Gibbs Sampling via JAGS (Just Another Gibbs Sampler; Plummer 2015) to estimate the posterior distribution of λ, given the observed carcasses (X) and fitted detection parameters ($\hat{g}$, Ba, Bb) for each year (Dalthorp et al. 2017). Bayesian posteriors are not processed under frequentist frameworks that, for example, seek to ask if distributions are "statistically significantly different" from each other at confidence level α. Rather, consistent with the Bayesian approach, detecting effects involve asking "how much do these λ distributions overlap?" and directly answering with a specific value, called the Overlap Coefficient (o) (Weitzman 1970, Jose et al. 2019, Simonis 2021). The relation of post-deterrence to pre-deterrence λ values is quantified using a ratio distribution for δ and asking "how much of that distribution lies at or above a value of 1.0? (equivalent pre- and post-deterrence λ distributions)."

A ratio distribution is created by taking the quotient of two distributions (Springer 1979), and this approach is used to evaluate the impact of deterrence on fatality rates. For example, the distribution for the fatality rate for year i (λ_i) divided by the distribution for the fatality rate for year j (λ_j) is the ratio distribution δ_{ij}, and therefore the Bayesian estimate for rho is the estimated impact of deterrents between years i and j:

$$\delta_{j,i} = \frac{\lambda_j}{\lambda_i}$$

In the situation where the two yearly distributions are equivalent ($\lambda_i \equiv \lambda_j$), the ratio distribution then has an expected value of 1.0 (Conner et al. 2016). In computing the ratio distribution, a Monte Carlo approach repeatedly draws from the posterior distributions for the respective yearly λ's (multiple i and j values) to create a sample draw of δ values from the distribution (Conner et al. 2016).

The δ of interest is that between seven pre-deterrence years (λ_i : FY 2013 to FY 2019) and six post-deterrent years (λ_j : FY 2020 to FY 2025). Two methods to estimate δ are described below, the composite year approach (Section 2.1) and single year approach (Section 2.2). These approaches result in two median δ values generated by the code. Given the skewness of the δ distributions, the median value is the appropriate measure of center to use for analysis.

2.1 Composite Year Methods

In this approach, an average of all seven pre-deterrence year distributions (λ_{pre}) and an average of all six post-deterrence years distributions (λ_{post}) are computed. Then, the averages for each period are divided to get an estimate distribution of δ, the impact of deterrents on annual fatality rates. This process is described in Figure 2 below.

$$\lambda_{post} = \frac{\sum_{i=1}^{6} \lambda_i}{6}$$

$$\lambda_{pre} = \frac{\sum_{i=1}^{7} \lambda_i}{7}$$

$$\delta_{post,pre} = \frac{\lambda_{post}}{\lambda_{pre}}$$

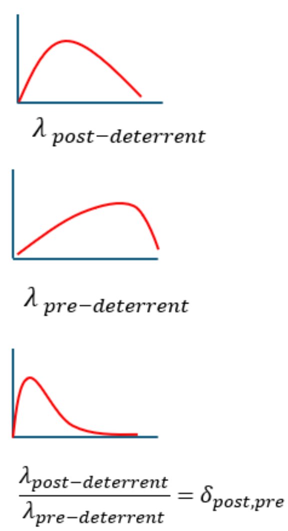

Figure 2. Composite Year δ Distribution Calculation

In this calculation, all of the among-year within-treatment variance is lost, effectively calculating the quotient of the average years. Therefore, a more complex approach is described in Section 2.2 that accounts for variance. The purpose of using two approaches is so that the more conservative estimate of rho can be used each year to estimate fatality rates, which means using the rho value where the benefit of deterrents is expected to be less.

2.2 Single Year Methods

This method takes a year-level Monte Carlo approach to the selection of years to incorporate among-year variance. Pairs of pre-deterrent (one λ_{pre} from 1 to 7) and post-deterrent (one λ_{post} from 8 to 13) fatality rates are repeatedly randomly drawn and used to calculate δ between these years of operation. The result is a large distribution of possible δ values between pre and post years. This process is illustrated in Figure 3.

Calculations are executed using code in R v4.0.5 (R Core Team 2021) from the EoA v2.0.7 (Dalthorp et al. 2017) and bbplot v0.0.1 (Simonis 2020) packages using existing methods (Simonis 2021) and additional custom-written scripts (Appendix A in DAPPER Stats 2023).

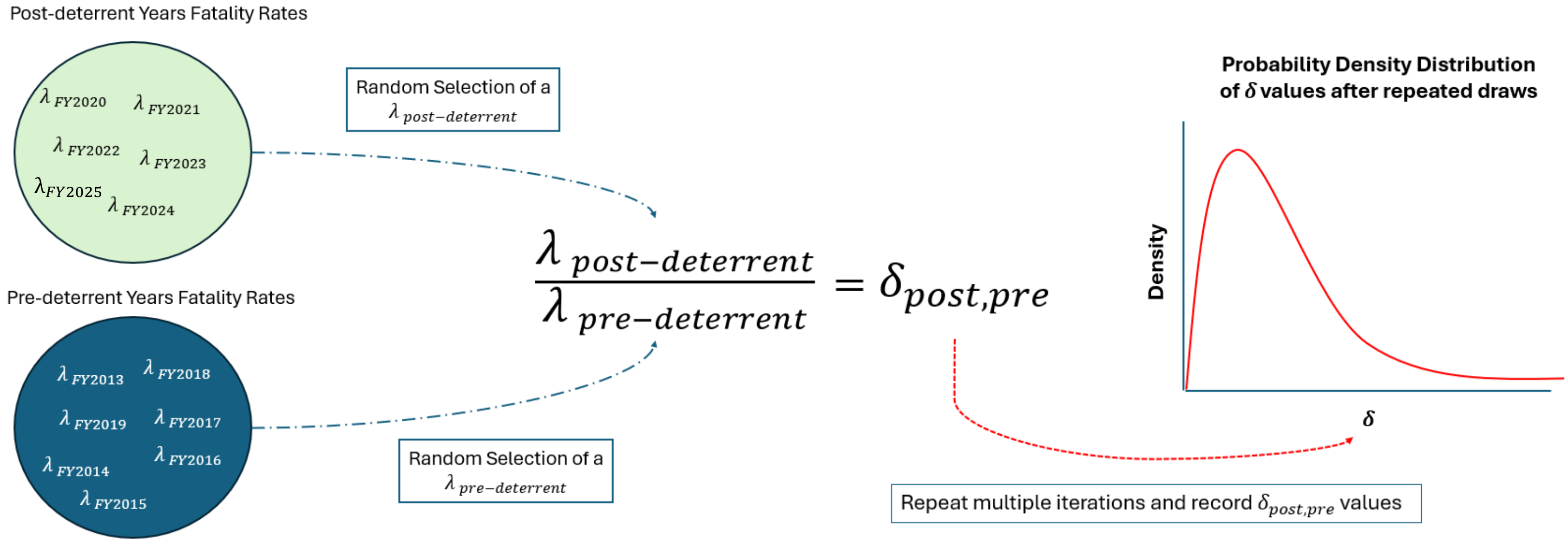

Figure 3. Single Year δ Distribution Calculation

3.0 Results

Analyses of single year and composite overlap distributions (δ) were completed with FY 2023, FY 2024, and FY 2025 data to get estimates of δ each fiscal year to support annual reports. Overlap coefficients (δ) between different years range between functionally 0 (no overlap in distributions) and 1 (two compared distributions are identical). Summary statistics for FY 2023, FY 2024, and FY 2025 are shown in Table 1 below.

Table 1. Results of Composite and Single Year Approaches

Metric	Composite Year Approach	Single Year Approach
FY 2023		
Median δ	**0.117**	0.101
95% CI	0.022, 0.364	0.001, 1.131
Proportion of values greater than 1	0	0.063
FY 2024		
Median δ	**0.127**	0.122
95% CI	0.032, 0.338	0.001, 1.581
Proportion of values greater than 1	0	0.059
FY 2025		
Median δ	**0.101**	0.099
95% CI	0.026, 0.268	0.0006, 1.453
Proportion of values greater than 1	0	0.050
Note: Bolded δ values indicate the most conservative estimate, and therefore the one selected for fatality estimation.		

Since δ is low for both the composite year and single year approaches, there is very little similarity in annual fatality rate distributions between pre-deterrence and post-deterrence years. This is also seen in differences in summary statistics for annual fatality rates shown in Table 2 and Figure 4.

Table 2. Pre-deterrent and Post-deterrent Years Fatality Rate Estimates

Metric	Pre-deterrent (λ_{pre})	Post-deterrent (λ_{post})
Median	11.04	1.11
Mean	11.14	1.23
Standard Deviation	1.81	0.65
95% CI	7.89, 14.95	0.30, 2.80

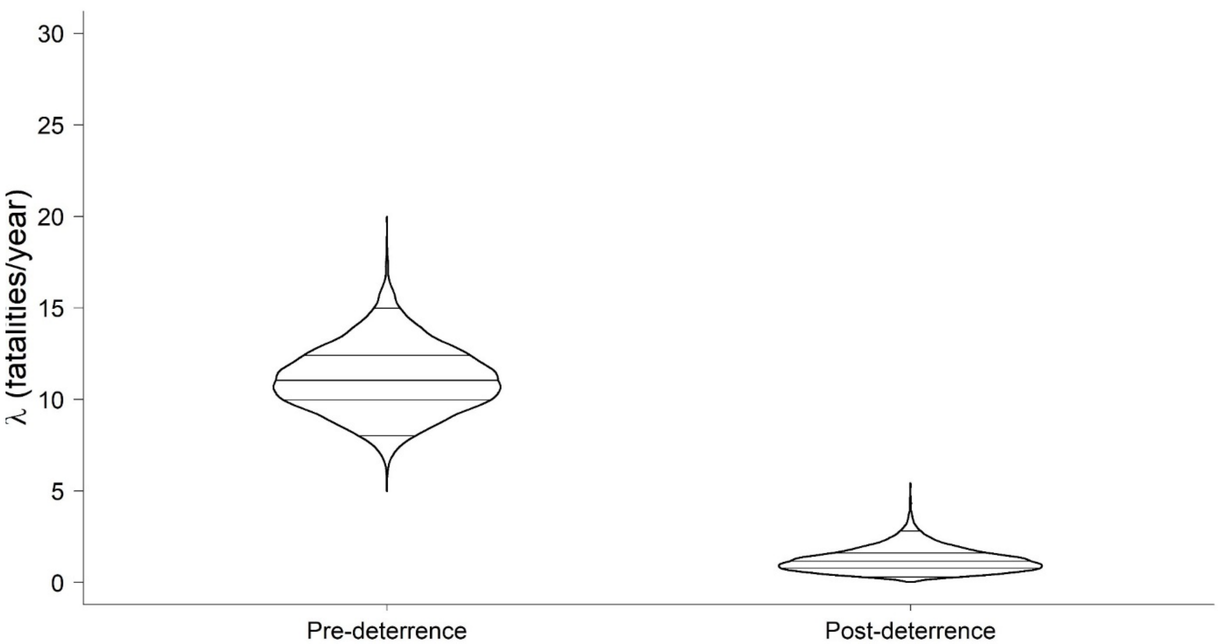

Figure 4. Distribution of Pre- and Post-deterrent Annual Fatality Rates

Note: Horizontal lines across violins represent the 2.5%, 25%, 50%, 75%, and 97.5% values.

The ratio distributions for both the composite year approach and the single year approach are also strongly skewed, with a majority of the distribution of δ values being less than 1 (Figure 5). In FY 2025, only 5.0 percent of the δ distribution for the single year approach and none of the δ distribution for the composite year approach was at or above 1, which is the value at which pre- and post-deterrent fatality rates would be unchanged.

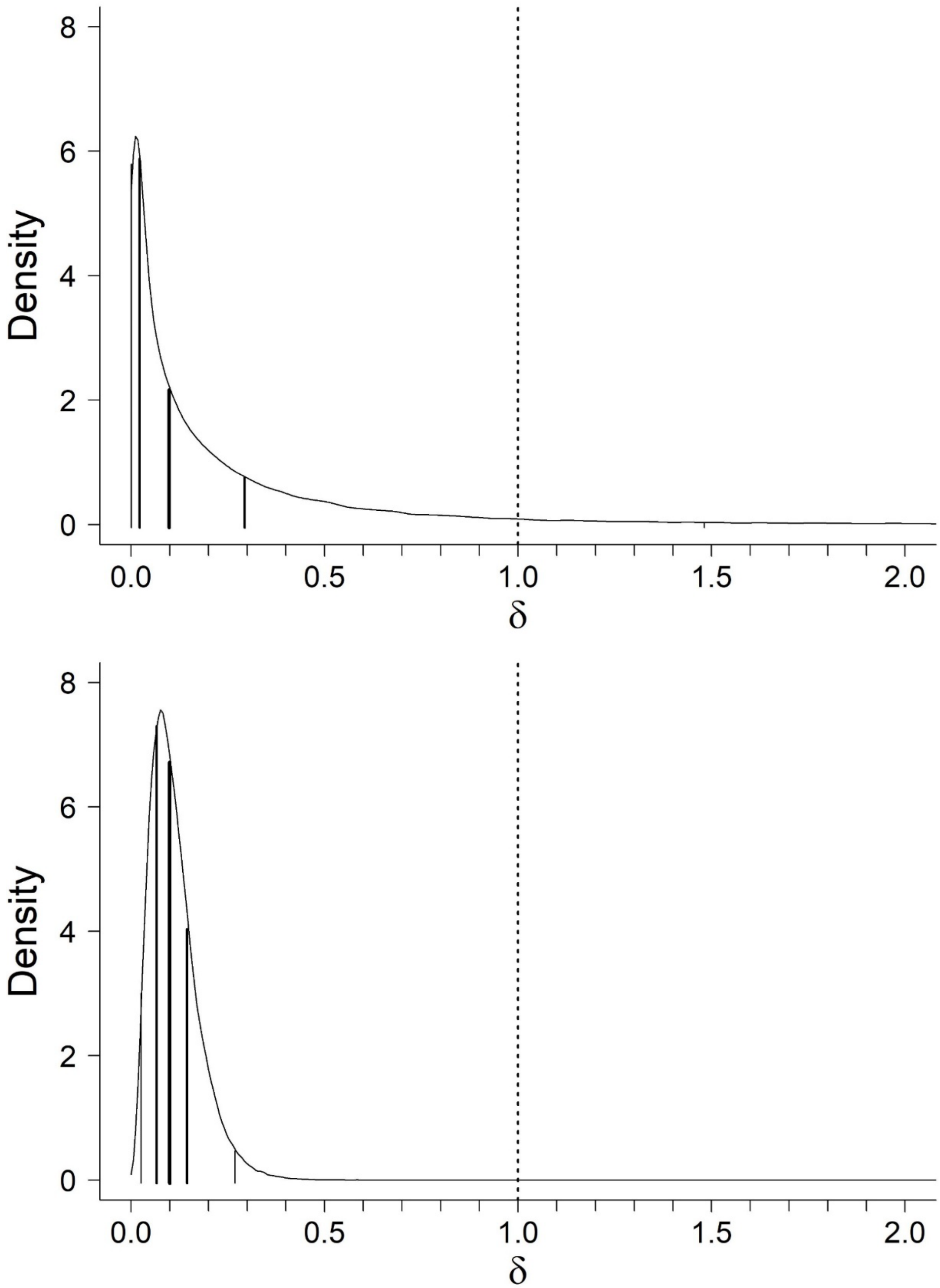

Figure 5. Probability Density Functions for the Single-Year (Top) and Composite (Bottom) Λ Approaches to Calculating δ

Note: Vertical lines within the distributions show the 2.5%, 25%, 50%, 75%, and 97.5% values. The vertical dashed line at 1.0 indicates the point of equivalence between λ values.

4.0 Discussion

Six years of post-construction monitoring data suggest that installing UADs at turbines at Kawailoa reduces annual fatality rates. Therefore, adjusting the rho value (ρ) used in EoA software to estimate future fatalities over the permit term is appropriate to reflect this change. Instead of weighting each component year in the model the same way, this approach weighs post-deterrent years less than pre-deterrent years to reflect a reduction in fatalities in the future. Between the results of the two approaches, the larger δ value is the most conservative and is selected for use in analysis. Larger δ values mean the deterrent impact is estimated to be less, leading to larger and more conservative fatality estimates over the permit term.

There are currently a limited set of model tools to compare the pre- and post-deterrence fatality estimates, based on the study design (implementation across all turbines), current duration of observations, and aggregation of the available data. Given these restrictions, simple, descriptive comparisons between pre- and post-deterrent λ's using two approaches were used to estimate the appropriate value for fatality estimation. Additional years of post-deterrence data will aid in the estimation of effects by improving precision and providing a more representative sample.

5.0 References

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Appendix 4.
Dalthorp et al. (2017) Fatality Estimation for Hawaiian Petrel at the Project through FY 2025

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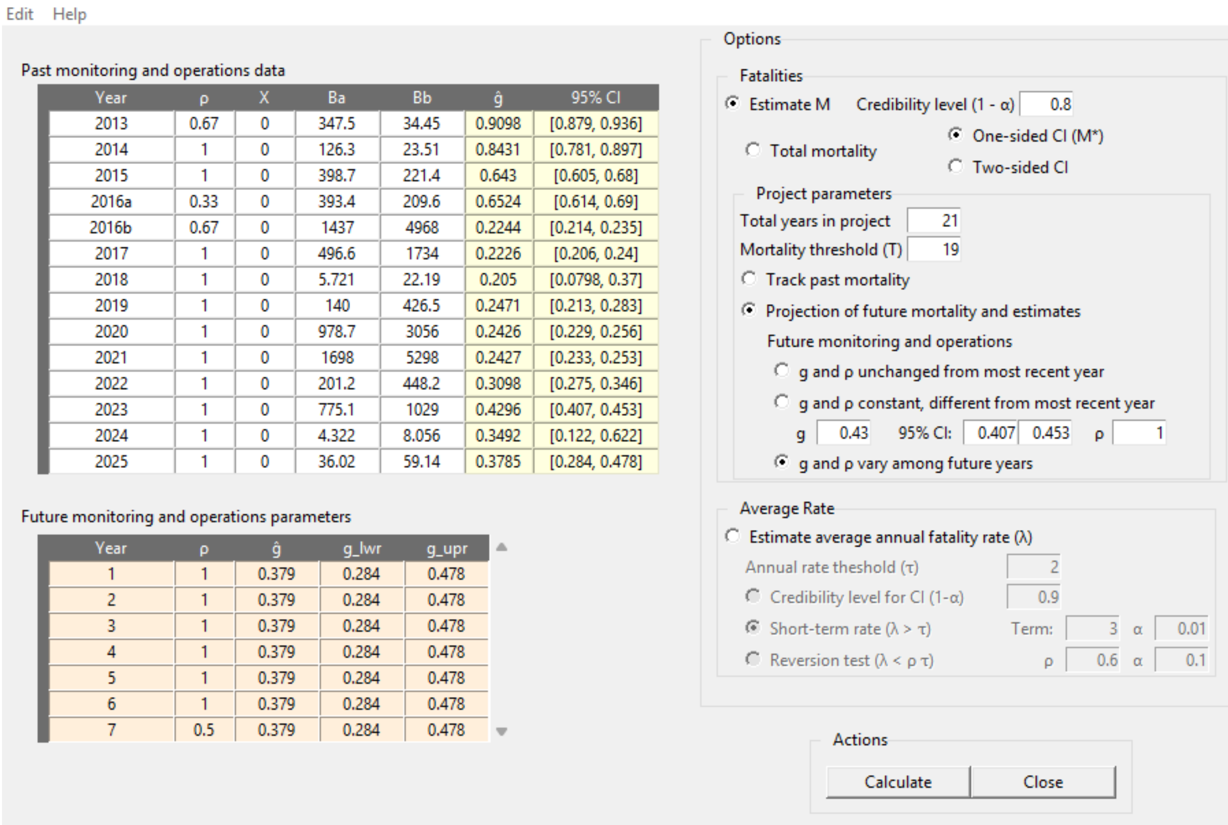

Past monitoring and operations data

Year	ρ	X	Ba	Bb	ĝ	95% CI
2013	0.67	0	347.5	34.45	0.9098	[0.879, 0.936]
2014	1	0	126.3	23.51	0.8431	[0.781, 0.897]
2015	1	0	398.7	221.4	0.643	[0.605, 0.68]
2016a	0.33	0	393.4	209.6	0.6524	[0.614, 0.69]
2016b	0.67	0	1437	4968	0.2244	[0.214, 0.235]
2017	1	0	496.6	1734	0.2226	[0.206, 0.24]
2018	1	0	5.721	22.19	0.205	[0.0798, 0.37]
2019	1	0	140	426.5	0.2471	[0.213, 0.283]
2020	1	0	978.7	3056	0.2426	[0.229, 0.256]
2021	1	0	1698	5298	0.2427	[0.233, 0.253]
2022	1	0	201.2	448.2	0.3098	[0.275, 0.346]
2023	1	0	775.1	1029	0.4296	[0.407, 0.453]
2024	1	0	4.322	8.056	0.3492	[0.122, 0.622]
2025	1	0	36.02	59.14	0.3785	[0.284, 0.478]

Future monitoring and operations parameters

Year	ρ	ĝ	g_lwr	g_upr
1	1	0.379	0.284	0.478
2	1	0.379	0.284	0.478
3	1	0.379	0.284	0.478
4	1	0.379	0.284	0.478
5	1	0.379	0.284	0.478
6	1	0.379	0.284	0.478
7	0.5	0.379	0.284	0.478

Figure 4-1. Dalthorp et al. (2017) Fatality Estimation for Hawaiian Petrels at Project through FY 2025

Note: Rho represents the portion of a year represented for each line of data. FY 2013 represents a partial year (November 2012 to June 2013) because the Project began operations in November 2012. In FY 2016 the search strategy was changed, so the analysis period is broken into two components. All remaining years represent a full fiscal year**.**

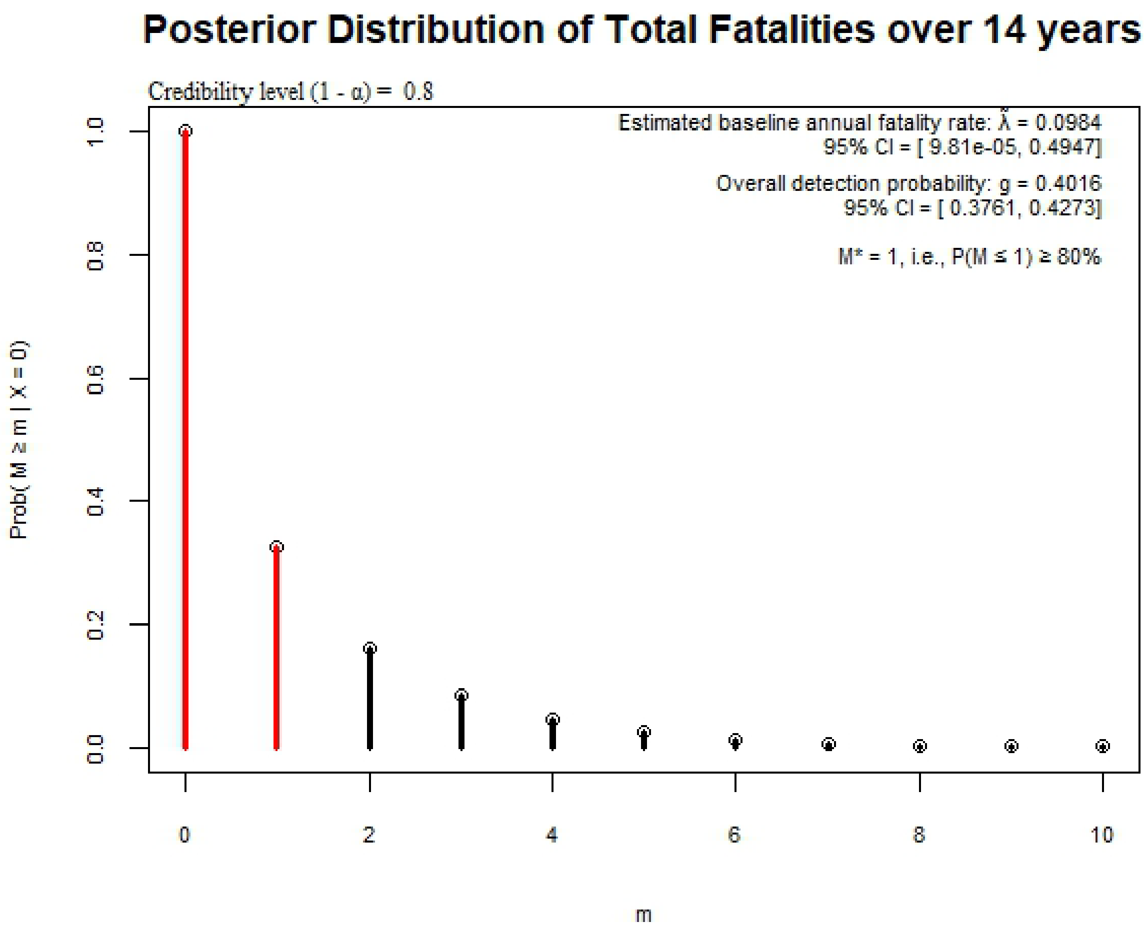

Figure 4-2. Posterior Distribution: Dalthorp et al. (2017) Fatality Estimation for Hawaiian Petrels at Project for FY 2025