Appendix A

Scoping Report

Programmatic Environmental Impact Statement Addressing the Issuance of Incidental Take Permits for Four Wind Energy Projects in Hawai‘i

U.S. Department of the Interior
U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office

Table of Contents

_Toc519599210

Tables

Attachments

Abbreviations and Acronyms

Abbreviation	Definition
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
DLNR-DOFAW	State of Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife
DOI	Department of the Interior
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FR	Federal Register
HCP	Habitat Conservation Plan
HRS	Hawaii Revised Statutes
ITL	Incidental Take License
ITP	Incidental Take Permit
kV	kilovolt
KWP II	Kaheawa Wind Power II
LLC	Limited Liability Company
MW	Megawatt
NEPA	National Environmental Policy Act
NOI	Notice of Intent
PEIS	Programmatic Environmental Impact Statement
PONC	Public Open Space Natural Preservation Commission
Service (USFWS)	U.S. Fish and Wildlife Service
USC	United States Code

Chapter 1
Introduction

The United States Department of the Interior (DOI), Fish and Wildlife Service (hereafter referred to as the "Service") is preparing a programmatic environmental impact statement (PEIS) in compliance with the National Environmental Policy Act (NEPA) (42 U.S.C. 4321 *et seq.*) to evaluate the environmental impacts associated with three habitat conservation plan amendments and one new habitat conservation plan (HCP), and the issuance of the associated four Incidental Take Permits (ITPs). The issuance of the four ITPs are separate decisions to be made by the Service. However, all four projects have similar geography, impacts to endangered species, and proposed minimization and mitigation measures. Under the Final Guidance for Effective Use of Programmatic NEPA Reviews published on December 23, 2014 (79 Federal Register [FR] 76986–76990), a combined programmatic NEPA analysis is the most efficient and comprehensive way to consider the impacts of these four actions.

The applicants are four separate private companies, namely, Sempra Renewables, D.E. Shaw Renewable Investments, TerraForm Power, and Tawhiri Power. The applicants are developing their separate HCP and ITP applications to comply with the Endangered Species Act of 1973 (ESA) (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*). The HCPs will likely address impacts associated with wind energy facility operations and maintenance activities on the Hawaiian Islands of O‘ahu, Maui, and Hawai‘i. All four wind energy facilities are land-based and are already constructed and in operation.

As part of the NEPA environmental review process the Service held three public scoping meetings, one each on the islands of O‘ahu, Maui, and Hawai‘i, to obtain public and stakeholder input and to comply with environmental regulations. This Scoping Report provides a project overview, purpose of the Services' action, and documents the scoping process that occurred for the PEIS. This report also provides a summary of all comments received by July 2, 2018.

1.1 Service Regulatory Background

The Service is dedicated to the management of fish, wildlife, and natural habitats. The Service responsibilities include enforcing federal wildlife laws, protecting endangered species, managing migratory birds, restoring nationally significant fisheries, conserving and restoring wildlife habitat, such as wetlands, helping foreign governments with their international conservation efforts, and distributing money to states' fish and wildlife agencies through the Wildlife Sport Fish and Restoration program.

The ESA is one of the key pieces of legislation for the Service. Section 9 of the ESA prohibits "take" of fish and wildlife species listed as endangered or threatened. Under section 3 of the ESA, the term "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct (16 U.S.C. 1532(19)). The term "harm" is further defined by regulation in title 50 of the Code of Federal Regulations (CFR) as an act that actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3). The term "harass" is also further defined in the regulations as an intentional or negligent act or omission that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns, which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3).

Pursuant to section 10(a)(1)(B) of the ESA, the Service may authorize take of federally listed species, if such take occurs incidental to otherwise legal activities and a HCP has been developed under section 10(a)(2)(A) that describes: (1) the impact that will likely result from such taking; (2) the steps an applicant will take to minimize and mitigate that take to the maximum extent practicable and the funding that will be available to implement such steps; (3) alternative actions to such taking that an applicant considered and the reasons why such alternatives are not being used; and (4) other measures the Service may require as being necessary or appropriate for the purposes of the plan.

Section 10(a)(1)(B) of the ESA contains provisions for issuing ITPs to non-Federal entities for the take of endangered and threatened species, provided the following criteria are met: (1) the taking will be incidental to otherwise lawful activities; (2) an applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking; (3) an applicant has ensured that adequate funding for the plan will be provided; (4) the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and (5) the applicant will carry out any other measures we require as necessary or appropriate for the purposes of the plan. Regulations governing permits for endangered and threatened species are at 50 CFR 17.22 and 17.32, respectively. The Service's general permitting regulations, found at 50 CFR 13.1–13.29, also apply to these actions.

The HCP is a voluntary applicant-driven process. The Service's role during HCP development is to provide technical assistance and work closely with the non-federal applicants to ensure compliance with the ESA and protection for threatened and endangered species. If the Service determines an HCP meets permit issuance criteria and complies with all other laws and regulations, then the Service issues an ITP in accordance with the associated HCP.

1.2 Project Overview

Wind energy turbines have the potential to harm or kill birds and bats unable to visually detect and avoid these structures. Previously permitted HCP applicants in the State of Hawaiʻi have documented higher than expected Hawaiian hoary bat (ʻōpeʻapeʻa in Hawaiian; *Lasiurus cinereus semotus*) deaths and, therefore, are requesting permit amendments to increase their take levels. Table A-1 lists the four applicants and identifies their respective wind project name and location.

Table A-1. The four applicants and projects that are the focus of the PEIS.

Company	Wind Project	Island	Location Area	Seeking Amendment or New HCP
Sempra Renewables	Auwahi Wind	Maui	Ulupalakua Ranch in east Maui	Amendment
D.E. Shaw Renewable Investments	Kawailoa Wind Power	O‘ahu	North Shore above Hale‘iwa town	Amendment
TerraForm Power	Kaheawa Wind Power II	Maui	Kaheawa Pastures above Mā‘alaea town	Amendment
Tawhiri Power	Pakini Nui Wind Farm	Hawai‘i	Ka Lae or South Point	New HCP

While take of the Hawaiian hoary bat is a major concern for all four applicants, there are other endangered species for which take is being requested. In addition to the Hawaiian hoary bat, some applicants are also requesting take of the endangered Hawaiian goose (nēnē in Hawaiian; *Branta sandvicensis*), and the endangered Hawaiian petrel (‘ua‘u in Hawaiian; *Pterodroma sandwichensis*). Table A-2 provides detailed estimates for the current take requested for the three endangered species per project applicant, including incidental take previously authorized.

Table A-2. Estimated change in authorized take requested for the Hawaiian hoary bat, the Hawaiian petrel, and the Hawaiian goose, per project applicant.

Project	**Take currently authorized** [1, 2]	**Change** [3]	**Total** [4]
Hawaiian Hoary Bat			
Auwahi Wind	21	+119	140
Kawailoa Wind Power	60	+205	265
Kaheawa Wind Power II	11	+27	38
Pakini Nui	NA	+26	26
Total	92	+334	426
Hawaiian Petrel [5]			
Auwahi Wind	87	0	87
Kawailoa Wind Power	0	+24	24
Kaheawa Wind Power II	43	0	43
Pakini Nui	NA	+3	3
Total	130	+10	140
Hawaiian Goose [5]			
Auwahi Wind	5	0	5
Kawailoa Wind Power	0	0	0
Kaheawa Wind Power II	30	+14	44
Pakini Nui	NA	+3	3
Total	35	+17	52

[1] Take for the Hawaiian hoary bat was originally authorized for adults and juveniles separately.

[2] A clarification issued in 2014 simplified the way in which indirect take (e.g., loss of dependent juveniles) associated with the mortality of a breeding adult was accounted for and tracked. Juveniles were converted to adult equivalencies using calculations based on life-history information included in the respective original HCPs, resulting in authorized take represented as a whole number as opposed to listing adults and juveniles separately.

[3] The Auwahi Wind project updated their estimated take request for the Hawaiian hoary bat, therefore these numbers have been updated since the June 1, 2018 publishing date of the Notice of Intent (83 FR 25475–25479).
[4] Represents the currently authorized take plus the new requested take.
[5] Take amounts for these species are summed or combined for adults, subadults, nestlings, or eggs.

Nearly 30 percent of renewable energy generated on the islands of Hawaiʻi, Maui, and Oʻahu is sourced solely from land-based wind. Combined, the four proposed ITP actions to be evaluated in the PEIS would address 50 percent of the existing wind energy operations in the State of Hawaiʻi. The following paragraphs provide a background overview of each specific wind project.

1.2.1 Auwahi Wind

The Auwahi Wind project began commercial operation on December 28, 2012, and is located on Ulupalakua Ranch in east Maui, Hawaiʻi. Auwahi Wind Energy, LLC, was originally issued an ITP from the Service and an incidental take license (ITL) from the Hawaiʻi Department of Land and Natural Resources Division of Forestry and Wildlife on February 24 and February 9, 2012, respectively. The Auwahi Wind project consists of eight Siemens 3.0-megawatt (MW) wind turbines, augmented with an 11–MW battery storage system. Ancillary facilities include an underground electrical collection system, an operation and maintenance facility, an approximately 9-mile 34.5-kilovolt (kV) above-ground generator-tie line, and an interconnection substation.

The original ITP and ITL, with 2014 amendments, authorized the following amounts of incidental take over the 25-year permit term: 21 Hawaiian hoary bats; 87 Hawaiian petrels; 5 Hawaiian geese; and Blackburn's sphinx moths (*Manduca blackburni*). The authorized levels of take were expected to result from project construction and operations, including collision with vehicles, generator tie-lines, substations, wind turbines and other project structures.

Auwahi Wind Energy, LLC, is requesting a permit amendment to address a higher than anticipated amount of take of the Hawaiian hoary bat that has occurred during the first 5 years of operation. Auwahi Wind Energy, LLC, is requesting incidental take coverage for an additional estimated 119 Hawaiian hoary bats (for a total of 140 bats) over the 25-year permit term, which expires in 2037.

1.2.2 Kawailoa Wind Power

The Kawailoa Wind Power project is located approximately 4 miles from Haleʻiwa town, on the north shore of the island of Oʻahu, Hawaiʻi, and began commercial operations in November of 2012. Kawailoa Wind Power, LLC, was issued an ITP and an ITL on December 8, 2011, and January 6, 2012, respectively. The Kawailoa Wind Power project consists of 30 2.3–MW wind turbine generators. Ancillary facilities include an underground electrical collection system, an operation and maintenance facility, and an approximately 4.0-mile above-ground transmission line.

The original ITP and ITL authorized the following amounts of incidental take over a 20-year permit term: 60 Hawaiian hoary bats; 12 Hawaiian ducks (koloa maoli; *Anas wyvilliana*); 18 Hawaiian moorhen (ʻalae ʻula; *Gallinula galeata sandvicensis*, also known as the Hawaiian gallinule); 18 Hawaiian coots (ʻalae kea; *Fulica americana alai*); 24 Hawaiian stilts (kukuluaeʻo; *Himantopus mexicanus knudseni*); and 15 Newell's shearwaters (ʻaʻo; *Puffinus auricularis newelli*). The authorized levels of take were expected to result from project construction and operations, including collision with vehicles, generator tie-lines, substations, wind turbines, and other project structures. Kawailoa Wind Power, LLC, is requesting a permit amendment to address a higher than anticipated amount of take of the Hawaiian hoary bat that has occurred during the first 5 years of operation.

Kawailoa Wind Power, LLC, is requesting incidental take coverage for an additional estimated 162 Hawaiian hoary bats (for a total of 222 bats), over the 20-year permit term, which expires in 2031. Additionally, in 2017, Kawailoa Wind Power, LLC, documented the death of at least one Hawaiian petrel at their project site. Incidental take of this species was not authorized in their existing ITP or ITL; therefore, Kawailoa Wind Power, LLC, is requesting incidental take authorization for seven Hawaiian petrels in their permit amendment.

1.2.3 Kaheawa Wind Power II

The Kaheawa Wind Power II (KWP II) project is located at Kaheawa Pastures above Māʻalaea town, in the southwestern portion of the island of Maui, Hawaiʻi, and began commercial operations in July 2012. KWP II, LLC, was issued an ITP and an ITL in January 2012. The KWP II project consists of 14 1.5–MW wind turbine generators. Ancillary facilities include an underground electrical collection and communication system, an operation and maintenance facility, a battery energy storage system, and an overhead electrical transmission line connecting the facility substation to the County's electrical grid.

The original ITP and ITL authorized the following levels of incidental take over the 20-year permit term, which expires in 2032: 11 Hawaiian hoary bats, 30 Hawaiian geese, 8 Newell's shearwater, and 43 Hawaiian petrel. The authorized levels of take were expected to result from project construction and operations, including collisions with vehicles, generator tie-lines, substations, wind turbines and other project structures.

Kaheawa Wind Power II, LLC, is requesting a permit amendment to address a higher than anticipated amount of take of the Hawaiian hoary bat and the Hawaiian goose that has occurred during the first 6 years of operation. Kaheawa Wind Power II, LLC, is requesting incidental take authorization for an additional estimated 27 Hawaiian hoary bats (for a total of 38 bats) over the 20-year permit term. Additionally, KWP II, LLC, is also requesting incidental take authorization for an additional estimated 14 Hawaiian geese (for a total of 44 geese) over the 20-year permit term.

1.2.4 Pakini Nui Wind Farm

The Pakini Nui Wind Farm is operated by Tawhiri Power, LLC, and is located on Ka Lae, or South Point, on the island of Hawai‘i, Hawai‘i. The Pakini Nui Wind Farm is currently not covered by a valid ITP or ITL, and Tawhiri Power, LLC, has not previously applied for an ITP or ITL. Tawhiri Power, LLC, has submitted a draft HCP to support their requests for an ITP and an ITL. The Pakini Nui Wind Farm began operations in April 2007 and consists of 14 1.5–MW wind turbine generators. Ancillary facilities include one mile of underground connector lines, an operation and maintenance building, a substation, and an overhead electrical transmission line connecting the facility substation to the County’s electrical grid. The entire project facility footprint is 79.42 acres. Tawhiri Power, LLC, is requesting incidental take authorization for an estimated 26 Hawaiian hoary bats, 3 Hawaiian petrels, and 3 Hawaiian geese over a 20-year permit term.

1.3 Purpose of the Service Action

The purpose of the Service’s action is to ensure that the ESA permit issuance criteria are met; comply with all other applicable Federal laws and regulations; and, consistent with our legal authorities, contribute to the recovery of the Hawaiian hoary bat, Hawaiian petrel, and Hawaiian goose and protect and enhance the ecosystems on which they depend at ecologically appropriate scales. The Service’s consideration of whether or not to issue an ITP to each of the four applicants listed in Table A-1, is a federal action that triggers the need for compliance with NEPA.

The process for implementing NEPA is codified in 40 CFR Parts 1500–1508, Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act. The regulations specify that an environmental impact statement (EIS) be prepared when a federal agency is proposing a major action (such as issuing an ITP) with potential to “significantly affect the quality of the human environment” (40 CFR 1501). Significance is determined by evaluating two distinct factors: context and intensity (40 CFR 1508.27). Context refers to the geographic scale (local, regional, or national) of significance of short- and/or long-term effects/impacts of a proposed action. Intensity refers to the severity of the effects/impacts relative to the affected settings, including the degree to which the proposed action affects: an endangered or threatened species or designated critical habitat; public health or safety; scientific, historic or cultural resources; or other aspects of the human environment. When an agency begins to consider the context and intensity of their action, initial scoping has begun.

Chapter 2
Scoping Activities

NEPA regulations require scoping to determine the scope of the issues to be addressed in the environmental review and to identify significant issues related to a proposed action (40 CFR 1501.7). According to NEPA, scoping should occur early on in the environmental review process and should involve the participation of the affected parties. Scoping begins with the first internal agency scoping meeting where the scope of the proposed action is discussed. Federal agencies are required to make diligent efforts to involve the public in preparing and implementing their NEPA procedures (40 CFR 1506.6(a)). Public scoping meetings help to satisfy this requirement.

The Service, as lead Federal agency of the proposed actions, is required during scoping to:

- Invite the participation of affected Federal, State, and local agencies, and any affected Indian tribe, the proponent of the action, and other interested persons (including those who might not be in accord with the action on environmental grounds);
- Determine the scope and the significant issues to be analyzed in depth in the EIS;
- Identify and eliminate from detailed study the issues which are not significant or which have been covered by prior environmental review, narrowing the discussion of these issues in the statement to a brief presentation of why they will not have a significant effect on the human environment or providing a reference to their coverage elsewhere;
- Allocate assignments for preparation of the EIS among the lead and cooperating agencies, with the lead agency retaining responsibility for the Statement;
- Indicate any public environmental assessments and other EISs which are being or will be prepared that are related to but are not part of the scope of the EIS under consideration;
- Identify other environmental review and consultation requirements so the lead and cooperating agencies may prepare other required analyses and studies concurrently with, and integrated with, the EIS; and
- Indicate the relationship between the timing of the preparation of environmental analyses and the agency's tentative planning and decision making schedule. (40 CFR 1501.7)

This chapter documents the Service's activities conducted during the scoping process, including internal and agency scoping, public scoping announcements, stakeholder coordination, and a detailed account of the three public scoping meetings held.

2.1 Internal and Agency Scoping

Internal scoping on the proposed actions began in August 2017. The Service performed internal NEPA scoping for the four proposed ITP actions and briefly identified the environmental issues requiring detailed analysis and also identified connected, similar, and cumulative actions. After considering the 10 components of intensity, as set forth under 40 CFR 1508.27(b), the Service determined that the four proposed ITP actions have the potential to significantly impact the human environment. On that basis and in accordance with regulations at 40 CFR 1501.4, 1507.3, and 1508.27, the Service concluded preparation of an EIS is warranted to analyze the project-specific and cumulative environmental impacts associated with these four individual proposed ITP actions. Table A-3 lists the internal scoping meeting dates and outcomes.

Table A-3. Internal scoping meetings held to discuss the scope of the proposed actions.

Meeting Date	Outcome / Discussion
August 3, 2017	Field team leaders discussed the timing and scope of the four proposed actions, and recommended an EIS would be warranted.
August 8, 2017	Field team leaders and Field Supervisor discussed scope of the actions, including the reasoning to conduct a single programmatic analysis versus four separate environmental impact statements and timing for each.
September 22, 2017	Field team leaders, Field Supervisor, Regional Office representative, and Solicitor discussed appropriateness of a batched or programmatic environmental impact analysis.
October 18, 2017	Field Supervisor, Team leaders, and staff discussed work load resources, appropriateness of a batched or programmatic environmental impact analysis, and potential environmental issues related to the proposed actions.
October 20, 2017	Field Office, Regional Office, and Office of the Solicitor discussed issues related to the proposed actions, and decision was made to move forward with a programmatic environmental review.

On September 15, 2017 the Service met with the State of Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife (DLNR-DOFAW) to discuss the Service's idea to conduct a programmatic environmental review to address the impacts of the four proposed ITPs. During this meeting the DLNR-DOFAW declined to participate as a cooperating agency, due to the fact that not all four project applicants require compliance with the Hawaiʻi Environmental Policy Act (Hawaii Revised Statutes [HRS] Chapter 343), the State's equivalent of NEPA. Other project applicants were in different stages of the State's ITL review process, in accordance with HRS Chapter 195D, the State's equivalent of the ESA. Under these circumstances, both the Service and DLNR-DOFAW agreed to coordinate the environmental review and processing of the four ITP and ITL applications to the fullest extent possible. The federal and state processes would be separate, but attempts would be made to utilize the same documents and administer the processes concurrently to avoid duplication of efforts.

On November 1, 2017, the Service informed the four applicants of the decision to pursue a programmatic environmental analysis, and the basis for that decision. The Service also informed the applicants that the public would be asked to comment on the appropriateness of the Service's decision to pursue a programmatic NEPA approach, or separate NEPA evaluations for each of the four wind energy projects.

From May 2018—June 2018, the following federal agencies were asked if they would have any interest in being a cooperating agency in the PEIS or participate in agency scoping:

- U.S. Army Corps of Engineers
- Federal Aviation Administration
- U.S. Department of Agriculture, Wildlife Services
- U.S. Department of Transportation, Federal Highways Administration

Due to lack of jurisdiction and special expertise, all of the above federal agencies declined to participate in the PEIS.

2.2 Public Scoping Announcements

The scoping period for the Service's PEIS Addressing the Issuance of Incidental Take Permits for Four Wind Energy Projects in Hawai‘i, was announced through a Notice of Intent (NOI) in the Federal Register, a press release, and social media, as detailed below.

2.2.1 Notice of Intent

On June 1, 2018, the Service published an NOI to announce its intent to prepare a PEIS Addressing the Issuance of Incidental Take Permits for Four Wind Energy Projects in Hawai‘i, provided in **Attachment A**. The publishing of the NOI began the 30-day public scoping period. The NOI provides a project overview, the need for and general focus of the PEIS, including details of the public scoping process.

2.2.2 Press Release

On May 31, 2018, the Service issued a press release (**Attachment B**) to 10 news media. Table A-4 lists the local news media outlets that received the press release. The press release provided background on the PEIS; a link to the NOI; the dates, times, and locations of the three public meetings; and information regarding the public comment period and how to comment.

Table A-4. Local news media that received the Service press release on May 31, 2018.

News Media Entities, Print / Online			
Honolulu Civil Beat	Maui Watch	Hawaii News Now	Maui News Now
The Maui News	Honolulu Associated Press	Honolulu Star Advertiser	
West Hawaii Today	The Garden Isle	Hawaii Tribune–Herald	

2.2.3 Social Media

On May 31, 2018, the Service posted information of the PEIS public scoping period on the following social media accounts and sites:

- USFWS Pacific Region Tumblr blog: http://usfwspacific.tumblr.com/
- Pacific Islands: U.S. Fish and Wildlife Service Facebook page: https://www.facebook.com/PacificIslandsFWS/
- USFWS Pacific Region Twitter account: https://twitter.com/usfwspacific?lang=en

2.3 Stakeholder Coordination

On May 30, 2018, State legislators of Hawaiʻi, Maui, and Oʻahu islands and Hawaiʻi's delegation to the U.S. Congress were notified of the PEIS public scoping period, and given a copy of the press release. Additionally, the Hawaiʻi Volcanoes National Park on Hawaiʻi Island and Haleakalā National Park on Maui were both notified. Notifications were also sent to all members of the State's Endangered Species Recovery Committee. All notifications were made via electronic mail. The Service offered to provide individual briefings, however, no follow-up briefings were requested. Table A-5 provides a list of elected officials contacted. Table A-6 provides a full list of other stakeholders contacted.

Table A-5. List of elected officials notified of the PEIS public scoping period.

U.S. Congressional Delegation			
Office of Senator Brian Schatz		Office of Senator Mazie Hirono	
Office of Representative Colleen Hanabusa		Office of Representative Tulsi Gabbard	
Hawaiʻi State Legislature			
Sen. Rosalyn H. Baker	Sen. Breene Harimoto	Sen. Sean Quinlan	Sen. Laura H. Thielen
Sen. Stanley Chang	Sen. Les Ihara	Sen. Clarence Nishihara	Sen. Jill N. Tokuda
Sen. Donovan Dela Cruz	Sen. Lorraine Inouye	Sen. Karl Rhoads	Sen. Glenn Wakai
Sen. J. Kalani English	Sen. Kaialiʻi Kahele	Sen. Gil Riviere	Sen. Will Espero
Sen. Mike Gabbard	Sen. Gilbert Keith-Agaran	Sen. Russell E. Ruderman	Rep. Henry J.C. Aquino
Sen. Brickwood Galuteria	Sen. Michelle N. Kidani	Sen. Maile S.L. Shimabukuro	Rep. Della Au Belatti
Sen. Josh Green	Sen. Donna Mercado Kim	Sen. Brian T. Taniguchi	Rep. Tom Brower
Rep. Romy M. Cachola	Rep. Cindy Evans	Rep. Troy N. Hashimoto	Rep. Aaron Ling Johanson
Rep. Isaac W. Choy	Rep. Beth Fukumoto	Rep. Daniel Holt	Rep. Jarrett Keohokalole
Rep. Richard P. Creagan	Rep. Cedric Asuega Gates	Rep. Linda Ichiyama	Rep. Bertrand Kobayashi
Rep. Ty J.K. Cullen	Rep. Sharon E. Har	Rep. Kaniela Ing	Rep. Sam Satoru Kong
Rep. Lynn DeCoite	Rep. Mark J. Hashem	Rep. Ken Ito	Rep. Lei R. Learmont
Rep. Chris Lee	Rep. Nicole E. Lowen	Rep. Lauren Matsumoto	Rep. Angus L.K. McKelvey
Rep. Matthew S. LoPresti	Rep. Sylvia Luke	Rep. Bob McDermott	Rep. John M. Mizuno
Rep. Mark M. Nakashima	Rep. Scott Y. Nishimoto	Rep. Takashi Ohno	Rep. Richard H.K. Onishi
Rep. Scott K. Saiki	Rep. Joy San Buenaventura	Rep. Calvin K.Y. Say	Rep. Gregg Takayama
Rep. Roy M. Takumi	Rep. Cynthia Thielen	Rep. Chris Todd	Rep. Andria P.L. Tupola
Rep. Gene Ward	Rep. Justin H. Woodson	Rep. Ryan I. Yamane	Rep. Kyle T. Yamashita

Table A-6. List of other stakeholders notified of the PEIS public scoping period.

Hawaiʻi Volcanoes National Park, Chief of Natural Resources Management	Hawaiʻi Endangered Species Recovery Committee, Members
Haleakalā National Park, Endangered Species Management Program	U.S. Geological Survey, Pacific Island Ecosystems Research Center

2.4 Public Scoping Meetings

The Service conducted three public scoping meetings to solicit input on the scope of the PEIS and to identify issues that should be addressed in the development of the PEIS. Table A-7 lists the date, time, location, and number of attendees of the three public scoping meetings. Where possible, public meetings were held in the affected town where the subject wind facility was located. A consistent group of applicants attended all three meetings and were available to answer questions about the existing conditions at their site. The Service's PEIS team members were available for personal, one-on-one interaction during the meetings to answer questions or clarify project details.

Table A-7. Dates, locations, and number of attendees for the three public scoping meetings.

Island	**Date/Time**	**Address**	**Attendees**		
			Service	Applicants	Public
Hawaiʻi	June 18, 2018 6 to 8 p.m.	Nāʻālehu Community Center 95–5635 Māmalahoa Highway Nāʻālehu, Hawaiʻi, HI 96772	8	7	3
Maui	June 20, 2018 6 to 8 p.m.	Malcolm Center 1305 North Holopono Street, Suite 5 Kīhei, Maui, HI 96753	9	8	0
Oʻahu	June 21, 2018 6 to 8 p.m.	Sunset Beach Recreation Center 59–540 Kamehameha Highway Haleʻiwa, Oʻahu, HI 96712	11	7	15
			Total Members of the Public		18

2.4.1 Format and Content

The meetings were organized in an open house format. A brief introduction was given and refreshments were available throughout the meeting. Poster board stations were organized thematically into the following eight topics:

1. Welcome, and Purpose for the Meeting
2. Understanding the NEPA Process
3. What is Being Considered? – Habitat Conservation Plans and Incidental Take Permits
4. How to Submit a Comment

5. Auwahi Wind
6. Kawailoa Wind
7. Kaheawa Wind Power II
8. Pakini Nui Wind Farm

At station 4, relating to comment submissions, members of the public were asked to help shape the issues and content that will be considered as part of the PEIS and were informed that the Service was specifically seeking comments on the following:

- Biological information about the Hawaiian hoary bat, Hawaiian goose, and Hawaiian petrel.
- Potential direct and indirect impacts to people, as a result of the proposed actions.
- Whether the applications should be evaluated together or separately, and why.
- Potential alternatives of the proposed incidental take permit applications.
- Presence of cultural sites, practices, or historic preservation concerns in the vicinity of the proposed actions that should be covered under the National Historic Preservation Act.
- Any activity that may contribute to the cumulative impact on the Hawaiian hoary bat, Hawaiian goose, or Hawaiian petrel.

Service staff were placed at all eight stations. A project overview sheet with space to submit written comments was provided. Only written comments were received at the meeting and collected through a comment box. Copies of the meeting materials, as well as photos from the public scoping meetings, are provided in **Attachment C**.

Chapter 3
Summary of Comments Received

Written comments were accepted through July 2, 2018. During the 30-day scoping period, 12 comment letters were received from stakeholders and non-profit or community organizations. Table A-8 lists the public organizations or businesses that commented during the scoping period.

Table A-8. List of organizations that commented during the scoping period.

Nā Mamo O Kāwā – Kāwā Stewardship	North Shore Neighborhood Board No. 27
Center for Biological Diversity	Conservation Law Center
American Bird Conservancy	Sempra Renewables, LLC

All letters, including electronic mail, from individuals and organizations were numbered and each specific comment in each letter was identified. All comments were cross-referenced and duplicate comments were combined into a single topic. Next, comments were screened and placed into one of four general categories:

1. Relevant Issues: Defined as actual or perceived effects, risks, or hazards on physical, biological, social, or economic resources from the proposed action or its alternatives.
2. For or Against Certain Actions: Defined as comments that are for or against a possible agency action, and are best addressed in one or more NEPA alternatives.
3. Relating to the NEPA Approach: Defined as comments that contained input on whether a programmatic NEPA approach, as proposed, or separate NEPA evaluations for each of the four wind energy projects, is appropriate.
4. Issues Considered but Eliminated from Further Analysis: Defined as comments that identified issues, but such issues were eliminated from further analysis based on specific rationale.

The remaining chapter provides a summary of all comments, thematically organized in one of the four categories listed above. **Attachment D** contains a compilation of all comments as received, indexed with a chronological number. The bolded numbers in parentheses next to each comment below corresponds to the indexed number in Attachment D.

3.1 Relevant Issues

These comments identified three major issues that will be addressed in the NEPA analysis. These comments contained actual or perceived environmental impacts, risks, or hazards on physical, biological, social, or economic resources from the proposed action or its alternatives.

Issue 1: Increased risk of local extinction of Hawaiian hoary bat populations.

- Relating to uncertainty of the risk.
  - What's imperiling the endangered bats is wind farms (and possibly rat predation and possibly agricultural pesticide spraying.) **(3)**
  - The planned increase in take is likely too high to be sustained by the local bat population. **(11)**
  - The agency should be implementing a high level of precaution when authorizing take of the Hawaiian hoary bat, given the following:
    - high uncertainty surrounding population abundance on each island as well as range wide;
    - high uncertainty about the ability of habitat restoration to offset (i.e., compensate for) the authorized take; and
    - potential for meta-population dynamics across local populations. **(11) (9)**
  - The new level of requested take for the Auwahi Wind facility alone is 197 adult equivalents over the ITP term. Given a permit term of 25 years, this take is about 8 adult equivalents per year. Unless the agency can show that this level of take on one island will not cause a decline in the local population of bats, this level of take is unacceptable. **(11)**
  - The new requested take for the Kawailoa facility alone is 222 adult equivalents over the ITP term. Given a permit term of 20 years, this take is about 11 adult equivalents per year. Unless the agency can show that this level of take on one island will not cause a decline in the local population of bats, this level of take is unacceptable. **(11)**
- Relating to reliability of take estimates.
  - Take of bats is extremely concerning – almost five times greater than previously authorized estimates. Describe measures being used to increase the reliability of future take estimates. **(4) (9)**
- Relating to measures to prevent take exceedance.
  - The adaptive management plans for the existing HCPs unacceptably does not call for any changes to avoidance or minimization measures when authorized take is exceeded. The PEIS should analyze specific additions to avoidance and minimization measures and protections to be implemented under an adaptive management plan. **(11)**
  - Instead of waiting till the PEIS is done, begin implementing measures immediately to reduce take. **(4)**
- Relating to mitigation.
  - You cannot authorize killing the bats and offsetting the death by purchasing land. There's plenty of habitat; what we don't have a lot of is living bats. **(3)**
  - There is no known method to offset take of the Hawaiian hoary bat. **(3) (11)**
  - Mitigation plans should be evaluated in light of the findings that bats are attracted to wind turbines. **(4)**

  - Although it is alarming to see such large take estimate numbers for bats, I find it is helpful to fully comprehend the level of restoration necessary to fully offset those individuals lost in the local population. **(7)**
  - Neither the existing HCPs nor associated NEPA documents present evidence or analysis that the planned mitigation will maintain or increase local Hawaiian hoary bat populations. The PEIS should present and analyze such evidence if it exists. **(11) (10) (9)**
  - It is unacceptable that mitigation will be deemed successful even without increasing Hawaiian hoary bat reproduction on Maui. The PEIS should present and analyze measures of success for mitigation that include the demographic effects of the mitigation on bat populations. Ideally, the measures of mitigation success should include whether bat productivity, or a suitable surrogate, is increased. The measures of mitigation success should also include increased use of the mitigation area by bats for foraging or roosting. If there is no indication the restored mitigation area has likely increased the productivity of the Hawaiian hoary bat population on Maui, the mitigation should be deemed unsuccessful and additional avoidance, minimization, or mitigation should be implemented. **(11)**

Issue 2: Combined cumulative impacts (past, present, and reasonably foreseeable future actions) may negatively affect the statewide populations for three endangered species (Hawaiian hoary bat, Hawaiian petrel, and Hawaiian goose).

- Evaluate impacts on the three endangered species from Rimpac military exercises and planned expansion at Pōhakuloa Training Area. **(4)**
- Explain how it is permissible for Pakini Nui to be operating for 11 years with no ITP, ITL, or HCP. What are the impacts of that? **(4)**
- Cumulative effects of increasing take for all three endangered species is a concern. Take at the existing facilities and presumably at future facilities should all be considered when evaluating these amendments. **(4) (6)**
- The American Bird Conservancy is highly concerned with the cumulative impacts of these wind projects to Hawaiian petrel and other Covered Species. Recent information from Raine et al. (2017) demonstrated a 78% decline for Hawaiian petrel on Kaua‘i. The population is split predominantly between Maui, Kaua‘i and Lāna‘i. The Hawaiian Petrel population also has distinct genetic sub-units on the different Hawaiian Islands, and mitigation should be implemented in such a way as to compensate all the sub-populations affected by the proposed actions. Given this precipitous decline, and that few colony data are available for other islands, a precautionary approach is needed to minimize take from the combined wind infrastructure across all sites. **(12)**
- PEIS must assess impacts to all endangered species on various scales including, for example, both island-by-island and range-wide scales. Federal law requires a range-wide assessment of impacts and State of Hawai‘i statutes (195-D) require island specific analyses of impacts. The EIS should produce population viability analyses for each

covered species. In addition, cumulative population viability analyses should be completed that include all operational wind projects in Hawaiʻi. **(10)**

Issue 3: Potential harm to the threatened Newell's shearwater (*Puffinus auricularis newelli*) and endangered band-rumped storm-petrel (*Oceanodroma castro*).

- Potential risk and mitigation should be addressed for the threatened Newell's shearwater in the PEIS. This species is known to breed in remnant numbers on the island of Hawaiʻi. **(12)**
- The band-rumped storm-petrel was not included as a covered species in the previous applications (i.e. HCPs from Auwahi, Kaheawa, and Kawailoa), but should be included in this PEIS, given the risk of collision and light attraction known at other sites, and potential impact from wind infrastructure. **(12)**

3.2 For or Against Certain Actions

These comments were for or against a possible action without identifying a perceived risk or concern for a certain environmental resource. These comments are best addressed in one or more NEPA alternatives. Comments in this category are organized in the following seven topics.

- <u>Relating to a no action alternative.</u>
    - Additional taking of the species should not be allowed. Those species already have enough problems regarding their survival without adding further ways in which their populations can be injured. **(2)**
- <u>Relating to avoidance or minimization measures.</u>
    - Shut down or curtail the number of hours that wind farms operate at night, so that the turbines do not coincide with bat activity. **(1) (9)**
    - Shut the turbines down at night at all of the Hawaiʻi wind farms until a deterrent is implemented that prevents endangered Hawaiian hoary bats from being struck by the spinning blades. **(3)**
    - Need to identify effective bat deterrents to keep bats away from wind turbine risks/hazards. **(4) (9)**
    - Evaluate raising the cut-in speed to 6.5 m/s in light of the following: "...the best scientific knowledge currently available suggests that increasing cut-in speed to 6.5 m/s, rather than 5 m/s, would minimize impacts [to bats] to the maximum extent…" [wrote hearing officer Yvonne Izu re. the Na Pua Makani wind farm] *Wind Farm Plan to Protect Rare Bats Is Inadequate, Hearing Officer Finds, Environment Hawaiʻi, December 2017* **(4)**
    - The PEIS should quantify and incorporate correction factors for take with respect to turbine specifications (i.e., rotor diameter, nacelle height, and manufacturer) as well as the value of minimization efforts like low wind speed curtailment. **(10)**

    - Given the high numbers and increase of proposed take of Hawaiian hoary bats for some projects, there should be heavy emphasis on minimization. This minimization should be through either low wind speed curtailment and/or the use of deterrent devices. As a minimum, projects affecting bats should consider and analyze operational options using no power generation at night, as well as minimum cut-in/cutout wind speeds of 8.0 meters per second and 6.5 meters per second. Blades should always be feathered whenever turbines are not actively generating power. **(10) (11)**
- <u>Relating to mitigation measures.</u>
    - Mitigation areas for bats should include both upland and lowland habitats. **(6)**
    - Mitigation of impacts to seabirds. Hawaiian seabirds are primarily limited by non-native predators. Restoration actions to benefit existing colonies should be given the highest priorities. Site with multiple-species benefits and those sites with the most breeding pairs and those sites which offer a diverse genetic make-up (i.e., represent as many genetic segments as possible) should be the next level of prioritization.
        - Mitigation is directed at increasing adult survival, a key driver of population declines.
        - Sufficient monitoring is conducted at all facilities across the four covered wind energy project to ensure accurate, reliable, and robust assessment of the take for all federally listed species.
        - Seabird restoration techniques such as colony protection, species translocation, and social attraction are used to the extent possible to protect, enhance, and create new predator-free colony areas. **(12)**
    - Compensatory mitigation for endangered species should be consistent with the U.S. Fish and Wildlife Service's policy on compensatory mitigation for endangered species. Special attention should be given to ensuring that impacts are fully mitigated, the mitigation is additive and not subsidized by federal or state agencies, and monitoring confirms that expected benefits are achieved during the permit period. **(10) (12)**
    - I am the Executive Director for the Kaʻū based 501(c)3 non-profit organization, Nā Mamo O Kāwā and we are County appropriated stewards of the Kāwā PONC (Public Open Space Natural Preservation Commission) property. We have been awarded a PONC stewardship grant, Hawaiʻi Tourism Authority Aloha ʻĀina award, and Hawaiʻi People's Fund to restore dry forest and coastal habitat at Kāwā. These lower elevation forests and coastal areas provide a place for bats to forage, socialize, and mate. In addition we have shore birds, kolea, ʻūlili, iwa, and noio that populate our coastline. With this is mind, we are interested in continuing our ʻōpeʻapeʻa and shorebird restoration as candidates to receive mitigation funds to do so. Please consider our project and call if you have any questions. **(8)**
- <u>Relating to the use of tiered take levels.</u>
    - Incidental take is the amount of take that is "reasonably expected to occur," not the level of take that the applicant would like coverage for. The use of "tiers of take" is not appropriate. There is now over a decade of detailed information on endangered

species mortality associated with Hawaiian wind projects. Tiers appear to be used primarily as a convenience or cost savings feature by facility operators, rather than as the only option to address the uncertainty of take levels. The HCP/ITPs should not incorporate "tiers of take" and the PEIS should not rely on this framing in its analysis of impacts. **(10)**
    - Any use of tiered take must be tied to a strong adaptive management plan that specifies additional or more rigorous avoidance, minimization, and mitigation measures that will be implemented at each tier. Each tier must afford successively greater protections to the local bat population. **(11)**
- Relating to Hawaiian hoary bat research.
    - Wind farms can propose to conduct research first, and then if the research elucidates a method that would increase the bat population to offset the wind farm bat killing, then the applicant can come back to request a permit to take bats. **(3)**
- Relating to adaptive management.
    - Plan for changes in mitigation strategies as research advances. **(4)**
    - The agency should analyze in its PEIS or EISs at least two alternative adaptive management plans setting forth specific additions of, or changes to, avoidance, minimization, and mitigation measures that will be triggered by take exceedance(s), at a level of specificity appropriate to ensure compliance. **(11)**
- Relating to public involvement.
    - Allow for public involvement in periodic meetings and other oversight activities. **(4)**

3.3 Relating to the NEPA Approach

These comments provide input on whether a programmatic NEPA approach, as proposed, or separate NEPA evaluations for each of the four wind energy projects, is appropriate. This type of input was specifically solicited for in the NOI (published June 1, 2018; 83 FR 25475–25479).

- I think the species would benefit from a programmatic EIS. Although the wind farms are different in habitats and are on different islands, streamlining the HCPs and considering them together will be a better way to envision cumulative effects on the statewide population of bats, and work toward common goals that will build roosting and foraging habitats for bats at upper and lower elevations and on each island where the take will occur. **(7)**
- Combining unique projects with separate and unrelated applicants on different islands with take requests for different species into a single PEIS will be extremely challenging and potentially confusing. Doing so in a timely manner and within the page limits of Secretarial Order No. 3355 on NEPA Streamlining will likely be impossible without sacrificing quality and thoroughness. **(5)**
- Critical public comments about any one of the applications will cause problems for the others, and any delays associated with public comments or other issues on one project would delay all the projects. The Service's PEIS approach unfairly subjects each of the projects to any delays associated with the others. **(5)**

- While drafts of each HCP may be submitted for consideration at close to the same time, each of the HCPs is at a different stage of consideration by the State of Hawai‘i, which will also be called upon to grant permits for the species under consideration for take authorization. Forcing all the projects into one PEIS makes the coordination process with the State more difficult and is contrary to the Endangered Species Act Section 6 and CEQ Guidelines Section 1506.2. **(5)**

3.4 Issues Considered but Eliminated from Further Analysis

These comments identified issues or concerns that were beyond the Service's decision-making capacity for this project or outside the Service's jurisdiction. As such these issues were eliminated from further analysis based on specific rationale. Comments in this section are summarized and categorized into eight non-relevant issues, including a rationale explaining why the issue is eliminated from further analysis.

<u>Non-relevant Issue #1: Consider alternatives to wind energy development that are less impactful.</u>

- Include a solar photovoltaic alternative to the Kawailoa Wind Farm. **(3)**
- Please disclose the opportunity cost of getting energy from wind farms instead of burning liquefied natural gas or coal and using the excess money that would be left over to pay for planting trees like koa (that live a long time and that the products made from them last 100 years) to sequester carbon. The math done indicates the carbon offsets would be 20- to 36-times more carbon sequestered than burned if we were not throwing our money away by giving it to these wind farms. **(3)**
- Remove the three turbines at the front of Waimea Valley and replace them either with turbines farther up on the hill or replace them with solar photovoltaic with hydrogen or battery storage. **(3)**

Rationale for Dismissal: The four wind energy facilities are already constructed and in operation. It is outside the Service's jurisdiction to consider dismantling and re-developing these energy facilities. The alternative to remove a turbine that consistently poses a threat to the local population of the endangered Hawaiian hoary bat may be examined in the PEIS.

<u>Non-relevant Issue #2: Disclose the adverse effect of nighttime noise at the four existing wind farms.</u>

- Disclose the adverse effect of nighttime noise at Kawailoa Wind Farm. Either disclose the adverse noise effect or require the wind turbines be shut down to avoid the adverse effect. **(3)**

Rationale for Dismissal: The four wind energy facilities are already constructed and in operation. The environmental analysis for noise effects would have been included in previous NEPA reviews that considered facility siting, construction, and operation effects, conducted prior to the energy facility beginning operations. The Service's action and its alternatives would not increase nighttime operations at the four wind energy facilities, therefore there would be no effect to nighttime noise levels at the wind facilities.

<u>Non-relevant Issue #3: Kawailoa Wind adversely affects easement access for adjacent property owners.</u>

- Kawailoa Wind Farm adversely affects easement access for adjacent property owners. **(3)**

Rationale for Dismissal: The four wind energy facilities are already constructed and in operation. The environmental analysis for land use effects would have been included in previous NEPA reviews that considered facility siting, construction, and operation effects, conducted prior to the energy facility beginning operations. The Service's action and its alternatives would not alter the existing facility footprint or change existing roads at or near the four wind facilities, therefore there would be no land access or land use effects at the wind facilities.

<u>Non-relevant Issue #4: Consider the adverse effect of increased precipitation in the neighborhoods of Hale'iwa and Waialua, caused by the Kawailoa Wind facility.</u>

- When the air is near its dew point, increased condensation and precipitation are caused by wind turbines, so there is the potential for the dried out air on the leeward side of wind farms to be warmer than it would have been without the wind farm (similar to how hot it is on the leeward side of mountains after the water is removed from the air). So Hale'iwa and Waialua average temperatures may actually be increased due to the Kawailoa Wind Farm. Disclose the adverse effect the wind farm has to the downwind neighborhoods of Hale'iwa and Waialua – when the air is near its dew point, the wind turbines' effect on the air increases rainfall and the dryer air is warmer – the conditions when this occurs are probably infrequent, but still, the frequency of this occurrence of increased precipitation and increased air temperature in Hale'iwa and Waialua should be disclosed to the public. **(3)**

Rationale for Dismissal: The four wind energy facilities are already constructed and in operation. The environmental analysis for effects to water resources would have been considered in previous NEPA reviews that considered facility siting, construction, and operation effects, conducted prior to the energy facility beginning operations. The Service's action and its alternatives would have no effect to water resources or local climate patterns at or near the four wind energy facilities.

<u>Non-relevant Issue #5: Consider the adverse effects to scenic views caused by the wind facilities.</u>

- Kawailoa Wind Farm/ First Wind's consultants misled the agencies and the public regarding the adverse effect of Kawailoa on our views. They used a wide-angle camera lens in their rendering of the Waimea Valley view. At night, the red blinking lights make the site look like an oil refinery industrial area, and during the day the turbines are visible from the ocean areas, from Pūpūkea neighborhoods, from Waimea Valley, and from Haleiwa, Waialua, Mokulēʻia, and Schofield Barracks. **(3)**

Rationale for Dismissal: The four wind energy facilities are already constructed and in operation. The environmental analysis for effects to visual resources would have been included in previous NEPA reviews that considered facility siting, construction, and operation effects, conducted prior to the energy facility beginning operations. The Service's action and its alternatives would have no effect to visual resources at or near the four wind energy facilities.

<u>Non-relevant Issue #6: Consider the adverse effects to surfing conditions caused by the wind facilities.</u>

- Please disclose the adverse effect the wake turbulence from the wind turbines has to the North Shore's offshore wind conditions and shut down the Kawailoa Wind Farm during the very few hours per year when the swell is larger than 10-feet, 14-seconds and the wind turbines are downwind from the very most critically important Waimea surf break when it is breaking. **(3)**
- We request implementation of wind turbine shut down under the following conditions to protect surf conditions: Feather wind turbine blades so the blades are oriented parallel to the wind, free-wheeling, not catching the wind, shut down, when the most recent NOAA reading on the Waimea buoy (Station 51201) is 8-feet, 14-seconds or higher and wind direction at the wind turbine is between sunrise and sunset when 10-minute average wind speed is higher than five mph. This action will conserve the clean offshore wind conditions for surfers at the Velzyland to Waimea Bay surf breaks. **(3)**

Rationale for Dismissal: The four wind energy facilities are already constructed and in operation. The environmental analysis for effects to recreation resources would have been considered in previous NEPA reviews that considered facility siting, construction, and operation effects, conducted prior to the energy facility beginning operations. The Service's action and its alternatives would have no effect to recreation resources at or near the four wind energy facilities.

<u>Non-relevant Issue #7: Evaluate and compare the effectiveness of wind turbine design alternatives and related infrastructure that are less likely to kill wildlife.</u>

- Evaluate and compare the effectiveness of various alternative turbine designs less likely to kill wildlife, as guidance for future wind projects. **(4)**
- Design guy wires to prevent fatalities. **(4)**
- Past HCP documents have erroneously stated that one way to minimize the take of bats was to use larger wind turbines. Recent studies have shown that larger turbines kill more bats than smaller turbines even with low wind speed curtailment in place. This is both on a turbine-by-turbine basis and per megawatt (MW) generated. This issue and others related to the size of the wind turbines must be fully evaluated in the PEIS. **(10)**

Rationale for Dismissal: The ability for the Service to evaluate and implement alternatives to existing turbine designs are outside the Service's jurisdiction and decision-making capacity for this project. Discussions with stakeholders and industry experts would be warranted in order for such an evaluation to go forward. The Service's action and its alternatives would not alter existing turbine designs at the four wind energy facilities. However, an evaluation of different wind turbine designs and their effects to wildlife may be warranted for new wind energy projects not yet constructed. The influence of existing wind turbine height on take estimates may be examined in the PEIS.

<u>Non-relevant Issue #8: Consider a wildlife-friendly or bird-smart approach be taken for new development.</u>

- American Bird Conservancy advocates that a "Bird-Smart Wind" approach be taken for new development. Bird-Smart Wind energy adheres to the following principles:
  - Ensures turbines are located away from areas of high risk of bird collision;
  - Employs effective mitigation to minimize bird fatalities;
  - Conducts independent, transparent post-construction monitoring of bird deaths to help inform mitigation and;
  - Calculates compensation for the loss of ecologically-important, federally-protected birds. **(12)**

Rationale for Dismissal: The four wind energy facilities are already constructed and in operation. Some of the principles for a "Bird-Smart Wind" approach will be achieved, in accordance with ESA section 10, including mitigation and minimization measures and fatality monitoring. A "Bird-Smart Wind" approach should be considered for all new energy development projects.

Chapter 4
Next Steps in the NEPA Process

The Service will determine which modifications of, and alternatives to, the Proposed Action and No Action should be carried forward for full analysis in the PEIS based on a relevance to, or compatibility with, the Purpose of and Need for Action. The Service is reviewing in detail the full suite of the Proposed Action as defined in the completed draft habitat conservation plans submitted by the four applicants, in accordance with ESA section 10(a)(2)(A). For each of the viable alternatives carried forward for full analysis, potentially affected resources will be identified and potential impacts on each of those resources will be assessed. If needed, measures to mitigate resource impacts will be included in the PEIS.

This Scoping Report will be used as a guide during the development of the PEIS, to ensure that all relevant issues and recommendations identified by the public, are properly considered.

The next formal comment period will open when the Notice of Availability of the draft PEIS and draft HCPs are published. The Service will circulate a notice of the draft PEIS and draft HCPs to interested parties. The draft documents will be available to the public on the Service website, and by request from the Service. Availability of the draft PEIS will be announced by publication of a notice in the Federal Register. Following the release of the drafts, there will be a minimum 60-day public comment period.

At the conclusion of this second public comment period, the draft PEIS and draft HCPs will be revised, and the proposed final PEIS and final HCPs will be prepared. Availability of the proposed final PEIS will be announced by publication of a notice in the Federal Register, at which time a 30-day waiting period will commence. Notification will also be sent to all persons who provided comments during any phase of the public comment process.

Alternatives Analyzed in the Programmatic Environmental Impact Statement

Appendix B. Alternatives analyzed in detail in the PEIS.

Alternative Type	General Description	Project Specific Description (Sub-Alternative)	Management Activities	Monitoring Activities
1: No Action	The Service would not issue the ITP and the respective HCP would not be implemented. The Service expects that the Applicants would act in a reasonable manner in order not to be legally liable for unauthorized take of the Hawaiian hoary bat, Hawaiian petrel, and the Hawaiian goose. The Service assumes that all Applicants would shut-off wind turbine operations at night to fully avoid take of Hawaiian hoary bat. The three Applicants seeking to amend their existing permits would continue operating turbines during the day as long as they continued to be in compliance with their existing permit. Pakini Nui would implement other possible measures to avoid take of listed species. Any take that may occur outside of an existing permit would not be authorized and would remain unmitigated.	*1A: Auwahi Wind:* The Service would not issue an ITP amendment to Auwahi Wind and the Auwahi HCP amendment would not be implemented.	No wind turbine operations at night. The management activities under the original HCP (Tetra Tech 2012) would continue to be implemented, according to the terms and conditions of Permit Number TE64153A-0.	The monitoring activities under the original HCP (Tetra Tech 2012) would continue to be implemented pursuant to the terms and conditions of Permit Number TE64153A-0, and Service- approved adaptive management provisions.
		1B: Kawailoa Wind: The Service would not issue an ITP amendment to Kawailoa Wind and the Kawailoa Wind HCP amendment would not be implemented.	No wind turbine operations at night. The management activities under the original HCP (SWCA 2011d) would continue to be implemented, according to the terms and conditions of Permit Number TE59864A-0.	The monitoring activities under the original HCP (SWCA 2011d) would continue to be implemented pursuant to the terms and conditions of Permit Number TE59864A-0, and Service-approved adaptive management provisions.
		1C: KWP II: The Service would not issue an ITP amendment to KWP II and the KWP II HCP amendment would not be implemented.	No wind turbine operations at night. The management activities under the original HCP (SWCA 2011c) would continue to be implemented, according to the terms and conditions of Permit Number TE27260A-0. No wind operations during the day if take of Hawaiian goose under TE27260A-0 is met or exceeded.	The monitoring activities under the original HCP (KWP II 2011c) would continue to be implemented pursuant to the terms and conditions of Permit Number TE27260A-0, and Service-approved adaptive management provisions.
		1D: Pakini Nui: The Service would not issue an ITP to Pakini Nui and the Pakini Nui HCP would not be implemented.	No wind turbine operations at night. Pakini Nui would not be required to conduct any management activities to address impacts to federally listed species.	Pakini Nui would not be required to conduct any monitoring activities to evaluate impacts to federally listed species.
2: Proposed Action	The Service would issue the ITP and the respective HCP would be implemented as proposed by the applicant. The applicant's operations and activities under the HCP would be subject to the terms and conditions of the ITP as well as any other applicable Federal, State, or local laws or regulations.	*2A: Auwahi Wind:* The Service would issue an ITP amendment to add three additional tiers of take, to include a Tier 4, Tier 5, and Tier 6. These tiers amount to take of an additional 119 Hawaiian hoary bats through the permit term ending in year 2037.	Turbine operational changes: Implement Low Wind Speed Curtailment (LWSC) at 5.0 meters per second (m/s) cut-in speed year-round, from 30 minutes before sunset to 30 minutes after sunrise. For the months of August to October, when data from the first five years of operation has shown that most bat fatalities have occurred, Auwahi Wind would implement increased nighttime LWSC to 6.9 m/s, from 30 minutes before sunset to 30 minutes after sunrise. All mitigation management activities would occur as described under the Auwahi Wind No Action alternative, in addition to the following new mitigation measures for the Hawaiian hoary bat: <u>Tier 4</u>: Reforest and create water sources within 1,752 acres of bat foraging habitat on 'Ulupalakua ranch lands, at an approximate cost of $2,847,790. <u>Tier 5</u>: Restore and manage a minimum of 690.2 ac of bat habitat on a yet to be identified parcel on Maui. <u>Tier 6</u>: Restore and manage a minimum of 487.2 ac of bat habitat on a yet to be identified parcel on Maui. Restoration and management actions would consist of: fencing and removal of ungulates; invasive vegetation removal; planting of	All monitoring activities would occur as described under the Auwahi Wind No Action alternative, in addition to the following: <u>Tier 4</u>: The following methods would be used to discern an increase in bat activity at the site: (1) acoustic monitoring of bat feeding buzzes; (2) assessment of percent native forest cover after year 5 of management actions; (3) thermal cameras to document bat behavior at water troughs; and (4) quarterly insect monitoring to evaluate bat prey availability. <u>Tier 5 & 6</u>: Monitoring mitigation site resources would be site-specific and based on a mitigation monitoring program established and implemented for the duration of the mitigation project. Monitoring activities would include acoustic monitoring for bat activity and/or monitoring of other surrogate measures.

			native forest trees; and installation or improvement of water features.	
		2B: Kawailoa Wind: The Service would issue an ITP amendment to add three additional tiers of take, to include a Tier 4, Tier 5, and Tier 6. These tiers amount to take of an additional 205 Hawaiian hoary bats, and 24 Hawaiian petrels through the permit term ending in year 2032.	Turbine operational changes: Extend LWSC at 5.0 m/s cut-in speed year-round from sunset to sunrise, increase LWSC cut-in speed to 5.2 m/s through a 0.2 m/s hysteresis, and test a bat deterrent device in collaboration with NRG Systems. Additionally, Kawailoa Wind commits to installing bat deterrent devices at all 30 turbines once effective deterrents become commercially available. New mitigation measures for the Hawaiian petrel: Fund predator control activities within Hawaiian petrel breeding colonies at Hanakāpīʻai and Hanakoa, Kauaʻi, to be conducted by the Hawaii Department of Land and Natural Resources (DLNR) Division of Forestry and Wildlife (DOFAW). All mitigation management activities would occur as described under the Kawailoa Wind No Action alternative, in addition to the following new mitigation measures for the Hawaiian hoary bat: <u>Tier 4</u>: Contribute $2,750,000 to a land acquisition project of 2,882 acres in the northern lower Koʻolau Mountains on Oʻahu, of which a portion (1,527 acres) is existing native and mixed forest habitat for bats. <u>Tier 5</u>: Protect/preserve or restore/manage a minimum of 1,725 ac of bat habitat on a yet to be identified parcel on Oʻahu. <u>Tier 6</u>: Protect/preserve or restore/manage a minimum of 1,319 ac of bat habitat on a yet to be identified parcel on Oʻahu. Protection and preservation of existing bat habitat would occur through acquisition, easement, or other legal conservation instrument. Restoration and management of bat habitat, if deemed the best suitable option, would include the following activities: fencing and removal of ungulates; invasive vegetation removal; and planting of native forest trees. Activities would occur within the Helemano Wilderness Area, Waimea Native Forest, or a yet to be identified parcel on Oʻahu.	All monitoring activities would occur as described under the Kawailoa Wind No Action alternative, in addition to the following: Monitoring Hawaiian petrel mitigation areas with cameras, song meters, and on the ground surveys. Metrics recorded would include: (1) seabird call rates, (2) number of burrows, (3) reproductive success, (4) number of fledglings, and (4) number of depredation events. <u>Tier 5 & 6</u>: Monitoring of bat restored/managed habitat would include the following: (1) acoustic monitoring for bat activity throughout the duration of the project; (2) measures of canopy cover; (3) monitoring for out-planted native tree survival; and (4) monitoring and maintenance to prevent invasive species encroachment.
		2C: KWP II: The Service would issue an ITP amendment to add two additional tiers of take, to include a Tier 3 and Tier 4. These tiers amount to take of an additional 27 Hawaiian hoary bats, and 14 Hawaiian geese through the permit term ending in year 2032.	Turbine operational changes: Implement LWSC at 5.0 m/s cut-in speed year-round, and implement increased LWSC at 5.5 m/s from February 15 through December 15, between sunset and sunrise. New mitigation measures for the Hawaiian goose: Fund fence maintenance and predator control activities to be conducted by DOFAW at Piʻiholo Ranch on Maui with an approximate cost of $162,750. All mitigation management activities would occur as described under the	All monitoring activities would occur as described under the KWP II No Action alternative, in addition to the following: Monitoring Hawaiian goose predator controlled areas for fledgling success and depredation events. <u>Tier 3</u>: Monitor bat mitigation research quarterly through detailed research reports to ensure objectives are being met. <u>Tier 4</u>: Monitoring mitigation site resources would be site specific and based on a mitigation monitoring

			KWP II No Action alternative, in addition to the following new mitigation measures for the Hawaiian hoary bat: Tier 3: Fund a three-year research project conducted by the United States Geological Survey (USGS) to determine Hawaiian hoary bat home range size, habitat use, diet composition, and mother-pup demographics at roosting sites on Hawaiʻi Island, at a total cost of $950,000. Tier 4: Contribute to protecting and/or restoring a minimum of 162.4 ac of habitat considered favorable for bat roosting, pupping and/or feeding on Maui. Restoration activities would include all or a combination of ungulate fencing, ungulate control, fire-fuel management, native tree out-planting, native plant seed dispersal, and invasive species control. If deemed the best suitable option, Tier 4 management activities may include purchase of appropriate land for bat conservation on Maui.	program established and implemented for the duration of the restoration mitigation project. Monitoring activities would include acoustic monitoring for bat activity and/or monitoring of other surrogate measures.
		2D: Pakini Nui: The Service would issue an ITP to allow take of 26 Hawaiian hoary bats, 3 Hawaiian petrels, and 3 Hawaiian geese through a permit term ending in year 2029.	Fund reforestation activities of bat habitat covering 1,200 acres at Hawaiʻi Volcanoes National Park (HVNP). Fund increased predator control activities and maintenance of a 5-mile barrier fence encompassing 600 acres of Hawaiian petrel breeding habitat at HVNP. To mitigate for the take of Hawaiian geese, Pakini Nui would fund the construction of a 7-acre fenced enclosure to provide Hawaiian geese breeding habitat, with work conducted by DOFAW. To minimize take of Hawaiian hoary bats, Pakini Nui would implement LWSC at 5.0 m/s cut-in speed year-round from sunset to sunrise, and increase LWSC cut-in speed to 5.5 m/s during sunset and sunrise.	Conduct long-term monitoring for downed wildlife, consisting of wind turbine search plots extending 197 ft upwind and 295 ft downwind. Conduct searcher efficiency (SEEF) and carcass retention (CARE) trials at least annually to aid in monitoring take levels. Monitor vegetation plots to demonstrate bat habitat restoration success. Monitor bat activity and invertebrate diversity within the 1,200 acre restoration site to detect an increase in bat activity and invertebrate density over baseline. Monitor Hawaiian petrel reproductive success using game cameras in the predator controlled area at HVNP.
3: Increased Curtailment	The Service would issue the ITP with a condition that the applicant will shut down turbines at night, between April 15 and September 15 when Hawaiian hoary bats are observed to be rearing young and are most active. Mitigation management activities would be reduced commensurate with take levels. LWSC activities listed under Alternative 2 would occur during the remainder of the year (September 16 – April 14).	***3A: Auwahi Wind:*** The Service would issue an ITP amendment to add two additional tiers of take, to include a Tier 4 and Tier 5. These tiers amount to take of an additional 84 Hawaiian hoary bats through the permit term ending in year 2037.	Turbine operational changes: Turbines would be shut down at night, between April 15 and September 15. All mitigation management activities would occur as described under the Auwahi Wind No Action alternative described above, in addition to the following new mitigation measures for the Hawaiian hoary bat: Tier 4: Reforest and create water sources within 1,752 acres of bat foraging habitat on 'Ulupalakua ranch lands, at an approximate cost of $2,847,790. Tier 5: Restore and manage a minimum of 180 ac of bat habitat on a yet to be identified parcel on Maui. Restoration and management actions would consist of: fencing and removal of ungulates; invasive vegetation removal; planting of native forest trees; and installation or improvement of water features.	All monitoring activities would occur as described under the Auwahi Wind No Action alternative, in addition to the following: Tier 4: The following methods would be used to discern an increase in bat activity at the site: (1) acoustic monitoring of bat feeding buzzes; (2) assessment of percent native forest cover after year 5 of management actions; (3) thermal cameras to document bat behavior at water troughs; and (4) quarterly insect monitoring to evaluate bat prey availability. Tier 5: Monitoring mitigation site resources would be site specific and based on a mitigation monitoring program established and implemented for the duration of the mitigation project. Monitoring activities would include acoustic monitoring for bat activity and/or monitoring of other surrogate measures.

		3B: Kawailoa Wind: The Service would issue an ITP amendment to add two additional tiers of take, to include a Tier 4 and Tier 5. These tiers amount to take of an additional 83 Hawaiian hoary bats, and 9 Hawaiian petrels through the permit term ending in year 2031.	Turbine operational changes: Turbines would be shut down at night, during April 15 through September 15. All mitigation management activities would occur as described under the Kawailoa Wind No Action alternative, in addition to the following: Tier 4: Contribute $2,750,000 to a land acquisition project of 2,882 acres in the northern lower Koʻolau Mountains on Oʻahu, of which a portion (1,527 acres) is existing native and mixed forest habitat for bats. Fund predator control activities within Hawaiian petrel breeding colonies at Hanakāpīʻai and Hanakoa, Kauaʻi, to be conducted by DOFAW. Tier 5: Protect/preserve or restore/manage a minimum of 365.4 ac of bat habitat on a yet to be identified parcel on Oʻahu. Protection and preservation of existing bat habitat would occur through acquisition, easement, or other legal conservation instrument. Restoration and management of bat habitat, if deemed the best suitable option, would likely include the following activities: fencing and removal of ungulates; invasive vegetation removal; and planting of native forest trees. Activities would occur within the Helemano Wilderness Area, Waimea Native Forest, or a yet to be identified parcel on Oʻahu.	All monitoring activities would occur as described under the Kawailoa Wind No Action alternative, in addition to the following: Tier 4: Monitoring nesting seabirds with cameras, song meters, and on the ground surveys. Metrics recorded would include: (1) seabird call rates, (2) number of burrows, (3) reproductive success, (4) number of fledglings, and (5) number of depredation events. Tier 5: Monitoring of bat restored/managed habitat would include the following: (1) acoustic monitoring for bat activity throughout the duration of the project; (2) measures of canopy cover; (3) monitoring for out-planted native tree survival; and (4) monitoring and maintenance to prevent invasive species encroachment.
		3C: KWP II: The Service would issue an ITP amendment to add a single additional Tier. This Tier 3 would authorize take of an additional 16 Hawaiian hoary bats, and 14 Hawaiian geese through the permit term ending in year 2032.	Turbine operational changes: Turbines would be shut down at night, during April 15 through September 15. All mitigation management activities would occur as described under the KWP II No Action alternative, in addition to the following: Tier 3: Fund a three-year research project conducted by the USGS to determine Hawaiian hoary bat home range size, habitat use, diet composition, and mother-pup demographics at roosting sites on Hawaiʻi Island, at an approximate cost of $950,000. Fund fence maintenance and predator control activities to be conducted by DOFAW at Piʻiholo Ranch on Maui.	All monitoring activities would occur as described under the KWP II No Action alternative, in addition to the following: Monitoring Hawaiian goose predator-controlled areas for fledgling success and depredation events. Tier 3: Monitor mitigation research quarterly through detailed research reports to ensure objectives are being met.
		3D: Pakini Nui: The Service would issue an ITP to allow take of 16 Hawaiian hoary bats, 3 Hawaiian petrels, and 3 Hawaiian geese through a permit term ending in year 2029.	Turbine operational changes: Turbines would be shut down at night, during April 15 through September 15. Fund reforestation activities of bat habitat covering 738 acres at HVNP. Fund increased predator control activities and maintenance of a 5-mile barrier fence encompassing 600 acres of Hawaiian petrel breeding habitat at HVNP. To mitigate for the take of Hawaiian geese, Pakini Nui would fund the construction of a 7-acre fenced enclosure to provide Hawaiian geese breeding habitat, with work conducted by DOFAW.	Conduct long-term monitoring for downed wildlife, consisting of wind turbine search plots extending 197 ft upwind and 295 ft downwind. Conduct SEEF and CARE trials at least annually to aid in monitoring take levels. Monitor vegetation plots to demonstrate bat habitat restoration success. Monitor bat activity and invertebrate diversity within the 738 ac restoration site to detect an increase in bat activity and invertebrate density over baseline. Monitor Hawaiian petrel reproductive success using game cameras in the predator-controlled area at HVNP.

Take Estimation for Hawaiian Hoary Bats

Table of Contents

List of Figures

List of Tables

INTRODUCTION

This appendix describes the general approach, statistical and modeling methodology, and the factors that inform estimated project-related incidental take of the Hawaiian hoary bat, or 'ōpe'ape'a, (*Lasiurus cinereus semotus*) for the purposes of mitigation offset at these wind facilities. Its intent is to introduce the reader to the basic concepts the Service and the projects use for fatality monitoring. The Service uses the most recent r-based Evidence of Absence ver 2.0.6 software for estimating the probability that a level of take has not been exceeded and for long-term take projection of rare fatality events. For a detailed in depth and technical description of the statistical methodologies and basis for using this model, the reader is referred to Evidence of Absence (v2.0) software user guide, U.S. Geological Survey Data Series 1055 (Dalthorp et al, 2017). The software and manual are available at https://pubs.er.usgs.gov/publication/ds1055. For additional background and technical information on the evolution of the models and their application for estimation the reader is referred to (Dalthorp and Huso 2015, Huso 2009, Huso and Dalthorp 2014, Huso et al 2015, Korner-Nievergelt et al 2015). The software is in the public domain and is freely available at the website shown above. The r-based GenEst model, (Dalthorp et al 2018; Simmons et al 2018) recently released to the public can also be used, though the user should understand the ramifications of using a k-value between 0 and 1 and adjust accordingly for the site and species in Hawai'i. The software and user manual are available at https://pubs.er.usgs.gov/publication/tm7A2. The Service has worked with all of the Applicants to standardize fatality monitoring. However, each site has its own unique set of characteristics that can affect parameter values used in the model. Specific details for each projects' fatality monitoring are included in the Auwahi, Kaheawa Wind Phase II, and Kawailoa draft HCP amendments and Pakini Nui draft HCP, and are incorporated by reference. In addition, Auwahi Wind, KWP II, and Kawailoa provide detailed annual reports to the wildlife agencies that are hereby referenced and by incorporated into this document (Auwahi Wind 2018; Kaheawa Wind Phase II 2018, and Kawailoa Wind 2018.

EXPLANATION OF INCREASED INCIDENTAL TAKE REQUESTS

Incidental take of Hawaiian hoary bat at Auwahi, Kaheawa Wind Phase II, and Kawailoa wind projects has been higher than anticipated under the approved HCPs, in part because risk to bats associated with wind energy development in Hawai'i was largely unknown and underestimated at the time at the time of permitting. The amount of incidental take includes observed and unobserved fatalities as well as dependent young. Advancements have been made in how fatality rates are estimated to appropriately account for imperfect detection and unobserved fatalities that may have occurred. The Service has adopted a conservative standard for estimating take and has rigorous compliance monitoring standards. The probability of detecting a fatality is informed by measured factors and variables. These include project-specific searcher efficiency, carcass retention, interval between searches, probability that if a carcass is missed it will be found on a subsequent search, size and terrain of the searchable area, portion of fatalities expected to occur in the actual searched area based on density dependent ballistics, turbine height, wind direction, and number of turbines. It is important to understand that each project has its own set of numerical values for each of the factors because of their unique site and monitoring characteristics. When the original approved HCPs were prepared for these three projects, post-construction mortality monitoring data from Hawai'i wind farms were limited. Estimates of take were based on the best available monitoring data from one operating wind farm in Hawai'i and general comparisons of bat acoustic activity between sites, which underestimated collision risk for bats. Advancements in acoustic monitoring and thermal imaging have shown that prior population estimates significantly under-reported abundance of the Hawaiian hoary bat. The Evidence of Absence software (ver. 2.0.6) used as a standard by PIFWO to project future take and calculate current take, incorporates project-specific inputs from the all project specific monitoring efforts, resulting in reduced uncertainty and more accurate project-specific estimates and projections. It is therefore anticipated that these HCP Amendments more accurately estimate the range of Hawaiian hoary bat take over the remaining years of Project operation.

TERMINOLOGY USED IN THIS APPENDIX

Incidental take. For the purposes of this appendix, incidental take refers to fatality or mortal injury of a protected species and is comprised of direct take (observed and unobserved) and indirect take that is assessed on observed and unobserved direct take.

Direct observed take. This refers to the number of fatalities (carcasses) found during fatality searches of a given species. This number is a known number entered into the model for each project and period.

Direct unobserved take. This represents the number of fatalities that *may* have occurred but that may have been missed or removed without being observed. It is an output of the model and should not be interpreted as the known number of unobserved fatalities that occurred. The model provides a range of numbers inferred by the 1) number of observed fatalities and, 2) the imperfect detection. Each number in that output range has an associated probability that the number has not been exceeded. Examples are provided later in this document.

Total direct take. The total of direct observed take plus direct unobserved take.

Indirect take. This represents the *assumed* loss of a dependent young of the fatality. In the case of bats, indirect take is assessed on the total direct take of females taken during the breeding season using a standardized formula. In the case of nene or Hawaiian petrel, it is assessed for the take of female or male during the breeding season because it is assumed that both sexes contribute equally to the rearing of the dependent young. Please note that indirect take is not an output of the model but is calculated separately and added to the total direct take based on the model's output value at the 80% credibility level.

Total take. This represents the sum total of the total direct take plus the total indirect take. Note that this does not represent the actual known total take. It is a value that the Service is confident has not been exceeded given imperfect detection. This is the value used for measuring compliance. Total take should always be stated as "we are X% confident that X total take has *not* been exceeded.

Credibility or assurance level. This represents the probability that an associated value has not been exceeded. The Service is conservative on the side of the species and uses the model output at the 80% credibility level.

GENERAL APPROACH AND METHODOLOGY

The need for modeling

If every fatality attributed to a project could be detected, we would use that number as the actual amount of total direct take. If this was the case, the probability of detection, *g*-value, would be equal to 1.0, meaning 100% of the fatalities directly attributed to the project would be found.

The probability of finding a rare fatality is much less than 100% ($g < 1.0$) under the conditions present at the wind facilities in Hawai'i. Because of imperfect detection, the simple count of observed fatalities does not accurately represent the actual number of animals killed at the project, nor can it be used as an "index" of mortality because it is not linearly related to the number it is intended to represent. This is because a relatively small bat carcass may be hidden by vegetation or surface topography, missed by the human or human/canine searchers, removed by a scavenger, wind, flooding, or other cause before it is found, decay before it is found, or a carcass may fall in an unsearched or unsearchable area such as a ravine. These types of factors are referred to as detection biases and contribute to a carcass not being observed, hence imperfect detection. Accurate estimation of the detection biases is critical to reasonably inferring total mortality. These factors or their effects can be measured and combined to form an overall probability of detecting a carcass. Although we cannot be certain of how many actual fatalities occurred within a period of time, we can use information about the overall probability of detection and the number of carcasses we do observe to develop a probability-based range of the possible number of fatalities that ***may have occurred and that have not been exceeded***.

Software

The Service uses modeling software. Presently, we, the applicant, and all incidental take permit holders in Hawai'i, use Evidence of Absence ver. 2.0.X (EoA) software developed by Dan Dalthorp, Manuela Huso, David Dail, and Jessica Kenyon [https://doi.org/10.3133/ds1055] as an estimator for inferring direct incidental take when fatality incidents are rare and detection probability is imperfect ($g < 1.0$). The software uses a probability (Baysian) approach to infer incidental take or the absence of incidental take, based on the number of observed fatalities found under a set of site-specific search parameters and carcass retention characteristics known as a detection probability.

Site-specific factors that inform the detection probability (g)

The detection probability, denoted by *g*, is the chance of a carcass being found. The factors that influence the chance of finding a carcass include: 1) the spatial coverage and complexity of the area designated to be searched; 2) temporal coverage; 3) searcher efficiency, 4) carcass persistence, 5) search interval, and 6) the factor by which searcher efficiency changes with each subsequent search. Structured spreadsheets are used for much of the data collection and input to minimize errors.

Spatial coverage

Unlike the mainland U.S, where only a subset of turbines are searched, in Hawai'i, the expected fall out area for fatalities under *all* turbines and meteorological towers at the four wind projects covered under this PEIS are searched. The expected fall out area for a given species is defined as the area where a carcass may fall or be thrown if that species collides with a rotating turbine blade. This fall out area extends radially out from the turbine monopole or tower of the turbine. Size of the fall out area is based on the mass of the individual, the height of the turbine, the blade length (Hull & Muir 2010) and the speed of the rotating blades. Hull and Muir (2010) found that larger animals are capable of being thrown a much greater distance due to their "central mass condensation" when they collide with a rotating blade. Thus, larger fall out areas are expected for larger birds. Hull and Muir (2010) found that for small turbines (65 m [213 feet] hub height and 33 m [108 feet] blade length), 99% of bat fatalities landed within 45 m (147 feet) of the turbine base, and for medium-sized carcasses, 99% fall within 108 m (354 feet).

The number of carcasses expected to arrive within the fall out range is not distributed evenly across the entire fall out area. In very general, the number of carcasses decreases with distance from the turbine monopole. If you were to overlay series of concentric rings spaced at 5 meter increments centered around the turbine monopole, the area contained within each ring increases with distance from the turbine, whereas the density of fatalities arriving in each ring, may be expected to decrease with distance from the turbine as the area of the ring is growing larger. The ballistic pattern formed by each ring can be associated with the proportion of total fatalities that may be expected to fall within a given ring. This is referred to as a density weighted proportion or average.

The mean distance from the monopole that a fatality may fall is dependent on speed of the rotor at time of impact, wind speed, turbine height, and mass of the body. Typically, we do not know the speed of the blades at the moment of impact and empirical data is limited in Hawai'i because many facilities have few if any observed fatalities per year which is not sufficient to establish a reliable and robust distribution pattern. If wind is predominantly from a single direction, it can contribute to anisotropic distribution of carcasses. The Service recommends rings that are 5 meters in width and no more than 10 meters in width. Sufficient data to accurately map this effect on carcass fall out pattern in Hawai'i is limited because the number of carcasses found are extremely low, even if data were pooled across different facilities or species of similar masses. In addition, pooling values and distributions across facilities has its own set of constraints and variabilities. As a result of this, the Service and the Applicants use the findings of Hull and Muir (2010) and other data sets as they become available for bat and avian fatalities from the mainland at facilities with similar turbines and wind profiles to estimate the proportion of fatalities that may be expected to occur at a given distance from the turbine. As additional fatality distributions are refined and data sets become available from other mainland sites with statistically robust distributions, each projects density weighted proportions are reviewed and the Service will require adjustments if necessary to the density weighted proportions.

Density weighted proportion (a)

The area in which a carcass may fall, denoted by *a,* is not always searchable under a turbine. A carcass may fall within a ravine or in tall vegetation that is not accessible for a thorough search. The proportion of carcasses that could fall in an unsearchable area is an important factor in determining the likelihood that a carcass may have arrived in the unsearchable area and thus would need to be accounted for since it will not be found. Thus, the spatial coverage that is entered in the model is based on the density-weighted proportion of the actual area searched. For example, a full search area would be expected to cover the entire fall out area for a species of a given mass. If there are 10 turbines and all 10 are intensively searched to a radius that encompasses the entire area where a carcass may fall and there is no unsearched area within that search radius, then $a = 1.0$. This means the spatial area searched represents 100% of the expected fall out distribution for the species. But, what if there are some turbines under which only part of the area can be searched? In this case, a will be less than 1 and the value will be based on the proportion of the carcasses that are expected to land in the searched area around the turbine.

The value for a must be between 0 and 1 for each site. A zero would mean no area is searched where carcasses are likely to fall. This is not the case in Hawai'i, because sizeable areas below every turbine are searched at permitted facilities. It must be emphasized that a is not the fraction of the total expected fallout area that is searched but the proportion of carcasses that are expected to arrive in the searched area based on the density weighted proportion. (Huso and Dalthorp, 2014).

Vegetation classes

The Evidence of Absence model provides a feature that allows search areas to be divided into classes based on degree of difficulty to search. Each area will have its own set of carcass retention and searcher efficiency trials that are overseen by the third party trial administrator.

Size of search area

Most projects have at least some areas that cannot be searched either because of a ravine or because dense vegetation prevents searching the area. The use of canines has improved the ability to search some of the areas that were less searchable with human searchers. However, this does not mean the carcasses that may fall in the unsearched area are not accounted for. The model considers the density weighted proportion of the possible fall out area that is searched AND also considers the probability that a carcass may have fallen in an unsearched area.

Facilities have been authorized to reduce the searched area because of safety or other limiting factors after conducting multiple years of searching the maximum area possible. But, the model accounts for this reduction in search area. The effect of this is a reduced probability of detection (g) and more uncertainty, that must be accounted for in the unobserved take and mitigated. Reduction of search area is only allowed after baseline fatality rates are established which requires several years of intensive monitoring.

Carcass retention or persistence

Another factor that informs the probability of finding a fatality is the carcass retention (CARE). A carcass can be expected to decay over time reducing the chances of finding evidence of a fatality. In addition, scavengers may also remove carcasses before they are observed. Facilities are required to conduct trials overseen by a third party trial administrator to evaluate how long a carcass is available to be found. In these trials, surrogates that closely resemble the target species in size, shape, and color are used in place of the protected species. Rats obtained through authorized sources are typically used as surrogates for Hawaiian hoary bats. Nonprotected avian carcasses are typically used as surrogates for protected avian species such as the Hawaiian petrel and nene. Trials need to be statistically robust, meaning they must capture the spatial and temporal variability of the site over time. Seasonal and spatial distribution along with duration of the carcass being out is an important consideration. This is especially important when placing larger carcasses so as not to attract scavengers that may remove other carcasses or become resident. The Service recommends to the applicants to deploy cameras as part of their persistence studies so the actual cause is known if a carcass is removed. Carcasses are randomly placed throughout the areas that are searched for protected species and are monitored to determine how long the carcass is available to be found. If the trials indicate scavengers are reducing carcass retention, facilities are advised to incorporate scavenger trapping and control measures to improve carcass retention. Sets of trials may be repeated multiple times annually if there are seasonal variations. The retention time of each carcass within a trial is input into the Evidence of Absence model and the best curve that fits the data is selected based on lowest AIC value of the distribution. In Hawaiʻi, two-parameter curves that have location and scale such as Wiebull, and log lognormal models typically provide the best fit, though occasionally, the exponential model, which is a single parameter curve, has the best fit. In general, an exponential curve can under estimate long term persistence and over-estimate short term persistence. This results in overestimating persistence and thus under estimating fatalities. Each trial or temporal period can be fit to a different curve to best inform the model on carcass retention. It is important to make sure the model fits well at the search interval rather than much beyond that interval.

Scavenger control is deployed at the project sites. Traps include live traps, Doc-250, and GoodNature A24 traps. Scavengers removed consist of feral cats, mongoose, and rats. Traps that may pose a risk to goslings of protected species are equipped with gosling guards to prevent accidental entrapment.

ITP holders provide the trial data to the Service in their annual reports. It is important to note that CARE is not just a mean and standard deviation. As discussed above, the carcass retention also informs what search interval may be appropriate. It is in the best interest of a project to increase the chances of finding a carcass (having a high detection probability) because it will reduce the amount of uncertainty that the model must accommodate. The greater the uncertainty the larger the range of possible unobserved fatalities.

Search frequency

A wind facility compliance individual or team conducts searches at every turbine and met tower at a regular interval. All of the projects conduct searches every 3.5 days or every 7 days year round. Carcass persistence inform this interval. The ideal is to have the interval between searches shorter than the carcass persistence that is estimated by CARE trials. Carcass retention is increasingly being monitoring by cameras at project site to obtain real time data.

Temporal coverage of the searches

In Hawaiʻi, searches are conducted at facilities with an ITP at least weekly, year round at every turbine. The three amending wind farms have been in compliance with all fatality monitoring requirements since permitted. On rare occasions, a search cannot be conducted on the day it was scheduled. The projects seeking amendments have notified the agencies. These occasions have been limited to safety constraints related to high winds or searcher availability issues (illness or injury). When this does occur, the search is conducted at the next available opportunity. The model accommodates and accounts this deviation from the set schedule. The amending facilities have made an effort to conduct searches on a rigorous schedule. The model can also accommodate different searchers over time and associated searcher efficiencies so long as trials have been conducted to evaluate the searcher for efficiency.

Searcher efficiency

Searcher efficiency (SEEF), denoted by *p*, is the probability of a searcher observing a carcass if one is present in the search area when the search is conducted. Searches at the wind facilities in Hawaiʻi were initially conducted by human searchers. The advent of scent- trained canines has vastly improved searcher efficiency for small carcasses such the Hawaiian hoary bat. In addition, canines are able to find carcasses that are not visible due to vegetation or other obstructions. The canines are scent trained on the scent of Hawaiian hoary bat carcass-scent and surrogate carcasses and are handled by professional handlers/trainers. Searcher efficiency for canine/handler teams generally ranges from 80-100% for small carcasses and 95-100 for medium to large carcasses.

Searcher efficiency is estimated through field trials. A search administrator implements and proctors the trials which are repeated throughout the year to evaluate searcher efficiency. Surrogates that are similar in size and color to the protected species that are taken by the project are placed randomly in the areas searched to measure the searcher efficiency. The searcher or canine/handler team do not know when a trial may be conducted, where a carcass may be placed, or how many carcasses may have been placed. The searcher is required to report the find of all carcasses when found and provide required information for verification. If a placed carcass is not found by the searcher during a scheduled search, the search administrator confirms that the carcass is still present, and then records it as a miss. If the carcass is gone that trial is not eligible for inclusion in the searcher efficiency trial data. The outcome of each trial is input into the model. The model can accommodate repeated searches if the carcass was missed and remains available for the next search. Typically the carcass retention for small size mammals is such that it is unlikely a human searcher would find the remains on the next search if the interval is 7 days, but canine/handler teams have a higher likelihood of finding the remains because initial discovery is scent based rather than visual based. The factor by which searcher efficiency changes with each subsequent search is also a factor in the model, referred to as k. A value of $k = 0$ implies the carcasses that are missed on the first search are not available to be found on each subsequent search, either because they decay or are removed. A value of $k = 1$ means the searcher efficiency remains constant regardless of carcass age and the number of times a carcass has been missed in previous searches. This is typical of larger carcasses if scavenging is not a factor and canines are used. Searcher efficiency typically varies with characteristics of the carcass such as size, conditions of the search, such as vegetation height or density, wind, season, the individual searcher, and type of searcher. Canine handlers in Hawaiʻi are particularly adept at managing their canines in windy situations.

Vegetation height or density may vary at a project, so, as mentioned in the density weighted proportion section, the vegetation class (easy, moderately difficult, difficult) is used as a category in the model and will have its own searcher efficiency associated with the vegetation class based on trials conducted in that vegetation type.

Searcher efficiency and carcass retention trials

A trial administrator is responsible for conducting the independent searcher efficiency trials. The results of each carcass placement (find or miss) is recorded in a standardized data sheet for use in Evidence of Absence. Trials are expected to represent actual searcher efficiency even though surrogate carcasses are used in place of the protected species. Rats that are similar in size and color are used as a surrogate for bats. Canine's used for searches are cross-trained on rats in addition to the protected species. Searchers (human searchers or canine/handler teams) are unaware of when or how many surrogate carcasses may be placed on any given search day for evaluating searcher efficiency. Placement of the carcasses by the trial administrator is conducted prior to the searchers' arrival to the project for a typical search day. Locations for carcass placement are randomly generated within the project search area. The carcass distribution covers each vegetation or difficulty class and the number of carcasses placed within a class represent the proportion of carcasses that may be expected to fall in that class of search area. The search administrator uses GPS to locate the random positions generated and drops the surrogate carcass over their shoulder. If the searcher does not find the surrogate carcass, the search administrator checks to see if the carcass is still in place after the searcher has left the site. If the carcass is present, it is recorded as a 0, which means the carcass was not found. A miss reduces the searcher efficiency. If it is found it is recorded as a 1. The number of carcasses placed is determined statistically and is based on the variability of the site. Typically, it is no fewer than 20 per class per trial for small size carcasses. Separate searcher efficiencies are conducted for the human searchers and for the canine searchers if a project uses both types. A trial will span a number of search dates. In other words, not all 20+ carcasses are put out at once. The searcher does not know when or how many carcasses have been placed. More than one trial is conducted during a year when there are seasonal variations or changes in site conditions or searchers.

Relative mortality rate, (ρ)

The assumed relative mortality rate, or rho-value (ρ), can be used to adjust for operational changes if the effect is known. A $\rho = 1$ is typically used for a 1 year period that had typical operating conditions and there is no reason to suspect mortality rates varied systematically from year to year. But let's say a project expands by 20%, then the ρ would be 1.20 for the future, because the site is now 20% larger. Alternatively, if minimization measures that were expected to reduce fatalities by 30% were implemented then ρ would be 0.7 for that period that the measure was implemented. For instance, on the mainland, studies have shown raising the curt-in speed and/or feathering turbine blades may reduce fatalities of some species of migrating bats (see Appendix D for a more thorough discussion of curtailment). As a result, a rho value may be used, when higher cut-in speeds are deployed, to inform the model that the rate of fatalities under this avoidance and minimization regime is expected to be less, and thus the model will address that change be reducing the take estimates. The core difficulty with deploying ρ is determining the correct or most appropriate value. In Hawai'i, the effectiveness of raising a cut-in speed is not known. The Hawaiian hoary bat may be around the turbines year around and may have different behaviors with regard to the turbines relative to their counterparts on the mainland. The danger with deploying a rho value below 1, is that it may decrease the fatality estimates when no reduction occurred. The unobserved take is always relative to the observed take and the detection probability. Extremely low numbers of observed fatalities and annual variability, make it difficult to determine if a reduction (or increase) is the result of the avoidance and minimization actions or is simply due to stochastic variation between years. All projects start off with using $\rho = 1$. 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.

Data use and interface

The parameters briefly described above are, in part, the basis upon which the unobserved take is inferred. All of these measured factors and variables are entered into the Evidence of Absence model software which formulates them into a detection probability. The detection probability, *g*-value are specific to an individual project because the values are dependent on the site conditions, the SEEF, CARE, etc. The detection probability is not static and may be different for each unique set of conditions or time period. For instance, a facility may have a detection value for the wet season and a different one for the dry season. There may be a scavenger problem, vegetation fluxes, searcher differences, etc. Detection probabilities vary each year, hence the need for conducting repeated trials to capture and measure seasonal or annual variations. The *Ba* and *Bb* parameters characterize the estimated detection probability along with its uncertainty.

Monitoring plans are reviewed annually and often much more frequently by the Service and DOFAW. Permit holders are required to provide detailed annual and semiannual reports to the agencies that include detailed fatality monitoring data and parameter inputs and outputs, along with other reporting requirements. The Service staff review these reports and provide comments and recommendations. If there are deficiencies the Service contacts the permit holder for a meeting or discussion. It is recommended to applicants and permit holders to design and maintain a sound and robust fatality monitoring plan. A robust and fatality monitoring plan can and will provide higher a detection probability value. The higher the probability of detecting a carcass, the lower the uncertainty associated with estimating the probability that carcasses were there but not found. The data collected in a structured format is uploaded to the software which can directly utilize SEEF, CARE, search dates, and other spreadsheet based information. The software user must input the number of observed fatalities found within the search area, search interval if not custom, and other site specific parameters described above and quantified for each monitoring period into the Evidence of Absence model.

Data output

The software will use the inputs to calculate the beta distribution parameters that characterize the estimated detection probability, *g*, for each year or period and produce a range of numerical estimates of the direct take (*m*) within which the actual amount of total direct take, M (observed and unobserved) most likely occurs. Each estimate of direct take (m) within this range will have two probabilities associated with it. The first value represents a probability that the estimate (*m*) is the actual amount of direct take (M = *m*). The median is the estimate (*m*) that has the highest probability that *m* really is the *actual* amount of direct take. But, this value does not mean that the value is correct, it simply means that estimate would be closest to the actual estimate most frequently. The actual value may be above or below that value.

The second probability is the credibility or assurance level that the actual direct take (M) has not exceeded the estimate (m) (M>m). The credibility or assurance level associated with each estimate (*m*) represents the confidence we have that the given numerical value representing total direct take *has not been exceeded*. This is a very important point. In rare event modeling, the numerical value is not likely to be a precise point estimate of the actual direct take. We may never know what the actual direct take is. **The reporting of this type of numerical value should always be accompanied by the level of credibility that is associated with it in a given model run.** Values often published in public are often reported as the actual known take amount rather than what the Service is confident has not been exceeded. We do not have a way to come up with an accurate point estimate because detection is less than perfect. Thus, we use the "*has not been exceeded"* approach.

The wildlife agencies in Hawai'i presently support the use an 80% credibility level as the surrogate point estimate that has not been exceeded for the total observed and unobserved direct take. Essentially, we are 80% confident that the directly-caused number of fatalities (observed + unobserved) lies somewhere between the number of observed fatalities and the output at 80%. This also infers that there is a 20% probability that the actual fatality number may be larger than the output at 80%. The higher the detection probability, *g*, the closer the median and the value at the 80% credibility level become. The Service does not use the median as the surrogate estimate for direct take because the probability that the actual direct take (M) could be larger. The median and 80% credibility level will be provided in the project-specific sections of this document.

Given the paucity of what is presently known about the Hawaiian hoary bat population size, biology, genetic diversity, and distribution, the wildlife agencies require a high level of confidence that a certain level of take has not been exceeded. The median output of the model represents the number that will be closest to the actual total direct take, but it could underestimate take, because the second probability value associated with that estimate is typically below 80%. If we were to use a 50% credibility level we would run the risk of underestimating the direct take 50% of the time. The Service is risk adverse and needs to be reasonably sure that the take estimate we are using are conservative on the side of the species, especially based on the paucity of our knowledge of the Hawaiian hoary bat and have adopted the 80% credibility level for estimating take at all wind farms in Hawai'i. The 80% credibility level assumes a higher number of bats have been taken.

The outputs from the Evidence of Absence software are based on the detection probability, *g*, which is derived from the parameters such as the searcher's efficiency, the carcass retention, the amount of area that is searched, the likelihood of a carcass falling in the searched area, and the length of the interval between searches, discussed earlier. The estimated *g*-value and the associated uncertainty is characterized by the *Ba* and *Bb* parameters. The factors that inform the estimated detection probability and the uncertainty can be controlled to some extent in the compliance monitoring plan design. For instance, if you have a short carcass persistence because of scavenger pressure, the project could implement scavenger control measures or shorten the interval between searches. If searcher efficiency is low, canine assisted searches may improve the carcass detection efficiency. Also, removal or maintenance of vegetation can improve carcass visibility and increase searcher efficiencies.

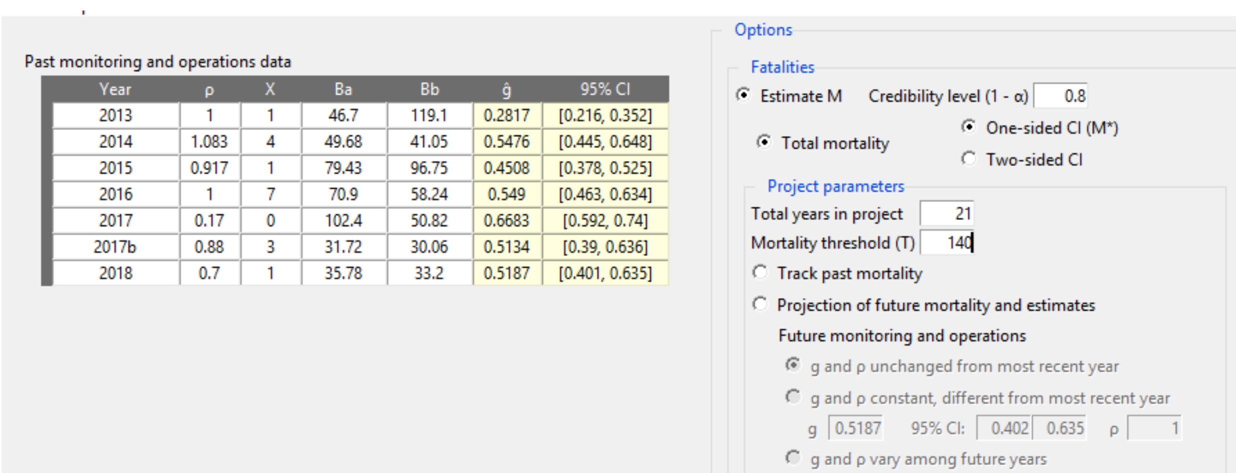
Estimated annual (baseline) fatality rate (λ)

This is the estimated number of fatalities that is most likely to occur each year based on what has been observed in previous years, the detection probability, yearly variation, and the uncertainty.

PROJECT-SPECIFIC MODEL INPUTS AND OUTPUTS

Auwahi Wind

Project specific parameters are provided in the semi-annual and annual reports provided by the project. These annual reports include searcher efficiency trial data, carcass persistence data, scavenger control, fatalities observed, and model inputs and outputs and are hereby incorporated by reference (Auwahi Wind 2013, 2014, 2015, 2016, 2017, 2018). The Service tracks incidental take in real time, when a fatality is observed. The Evidence of Absence model summarized inputs for Auwahi through September 2018 are shown in Figure C-1 and outputs are shown in Figure C-2. The mean detection probability for the 5.7 years of operation is 0.481; on the average about 48% of the fatalities that might occur are found. The estimated baseline fatality (λ) rate is 6.3 (95% C.I. = 3.7, 9.7), which is the most likely rate of bat fatalities per year. The column labeled with m is the estimated direct take. The second column labeled with p(M = m) is the probability that the value m is the actual amount of direct take. The third column labeled with p(M>m) is the probability that the actual direct take exceeds the associated m value. The median value of direct take is 34 (Figure C-2, highlighted in grey). Based on the probabilities listed in the second column, there is a 6.37 % chance that this is the actual direct take, but the third column shows a probability of 0.5564 which means there is a 55.64% chance the direct take does not exceed that value and a 44.36% (1-0.5564 x 100) chance that the actual direct take exceeds that value. Based on 17 observed fatalities, the Service is 80% confident that the actual direct take (observed and unobserved) does not exceed 41 (highlighted in yellow). There is a 3.88% chance that number is the actual direct take (number shown in the second column, 0.0388 x 100).



Past monitoring and operations data

Year	ρ	X	Ba	Bb	ĝ	95% CI
2013	1	1	46.7	119.1	0.2817	[0.216, 0.352]
2014	1.083	4	49.68	41.05	0.5476	[0.445, 0.648]
2015	0.917	1	79.43	96.75	0.4508	[0.378, 0.525]
2016	1	7	70.9	58.24	0.549	[0.463, 0.634]
2017	0.17	0	102.4	50.82	0.6683	[0.592, 0.74]
2017b	0.88	3	31.72	30.06	0.5134	[0.39, 0.636]
2018	0.7	1	35.78	33.2	0.5187	[0.401, 0.635]

Figure C-1. Detection probabilities and observed fatalities for the Auwahi Wind Project from 2013 through September 2018.

Summary statistics for total mortality through 6 years
M* = 41 for 1 - a = 0.8, i.e., P(M <= 41) >= 80%
Estimated overall detection probability: g = 0.481, 95% CI = [0.443, 0.519]
Ba = 321.5, Bb = 346.93
Estimated baseline fatality rate: lambda = 6.343, 95% CI = [3.7, 9.7]
Posterior distribution of M

m	p(M = m)	p(M > m)	m	p(M = m)	p(M > m)
0	0.0000	1.0000	35	0.0632	0.4932
1	0.0000	1.0000	36	0.0613	0.4319
2	0.0000	1.0000	37	0.0581	0.3738
3	0.0000	1.0000	38	0.0540	0.3198
4	0.0000	1.0000	39	0.0492	0.2706
5	0.0000	1.0000	40	0.0441	0.2266
6	0.0000	1.0000	41	0.0388	0.1877
7	0.0000	1.0000	42	0.0337	0.1540
8	0.0000	1.0000	43	0.0289	0.1252
9	0.0000	1.0000	44	0.0244	0.1008
10	0.0000	1.0000	45	0.0203	0.0805
11	0.0000	1.0000	46	0.0168	0.0637
12	0.0000	1.0000	47	0.0137	0.0500
13	0.0000	1.0000	48	0.0110	0.0390
14	0.0000	1.0000	49	0.0088	0.0302
15	0.0000	1.0000	50	0.0070	0.0232
16	0.0000	1.0000	51	0.0055	0.0177
17	0.0000	1.0000	52	0.0043	0.0134
18	0.0000	1.0000	53	0.0033	0.0101
19	0.0001	0.9998	54	0.0025	0.0076
20	0.0005	0.9994	55	0.0019	0.0056
21	0.0012	0.9982	56	0.0015	0.0042
22	0.0026	0.9955	57	0.0011	0.0031
23	0.0051	0.9905	58	0.0008	0.0022
24	0.0087	0.9818	59	0.0006	0.0016
25	0.0136	0.9683	60	0.0005	0.0012
26	0.0197	0.9486	61	0.0003	0.0008
27	0.0267	0.9219	62	0.0002	0.0006
28	0.0343	0.8876	63	0.0002	0.0004
29	0.0418	0.8458	64	0.0001	0.0003
30	0.0489	0.7969	65	0.0001	0.0002
31	0.0549	0.7420	66	0.0001	0.0001
32	0.0595	0.6825	67	0.0000	0.0001
33	0.0624	0.6201	68	0.0000	0.0000
34	0.0637	0.5564	69	0.0000	0.0000

Figure C-2. Binomial distribution of estimated direct take for Auwahi Wind Project from 2013 through September 2018.

Total project-specific fatalities (direct plus indirect take) that the Service in 80% confident has not been exceeded at Auwahi Wind

Based on Service' calculations using Evidence of Absence and the standardized protocol for calculating indirect take (described in Appendix E), there is an 80% probability that total direct take does not exceed 41 as of September 30, 2018. Estimated indirect take is 4 based on this direct take, and the total take is not expected to exceed 45. This summary from the Service includes the results of the genetic DNA-based sex determination of the bat fatalities that have been determined by Pinzari and Bonaccorso (2018) for bat fatalities that occurred through December 31, 2016. A breakdown of the calculations is provided below.

Calculations based on indirect take standardization

As of September 30. 2018, there are 21 observed bat fatalities: 17 are considered observed and 4 are considered incidental and are accounted for in the unobserved take probability. Of the four considered incidental (8/5/2017, 9/1/2017, 1/29/2018, and 8/13/2018), three have been found during the breeding season. Nine bat fatalities have been observed during the breeding season from April 1 through September 15. Of those nine, two were genetically confirmed as female (7/7/2016 and 8/15/2016), four are genetically confirmed as male (8/30/2014, 6/10/2016, 8/30/2016, and 9/2/2016) and three are unknown (8/28/2017, 9/5/2017, 9/13/2017) and have not yet been genetically tested.

[2 females x 1.8 juveniles = 3.6 juveniles x 0.3 survival = 1.08]

We assume a 50:50 (female:male) ratio of the remaining 3 observed bat fatalities taken during the breeding season. Thus, there are 2 females and 1 males (extra bat considered female until genetic determination is made)

[2 females x 1.8 juveniles = 3.6 juveniles x 0.3 = 1.08]

No indirect take assessed is for eight observed fatalities outside of the breeding season. Based on the 80% probability that total take does not exceed 41, and 17 fatalities have been observed during routine searches in the designated search areas, 24 fatalities may have been unobserved. This would include the 4 fatalities observed, but that are treated as unobserved because found outside the search area or routine search period and fit the definition of unobserved take for the purposes of the Evidence of Absence model.

[24 unobserved fatalities/2 based on assumed female to male ratio = 12 females x 0.25 which is the chance that a female had dependent young =3.0 x 1.8 based on the number of juveniles per female = 5.4 x 0.3 survival rate = 1.62]

Four observed fatalities are classified as unobserved fatalities because of the fatalities being considered as incidental finds (outside of the search area or found incidentally during non-scheduled search). Accounting for discovery during non-incidental search and the options for accounting for the fatality appropriately in the model has been documented in an additional Service guidance document provided in the section called ***Wildlife agency standardized protocols for wildlife fatalities found outside the designated search area or discovered***

incidentally outside of a routine search (ver. March 31, 2018) and included at the end of this appendix and provided to the applicants in April 2018. Three of these four fatalities that are treated as unobserved were found during the breeding season. These three fatalities represent 12.5% of the total unobserved take. The standardization considers 25% of the unobserved take to occur in the breeding period, thus the three observed take do fit the assumption that they can be considered unobserved.

Indirect take summary:
1.08 (adult equivalencies from known observed females taken during the breeding season)
1.08 (adult equivalencies from observed fatalities of unknown sex assuming 1:1 sex ratio)
1.62 (adult equivalencies from unobserved fatalities assuming 1:1 sex ratio)
Total indirect 1.08 + 1.08 + 1.62 = 3.78 rounded to 4 by Service.

Direct take projections

The direct take projection for the 20 year operational period of the Auwahi project at 1-α = 0.8 show that the direct take is not expected to exceed 133 (Figure C-3, value under *m** column). This estimate is based on 2 years of take observed during implementation of no low wind speed curtailment above the manufacturers' and about 3.5 years of a 5.0 m/s cut in speed. It also assumes the detection probability would remain the same for the life of the project. Recently, Auwahi raised the cut- in speed to 6.9 m/s for the months of August through October, which spans the period the most take has been observed at Auwahi as an experimental measure to reduce take during that period. If that minimization measure does reduce the number of observed fatalities and is continued, for the life of the project, then the projections would be expected to be less. The limitation with projecting the take in the future is the uncertainty around the effectiveness of the low wind speed cut-in speed of 6.9 relative to the 5.0 m/s. It also does not include any reduction that would be associated with the deployment of an effective deterrent system. The further out in the future the projection spans, the more the uncertainty surrounding the estimate as is shown by the expanding grey areas in the whisker plots (Figure C-4). The blue line indicates the request of 140. The degree of shading around the box plots represent confidence around the projected take.

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================================================================================
Summary statistics from posterior predictive distributions for 10000 simulated projects
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Estimated annual baseline fatality rate (lambda for rho = 1): mean = 6.34, 95% CI = [3.7, 9.7]

Projected fatalities and fatality estimates...
p(M > Tau within 21 years) = 0.2401  [exceedance]
p(M* > Tau within 21 years) = 0.3614  [triggering]
M* based on credibility level 1 - alpha = 0.8

Among projects with triggering (36.14%), mean(M) = 131.25 at time of triggering, with median = 131 and IQR = [123, 139]
Among projects with no triggering (63.86%), mean(M) = 111.72 at end of 21 years, with median = 112 and IQR = [101, 123]

Years of operations without triggering:
 Mean = 20.30, with median =  21 and IQR = [20, 21]

----------------------------------------
Summary statistics for projection years
```

Yr	Mean M	Mean M*	quantiles of M 0.05	0.10	0.25	0.50	0.75	0.90	0.95	quantiles of M* 0.05	0.10	0.25	0.50	0.75	0.90	0.95
1	42.4	47.8	32	34	37	42	47	52	55	41	43	45	47	49	54	56
2	48.6	54.6	36	39	43	48	54	59	63	45	47	49	53	58	64	66
3	55.0	61.2	41	44	49	54	61	67	71	49	51	55	59	66	72	77
4	61.3	67.9	46	49	54	61	68	75	79	53	55	61	68	74	80	87
5	67.6	74.6	50	54	60	67	75	82	87	57	59	65	74	82	91	97
6	73.9	81.2	55	58	65	73	82	91	96	61	65	71	80	90	99	105
7	80.3	87.8	59	63	71	79	89	98	105	65	69	77	86	96	109	115
8	86.6	94.4	63	68	76	86	96	107	113	69	73	81	92	104	117	125
9	93.0	101.0	68	72	81	92	104	115	122	73	79	87	100	112	125	133
10	99.3	107.6	72	77	86	98	111	123	131	77	83	94	106	121	135	143
11	105.7	114.2	76	82	92	104	118	131	140	81	87	100	112	129	143	153
12	112.0	120.8	80	86	97	110	125	139	149	85	91	104	118	137	151	163
13	118.3	127.3	84	91	102	117	132	148	158	89	97	110	126	143	161	173
14	124.6	133.8	88	96	108	123	140	156	167	93	101	116	132	151	169	181

Figure C-3. Projected take at the 80% credibility level for the next 14 years based on six years of data from Auwahi Wind.

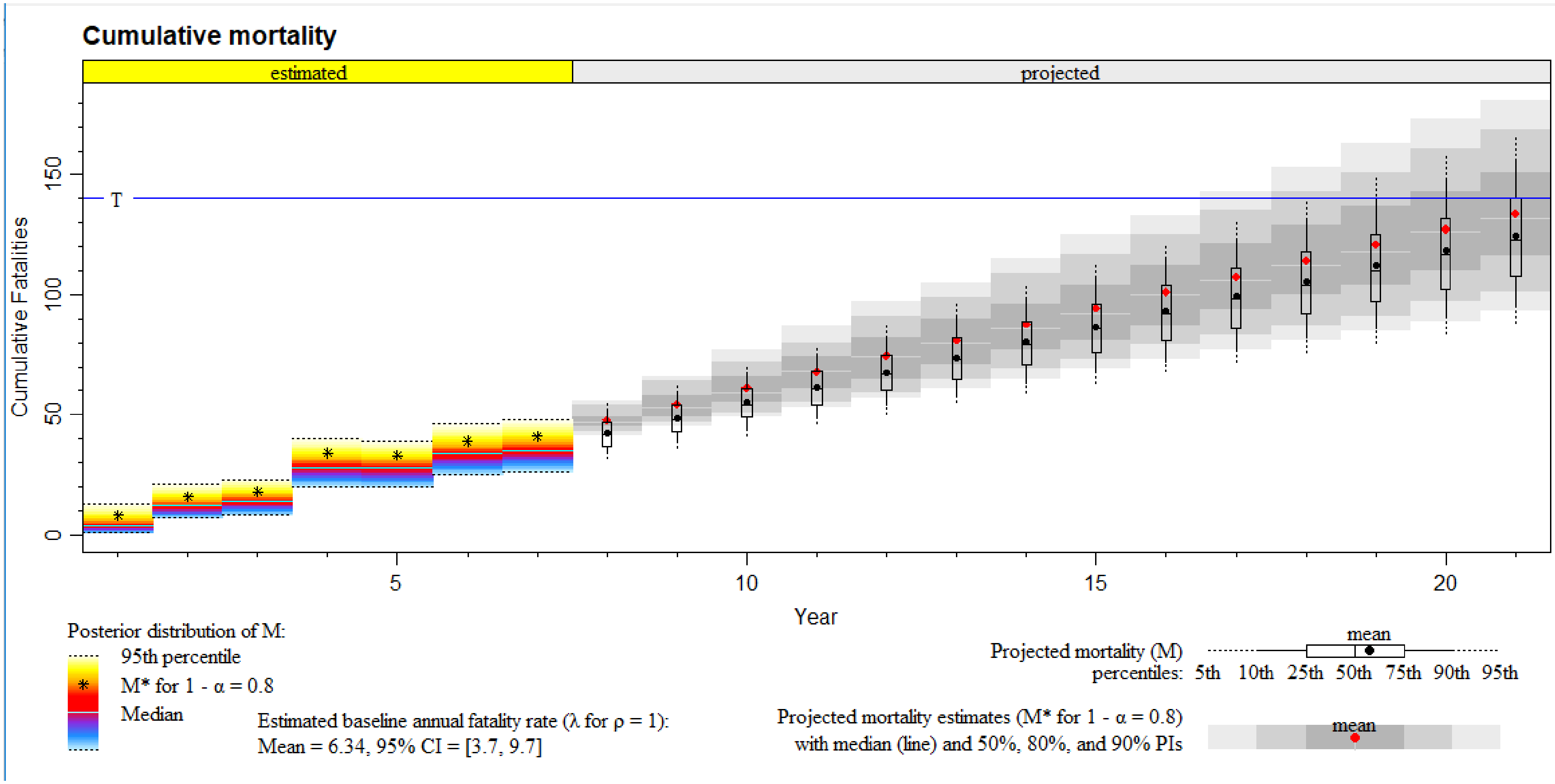
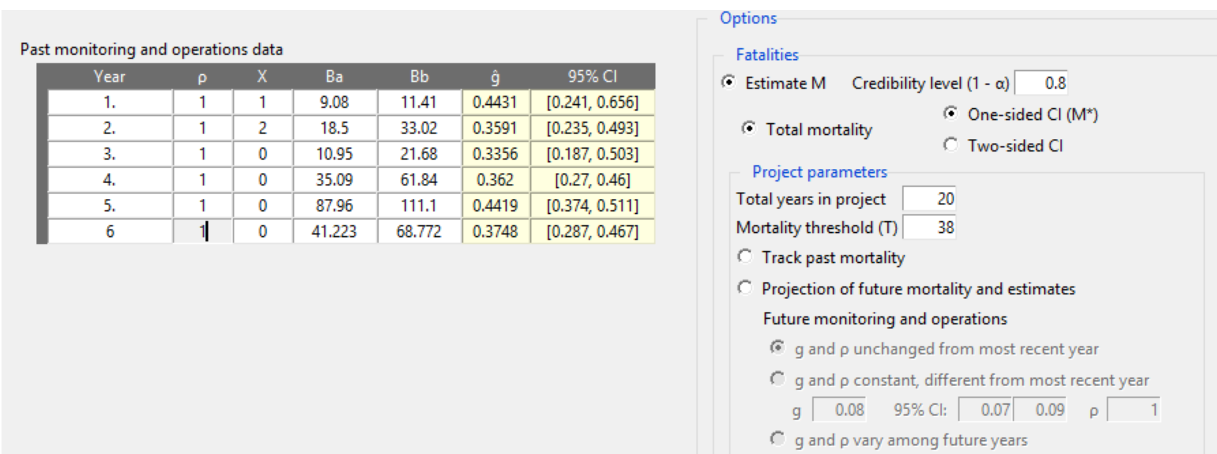


Figure C-4. Box and whisker plots showing estimates of past mortality (colored) and projections of future mortality and mortality estimates at 1 – α = 0.8 for Auwahi Wind.

Kaheawa Wind Phase II

Project specific parameters are provided in the semi-annual and annual reports provided by the project. These annual reports include searcher efficiency trial data, carcass persistence data, scavenger control, fatalities observed, and model inputs and outputs and are hereby incorporated by reference (Kaheawa Wind Phase II 2012, 2013, 2014, 2015, 2016. 2017, 2018). The Service tracks incidental take in real time, when a fatality is observed. The Evidence of Absence model summarized inputs for Kaheawa Wind Phase II through September 2018 are shown in Figure C-5 and outputs are shown in Figure C-6. The mean detection probability for the 6.7 years of operation is 0.387; on the average about 39% of the fatalities that might occur are found. The estimated baseline fatality (λ) rate is 1.6 (95% C.I. = 0.379, 3.67), which is the most likely rate of bat fatalities per year. The column labeled with m is the estimated direct take. The second column labeled with p(M = m) is the probability that the value m is the actual amount of direct take. The third column labeled with p(M>m) is the probability that the actual direct take exceeds the associated m value. The median value of direct take is 6 (Figure C-6, highlighted in grey). Based on the probabilities listed in the second column, there is a 11.8 % chance that this is the actual direct take, but the third column shows a probability of 0.6641 which means there is a 66% chance the direct take does not exceed that value and a 34% (1-0.6641 x 100) chance that the actual direct take does exceed that value. Based on 3 observed fatalities, the Service is 80% confident that the actual direct take (observed and unobserved) does not exceed 12 (highlighted in yellow). There is a 5% chance that number is the actual direct take (number shown in the second column, 0.1511 x 100).



Past monitoring and operations data

Year	ρ	X	Ba	Bb	ĝ	95% CI
1.	1	1	9.08	11.41	0.4431	[0.241, 0.656]
2.	1	2	18.5	33.02	0.3591	[0.235, 0.493]
3.	1	0	10.95	21.68	0.3356	[0.187, 0.503]
4.	1	0	35.09	61.84	0.362	[0.27, 0.46]
5.	1	0	87.96	111.1	0.4419	[0.374, 0.511]
6	1	0	41.223	68.772	0.3748	[0.287, 0.467]

Figure C-5. Detection probabilities and observed fatalities for the Kaheawa Wind Phase II Project from 2012 through September 2018.

Summary statistics for total mortality through 6 years
M* = 12 for 1 - a = 0.8, i.e., P(M <= 12) >= 80%
Estimated overall detection probability: g = 0.387, 95% CI = [0.331, 0.444]
Ba = 110.74, Bb = 175.73
Estimated baseline fatality rate: lambda = 1.588, 95% CI = [0.379, 3.67]

Posterior distribution of M

m	p(M = m)	p(M > m)
0	0.0000	1.0000
1	0.0000	1.0000
2	0.0000	1.0000
3	0.0358	0.9642
4	0.0766	0.8876
5	0.1053	0.7822
6	0.1181	0.6641
7	0.1176	0.5465
8	0.1082	0.4383
9	0.0942	0.3440
10	0.0788	0.2653
11	0.0638	0.2015
12	0.0504	0.1511
13	0.0390	0.1121
14	0.0297	0.0824
15	0.0223	0.0601
16	0.0166	0.0436
17	0.0122	0.0314
18	0.0089	0.0225
19	0.0064	0.0160
20	0.0046	0.0114
21	0.0033	0.0080

Figure C-6. Binomial distribution of estimated direct take for Kaheawa Wind Project II from 2012 through September 2018.

Total project-specific fatalities (direct plus indirect take) that the Service in 80% confident has not been exceeded at Kaheawa Wind Phase II

Based on Service' calculations using Evidence of Absence and the standardized protocol for calculating indirect take (described in Appendix E), there is an 80% probability that total direct take does not exceed 12 as of September 30, 2018. Estimated indirect take is 1 based on this direct take, and the total take is not expected to exceed 13. This summary from the Service includes the results of the genetic DNA-based sex determination of the bat fatalities that have been determined by Pinzari and Bonaccorso (2018) for bat fatalities that occurred through December 31, 2016. A breakdown of the calculations is provided below.

Calculations based on indirect take standardization

As of September 30. 2018, there are 3 observed bat fatalities: 3 are considered observed and 0 are considered incidental and are accounted for in the unobserved take probability. Zero bat fatalities have been observed during the breeding season from April 1 through September 15. Therefore, no indirect take assessed for three observed fatalities outside of the breeding season.

Based on the 80% probability that total take does not exceed 12, and 3 fatalities have been observed during routine searches in the designated search areas, 9 fatalities may have been unobserved.

> [9 unobserved fatalities/2 based on assumed female to male ratio = 4.5 rounded to 5 by the Service females x 0.25 which is the chance that a female had dependent young =1.25 x 1.8 based on the number of juveniles per female = 2.25 x 0.3 survival rate = 0.675]

Indirect take:
0 (adult equivalencies from observed fatalities of unknown sex assuming 1:1 sex ratio)
0.675 (adult equivalencies from unobserved fatalities assuming 1:1 sex ratio)
Total indirect 0 + 0.675 = 0.675 rounded to 1 by Service.

Direct take projections

The direct take projection for the 20 year operational period of the Kaheawa Wind Phase II project at $1-\alpha = 0.8$ show that the direct take is not expected to exceed 36 (Figure C-7, value under *m** column). This estimate is based on the initial implementation of seasonal low wind speed curtailment of a 5.0 m/s cut in speed. Two observed fatalities occurred outside of this period and the project expanded low wind speed curtailment at 5.0 m/s to cover those periods. Subsequently, the project raised the low wind speed curtailment cut-in speed to 5.5, based on a fatality observed at a neighboring facility. Following the increase of low wind speed curtailment cut-in speed to 5.5 m/s, no bat fatalities have been observed. The projections assumes the detection probability would remain the same for the life of the project. If the minimization measure of low wind speed curtailment at 5.5 m/s does reduce the number of observed fatalities and is continued, for the life of the project, then the projections would be expected to be less. The limitation with projecting the take in the future is the uncertainty around the effectiveness of the low wind speed cut-in speed of 5.5 m/s relative to the 5.0 m/s. It also does not include any reduction that would be associated with the deployment of an effective deterrent system. The further out in the future the projection spans, the more the uncertainty surrounding the estimate as is shown by the expanding grey areas in the whisker plots (Figure C-8). The blue line indicates the request of 38. The degree of shading around the box plots represent confidence around the projected take. The higher relative level of uncertainty associated with the project relative to other projects in the PEIS is because of the lower mean detection probability and the variation that has occurred over the years of operation.

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==============================================================================
Summary statistics from posterior predictive distributions for 10000 simulated projects
------------------------------------
Estimated annual baseline fatality rate (lambda for rho = 1): mean = 1.52, 95% CI = [0.364, 3.52]

Projected fatalities and fatality estimates...
p(M > Tau within 20 years) = 0.2244  [exceedance]
p(M* > Tau within 20 years) = 0.3951  [triggering]
M* based on credibility level 1 - alpha = 0.8

Among projects with triggering (39.51%), mean(M) = 31.83 at time of triggering, with median = 31 and IQR = [27, 36]
Among projects with no triggering (60.49%), mean(M) = 23.06 at end of 20 years, with median = 23 and IQR = [18, 28]

Years of operations without triggering:
 Mean = 18.54, with median =  20 and IQR = [17, 20]

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Summary statistics for projection years
```

Yr	Mean M	M*	quantiles of M 0.05	0.10	0.25	0.50	0.75	0.90	0.95	quantiles of M* 0.05	0.10	0.25	0.50	0.75	0.90	0.95
1	10.2	13.8	5	5	7	9	13	16	18	12	12	12	12	15	18	18
2	11.8	15.5	6	6	8	11	14	18	20	12	12	12	15	18	21	24
3	13.3	17.2	6	7	9	13	16	20	23	12	12	15	15	21	24	27
4	14.8	19.0	7	8	11	14	18	23	25	12	12	15	18	21	27	30
5	16.4	20.7	8	9	12	16	20	25	28	12	12	15	18	24	30	33
6	17.9	22.4	8	10	13	17	22	27	31	12	15	18	21	27	33	36
7	19.4	24.1	9	11	14	18	24	30	34	12	15	18	24	30	36	41
8	21.0	25.7	9	11	15	20	26	32	37	12	15	18	24	30	38	44
9	22.5	27.4	10	12	16	21	28	35	40	15	15	21	27	33	41	47
10	24.0	29.1	11	13	17	23	30	37	43	15	15	21	27	36	44	50
11	25.6	30.8	11	13	18	24	32	40	46	15	18	21	30	39	47	53
12	27.1	32.5	12	14	19	26	33	42	49	15	18	24	30	39	50	56
13	28.6	34.1	12	15	20	27	35	45	52	15	18	24	33	41	53	62
14	30.2	35.8	13	16	21	28	37	47	55	15	18	24	33	44	56	64

Figure C-7. Projected take at the 80% credibility level for the next 14 years based on six years of data from Kaheawa Wind Phase II.

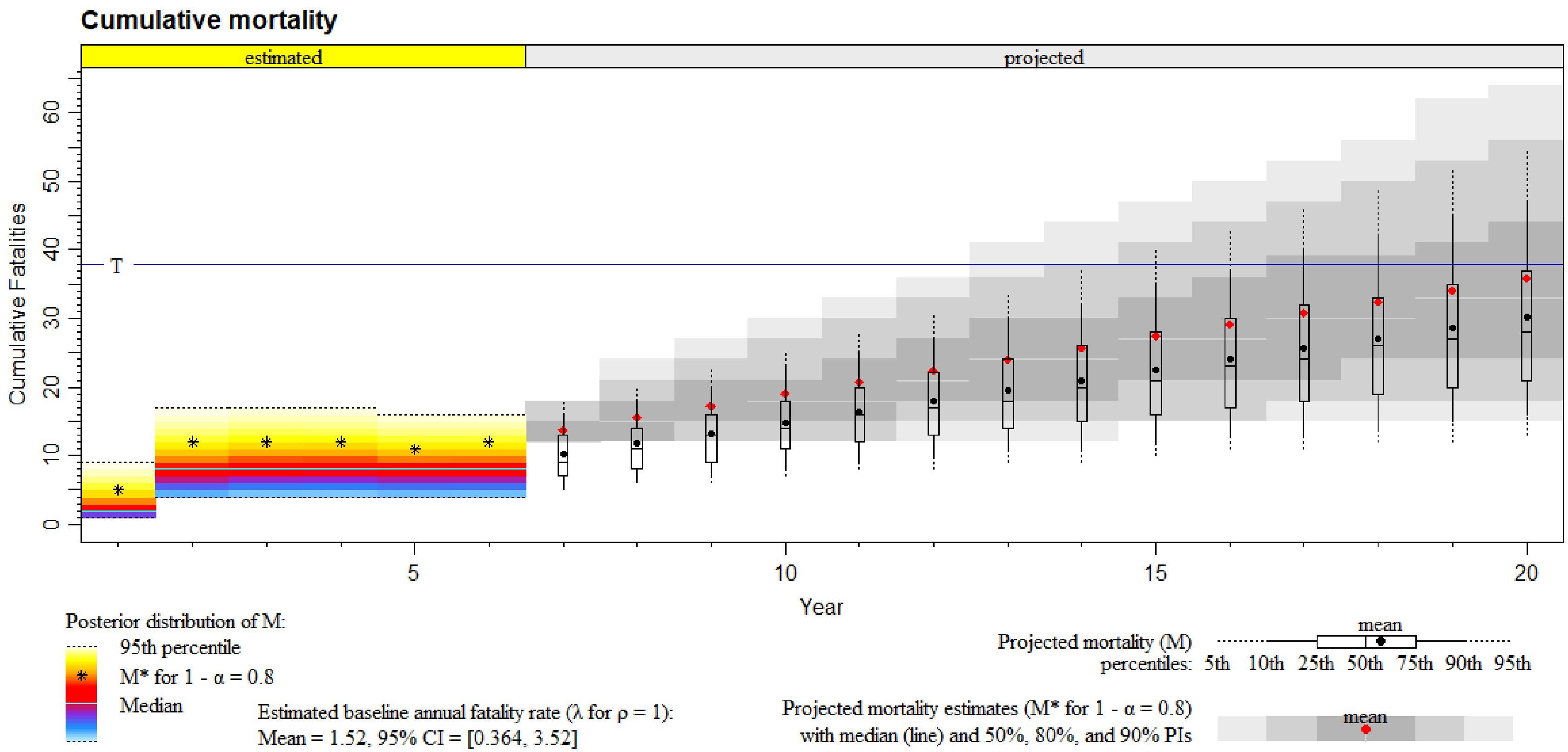
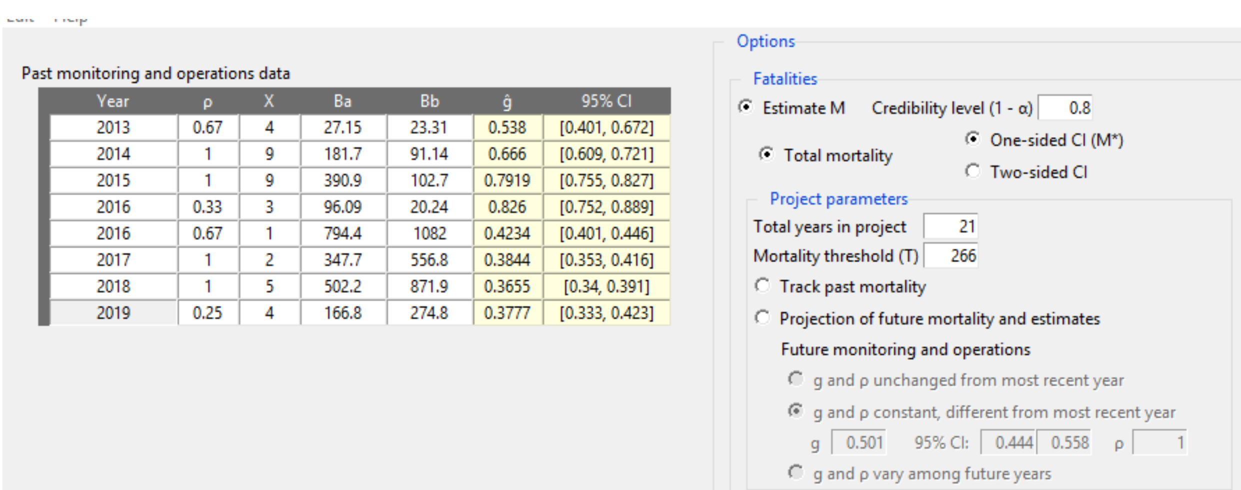


Figure C-8. Box and whisker plots showing estimates of past mortality (colored) and projections of future mortality and mortality estimates at 1 – α = 0.8 for Kaheawa Wind Phase II.

Kawailoa Wind

Project specific parameters are provided in the semi-annual and annual reports provided by the project. These annual reports include searcher efficiency trial data, carcass persistence data, scavenger control, fatalities observed, and model inputs and outputs and are hereby incorporated by reference (Kawailoa Wind 2012, 2013, 2014, 2015. 2016, 2017, 2018). The Service tracks incidental take in real time, when a fatality is observed. The Evidence of Absence model summarized inputs for Kawailoa Wind through September 2018 are shown in Figure C-9 and outputs are shown in Figure C-10. The mean detection probability after 6 years of operation is 0.544; on the average about 54% of the fatalities that might occur are found. The estimated baseline fatality (λ) rate is 11.7, which is the most likely rate of bat fatalities per year. The column labeled with m is the estimated direct take. The second column labeled with p(M = m) is the probability that the value m is the actual amount of direct take. The third column labeled with p(M>m) is the probability that the actual direct take exceeds the associated m value. The median value of direct take is 67 (Figure C-10, highlighted in grey). Based on the probabilities listed in the second column, there is a 5.23 % chance that this is the actual direct take, but the third column shows a probability of 0.5278 which means there is a 52.78% chance the direct take does not exceed that value and a 47.22% (1-0.5278 x 100) chance that the actual direct take exceeds that value. Based on 37 observed fatalities, the Service is 80% confident that the actual direct take (observed and unobserved) does not exceed 75 (highlighted in yellow). There is a 3.24% chance that that number is the actual direct take (number shown in the second column, 0.0324 x 100).



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	0.33	3	96.09	20.24	0.826	[0.752, 0.889]
2016	0.67	1	794.4	1082	0.4234	[0.401, 0.446]
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	0.25	4	166.8	274.8	0.3777	[0.333, 0.423]

Figure C-9. Detection probabilities and observed fatalities for the Kawailoa Wind Project from 2011 through September 2018.

M* = 75 for 1 - a = 0.8, i.e., P(M <= 75) >= 80%

Estimated overall detection probability: g = 0.544, 95% CI = [0.523, 0.565]

Ba = 1190.7, Bb = 999.13

Estimated baseline fatality rate: lambda = 11.66, 95% CI = [8.21, 15.7]

Posterior distribution of M

m	p(M = m)	p(M > m)	m	p(M = m)	p(M > m)	m	p(M = m)	p(M > m)
0	0.0000	1.0000	35	0.0000	1.0000	70	0.0487	0.3764
1	0.0000	1.0000	36	0.0000	1.0000	71	0.0462	0.3302
2	0.0000	1.0000	37	0.0000	1.0000	72	0.0431	0.2871
3	0.0000	1.0000	38	0.0000	1.0000	73	0.0397	0.2474
4	0.0000	1.0000	39	0.0000	1.0000	74	0.0361	0.2114
5	0.0000	1.0000	40	0.0000	1.0000	75	0.0324	0.1790
6	0.0000	1.0000	41	0.0000	1.0000	76	0.0287	0.1503
7	0.0000	1.0000	42	0.0000	1.0000	77	0.0251	0.1252
8	0.0000	1.0000	43	0.0000	1.0000	78	0.0218	0.1034
9	0.0000	1.0000	44	0.0000	1.0000	79	0.0187	0.0847
10	0.0000	1.0000	45	0.0001	0.9999	80	0.0158	0.0689
11	0.0000	1.0000	46	0.0001	0.9998	81	0.0133	0.0556
12	0.0000	1.0000	47	0.0002	0.9996	82	0.0111	0.0445
13	0.0000	1.0000	48	0.0005	0.9991	83	0.0091	0.0354
14	0.0000	1.0000	49	0.0008	0.9983	84	0.0075	0.0279
15	0.0000	1.0000	50	0.0015	0.9968	85	0.0060	0.0219
16	0.0000	1.0000	51	0.0024	0.9944	86	0.0049	0.0170
17	0.0000	1.0000	52	0.0037	0.9907	87	0.0039	0.0132
18	0.0000	1.0000	53	0.0055	0.9852	88	0.0031	0.0101
19	0.0000	1.0000	54	0.0078	0.9774	89	0.0024	0.0077
20	0.0000	1.0000	55	0.0107	0.9667	90	0.0019	0.0058
21	0.0000	1.0000	56	0.0142	0.9525	91	0.0014	0.0044
22	0.0000	1.0000	57	0.0182	0.9343	92	0.0011	0.0033
23	0.0000	1.0000	58	0.0226	0.9117	93	0.0008	0.0024
24	0.0000	1.0000	59	0.0272	0.8845	94	0.0006	0.0018
25	0.0000	1.0000	60	0.0320	0.8525	95	0.0005	0.0013
26	0.0000	1.0000	61	0.0367	0.8158	96	0.0004	0.0010
27	0.0000	1.0000	62	0.0410	0.7749	97	0.0003	0.0007
28	0.0000	1.0000	63	0.0448	0.7300	98	0.0002	0.0005
29	0.0000	1.0000	64	0.0480	0.6821	99	0.0001	0.0003
30	0.0000	1.0000	65	0.0503	0.6318	100	0.0001	0.0002
31	0.0000	1.0000	66	0.0518	0.5800	101	0.0001	0.0001
32	0.0000	1.0000	67	0.0523	0.5278	102	0.0001	0.0001
33	0.0000	1.0000	68	0.0519	0.4758	103	0.0000	0.0001
34	0.0000	1.0000	69	0.0507	0.4251	104	0.0000	0.0000

Figure C-10. Binomial distribution of estimated direct take for Kawailoa Wind Project from 2011 through September 2018.

Total project-specific fatalities (direct plus indirect take) that the Service in 80% confident has not been exceeded at Kawailoa Wind

Based on Service' calculations using Evidence of Absence and the standardized protocol for calculating indirect take (described in Appendix E), there is an 80% probability that total direct take does not exceed 75 as of September 30, 2018. Estimated indirect take is 8 based on this direct take, and the total take is not expected to exceed 83. This summary from the Service includes the results of the genetic DNA-based sex determination of the bat fatalities that have been determined by Pinzari and Bonaccorso (2018) for bat fatalities that occurred through December 31, 2016. A breakdown of the calculations is provided below.

Calculations based on indirect take standardization

As of September 30, 2018, there are 39 observed bat fatalities: 37 are considered observed and 2 are considered incidental and are accounted for in the unobserved take probability. Of the two considered incidental (6/29/2013 and 2/23/2016), zero have been found during the breeding season. Twenty-four observed bat fatalities have been observed during the breeding season from April 1 through September 15. Of those 24, 1 was reported as a female (7/19/2018) but has not yet been genetically confirmed), 4 were genetically determined to be females (8/12/2013, 6/2/2014, 8/29/2014, and 9/8/2014) and 12 were genetically determined to be males. The remaining 7 are considered sex unknown and are awaiting genetic testing.

> [5 females x 1.8 juveniles = 9.0 juveniles x 0.3 survival = 2.70]

We assume a 50:50 (female:male) ratio of the remaining 7 observed bat fatalities taken during the breeding season. Thus, there are 4 females and 3 males (extra bat considered female until sex determined with genetic testing).

> [4 females x 1.8 juveniles = 7.2 juveniles x 0.3 = 2.16]

No indirect take is assessed for 13 observed fatalities outside of the breeding season.
Based on the 80% probability that total direct take does not exceed 75, and 37 fatalities have been observed during routine searches in the designated search areas, 38 fatalities may have been unobserved. The 38 would include the 2 observed fatalities (6/29/2013 and 2/23/2016) that are treated as unobserved because found outside the search area or routine search period.

> [38 unobserved fatalities/2 based on assumed female to male ratio = 19.0 females 19.0 x 0.25 which is the chance that a female had dependent young = 4.75 x 1.8 based on the number of juveniles per female = 8.55 x 0.3 survival rate = 2.57]

Accounting for discovery during non-incidental search and the options for accounting for the fatality appropriately in the model has been documented in an additional Service guidance document provided in the section called *Wildlife agency standardized protocols for wildlife fatalities found outside the designated search area or discovered incidentally outside of a routine search (ver. March 31, 2018)* and included at the end of this appendix and provided to the applicants in April 2018.

Indirect take summary:
2.72 (adult equivalencies from known observed females taken during the breeding season)
2.16 (adult equivalencies from observed fatalities of unknown sex assuming 1:1 sex ratio)
2.59 (adult equivalencies from unobserved fatalities assuming 1:1 sex ratio)
Total indirect 2.72 + 2.16 + 2.57 = 7.45 rounded to 8 by Service.

Direct take projections

The direct take projection for the 20 year operational period of the Kawailoa project at 1-α = 0.8 show that the direct take is not expected to exceed 225 (Figure C-11, value under *m** column). This estimate is based on 6 years of take observed during implementation of low wind speed curtailment at a cut-in speed of 5.0 m/s. It also assumes the detection probability would remain the same for the life of the project. Kawailoa Wind expanded the curtailment period in response to additional fatalities being observed outside of the low wind speed curtailment period. Recently, Kawailoa implemented a hysteresis of .2 m/s and increased the rolling average interval to 20 minutes. If that minimization measure does reduce the number of observed fatalities and is continued, for the life of the project, then the projections would be expected to be less. The limitation with projecting the take in the future is the uncertainty around the effectiveness of the low wind speed cut-in speed of 5.2 m/s relative to the 5.0 m/s and the 20 minute rolling average. It also does not include any reduction that would be associated with the deployment of an effective deterrent system, which Kawailoa Wind has been experimenting with in conjunction with NRG. The further out in the future the projection spans, the more the uncertainty surrounding the estimate as is shown by the expanding grey areas in the whisker plots (Figure C-12). The projection for this project shows less uncertainty than other projects because the detection probability has been relatively high with tighter confidence intervals. The blue line indicates the request of 265. The degree of shading around the box plots represent confidence around the projected take.

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================================================================================
Summary statistics from posterior predictive distributions for 10000 simulated projects
------------------------------------
Estimated annual baseline fatality rate (lambda for rho = 1): mean = 10.7, 95% CI = [7.55, 14.4]

Projected fatalities and fatality estimates...
p(M > Tau within 21 years) = 0.0276  [exceedance]
p(M* > Tau within 21 years) = 0.0676  [triggering]
M* based on credibility level 1 - alpha = 0.8

Among projects with triggering (6.76%), mean(M) = 250.29 at time of triggering, with median = 250 and IQR = [239, 262]
Among projects with no triggering (93.24%), mean(M) = 206.83 at end of 21 years, with median = 207 and IQR = [190, 223]

Years of operations without triggering:
 Mean = 20.96, with median =  21 and IQR = [21, 21]

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Summary statistics for projection years
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```

Yr	Mean M	Mean M*	quantiles of M 0.05	0.10	0.25	0.50	0.75	0.90	0.95	quantiles of M* 0.05	0.10	0.25	0.50	0.75	0.90	0.95
1	81.6	89.1	68	71	75	81	87	93	97	83	83	87	89	91	95	97
2	92.4	100.6	77	80	85	92	99	105	110	90	92	96	100	105	109	113
3	103.1	112.1	85	89	95	103	111	117	122	99	101	105	112	118	125	127
4	113.8	123.4	94	98	105	113	122	130	135	107	110	116	123	130	138	143
5	124.6	134.8	102	107	115	124	134	143	148	116	118	125	134	143	152	157
6	135.3	146.1	111	116	124	135	145	156	162	125	127	136	145	154	166	170
7	146.1	157.5	119	124	134	145	157	168	175	131	138	145	156	168	180	186
8	156.8	168.8	127	133	144	156	169	181	189	142	146	156	168	182	193	200
9	167.4	179.9	136	142	153	167	181	194	203	150	155	167	179	193	207	214
10	178.1	191.1	144	151	163	177	192	207	216	156	164	175	190	204	221	230
11	188.9	202.4	152	159	172	188	204	220	230	165	172	186	201	218	234	244
12	199.6	213.5	160	168	182	198	216	233	244	173	183	195	212	231	248	257
13	210.3	224.7	168	177	191	209	228	246	257	182	191	206	223	242	262	271

Figure C-11. Projected take at the 80% credibility level for the next 14 years based on six years of data from Kawailoa Wind.

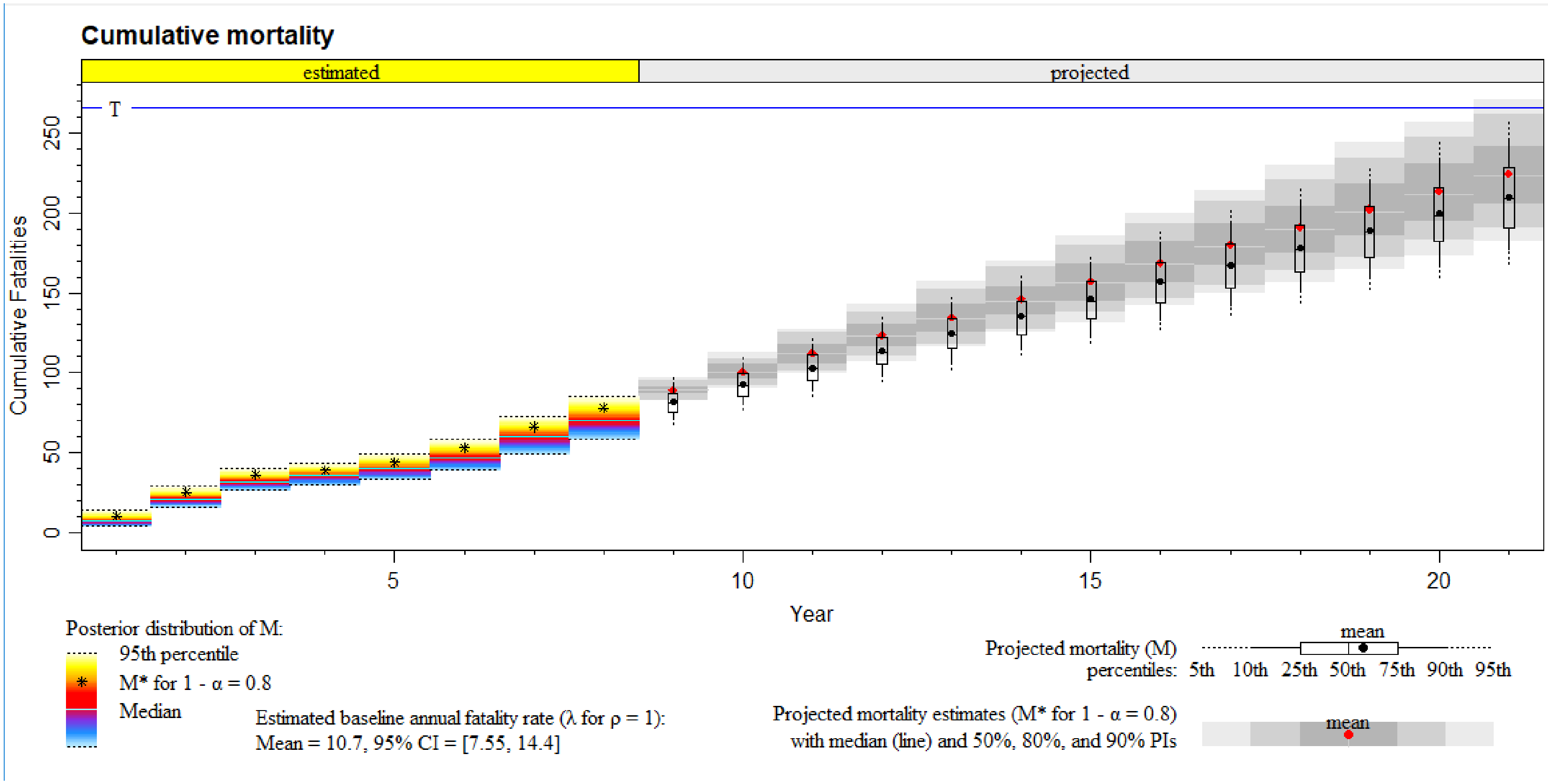


Figure C-12. Box and whisker plots showing estimates of past mortality (colored) and projections of future mortality and mortality estimates at 1 – α = 0.8 for Kawailoa Wind.

Pakini Nui Wind

Model inputs

Pakini Nui does not have an incidental take permit and thus annual reports are not available. Project-specific inputs for the model parameters were provided to the Service by the project during the preparation of the draft HCP and are summarized in Tables C-1, C-2, and C-3 for the reader. No monitoring data was provided for operating years of 2007 through July 2013. Monitoring from 2007 through July 2013 was conducted monthly and did not include the standardizations that are now required to be implemented by wind energy projects with ITPs

The search plots at Pakini Nui are treated differently than at the other three projects in this PEIS. Hull and Muir (2010) found that for small turbines (65 m [213 feet] hub height and 33 m [108 feet] blade length), 99% of bat fatalities landed within 45 m (147 feet) of the turbine base, and for medium-sized carcasses, 99% fall within 108 m (354 feet). Search plots at wind farms in Hawai‘i typically range from 75–100% of turbine height. However, because of the strong prevailing winds at the Pakini Nui Project that blow consistently from the east (between 70 and 90 degrees) for more than 90% of the time, it was agreed, with USFWS and DLNR concurrence (meeting with the USFWS and DLNR, February 20, 2014), that the upwind portion of the search plot could be reduced to 60% of turbine height, whereas the downwind portion could be lengthened to 90% of turbine height. This would increase the chances of locating a fatality if it were blown downwind, although bats could fall into the upwind direction during low wind speed conditions. The wind turbine search plot extends 60 m (197 feet) upwind and 90 m (295 feet) downwind. Because the turbines are placed close to one another and all individual turbine search areas overlap, a single final search area was designed. More carcasses are expected to be found in the downwind portion of the site because of the strong prevailing winds. The downwind portion of the search plots of several turbines is unsearchable due to their proximity to vertical cliffs. This reduction in the searchable area is accounted for in the Evidence of Absence model and results in a lower g value and increased uncertainty, thus, a higher take estimate (Dalthorp et al. 2017). The specific model inputs to be used are described in Section 4.1.1.of the draft HCP and are summarized here (Tables C-1, C-2, C-3). The radius of the met tower search area will be equal to 50% of its height.

Five of the 14 turbine search areas are only partially searchable due to turbine proximity to a cliff located 40 m downwind, on average. The fatality estimate is corrected for the searchable area, which is an estimate of the percentage of carcasses that are expected to fall in searchable areas. Based on the ballistics modeling data from Hull and Muir (2010), it is estimated that 80% of bat carcasses will fall within 31.94 m of a small turbine. Considering the shape of the search plots, the distance of the turbines from the cliff, the carcass distributions predicted by Hull and Muir (2010), and prevailing winds, it was estimated that 63% of bat fatalities at Turbines 1–5 will fall in searchable areas. The search plots for the remaining turbines are of sufficient size and distance from the cliff that they can be assumed to be 100% searchable. If 63% of the bat fatalities at Turbines 1–5 fall into searchable areas, and 100% of the bat fatalities at Turbines 6–14 fall into searchable areas, the searchable area for the Project as a whole is 87% (i.e., sampling coverage, a = 0.87). That is, 87% of all bat fatalities will fall within searchable areas, whereas the remaining

13% will fall outside the searchable areas, assuming that the likelihood of incidental take is equal across all turbines.

Table C-1. Annual searcher efficiency estimates for monitoring years 2014–2017 for each searcher type. (Adapted from Pakini Nui draft HCP)

Searcher Type	Monitoring Year	Surrogate Carcasses Placed	Surrogate Carcasses Found	SEEF (p-hat)	95% C.I.	
					Lower	Upper
Canine-handler team[1]	2017	15	13	0.867	0.637	0.971
Human	2014	76	55	0.714	0.607	0.806
	2015	38	23	0.605	0.447	0.748
	2016	47	6	0.128	0.055	0.244
	2017	8	1	0.125	0.014	0.454
	All years	169	85	0.503	0.428	0.578

[1] Canine-led searches replaced human-led searches on July 7, 2017, and this search method continues to be used at this time.

Table C-2. Annual carcass persistence estimates for rats for monitoring years 2014–2017. (Adapted from Pakini Nui draft HCP)

Monitoring Year	r[1]	Shape (a)	Scale (β)	95% C.I. for β	
				Lower	Upper
2014	0.584	2.0247	4.7952	3.536	6.503
2015	0.583	0.1712	5.8396	2.971	11.480
2016	0.326	0.7042	0.5416	0.07724	1.006
2017	0.463	0.2581	3.8751	0.9269	16.200
All years	0.500	0.9073	1.075	0.802	1.347

[1] The probability the carcass will persist to the next survey given surveys at 7-day intervals

Table C-3. Probability of detection (g) for monitoring years 2014–2017. (Adapted from Pakini Nui draft HCP)

Year	Searcher Type	rho[1]	95% C.I. for g		Fitted Beta (β) Distribution Parameters	
			Lower	Upper	βa	βb
2017	Canine-handler team	0.342 (0.73)	0.147	0.572	6.0064	11.5554
2014	Human	0.366 (1.00)	0.269	0.470	31.7163	54.8437
2015		0.307 (1.00)	0.197	0.429	18.0207	40.7155
2016		0.0392 (1.00)	0.014	0.0763	5.6335	138.2321
2017		0.0688 (0.27)	0.00468	0.208	1.4221	19.2491
All years		0.221 (1.00)	0.173	0.274	57.2098	201.2206

[1] Rho is the proportion of the year represented by this searcher type.

Pakini Nui has been operating since 2007, though weekly systematic and standardized monitoring did not begin until August 2013. The Service analyzed the projects potential bat fatality rate using two different approaches. The first, is to use only the data from 2013 through September 2018. .

Estimated bat fatalities for years 2013 through September 2018

The Evidence of Absence model summarized inputs for Pakini Nui through September 2018 are shown in Figure C-13 and outputs are shown in Figure C-14. The mean detection probability after about 5 years of monitoring is 0.201. The estimated baseline fatality (λ) rate is 3.14 (95% C. I. 0.747, 7.28), which is the most likely rate of bat fatalities per year. The column labeled with m is the estimated directly associated fatalities. The second column labeled with p(M = m) is the probability that the value m is the actual amount of direct fatalities. The third column labeled with p(M>m) is the probability that the actual direct fatalities exceed the associated m value. The median value of direct fatalities is 12 (Figure C-14, highlighted in grey). Based on the probabilities listed in the second column, there is a 5.41 % chance that this is the actual direct fatalities, but the third column shows a probability of 0.6600 which means there is a 66% chance the direct take does not exceed that value and a 34% (1-0.6600 x 100) chance that the actual direct take exceeds that value. Based on 3 observed fatalities, the Service is 80% confident that the actual direct fatalities (observed and unobserved) do not exceed 23 (highlighted in yellow) for the period evaluated. There is a 2.71% chance that that number is the actual direct fatalities (number shown in the second column, 0.0271 x 100).

Total project-specific fatalities (direct plus indirect take) that the Service in 80% confident has not been exceeded at Pakini Nui from August 2013 through September 2018

Based on Service' calculations using Evidence of Absence and the standardized protocol for calculating indirect take (described in Appendix E), there is an 80% probability that total direct take does not exceed 23 as of September 30, 2018. Estimated indirect take is 2 based on this direct take, and the total take is not expected to exceed 25. A breakdown of the calculations is provided below.

Calculations based on indirect take standardization

As of September 30, 2018, there are 3 observed bat fatalities: one reported August 31, 2013, a male reported March 1, 2016, and one reported April 12, 2018 (sex yet to be determined). Of these three fatalities, two were found during the breeding season from April 1 through September 15. (August 31, 2013 and April 12, 2018). The other fatality, found March 3, 2016, was found outside of the breeding period and was male.

We assume a 50:50 (female:male) ratio of the two bat fatalities taken during the breeding season. This number could change once the sex of the fatalities are determined.

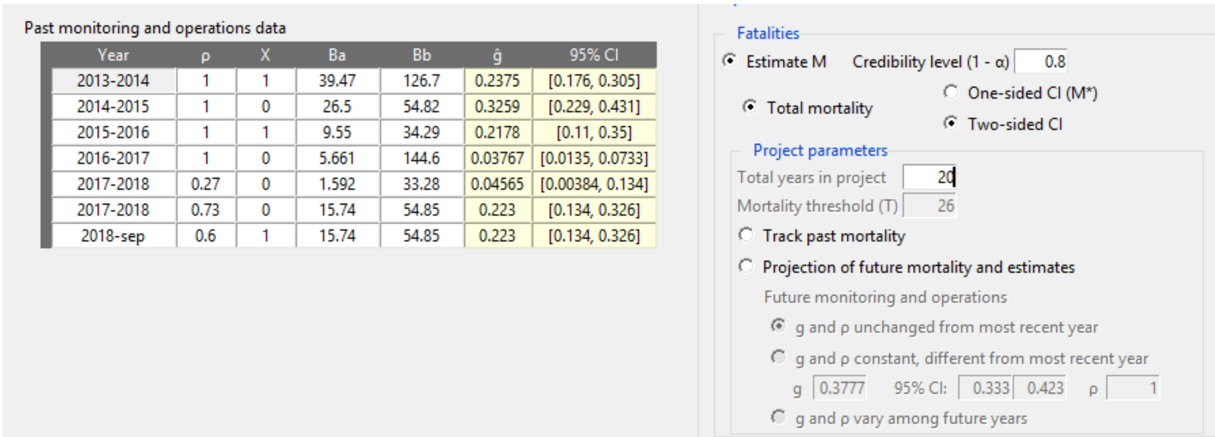
> [1 female x 1.8 juveniles = 3.6 juveniles x 0.3 = 0.54].

No indirect take assessed for one observed fatality (March 1, 2016) taken outside of the breeding season.

Based on the 80% probability that total take does not exceed 23 during the period in which systematic monitoring was conducted. Based on the 3 fatalities that have been observed, up to 20 fatalities may have been unobserved.

> [20 unobserved fatalities/2 based on assumed female to male ratio = 10 females x 0.25 which is the chance that a female had dependent young = 2.5 x 1.8 based on the number of juveniles per female = 4.5 x 0.3 survival rate = 1.35]

Indirect take summary:
0 (adult equivalencies from known observed females taken during the breeding season)
0.54 (adult equivalencies from observed fatalities of unknown sex assuming 1:1 sex ratio)
1.35 (adult equivalencies from unobserved fatalities assuming 1:1 sex ratio)
Total indirect 0 + .54 + 1.35 = 1.89 rounded to 2 by Service.



Past monitoring and operations data

Year	ρ	X	Ba	Bb	ĝ	95% CI
2013-2014	1	1	39.47	126.7	0.2375	[0.176, 0.305]
2014-2015	1	0	26.5	54.82	0.3259	[0.229, 0.431]
2015-2016	1	1	9.55	34.29	0.2178	[0.11, 0.35]
2016-2017	1	0	5.661	144.6	0.03767	[0.0135, 0.0733]
2017-2018	0.27	0	1.592	33.28	0.04565	[0.00384, 0.134]
2017-2018	0.73	0	15.74	54.85	0.223	[0.134, 0.326]
2018-sep	0.6	1	15.74	54.85	0.223	[0.134, 0.326]

Figure C-13. Detection probabilities and observed fatalities for the Pakini Nui Project from 2013 through September 2018.

Direct take projection based on 5 years of monitoring

The direct take projection that includes the operating period from 2013 through September 2018 and the remaining 8 years of operation, shows that the direct take is not expected to exceed 47 (Figure C-15, value under *m** column) at 1-α = 0.8. This estimate is based on the continued implementation of seasonal low wind speed curtailment of a 5.5 m/s cut in speed. Two of the three bat fatalities observed have occurred under the low wind speed curtailment regime. The projected take exceeds the requested take because the Service cannot authorize take retroactively that is associated with the operation of the project from 2013 through September 2018. An incidental take permit, if issued, would authorize only the take expected to occur during the ITP period (8 years of operation for which the request covers). The legal ramifications of unauthorized take are beyond the scope of this draft PEIS and are a separate legal matter. In order to determine the likely amount of take that would not be exceeded during the remaining years of operation, the Service subtracts the current estimated direct fatalities from the projected take. Thus, the projected direct take that the Service 80% assured will not be exceeded is 24 (47-23 = 24), not including indirect take. The projections assumes the detection probability would remain the same for the life of the project as the last year of monitoring. The further out in the future the projection spans, the more the uncertainty surrounding the estimate as is shown by the expanding grey areas in the whisker plots (Figure C-16). The blue line indicates the request of 26, but the projection is not adjusted to remove unauthorized take prior to a permit being issued. The degree of shading around the box plots represent confidence around the projected take. The higher relative level of uncertainty associated with the project relative to other projects in the PEIS is because of the extreme variation in mean detection probability.

Summary-
80% CI for M = [8, 28]
Estimated overall detection probability: g = 0.201, 95% CI = [0.167, 0.238]
Ba = 100.96, Bb = 400.35
Estimated baseline fatality rate: lambda = 3.14, 95% CI = [0.747, 7.28]
Posterior distribution of M

m	p(M = m)	p(M > m)	m	p(M = m)	p(M > m)	m	p(M = m)	p(M > m)
0	0.0000	1.0000	31	0.0103	0.0662	62	0.0001	0.0005
1	0.0000	1.0000	32	0.0090	0.0572	63	0.0001	0.0004
2	0.0000	1.0000	33	0.0078	0.0494	64	0.0001	0.0003
3	0.0037	0.9963	34	0.0068	0.0426	65	0.0001	0.0003
4	0.0102	0.9861	35	0.0059	0.0367	66	0.0000	0.0002
5	0.0183	0.9678	36	0.0051	0.0315	67	0.0000	0.0002
6	0.0268	0.9410	37	0.0044	0.0271	68	0.0000	0.0001
7	0.0347	0.9063	38	0.0038	0.0233	69	0.0000	0.0001
8	0.0415	0.8648	39	0.0033	0.0199	70	0.0000	0.0001
9	0.0469	0.8179	40	0.0029	0.0171	71	0.0000	0.0001
10	0.0507	0.7672	41	0.0025	0.0146	72	0.0000	0.0001
11	0.0531	0.7141	42	0.0021	0.0125	73	0.0000	0.0000
12	0.0541	0.6600	43	0.0018	0.0107	74	0.0000	0.0000
13	0.0540	0.6061	44	0.0016	0.0091	75	0.0000	0.0000
14	0.0529	0.5532	45	0.0013	0.0078	76	0.0000	0.0000
15	0.0510	0.5022	46	0.0011	0.0066	77	0.0000	0.0000
16	0.0486	0.4535	47	0.0010	0.0057			
17	0.0458	0.4077	48	0.0008	0.0048			
18	0.0427	0.3650	49	0.0007	0.0041			
19	0.0395	0.3255	50	0.0006	0.0035			
20	0.0363	0.2892	51	0.0005	0.0030			
21	0.0331	0.2561	52	0.0004	0.0025			
22	0.0300	0.2261	53	0.0004	0.0021			
23	0.0271	0.1990	54	0.0003	0.0018			
24	0.0243	0.1747	55	0.0003	0.0015			
25	0.0217	0.1530	56	0.0002	0.0013			
26	0.0193	0.1337	57	0.0002	0.0011			
27	0.0171	0.1166	58	0.0002	0.0009			
28	0.0151	0.1015	59	0.0001	0.0008			
29	0.0133	0.0882	60	0.0001	0.0007			
30	0.0117	0.0765	61	0.0001	0.0005			

Figure C-14. Binomial distribution of estimated direct take for Pakini Nui from 2013 through September 2018.

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Estimated annual baseline fatality rate (lambda for rho = 1): mean = 2.91, 95% CI = [0.693, 6.75]

Projected fatalities and fatality estimates...
p(M > Tau within 14 years) = 0.7527  [exceedance]
p(M* > Tau within 14 years) = 0.9435  [triggering]
M* based on credibility level 1 - alpha = 0.8

Among projects with triggering (94.35%), mean(M) = 22.75 at time of triggering, with median = 21 and IQR = [16, 28]
Among projects with no triggering (5.65%), mean(M) = 24.03 at end of 14 years, with median = 23 and IQR = [17, 29]

Years of operations without triggering:
 Mean = 9.44, with median =  9 and IQR = [8, 10]

----------------------------------------
Summary statistics for projection years
----------------------------------------------------------------------------------------------------
Yr   Mean             quantiles of M                        | quantiles of M*
      M       M*  0.05  0.10  0.25  0.50  0.75  0.90  0.95 |  0.05  0.10  0.25  0.50  0.75  0.90  0.95
----------------------------------------------------------------------------------------------------
1      19.8   26.9     8    10    13    18    25    32    36 |    23    23    23    23    29    35    35
2      22.7   30.1    10    12    16    21    28    35    40 |    23    23    23    28    34    40    45
3      25.7   33.4    12    14    18    24    31    39    44 |    22    22    28    34    39    45    50
4      28.6   37.0    13    16    20    27    35    43    49 |    22    22    28    34    45    56    61
5      31.5   40.1    14    17    23    30    39    48    54 |    22    22    28    39    50    61    66
6      34.4   43.4    16    19    25    33    42    52    60 |    22    28    33    39    49    65    76
7      37.4   47.0    17    20    27    35    46    57    65 |    22    28    33    44    55    70    81

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Figure C-15. Projected take at the 80% credibility level for the next 8 years based on about five years of data from Pakini Nui.

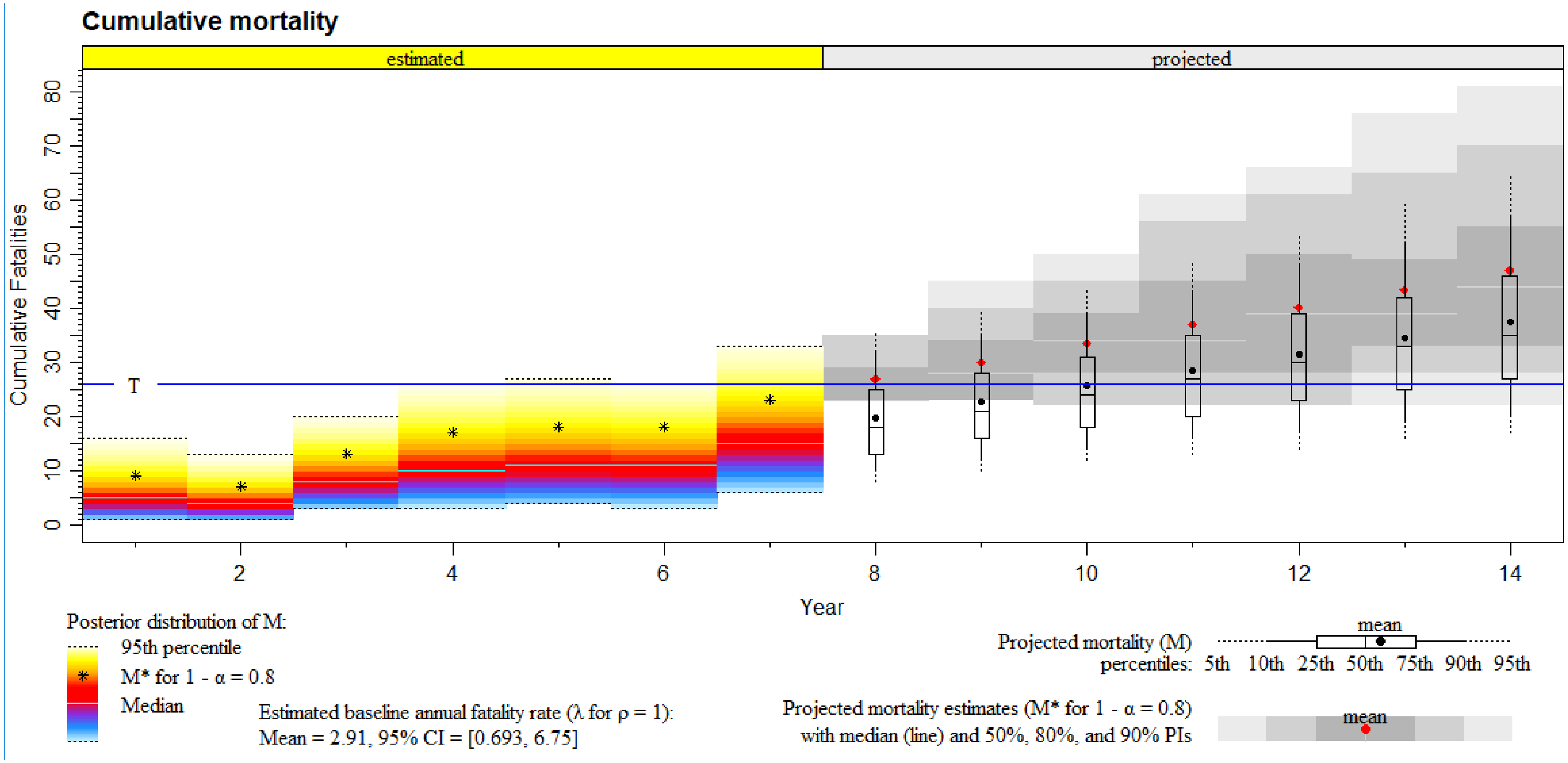


Figure C-16. Box and whisker plots showing estimates of past mortality (colored) and projections of future mortality and mortality estimates based on about 5 years of monitoring at 1 – α = 0.8 for Pakini Nui.

WILDLIFE AGENCY STANDARDIZED PROTOCOLS FOR WILDLIFE FATALITIES FOUND OUTSIDE THE DESIGNATED SEARCH AREA OR DISCOVERED INCIDENTALLY OUTSIDE OF A ROUTINE SEARCH (VER. MARCH 31, 2018)

Evidence of Absence software (Dalthorp et al 2017; https://pubs.er.usgs.gov/publication/ds1055) utilizes the number of observed carcasses and the detection probability to produce a probability distribution of the number of fatalities that may have occurred based on imperfect detection. The number of carcasses entered as "observed" assumes that the carcasses were found in the designated search area and during a routine search. In January 2018, the wildlife agencies discussed the need for establishing a standardized protocol for fatalities of protected wildlife species that are modeled with Evidence of Absence Ver. 2.0.6., but fail to meet the input criteria required by the model. Such exceptions may include carcasses found outside of the designated search area during a routine search, or carcasses incidentally discovered outside of a routine search day. "Rules" for treating these exceptions in the Evidence of Absence model should recognize and encumber the best science in order to maintain the validity of the software's output and not purposefully violate the basic mathematical assumptions that drive the model.

To best accommodate these types of Observed carcasses, the wildlife agencies provide the following standardized guidance. For the purposes of this guidance, assume the carcass found is of the species you are modeling.

Fatality found outside of the designated reduced search area

This situation would only apply to projects that have a carcass search area that has been reduced below where a carcass could potentially fall.The Downed Wildlife Protocol and accompanying reporting procedures should be followed for carcasses found outside of the reduced routine search area. The carcass will be considered accounted for in the unobserved take by the Evidence of Absence model. The report should clearly note the measured location of the carcass and relationship to the area searched in addition to the standard data required on the downed wildlife report. Measurements reported in meters will be based on distance from the turbine base or nearest structure. Such measurement should be conducted with a tape measure and with GPS. Project reports should also clearly identify the carcasses that fall in this category.

Fatality found outside of the designated "full" search area

This situation would imply that the initial monitoring and search area based on turbine height and carcass size may have been undersized and will require expanding the area. A designated "full" search area is expected to account for all carcasses. The lack of project specific data for small carcass sizes as resulted in the general adoption of the standards presented in Hull and Muir (2010). The wildlife agencies recommend an additional buffer zone of 20% be added to account for the wind effect on carcass fallout and uncertainty until adequate data is gathered for a site. The additional 20% buffer zone would need to be included in the routine searches. The buffer should be located on the down-wind side of the project if the wind is predominantly from one direction. The calculated area based on Hull and Muir plus the buffer area is designated as the "full" search area. Fatalities found during a routine search of the "full" search area (Hull & Muir predicted + 20% buffer zone) would be treated as an observed fatality in the model.

If the carcass is found beyond this "full" monitoring area, the Downed Wildlife Protocol and accompanying reporting procedures should still be followed. In addition, the permittee should contact the appropriate wildlife agency personnel listed in the Downed Wildlife Protocol to discuss adjusting the size of the fall out area and if expanding the area searched is needed to account for all potential fallout.

Fatality found incidentally (not during a routine scheduled search) in the designated search area

The model takes into account the frequency of searches. If a carcass is found incidentally, then it must be determined if the carcass would have been found on the next routine search day and therefore counted as observed, or if the carcass would have been missed or be gone on the next routine search and accounted for in the unobserved portion of fatalities." The Hawaiian hoary bat, ʻōpeʻapeʻa, carcasses are important to ongoing genetic research, so leaving the listed carcass in place is not in the best interest for the species. If a carcass is found incidentally, in the designated search area the Downed Wildlife Protocol and reporting should be followed. The report should clearly indicate who found the carcass, and under what circumstances (turbine maintenance, weeding, mowing, etc). The report should also indicate the method of determining how to categorize the carcass. The three methods are:

1) Permittee chooses to include the carcass as observed in the model, regardless of searcher efficiency.

2) Wildlife agencies will include the carcass as observed in the model when the documented detection probability is sufficiently high so as to reasonably assume the carcass would have been found on a subsequent scheduled search. Specifically, this method makes the assumption that the search efficiency and *k* value are such that there is a high probability that the carcass would have been found on a subsequent search. This method will be used for all large and medium carcasses found. This method will also be used for smaller carcasses when it is reasonable to assume the carcass or carcass trace would have been found on a subsequent search. The wildlife agencies will assume a carcass would have been found when the documented searcher efficiency ≥75% and *k* value ≥ 0.7.

3) In the case of small carcasses where the searcher efficiency is less than 75% (based on permittee's documented efficacy), a double-blind search with a replacement surrogate should be conducted to determine how the recovered carcass shall be categorized: observed or unobserved. That trial shall include the following criteria:

a. The surrogate (typically a rat) should be identical to that used for search efficacy trials and similar in size to the carcass found.

b. The surrogate carcass should be labeled as a surrogate for the specific carcass it is representing, and placed by a third party in the proximity of where the carcass that was recovered was found with label hidden.

c. The placement of this carcass should be conducted by the same party responsible for placing carcasses for efficiency trials, whenever possible.

d. Under no circumstances should the searcher conducting the routine search, be the one placing the surrogate or have knowledge of the surrogate's location or the timing of the placement.

e. Routine fatality searches should be carried out following standard search procedures.

f. The outcome of the trial should be reported in the compliance report and include the date the surrogate was placed and the date the carcass was found. If the carcass was never found, the third party should check on the status of the carcass. If the carcass is still present, leave it in place for subsequent searches. Include this information in the compliance report.

g. If the surrogate was found, the original carcass should be reported as observed. If the surrogate was not found, the original carcass should be reported as unobserved.

Note: The wildlife agencies expect the permittee's to conduct thorough, fair, and impartial searches and not to purposefully conduct searches for carcasses outside of the scheduled routine fatality searches in an attempt to manipulate fatality documentation or calculation of take. The agencies also acknowledge the amount of effort it takes to conduct the thorough routine fatality searches and trials necessary to measure carcass retention and searcher efficiency. If a carcass is found outside of a routine search and a searcher efficiency trial is scheduled to be conducted within the next 30 days, it may be possible to include option 3 within that searcher efficiency trial. However, you must contact the wildlife agencies for approval.

LITERATURE CITED

Auwahi Wind. 2013. Auwahi Wind Farm Habitat Conservation Plan FY 13 Annual Report: Incidental Take Permit TE64153A-0/ Incidental Take License ITL-17. August 2013, Kula, HI.

Auwahi Wind. 2014. Auwahi Wind Farm Habitat Conservation Plan FY 14 Annual Report: Incidental Take Permit TE64153A-0/ Incidental Take License ITL-17. August 2014, Kula, HI.

Auwahi Wind. 2015. Auwahi Wind Farm Habitat Conservation Plan FY 15 Annual Report: Incidental Take Permit TE64153A-0/ Incidental Take License ITL-17. August 2015, Kula, HI.

Auwahi Wind. 2016. Auwahi Wind Farm Habitat Conservation Plan FY 16 Annual Report: Incidental Take Permit TE64153A-0/ Incidental Take License ITL-17. August 2016, Kula, HI.

Auwahi Wind. 2017. Auwahi Wind Farm Habitat Conservation Plan FY 17 Annual Report: Incidental Take Permit TE64153A-0/ Incidental Take License ITL-17. August 2016, Kula, HI.

Auwahi Wind. 2018. Auwahi Wind Farm Habitat Conservation Plan FY 2018 Annual Report Incidental Take Permit TE64153A-0/ Incidental Take License ITL-17. August 2018, Kula, HI

Dalthorp, Daniel, and M. Huso. 2015. A framework for decision points to trigger adaptive management actions in long-term incidental take permits: U.S. Geological Survey Open-File Report 2015-1227, 88 pp. http://dx.doi.org/10.3133/ofr20151227.

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

Dalthorp, D., L. Madsen, M. Huso, P. Rabie, R. Wolpert, J. Studyvin, J. Simonis, and J. Mintz. 2018. GenEst statistical models - A generalized estimator of mortality: U.S. Geological Survey Techniques and Methods, book 7, chap. A2, 13 p., https://doi.org/10.3133/tm7A2.

Hull, C.L., and Muir, S., 2010, Search areas for monitoring bird and bat carcasses at wind farms using a Monte-Carlo model. Australasian journal of Environmental Management, v. 17, p. 77-87.

Huso, M.M.P. 2009. An estimator of wildlife fatality from observed carcasses. Environmetrics 22:318-329.

Huso, M.M.P., and D. Dalthorp. 2014. Accounting for unsearched areas in estimating wind turbine-caused fatality: The Journal of Wildlife Management 78:347-358.

Huso, M.S.P., D. Dalthorp, D. Dail, and L., Madsen. 2015, Estimating wind-turbine-caused bird and bat fatality when zero carcasses are observed. Ecological Applications 25: 1213-1225.

Kaheawa Wind Power II. 2012. Kaheawa Habitat Conservation Plan- FY-2012 Annual Report Year 2012. August 2012. Wailuku, HI.

Kaheawa Wind Power II. 2013. Kaheawa Habitat Conservation Plan- FY-2013 Annual Report Year 2013. August 2013. Wailuku, HI.

Kaheawa Wind Power II. 2014. Kaheawa Habitat Conservation Plan- FY-2014 Annual Report Year 2014. August 2014. Wailuku, HI.

Kaheawa Wind Power II. 2015. Kaheawa Habitat Conservation Plan- FY-2015 Annual Report Year 2015. August 2015. Wailuku, HI.

Kaheawa Wind Power II. 2016. Kaheawa Habitat Conservation Plan- FY-2016 Annual Report Year 2016. August 2016. Wailuku, HI.

Kaheawa Wind Power. 2017. Kaheawa Habitat Conservation Plan- FY-2017 Annual Report Year 2017. August 2017. Wailuku, HI.

Kaheawa Wind Power. 2018. Kaheawa Habitat Conservation Plan- FY-2018 Annual Report Year 2018. August 2018. Wailuku, HI.

Kawailoa Wind Power (Kawailoa Wind Power, LLC). 2013. Kawailoa Habitat Conservation Plan—ITL 14: FY 2013 Annual Report—Year 1. Haleiwa, HI.

Kawailoa Wind Power. 2014. Kawailoa Habitat Conservation Plan- FY-2014 Annual Report Year 2014. August 2014. Haleiwa, HI.

Kawailoa Wind Power. 2015. Kawailoa Habitat Conservation Plan- FY-2015 Annual Report Year 2015. August 2015. Haleiwa, HI.

Kawailoa Wind Power. 2016. Kawailoa Habitat Conservation Plan- FY-2016 Annual Report Year 2016. August 2016. Haleiwa, HI.

Kawailoa Wind Power. 2017. Kawailoa Habitat Conservation Plan- FY-2017 Annual Report Year 2017. Oct 2017. Haleiwa, HI.

Kawailoa Wind Power. 2018. Kawailoa Habitat Conservation Plan- FY-2018 Annual Report Year 2018. August 2018. Haleiwa, HI.

Korner-Nievergelt, F., O. Behr, R. Brinkmann, M.A. Etterson, M.M.P. Huso, D. Dalthorp, P. Korner-Nievergelt, T. Roth, and I. Niermann, I. 2015. Mortality estimation from carcass searches using the R-package carcass — a tutorial. Wildlife Biology 21: 30-43.

Pakini Nui Draft Habitat Conservation Plan. 2018. Prepared by SWCA. September 2018.

Pinzari, C.A., and F. J. Bonaccorso. 2018. A test of sex specific genetic markers in the Hawaiian hoary bat and relevance to population studies. Technical Report HCSU-085. 13 pp.

Simonis, J., M. Huso, D. Dalthorp, J. Mintz, L. Madsen, P. Rabie, and J. Studyvin. 2018. GenEst user guide-software for a generalized estimator of mortality. U.S. Geological Survey Techniques and Methods, book 7, chapter C19 72 pp. https://doi.org/10.3133/tm7C19.

Low Wind Speed Curtailment as a Species Protection Measure

Table of Contents

List of Tables

TERMINOLOGY USED IN THIS APPENDIX

Acceleration and deceleration profile. Refers to how fast a turbines' blades reach the cut-in speed (acceleration) or slow down after the cut-out speed (deceleration).

Anemometer. A device used to measure wind speed measured in meters per second. Anemometers are typically mounted on the turbine nacelle and the meteorological tower located at the project site.

Blades. The extensions that extend from the rotor and are designed to capture the wind and rotate the rotor assembly which in turn rotates the drive train. Wind traveling across the blades creates lift. When lift exceeds drag, the blades begin rotating around the hub. This rotation drives a generator to produce electricity. A blade on most commercial turbines can be rotated or pitched along its own axis to modify the amount of wind intercepted (lift and drag) and thus rotational speed.

Brake system. Most advanced utility-grade turbines are equipped with aerodynamic brakes and mechanical brakes. Aerodynamic braking involves turning the blades or blade tips about 90 degrees around their longitudinal axis to stop blade rotation within a few revolutions. The mechanical brake system is akin to automobile brakes and stops rotation of the rotor and drive train. Mechanical breaks are used to lock a turbine during maintenance.

Curtailment. The action of ceasing power generation in such a way that rotation of the rotor and transfer of the rotational energy to the drive train is suspended. The turbine blades may continue to rotate (freewheel) or be stopped (braked). Curtailment can occur because of a turbine limitations to produce power in low or extremely high winds or through operational minimization actions (low wind speed curtailment) that modify the rotational speed and power production. Alternatively, curtailment and suspension of power production can be implemented by the power company when the utility needs to stop receiving power from the wind facility.

Cut-in speed. The wind speed at which a turbine begins to produce power through the rotation of the blades. At wind speeds that equal or are greater than the cut-in speed, the blades are positioned in such a ways as to use the wind force to rotate the blades at a higher rate of speed and thus produce power. All turbines have a manufacturer's recommended cut-in speed which is typically between wind speeds of 3.0 and 4.5 meters/second.

Cut-out speed. The wind speed at which a turbine ceases to produce power (curtailed). Typically, this is accompanied by feathering of blades. The actual curtailing of turbine's blade rotation is based on the rolling average of the wind speed, either measured at the nacelle or the meteorological tower at the project. Typically, in Hawai'i, the wind speed is measured at the nacelle of each turbine.

Feathering. Turbine blades are rotated to be at a parallel angle with the wind resulting in the rotor slowing down from lack of wind force on the blades. Turbine blades that are feathered will have very slow rotational movement, generally on the order of 0 to 3 rotations per minute depending on blade length.

Free-wheeling. The stage in which the rotation of the rotor and blades around the hub of a turbine that is not producing power. Free-wheeling occurs as the wind speeds are coming up to the cut-in speed and the turbine is turning but has not up to the rapid rotation for power production. Free-wheeling also occurs when winds subside.

Hub. The part of the turbine in front of the nacelle where the turbine blades attach to the rotor.

Hysteresis. To prevent frequent shutdowns and restarts of the turbine rotor the cut in speed is raised above the cut out speed.

Low wind speed curtailment (LWSC). An operational adjustment made by a wind facility that restricts power production from the rotation of turbine blades to periods when the wind speed reaches a predetermined speed (cut-in or cut-out speed).

Meters per second (m/s). Rate of wind measured in meters per second. Examples of converting m/s to miles per hour (mph): 1.0 meter/second ≈ 2.2 miles per hour (mph); 3.0 m/s ≈ 6.7 mph; 4.0 m/s ≈ 8.9 mph; 4.5 m/s ≈ 10 mph; 5.0 m/s ≈ 11.18 mph; 5.5 m/s ≈ 12.3 mph; 6.5 m/s ≈ 14.5 6.9 m/s ≈ 15.4

Nacelle. The cover that houses the generator, gearbox, drive train, and brake assembly located at the top of the monopole or tower of the turbine. The nacelle is located behind the rotor of the wind turbine.

Operational minimization measures. For the purpose of this appendix, the actions taken by a project to avoid and minimize Hawaiian hoary bat, or ʻōpeʻapeʻa, fatalities associated with operation of wind turbine generators.

Power purchase agreement (PPA). A contract between the wind facility and Hawaiian Electric or its subsidiaries' that sets the price and amount of power that HECO will purchase from the wind farm. There are operational restrictions in the PPA that require wind farms to generate a certain level or range of power during predetermined periods. If a wind farm fails to provide that amount of power the wind farm may be fined, or paid less for the power.

Rolling average. The length of time the average wind speed needs to be sustained to trigger blade rotation shutdown or startup. A rolling average in Hawaiʻi is typically based on 10 to 20 minute continuous intervals. Rolling averages are used to minimize the number of stop and starts of the turbine.

Rotor. The rotor is the area of a wind turbine that consists of the hub and the blades. The blades attach to the hub.

Wind turbine generator. Uses moving air to create electricity.

Wind speed. The speed of the wind in meters per second (m/s). When the term is used in conjunction with cut-in speeds, cut-out speed, or curtailment, it means that the wind speed was averaged, in real time, over a continuous period (rolling average). For instance, a cut-in speed of

5.0 m/s would mean that the wind speed average over a predetermined continuous period (rolling average) would need to be 5.0 or greater for the turbine to begin rotating to produce power.

Yaw drive. The yaw drive system keeps the rotor facing into the wind to produce the maximum amount of energy. It is located below the nacelle and can pivot the nacelle and rotor around the axis of the monopole or tower.

BACKGROUND AND BASIS FOR IMPLEMENTING OPERATIONAL MINIMIZATION MEASURE

Brief summaries of the main studies cited in this section are included in the *Synopsis of studies* section.

An operational minimization measure that is implemented to reduce bat fatalities is modification of a wind turbines curtailment speed. Wind turbine generators have a manufacturer's designated curtailment wind speed, below which, the turbine blades are free-wheeling and not producing power and above which the blades overcome drag to produce lift during rotation and produce power. Manufacturer's cut-in wind speeds typically range from 3.0 to 4.0 m/s (6.7 – 8.9 mph). Increasing cut-in speeds 1.5 to 3.0 m/s above the manufacturers' cut-in speed have been correlated with a reduction in number of bat fatalities in areas where bat fatalities are frequent (Good et al 2011, Arnett et al 2013).

Modifying the acceleration and deceleration profile of the turbine blades when wind speeds are below the cut-in speed has also been associated with reduced bat fatalities. Feathering the blades when wind speeds are below the cut-in speed reduces the wind force on the blades and slows the rotation of the blades to 0-3 rotations per minutes. Many studies have shown beneficial reductions in bat fatalities may be achieved by feathering blades to be parallel to the wind, or a low rotational-speed idle approach (Baerwald et al. 2009; Young et al. 2011, 2012, 2013; Good et al 2012).

Studies have also evaluated the benefits of combined feathering and low wind speed curtailment. Significant reductions in bat fatality rates have been demonstrated on the mainland and abroad when cut-in speeds are raised incrementally from 3.5 to 4.5 to 5.0 and 5.5 m/s (Good et al 2013, 2015, 2016, 2017, 2018, Arnett et al 2009, 2010, 2011, Good & Adachi 2014, Hein et al 2014). Results from studies evaluating the additive benefits that may be had from raising cut-in speeds above 5.5 m/s with or without feathering are less certain (Good et al 2011, Hein et al 2014, Martin et al 2017, Tidhar et al 2013, Stantec 2015).

It is possible to extrapolate that higher wind speed cut-in would result in a reduction in bat fatalities, but the cause of the effect is less clear. As wind speed cut-in increases, so does the amount of time a turbine spends not rotating at a rapid speed (feathered and curtailed) and generating electricity. The period of turbine minimized operation (feathered and curtailed) can be lengthy at sites that have wind speeds which frequently fall below a cut-in speed rolling average. A site with high wind speeds would spend less time in the curtailed and feathered state; whereas a site with low wind speeds could be curtailed for a great amount of time. Raising the cut in speed only has the advantage of potentially decreasing take *if* bats are present during this time period. Another limitation to our interpretation of correlations between bat fatalities and operational minimization is not knowing the exact time of the fatality for the vast majority of bat fatalities. Turbine-blade technologies to detect the precise moment of collision and the environmental and operational conditions at the time are, as yet, untenable. Advancing technologies are expected to solve this issue.

Feathering and low wind speed curtailment of turbine blades are operational minimizations voluntarily deployed at the recommendation of the Service by all operating wind farms in Hawai‘i. It has not been possible to confidently calculate the reductions in Hawaiian hoary bat fatalities in Hawai‘i that have resulted from the local implementation of low wind speed curtailment (operational minimizations). Variability in fatality rates between facilities, location, turbine design, and the limitation of using observed bat fatalities, do not provide a statistically robust sample from which to draw conclusions. Instead, the Service relies on studies conducted on the mainland and abroad that have included hoary bats, where possible to make informed recommendations. The *perceived* reductions in bat fatalities from the implementation of low wind speed curtailment have shown promise at some projects in Hawai‘i, though evidence is largely anecdotal because of the lack of a simultaneous control against which to compare, and the lack of a robust sample size. Use of low wind speed curtailment has not avoided fatalities at other facilities in Hawai‘i.

Low wind speed curtailed wind turbines typically use a 10 minute rolling average of wind speed to control blade rotation, feathering and curtailment. Shirmacher et al (2016) recently reported a reduction in bat fatalities associated with increasing the rolling average from 10 minutes to 20 minutes on the mainland. The premise behind increasing the rolling average to a longer period of time is that it decreases the number of turbine starts and stops. It is presumed this decreases the number of bat fatalities associated with bats being in the presence of non-moving or slowly rotating feathered blades when they unfeather and begin to rotate rapidly in higher winds. A 20 minute rolling average resulting in fewer stop starts and may increase or decrease operating time depending on wind profile at the site and operational parameters. Presently, all but one of the wind facilities in Hawai‘i use a 10-minute rolling average. Kawailoa Wind recently changed to a 20 minute rolling average as an experimental measure intended to reduce fatalities.

Shirmacher et al (2016) also suggested that using average wind speeds from anemometers located at the meteorological towers rather than on turbine nacelles may reduce bat fatalities. This may be dependent on how accurately the anemometer at the meteorological station represents the wind speeds at the site. In Hawai‘i, sites are not typically located on flat topography. Lack of wind speed uniformity across a site would confound the outcome of this approach unless multiple meteorological towers were in place. In Hawai‘i, additional meteorological towers may pose a collision risk to other species including seabirds. In general, wind energy facilities in Hawai‘i use turbine-based anemometers to inform each turbines operational minimization actions.

Bat behavior at turbines also plays a role in risk of fatality. Cryan et al (2014) observed wind speed and the speed of the rotating turbine blades influences the way bats approach the turbines. Bats approach turbines less frequently when the blades were spinning fast. The prevalence of leeward versus windward approaches to the nacelle increased with wind speed at turbines with slow-moving or stationary blades. Leeward approaches declined when the blades were rotating.

The group also observed that tree bats show a tendency to closely investigate curtailed or feathered turbines and sometimes linger for minutes to hours. This observation suggests the possibility that bats are drawn toward turbines in low winds, but sometimes remain long enough to be put at risk when wind picks up and blades reach higher speeds. Thermal imaging video events involving Hawaiian hoary bats at turbines on Oʻahu showed typical visits to turbines lasted only a few seconds, although 10% of the visits were sustained for longer periods of time, similar to what Cryan et al (2014) observed in Indiana (Gorresen et al 2015). This may suggest that the Hawaiian hoary bat, on the average, spends less time in the vicinity of a turbine than their conspecifics on the mainland. It was postulated that this may be due to the bat's familiarity with the presence of the turbines in the landscape in Hawaiʻi where the bats are resident, whereas on the mainland, bats mostly encounter turbines during migration, and thus are less familiar with the turbines and may spend more time "exploring" them.

Hawaiian hoary bat behaviors, including close approaches to turbine monopole, blades, and nacelle occur across a range of wind speeds typically from 0–9.6 m/s, though occasionally 12-15 m/s. In general, the bats were detected more frequently at low blade-rotation speeds (<1.0 m/s) and less frequently at intermediate (1-10 m/s) and high speeds above 10 m/s (Gorresen et al 2015). Prevailing wind speeds at the Oʻahu study site, ranged from 5.5 to 8 m/s and may have contributed to the upper limit at which bats were observed flying. Higher bat occurrence was also observed at turbines during times when barometric pressure was relatively low (≤ 972 mb) but pressure was rising over a period of at least 24 hours, indicating Hawaiian hoary bats may be more likely to approach and forage near turbines when weather conditions are clearing and becoming favorable for foraging (Gorresen et al 2015).

It is unclear if Hawaiian hoary bats actively forage at the turbine nacelle. Frequent thermal video detections of erratic flight indicative of Hawaiian hoary bats foraging were made at the turbines on Oʻahu. However, feeding buzzes were very infrequently recorded acoustically which suggests that bats are not encountering insect prey around the turbine nacelle (Gorresen et al 2015). Acoustic detection of feeding buzzes and comparison of the insect prey present at the turbines, verses the contents of hoary bat's stomachs, suggested that hoary bats do forage at turbines, based on a study at a wind farm in the Great Plains (Foo et al 2017). Despite the contrasting acoustical information, nightly insect abundance and Hawaiian hoary bat detections were significantly and positively correlated, suggesting that nightly patterns of insect abundance may, in part, predict risk to Hawaiian hoary bats (Gorresen 2015). Gorresen et al (2015) reported Hawaiian hoary bats were frequently observed by thermal video flying in close proximity to the turbine nacelle and near detector microphones, yet were not recorded acoustically. This implies that bats may be much less vocal than previously believed, at least at wind turbines. Hoary bats may not emit a signal detectable by the current acoustic technology available. For instance, microcalls, would not be detectable unless a bat is within a few feet of a detector (Corcoran & Weller 2018). The evidence provided by Corcoran and Weller (2018) shows that hoary bats sometimes fly without echolocation or use micro calls that are not detected by acoustical detectors. This silence may help to explain the inconsistent results in the ability to predict the potential for post-construction bat fatalities at wind facilities. Thermal video imaging provides a means of detecting bats at night but the method is spatially challenging for implementation across a project because of the severally reduced visual scope it can cover and the real time monitoring needed.

The timing of operational minimization actions (feathering and low wind speed curtailment) also plays a role in reducing the risk to Hawaiian hoary bat. Gorresen et al (2015) found the hourly rate of nightly bat detection (number/hour/turbine) was highly variable but more than doubled from mid-May to mid-November. Acoustic and thermal video detection and lack of roosting resources suggests bats are not constantly present at a wind project but may use sites opportunistically or intentionally, depending on resources and season. In Hawai'i, the implementation of low wind speed curtailment is not based on actual bat presence each night, rather it is implemented year-round at most facilities. While this is assumed to reduce the risk of bat fatalities, it also reduces electricity generated. At some mainland wind facilities, technologies that implement operational minimization and avoidance in real time based on species detection are being put to the test. These systems are based on shutting blade rotation down in the presence of bats. Such systems can be effective when there is a good chance of detecting bat presence at the site, but are not as effective if the detection is poor. On the mainland, migratory bats tend to appear in great numbers, and thus detection has a greater chance of success. Detection-based implementation of low wind speed curtailment is especially limiting when dealing trying to detect rare occurrences, as is the case in Hawai'i. Additionally, hoary bats, are not always transmitting a detectable sound (Cochran and Weller 2018). Gorresen et al (2015) reported acoustical detectors were only detecting about 8% of the bat occurrences that were detected with thermal videography, despite the bats being in the vicinity of the detector. Improvements in bat detection are needed to create a robust and applicable system that can effectively detect a bat in the airspace of an operating project in Hawai'i. To date, the limitation is substantial and may lead to false security that a fatality will not occur.

Size of the rotor sweep may affect the rate of bat fatalities (Good et al 2011). Fatality rates at different turbine types suggested the larger the rotor sweep, the greater the area occupied by a rotating blade and the higher the risk. In 2012, Good et al determined that the deceleration and acceleration characteristics of the turbines contributed to the difference, though rotor sweep was not ruled out as a contributing factor. Hub height of a turbine, influences where a fatality falls (fatality distribution) (Hull and Muir 2010). In general, the higher the turbine hub, the larger the rotor and the further out the fatality distribution, or fall out zone, extends. Thus, finding fatalities at taller turbines with longer blades requires exponentially more area to be searched to locate fatalities. Riser-Espinoza (2018) and others have recently reported a difference in the patterns of fatality distributions between turbines with and without modified cut-in speeds. The mode of a fall distribution moves significantly farther from the turbine monopole with increased cut-in speed Riser-Espinoza (2018). This finding is highly relevant with regard to comparing the number of fatalities between cut-in speed treatments if search area is not adjusted. Models such as Evidence of Absence (Huso et al 2015, Dalthorp et al 2017) and GenEst (Dalthorp et al 2018; Simmons et al 2018) use density weighted proportions for fatalities in the calculations if a reduced search area is used, but it is up to the user to determine the correct DWP for each treatment. The recent finding suggests that different density weighted proportions should be used for standardizing comparisons between cut-in speeds if 100% of the carcass fall out area are not searched. Hull and Muir (2010) and others have analyzed ballistic patterns based on turbine height and blade tip, but past studies have not addressed the change with regard to cut-in speed. Essentially, fatalities occurring at turbines deploying high cut-in speeds such as of 6.9 may not be capturing the full range of fatality distribution if search areas are inadequate or if density weighted proportions are not adjusted. Reductions observed with higher cut-in speeds may be an artifact of inadequate search radius is no adjustment is made.

SYNOPSIS OF STUDIES

Low wind speed curtailment with no feathering

Good et al (2011) compared turbines curtailed at 5.0 and 6.5 m/s to turbines curtailed only at the manufacturer's cut in speed of 3.5 m/s at Fowler Ridge. Low wind speed curtailment was implemented from August 1 through October 15 and bat fatalities were Eastern red bat, hoary bat, silver-haired bat, big brown bat, tri-colored bat, Indiana bat (*Myotis sodalis*), and little brown bat. Bat fatality incidence was significantly reduced when turbines were curtailed at 5.0 (50%, 90% C.I. 37.3 %– 60.6%) and 6.5 m/s (78%, 90% C.I. 70.5 % – 84.9%) compared to turbines curtailed only at the manufacturer's cut in speed of 3.5 m/s. Percent reductions between treatments were considered statistically significant because point estimated did not overlap with other treatment's confidence intervals. Bat fatalities per turbine per season were 14, 7, and 3 for turbines curtailed at 3.5 m/s, 5.0 m/s, and 6.5 m/s treatment conditions respectively. Differences between 5.0 m/s and 6.5 m/s cut-in speeds were also significant. Wind data collected at the Fowler Ridge wind facility (Indiana) suggest that wind speeds were between 5.0 m/s and 6.5 m/s for a significant amount of the fall study period (19.4%) (Good and Adachi 2014). Unfortunately, with that type of wind profile, higher cut in speeds at this site auto-correlate with significantly more time spent not operating. It is unclear if the higher cut in speed or the greater amount of time spent with the blades curtailed was responsible for the reduction in fatalities. Significant reductions at 6.5 m/s have not been observed at Alberta, Canada or Casselman Wind in Pennsylvania (Baerwald et al 2009; Arnett et al 2010). This is particularly important in Hawai'i, where bats are known to fly in wind speeds as high at 12 m/s, but raising cut in speed in lower wind speed areas may result in extensive non-operational periods.

Arnett et al. (2013) synthesized the results of 10 wind energy projects in North America. Results from a comparison of bat fatalities at turbines set to a cut-in speed of 3.0 m/s, 4.0 m/s, 5.0 m/s and 6.0 m/s showed reductions of 20.1% at 4.0 m/s, 34.5% at 5.0 m/s, and 38.1% at 6.0 m/s during the first four hours after dark, and 32.6% for turbines raised to 5.0 m/s all night long wind farm in the southwest US. None of the reductions in fatality were considered statistically significant (chi-square test $p>0.05$) between turbines with cut-in speeds raised to 5.0 or 6.0 m/s, regardless of whether the treatment occurred only during the first four hours after dark (5.0 and 6.0 m/s) or was left in place all night (5.0 m/s).

Feathering

Baerwald et al (2009) conducted a study during the peak period of migration (August 1–September 7, 2007) for hoary bats (*Lasiurus cinereus*) and silver-haired bats (*Lasionycteris noctivagans*) at a wind energy installation in southwestern Alberta, Canada, where the two bat species comprised the dominant fatalities. The study was conducted from July 15 through September 30. The turbines in the study were 1.8 MW Vesta V80 with a 65 meter hub height and 80 meter rotor diameter. They tested three treatment groups (control turbines, treatment turbines with increased cut-in speed at 5.5 m/s, and experimental idling turbines with the blades feathered). When the group combined the two experimental treatment results and compared them to control turbines, they concluded that the experimental turbines had a 60% lower fatality rate, but there was no difference between only feathering and 5.5 m/s curtailment without feathering.

Young et al (2010 and 2011) evaluated 2.0 MW Gamesa G 80 turbines with a 78 meter hub and an 80 meter rotor diameter in Mount Storm, WV. Turbines were feathered at the manufacturer's cut in speed at 4.0 m/s and compared to unfeathered, free-wheeling turbines. Treatments were compared for first half vs. second half of the night from July 16 through October 15. Hoary bat, eastern red bat (*Lasiurus borealis*), silver-haired bat, tricolored bat (*Perimyotis subflavus*), big brown bat (*Eptesicus fuscus*) and Seminole bat (*Lasiurus seminolus*) fatalities were observed, though sample size was small during one of the study years. Wind speeds were reportedly above 6 m/s during most of the time. Feathered turbines (treatment) had significantly fewer mortalities (47%) than unfeathered, free-wheeling (control) turbines. Bat fatalities were also significantly lower for feathered turbines during the first half of the night vs the second half.

Young et al. (2012) again evaluated the effect of feathering only, without increasing cut-in speed above 4.0 m/s/for 2.0 MW Gamesa G 80 turbines with a 78 meter hub and an 80 meter rotor diameter in Mount Storm, WV. The study was conducted from July 16 through October 15 and hoary bat, eastern red bat, silver-haired bat, tricolored bat, big brown bat fatalities were observed. No significant difference in fatalities was found between control turbines and feathered turbines.

- Young (2013) saw a 62% reduction in bat fatalities when feathering was implemented at 5.0 m/s and below compared to unfeathered turbines with a cut-in speed of 4.0 m/s. The study was a comparison made across two years, 2011 (no feathering) and 2012 (with feathering), and assumes that other factors that may influence bat fatality were the same in years 2011 and 2012 at Criterion Wind, MD.
- Good et al. (2012) evaluated bat fatality rates under three different blade feathering treatments, 3.5 m/s, 4.5 m/s, and 5.5 m/s, and two sets of "control" turbines with no cut-in speed adjustment. The 2011 study was conducted at Fowler Ridge with 1.5 MW GE SLE turbines (80 meter hub height and 77 meter rotor diameter); 1.65 MW Vestas V82 turbines (80 meter hub height and 82-meter rotor diameter), and 2.5 MW Clipper C96 turbines (80-m hub height and a 96 meter rotor diameter). The study period covered April 1 to May 15 and July 15 to October 29. Bat fatalities were eastern red bat, hoary bat, silver-haired bat, big brown bat, evening bat (*Nicticeius humeralis*), tri-colored bat, Seminole bat, and little brown bat (*Myotis lucifugus*). Turbines that were feathered at speeds of 3.5 m/s, 4.5 m/s, or 5.5 m/s had significantly fewer fatalities (37%, 57%, and 73%) than turbines that were not feathered. Reductions in bat fatalities under each treatment were significantly different from each other and from the control turbines. Fatalities decreased with each feathering increment up to 5.5 m/s.

Low wind speed curtailment with feathering

Good and Adachi (2014) reported that the effectiveness of curtailment speeds can depend on the deceleration and acceleration profile of the specific turbine model. Studies conducted at Fowler Ridge in 2010 with GE SLE, Clipper C96, and Vesta turbines showed a 50% reduction in overall bat fatalities when the cut-in speed was raised to 5.0 m/s and a 78%

reduction when cut in speed was raised to 6.5 m/s (Good et al 2011). However, there was also a difference in fatalities between the turbine models that had the same nacelle height and manufacturer's cut-in speed of 3.5 m/s. The Vesta turbines spent more time spinning at lower wind speeds, when bat activity was highest and that group of turbines had higher fatalities. When low wind speed curtailment was combined with feathering of the blades in 2012 and 2013, the reduction was 84% and 77%, respectively when compared against the fatality rate observed in 2010 at turbines that were only curtailed at the manufacturer's cut-in speed.

Good et al (2013, 2015, 2016, 2017, and 2018) found 84%, 78%, 72%, and 66% reduction in fatalities with feathering and low wind speed curtailment at 5.0 m/s when compared to the results from 2010 when turbines were only curtailed at the manufacturer's cut-in speed of 3.5 m/s. The study was conducted at Fowler Ridge, IN. Other cut-in speeds were not compared.

- Arnett et al. (2009, 2010, and 2011) evaluated the rate of bat fatalities at Casselman Wind, PA late July through October under a curtailment regime of 5.0 m/s with feathering. Turbines at the site are 1.5 MW GE SLE with a hub height of 80 meters and rotor diameter of 77 meters. A 54.4% (95% C.I. 17.7–74.7) and 76.1% (95% C.I. 49.1–88.8) reduction in bat fatalities for the 5.0 m/s and 6.5 m/s treatments, respectively was observed, depending on year, with the implementation of curtailment and blade feathering when compared to the manufacturer's cut in speed of 3.5 m/s. However, the fatality rate for the 6.5 m/s treatment was not significantly lower than the fatality rate for the 5.0 m/s treatment ($P = 0.103$).

Hein et al. (2014) compared feathering with low wind speed curtailment at 5.0 m/s and 6.5 m/s feathered turbines with a cut-in speed of 3.0 m/s at Pinnacle Wind, WV. The turbines are 2.4 MW Mitsubishi with 80 meter hub height and 95 meter rotor diameter. Low wind speed curtailment was implemented from sunset to sunrise from July 15 to September 30. Bat fatalities were eastern red bats, hoary bats, silver-haired bats, tri-colored bats, and big brown bats. A significant reduction in bat fatality rates was observed when turbines were curtailed and blades fully feathered at 5.0 m/s and at 6.5 m/s compared to turbines that were not curtailed. However, the bat fatality rate for the 6.5 m/s treatment was not was not significantly lower than the fatality rate for the 5.0 m/s treatment (P – 0.103).

Martin et al (2017) combined results from 2012 and 2013 at Sheffield, VT comparing manufacturer's cut in speed of 4.0 m/s and 6.0 m/s and found a significant reduction of 67% in fatalities between treatments. Lower cut in speeds were not tested. Turbines were 2.5 MW Clipper with 80-m hub height and 93-m rotor diameter. Cut-in speed at treatment turbines was raised from 4.0 to 6.0 m/s whenever nightly wind speeds were < 6.0 m/s and temperatures were > 9.5°C, from June 3 through September 30 which covered spring and fall migration. Significant reduction in fatalities at 6.0 m/s as compared to 4 m/s cut-in speeds. Bat fatalities were hoary bat, eastern red bats, and silver-haired.

Tidhar et al (2013) compared 6.9 m/s curtailment with feathering of turbines at Beechridge Wind, WV to the turbines at nearby farms (Mount Storm WV and Mountaineer Wind, WV) operating at the manufacturer's cut in speed of 3.5. The turbines at Beechridge were 1.5 MW GE SLE with a 80 meter hub height and 70 meter rotor diameter. The turbines at Mount Storm were 2.0 MW Gamesa G80 with a 78 meter hub height and 80 meter rotor diameter. Turbines at Mountanier Wind are 1.5 MW NEG Micon with a 72 meter rotor sweep. Low wind speed curtailment was implemented 30 minutes before sunset to 15 minutes after sunrise from April 1 to November 15. Bat fatalities were eastern red bat, hoary bat, silver-haired bat, and tricolored bat. Though there was a difference of 73-87% but there was no statistical difference when compared to the control set of turbines.

Stantec (2015) compared low wind speed curtailment at 6.9 m/s with the manufacturer's cut-in speed of 3.5 m/s at Laurel Mountain Wind Energy, WV. The turbines were 1.6 MW GE XLE with 80 meter hub height and 82.5 meter rotor diameter. Low wind speed curtailment was implemented from sunset to sunrise between April 1 and November 15. Bat fatalities were eastern red bats, silver-haired bats, hoary bats, and big brown bats. A significant reduction in bat fatalities when compared to turbines with cut-in speed of 3.5 m/s were observed, but other incremental cut-in speeds were not tested.

Greater rotor diameter

- Good et al (2011) observed bat fatality rates were not equal among turbine manufacturers. Comparisons were between 1.5. MW GE SLE turbines with an 80 meter hub height and 77 meter rotor diameter, 1.65 MW Vesta with an 80 meter hub height and 82 meter rotor diameter and 2.5 MW Clipper C96 80 meter hub height and a 96 meter rotor diameter at Fowler Ridge, IN. Higher bat fatality rates were observed at turbines with greater rotor diameters in 2010. This pattern was potentially a function of increasing rotor swept area, and bats may have had an increased probability of colliding with turbines that had greater rotor swept areas. In 2011, however, although the Clipper turbines had a greater rotor swept area, the Vestas turbines showed a higher per turbine fatality rate compared to the Clipper and GE turbines. Further examination in 2011 suggests that turbine behavior prior to reaching cut-in speeds also affected bat fatality rates and lead to implementation of feathering in future years.

Rolling average

- Shirmacher et al (2016) evaluated increasing the length of time used for determining the average wind speed from 10 minutes to 20 minutes. Shirmacher et al (2016) reported fewer bat fatalities were observed with a 20 minute rolling average based on wind speed at the met tower anemometer though they were not able to separate fatality risk due to low wind speeds (5.0 m/s) verse risk at start up. Their results also suggested that using average wind speeds from anemometers located at the met towers rather than on turbine nacelles may reduce bat fatalities. Efforts to minimize bat fatalities at wind facilities might benefit by averaging wind-speed curtailment thresholds over longer periods of time (e.g., >10 min) to prevent gusts from intermittently pushing blades to lethal speed during low-wind periods.

Bat behavior at turbines

Cryan et al. (2014) analyzed wind turbine activities at a facility in northwestern Indiana using thermal video-surveillance cameras, supplemented with near-infrared video, acoustic detectors, and radar. Wind speed and blade rotation speed influenced the way bats approached turbines. They observed that bats approached turbines less frequently when their blades were spinning fast, and leeward approaches, as opposed to windward approaches, to the nacelle increased with wind speed at turbines with slow-moving or stationary blades. Leeward approaches declined when the blades were rotating. Insects often accumulate on the leeward sides of artificial and natural structures that provide windbreaks as wind speed increases (Lewis 1965, 1969). Based on this insect behavior, Cryan st al suggested that the behaviors of bats on the leeward side of wind turbines might be associated with bats expecting insects at the structures as they approached, irrespective of the actual presence of insects. The group also observed that tree bats show a tendency to closely investigate curtailed or feathered turbines and sometimes remain for minutes to hours. This observation suggests the possibility that bats are drawn toward turbines in low winds, but sometimes remain long enough to be put at risk when wind picks up and blades reach higher speeds. Therefore, the frequency of intermittent, blade-spinning wind gusts within such low-wind periods might be an important predictor of fatality risk; fatalities may occur more often when turbine blades are transitioning from potentially attractive (stationary or slow) to lethal (fast) speeds.

Gorresen et al (2015) studied the landscape distribution of Hawaiian hoary in the north Koʻolau Mountains of Oʻahu, Hawaiʻi, from May 2013 to May 2014, while simultaneously studying their behavior at wind turbines located at Kawailoa Wind, on the north shore of Oʻahu. The Kawailoa Wind facility consists of 2.3 MW Siemens SWT-2.3-101 turbines with a hub height of 100 meters and rotor diameter of 108 meters. Prevailing wind speeds are typically 5.5 to 8 m/s. Monitoring at four turbines was conducted with acoustic detectors and thermal videography. Video events involving Hawaiian hoary bats at turbines on Oʻahu showed typical visits to turbines lasted only a few seconds, although 10% of the visits were sustained for longer periods of time, similar to what Cryan et al (2014) observed in Indiana. The thermal video detections indicate that Hawaiian hoary bats on Oʻahu spend about 42 seconds on average (cumulative total) within the rotor sweep zone. Over half (57%) of the acoustic detections of Hawaiian hoary bat were leeward and above the nacelle, and relatively fewer detections (10%) were directly below and towards the windward side of the nacelle. Most (86%) thermal video detections at a wind farm on Oʻahu involved single bats passing the turbine once, the largest proportion involved erratic (41%) flight indicative of foraging in the immediate area of the turbine. Frequent detections by video of erratic flight indicative of Hawaiian hoary bats foraging were made. However, terminal phase calls (feeding buzzes) were very infrequently recorded acoustically and infers that bats are not encountering insect prey around the turbine nacelle area. In light of the video evidence of foraging behaviors on Oʻahu, the low acoustic detection rate suggests that acoustic detectors mounted on turbines may chronically under-sample bat activity. Bats were more likely to occur following periods when barometric pressure had declined and was near or at a low (≤ 972 mb) and beginning to rise over at least one 24-hour period, indicating Hawaiian hoary bats may be more likely to approach and forage near turbines when weather conditions are clearing and becoming favorable for foraging. Hawaiian hoary bats were seen near turbines more often than expected during low-wind periods, based on thermal videography. Higher rates of Hawaiian hoary bat detection generally occurred when nightly wind speeds dropped to a low relative to the previous night and mean speeds were < 4.6 m/s and maximum speeds were < 8.2 m/s. Higher rates of bat detection generally occurred when nightly wind speeds dropped to a low relative to the previous night and mean speeds were < 4.6 m/s and maximum speeds were < 8.2 m/s. The conditions that favored the highest proportion of bat detections included conditions where maximum wind speeds were ≤ 7.7 m/s (or between 7.7 and 8.7 m/s with temperatures > 21.5 °C). Conditions that favored the lowest bat activity included humidity levels > 90.0% and maximum wind speeds > 8.7 m/s, or humidity levels ≤ 90.0% and maximum wind speeds > 12 m/s. Proportion of detections were also low where wind speeds were between 7.7 and 8.7 m/s and temperatures were ≤ 21.5 °C. With regard to precipitation, the highest rates of activity were when nightly maximum wind speeds were ≤ 8.3 m/s and cumulative rain ≤ 0.8 mm. Conditions that favored the lowest activity rates included maximum wind speeds > 9.8 m/s, where humidity levels were > 85.0%, and temperatures were ≤ 21.4 °C. Turbines during this study were feathered at wind speeds below 5 m/s and bat behavior may only reflect associated with this curtailment operation and the wind speed profile of the site. Hawaiian hoary bat detection rates tend to be higher when temperatures were > 22.2 °C, but this may partly reflect the presence of newly volant young in late summer and fall periods rather than the effect of temperature on the activity of individual bats when the study was conducted on Oʻahu (Gorresent et al 2015). Hawaiian hoary bat detection was only weakly related to moon illumination (Gorresen et al 2015. Lima and O'Keefe (2013) reported there was no evidence that tree bat activity varies with lunar cycles or illumination. In contrast, Cryan et al (2014) reported that thermal video cameras detected bats at turbines more often during periods of night with bright moon illumination and less often during periods with lower levels of moonlight, suggesting that vision plays a role in bats perceiving and approaching wind turbines. The hourly rate of nightly bat detection (number/hour/turbine) was highly variable but more than doubled from mid-May to mid-November. It is plausible that this may be attributable to increased foraging needs by reproductive females tending dependent pups and the activity of newly volant bats.

Corcoran and Weller (2018) demonstrated that hoary bats (*Lasiurus cinerus*) use a novel call type called "micro' calls" that has three orders of magnitude less sound energy than other bat calls used during typical echolocation in open habitats. Hawaiian hoary bats use higher frequency calls then the larger subspecies, *Lasiurus cinereus cinereus* (Barclay 1999). Peak frequency is 26.2–29.8 kHz, though reported range varies from 23 to 46 kHz and may not encompass the complete range of echolocation frequency. Acoustic modelling indicates the bats are not producing call that exceed 70-75 dB at 0.1 m (Corcoran and Weller 2018). This indicates bats sometimes fly without echolocation. At this level, the call would have little or no known use for a bat flying in the open at speeds exceeding 7m/s. Using established sonar theory (Stilz and Schnitzler 2012) Cochran and Weller (2018) suggest switching from normal echolocation to micro calls reduces the detection range for a tree from 26.9 to 7.5 m, and reduces the detection range of a medium-sized insect (3 cm wingspan) from 6.9 to 2.1 m. Gerberi et al (2015) reported that bats have a sensori-motor reaction time of 0.1 s before they can execute a coordinated avoidance, evasion or capture maneuver. Assuming an average flight speed of 7 m/s, switching from normal to micro calls would reduce the time available for avoiding a collision with a stationary object such as a tree from 3.5 to 0.9 s and reduce time for capturing prey from 0.89 to 0.24 s. Under these conditions, hoary bats using micro calls should have sufficient time to detect and avoid large obstacles such as tree branches at 1.5 meters, but have difficulty avoiding smaller objects, mist nets or rapidly moving wind turbine blades.

PROJECT SPECIFIC AVOIDANCE AND MINIMIZATION

The amount of reduced risk to bats with higher increments of operational minimization, (feathering with low wind speed curtailment above 5.0 - 5.5 m/s) is clearly dependent on project-specific characteristics such as wind regime, bat species at risk, deceleration and acceleration profile of the turbines, surrounding land uses, and other factors (Arnett et al. 2013). Feathering and low wind speed curtailment of turbine blades are operational minimizations recommended by the Service and voluntarily deployed by all operating wind farms in Hawaiʻi. Auwahi Wind, Kaheawa Wind Phase II, and Kawailoa all began operations in 2012 when low wind speed curtailment and feathering to reduce bat fatalities was in its infancy. There was a perceived risk to the Hawaiian hoary bat due to nighttime operation of wind turbines over the lifetime of each projects' permit, but the modelled rate of fatalities under the operating regimes at the time were not anticipated. As a result of the studies conducted on the mainland, observed fatalities in Hawai'i, and the advancement of modelling for rare fatalities, the Service recommends a baseline cut-in speed of 5.0 m/s or higher, with feathering of blades at and below the cut-in speed for all projects with potential impacts to Hawaiian hoary bats.

Each project in this PEIS has implemented the recommended minimum and, in some cases, have voluntarily implemented higher cut-in speed and other experimental minimization measures to reduce potential fatalities based on the project sites' wind profile, turbine capabilities, and temporal Hawaiian hoary bat fatality incidence and rate, while maintaining economic viability. The limiting factor to recommending a specific or "perfect" cut-in speed that provides nighttime renewable energy but avoids Hawaiian hoary bat fatalities, is interpreting correlations between bat fatalities and operational minimization when the exact time of the fatality is not known for any of the bat fatalities. Nighttime thermal imaging to further elucidate project-specific turbine-associated Hawaiian hoary bat fatalities are underway, though it is exceptionally challenging in Hawai'i because of the relative (to the mainland) rarity of a bat fatality.

As described in Appendix C, modelled probability distributions of project-associated fatalities and each projects' projected take is NOT the number of bat fatalities observed. Rather, the modelled probability-based estimates represent the credibility level that we are 80% sure has not been exceeded, and for which, the project must mitigate because of the uncertainty around actual fatality amount and productivity of the mitigation. The following project-specific sections provide the rationale and temporal sequence of minimization actions, observed Hawaiian hoary bat fatalities, area searched and detection probability during each period. What becomes very evident is the variability among projects with regard to take relative to the number and type of turbines at each site. While it is accurate to say that the projects with the highest number of turbines has observed the highest number of fatalities, the same cannot be said for the project with the fewest number of turbines.

Auwahi Wind

Auwahi Wind was issued an ITP February 24, 2012 and began commercial operations on December 28, 2012. Auwahi operates 8, 3.0 MW Siemens turbines with a hub height of 80 meters and a rotor diameter of 101 meters. The Auwahi Wind turbine operational regime and Hawaiian hoary bat fatalities observed during the commercial operating period as of September 2018 are shown in Table D-1. The first observed (found project-associated Hawaiian hoary bat fatality was reported on October 9, 2013. The exact time of a fatality is not known for any fatalities because turbine-blade technologies to detect the exact time of collision are not available. The project implemented a year-round cut-in speed of 5.0, from sunset to sunrise, beginning on February 5, 2015 (Table D-1).

Beginning in June 2018, Auwahi Wind initiated a year-long acoustic study of bat activity at the turbine nacelles. The project also incorporated thermal video imaging paired with acoustic monitoring to gather data on the wildlife interactions with the turbines during the high-risk months of August through October. About 71% of the observed fatalities have between August 5 and October 14. The thermal videography is intended to validate the findings of the acoustic survey, inform the raised cut-in speed strategy, and inform placement of potential deterrent technologies. Auwahi Wind also implemented a raised cut-in speed of 6.9 m/s, with feathering, nightly from August through October, for evaluation purposes. A bat fatality was found under the higher 6.9 m/s low wind speed curtailment regime 35 meters from the turbine but not in the designated pads and roads search area, so it is accounted for in the unobserved modelled take. It does, however, demonstrate the risk of bat fatality even under a higher wind speed curtailment regime. It is unknown if the fatality occurred during an acceleration or deceleration periods associated with low wind speed curtailment that occurred in the days prior to the fatality being found.

Table D-1. Project specific data for observed fatalities at Auwahi Wind and the curtailment regime and search parameters in place at the time. Shaded rows indicate the curtailment regime that was in place at the presumed time of Hawaiian hoary bat fatality.

Period	Curtailment (m/s)[1]	Observed fatalities	Area searched	Detection Probability
Jan 25 2013 – Jan 2014	No	1	0.97	0.28
Jan 2014 - Feb 4 2015	No	4	0.94	0.55
Feb 5 2015 – Jan 2016	5.0	1	0.76	0.45
Jan 2016 – Jan 2017	5.0	7	0.76	0.55
Jan 2017 – Jan 2018	5.0	3 (2)[2]	0.76	0.56
Jan 2018 – Jul 31 2018	5.0	1 (1)[2]	0.76	0.52
Aug 1 2018 – Sep 30 2018	6.9	(1)[2]	0.76[3]	0.52[4]

[1] Average wind speed based on a 10 minute rolling average at which the turbine blades will begin rotating and producing power; blades are feathered (parallel with the wind) when wind speeds are below the speed shown

[2] Values in parentheses are additional fatalities that were observed but are considered included in the modelled unobserved take because the fatalities were outside of the reduced search area. The area outside of the reduced search area is accounted for in the unobserved take of the Evidence of Absence model.

[3] There is evidence that the mean of the fatality distribution shifts outward with higher cut in speeds assuming the fatality is occurring when the turbines are rotating thus 0.76 may not be representative of the density weighted proportion.

[4] Estimated

This project has the fewest turbines of the facilities included in this PEIS. It has 17 observed bat fatalities, or 21 observed if we include all observed fatalities. The value of 17 is used for the purposes of modeling a level of take that we are certain has not been exceeded, as well as projecting future take (Appendix C). Evaluating the impacts of low wind speed curtailment is challenging and highly speculative given the lack of statistical power. The annual observed take per turbine per year for the first two years was 0.31 or 2.5 observed fatalities per year and modelled direct take at the 80% credibility level indicates take did not exceed 1.0 bats per turbine per year, or 8 bats per year. The project implemented a 5.0 m/s low wind speed curtailment on February 5, 2015 and continued that regime through July 2018. After implementation of low wind speed curtailment the annual observed take per turbine per year was 0.4 or 3.4 observed fatalities per year. Modelled direct take at the 80% credibility level indicates take did not exceed 0.9 bats per turbine per year, or 7.1 bats per year. The modeled take, which accounts for the detection probability, suggests a slight decrease in take may be associated with implementation of the low wind speed curtailment at 5.0 m/s though not statistically different. The observed take fails to show this difference and it is likely because of the lower detection probability of 0.28 in the first year of operation. The implementation of 6.9 m/s low wind speed curtailment from August to October did appear to reduce take during the first season of implementation, though a bat fatality was found. Recently Riser-Espinoza (2018) and others have found that the mode of fatality distributions shifts outward from the turbine monopole when higher cut in speeds are implemented. Such findings may have an effect on the density weighted proportions represented within the reduced search area of roads and pads.

Kaheawa Wind Phase II

Kaheawa Wind Phase II was issued an ITP in January 2012 and began commercial operations on July 2012. Kaheawa Wind Phase II operates 14, 1.5 MW GE-SE turbines with a hub height of about 65 meters and a rotor diameter of 70 meters. The Kaheawa Wind Phase II turbine operational regime and Hawaiian hoary bat fatalities observed during the commercial operating period as of September 2018 are shown in Table D-2. The first observed (found) project-associated Hawaiian hoary bat fatality was reported on March 13, 2013. The exact time of a fatality is not known for any fatalities because turbine-blade technologies to detect the exact time of collision are not available. The project initially implemented a 5.0 m/s curtailment regime spanning April 1 through November 30 from sunset to sunrise. After the fatality was observed March 13, which was outside the low wind speed curtailment period, Kaheawa Wind Phase II modified the curtailment period to span March 13 through November 30. A second fatality was observed in November 2013. Low wind speed curtailment was in effect during the time the second fatality was found. A third bat fatality at Kaheawa Wind Phase II was documented on February 26, 2014 and low wind speed curtailment began immediately and was implemented in following years beginning February 15. After a bat fatality was documented at the neighboring facility, Kaheawa Wind Phase I, on December 14, 2013, the low wind speed curtailment at Kaheawa Wind Phase II was extended in 2014, and subsequent years through December 15. In addition, Kaheawa Wind Phase II raised the low wind speed cut-in speed to 5.5 m/s. Kaheawa Wind Phase II currently implements 5.5 m/s low wind speed curtailment from February 15 through December 15. No bat fatalities have been observed at KWP II between December 15 and February 15.

Table D-2. Project specific data for observed fatalities at Kaheawa Wind Phase II and the curtailment regime and search parameters in place at the time. Shaded rows indicate the curtailment regime that was in place at the presumed time of Hawaiian hoary bat fatality.

Period	Curtailment (m/s)[1]	Observed fatalities	Area searched	Detection Probability
Jul 1 2012 – Nov 2012	5.0	0	1	0.4431
Dec 1 2012 – Mar 2013	No	1	1	0.4431
Apr 2013 – Jun 2013	5.0	0	1	0.4431
July 2013 – Nov 2013	5.0	1	1	0.3591
Dec 2013 – Feb 27 2014	No	1	1	0.3591
Feb 28 2014-Jun 2014	5.0	0	1	0.3591
Jul 2014	5.0	0	1	0.3356
Aug 1 2014 – Dec 15 2014	5.5	0	1	0.3356
Dec 16 2014-Feb 14 2015	No	0	1	0.3356
Feb 15 2015 – Jun 2015	5.5	0	1	0.3356
Jul 2015 – Dec 15 2015	5.5	0	0.559	0.3620
Dec 16 2015 – Feb 14 2016	No	0	0.559	0.3620
Feb 15 2016 – Jun 2016	5.5	0	0.559	0.3620
Jul 2016 – Dec 15 2016	5.5	0	0.559	0.4419
Dec 16 2016 – Feb 14 2017	No	0	0.559	0.4419
Feb 15 2017 – June 2017	5.5	0	0.559	0.4419
Jul 2017 – Dec 15 2017	5.5	0	0.559	0.3748
Dec 16 2017 – Feb 14 2018	No	0	0.559	0.3748
Feb 15 2018 – Jun 2018	5.5	0	0.559	0.3748
Jul 2018 – Sep 2018	5.5	0	0.559	0.3748[2]

[1] Low wind speed curtailment is based on wind speed using a 10 minute rolling average; blades are feathered when average wind speed is below the speed shown

[2] Estimated

Kawailoa Wind

Kawailoa Wind was issued an ITP December 8, 2011 and began commercial operations on November 12, 2012. Kawailoa Wind operates 30, 2.3 MW Siemens turbines with a hub height of about 100 meters and a rotor diameter of about 101 meters. The Kawailoa Wind turbine operational regime and Hawaiian hoary bat fatalities observed during the commercial operating period as of September 2018 are shown in Table D-3. Kawailoa Wind initially implemented low wind speed curtailment at 5.0 m/s from March 1 through November. The first observed (found) project-associated Hawaiian hoary bat fatality was reported on November 27, 2012. The exact time of a fatality is not known for any fatalities because turbine-blade technologies to detect the exact time of collision are not available. The project has extended the low wind speed curtailment period in response to observed bat fatalities outside of the curtailment period. In 2012, low wind speed curtailment was extended to December 15 and to February 10 in 2013. In 2015, the period was extended to February 6 and after a fatality was observed in December 2016, low wind speed curtailment was further extended to December 31 for 2017.

As a further minimization measure, Kawailoa Wind implemented a modified low wind speed curtailment regime that utilizes a 5.0 m/s cut-out wind speed with a 0.2 m/s hysteresis that results in a turbine cut-in speed of 5.2 m/s on June 21, 2018. In July the project increased the rolling average basis from a 10 minute interval to a 20 minute interval. The increase in the rolling average is expected to reduce stop and start of rapid blade rotation and showed reduced fatalities when compared to a 10 minute interval in a study on the mainland US (Shirmacher et al 2016). Kawialoa Wind had committed to continue this curtailment regime in the draft HCP. There have been four observed bat fatalities at the project between July 19, 2018 and August 17, 2018

Kawailoa Wind has worked with NRG Systems to install an ultrasonic acoustic bat deterrent system on a turbine at Kawailoa Wind in July 2018. The turbine selected has been associated with the most (16%) observed bat fatalities at the project. The effectiveness of the deterrent at reducing bat activity levels is being evaluated using thermal imaging over a 60-day study period to document the bat approach paths and activity in relation to the rotor swept area at the turbine. Data collected at the Project will supplement the results of NRG Systems' ongoing testing at wind farms on the mainland. Results of NRG Systems' testing and those of other deterrent systems will be used to inform future minimization measures at the Project. Kawailoa Wind will install bat deterrents at all 30 Project turbines when bat deterrents become commercially available and are shown to be at least as effective as low wind speed curtailment at reducing bat take. Take estimation Wind assumes deterrents will be installed by 2022.

This project has the most turbines of the facilities included in this PEIS and in Hawaiʻi, in general. It also has the highest observed take, at 37 or 39 if we include all observed fatalities, regardless of how they are treated in the model (Table D-3). The annual observed take per turbine per year that we would expect, if no changes occurred, is 0.19 bat fatalities or about 6 bats at the facility per year. This is based on observed take only and does not include modelled unobserved take or indirect take of dependent young. If we exclude the 5 bats that were observed outside of low wind speed implementation the number of fatalities expected to occur per turbine is 0.17 or about 5 per year. Anecdotally, this suggests the curtailment implemented by Kawailoa over the last 6.8 years may have reduced observed take by about 1 bat per year. Calculating take per MW of power produced is not presented here because, while each turbine may have a nameplate power generating capacity of 2.3 MW, that does not mean the facility is producing that amount of power per turbine. Various curtailment and operational minimizations, wind speed, and the power purchase agreement have an effect of power sent into the public electrical grid.

Table D-3. Project specific data for observed fatalities at Kawailoa Wind and the curtailment regime and search parameters in place at the time. Shaded rows indicate the curtailment regime that was in place at the presumed time of Hawaiian hoary bat fatality.

Period	Curtailment (m/s)[1]	Observed fatalities	Area searched	Detection Probability
Nov 2012 – Nov 2012	5.0	1	0.95	0.538
Nov 2012 – Feb 28 2013	No	2	0.95	0.538
Mar 2013 – Jun 15 2013	5.0	1 (1)[2]	0.95	0.538
Jul 2013 – Dec 15 2013	5.0	7	0.95	0.666
Dec 16 2013 – Feb 10 2014	No	0	0.95	0.666
Feb 11 2014 - Jun 2014	5.0	2	0.95	0.666
Jul 2014 – Dec 15 2014	5.0	6	0.95	0.792
Dec 16 2014 – Feb 10 2015	No	1	0.95	0.792
Feb 11 2015 – Jun 2015	5.0	2	0.95	0.792
Jul 2015 - Oct 2015	5.0	3	0.95	0.826
Nov 2015 – Dec 15 2015	5.0	0	0.42	0.423
Dec 16 2015 – Feb 6 2016	No	0	0.42	0.423
Feb 7 2016 – Jun 2016	5.0	1 (1)[2]	0.42	0.423
Jul 2016 – Dec 15 2016	5.0	1	0.42	0.384
Dec 15 2016 – Feb 6 2017	No	1	0.42	0.384
Feb 7 2017 –Jun 2017	5.0	0	0.42	0.384
Jul 2017 – Dec 15 2018	5.0	4	0.42	0.365
Dec 16 2017 – Feb 6 2018	No	1	0.42	0.365
Feb 7 2018 – Jun 20 2018	5.0	0	0.42	0.365
Jun 21 2018 –Jul 2018	5.0/5.2	1	0.42	0.378
Jul 2018 – Sep 2018	5.0/5.2/20 min[3]	3	0.42	0.378[4]

[1] Low wind speed curtailment is based on the wind speed using a 10 minute rolling average unless noted otherwise; blades are feathered when the turbines are curtailed

[2] Values in parentheses are additional fatalities that were observed but are considered included in the modelled unobserved take because the fatalities were outside of the reduced search area. The area outside of the reduced search area is accounted for in the unobserved take of the Evidence of Absence model.

[3] Low wind speed curtailment was modified to a cut out speed of 5.0 and cut-in speed of 5.2 and the rolling average basis was extended from a 10 minute interval to a 20 minute interval

[4] Estimated

Pakini Nui

Pakini Nui began commercial operation April 3, 2007 and is comprised of 14, 1.5 MW GE-SE turbines with a hub height of 65 meters and a rotor diameter of 70 meters. The Pakini Nui turbine operational regime and Hawaiian hoary bat fatalities observed during the commercial operating period as of September 2018 are shown in Table D-4. Standardized compliance monitoring from 2007 until August 2013 was not conducted and so there is no way to know if, or how many, bat fatalities occurred during that period. The first observed (found) project-associated Hawaiian hoary bat fatality was reported on August 31, 2013. The exact time of a fatality is not known for any fatalities because turbine-blade technologies to detect the exact time of collision are not available. The Project implemented a curtailment regime in March 2014. The Project currently curtails turbines year-round between the hours of 6:00/6:30 p.m. approximately 1 hour before civil sunset) and 6:30/7:00 a.m. (approximately 1 hour after civil sunrise). Turbines shut down and the blades are feathered if the 10-minute average wind speed is 5.0 m (16 feet) per second or less (cut-out wind speed) and will start back up if the 10-minute average wind speed is greater than or equal to 5.5 m (18.0 feet) per second (cut-in wind speed). This curtailment regime will continue for the life of the project. There were periods of poor detection probability from April 2016 to July 2017 that add a high level of uncertainty into what may have been observed if detection probability would have been higher. Low wind speed curtailment was being implemented during the time the second and third bat fatality were found.

Table D-4. Project specific data for observed fatalities at Pakini Nui and the curtailment regime and search parameters in place at the time. Shaded rows indicate the curtailment regime that was in place at the presumed time of Hawaiian hoary bat fatality.

Period	Curtailment (m/s)[1]	Observed fatalities	Area searched	Detection Probability
Apr 2007 – August 2013	No	0	UNK[2]	<0.01[3]
August 2013-Feb 2014	No	1	0.87	0.2375
Mar 2014	5.0/5.5	0	0.87	0.2375
Apr 2014 – Mar 2015	5.0/5.5	0	0.87	0.3259
Apr 2015 – Mar 2016	5.0/5.5	1	0.87	0.2178
Apr 2016 – Mar 2017	5.0/5.5	0	0.87	0.0377
Apr 2017- Jul 3 2017	5.0/5.5	0	0.87	0.0457
Jul 10 2017 – Mar 2018	5.0/5.5	0	0.87	0.2330
Apr 2018 – Sep 2018	5.0/5.5	1	0.87	0.2330[4]

[1] Low wind speed curtailment is based on a cut out speed of 5.0 m/s with feathering and a cut-in speed of 5.5 m/s; cut-out and cut-in speed based on a 10 minute rolling average

[2] Non-standardized monthly searches were conducted

[3] Estimated only because model parameters (searcher efficiency, carcass persistence) were not measured, searches were only conducted monthly, and search transects were not standardized

[4] Estimated

LITERATURE CITED

Arnett, E. B., M. M. P. Huso, J. P. Hayes, and M. Schirmacher. 2010. Effectiveness of changing wind turbine cut-in speed to reduce bat fatalities at wind facilities. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, TX, USA.

Arnett, E.B. M.M.P. Huso, M.R. Schirmacher, and J.P. Hayes. 2011. Altering turbine speed reduces bat mortality at wind-energy facilities. Frontiers in Ecology and the Environment 9: 209-214.

Arnett, E.B., G.D. Johnson, W.P. Erickson, and C.D. Hein. 2013. A synthesis of operational mitigation studies to reduce bat fatalities at wind energy facilities in North America. A report submitted to the National Renewable Energy Laboratory. Bat Conservation International. Austin, Texas, USA.

Arnett, E.B., M. Schirmacher, M.M.P. Huso, and J.P. Hayes. 2009. Effectiveness of changing wind turbine cut-in speed to reduce bat fatalities at wind facilities. An annual report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Baerwald, E.F., J. Edworthy, M. Holder, and R.M.R. Barclay. 2009. A large scale mitigation experiment to reduce bat fatalities at wind energy facilities. Journal of Wildlife Management 73: 1077-1081.

Barclay, R.M.R., H.J. Fullard, and D.S. Jacobs. 1999. Variation in the echolocation calls of the hoary bat (*Lasiurus cinereus*): influence of body size, habitat structure, and geographic location. Canadian Journal of Zoology 77:530-534.

Corcoran, A. J. and T. J. Weller. 2018. Inconspicious echolocation in hoary bats (*Lasiurus cinereus*). Proceedings of the Royal Society B 285: 20180441.

Cryan, P.M., P.M. Gorresen, C.D. Hein, M.R. Schirmacher, R.H. Diehl, M. M. Huso, D.T.S. Hayman, P.D. Fricker, F.J. Bonaccorso, D.H. Johnson, K. Heist, and D.C. Dalton. 2014. Behavior of bats at wind turbines. Proceedings of the National Academy of Science 111:15126-15131.

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

Dalthorp, D., L. Madsen, M. Huso, P. Rabie, R. Wolpert, J. Studyvin, J. Simonis, and J. Mintz. 2018, GenEst statistical models - A generalized estimator of mortality: U.S. Geological Survey Techniques and Methods, book 7, chap. A2, 13 p., https://doi.org/10.3133/tm7A2.

Foo, C., V.J. Bennett, A. M. Hale, J. M. Korstian, A. J. Shildt, and D. A. Williams. 2017), Increasing evidence that bats actively forage at wind turbines. PeerJ 5:e3985; DOI 10.7717/peerj.3985

Good, R.E. and K. Adachi. 2013. Fowler Ridge Research Summary. Poster presented at the 2014 National Wind Coordinating Collaborative, Research Meeting X, December 2-5, 2014, Broomfield, CO. Western EcoSystems Technology, Inc. Bloomington, Indiana.

Good, R.E. and K. Adachi. 2014. Fowler Ridge Research Summary. West Inc., Bloomington, Indiana and Cheyenne, Wyoming. Poster.

Good. R.E., A. Ciecka, G. Iskali, and K. Nasman. 2017. Bat Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana: August 3 – October 12, 2016. Prepared for Fowler Ridge Wind Farm, Fowler, Indiana. Prepared by Western EcoSystems Technology, Inc., Bloomington, Indiana.

Good, R. E., G. Iskali, and K. Adachi. 2015. Bat Evaluation Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana: August 4 - October 14, 2014. Prepared for Fowler Ridge Wind Farm. Prepared by Western EcoSystems Technology, Inc., Bloomington, Indiana.

Good, R. E., G. Iskali, and K. Nasman. 2016. Bat Evaluation Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana: August 3 - October 14, 2015. Prepared for Fowler Ridge Wind Farm. Prepared by Western EcoSystems Technology, Inc., Bloomington, Indiana.

Good. R. E., G. Iskali, K. Nasman, and A. Ciecka,. 2018. Bat Evaluation Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana: August 1 – October 15, 2017. Prepared for Fowler Ridge Wind Farm, Fowler, Indiana. Prepared by Western EcoSystems Technology, Inc., Bloomington, Indiana.

Good, R.E., W. Erickson, A. Merrill, S. Simon, K. Murray, and K. Bay. 2012. Bat monitoring studies at the Fowler Ridge Wind Energy Facility, Benton County, Indiana. Prepared for Fowler Ridge Wind Farm by Western EcoSystems Technology, Inc., Cheyenne, Wyoming.

Good. R. E., W. Erickson, A. Merrill, S. Simon, K. L. Murray, K. Bay, and Chris Fritchman. 2011. Bat monitoring studies at the Fowler Ridge Wind Energy Facility Benton County, Indiana, April 13 – October 15, 2010. Prepared for Fowler Ridge Wind Farm, Fowler, Indiana. Prepared by Western EcoSystems Technology, Inc. Cheyenne WY.

Gorresen, M. P., P. M. Cryan, M. Huso, C. Hein, M. Schirmacher, J. Johnson, K. Montoya-Aiona, K. W. Brinck and F. J. Bonaccorso. 2015. Behavior of the Hawaiian hoary bat at wind turbines and its distribution across the North Koʻolau Mountains, Oʻahu. Technical Report HCSU-064, Hawai`i Cooperative Studies Unit, University of Hawaiʻi at Hilo, Hawaiʻi, 68 pp.

Hein, C. D., A. Prichard, T. Mabee, and M. R. Schirmacher. 2014. Efficacy of an operational minimization experiment to reduce bat fatalities at the Pinnacle Wind Farm, Mineral County, West Virginia, 2013. An annual report submitted to Edison Mission Energy and the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, TX, USA.

Hull, C.L., and Muir, S., 2010, Search areas for monitoring bird and bat carcasses at wind farms using a Monte-Carlo model. Austalasian journal of Environmental Management, v. 17, p. 77-87.

Huso, M.S.P., D. Dalthorp, D. Dail, and L., Madsen. 2015, Estimating wind-turbine-caused bird and bat fatality when zero carcasses are observed. Ecological Applications 25: 1213-1225.

Lewis, T. 1965. The effects of an artificial windbreak on the aerial distribution of flying insects. Annals of Applied Biology 55:503–512.

Lewis, T. 1969. The distribution of flying insects near a low hedgerow. Journal of Applied Ecology 6:443–452.

Lima, S.L., and J.M. O'Keefe. 2013. Do predators influence the behaviour of bats? Biological Review of the Cambridge Philosophical Society 88:626–644.

Martin C., E. Arnett, R. Stevens, and M. Wallace. 2017. Reducing bat fatalities at wind facilities while improving the economic efficiency of operational mitigation. Journal of Mammalogy 98(2):378-385.

Riser-Espinoza, D., P. Rabie, and J. Studyvin. 2018. Assessing patterns in the spatial distribution of fatalities around wind turbines with and without modified cut-in speeds. West, Inc. Fort Collins, CO. NWCC Wind and Wildlife Research Meeting, November 27-November 30, 2018. Minneapolis-St. Paul, MN. *Poster*

Shirmacher, M., A. Prichard, T. Mabee, and C. Hein 2016. Multiyear operational study in WV: Potential novel strategy to reducing bat fatalities at wind turbines. NWCC Wind Wildlife Research Meeting XI. December 1, 2016, Broomsfield, Colorado.

Simonis, J., M. Huso, D. Dalthorp, J. Mintz, L. Madsen, P. Rabie, and J. Studyvin. 2018. GenEst user guide-software for a generalized estimator of mortality. U.S. Geological SurveyTechniques and Methods, book 7, chapter C19 72 pp. https://doi.org/10.3133/tm7C19.

Stantec. 2015. Bird and bat post-construction monitoring report – Laurel Mountain Wind Energy Project. Prepared for: AES Laurel Mountain Wind, LLC 95 Turbine View Road Belington, WV 26250.

Tidhar, D., M. Sonnenberg, and D. Young. 2012. Post-construction carcass monitoring study for the Beech Ridge Wind Farm Greenbrier County, West Virginia. Western EcoSystems Technology, Inc. Prepared for: Beech Ridge Wind Farm Beech Ridge Energy, LLC, One South Wacker Drive, Suite 1900 Chicago, IL 60606.

Young, D.P., Jr., K. Bay, S. Nomani, and W.L. Tidhar. 2011. NedPower Mount Storm Wind Energy Facility post-construction avian and bat monitoring: July - October 2010. Prepared for NedPower Mount Storm, LLC, Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, WY.

Young, D.P., Jr., C. Nations, M. Lout and K. Bay. 2013. 2012 post-construction monitoring study, Criterion Wind Project, Garrett County, Maryland: April – November 2012. Prepared for Criterion Power Partners, LLC. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, WY.

Young, D.P., Jr., S. Nomani, Z. Courage, and K. Bay. 2012. NedPower Mount Storm Wind Energy Facility post-construction avian and bat monitoring: July - October 2011. Prepared for NedPower Mount Storm, LLC, Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming.

Method for Calculating Indirect Take for the Covered Species

Table of Contents

List of Tables

TERMINOLOGY USED IN THIS APPENDIX

Direct observed take. This refers to the number of fatalities (carcasses) found during fatality searches of a given species. This number is a known number entered into the model for each project and period.

Direct unobserved take. This represents the number of fatalities that *may* have occurred but that may have been missed or removed without being observed. It is an output of the model and should not be interpreted as the known number of unobserved fatalities that occurred.

Total direct take. The total of direct observed take plus direct unobserved take. The model provides a range of numbers inferred by the 1) number of observed fatalities and, 2) the imperfect detection. Each number in that output range has two associated probabilities; one that represents the probability that that number is the actual direct take, and the second is the probability that the number has not been exceeded.

Indirect take. This represents the *assumed* loss of a dependent young of the fatality.

Total take. This represents the sum total of the total direct take plus the total indirect take. Note that this does not represent the actual known total take. It is a value that the Service is confident has not been exceeded given imperfect detection. This is the value used for measuring compliance. Total take should always be stated as "we are X% confident that X total take has *not* been exceeded.

Credibility or assurance level. In reference to the Evidence of Absence modeling software, this represents the probability that an associated value has not been exceeded. The Service is conservative on the side of the species and uses the model output at the 80% credibility level.

INTRODUCTION

The fatality of an adult of a species during that individuals breeding season could result in the loss of dependent young. This potential loss is called indirect take because the death of the parent indirectly could cause the loss of the dependent young. It is rarely known if a fatality had dependent young at the time of death. For the purposes of indirect take assessment we need to determine the probability that adult fatalities taken during the breeding season period in which young were dependent, had dependent offspring. The criteria used to determine when indirect take should be applied to an adult of a species taken during the breeding season includes the age of the fatality, sex of the fatality, predicted activity during the time of take; number of offspring, and amount of parental contribution provided by the fatality.

Parental contribution differs between species. In the case of the Hawaiian hoary bat or ʻōpeʻapeʻa, indirect take is assessed on the total direct take of females taken during the breeding season using a standardized formula. In the case of Hawaiian goose or Hawaiian petrel, it is assessed for the observed take of female or male during the breeding season because it is assumed that both sexes contribute equally to the rearing of the dependent young. Indirect take is not an output of the model but is calculated separately and added to the total direct take based on the model's output value at the 80% credibility level.

STANDARDIZED CALCULATION OF INDIRECT TAKE FOR HAWAIIAN HOARY BAT

In June 2016, the wildlife agencies discussed the possibility for standardizing the incidental take calculations for Hawaiian hoary bat for projects that have incidental take permits or incidental take licenses. As a result of that discussion we recommended that permittees and their consultants consider using the following time periods and biological factors in their calculation of indirect take for observed Hawaiian hoary bat fatalities and for indirect take of unobserved Hawaiian hoary bats.

Calculation of observed and unobserved take will continue to be conducted with the Evidence of Absence ver 2.0.6+ software (Dalthorp and Huso 2014; Dalthorp et al 2015). The 80% credibility output will be used as a *general* guide for what the agencies are 80% assured has not been exceeded. This output plus the indirect take converted to adult bats will represent total take that we are 80% certain has not been exceeded. This total take at the 80% credibility level will also be used as the value to guide the triggering of the next tier level. The next tier level shall be triggered when 75% of the estimated take of the existing tier is reached or exceeded based on the output at the 80% credibility level plus indirect take.

Female Hawaiian hoary bats may be pregnant or supporting dependent young from April 15 through September 15 (Tomich 1986ab; Menard 2001; Uyehara and Wiles 2009; C. Pinzari, pers. comm. 2015). This is based on best science for the Hawaiian hoary bats or North American hoary bat surrogates and information in our files. The wildlife agencies understand that exceptions to this range can occur. However, the need to be conservative on the side of the species is primary. Second, the use of lactation to determine whether or not a female has dependent pups has been challenging, given the condition of the carcasses that are found. Thus, for these reasons, the Service recommends using April 15 through September 15 as a period in which a female bat taken may have been pregnant or lactating and will result in indirect take assessment on the direct take during this time period. This range would apply to all female observed carcasses. The USGS has been authorized to conduct genetic testing on samples from the fatalities so that the sex of all fatalities found can be determined (Pinzari and Bonaccorso, 2018). The final resting place of the majority of the remains is the Bishop Museum, Honolulu, Hawaiʻi.

The average number of pups attributed to a female that survive to weaning is assumed to be 1.8 which is based on Bogan, 1972 and Koehler and Barclay, 2000. The sex ratio of bats taken through unobserved direct take will be assumed to be 50% female, until the sex can be determined through genetic testing by the USGS. Sex determination based on observation has been shown to under-represent females, so all fatalities are to be sampled and sex determined with DNA testing.

The assessment of indirect take to a modeled unobserved direct bat take accounts for the fact that we do not know 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%, or 0.25.

The conversion of juveniles to adults has generally been 1 juvenile to 0.3 adults, though it has varied slightly from project to project in the past. Because we lack survival and mortality information for the Hawaiian hoary bat, the conversion of juvenile to adult equivalency is based on the estimated survival of the little brown bat (*Myotis lucifugus*) which is known and ranges from 20-48% (Humphrey & Cope 1976). The Service recognizes that this is a less than ideal surrogate for estimating Hawaiian hoary bat survival of a weaned pup to adult, but we have little other scientific evidence to base survival on, until it is established for the Hawaiian hoary bat. Thus, indirect take will be converted from juvenile to adult equivalency uses the 0.3 conversion.

Based on the rationale presented above, the wildlife agencies recommend estimated total take be calculated as follows:

Observed and Unobserved direct take should be calculated with Evidence of Absence ver 2.0.6 or better and the output at 80% credibility used as a basis for calculating indirect take.
Indirect take assessed for females taken between April 15 and September 15 shall be calculated as follows:

> The number of observed female bats taken between April 15 and September 15 x the average number of pups estimated at 1.8
>
> Indirect take assessed for observed males taken at any time or females taken from September 16 through April 14 would be 0.

Indirect take assessed for unobserved take shall be calculated as follows:

> The estimated number of unobserved bats taken x the proportion of unobserved take that is female, which is assumed to be 0.50 (until determined genetically) x the proportion of the calendar year in which a female may be pregnant or have dependent young which is 0.25 x the average number of pups estimated at 1.8.

To convert the indirect (juvenile) take to adults:

> (Total indirect take based on observed take + Total indirect take based on unobserved take) x the conversion of juveniles to adults, 0.30.

Example using the equations above:
Observed take 5 bats. Assume Evidence of Absence output at 80% for the 5 observed bats is 13. This means 8 unobserved bats.
Indirect take
2 of the observed bats were females taken between April 1 and September 15: 2 x 1.8 = 3.6
1 of the observed bats was a female taken between September 16 and March 31: 0
2 of the observed bats were males: 0
We assume 4 of the 8 unobserved bats taken were female: 4 x 0.25 x 1.8 = 1.8
Total indirect take of juveniles 3.6 + 0 + 0 + 1.8 = 5.4
Conversion of juveniles to adults 5.4 x 0.3 = 1.62
Total take based on 80% credibility basis: 13 +1.6 = 14.6 rounded up to 15 bats.

CALCULATING EXPECTED INDIRECT TAKE ON PROJECTIONS OF FUTURE HAWAIIAN HOARY BAT DIRECT TAKE

The formulas described above are used for take tracking and compliance monitoring. The amount of indirect take assessed is based on the number of observed and unobserved carcasses. In other words, we know how many carcasses have been observed and the model provides a range of values for the amount of unobserved take. Calculating the indirect take applicable to a projection of future take is conducted in a slightly different manner because we do not know exactly how many observed take we will have in the future. The general formula used for estimating indirect take on projections uses a value of 0.0675 which is derived from the proportion of direct take assumed to have dependent young * the portion of the future take expected to be female * the number of pups per female * the proportion of pups surviving to adulthood. It is applied as follows:

> (Projected direct take – current total take) * 0.25 (the proportion of direct take assumed to have dependent young) * 0.5 (the proportion of the future take expected to be female) * 1.8 (estimated pups per female) * 0.3 (proportion of pups surviving to adulthood) = indirect take amount estimated for future fatalities.

Slight variations in the calculations occurs between projects depending on the amount of current take and existing indirect take that applies to the observed take. The estimated indirect take each project is shown below (Table E-1). The specific breakdown of each projects' indirect take request is provided for each project in the sections that follow (Tables E-2, E-3, E-4).

Table E-1. Indirect take forecast for Hawaiian hoary bats at the four wind projects.

Project	Projected direct take	Estimated Indirect take
Auwahi	129	11
Kawailoa	246	19
Kaheawa Wind Phase II	36	2
Pakini Nui	23	3

Auwahi Wind

The indirect take estimate for Hawaiian hoary bat on the projected future take is shown in Table E-2. The Table shown is adapted from the Auwahi Wind HCP Amendment (Tetra Tech 2018).

Table E-2. Indirect take estimate for Hawaiian hoary bat, combined with the new estimated future direct take (observed and unobserved) for the Auwahi HCP Amendment.

Component	Calculation of Count	Number of Bats	Calculation of Indirect Take[1]	Indirect Take Assessment
Observed[2] male fatalities, or observed fatalities outside the breeding season	Observed	8	No impact to dependent young, multiply by 0	0
Observed[2] female fatalities within the breeding season	Observed	2	Multiply by estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	1.08
Observed[2] fatalities of unknown sex within the breeding season	Observed	6	Multiply by proportion of population assumed to be female 0.5 * estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	1.62
Unobserved fatalities	38 estimated at 80% CI using EoA[3] minus 16 observed	22	Multiply by proportion of the population assumed to be taken with dependent young 0.25 * proportion of population assumed to be female 0.5 * estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	1.49
Future direct take (unobserved)	129 predicted at the 80% CI using EoA[3] minus 38 current take estimated at the 80% CI	91	Multiply by proportion of the population assumed to be taken with dependent young 0.25 * proportion of population assumed to be female 0.5 * estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	6.14
Future Indirect take	Sum the indirect take assessment for line numbers 1-5, rounded up to the nearest whole number	11	Sum the indirect take assessment for line numbers 1-5, rounded up to the nearest whole number	11
Total take estimated at the 80% CI	Sum the count for line numbers 1-6	**140[5]**		

1. Calculations based on USFWS Wildlife agency guidance for calculation of Hawaiian hoary bat indirect take, unless otherwise noted.
2. Observed take counts only those fatalities observed during systematic monitoring. Carcasses found incidentally are accounted for through Evidence of Absence modelling.
3. Dalthorp et al. 2017.4. Calculations of future indirect take are based on USFWS guidance and actual estimates of indirect take will depend on the timing and gender of observed fatalities
5. The total take estimate includes 21 bats authorized under the approved HCP and 119 additional bats requested in the HCP Amendment.

Kaheawa Wind Phase II

Based on the three observed Hawaiian hoary bat fatalities, the estimated direct take at the 80% credibility level as of June 2018 was 12 bats. Base on the outputs of Evidence of Absence Model ver 2.0.6 (Huso *et al.* 2015, Dalthorp *et al.* 2017) the estimated 20-year (Tier 4) total direct take is no more than 35.2 bats with 80% credibility. The unobserved direct take not yet accrued for the remaining years estimated to be 23.2 bats (35.2 – 12 = 23.2).

Estimating Indirect Take

All three fatalities, two males and one of unknown sex, were documented at KWP II during the non-breeding season (April 1 through September 15) in February, March, and November, therefore, no indirect take (i.e., consideration of potential lost offspring) was assessed for the previously observed fatalities. For the purposes of estimating indirect take for the 20-year permit term the 32.2 of the 35.2 projected estimated direct take for the 20-year permit are considered unobserved direct take (35.2 total estimated direct take – 3 observed to date = 32.2 unobserved take). Indirect take is assessed to bats lost through unobserved direct take at the rate of 0.225 juvenile/bat. Based on these calculations, an indirect take totaling 7.25 juveniles (32.2 x 0.225 = 7.25), is estimated. For purposes of indirect take, juvenile bats are converted to adults based on a 30% survival rate of juvenile to adult. Hawaiian hoary bats are considered mature one year after their birth. This converts the total indirect take of 7.25 juveniles to 2.17 adults.

Adding these 2.17 adults to the estimated total direct take of 35.2 bats, results in an estimated total adjusted take of 37.4 adult bats for the 20-year permit period or 38 adult bats rounded up.

Kawailoa Wind

The indirect take estimate for Hawaiian hoary bat on the projected future take is shown in Table E-3. The Table shown is adapted from the Kawailoa Wind HCP Amendment (Tetra Tech 2018).

Pakini Nui Wind

The indirect take estimate for Hawaiian hoary bat on the projected future take is shown in Table E-4. The Table shown is adapted from the Pakini Nui Wind HCP Amendment (SWCA 2018).

Table E-3. Variables Used for Calculation of Indirect Take for Hawaiian Hoary Bat at Kawailoa Wind.

Component	Calculation of Count	Number of Bats	Calculation[1]	Indirect Take Assessment in Adult Equivalents
Observed males, or individuals outside the breeding season	Observed	19	No impact to dependent young, multiply by 0	0
Observed females within the breeding season	Observed	2	Estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	1.08
Observed unknown within the breeding season	Observed	11	Proportion of population assumed to be female 0.5* estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	2.97
Unobserved estimated by Evidence of Absence	62 estimated at 80% CI estimated by EoA[2] – 32 observed	30	Proportion of the year females are assumed to have dependent young 0.25 * proportion of population assumed to be female 0.5 * estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	2.03
Future take (unobserved)	246 estimated total take at the 80% CI[2]- 62 current take estimated at the 80% CI[2]	184	Proportion of the year females are assumed to have dependent young 0.25 * proportion of population assumed to be female 0.5 * estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	12.42
Indirect take	Sum the indirect take assessment for lines 1-5, rounded up to the nearest whole number	19	Sum the indirect take assessment for Lines 1-5, rounded up to the nearest whole number	19
Total take estimated at the 80% CI	Sum the count for lines 1-6	265		

[1] Calculations based on USFWS guidance for calculation of Hawaiian hoary bat indirect take. The actual estimation of indirect take will depend on the timing and gender of observed fatalities.

[2] Output based on projections of future take from Evidence of Absence (Dalthorp et al. 2017).

Table E-4. Estimation for indirect take of Hawaiian hoary bats at Pakini Nui.

Component	Description/Rationale	Result
A. Total direct take requested	Estimated total direct take	23
B. Proportion of take that is adult	Erring toward a conservative estimate, it is assumed that 100% of take (observed and unobserved) will be adult individuals, despite the opportunity for first-year juveniles to pass through the Project Area.	1.00
C. Proportion of take that is female	Hawaiian hoary bats are assumed to have a ratio of 1:1. Furthermore, it is assumed there is no sex-based bias for differential susceptibility for fatal interaction with turbines. Therefore, approximately 50% of bats are assumed to be females.	0.50
D. Proportion of year that is the pupping period (24 of 52 weeks)	Adults are present in the Project Area throughout the year, but the pupping season is recorded as occurring from April to September 15, or 24 weeks. Indirect take of an offspring can only occur from direct take of an adult during these months.	0.46
E. Proportion of breeding adults taken with dependent young	Juvenile bats are completely dependent on females until they are weaned and therefore their survival depends on the mother bat's ability to provide care. Therefore, all direct take of females with young during the pupping season results in the offspring's indirect take.	1.00
F. Average offspring/breeding pair	Reproductive success is based on Bogan (1972) and Koehler and Barclay (2000)	1.8
G. Conversion of juveniles to adults	Juveniles are converted to adults by multiplying by 0.3, which is in accordance with the *Wildlife agency guidance for calculation of Hawaiian hoary bat indirect take* (USFWS 2016).	0.3
H. Total indirect take	Indirect take is estimated by multiplying the probabilities of lines A–G. This estimate is rounded up to the nearest whole number.	3

STANDARDIZED CALCULATION OF INDIRECT TAKE FOR HAWAIIAN GOOSE

Calculation of observed and unobserved take will continue to be conducted with the Evidence of Absence ver 2.0.6+ software (Dalthorp and Huso 2014; Dalthorp et al 2015). The 80% credibility output will be used as a *general* guide for what the agencies are 80% assured has not been exceeded. This output plus the indirect take converted to adult Hawaiian goose will represent total take that we are 80% certain has not been exceeded. This total take at the 80% credibility level will also be used as the value to guide the triggering of the next tier level. The next tier level shall be triggered when 75% of the estimated take of the existing tier is reached or exceeded based on the output at the 80% credibility level plus indirect take.

Indirect take to account for loss of dependent young is assessed for adult Hawaiian goose only when mortality occurs during the breeding season which is August through April (Table E-5). Adults found during the months of October through March are assumed to have had a 60% chance of having been actively breeding because 60% of the population has been recorded to breed in any given year (Banko *et al.* 1999). Adult Hawaiian goose fatalities that occur in April, August or September are assumed to have had a 25% chance of breeding.

Male and female Hawaiian goose equally contribute to the care for their young (Table E-5). Thus, indirect take is assessed to the direct take of any male or female adult Hawaiian goose found during the breeding season. The number of young possibly affected by loss of an adult is based on the average number of fledglings produced per pair. The average number of fledglings produced annually per pair of Hawaiian goose is 0.3 (Hu 1998).

Based on these assumptions, the amount of indirect take that is assessed for each direct take of an adult Hawaiian goose during the months of October through March is 0.09. The amount of indirect take assessed for each direct take of an adult Hawaiian goose during the remainder of the breeding season is 0.04 (Table E-5).

Table E-5. Calculation of indirect take of Hawaiian goose.

Hawaiian goose	Season	Number of fledglings per pair (A)	Likelihood of breeding (B)	Parental contribution (C)	Indirect (A*B*C)
Adult, any gender	Oct-Mar	0.3	0.6	0.5	0.09
Adult, any gender	Apr, Aug and Sep	0.3	0.25	0.5	0.04
Adult, any gender	May-Jul		0		0
Immature	All year		0		0

CALCULATING EXPECTED INDIRECT TAKE ON PROJECTIONS OF FUTURE HAWAIIAN GOOSE DIRECT TAKE

The formulas described above are used for take tracking and compliance monitoring. The amount of indirect take assessed is based on the number of observed and unobserved carcasses. Calculating the indirect take applicable to a projection of future take is conducted in a slightly different manner because we do not know exactly how many observed take we will have in the future. The general formula used for estimating indirect take on projections uses a value of 0.06. The formula assumes a Hawaiian goose could fly through the project any time of year. Based on breeding period of 4.5 months (a one-month incubation period followed by parental care for 3.5 months) the chance of an unobserved take during breeding is 4.5/12 = 0.375. Thus, 0.375 (proportion of time a nene is breeding)*0.3 (number of fledglings per pair)*0.50 (proportion of parental contribution) = 0.0563, rounded to 0.06. Total take and associated indirect take for Hawaiian goose for Kaheawa Wind and Pakini Nui are shown in Table E-6.

Kaheawa Wind Phase II

As of June 1, 2018, five Hawaiian goose mortalities have been documented within the search area at KWP II. These were observed on April 22, 2014; December 22, 2014; February 23, 2015; October 13, 2015, and February 6, 2018. Indirect take for the five observed take is assessed to be 0.31 fledglings (0.09 + 0.04 + 0.09 + 0.09 + 0.09 = 0.40). Projections based on these findings using the Evidence of Absence Model (versions 1.0 and 2.0; Huso *et al.* 2015, Dalthorp *et al.* 2017) results in a 20-year expected total direct take of not more than 42.3 adults with 80% credibility level. For the purposes of estimating indirect take the projection, we take the projection of 42.3 – 5 observed fatalities that have already occurred = 37.3. Then 37.3 * 0.06 (indirect take rate for unobserved) = 2.24 fledglings. Adding the indirect take of 0.40 fledglings from observed fatalities, the total fledglings indirectly taken is projected to be 2.64 fledglings.

Hawaiian goose mature at age two for males and age three for females and an annual survival rate is estimated to be 80%. One fledgling is thus the equivalent of 0.64 adults (1 * 0.8 * 0.8 = 0.64). Assuming all fledglings mature at age two and an annual survival rate of 80% for two years, 2.64 fledglings would be expected to yield 1.69 adults after two years (2.64* 0.64 = 1.69). The addition of indirect take to the expected total direct take of 42.26 individuals results in a total adjusted take with 80% credibility of no more than 44 adult Hawaiian goose (Table E-6).

Pakini Nui

For purposes of HCP, it is assumed that all birds taken, including unobserved take, will be adults. The direct take requested in 2 adults. Indirect take on unobserved direct take is 2.0 * 0.06 = 0.12 fledglings, rounded up to 1. Total take requested is 3 Hawaiian goose (Table E-6).

Table E-6. Indirect take forecast for Hawaiian goose at the two wind projects.

Project	Projected direct take	Estimated Indirect take
Kaheawa Wind Phase II	42	2
Pakini Nui	2	1

STANDARDIZED CALCULATION OF INDIRECT TAKE FOR HAWAIIAN PETREL

Calculation of observed and unobserved take will continue to be conducted with the Evidence of Absence ver 2.0.6+ software (Dalthorp and Huso 2014; Dalthorp et al 2015). The 80% credibility output will be used as a *general* guide for what the agencies are 80% assured has not been exceeded. This output plus the indirect take converted to adult Hawaiian goose will represent total take that we are 80% certain has not been exceeded. This total take at the 80% credibility level will also be used as the value to guide the triggering of the next tier level. The next tier level shall be triggered when 75% of the estimated take of the existing tier is reached or exceeded based on the output at the 80% credibility level plus indirect take.

The incidental take of a Hawaiian petrel during the breeding season may result in the indirect loss or take of a dependent chick. Several variables are used in the assessment of indirect take (Table E-7). The age of the petrel at the time of fatality is one such consideration. If the petrel is newly fledged, the individuals' fatality is accounted for with direct take, but no indirect take is assessed because it would not have had a dependent egg or offspring. If it is not a fledgling, the petrel is considered adult. No distinction is made as to whether the bird is reproductively mature or not for the purposes of assessing indirect take. Another consideration is the time of year the fatality occurred and what type of activity characterizes that period. March-April is characterized predominantly by prospecting and exploring the colony, May-August 89% of the adults present are considering to be breeding, and the offspring is 100% dependent on both parents, by September only breeding petrels remain, by October the chick is considered dependent on only one parent (Simons and Hodges 1998). The remaining considerations include the likelihood that a given adult is reproductively active, the likelihood that the loss of a reproductively active adult results in the loss of its chick, and the average reproductive success (Table E-7).

Based on the assumptions described in Table E-7, there is an 89% probability that a male or female adult Hawaiian petrel fatality observed between May through August has a dependent chick and therefore is assessed the in direct take of 1, after rounding. There is a 100% chance that a male or female Hawaiian petrel fatality observed in September has a dependent chick and the indirect take assessed is 1. There is a 50% chance that a male or female fatality taken in October has a dependent chick, but the chick would likely be able to survive under the assumptions used to model the indirect take. (Table E-8)

Total take and associated indirect take for Hawaiian petrel at Kawailoa Wind and Pakini Nui are shown in Table E-9. Project specific calculations for Kawailoa Wind are shown in Table E-10. Project specific calculations for Pakini Nui are shown in Table E-11.

Table E-7. Variables used for calculation of indirect take of Hawaiian petrel.

Component	Rationale/Description	Parameter
	The impact of the loss of a single parent on a dependent chick varies within the breeding season (Simons and Hodges 1998).	
Proportion of parental contribution to dependent young	May to September, both parents are deemed critical to chick survival. Necessary for chick survival	1.0
	October, the chick is no longer dependent on both parents (100 percent breeding * 1 chick/pair * 50 percent parental contribution).	0.50
Proportion of breeding adults	May-August, only 89 percent of adults are breeding (89 percent breeding * 1 chick/pair * 100% parental contribution).	0.89
	By September, only reproductively active adults are present on the colony (100 percent breeding * 1 chick/pair * 100 percent parental contribution).	1.00
Reproductive success (average chicks/pair)	Average reproductive success for petrels on Maui (Simons and Hodges 1998).	0.63

Table E-8. Calculations for probability of indirect take of Hawaiian petrel.

Hawaiian petrel	Season	Number of fledglings per pair (A)	Likelihood of breeding (B)	Parental contribution (C)	Indirect (A*B*C)
Adult, any gender	May-Aug	1.0	0.89	1.0	0.89
Adult, any gender	Sep	1.0	1.0	1.0	1.0
Adult, any gender	Oct	1.0	1.0	0.5	0.5
Immature	All year		0		0

Table E-9. Indirect take forecast for Hawaiian petrel at the two wind projects.

Project	Projected direct take	Estimated Indirect take
Kawailoa	19	5
Pakini Nui	2	1

Kawailoa Wind

Calculation of the indirect take associated with the projected direct take of 19 Hawaiian petrels is shown in Table E-8. Indirect take of petrels associated with the projected take is estimated to be 0.95 petrels per year (Table E-8). Thus, over the remainder of the permit term, the total indirect take is calculated as 14 years * 0.34 chicks/year = 5 chicks (4.76 rounded upward) (Table E-10).

Table E-10. Variables for calculation of indirect take for Hawaiian petrel at Kawailoa Wind. Adapted from the Kawailoa draft HCP amendment.

Component	Supporting Evidence or Rationale	Parameter
A. Annual Direct Take (adults/year)	Annual direct take as estimated from Evidence of Absence (19 predicted over 20 years).	0.95
B. Proportion of take that is adult	Conservative assumption that 100 percent of direct take was of adult birds.	1.00
C. Proportion of "year" that is breeding period (6 of 8 months)	Although adult birds may be present at a breeding colony over an 8-month period (March-October), only six of these months (May – October) represent the breeding period (Simons and Hodges 1998).	0.75
D. Proportion of adults that breed	The proportion of adults attending the breeding colony that attempt to breed in a given year (Simons and Hodges 1998).	0.89
E. Proportion of taken breeding adults with dependent young	The impact of the loss of a single parent on a dependent chick varies within the breeding season: • During May to September, both parents are deemed critical to chick survival. • During May-August, only 89 percent of adults are breeding (89 percent breeding * 1 chick/pair * 100% parental contribution). • By September, only reproductively active adults are present on the colony (100 percent breeding * 1 chick/pair * 100 percent parental contribution). • In October, the chick is no longer dependent on both parents (100 percent breeding * 1 chick/pair * 50 percent parental contribution). The proportion of taken breeding adults with dependent young was calculated as: ((0.89*1*1*4 months) + (1.00*1*1*1 month) + (0.5*1*1*1 month))/6 months = 0.84.	0.84
F. Reproductive success (average chicks/pair)	Average reproductive success for petrels on Maui (Simons and Hodges 1998).	0.63
G. Annual Indirect Take (chicks/year)	Multiply Lines A through F.	0.34
H. Total Indirect Take (chicks)	Multiply Line G by 14 years and round up to nearest integer.	5
I. Total take estimated at the 80% confidence interval	Sum of total direct take as estimated from Evidence of Absence (19 adults) and total indirect take from Line H.	**24**

Pakini Nui

The 10-year fatality estimate of Hawaiian petrels at Pakini Nui is between 0.0437 and 0.2187, for 99% and 95% avoidance rates, respectively. Therefore, it is unlikely that a fatality will be detected during 8 years of operation and 2 years of decommissioning. However, to cover for the stochastic event of an incidental take of Hawaiian petrels, and allowing for unobserved direct take, the requested take is based on the direct take of two Hawaiian petrels. The indirect take is one egg/chick; therefore, the total requested take is three Hawaiian petrels. Calculations used are shown in Table E-11.

Table E-11. Calculation of Indirect Take for Hawaiian Petrel at Pakini Nui. Adapted from the Pakini Nui draft HCP.

Hawaiian Petrel	Season	Average No. of Chicks per Pair (A)	Likelihood of Breeding (B)	Parental Contribution (C)	Indirect Take (A × B × C)
Adult	March–April	–	0.00	–	0
Adult	May–July	1	0.89	1.0	0.89 egg
Adult	August	1	0.66	1.0	0.66 chick
Adult	September	1	1.00	1.0	1.00 chick
Adult	October	1	1.00	0.5	0.50 chick
Adult	November–April	–	0.00	–	0
Immature	All year	–	0.00	–	0

LITERATURE CITED

Bogan, B.A. 1972. Observations on parturition and development in the hoary bat, *Lasiurus cinereus*. Journal of Mammalogy 53:611-614.

Dalthorp, D. and Huso, M. 2015. A framework for decision points to trigger adaptive management actions in long-term incidental take permits. U.S. Geological Survey Open-File Report 2015-1227**:**88.

Dalthorp, D., Huso, M., Dail, D., and Kenyon, J. 2014. Evidence of absence software user guide: U.S. Geological Survey Data Series 881, 34 pp. http://dx.doi.org/10.3133/ds881.

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

Humphrey, S. R. and Cope, J.B. 1976. Population ecology of the little brown bat, *Myotis lucifugus*, in Indiana and North-central Kentucky. Special Publication No. 4 of the American Society of Mammalogists. i-vii, 1-81.

Huso, M.S.P., Dalthorp, D. Dail, D. and Madsen, L. 2015. Estimating wind-turbine-caused bird and bat fatality when zero carcasses are observed. Ecological Applications 25:1213-1225.

Koehler, C.E. and Barclay, R.M.R. 2000. Post-natal growth and breeding biology of the hoary bat (*Lasiurus cinereus*). Journal of Mammalogy 81:234-244.

Menard, T. 2001. Activity patterns of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) in relation to reproductive time periods. M.S. Thesis, Ecology, Evolution, and Conservation Biology Program, University of Hawaii, Manoa. 149 pp.

Pinzari, C. 2015. Observation of dependent Hawaiian hoary bat pup September 2-3, 2015 on the island of Hawaii. Email to Dawn Bruns, et al., USFWS and DOFAW personnel, September 3, 2015.

Pinzari, C.A. and F. J. Bonaccorso. 2018. A test of sex specific genetic markers in the Hawaiian hoary bat and relevance to population studies. Technical Report HCSU-085. University of Hawaii, Hilo. Cooperative Studies Unit. 13 pp.

Simons, T.R., and C.N. Hodges. 1998. Dark-rumped Petrel (*Pterodroma phaeopygia*). In The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. Available online at: http:/bna.birds.cornell.edu/bna/species/345.

Tomich, P. Q. 1986. Endangered species information system species workbook. Part I - Species distribution. Unpublished U.S. Fish and Wildlife Service Report. Available at U.S. Fish and Wildlife Service, Ecological Services, Honolulu. 20 pp.

Tomich, P.Q. 1986. Endangered species information system species workbook. Part II – Species biology, Unpublished U.S. Fish and Wildlife Service Report. Available at U.S. Fish and Wildlife Service, Ecological Services, Honolulu. 38 pp.

Uyehara, K. and Wiles, G. 2009. Bats of the U.S. Pacific Islands. U.S.D.A. National Resources Conservation Service. Biology Technical Note 20. 34 pp.

Appendix F

Method for Developing Take Calculations for Alternative 3

Table of Contents

List of Figures

List of Tables

PURPOSE, ASSUMPTIONS, AND METHODOLOGY

This appendix describes the general approach and methodology we use to calculate the number of projected fatalities if the four wind projects were to implement complete shutdown of turbine operation between dusk and dawn from April 15 through September 15 that is presented in Alternative 3 of the PEIS.

Evidence of Absence ver. 2.0.6 was used for the calculations. For a detailed description of the statistical methodologies and basis for using this model, the reader is referred to Evidence of Absence (v2.0) software user guide, U.S. Geological Survey Data Series 1055 (Dalthorp, et al, 2017). The r-based software and user manual are available at https://pubs.er.usgs.gov/publication/ds1055. A general overview of the project-specific factors that are considered and how the model is used in presented in Appendix C.

Projections are based on reported Hawaiian hoary bat fatalities and detection probabilities specific for each project. The detection probability (*g*) for future years are based on a projects most recent *g* value. For a general discussion of how a *g* –value is calculated and the use of a rho value the reader is referred to Appendix C and, for a thorough technical discussion to Dalthorp et al 2017. The period from April 15 to September 15 spans the Hawaiian hoary bat breeding period in which females may be carrying young through the time that pups (offspring) become independent. The vast majority of bat activity occurs between dusk through dawn period.

The effects of implementing turbine shutdown and feathering of blades between dusk and dawn from April 15 through September 15 were analyzed using two different approaches. Turbine shutdown and blade feathering refers to the blades being placed parallel to the wind to minimize rotation and the curtailment of power being produced. [For a general discussion of low wind speed curtailment and synopsis of literature, the reader is referred to Appendix D and to each projects draft HCP amendment or draft HCP.] The projections that resulted from these two approaches were then compared against the projection based on operating during the breeding season. All projections are based on the expected remaining years of project operation. All projections were run at an 80% credibility level (1-α).

The first approach we used assumed uniform occurrence of the bat throughout the year and that the probability of a fatality occurring was equal across all months. Thus, if turbines were not operating between dusk and dawn from April 15 through September 15, a project would not be operating at night for 5 months of the year (5 months/12 months = 0.4167). The remainder of the year (1 - 0.4167 = 0.5833) the project would be operating at night under the project-specific low wind speed curtailment regimes described in alternative 2. In order to model this effect, a rho value was used. Rho represents the assumed relative mortality rate. If there are no changes in operation and no reasons to suspect mortality rates varied systematically from year to year, then rho = 1 each year. Accordingly, a rho value of 0.5833 was used for the remaining years of the project. This directs the model to assume the project would be operating only 58.33% of the time it had previously operated during the nighttime period. Past monitoring and operations data (observed fatalities and detection probabilities) specific for each project were used and the detection probability for the future years was based on the most recent year of a project.

The second approach to projecting the effects of complete nighttime shutdown of turbines and feathering of blades from April 15 through September 15 was based on the proportion of observed take that has occurred between April 15 and September 15 at each project during the years they have been operating. This approach uses the fatality distribution that is specific to the project in case uniform occurrence is not occurring at the project. Past monitoring and operations data (observed fatalities and detection probabilities) were the same used for the Uniform occurrence analysis and are project specific.

A rho-value of 1 was used for the year-round operation projection for each project. This assumes no additional avoidance or minimization actions were implemented beyond those which were already being deployed. The year-round projections do not include associated indirect take. Indirect take is the assumed loss of young associated with the fatality of a female during the breeding season, whether from observed take or from unobserved take. [For a general discussion of observed, unobserved, and indirect take, the reader is referred to Appendix E] There is no associated indirect take for the projections based on nighttime shutdown of the turbines during the breeding season because it is assumed in that there would be no Hawaiian hoary bat fatalities attributable to the project because they would not be operating during the breeding period.

In addition to evaluating projections for shutdown of turbine operation between April 15 and September 15, we also evaluated a shorter shutdown period from June 15 to September 15. This period spans the pupping period when females are most likely tending dependent pups. This 3-month long, dusk to dawn turbine shutdown option would be expected to have less impact on power generation than the five-month nighttime shutdown. A rho value of 0.75 (3/12 = 0.25; 1-0.25 = 0.75) was used for projecting estimated fatalities.

AUWAHI WIND

A detection probability of 0.5187(95% C.I. 0.402 – 0.635) was used for projections. The input for uniform occurrence using a rho of 0.5833 is shown in Figure F-1A. In the case of Auwahi, there were 21 observed fatalities, though only 17 were included in the observed take for the model because four of the fatalities had been found outside of the search area and are accounted for in the modeled unobserved take. Of the 17 fatalities, 9 were observed between April 15 and September 15. Thus, 9/17=0.529 and a resulting rho value for future years would be 1 – 0.529 = 0.471 (Figure F-1B). During the pupping season from June 15 to September 15, there have been 8 observed fatalities. Thus 8/17 = 0.471 and a resulting rho value for future years would be 1 – 0.471 = 0.529.

A. Uniform occurrence

Past monitoring and operations data

Year	ρ	X	Ba	Bb	ĝ	95% CI
2013	1	1	46.7	119.1	0.2817	[0.216, 0.352]
2014	1.083	4	49.68	41.05	0.5476	[0.445, 0.648]
2015	0.917	1	79.43	96.75	0.4508	[0.378, 0.525]
2016	1	7	70.9	58.24	0.549	[0.463, 0.634]
2017	0.17	0	102.4	50.82	0.6683	[0.592, 0.74]
2017b	0.88	3	31.72	30.06	0.5134	[0.39, 0.636]
2018	1	1	35.78	33.2	0.5187	[0.401, 0.635]

Future monitoring and operations parameters

Year	ρ	ĝ	g_lwr	g_upr
1	.5833	0.5187	0.402	0.635
2	.5833	0.5187	0.402	0.635
3	.5833	0.5187	0.402	0.635
4	.5833	0.5187	0.402	0.635
5	.5833	0.5187	0.402	0.635
6	.5833	0.5187	0.402	0.635
7	.5833	0.5187	0.402	0.635
8	.5833	0.5187	0.402	0.635
9	.5833	0.5187	0.402	0.635
10	.5833	0.5187	0.402	0.635
11	.5833	0.5187	0.402	0.635
12	.5833	0.5187	0.402	0.635
13	.5833	0.5187	0.402	0.635
14	.5833	0.5187	0.402	0.635

B. Site-specific

Past monitoring and operations data

Year	ρ	X	Ba	Bb	ĝ	95% CI
2013	1	1	46.7	119.1	0.2817	[0.216, 0.352]
2014	1.083	4	49.68	41.05	0.5476	[0.445, 0.648]
2015	0.917	1	79.43	96.75	0.4508	[0.378, 0.525]
2016	1	7	70.9	58.24	0.549	[0.463, 0.634]
2017	0.17	0	102.4	50.82	0.6683	[0.592, 0.74]
2017b	0.88	3	31.72	30.06	0.5134	[0.39, 0.636]
2018	1	1	35.78	33.2	0.5187	[0.401, 0.635]

Future monitoring and operations parameters

Year	ρ	ĝ	g_lwr	g_upr
1	0.471	0.5187	0.402	0.635
2	0.471	0.5187	0.402	0.635
3	0.471	0.5187	0.402	0.635
4	0.471	0.5187	0.402	0.635
5	0.471	0.5187	0.402	0.635
6	0.471	0.5187	0.402	0.635
7	0.471	0.5187	0.402	0.635
8	0.471	0.5187	0.402	0.635
9	0.471	0.5187	0.402	0.635
10	0.471	0.5187	0.402	0.635
11	0.471	0.5187	0.402	0.635
12	0.471	0.5187	0.402	0.635
13	0.471	0.5187	0.402	0.635
14	0.471	0.5187	0.402	0.635

Figure F-1. Input parameters for Auwahi Wind if turbine operation was shut down between dusk and dawn from April 15 through September 15 based on (A) uniform occurrence of fatalities year-round (rho = 0.5833), or (B) using the site-specific fatality distribution (rho = 0.471).

The projections for operating year-round (Table F-1A and Figure F-2A) and for turbine shutdown between dusk and dawn from April 15 to September 15 (Table F-1B and 2C and Figure F-2B and 2C) show a reduction in fatalities would likely occur. Assuming conditions remained the same for the duration of the project that had been observed in the previous 6 years of operation, the estimated projected take (M*) after a total of 20 years of operation (shown in row 14 under M*) would be about 129 assuming that no additional avoidance and minimizations actions were available (Table F-1A). Under the same assumption of conditions remaining the same, projections using full nighttime shutdown of power production and blade rotation between April 15 and September 15 would be about 93 under uniform occurrence (Table F-1B) and 83 based on project specific data (Table F-1C). Using site specific data had a slightly greater reduction than assuming a uniform occurrence. This is because the amount of observed take has been disproportionately higher at the Auwahi site during the bat breeding season than other times of year. Specifically, about 53% of the take has occurred from June 10 through September. The confidence intervals and increasing uncertainty, illustrated by the grey shaded area, that is associated with projecting urther out in time is shown in Figure F-2ABC. Box and whisker plots provide the confidence intervals for the projections. Blue lines in the figures represent the take request of the project for reference.

Projections using full nighttime shutdown of power production and blade rotation between June 15 and September 15 (rho= 0.750) would be about 107 under uniform occurrence. Projections from site specific data (rho=0.529) would be about 88.

Table F-1. Future fatality projections if Auwahi Wind were to (A) operate year-round and no additional avoidance or minimization measures were implemented, or alernatively, if the turbines were to not operate between dusk and dawn from April 15 through September 15 assuming (B) uniform occurance of fatalities year-round, or (C) using the observed site-specific fatality distribution.

A. Year-round operation as described in Alternative 2.

Yr	Mean		quantiles of M							quantiles of M*						
	M	M*	0.05	0.10	0.25	0.50	0.75	0.90	0.95	0.05	0.10	0.25	0.50	0.75	0.90	0.95
1	41.9	47.5	31	33	37	41	46	51	54	41	43	45	47	49	54	56
2	47.9	53.8	36	38	42	47	53	58	62	45	47	49	53	58	62	66
3	53.9	60.1	40	43	48	53	60	65	69	49	51	55	59	66	70	74
4	60.0	66.5	45	48	53	59	66	73	77	53	55	59	65	72	80	85
5	66.0	72.8	49	52	58	65	73	80	85	55	59	65	72	80	88	95
6	72.0	79.1	53	57	63	71	80	88	93	59	63	69	78	88	97	103
7	78.0	85.4	57	61	68	77	87	96	102	63	67	75	84	94	105	113
8	84.0	91.7	61	66	73	83	93	103	110	67	71	79	90	102	113	121
9	90.0	97.9	65	70	79	89	100	111	118	71	77	85	96	108	123	131
10	96.0	104.2	69	74	83	95	107	119	127	75	81	89	102	116	131	139
11	102.0	110.4	73	79	88	101	114	127	135	79	85	95	108	124	139	149
12	108.0	116.7	77	83	93	107	121	135	144	83	89	99	114	130	147	157
13	114.0	122.9	81	87	98	112	128	143	152	87	93	105	120	138	155	165
14	120.0	129.2	85	92	103	118	135	150	161	91	97	111	128	144	165	175

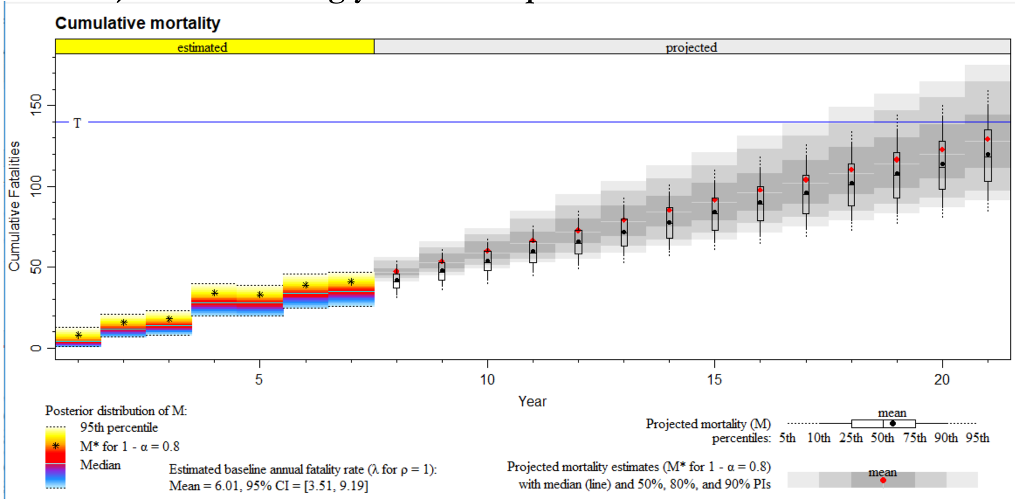
B. Uniform occurrence.

Yr	Mean		quantiles of M							quantiles of M*						
	M	M*	0.05	0.10	0.25	0.50	0.75	0.90	0.95	0.05	0.10	0.25	0.50	0.75	0.90	0.95
1	39.5	44.8	29	31	35	39	44	49	51	41	41	43	45	47	50	50
2	43.0	48.4	32	34	38	42	48	52	56	43	43	45	47	51	54	56
3	46.5	52.2	35	37	41	46	51	57	60	45	45	47	51	56	60	62
4	50.0	55.9	38	40	44	49	55	61	65	47	47	51	55	60	66	68
5	53.5	59.5	40	43	47	53	59	65	69	49	51	53	59	64	70	74
6	57.0	63.2	43	45	50	56	63	69	73	51	53	57	63	70	76	78
7	60.5	66.9	45	48	53	60	67	74	78	53	55	59	65	74	80	85
8	64.0	70.5	48	51	56	63	71	78	83	55	57	63	69	78	86	91
9	67.5	74.2	50	53	59	67	75	82	87	57	61	65	74	82	90	95
10	70.9	77.8	53	56	62	70	79	87	92	59	63	69	78	86	94	101
11	74.5	81.5	55	59	65	73	83	91	97	61	65	71	80	90	101	107
12	77.9	85.1	57	61	68	77	87	96	102	63	67	75	84	94	104	111
13	81.4	88.8	60	64	71	80	91	100	107	67	71	77	88	98	108	117
14	85.0	92.6	62	66	74	84	95	105	112	69	73	81	92	102	115	123

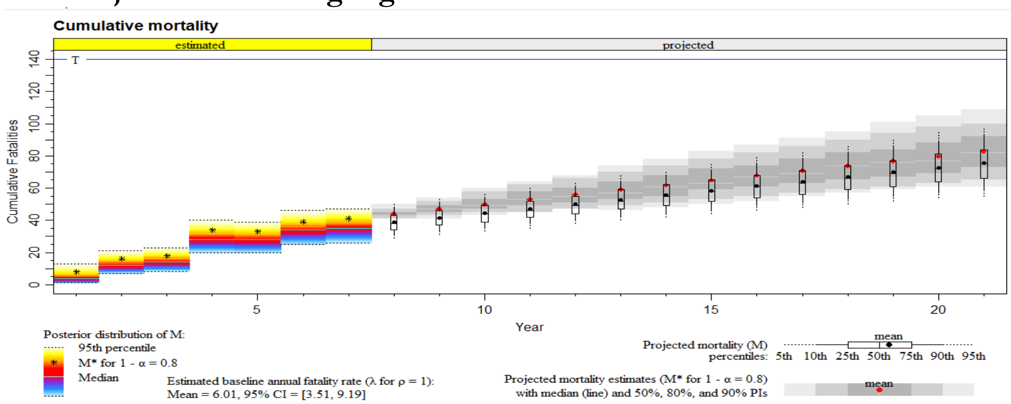
C. Site-specific fatality occurrence data.

Yr	Mean		quantiles of M							quantiles of M*						
	M	M*	0.05	0.10	0.25	0.50	0.75	0.90	0.95	0.05	0.10	0.25	0.50	0.75	0.90	0.95
1	38.7	44.0	29	31	34	38	43	48	51	41	41	43	43	45	47	50
2	41.5	47.1	31	33	37	41	46	51	54	41	43	45	47	49	52	54
3	44.3	50.0	33	35	39	44	49	54	57	43	45	47	49	53	58	60
4	47.1	53.0	35	38	42	46	52	58	61	45	45	49	53	58	62	64
5	50.0	56.0	38	40	44	49	55	61	64	47	47	51	55	60	66	68
6	52.8	59.0	40	42	47	52	59	64	68	46	49	53	57	64	70	74
7	55.6	61.9	42	44	49	55	62	68	71	48	51	55	61	68	74	78
8	58.5	64.9	44	46	52	58	65	71	75	50	53	59	63	72	78	83
9	61.3	67.9	46	49	54	61	68	75	79	52	55	61	67	74	82	87
10	64.1	70.8	48	51	56	63	71	78	83	55	57	63	69	78	86	91
11	66.9	73.9	50	53	59	66	74	82	87	57	59	65	74	82	90	95
12	69.8	76.8	52	55	61	69	77	86	91	59	61	67	76	84	94	101
13	72.6	79.7	54	57	64	72	81	89	95	61	63	69	77	88	98	105
14	75.4	82.6	55	59	66	75	84	93	98	61	65	73	82	92	100	109

A. Projection assuming year-round operations.



B. Projection assuming nighttime shutdown and uniform occurrence.



C. Projection assuming nighttime shutdown using site-specific data.

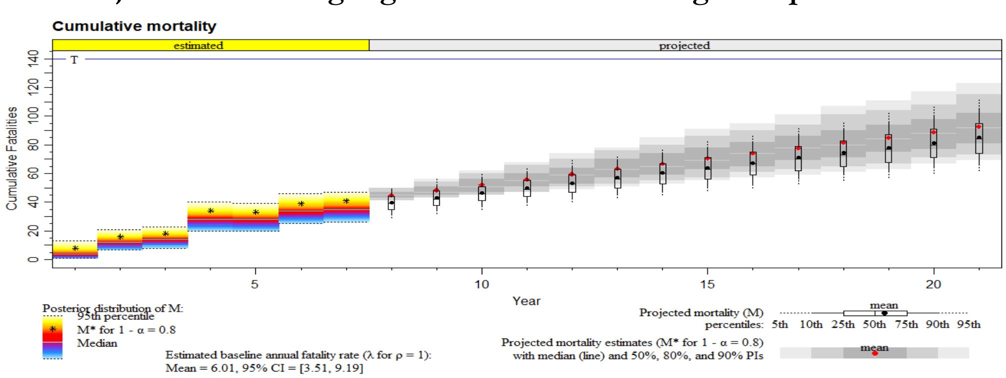


Figure F-2. Graphic depictions of the projected take at Auwahi Wind farm using the past 6 years of site-specific data based on (A) year-round operations with no additional avoidance and minimization measures being deployed in the future beyond what is already being implemented; or complete shutdown of turbines between dusk and dawn from April 15 to September 15 using (B) uniform occurrence of fatalities year-round, or (C) site-specific, fatality distributions.

KAHEAWA WIND PHASE II

A detection probability of 0.349 (95% C.I. 0.244 – 0.462) was used for projections. Kaheawa Wind Phase II, has observed three Hawaiian hoary bat fatalities in six years of operation. None of the reported bat fatalities were observed between April 15 and September 15. Because of this, only the uniform occurrence using a rho = 0.5833 was used for comparison against year-round operation. Input for uniform occurrence is shown in Figure F-3.

A. Uniform occurrence

Past monitoring and operations data

Year	ρ	X	Ba	Bb	ĝ	95% CI
2012-2013	1	1	9.08	11.41	0.4431	[0.241, 0.656]
2013-2014	1	2	18.5	33.02	0.3591	[0.235, 0.493]
2014-2015	1	0	10.95	21.68	0.3356	[0.187, 0.503]
2015-2016	1	0	35.09	61.84	0.362	[0.27, 0.46]
2016-2017	1	0	87.96	111.1	0.4419	[0.374, 0.511]
2017-2018	1	0	41.223	68.772	0.3748	[0.287, 0.467]

Future monitoring and operations parameters

Year	ρ	ĝ	g_lwr	g_upr
1	0.5833	0.3748	0.287	0.467
2	0.5833	0.3748	0.287	0.467
3	0.5833	0.3748	0.287	0.467
4	0.5833	0.3748	0.287	0.467
5	0.5833	0.3748	0.287	0.467
6	0.5833	0.3748	0.287	0.467
7	0.5833	0.3748	0.287	0.467
8	0.5833	0.3748	0.287	0.467
9	0.5833	0.3748	0.287	0.467
10	0.5833	0.3748	0.287	0.467
11	0.5833	0.3748	0.287	0.467
12	0.5833	0.3748	0.287	0.467
13	0.5833	0.3748	0.287	0.467
14	0.5833	0.3748	0.287	0.467

Figure F-3. Input parameters for Kaheawa Wind Phase II if turbine operation was completely shut down between dusk and dawn from April 15 through September 15 based on uniform occurrence (rho = 0.5833) of fatalities year-round.

The projections for operating year round (Table F-2A and Figure F-4A) and for full nighttime shutdown during the breeding season (Figure F-2B and Figure F-4B) show a reduction in fatalities would likely occur under modelled conditions. Because the model assumes that take is occurring year-round at the site, the nightime shutdown from April 15 to September 15 is projected to have an effect on take. Assuming conditions remained the same for the duration of the project that have been observed in the previous 6 years of operation, the estimated projected take (M*) after 20 years of operation (shown in row 14 under M*) would be about 36 assuming that no additional avoidance and minimizations actions were available (Table F-2A). Under the same assumption of conditions remaining the same, projections using full nighttime shutdown of power production and blade rotation bewteen April 15 and September 15 would be about 26 assuming uniform occurrence of fatalities throughout the year in the future. The confidence intervals and increasing uncertainty, illustrated by the grey shaded area, that are associated with projecting further out in time, are shown in Figure F-4. Box and whisker plots provide the confidence intervals for the projections. Blue lines in the figures represent the take request of the project for reference.

Table F-2. Future fatality projections if Kaheawa Wind Phase II were to (A) operate year-round and no additional avoidance or minimization measures were implemented, or alternatively, if (B) the turbines were to not operate between dusk and dawn from April 15 through September 15 assuming uniform occurrence of fatalities throughout the year.

A. Year-round operation as described in Alternative 2.

Summary statistics for projection years

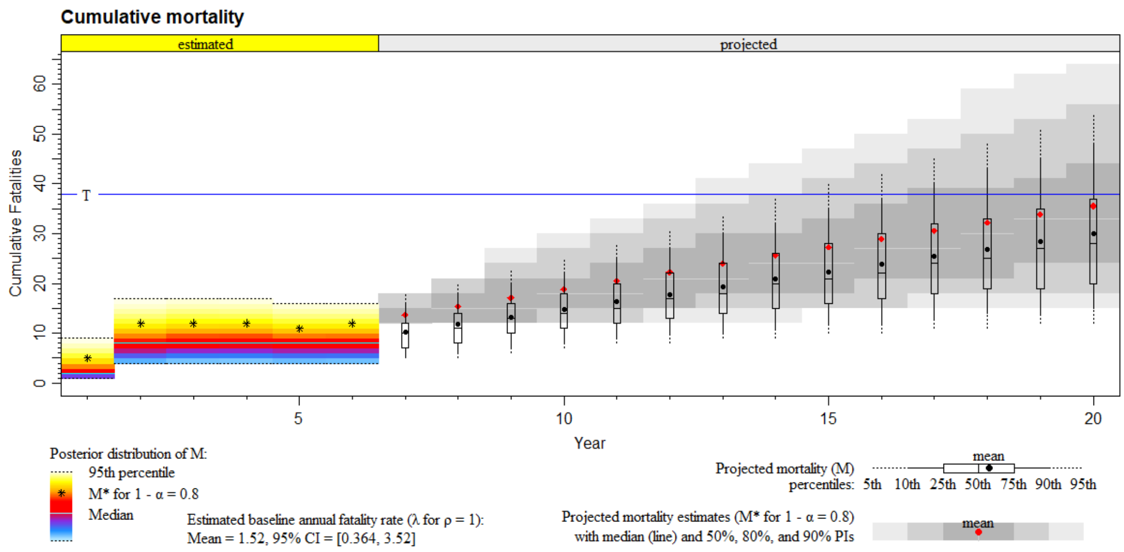
Yr	Mean M	M*	quantiles of M 0.05	0.10	0.25	0.50	0.75	0.90	0.95	quantiles of M* 0.05	0.10	0.25	0.50	0.75	0.90	0.95
1	10.2	13.7	5	5	7	10	12	16	18	12	12	12	12	15	18	18
2	11.7	15.4	5	6	8	11	14	18	20	12	12	12	15	18	21	21
3	13.2	17.1	6	7	10	13	16	20	23	12	12	12	15	21	24	27
4	14.8	18.8	7	8	11	14	18	22	25	12	12	15	18	21	27	30
5	16.3	20.5	8	9	12	15	20	25	28	12	12	15	18	24	30	33
6	17.8	22.2	8	10	13	17	22	27	31	12	15	15	21	27	33	36
7	19.3	23.9	9	10	14	18	24	30	34	12	15	18	21	30	36	41
8	20.9	25.6	9	11	15	20	26	32	37	12	15	18	24	30	38	44
9	22.4	27.3	10	12	16	21	28	35	40	15	15	18	24	33	41	47
10	23.9	28.9	10	12	17	22	30	37	42	15	15	21	27	36	44	50
11	25.4	30.6	11	13	18	24	32	40	45	15	18	21	27	39	47	53
12	26.9	32.2	11	14	19	25	33	43	48	15	18	21	30	39	50	59
13	28.4	33.9	12	14	19	27	35	45	51	15	18	24	33	41	53	62
14	30.0	35.5	12	15	20	28	37	48	54	15	18	24	33	44	56	64

B. Uniform occurrence.

Summary statistics for projection years

Yr	Mean M	M*	quantiles of M 0.05	0.10	0.25	0.50	0.75	0.90	0.95	quantiles of M* 0.05	0.10	0.25	0.50	0.75	0.90	0.95
1	9.5	13.0	4	5	7	9	12	15	17	12	12	12	12	15	15	18
2	10.4	14.0	5	6	7	10	13	16	18	12	12	12	12	15	18	18
3	11.3	15.0	5	6	8	11	14	17	20	12	12	12	15	18	21	21
4	12.2	16.0	6	7	9	12	15	18	21	12	12	12	15	18	21	24
5	13.1	16.9	6	7	9	12	16	20	22	12	12	12	15	18	24	27
6	14.0	17.9	7	8	10	13	17	21	24	12	12	15	18	21	24	27
7	14.9	18.9	7	8	11	14	18	23	25	12	12	15	18	21	27	30
8	15.8	19.9	7	9	11	15	19	24	27	12	12	15	18	24	30	33
9	16.6	20.9	8	9	12	16	20	25	28	12	12	15	21	24	30	35
10	17.5	21.8	8	10	13	17	21	27	30	12	12	15	21	27	33	35
11	18.4	22.9	8	10	13	17	23	28	32	12	15	18	21	27	33	38
12	19.3	23.9	9	10	14	18	24	30	33	12	15	18	21	27	36	41
13	20.2	24.8	9	11	14	19	25	31	35	12	15	18	24	30	36	41
14	21.1	25.8	10	11	15	20	26	32	37	12	15	18	24	30	38	44

A. Projection assuming year-round operations.



B. Projection assuming nighttime shutdown and uniform occurrence.

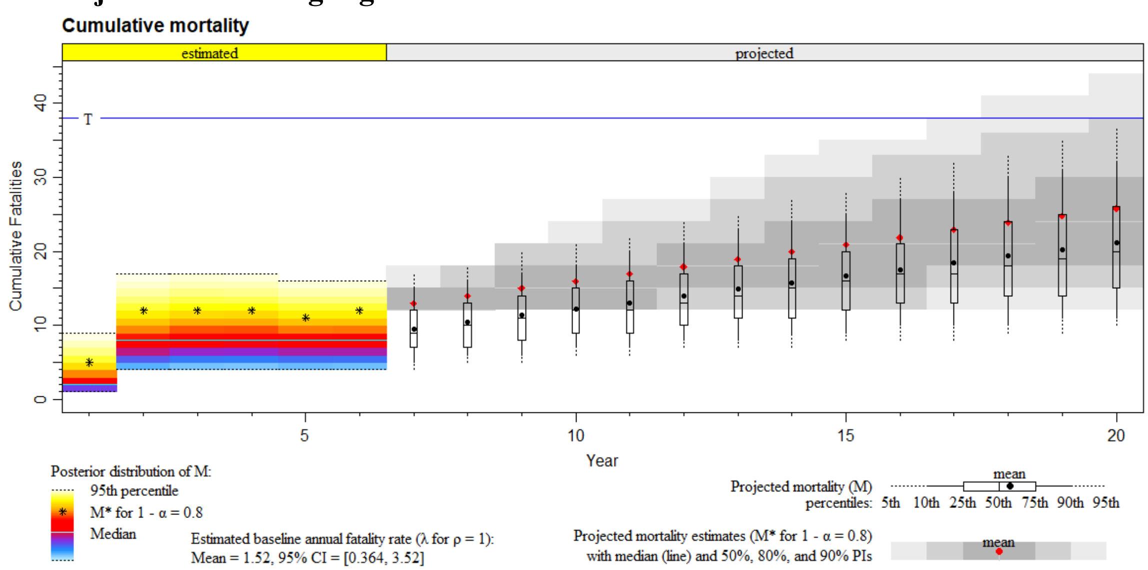


Figure F-4. Graphic depictions of the projected take at Kaheawa Wind Phase II farm using the past 6 years of site-specific data based on (A) year-round operations with no additional avoidance and minimization measures being deployed in the future beyond what is already being implemented; or (B) complete shutdown of turbine operation between dusk and dawn from April 15 to September 15 using uniform occurrence of fatalities year-round.

KAWAILOA WIND

A detection probability of 0.360 (95% C.I. 0.333 – 0.423) was used for projections. The input for uniform occurrence using a rho of 0.5833 is shown in Figure F-5A. In the case of Kawailoa Wind there were 39 observed fatalities, though only 37 were included in the observed take for the model because two of the fatalities had been found outside of the search area and are accounted for in the modeled unobserved take. Of the 37 fatalities, 24 were observed during the breeding season. Thus, 24/37=0.649 and a resulting rho value for future years would be 1 – 0.529 = 0.351 (Figure F-5B). During the pupping season from June 15 to September 15, there have been 21 observed fatalities. Thus 21/37 = 0.568 and a resulting rho value for future years would be 1 – 0.471 = 0.432.

A. Uniform

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	0.33	3	96.09	20.24	0.826	[0.752, 0.889]
2016	0.67	1	794.4	1082	0.4234	[0.401, 0.446]
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	4	166.8	274.8	0.3777	[0.333, 0.423]

Future monitoring and operations parameters

Year	ρ	ĝ	g_lwr	g_upr
1	.5833	0.3777	0.333	0.423
2	.5833	0.3777	0.333	0.423
3	.5833	0.3777	0.333	0.423
4	.5833	0.3777	0.333	0.423
5	.5833	0.3777	0.333	0.423
6	.5833	0.3777	0.333	0.423
7	.5833	0.3777	0.333	0.423
8	.5833	0.3777	0.333	0.423
9	.5833	0.3777	0.333	0.423
10	.5833	0.3777	0.333	0.423
11	.5833	0.3777	0.333	0.423
12	.5833	0.3777	0.333	0.423
13	.5833	0.3777	0.333	0.423

B. Site-specific

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	0.33	3	96.09	20.24	0.826	[0.752, 0.889]
2016	0.67	1	794.4	1082	0.4234	[0.401, 0.446]
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	4	166.8	274.8	0.3777	[0.333, 0.423]

Future monitoring and operations parameters

Year	ρ	ĝ	g_lwr	g_upr
1	.351	0.3777	0.333	0.423
2	.351	0.3777	0.333	0.423
3	.351	0.3777	0.333	0.423
4	.351	0.3777	0.333	0.423
5	.351	0.3777	0.333	0.423
6	.351	0.3777	0.333	0.423
7	.351	0.3777	0.333	0.423
8	.351	0.3777	0.333	0.423
9	.351	0.3777	0.333	0.423
10	.351	0.3777	0.333	0.423
11	.351	0.3777	0.333	0.423
12	.351	0.3777	0.333	0.423
13	.351	0.3777	0.333	0.423

Figure F-5. Input parameters for Kawailoa Wind if turbine operation was shut down between dusk and dawn from April 15 through September 15 based on (A) uniform occurrence (rho = 0.5833) of fatalities year-round, or (B) using the site-specific fatality distribution (rho = 0.351).

The projections for operating year round (Table F-3A and Figure F-6A) and for complete nighttime shutdown of the turbines during the breeding season show a reduction in fatalities would likely occur (Table F-3B and 3C and Figure F-6B and 6C). Assuming conditions remained the same for the duration of the project that had been observed in the previous 7 years of operation, the estimated projected take (M*) after 20 years of operation (shown in row 14 under M*) would be about 224 assuming that no additional avoidance and minimizations actions were implemented (Table F-3A). Under the same assumption of conditions remaining the same, projections using full nighttime shutdown of power production and blade rotation between April 15 and September 15 would be about 164 under uniform occurrence (Table F-3B) and 130 based on project specific data (Table F-3C). Using site specific data had a greater reduction than assuming a uniform occurrence. This is because the amount of observed take has been disproportionately higher at the Kawailoa Wind site during the breeding season than other times. Specifically, about 65% of the take has occurred from May through September. The confidence intervals and increasing uncertainty, illustrated by the grey shaded area, that is associated with projecting further out in time is shown in Figure F-6ABC. Box and whisker plots provide the confidence intervals for the projections. Blue lines in the figures represent the take request of the project for reference.

Projections using full nighttime shutdown of power production and blade rotation between June 15 and September 15 (rho= 0.750) would be about 188 under uniform occurrence. Projections from site specific data (rho=0.432) would be about 140.

Table F-3. Future fatality projections if Kawailoa Wind were to (A) operate year-round and no additional avoidance or minimization measures were implemented, or alternatively, if the turbines were to not operate between dusk and dawn from April 15 through September 15 based on (B) uniform occurrence of fatalities year-round, or (C) using the observed site-specific fatality distribution.

A. Year-round operation as described in Alternative 2.

Summary statistics for projection years

Yr	Mean M	M*	quantiles of M 0.05	0.10	0.25	0.50	0.75	0.90	0.95	quantiles of M* 0.05	0.10	0.25	0.50	0.75	0.90	0.95
1	81.6	89.0	68	70	75	81	87	93	97	83	83	85	89	91	95	97
2	92.3	100.4	77	80	85	92	99	105	109	90	92	96	100	105	109	113
3	103.1	111.9	85	89	95	103	110	118	122	99	101	105	112	118	123	127
4	113.8	123.2	94	98	105	113	122	130	136	107	110	116	123	130	136	143
5	124.5	134.5	102	107	115	124	133	143	149	116	118	125	134	143	150	157
6	135.2	145.8	110	116	124	135	145	155	162	125	127	136	145	154	164	170
7	145.8	157.0	119	125	134	145	157	168	175	131	136	145	156	168	177	184
8	156.5	168.2	127	133	143	156	169	181	189	139	146	156	168	179	191	200
9	167.2	179.4	136	142	153	166	180	194	202	148	155	164	179	193	205	214
10	177.9	190.6	144	151	163	177	192	207	216	156	164	175	190	204	218	228
11	188.6	201.9	152	160	172	187	204	219	230	165	172	186	201	218	232	244
12	199.3	213.0	161	168	181	198	216	232	243	173	180	195	212	229	245	257
13	210.1	224.2	169	177	191	209	227	245	256	182	191	206	223	242	259	271

B. Uniform occurrence.

Summary statistics for projection years

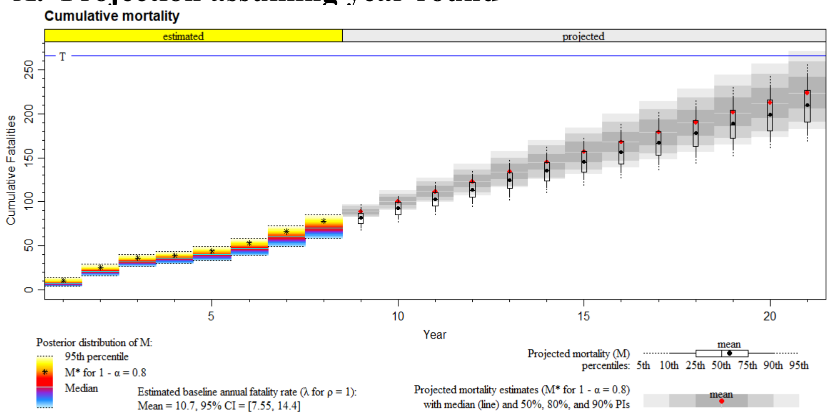
Yr	Mean M	M*	quantiles of M 0.05	0.10	0.25	0.50	0.75	0.90	0.95	quantiles of M* 0.05	0.10	0.25	0.50	0.75	0.90	0.95
1	77.3	84.8	64	66	71	77	83	89	92	80	80	82	84	86	90	90
2	83.5	91.1	69	72	77	83	89	96	99	83	85	87	90	94	98	100
3	89.7	97.6	74	77	83	89	96	103	106	89	89	93	98	102	106	108
4	96.0	104.2	79	83	89	95	103	110	114	93	95	99	103	110	114	116
5	102.2	110.9	85	88	94	102	109	117	121	98	101	105	109	116	122	127
6	108.4	117.4	90	93	100	108	116	124	129	102	106	111	117	124	130	135
7	114.6	124.0	95	98	106	114	123	131	136	107	110	116	123	132	139	143
8	120.9	130.7	100	104	112	120	130	139	144	113	115	122	129	138	147	151
9	127.2	137.3	105	109	117	127	137	146	152	116	121	128	137	146	155	159
10	133.5	143.8	109	114	123	133	144	153	159	122	127	133	143	154	163	168
11	139.7	150.4	114	119	129	139	150	161	167	128	132	139	148	160	171	176
12	145.9	157.0	119	125	134	145	157	168	175	133	138	145	156	168	179	184
13	152.2	163.5	124	130	140	151	164	176	183	136	141	150	162	174	185	195

C. Site-specific fatality occurrence data.

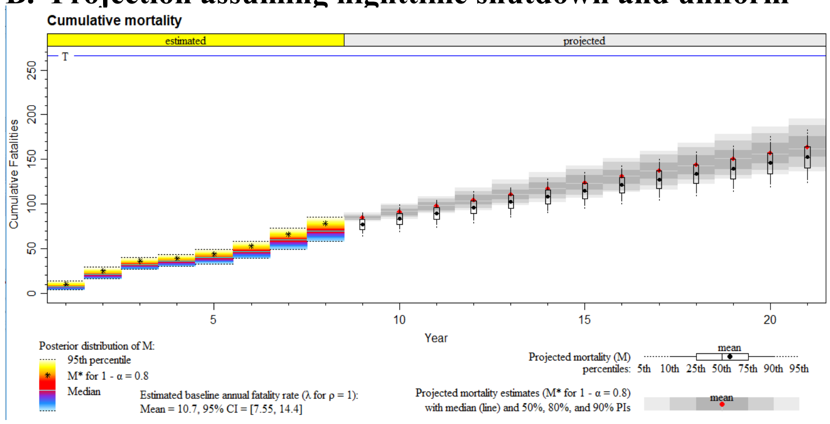
Summary statistics for projection years

Yr	Mean M	M*	quantiles of M 0.05	0.10	0.25	0.50	0.75	0.90	0.95	quantiles of M* 0.05	0.10	0.25	0.50	0.75	0.90	0.95
1	74.6	81.9	61	64	69	74	80	86	89	79	79	81	81	83	85	87
2	78.4	85.7	65	67	72	78	84	90	93	80	82	84	86	88	90	92
3	82.1	89.6	68	71	76	82	88	94	98	83	85	87	89	93	95	97
4	85.9	93.8	71	74	79	86	92	98	102	86	88	90	92	97	101	103
5	89.6	97.8	74	77	83	89	96	102	106	89	91	93	98	102	106	108
6	93.4	101.7	78	81	86	93	100	107	111	92	94	96	101	107	111	113
7	97.2	105.8	81	84	90	97	104	111	115	95	97	99	106	110	117	119
8	100.9	109.8	84	87	93	101	108	115	120	96	100	105	109	115	120	124
9	104.7	113.8	87	90	97	104	112	119	124	99	103	108	114	119	125	129
10	108.5	117.8	90	94	100	108	116	124	129	102	106	111	117	124	130	135
11	112.2	121.8	93	97	104	112	120	128	133	105	109	114	120	129	136	140
12	116.0	125.8	96	100	107	116	124	133	138	108	112	119	126	132	141	146
13	119.8	129.8	99	103	111	119	128	137	143	111	115	122	129	138	144	149

A. Projection assuming year-round



B. Projection assuming nighttime shutdown and uniform



C. Projection assuming nighttime shutdown using site-specific

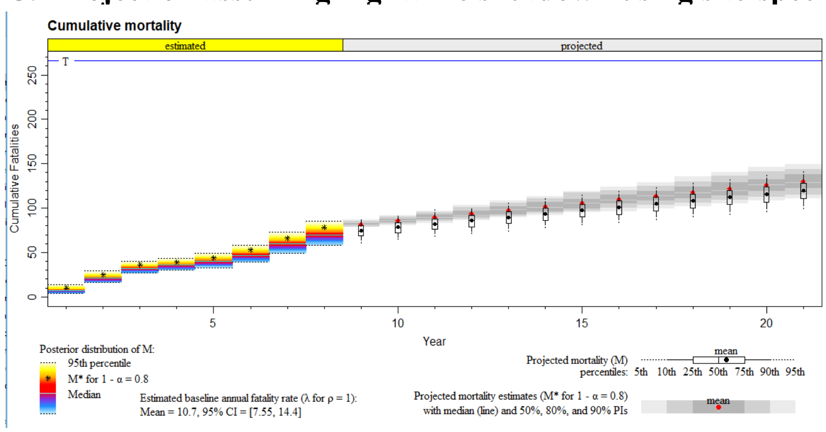


Figure F-6. Graphic depictions of the projected take at Kawailoa Wind farm using the past 6 years of site-specific data based on (A) year-round operations with no additional avoidance and minimization measures being deployed in the future beyond what is already being implemented; or complete shutdown of turbine operation between dusk and dawn from April 15 to September 15 using (B) uniform occurrence, or (C) site-specific, fatality distributions.

PAKINI NUI

This project has limited standardized monitoring from which to estimate the impacts of nighttime shutdown of turbine operation at the project during the breeding period. Years 2007-2013, from which there was no monitoring data available, were not included for the purposes of this analysis. Monitoring since 2013 has shown high variability with detection probabilities varying from 0.038 (95% C.I. 0.0135, 0.0733) to 0.326 (95% C.I. 0.229, 0.431). Three bat fatalities have been reported. The third bat fatality was reported in August 2018. No detection probabilities have been provided for the period covering that fatality. In the absence of that information, the Service used the detection probability from the projects' previous year as surrogate because the project is reportedly using canine searches. The use of a proxy detection probability is only done for the purpose of modelling and comparing potential effects of nighttime shutdown and does not imply that numerical value is the recognized regulatory detection probability that would be used for tracking fatalities at this project. A detection probability of 0.223 (95% C.I. 0.134, 0.326) was used for 2018 and future-year projections. Using the previous years' detection probability for future year projections is consistent with the approach and analyses of this appendix. The input for uniform occurrence using a rho of 0.5833 is shown in Figure F-7A. There have been three reported Hawaiian hoary bat fatalities associated with the operation of Pakini Nui. Of these observed fatalities, one was reported between April 15 and September 15. Thus, 1/3=0.333 and a resulting rho value for future years if nighttime shutdown was implemented between April 15 and September 15 would be 1 – 0.333 = 0.667 (Figure F-7B).

A. Uniform occurrence

Past monitoring and operations data

Year	ρ	X	Ba	Bb	ĝ	95% CI
2013-2014	1	1	39.47	126.7	0.2375	[0.176, 0.305]
2014-2015	1	0	26.5	54.82	0.3259	[0.229, 0.431]
2015-2016	1	1	9.55	34.29	0.2178	[0.11, 0.35]
2016-2017	1	0	5.661	144.6	0.03767	[0.0135, 0.0733]
2017-2018	0.27	0	1.592	33.28	0.04565	[0.00384, 0.134]
2017-2018	0.73	0	15.74	54.85	0.223	[0.134, 0.326]
2018-2019	1	1	15.74	54.85	0.223	[0.134, 0.326]

Future monitoring and operations parameters

Year	ρ	ĝ	g_lwr	g_upr
1	.5883	0.223	0.134	0.326
2	.5883	0.223	0.134	0.326
3	.5883	0.223	0.134	0.326
4	.5883	0.223	0.134	0.326
5	.5883	0.223	0.134	0.326
6	.5883	0.223	0.134	0.326
7	.5883	0.223	0.134	0.326

B. Site-specific

Past monitoring and operations data

Year	ρ	X	Ba	Bb	ĝ	95% CI
2013-2014	1	1	39.47	126.7	0.2375	[0.176, 0.305]
2014-2015	1	0	26.5	54.82	0.3259	[0.229, 0.431]
2015-2016	1	1	9.55	34.29	0.2178	[0.11, 0.35]
2016-2017	1	0	5.661	144.6	0.03767	[0.0135, 0.0733]
2017-2018	0.27	0	1.592	33.28	0.04565	[0.00384, 0.134]
2017-2018	0.73	0	15.74	54.85	0.223	[0.134, 0.326]
2018-2019	1	1	15.74	54.85	0.223	[0.134, 0.326]

Future monitoring and operations parameters

Year	ρ	ĝ	g_lwr	g_upr
1	.667	0.223	0.134	0.326
2	.667	0.223	0.134	0.326
3	.667	0.223	0.134	0.326
4	.667	0.223	0.134	0.326
5	.667	0.223	0.134	0.326
6	.667	0.223	0.134	0.326
7	.667	0.223	0.134	0.326

Figure F-7. Input parameters for Pakini Nui Wind if turbine operation was completely shut down between dusk and dawn from April 15 through September 15 based on (A) uniform occurrence (rho = 0.5833) of fatalities during the year, or (B) the site-specific fatality distribution (rho = 0.667).

The projections for operating year-round (Table F-4A and Figure F-8A) and for the turbines not operating between dusk and dawn from April 15 to September 15 (Table F-4B and Figure F-8B and Table F-4C and Figure F-8C) show a reduction in fatalities would likely occur if turbines were not operating nightly from April 15 to September 15.

Assuming the conditions observed in the previous 5.5 years of operation that have had periods of standardized monitoring remained the same, the estimated projected take (M*) after another 7.5 years of operation (shown in row 14 under M*) would be about 47 assuming that no additional avoidance and minimizations actions were available (Table F-4A). Under the same assumption of conditions remaining the same, projections using dusk to dawn shutdown of power production and blade rotation bewteen April 15 and September 15 would be about 37 under uniform occurrence (Table F-4 and Figure F-8B) and 39 based on project specific data (Table F-4 and Figure F-8C). Using site specific data shows less reduction than assuming a uniform occurrence because only three fatalities have been reported and only one of those fatalities occurred between April 15 and September 15. The confidence intervals and increasing uncertainty, illustrated by the grey shaded area, that is associated with projecting further out in time is shown in Figure F-6ABC. The uncertainty is large for this project because of the high variability in detection probabity and observed fatalities. Box and whisker plots provide the confidence intervals for the projections. Blue lines in the figures represent the take request of the project for reference.

The projections shown for this project in this appendix exceed the requested take. The Service does not retroactively permit unauthorized take and thus, if a permit were to be issued for Pakini Nui, the permit would only authorize the amount of take associated with the remaining years of project operation covered under the permit. Unauthorized take and restitution is a law enforcement issue beyond the scope of this document. Adjusting for that unauthorized take included in the projections that may have occurred beteen 2013 and 2019, when a permit would be issued if approved, would be 47 – 23 = 24 plue indirect take of 3 = 26. The projected take of 26 for Alternative 2 includes direct and indirect take. Applying the same adjustment to the projection for Alternative 3 assuming uniform arrival would result in 37 -23 = 14 and the site specific-arrival would be 39-23 = 16. The adjusted projects for alternative 3 would not include indirect take.

Table F-4. Future fatality projections if Pakini Nui were to (A) operate year-round and no additional avoidance or minimization measures were implemented, or alternatively, if the turines were to not operate between dusk and dawn from April 15 through September 15 based on (B) uniform occurrence of fatalities year-round, or (C) using the observed site-specific fatality distribution.

A. Year-round operation as described in Alternative 2.

Summary statistics for projection years

Yr	Mean M	M*	quantiles of M 0.05	0.10	0.25	0.50	0.75	0.90	0.95	quantiles of M* 0.05	0.10	0.25	0.50	0.75	0.90	0.95
1	19.7	26.9	8	10	13	18	25	32	37	23	23	23	23	29	35	35
2	22.6	30.1	10	12	16	21	28	35	40	23	23	23	28	34	40	45
3	25.5	33.3	12	14	18	24	31	39	44	22	22	28	34	39	45	50
4	28.4	36.9	13	15	20	27	35	43	49	22	22	28	34	45	55	61
5	31.3	40.1	14	17	22	30	38	47	54	22	22	28	39	50	60	66
6	34.2	43.5	16	19	25	32	42	52	59	22	28	33	39	49	65	76
7	37.1	46.7	17	20	27	35	46	57	64	22	27	33	44	55	70	81

B. Uniform

Summary statistics for projection years

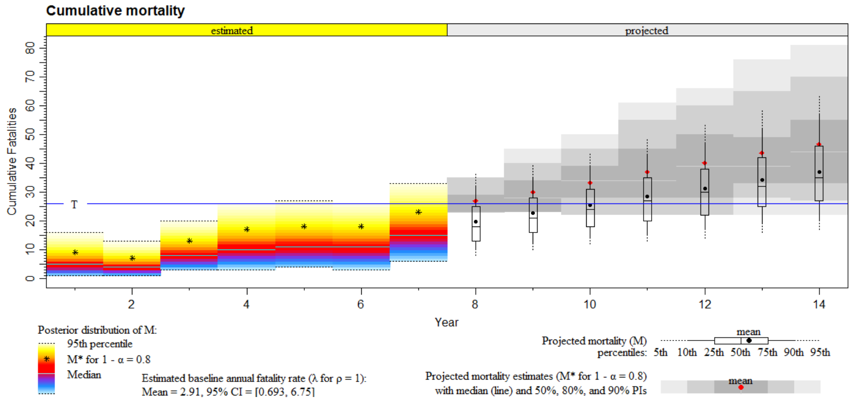
Yr	Mean M	M*	quantiles of M 0.05	0.10	0.25	0.50	0.75	0.90	0.95	quantiles of M* 0.05	0.10	0.25	0.50	0.75	0.90	0.95
1	18.8	25.3	8	9	13	17	23	30	35	23	23	23	23	29	29	35
2	20.5	27.4	9	10	14	19	25	32	37	23	23	23	23	29	34	40
3	22.2	29.2	10	12	16	21	27	34	40	23	23	23	28	34	40	45
4	23.9	31.0	11	13	17	23	29	37	42	22	22	22	28	34	45	45
5	25.6	33.1	11	14	18	24	31	39	44	22	22	28	34	39	45	50
6	27.4	35.2	12	15	20	26	33	42	47	22	22	28	34	39	50	56
7	29.1	37.0	13	16	21	28	36	44	50	22	22	28	33	44	55	61

C. Site-specific fatality occurrence

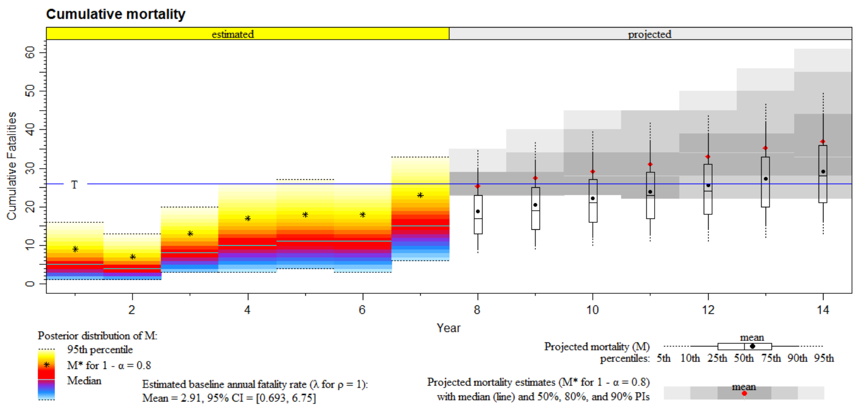
Summary statistics for projection years

Yr	Mean M	M*	quantiles of M 0.05	0.10	0.25	0.50	0.75	0.90	0.95	quantiles of M* 0.05	0.10	0.25	0.50	0.75	0.90	0.95
1	19.0	25.7	8	9	13	17	24	31	36	23	23	23	23	29	29	35
2	20.9	28.1	9	11	14	19	26	33	38	23	23	23	29	29	34	40
3	22.9	30.2	10	12	16	21	28	35	41	23	23	23	28	34	40	45
4	24.9	32.3	11	13	18	24	30	38	44	22	22	28	28	39	45	51
5	26.8	34.7	12	14	19	25	33	41	47	22	22	28	34	39	50	56
6	28.8	37.0	13	16	21	27	35	44	50	22	22	28	34	45	55	61
7	30.8	39.1	14	17	22	29	38	47	53	22	22	28	39	44	55	66

A. Projection assuming year-round



B. Projection assuming nighttime shutdown and uniform



C. Projection assuming nighttime shutdown using site-specific

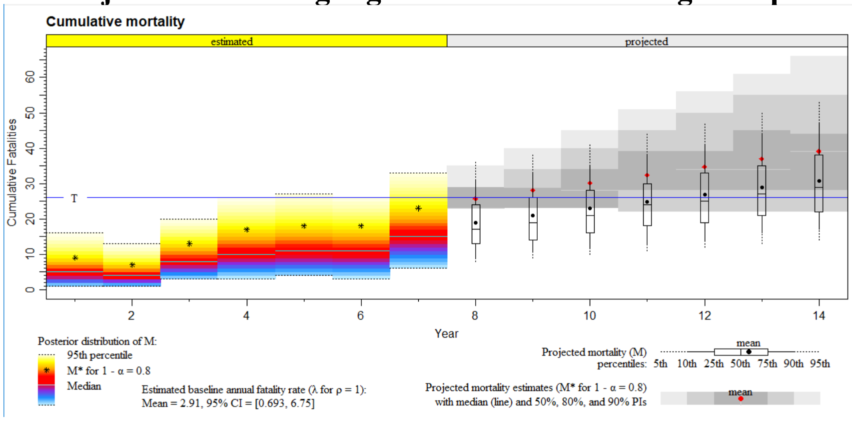


Figure F-8. Graphic depictions of the projected take at Pakini Nui using the past 5.5 years of site-specific data based on (A) year-round operations with no additional avoidance and minimization measures being deployed in the future beyond what has already being implemented; or complete shutdown of turbine operation between dusk and dawn from April 15 to September 15 using (B) uniform occurrence, or (C) site-specific, fatality distributions.

SYNTHESIS

Shutting down turbine operation between dusk and dawn from April 15 through September 15 would be predicted to reduce future take by 41.67% if we assume fatality rate is uniform across a year (Table F-5). The amount of take reduction is largely based on the prior years of fatality and compliance monitoring data. While the projections do assume that bats would continue to encounter the facility at the same rate as prior years, it is fairly certain that bats would indeed continue to visit the sites.

Projections that utilized site specific fatality distributions suggest projects such as Kawailoa Wind and Auwahi Wind could have significantly higher reductions because observed take has been disproportionately higher between the months of May and September and June and September, respectively. Projections based on the fatalities that have occurred during the breeding period suggest a 65% and 53% reduction of future take might occur for Kawailoa Wind and Auwahi Wind, respectively. Projections for Pakini Nui using the limited site specific data available showed a 33% reduction because only one fatality had been observed during the April 15 to September 15 period.

Shutting down of turbine operations from dusk to dawn during the breeding season also eliminates indirect take, assuming that fatalities are not attributed to other site risks besides rotating turbine blades. The benefits of shut down for Kaheawa Wind Phase II are less clear, because no bat fatalities have been observed between April 15 and September 15. However, if we assume bat fatalities may have occurred and have been missed because of imperfect detection probability, and assume the chance of bats occurring year-round at the project, and therefore at potential risk of collision with operating turbines, then it is highly likely that turbine shut down from dusk to dawn during the breeding period could reduce take at that facility also.

An alternative to using the April 15 to September 15 time period as a turbine shut down period, a more reduced shut down period spanning the period when female bats are likely tending their dependent pups was also considered. This period, from June 15 to September 15 would most likely eliminate the take of dependent pups, but would not alleviate the risk to pregnant females. This approach would cover the period from June 15 through September 15 and would reduce future take approximately 25%. The projected take from this option reduces the projected take slightly less than shutdown from April 15 to September 15 (Table F-5), but would likely have less impact on power production on an annual basis. Projections based on project specific fatality distributions are slightly lower for Auwahi (47%) and much lower for Kawailoa Wind (57%) when compared to the three-month uniform occurrence alternative (25%).

Relying on site-specific fatality distributions to determine the best periods of turbine curtailment/shutdown is not without problems. Less than perfect detection probabilities complicate determining whether fatalities do actually occur at a higher rate in some time periods or if the carcasses are simply less likely to be found during certain periods of the year. This is where carcass retention and searcher efficiency trials become very important for identifying site-specific conditions that could be contributing to such patterns. Using a seasonal turbine shutdown at facilities that have not had observed fatalities may be unnecessary. Alternatively, it may be that the fatalities are simply missed. Years of continued monitoring at all turbines in

Hawai'i appears to indicate fatality distributions at projects that have higher rates of take, do exhibit a higher number of fatalities in some periods of the year. Modeling of fatalities in Hawai'i has been based on the assumption of uniform arrival of fatalities, that is, bats are likely at risk at the project site year around. While fatalities have been observed in every calendar month, some projects do appear to have a repeating seasonal distribution pattern emerging. As a result, those facilities have implemented additional measures in an effort to reduce take during the months of highest observed take.

Table F-5. The resulting projections for each project (column 1), requested take (direct only/direct and indirect) by the project (column 2), Service projections for year-round operation based on project specific data from previous years of operation and assuming no new avoidance and minimization measures are deployed beyond what is already being implemented (Column 3), and projections for each project assuming the turbines are not operating between dusk and dawn from April 15 through September 15 based on uniform occurrence of fatalities year round (column 4) or project-specific fatality distribution (column 5).

Project	Total requested take by project	Projected take (without indirect take)	Dusk to dawn turbine shutdown from April 15 - September 15		Dusk to dawn turbine shutdown from June 15- September 15	
			Based on uniform occurrence (rho = 0.583)	Based on site-specific fatality distribution	Based on uniform occurrence (rho = 0.75)	Site-specific fatality distribution
Auwahi Wind	127/140	129	93	83 (rho = 0.471)	107	88 (rho = 0.529)
Kaheawa Wind Phase II	35/38	36	26	N.A.[2]	30	N.A. [2]
Kawailoa Wind	246/265	224	164	130 (rho = 0.351)	188	140 (rho = 0.432)
Pakini Nui	23/26	23[3]	14[3]	16[3] (rho=0.667)	17[3]	15[3] (rho=0.667)

1 Observed and unobserved direct take only/Total take.

2 Project has not reported any Hawaiian hoary bat fatalities occurring between April 15 and September 15

3 Projections include modelled take based on three fatalities reported at this project since 2013 and are adjusted to reflect only future projected take should a permit be issued because the Service cannot authorize take retroactively.

The uncertainty in the projections as illustrated by the grey shaded areas vary greatly among projects. The source of the uncertainty is from a variety of sources. Significant differences in detection probabilities between years and the associated confidence intervals is one source.

Others include large differences in the number of fatalities between years relative to the detection probability, or low detection probabilities also contribute to uncertainty in the model.

All of the projections presented in this appendix are based on continued implementation of the avoidance and minimization measures that are being implemented presently because the model relies on past data to inform projections. Kawailoa and Auwahi recently began implementing additional measures during the breeding season in an effort to reduce take during the period when take has been high. The effect of these methods is unknown at this time because they have only been implemented for several months. When observed fatalities are few in number, determining significant (real) effects on take amount are difficult to detect. In the case of Kawailoa and Auwahi, it may take several years of implementation of measures such as higher curtailment or increased rolling average, to produce a statistically detectable change. And a real change may take years to detect if present.

In the case of complete nighttime shutdown of turbine operation, the reduction would be considered absolute and an associated rho value would be used to effectively show the effect. Compliance monitoring would still be required because other covered species would not likely be effected, especially in the case of diurnally active species. Night flying seabirds might also collide with the non-operating turbines, though risk is negligible for sites that have not had take at previously. It would also be useful to confirm absolute elimination of risk to bats at projects that have typically had observed take during that period. The possibility of increasing the interval between searches under this regime would also be possible if the carcass retention of the other carcass species support longer intervals between searches. At projects such as Kaheawa Wind Phase II, which has a reasonable high detection probability relative to projects in Hawai'i, the effect of nighttime shutdown of turbines would be based on the assumption that undetected take is occurring during the breeding season and that it is going undetected.

Wind profiles at each project are different and varied. Making blanket predictions of how much power generation would be reduced is dependent on the wind speed differential between day and night, the curtailment regime that would have been in place instead of the nighttime shutdown, and power curtailment that may be implemented by the power company, over which the wind company has no control. If we make a general assumption that wind speeds are approximately equal between dusk to dawn and dawn to dusk, then a nighttime shutdown of turbines between dusk and dawn from April 15 to September 15 would represent between a 17-25% reduction in power generation based on the average day length during that period. A three-month nighttime shutdown would represent between a 9-15% power generation reduction. These are based on desk top analyses only and do not take into account actual wind speeds or other operational factors that impact wind generated energy production.

The estimates for the reduction in power outputs are based the proportion of time a project would be operating at night. It only provides the proportional reduction that could happen, not that would happen. Is not based on nameplate output or size of the project. The relative reductions are based on the effects each alternative could have on a facilities power generation if we assume that 100% power output would be what would occur under normal operation and in the absence of LWSC or nighttime shutdown. It is not a comparison between projects. It is a comparison of the alternatives impact on an individual project. Under Alternative 1, the Projects would not operate from dusk through dawn. We assume that roughly 50% of the time the project would be shutdown. Thus, up to a 50% reduction in power output could occur. It does not take into account wind speed during the day. Under Alternative 2, we assume that low wind speed curtailment would result in up to a 20% reduction of power generation. The actual reduction would be dependent on the amount of time the wind speeds, which vary, are below the LWSC cut-in speed at night. Alternative three would result in the Projects not operating at night for 5 months of the year. This would be equivalent to 41.6% of the time the projects would not be operating at night. Thus, up to a 20.5% power output reduction would be expected in addition to the loss from low wind speed curtailment implemented for the remaining seven months of the year (11.66%). Again, the amount of power output lost from LWSC would be dependent on wind speeds.

LITERATURE CITED

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

Appendix G

A Brief Review of New Information on the Hawaiian Hoary Bat

The information provided in this appendix is limited to new information that the Service has obtained since the last 5 Year Review was published in September 2011 (USFWS 2011). For additional background information the reader is referred to the Recovery Plan for the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) ('ōpe'ape'a) (USFWS 1998) and the previous 5-year Review Summary and Evaluation for the Hawaiian hoary bat (USFWS 2011) available at https://ecos.fws.gov/docs/five_year_review/doc3865.pdf).

INTRODUCTION

The Hawaiian hoary bat, or 'ōpe'ape'a., is an endangered endemic mammal found in the Hawaiian islands. Listed as a subspecies of *Lasiurus cinereus*, the Hawaiian hoary bat is distributed across all of the major islands of the Hawaiian Archipelago, including Kaua'i, O'ahu, Lāna'i, Maui, Moloka'i, and Hawai'i and, most recently, has been observed visiting Kaho'olawe. Hawaiian hoary bats roost alone or with dependent young in native and non-native trees, typically more than 3-5 meters (10-16 feet) tall. A 2015 observation extended the known pupping season later in the year (Corinna Pinzari, 2015, personal communication) and the Service currently recognizes it as June 1 to September 15. Hawaiian hoary bats primarily feed on nocturnal moths and beetles, which it hunts in flight across a wide array of habitat types and plant communities from sea level to at least 3,600 meters (11,800 feet) above sea level. No historical or current population estimates exist for this subspecies, though recent studies and ongoing research have shown the bats have a wide distribution across the Hawaiian islands. The Hawaiian hoary bat was listed based on apparent habitat loss and limited knowledge of its distribution and life history requirements. A brief synopsis of new genetic information and the current status and threats for Hawaiian hoary bat are provided below.

NEW INFORMATION

Genetics, Colonization and Morphology

Until 2015, published genetic studies on *Lasiurus cinereus* were limited to an analysis of species-level variation within the genus *Lasiurus* by Baker et al. (1988) and a separate analysis by Morales and Bickham (1995) that supported the taxonomic distinction of North American, South American, and Hawaiian populations at the subspecies level. Three different publications have been released in the past few years that analyzed the genetic relationships of the Hawaiian hoary bat within the larger *Lasiurus* complex and within the Hawaiian islands (Russell et al. 2015, Baird et al. 2015, Baird et al. 2017). These studies indicate that two genetically distinct groups or clades of hoary bats, derived from different arrivals to the islands, exist within Hawai'i.

Based on the mitochondrial and nuclear DNA sequences of the samples analyzed, Russell et al. (2015) identified two clades; one found across the Hawaiian archipelago, but not on the North American continent, and the other was found on Maui, O'ahu and the North American continent. In a different study, Baird et al. (2015) analyzed Y-chromsomal and mitochondrial sequences of nine Hawaiian hoary bats from Maui and Hawai'i islands, 13 different hoary bat representatives from North America, one representative from South America, and additional outgroup species. Individuals from the Hawaiian islands formed two distinct clades: one consisting of only Hawaiian hoary bats (*L. c. semotus*) from Maui and Hawai'i islands, and one consisting of other individuals from Maui and all of the sampled North American specimens (*L. c. cinereus*). Based on this study, Baird et al. (2015) recommended that the three subspecies of *L. cinereus* (*L. c. cinereus*, *L. c. semotus*, and *L. c. villosissimus*) each be raised to species status.

In 2017, Baird et al. conducted further analyses and identified a few individuals that possessed mitochondrial DNA haplotypes of the clade that appears to be limited to the Hawaiian islands and possessed nuclear alleles from the Maui and North America clade, and vice versa. These mismatched individuals are considered to have a hybrid ancestry suggesting hybridization among the two clades has occurred, though it does not appear to be widespread (<15%; 4/27 individuals) (Baird et al. 2017). Baird et al. (2017) identified three mitochondrial DNA haplotypes in the Hawaiian Islands, including one shared with North America and two endemic to the Hawaiian Islands. The Island of Maui contains the most diversity, with all three mitochondrial DNA haplotypes occurring there. They also found two nuclear alleles, one of which is present in multiple Hawaiian individuals and shared with multiple North American individuals and the other is unique to one Hawaiian individual, which is potentially a hybrid because its other allele is characteristic of the Hawaiian clade. The two clades have been found on Oʻahu and Maui, but the Maui/North America clade that includes *L. c. cinereus,* has not been found on the other islands as of yet, although putative hybrids between the two clades was noted from Hawaiʻi island (Baird et al. 2017). Very few samples have been tested from Kauaʻi, and no results for bats from Molokaʻi, Lānaʻi, or Kahoʻolawe have been published.

Data presented by both Baird et al. (2015) and Russell et al. (2015) indicate that the geographic origin for *Lasiurus* on the Hawaiian islands is North America, confirming the previous suggestion by Morales and Bickham (1995) using the same specimen, which Baird et al. (2015) also sequenced. Bonaccorso and McGuire (2013) modeled energetics and water balance of simulated colonization flights for *L. c. cinereus* founders arriving in Hawai'i. They concluded that physical conditions (trade wind velocity and direction) and physiological conditions during fall migration (fat storage, energy consumption, and water balance) would allow for long distance dispersal from the Pacific coast of North America (rather than from other parts of its range), and suggested that multiple colonization events may have been possible despite the energetic and physical constraints on dispersers. Baird et al. (2015) and Russell et al. (2015) found evidence for these multiple colonization events, which presumably led to the two different clades present in Hawaiʻi.

Baird et al. (2015) found that the older invasion, represented by the presumed *Lasiurus cinereus semotus* clade, occurred between 400,000 and 1.8 million years ago. The observation of two distinct North American *L. c. cinereus* haplotypes on Maui supported at least one and possibly two more recent invasions. In contrast, the results from Russell et al. (2015) suggested that Hawaiian *Lasiurus* populations resulted from at least two relatively more recent dispersal events from North American populations of *L. c. cinereus*, with the first colonization occurring no more than 10,000 years ago and the second perhaps 800 years ago. To address these marked inconsistencies between the results by Russell et al. (2015) and Baird et al. (2015), Baird et al. (2017) examined additional DNA sequences to further investigate the timing of colonization of the Hawaiian islands by hoary bats. This analysis proposed hoary bats colonized from North America around 1.3 million years ago to Kauaʻi, Oʻahu, or Maui (the islands existing at the time) and that a notable population increase occurred 20,000 years ago (Baird et al. 2017).

Jacobs (1996) reported morphological divergence in the Hawaiian hoary bat from the North American subspecies involving characteristics related to flight and feeding. According to Jacobs (1996), the Hawaiian hoary bat has a 45% reduction in body size with allometric responses in the size of its wings when compared to the continental North American subspecies, *L. c. cinereus.* The wing changes result in a lower ratio of weight to wing area, and are expressed as long, narrow wings relative to the continental North American subspecies. This physical trait permits slower and more maneuverable flight near vegetation and enduring flight in open areas. This increased flexibility in flight behavior has allowed the Hawaiian hoary bat to expand its foraging habitat to include both open habitats similar to those of *L. c. cinereus*, and closed habitats not used by *L. c. cinereus*. Skeletal features related to feeding also diverge with Hawaiian hoary bats having relative increases in the size of the mouth opening (gape), the size of the muscle that closes the jaw (masseter muscle) and the height of the coronoid process relating to the structure of the jawbone. These changes give the jaw more crushing power for more efficient processing of large and hard-bodied prey. This has enabled the Hawaiian hoary bat, despite a marked reduction in body size, to include large, hard-bodied insects such as beetles, not taken by *L. c. cinereus* in its diet.

Similarly, Barclay et al. (1999) found that Hawaiian hoary bats use on average higher frequency calls (26.2-29.8 kHz) compared to mainland hoary bats (20.1 kHz). The reported frequency range varies from 23 to 46 kHz and this may not encompass the complete range of echolocation frequency. The same study found the range varied depending on the island and area where the detection occurred.

DISTRIBUTION AND SEASONAL BEHAVIOR BY ISLAND

Island of Kauaʻi

Limited studies have been conducted on Kauaʻi, with the most comprehensive occurring on military land in the western portion of the island (Bonaccorso and Pinzari 2011). Occupancy values for all three sites, including Barking Sands, Mākaha Ridge and Kokeʻe, demonstrate year-round use of all these areas by Hawaiian hoary bat, although different seasonal values indicate varying use throughout the year. Bats appeared to be using low elevation habitats (Barking Sands) primarily during the late summer and fall, and then showed increased activity at higher elevations (Mākaha Ridge and Kokeʻe) during the winter months (Bonaccorso and Pinzari 2011). The increased activity in the fall season, is almost certainly related to fledging of pups as flying subadults and likely what is termed “fall swarming” by adult ōpeʻapeʻa in preparation for mating (Bonaccorso and Pinzari 2011). Although there is seasonal movement, the frequency of foraging activity indicates that the majority of the areas at the military base are used year-round by foraging bats, and thus are important for bat survival in western Kaua’i. Recordings of ōpeʻapeʻa vocalizations cannot be directly translated into population counts of hoary bats but the findings indicate that the collective Navy facility properties on Kaua’i have a high level of use by the bats for foraging and probably fall mating, and thus these collective lands offer important habitat for this endangered species (Bonaccorso and Pinzari 2011).

Hawaiian hoary bat activity was also monitored across the USFWS National Wildlife Refuge (NWR) complex in Hawaiʻi from January to December 2017 with 22 stationary acoustic detectors (Wolfe 2018). Bat activity was detected almost nightly at Hanalei NWR on Kauaʻi, while both Hulēʻia NWR and Kīlauea Point NWR had bats detected on a majority of nights throughout the year, indicating high occupancy at all three of these lowland sites year-round.

Island of Oʻahu

A 2013 capture of a lactating female with two dependent pups near Waimea Valley on the north shore of Oʻahu was the first direct evidence of breeding on Oʻahu (H. T. Harvey Consulting 2013). Additional detections of Hawaiian hoary bats have been made across Oʻahu, including on military lands in both the Koʻolau and Waiʻanae mountain ranges, as well as Waikīkī, Ford Island, the north shore of Oʻahu, the NWR complex, detections were made at James Campbell NWR, at the Kalaeloa Unit of the Pearl Harbor NWR and at the Oʻahu Forest NWR (Pinzari 2014, Oʻahu Army Natural Resource Program 2016, Wolfe 2018). Though little movement data has been published from the island, Gorresen et al. (2015) studied the landscape distribution of Hawaiian hoary bat in the north Koʻolau Mountains of Oʻahu from May 2013 to May 2014 integrating acoustic monitoring and thermal videography. Acoustic detections were consistently low from October through February and increased at most north shore sites peaking in April through August (Gorresen et al. 2015).

The preliminary findings from an island-wide study conducted with 83 randomly placed acoustical detectors across Oʻahu conducted in 2018 resulted in 5,135 Hawaiian hoary bat detections between June 8, 2017 and June 29, 2018 though not all detectors were deployed for the entire time period (Starcevich et al., 2019). At least one detection or more was recorded at 61% of the 83 sites. The level of detections recorded at each site ranged from 0 to 1,703, suggesting site usage by bats is highly variable. The highest number of detections occurred during the lactation period. Detections occurred across the island though the highest concentration of detections were made in the northern Koʻolau and Waianae Mountain ranges (Starcevich et al 2019).

Island of Molokaʻi

No new status information is known for the breeding population of Hawaiian hoary bat on Molokaʻi. However, recent surveys led by Kalaupapa National Historical Park reported detections of Hawaiian hoary bat across the island and in all months of the year (Hosten and Poland 2018), indicating that a resident population exists on the island. In addition, Wolfe (2018) surveyed bats at Kakahaiʻa NWR and found them present on 14 nights during the course of a year.

Island of Maui

On Maui, the most comprehensive, completed distribution study so far was conducted by Todd et al. (2016) on the upper leeward slopes of Haleakalā. Baseline occupancy and habitat-use acoustic surveys were conducted prior to the restoration of 3,200 hectares (8,000 acres) of habitat for bats in the Kahikinui Forest Reserve and adjoining Nakula Natural Area Reserve (KFR-NNAR) (State of Hawaiʻi 2015a, 2015b). Hawaiian hoary bat vocalizations were collected from July 2012 to November 2014 at 14 locations in the KFR-NNAR (Todd et al. 2016). The study area included remnants of recovering mesic montane forest with interspersed grasses from 1,250–1,850 meters (4,100–6,070 feet) and xeric subalpine shrubland plant communities from 1,860–2,800 meters (6,100-9,200 feet). Detections occurred on 65% of nights and in every month of the study, with monthly detection probability values highest from July to November 2012, and greater detections occurring in the remnant forests than in the shrubland for most months. Significantly higher detection probability for bat calls during 2012 and particularly in July and August of that year coincided with at least two environmental variables: low rainfall and presence of high ungulate density in the reserve. According to Todd et al. (2016), the reserve experienced very low average annual rainfall in 2012 followed by higher annual rainfall in 2013 and 2014.

Todd et al. (2016) also postulated that a high density of ungulates may have been positively linked to high detection numbers in the KFR-NNAR in July 2012. By the end of 2012, ungulates had been removed and exclusion fencing was in place at the NNAR. The presence of high ungulate densities have been shown in other studies to be associated with increased insectivorous bat presence and foraging activity (as reviewed by Downs and Sanderson 2010). In particular, dung feeding beetles and flies that associate with cattle and other herding ungulates are important food items for a number of insectivorous bats (Shiel et al. 1991). Scarab beetles and flies have been identified from fecal pellets of Hawaiian hoary bats captured near cattle farms on Hawai'i island (Todd 2012). Thus, Todd et al. (2016) concluded that the Hawaiian hoary bat, like other insectivorous bats, finds sufficient resources in areas with ungulates, like cattle. The reduction in bat activity in 2013 and 2014 is possibly associated with the elimination of ungulates in KFR-NNAR. Alternatively, the reduction in activity could be a temporary phenomenon and bat presence and foraging activity may rise over time as forest recovery resulting from ungulate exclusion and the associated turnover in plant and insect communities occurs. Noted as a generalist aerial insectivore feeding principally on moths and a diverse array of beetles in Hawai'i (Whitaker and Tomich 1983; Jacobs 1999; Todd 2012), Hawaiian hoary bats are expected to benefit in the long term as the insect fauna increases due to forest productivity increases across the KFR-NNAR. In addition, weather patterns over the course of these years may also have accounted for this pattern, as the first year had a higher number of clear nights with lower rainfall, and the subsequent years had higher rainfall (Todd et al. 2016). Follow up surveys for Hawaiian hoary bat will be conducted at KFR-NNAR to monitor the effect of restoration activities on bat activity, and which may enable a more definitive answer to this question.

Other monitoring on Maui has been done by Wolfe (2018), who detected bat activity almost nightly at Keālia Pond NWR in the coastal isthmus of Maui. Preliminary results from a more extensive project being undertaken by Johnston et al. (2018) reported that bats are active at low and high elevations summer through winter. However, no significant correlation with elevation was seen, suggesting bats do not "shift" to the high elevations during the late fall on Maui (Johnston et al. 2018), as has been seen on other islands (Menard 2001, Bonaccorso and Pinzari 2011, Todd 2012, Gorresen et al. 2013).

Island of Lāna'i

Hawaiian hoary bats have been documented on Lāna'i as a result of studies conducted by Castle & Cooke (2008, as reported by Tetra Tech 2008). The occurrence of pupping on the island has not been established.

Island of Kaho'olawe

Acoustic detectors placed by the Kaho'olawe Island Reserve Commission (KIRC) first detected vocalizations of the Hawaiian hoary bats in June 2016 (KIRC 2017). Additional acoustic detections were noted in August, September and October, before dropping in December and January. Their data suggests that bats occur seasonally on the island and at least some appear to travel to Kaho'olawe after dusk and then return to either Maui or Lāna'i before dawn. Peak detections occurred around 10:00 PM. It is unknown if breeding occurs on the island (KIRC 2017).

Island of Hawai'i

Surveys for Hawaiian hoary bat have been most extensive on Hawai'i. Todd (2012) found bat activity varied seasonally among elevations. Hawaiian hoary bats are most active at elevations < 1000 meters (< 3,300 feet) from late spring through summer and early fall, which coincides with the reproductive period. Sites at middle elevations had the highest bat activity during the reproductive period and had the largest decrease in bat activity during the non-reproductive period. High elevation sites generally had the least bat activity during the reproductive period. In general, this indicates that activities related to reproduction and pup rearing tend to take place in the low- to mid-elevations and movement to higher elevations occurs after pups fledge. This is supported by Hawaiian hoary bat activity at low elevation sites being higher during the reproductive period than during the non-reproductive period. Notably, bat activity at high elevation sites remained constant throughout the year.

Similarly, Gorresen et al. (2013) concluded hoary bats concentrate in the coastal lowlands of Hawai'i during the pupping season, May through October, and then move to interior highlands during the winter. This was based on acoustic recordings of Hawaiian hoary bats collected over a five-year period (2007–2011) from 25 survey areas across the Hawaiian hoary bats occupy and forage at elevations between 2,200 and 3,600 meters (7,200-11,800 feet) during November through March (F. Bonaccorso personal observation, cited by Gorresen et al. 2013). Highest occupancy in the coastal lowlands peaked in mid-September across the five-year average, which corresponded to the August-September fledging season of the young from that year (Gorresen et al. 2013). Although the Hawaiian hoary bat is a habitat generalist species and occurs from sea level to the highest volcanic peaks on Hawai'i, there was a significant association between occupancy and the prevalence of mature forest cover. Overall, the trend in occupancy, while strongly suggestive, but not conclusive, was that the population on the island was stable to slightly increasing based on the breeding season records over the five years of surveys. This was based on a threshold for ecological significance as a 25% change in occupancy over 25 years (Gorresen et al. 2013).

Acoustic surveys were also conducted at the coastal Kaloko-Honokōhau National Historical Park (Pinzari et al. 2014). Of the four sites surveyed, Kaloko Fishpond (wetland shoreline habitat) and

ʻAimakapā Fishpond (wetland shoreline habitat) had substantially more Hawaiian hoary bat activity than the xeric lava beds at the park's south boundary (lava and fountain grass [*Cenchrus setaceus*] habitat) and at the Northern Māmalahoa Trail (lava and haole koa [*Leucaena leucocephala*] habitat; Pinzari et al. 2014). Wolfe's (2018) acoustic study on NWRs across Hawaiʻi detected bat activity almost nightly at Hakalau Forest NWR, indicating bats occur year-round in this area.

DETECTION

Detectability refers to the ability to detect an animal if it is present. Acoustic and video findings from a study by Gorresen et al. (2015) show that Hawaiian hoary bat can be acoustically cryptic (8% chance of detection on a given night if it was present during the study when compared to thermal imaging). Multiple instances were observed in which bats flew close to microphones but were not recorded (Gorresen et al. 2015). They also noted a lack of recorded feeding calls despite concurrent video evidence of frequent foraging-like behavior, thus demonstrating acoustic detection is limited at detecting bat presence. Acoustic detectors are currently the most widely deployed mode of detection and can be used for occupancy studies which are statistically designed temporal comparisons. Advances in microphones are improving the detection range, but also require calibration with the previously used technology so the data from the past, present, and future can be compared. Thermal videography is being deployed more frequently in conjunction with acoustic detectors.

Recently, Corcoran and Weller (2018) demonstrated that hoary bats (*L. cinereus*) use a novel call type called "micro calls" that has three orders of magnitude less sound energy than other bat calls used during typical echolocation in open habitats. Acoustic modelling indicates the bats are not producing calls that exceed 70-75 dB at 0.1 meter indicating bats sometimes fly without echolocation. A possible benefit of hoary bats shifting from normal to micro calls is that it would make bats far less conspicuous to predators and conspecifics. However, at this level, the call would have little or no known use for a bat flying in the open at high speeds. A micro-calling bat should have sufficient time to detect and avoid large obstacles such as tree branches at close range, but they would have difficulty avoiding smaller objects, mist nets, or rapidly moving wind turbine blades (Corcoran and Weller 2018).

ROOSTING HABITAT

Day-roost habitat requirements for Hawaiian hoary bats are tall (greater than five-meter [15 feet] crown height), shady trees frequently including mature native ʻōhiʻa, but also including a wide variety of introduced species such as lychee (*Litchi chinensis*), various species of eucalyptus, mango (*Mangifera indica*), and numerous other tree species (Bonaccorso et al. 2015). Roost trees noted from radio-tracked bats on Maui include blue gum eucalyptus (*Eucalyptus globulus*), African tulip tree (*Spathodea campanulata*), and Monterey cypress (*Cupressus macrocarpa*) (Johnston et al. 2018).

The roosting behavior of five solitary adults using thermal imagery and surveillance video was observed during the summer in 2017. They found that Hawaiian hoary bats typically enter shallow torpor during the day while maintaining a mean differential body temperature above ambient temperature. Spikes in body temperature can be associated with arousal from sleep and activity such as urination or grooming (Moura et al. 2018).

BREEDING AND LIFESPAN

Hawaiian hoary bat breeding activity takes place between April and August, with pregnancy and the birth of two, or occasionally one, pups, occurring from April to June (Bogan 1972). The pups are completely dependent on the female until weaning at 3 months of age. Lactating females have been documented from June to August, and a female tending pups has been observed in early September (Pinzari, pers. comm). The average lifespan of the Hawaiian hoary bat has been estimated to be a minimum of 4 years (Bonaccorso 2016) and it is postulated they could live up to 10 years (DOFAW 2015).

DIET

Hawaiian hoary bat consume a wide variety of insects (Whitaker and Tomich 1983, Jacobs 1999, Todd 2012). Todd (2012) identified seven orders of insects (Insecta) in the diet of Hawaiian hoary bat: moths (Lepidoptera), beetles (Coleoptera), termites (Blattodea), flies (Diptera), true bugs (Hemiptera), bees and wasps (Hymenoptera), and lacewings (Neuroptera). However, moths and beetles are the most frequently consumed prey and together constituted 99% of the total prey items consumed by volume in this study. Moths dominated the insect fauna at middle and high elevations, and were also consumed by Hawaiian hoary bats significantly more than any other insect taxon at low elevations (Todd 2012). Hawaiian hoary bats at low elevations selected moths and beetles in proportion to their availability in the environment. However, at middle elevation sites, beetles accounted for 43% of the Hawaiian hoary bat diet, even though beetles comprised only 3.5% of the total insect availability at these sites. Essentially, insect taxa found in the diet of the bats were proportional to their availability at low elevations and disproportional to their availability at middle elevations. This suggests that bats opportunistically forage at low elevations and selectively forage at middle elevations (Todd 2012). This may be partially due to other stressors at low elevations in this study area, such as coqui frogs (*Eleutherodactylus coqui*) that consume a large percentage of the available insect fauna in these areas (Beard 2007, Todd 2012). The presence of animal dung and the associated dung beetles has also been implicated as a foraging resource (Todd et al 2016) and is further discussed in the Island of Maui section of this document.

A massive outbreak of the koa moth (Geometridea: *Scotorythra paludicola*) defoliated more than a third of the koa forest on Hawai'i island during 2013−2014. Although Hawaiian hoary bat detectability was notably lower during the outbreak year than in any year of the five-year study conducted by Gorresen et al. (2013) at both Hakalau and Laupāhoehoe, Banko et al. (2014) suggest that this may have be due to the relative ease in which Hawaiian hoary bats reached satiation during the koa moth abundance. Echolocation calls associated with searching and attacking insect prey peaked abnormally early in the night during the outbreak at Laupāhoehoe. Bats actively foraged over longer portions of the night and at lower success rates during non-outbreak times when prey (moth) densities were orders of magnitude lower.

Several studies have looked at how Hawaiian hoary bats move, forage, and use habitats across the islands (e.g. Todd 2012, Gorresen et al. 2013, Bonaccorso et al. 2015, Gorresen et al. 2015, Bonaccorso at el. 2016, Todd et al. 2016). These studies found that, overall, bat activity and movements on the landscape are not determined by one variable, but an interaction of a complex array of environmental factors. Seasonal changes in temperature, rainfall, wind, insect abundance and energetic costs associated with reproduction of Hawaiian hoary bat all play important roles in movements and habitat use.

The physical structure of the spaces in which the Hawaiian hoary bats forage are extremely varied, and include forest gaps and clearings, forest edges along planted windrows of trees, above forest canopies and along roads. These areas can occur in a range of habitats including undisturbed native forest, mature eucalyptus plantations having mixed understory trees and shrubs, lowland forest dominated by introduced trees, suburban and urban areas planted with ornamental trees, grassland/pasture, river gorges, arboretums, macadamia nut orchards, and coastal bays (Bonaccorso et al. 2015, Gorresen et al. 2013). Gorresen et al. (2013) found a significant association between Hawaiian hoary bat occupancy and the prevalence of mature forest cover at montane elevations in Laupahoehoe on Hawaii island (Reeves and Amidon 2018). However, native vegetation was not related to occupancy. This might be due to the fact that lowland forests on Hawai'i, which are important for pupping, are almost exclusively non-native vegetation, whereas the majority of the native forest remaining in Hawai'i occurs at montane elevations.

Bonaccorso et al. (2015) examined the movement of 28 radio-tagged Hawaiian hoary bats along the windward side of the island of Hawai'i during the summer and fall. One-way movements by Hawaiian hoary bats within a night were measured over distances of up to 11.3 kilometers (7.0 miles). The mean foraging range was 230.7 ± 72.3 hectares (570.1 ± 178.7 ac) (n = 28 bats) which included 2 outliers, an adult male with a foraging area of 1,593 hectares (3,936 acres) and a subadult male with a foraging area of 1,316 hectares (3,252 acres) that were considered atypical in their foraging range. However, in their preliminary analysis of radio-tracked bats on Maui, Johnston et al. (2018) found foraging areas on that island can range from 1,200-26,000 hectares (3,000-64,000 ac).

Bonaccorso et al. (2015) also looked at the mean core use area (the area that the bat used intensively for 50% of the time while it was radio-tracked) and found it averaged 25.5 ± 6.9 hectares (63.0 ± 17.1 ac) (n = 28 bats) or about 11% of the mean foraging range. One subadult male had an unusually large core use area of 176 hectares (435 ac). Statistical tests supported exclusion of this outlier and resulted in a mean core use area of 19.9 hectares (49.2 ac) (n = 27 bats) and a median of 20.3 ac. Core use areas did not typically overlap between radio-tagged individuals, though other Hawaiian hoary bats may have been present in these areas. Foraging areas, however, did overlap in some cases (Bonaccorso et al. 2015).

The wide variability in the foraging range and core use area may, in part, be influenced by the highly fragmented landscape characteristics of Hawai'i island and the ability of Hawaiian hoary bat, in the absence of any other bats, to exploit different localized food resources in a large number of diverse habitats (Bonaccorso et al. 2015, Todd 2012). Suitable foraging areas can be quite disjunctive in space, and Hawaiian hoary bats easily move within a night from sea level to elevations above the cloud inversion layer (~1,700 meters [~5,600 feet]) in order to forage in dry weather (Bonaccorso et al. 2015). One radio-tracked male moved to forage at different altitudes on several nights, allowing it to avoid rainfall at low elevations (Bonaccorso et al. 2015).

As such, temperature, wind and rainfall all appear to influence Hawaiian hoary bat foraging activity and movements (Todd 2012, Gorresen et al. 2015, Todd et al. 2016, Bonaccorso et al. 2016). Todd (2012) found a temperature and rainfall model the best predictor for Hawaiian hoary bat activity on Hawai'i island. However, temperature may be a stronger environmental influence on bat activity as bats move elevations seasonally. Females are solely responsible for rearing young, and energy demands increase significantly from pregnancy through lactation (Barclay 1989). Individual bats can and do fly more than 18 kilometers (11 miles) in less than a half hour (Bonaccorso et al. 2012, as cited by Todd 2012), a distance greater than a round trip from the ocean to the summit of Mauna Kea. Hawaiian hoary bats may easily roost at high elevations and forage at low elevations or vice versa during any time of the year in order to obtain optimal foraging conditions (Gorresen et al. 2013, Gorresen et al. 2015). Additional studies have demonstrated Hawaiian hoary bats can range between habitats and elevations within a single night to target optimal local foraging opportunities, with bats spending 20 to 30 minutes hunting in a feeding range before moving on to another (Bonaccorso 2010).

Gorresen et al. (2015) found higher rates of bat detection on O'ahu when nightly wind speeds dropped to a low relative to the previous night and mean speeds were < 4.6 meters/second and maximum speeds were < 8.2 meters/second. The conditions that favored the highest proportion of bat detections included conditions where maximum wind speeds were ≤ 7.7 meters/second or between 7.7 and 8.7 meters/second when temperatures > 21.5 °C. Conditions that favored the lowest bat activity included humidity levels > 90.0% and maximum wind speeds > 8.7 meters/second, or humidity levels ≤ 90.0% and maximum wind speeds > 12 meters/second. Proportion of detections were also low where wind speeds were between 7.7 and 8.7 meters/second and temperatures were ≤ 21.5 °C. With regard to precipitation, the highest rates of activity were when nightly maximum wind speeds were ≤ 8.3 meters/second and cumulative rain ≤ 0.8 millimeters. Conditions that favored the lowest activity rates included maximum wind speeds > 9.8 meters/second, where humidity levels were > 85.0%, and temperatures were ≤ 21.4 °C. 'Ōpe'ape'a were more likely to be detected when barometric pressure was relatively low (≤ 972 millibars), but rising over a period of at least 24 hours. Rising barometric pressure may indicate improved conditions for foraging and overall activity and/or increased availability of insect prey. The results indicate that relatively higher bat activity occurred as storm fronts passed and weather conditions were improving. Video detections of bats at wind energy turbines declined with increasing humidity. A likely biological explanation for fewer bat detections at high levels of humidity is that foraging by echolocation may be less efficient in wet air.

Bonaccorso et al. (2015) documented that flight activity ceased during periods of rain within a night as bats shelter in night roosts until conditions improve. 'Ōpe'ape'a activity increased at low and middle elevations during periods of lower mean rainfall, and increased at high elevations during non-reproductive periods with higher seasonal mean rainfall. On Hawai'i island, movements into high elevation during winter provides better foraging conditions as rainfall at high elevations at this time is half that at low elevations, while the availability of insect prey is the same as low elevations. Low annual rainfall with increased clear, calm nights can lead to improved conditions for bat foraging, which possibly contributed to locally increased bat activity in a Maui study in 2012 (Todd et al. 2016). In the two following years, higher rainfall and possibly other climatic variables may have contributed to increased foraging time outside of the study area by these highly mobile animals (Todd et al. 2016).

In addition, Bonaccorso et al. (2016) examined altitudinal movements involving previously unknown use of caves by ʻōpeʻapeʻa during winter and spring (November 2012 to April 2013) in the Mauna Loa Forest Reserve (MLFR), Hawaiʻi island. Acoustic detection of Hawaiian hoary bat vocalizations were recorded each month outside thirteen lava tube cave entrances situated between 2,200-3,600 meters (7,200-11,800 feet) above sea level. The occurrence of feeding buzzes around cave entrances and visual observations of bats flying in an "acrobatic fashion" in cave interiors point to the use of these spaces as foraging sites (Bonaccorso et al. 2016). *Peridroma* moth species (Family: Noctuidae), the only abundant nocturnal, flying insect sheltering in large numbers in rock rubble and on cave walls in the MLFR, apparently serve as the principal prey attracting ʻōpeʻapeʻa during winter to these lava tube caves. Bat foraging activity evidenced by the amount of search and feeding buzz calls in the MLFR is correlated with relatively low wind speeds, air temperatures above 6 °C, and conditions believed to be free of heavy fog and rain, similar to what Gorresen et al. (2015) observed on Oʻahu. Winds above six m/sec generally reduce vespertilionid bat flight activity (Arnett et al. 2008, Schuster et al. 2015). Visual searches found no evidence of Hawaiian hoary bats sheltering by day in these caves nor were there signs of hibernacula (Bonaccorso et al. 2016). However, the presence of over 300 skeletons and mummies of bats found in cave interiors indicates Hawaiian hoary bats occasionally fly deep into the caves. One possible way for Hawaiian hoary bats in Hawaiʻi to avoid inclement weather conditions while hunting for aerial nocturnal insects is to fly to elevations above the cloud inversion layer, a condition frequently occurring above the 1,700 meter (5,600 feet) elevation in the MLFR (Giambelluca and Schroeder 1998). Bonaccorso et al. (2016) shows that Hawaiian hoary bat make particularly heavy use of the high elevation caves in the MLFP during December and January, thus the MLFR and other areas of similar elevation with lava tube caves may be particularly important as winter foraging areas.

Seasonal torpor in Hawaiian hoary has not been researched extensively yet. Understanding the role of torpor and how bats in Hawaiʻi facilitate it at different elevations and temperatures will provide important ecological answers to habitat use and offer insight into determining times for timber harvest that minimize impact on the bat. For example, if bats choose to move to higher elevations during winter months in order to induce long-term torpor then these areas may not be suitable for tree harvest during the winter months. Understanding torpor also will be important when examining the possible effects of climate change.

NEW OR CHANGING THREATS

Wind Energy

Systematic and structured monitoring (as described in Appendix C) have shown that the expansion of land-based wind energy facilities is the greatest quantified source of mortality of the Hawaiian hoary bat. The number of fatalities have been higher than was anticipated at the time of the issuance of permits. Pre-construction monitoring under-represented the number of bats transgressing the proposed wind facility site or that may potentially visit the site after construction of the wind facilities in Hawaii. Stringent monitoring has shown that turbines do pose a collision risk to Hawaiian hoary bats and modelling has provided a means to account for the imperfect detection of fatalities, thus accounting for fatalities the *may* have occurred but that were not found.

Currently, there are eight operating wind facilities and one under construction in Hawaiʻi. Of those nine facilities, five have applied for and received Incidental Take Permits (ITP) under section 10(a)(1)(B) of the ESA, one is under a federal Biological Opinion and State approved habitat conservation plan (HCP), one is awaiting finalization of the HCP, and one has applied for an ITP. The other operating facility is developing a draft HCP. As of September 2018, there have been 81 observed Hawaiian hoary bat fatalities at the six operational wind energy facilities that are monitoring and reporting their take. Because of imperfect detection of the fatalities, and the potential loss of pups if the female is killed during the breeding season, the modeled estimate of fatalities that have occurred since 2006 is no more than 194 bats for the six operational facilities. The number of fatalities from collision that the Service is 80% certain has not been exceeded by the four projects in this PEIS through September 2018 is provided in Appendix C with the accompanying details associated with detection probability. The highest observed rates of wind turbine associated Hawaiian hoary bat fatalities occur on Maui and Oʻahu. Between 2012 and 2018 there were 5.6 bat fatalities/year observed (found) on Maui and 7.3 bat fatalities/year found on Oʻahu annually (Kawailoa Wind Annual Report 2018, Kahuku Wind Power Annual Report 2018, Kaheawa Wind Power I Annual Report 2018, Kaheawa Wind Power II Annual Report 2018, Auwahi Wind Annual Reports 2018). About 1-3 bat fatalities/year has also occurred on Hawaiʻi island though there is less systematic monitoring occurring at two of the three wind facilities on that island (SWCA 2018). Hawi, on Hawaiʻi island is not conducting standardized monitoring though an HCP is reportedly under development. Lalamilo Wind, also on Hawaiʻi island is operating only during daylight hours to avoid impacts to Hawaiian hoary bats while seeking an ITP SWCA 2017). On Oʻahu, Na Pua Makani Wind (Tetra Tech 2016), in Kahuku, Oʻahu, is not yet constructed but has obtained an incidental take permit that includes Hawaiian hoary bats and Pulehua Wind, in Makakilo, has coordinated with the Service and is preparing a draft HCP. For the wind facilities operating under an ITP and HCP, projects are required to avoid and minimize take to the maximum extent practicable and provide compensatory mitigation for impacts that cannot be avoided.

To avoid and minimize incidental take of Hawaiian hoary bat, the majority of the wind facilities are using Low Wind Speed Curtailment (LWSC) at various levels. Appendix D provides background for low wind speed curtailment. The goal of this approach is to limit the time turbines are spinning during periods of lower wind speed when bats are more likely to be flying. While LWSC does appear to reduce the level of take at wind facilities, it is difficult to determine how statistically effective they are due to the infrequency and high variability in take levels (Appendix D). The use of deterrents, which would deter bats from flying in the immediate vicinity of spinning turbines, are currently under development on the Mainland, but it is not yet clear at what point they will be commercially available and installed in Hawaiʻi. Further testing will be needed to determine the level of efficacy deterrents have in minimizing take of Hawaiian hoary bat. The only definitive approach to avoiding take of Hawaiian hoary bat is to fully curtail all turbines on all islands from dusk to dawn. This strategy, while effective, is not considered a long-term strategy for existing wind facilities as they already have signed Power Purchase Agreements with local utilities and such curtailment would make them no longer economically viable.

To offset take that cannot be avoided, wind facilities operating under an ITP implement a variety of conservation projects, including land purchase and protection, forest or wetland restoration, and targeted research projects for the Hawaiian hoary bat. The implementation of such projects would be anticipated to fully offset impacts, resulting in a "no net loss" for the species. However, given the limited information on basic life history needs and difficulty in tying land-based mitigation projects to a specific increase in bat numbers or fecundity, significant uncertainty remains regarding the effectiveness of land-based mitigation projects for Hawaiian hoary bat. Compensatory mitigation projects currently rely on adaptive management programs to ensure measures of success are met and take is effectively offset. The targeted research projects in the long-term should contribute to our collective understanding of the species' needs and life history parameters. These research needs are considered some of the highest priority recovery actions for Hawaiian hoary bat in the Recovery Plan (USFWS 1998).

In 2015, the State of Hawaiʻi passed a bill (HB623) setting a target of achieving 100% renewable energy by 2045. The renewable energy projects that are under development according to HECO or known to the Service are shown in Appendix I. Wind energy currently accounts for 29% of the renewable energy produced statewide. All future proposed wind facilities would be expected to develop Habitat Conservation Plans and seek ITPs from the Service if the projects would pose a risk to Hawaiian hoary bats. Thus far, the Service has been informed of the potential development of three additional wind facilities, one on the island of Oʻahu and two on Maui.

Timber Harvesting

Timber harvest of trees greater than five meters in height when Hawaiian hoary bat and their dependent pups are present continues to be a threat. Non-volant, dependent pups are reliant on their mother to move them out of a roost tree during timber harvest. The ability of a female Hawaiian hoary bat to accomplish this move is constrained by the weight of the pup and perception of the threat. Detection of roosting bats in trees with thermal imaging is limited by canopy structure and relatively small differences between ambient temperatures and Hawaiian hoary bat body temperatures. Silviculture and biomass harvest operations exist primarily on the islands of Kauaʻi and Hawaiʻi. The Service recommends to not cutting trees above 15 ft between June 1 and September 15 to avoid impact to dependent (non-volant) bat pups. Hawaiian hoary bat roost in a wide variety of trees (native and non-native), are widely distributed across all islands, thus limited removal of trees outside of the pupping season is not currently anticipated to result in adverse effects to Hawaiian hoary bat populations. However, removal of a functioning habitat that has taken years to develop, might be expected to have impacts on the activity and territoriality of bats. Degradation or removal of roosting and foraging resources may increase the distance ʻōpeʻapeʻa need to travel to obtain the necessary sustenance for survival and reproduction and may reduce fitness. The Service is working with the timber industry to avoid, minimize, and mitigate impacts should harvest occur during the pupping period.

Barbed Wire
Hawaiian hoary bat fatalities have been detected on barbed wire fences (Zimpfer and Bonaccorso 2010, USFWS unpublished data). The extent of this issue is unknown due to the lack of systematic monitoring of fences and/or reporting of mortalities. Landscape characteristics may affect the likelihood of bat fatalities occurring. Currently, there is limited data to assess the impact of this threat to Hawaiian hoary bat populations. The Service recommends removal or replacement of barbed wire in consultations that involve fencing. The use of barbed wire may be expected to be decreasing.

Pesticide
Pesticide use may have an impact on the species by reducing or altering the prey population, or through biomagnification via prey base. Effects are mostly unknown. Trace amounts of rodenticide residues have been detected in carcass tissues from 2/21 Hawaiian hoary bat carcasses examined (USFWS unpubl. data), but there is currently no data available in Hawaiʻi to evaluate the potential impact to Hawaiian hoary bats by island or statewide.

Predation
It is unknown if predation by introduced rats (*Rattus* spp.) and barn owls (*Tyto alba*) or the native pueo (*Asio flammeus sandwichensis*) is a significant threat to the Hawaiian hoary bat. There is no research in process or being planned to look at this potential due to the difficulty in finding and monitoring sufficient roost sites. Cats can also prey on dependent pups that may fall from a roost, though the frequency of this is not known (USFWS, unpubished).

Coqui Frogs
Coqui frogs, introduced to the State of Hawaiʻi in the late 1980s (Woolbright et al. 2006), are widely established on Hawaiʻi island, and are found in smaller areas on Maui, Oʻahu, and Kauaʻi islands (Hawaiʻi Invasive Species Council 2018). The highest densities of frogs (20,000–40,000 individuals/hectare) are found at elevations lower than 670 meters (2,200 feet) above sea level (Beard et al. 2009), but the frogs are now spreading to mid-elevation forests (900–1,200 meters [3,000-3,900 feet]) and have the ability to thrive and successfully overwinter at higher elevations in Hawaiʻi (Kraus and Campbell 2002, Hawaiʻi Invasive Species Council 2018). They have limited predators (mongoose, rats, and feral cats) enabling these frogs to become successful invaders across wet forest habitats and allowing their populations to grow extraordinarily dense compared to their native habitat of Puerto Rico (Woolbright et al. 2006). The spread to higher elevations poses increased threat to insect resources that overlap with the Hawaiian hoary bat. An analysis of coqui frog diets at lowland sites on the islands of Hawaiʻi and Maui found many invertebrates consumed by the frogs were leaf litter insects, as well as a large number of flying insects, indicating that these frogs are actively foraging while climbing trees (Beard 2007). Dietary analysis of the coqui frog on the island of Hawaiʻi showed that aerial insects make up 33.8% of the diet (Bernard and Mautz 2016). The frogs have the ability to consume 4,500–56,000 prey/hectare/night, with 1,500–19,000 of these being aerial insects (Bernard and Mautz

2016). As determined from the aerial arthropod counts from Todd (2012), low elevation study sites had an estimated 17,000–21,000 available aerial insects/hectare, and the high elevation sites were estimated to have 20,000–74,000 available aerial insects/hectare. At low elevation, coqui frogs could potentially consume up to 91% of the available aerial arthropods. While the diet of Hawaiian hoary bat is consistently dominated by moths at both high and low elevations, the bats displayed foraging preference at high elevations rather than taking prey proportional to availability as they do at low elevations (Todd 2012). In addition, the ground insect feeding behavior of the frogs can result in the consumption of larval stages of moths and beetles thereby reducing the adult aerial prey availability of moths and beetles. Increases in coqui frog densities at higher elevations has the potential to change the foraging patterns of Hawaiian hoary bat. Bats were found to consume fewer Coleoptera prey at low elevations where there were dense coqui frog populations compared to areas with few to no frogs (Bernard 2011). While the overall degree of dietary overlap between the Hawaiian hoary bat and the coqui frog was relatively low, the percentage of total available aerial arthropods shared by both species could be up to 64.9 % (Bernard and Mautz 2016). This estimate identifies the range of competition the Hawaiian hoary bat may have in low elevation sites shared with the coqui frog. The competitive impact of the invasive frog predator on the Hawaiian hoary bat may be measurable in areas that overlap with coqui frog occupancy, due to the high population densities the frog achieves and their continued altitudinal spread throughout the islands.

Climate Change

Climate change may exacerbate the impacts of coqui frogs by allowing an expansion of their numbers into higher elevation areas, where they would compete with Hawaiian hoary bat by changing the composition of the insect fauna available to forage. Other impacts from climate change to Hawaiian hoary bats are unknown. Warmer temperatures may allow an expansion of pupping habitat into higher elevation areas, but may also affect habitat conditions by effecting changes to the prey base resulting in sub-optimal foraging conditions. These impacts may be mitigated by the ability of the Hawaiian hoary bat to range widely in search of resources.

NEW MANAGEMENT ACTIONS

The projects described here only focus on those that are specifically conducted for the benefit of the Hawaiian hoary bat since 2011. The projects described do not include those that may benefit the bat but that were conducted or are underway for other protected species. Also, the management actions do not include actions of private property owners or projects that the Service does not monitor.

Compensatory mitigation and conservation actions for the Hawaiian hoary bats has been undertaken at Kahikinui Forest Reserve (FR) and the adjoining Nakula Natural Area Reserve (NAR) to improve habitat and food resources specifically for bats. A management plan was developed for the area to improve 3,200 hectares (8,000 acres) of habitat, through 7.3 miles of fencing for exclusion of non-native herbivores, restoration of native vegetation, weed control, and predator removal (State of Hawaiʻi 2015b). As of 2016, the fenced area is ungulate free and monitoring continues to maintain the fence and detect ingress, while restoration of the forest through weeding and outplanting continues. Additional monitoring of Hawaiian hoary bat is planned to determine the effectiveness of the restoration compared to baseline levels before restoration began.

Bat surveys have been conducted in Kahikiui Forest Reserve and Nakula NAR on Maui (KFR-NNAR; Todd et al. 2016). The baseline information from those surveys indicated detection probabilities, mean pulses/night, percentage of nights with feeding activity, and acoustic detections are greater in recovering forest areas than in unrestored shrublands (Todd et al. 2016). While not direct evidence that more bats are being produced in restoration areas, the results show that more detections are occurring in the restoration areas, than had previously occurred prior to restoration. It is these type of research outcomes that will guide the Service and DOFAW in identifying mitigation projects that continue to improve bat productivity and survival into the future.

Another project for the Hawaiian hoary bat is being conducted through forest restoration of approximately 52 hectares (128 acres) of pastureland at Pu'u Makua, located in the Waihou area of Maui. The area is located on the northern section of the 'Ulupalakua Ranch referred to as the Waihou Mitigation Area. Prior to the initiation of the restoration actions, the Waihou Mitigation Area was comprised of degraded and remnant patches of rare, native forest ecosystems and pastureland. Once restored, this are will provide improved and expanded roosting and foraging opportunities and a forested corridor for Hawaiian hoary bats to travel between habitats at the Kula Forest Reserve, Auwahi Forest Restoration Project, and the Kanaio Forest Reserve. Restoration actions began in 2012 and include installation of an ungulate proof fence, ungulate removal, removal of invasive vegetation, and native plant restoration. This parcel was also placed into a conservation easement held by the Hawaiian Islands Land Trust to be protected in perpetuity.

Pu'u Makua reforestation and vegetation management efforts were monitored in 2016-2017, three years after baselines were established in 2014, using plant species coverage surveys (line-intercept), out-planting plot survivorship surveys, and established photo points. Recorded native woody species coverage was 26.8%, average plot survival rate of 87% and invasive species cover was 0.01%. Target invasive species have been removed and biannual vegetation management activities will continue to maintain target invasive species coverages well below the 50 percent required. Quarterly fenceline checks performed to monitor fence integrity have incorporated the creation and maintenance of a 10-15 foot buffer of target invasive species along the outside periphery of the fence. Native reforestation, vegetation monitoring, and invasive species removal efforts will continue. Studies on Hawaiian hoary bat's prey resource abundance strongly indicate the project is providing improved prey resources.

In March of 2015, acoustic bat detectors were deployed within the Puu Makua parcel and surrounding Waihou mitigation area. Monitoring was conducted for a period of approximately one year to establish a baseline of seasonal occupancy for Hawaiian hoary bats within the mitigation area prior to outplanting. The acoustic monitoring also informs radio tagging and telemetry efforts to evaluate ōpe'ape'a home range size and habitat composition, seasonal activity patterns at the WMA, prey abundance and diet composition. During this research project, the USGS captured, sampled, and radio-tagged 11 ōpe'ape'a. A key finding of this ongoing research project was the observation of broadcast tower interference with radio-telemetry signals. In response to the interference, the radio-telemetry component of this project has been adaptively managed in consultation with the wildlife agencies. The resulting adaptive management measures include an increase in the staff effort devoted to nights of mist-netting at Puu Makua and outlying areas within Ulupalakua Ranch, to capture bats for genetic sampling and fecal collection for diet analysis, the addition of a second season of insect prey base sampling at WMA and mist net sites, and an increase in the number of insect prey species that will be bar-coded to screen bat fecal pellets in a dietary study. Based on preliminary evaluation it appears that a prey base to support foraging bats currently exists at WMA, and within the Pu'u Makua Restoration Area. With continued management to restore a self-sustaining forest, the area is expected to provide a stable abundance of prey, as well as roosting resources for generations of bats into perpetuity.

On O'ahu, a mitigation project has focused on restoring 32 hectares (79 acres) of the 'Uko'a wetland area to increase its foraging habitat value for Hawaiian hoary bat, and managing 16 hectares (40 acres) surrounding the wetland to create foraging lanes and increase native tree species favorable to bat roosting. The management plan was finalized in August 2014 (H.T. Harvey and SWCA 2014), and amended in March 2016. The wetland was fenced and maintained to keep the area inside ungulate-free. Invasive vegetation, primarily water hyacinth (*Eichhornia crassipes*), has been removed from the open water areas of the wetland to improve insect production for bat foraging. Quarterly maintenance visits will also be conducted to remove any small areas of water hyacinth that have regenerated through year 2032. Nonnative trees were removed to create 5-meter-wide corridors that have been shown to support bat foraging (Jantzen 2012, Kawailoa Wind 2017). Insect collection was conducted in June-October 2014 and June-October 2015 and submitted for analysis to establish baselines for Hawaiian hoary bat prey levels and composition prior to the removal of invasive vegetation and restoration actions. Baseline acoustical monitoring for Hawaiian hoary bats at the site began in April 2012 and is ongoing (Kawailoa Wind 2017).

Additional conservation actions for Hawaiian hoary bat are taking the form of long-term protection of areas that support forest suitable for this species from clearing and development. Two of these land acquisition projects have been, or will be, undertaken on O'ahu. Approximately 1,142 hectares (2,822 acres) of the Helemano Wilderness Area located near Wahiawā, in central O'ahu, was acquired in October 2018, protecting the area from development for perpetuity. The land will be managed for multiple uses, including for the benefit of bats and other protected and native species. Helemano Wilderness Area includes significant tracts of native forest habitat within the documented range of the Hawaiian hoary bat that are at risk due to the encroachment of invasive plant and animal species and potential anthropogenic activities (e.g., residential development). The property also includes non-forested fallow agricultural areas suitable for forest restoration and this mix of forested lands and fallow agricultural lands is anticipated to provide foraging and roosting habitat for bats. Hawaiian hoary bats have been detected in the immediate areas surrounding the property and it is highly likely the area itself is occupied by Hawaiian hoary bats. The area will also support the movement of bats between central O'ahu and the north shore along the major forested parcels in the Ko'olau mountains. A second project for protection of Hawaiian hoary bat is occurring on the north shore of O'ahu at

Pūpūkea Mauka, where the upper portions of the Waimea River watershed will come under long-term management by the State of Hawaiʻi for conservation of Hawaiian hoary bats and other native species. This 1,504 hectare (3,716 acre) property consists predominantly of native forest and Hawaiian hoary bat have been documented regularly in and around the property at high occupancies.

Approximately 1,326 hectares (3,277 acres) of the Kamehamenui Forest located on the leeward side of Haleakalā, Maui, are also expected to be acquired by DOFAW, protecting the area from development and enhancing mitigation opportunities for Hawaiian hoary bat on the island. DOFAW will fence portions of the property, followed by ungulate control and forest restoration. Management of the natural resources in the area will include: (1) conservation of the native subalpine habitat including fencing, ungulate removal, and restoration for Hawaiian hoary bat and other endangered species and native communities; and (2) native forest restoration below the subalpine habitat to connect existing habitat for Hawaiian hoary bats. The Kamekamenui Forest is likely occupied by Hawaiian hoary bats, based on detections above, below, and on both sides of the property in similar terrains. The property borders Haleakalā National Park, the Kula Forest Reserve, and nearby open ranches to provide transit interconnectivity for Hawaiian hoary bat movement.

ONGOING RESEARCH

The Recovery Plan for the Hawaiian Hoary Bat identifies the interim goal of the plan as determining the actual population status and habitat requirements of the Hawaiian hoary bat (USFWS 1998). As such, significant research is underway to build a better picture of the life history traits, ecological requirements, population and distribution, and genetic structure of the Hawaiian hoary bat.

An initial step in examining population and trends was a power analysis conducted by Western EcoSystems Technology, Inc. (WEST) to determine the approximate annual sample size of sites required to detect Hawaiian hoary bat occupancy trends of various magnitudes (WEST 2015). A pilot data set from a five-year study of Hawaiian hoary bat in Hawaiʻi provided the basis for the power simulation (Gorresen et al. 2013). The simulations indicated that the annual sample size of sites is more important than the number of within-year revisits to a site for improving the ability to detect trends. This analysis will assist in the development of projects that can monitor the population status of the Hawaiian hoary bat over the long-term.

One project that follows up on the power analysis is using acoustic monitoring to determine the distribution and occupancy of Hawaiian hoary bats across all habitats on Oʻahu (WEST 2016). This study expands the knowledge base of the species on Oʻahu, which is important due to potential wind facility expansion on the island and the limited previous island-specific data. Another project on Oʻahu looks to model foraging habitat suitability, which will serve to develop more robust occupancy models and examine habitat quality for foraging by including insect sampling as an additional variable (USGS-PIERC 2016). Objectives of this research project include simultaneous videography and acoustic analysis, insect collection, and modeling habitat characteristics, meteorological conditions, and available insect prey as potential predictors of bat occurrence and feeding activity. The results of this project are expected to inform actions to avoid and minimize risks to bats through operational actions and identify habitat characteristics that benefit Hawaiian hoary bats.

Additional conservation genetics research on Hawaiian hoary bats, including sexing of bat carcasses (Pinzari and Bonaccorso 2018) and evaluating genetic variability, intra-island divergence, genetically distinct populations, effective population size, and recent evolutionary bottleneck events, is ongoing (USGS-PIERC 2016). Objectives include genotyping and identifying the sex of bats obtained from existing USGS collection, wind facilities, and live bats captured in other research projects, evaluating mitochondrial DNA markers, nuclear micro-satellites, and single nucleotide polymorphisms, constructing a reference genome, evaluating genetic variability and intra-island divergence, and identifying genetically distinct populations, effective population size, and recent evolutionary bottleneck events. The outcomes of this research project will provide additional insight into the work published by Russell et al. (2015) and Baird et al. (2015, 2017), while examining population structure between islands.

Additional ecological field projects seeking to expand the knowledge base on the life history of this species are primarily taking place on Maui and Hawai‘i islands. Research is being conducted in the Pu‘u Makua restoration area of Maui to examine seasonality, prey base, diet analysis, and occupancy over time as restoration proceeds in the area (USGS-PIERC 2017b).

Another project on Maui is examining Hawaiian hoary bat home ranges, seasonal movements, habitat utilization, diet, and prey availability (H.T. Harvey & Associates 2016). This project is using acoustic monitoring and habitat associations, insect collection within the habitat types and barcoding to determine taxa, radio-telemetry studies of 16-20 bats, and analysis of habitat occupancy across a variety of habitat and elevations. Preliminary results indicate Hawaiian hoary bat home range averages about 1,200 acres (2,967 acres) and can range from 1,200-26,000 hectares (3,000-64,000 acres) (Johnston et al. 2019). Of the nine habitats being evaluated, grasslands, gulches, and low-density developed areas have the highest concentration of detections. The features shared by these three habitats is openness, allowing for unobstructed prey detection, and warmer temperatures, which is believed to be conducive to insect flight (Johnston et al., 2019).

A similar comprehensive study on the movements, roosting behavior, and diet of the Hawaiian hoary bat is being conducted on Hawai‘i island (USGS-PIERC 2016). Objectives of this study include radio-tagging and collecting data from up to 48 bats per year to look at seasonal and annual home range and movement patterns, conducting a fecal analysis with molecular barcoding for diet composition and food availability, identifying habitats used for foraging, roosting, and breeding, and mother-pup demographics and predation at maternity roosts. This study has the potential to verify and refine previous movement studies, while also collecting key life history data where significant data gaps currently exist.

A study developing video methods to monitor activity by nocturnal animals, studying bat behavior at turbines, modeling activity relative to weather and assessing fatality risk, and testing use of UV light to reduce bat flight activity near turbines is being led by USGS (USGS-PIERC

2017a). Ultraviolet light illumination at wind energy turbines may eventually be useful for deterring bat activity at turbines.

SYNTHESIS

Since the Service conducted the 5-year review in 2011, significant new information on the genetics, seasonal movements, foraging and diet, and distribution of the Hawaiian hoary bat has been collected. Ongoing research to develop and refine reliable detection tools, management and conservation actions, and bat deterrents to reduce the threats posed by wind energy turbines continues. There remain significant gaps in our understanding of the species' abundance, life history parameters, limiting factors, and overall population trend.

Recent genetic studies indicate the presence of multiple colonization events to the islands and two different clades within the Hawaiian hoary bat population across the state of Hawaiʻi. and. These groups appear to have different island distributions. Based on the limited genetic information available, each clade appears to have representation on more than one island, though the extent of the redundancy and representation of the clades on Molokaʻi, Kauai, and Lānaʻi, is not yet known. Hybridization between the two clades suggests species divergence is not completely established. The presence of multiple alleles at several of the loci examined in the genetic analyses suggest genetic diversity is present, at least at the loci evaluated. Recovery actions should focus on protection and conservation of the Hawaiian hoary bat statewide while recognizing the need to maintain the genetic diversity that each islands population represents. As of now, the taxon is considered as one unit statewide and the status is evaluated accordingly.

The Hawaiian hoary bat was listed in 1970 based on apparent habitat loss and limited knowledge of its distribution and life history requirements. Substantial monitoring efforts are underway to better understand the distribution and occupancy of the Hawaiian hoary bat on several of the major islands, namely Oʻahu, Maui, and Hawaiʻi. Though the population remains unknown, the Hawaiian hoary bat appears to be widely distributed, or at least wide-ranging, across the islands, based on current studies. It feeds on a variety of insects and may move seasonally or daily in search of resources. They roost in a wide variety of native and non-native trees, and have been documented in urban, semi-urban, and agricultural areas (in addition to native and non-native forests). Due to this, roosting habitat is not believed to be a limiting factor for the species.

Aside from roosting needs, there is limited understanding of the ecological needs or limiting factors of the species and whether those factors differ by island or season. On Hawaiʻi island, at least some individuals make daily movements above tree line to feed on moths in high elevation caves, a habitat not available on other islands. Other observations indicate that Hawaiian hoary bats use discrete core use areas within a larger foraging range, but these areas may shift seasonally or even nightly depending on local climatic and weather conditions. Overall, the information currently available points to a species that is well adapted to a range of environments and resilient to small-scale changes in habitat condition and available resources.

Hawaiian hoary bat are now known to be breeding on at least five islands and possibly two additional ones where they are known to occur. Gorresen et al. (2015) found stable to slightly increasing occupancy based on the breeding season over five years of surveys on Hawaiʻi island.

Interisland movement is thought to be low, with the possible exception of movement between Maui, Lānaʻi, and/or Kahoʻolawe (the islands of Maui Nui). Little to no information exists on demographic characteristics such as longevity, fecundity, survival rate, and others, for hoary bats, either in Hawaiʻi or on the Mainland.

Intensive monitoring has shown that nighttime operation of wind energy facilities in Hawaii has resulted in a greater number of Hawaiian hoary bat fatalities than previously anticipated when commercial wind energy turbines first began operating in Hawaii. Because the interisland movement of the Hawaiian hoary bat is considered to be low, localized impacts to the population may be expected to be greater on islands with wind energy facilities operating at night. Because of the protected status of the bat, wind energy facilities are required to avoid, minimize and mitigate to offset the loss through fatalities and not jeopardize the existence of the species. Mitigation actions are carried out on the island where the fatalities occur in an effort to sustain the islands representative population. The effectiveness of compensatory mitigation requires continued research, monitoring, feedback, and adaptive management to ensure the mitigation meets the success criteria and the needs of the bat. Hawaiian hoary bats that are resident on islands that do not have currently have wind energy facilities are not believed to be at direct risk by wind energy due to limited interisland movement.

Barbed wire-associated bat fatalities have been documented but, unlike wind energy turbines, most barbed wire fences are not monitored or, at best, are monitored infrequently. The impacts of pesticides, historically or presently is unknown. These threats would impact the Hawaiian hoary bat presumably statewide.

There remains uncertainty surrounding the taxonomic status of the species. Representatives of each clade are dispersed across more than one island. There is also uncertainty with regard to what factors limit the Hawaiian hoary bat and the archipelagos carrying capacity. Overall, Hawaiian hoary bats have a much wider distribution than was known at the time of listing and appear adapted to a range of environments and variable habitat and resource conditions. The species moves widely both nightly and seasonally (at least on some islands) and the bats are known to breed on at least five of the islands and possibly more.

LITERATURE CITED

Arnett, E. B., W. K. Brown, W. P. Erickson, J. K. Fiedler, B. L. Hamilton, T. H. Henry, A. Jain, G. D. Johnson, J. Kerns, R. R. Koford, C. P. Nicholson, T. J. O'Connell, M. D. Piorkowski, and R. D. Tankersly, Jr. 2008. Patterns of bat fatalities at wind energy facilities in North America. Journal of Wildlife Management 72:61-78.

Auwahi Wind. 2017. Auwahi Wind Farm Habitat Conservation Plan FY 2016 Annual Report. 94 pp.

Baird, A. B., J. K. Braun, M. A. Mares, J. C. Morales, J. C. Patton, C. Q. Tran, and J. W. Bickham. 2015. Molecular systematic revision of tree bats (Lasiurini): doubling the native mammals of the Hawaiian Islands. Journal of Mammalogy 96 (6): 1255–1274.

Baird, A. B, J. K. Braun, M. D. Engstrom, A. C. Holbert, M.G. Huerta, B.K. Lim, M. A. Mares, J. C. Patton, and J. W. Bickham. 2017. Nuclear and mtDNA phylogenetic analyses clarify the evolutionary history of two species of native Hawaiian bats and the taxonomy of Lasiurini (Mammalia: Chiroptera). PLoS ONE 12:e0186085. https://doi.org/10.1371/journal.pone.0186085

Baker. R. J., J. C. Patton, H. H. Genoways, and J. W. Bickham. 1988. Genic studies of *Lasiurus* (Chiroptera: Vespertilionidae). Occasional Papers the Museum Texas Tech University Number 117.

Banko, P. C., R. W. Peck, S. G. Yelenik, E. H. Paxton, F. J. Bonaccorso, K. Montoya-Aiona, and D. Foote. 2014. Dynamics and ecological consequences of the 2013−2014 koa moth outbreak at Hakalau Forest National Wildlife Refuge. Technical Report HCSU-058, Hawai'i Cooperative Studies Unit, University of Hawai'i at Hilo, Hawai'i, 89 pp

Barclay, R. M. R. 1989. The effect of reproductive condition on the foraging behavior of female hoary bats, *Lasiurus cinereus*. Behavioral Ecology and Sociobiology. 24: 31-37.

Barclay, R. M. R., J. H. Fullard, and D. S. Jacobs. 1999. Variation in the echolocation calls of the hoary bat (*Lasiurus cinereus*): influence of body size, habitat structure, and geographic location. Canadian Journal of Zoology 77:530-534.

Beard, K.H. 2007. Diet of the invasive frog, *Eleutherodactylus coqui*, in Hawai'i. Copeia 2007:281-291.

Bernard, R. F., J. T. Foster, E. V. Willcox, K. L. Parise, and G. F. McCracken. 2015. Molecular detection of the causative agent of white-nose syndrome on Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) and two species of migratory bats in the southeastern USA. Journal of Wildlife Diseases 51:519–522.

Bernard, R. F. and W. J. Mautz. 2016. Dietary overlap between the invasive coqui (*Eleutherodactylus coqui*) and the Hawaiian hoary bat (*Lasiurus cinereus semotus*) on the Island of Hawai'i. Biological Invasions 18:3409-3418.

Bogan, M.A. 1972. Observations on Parturition and Development in the Hoary Bat, *Lasiurus cinereus*. Journal of Mammalogy 53:611–614.

Bonaccorso, F. J. and C. A. Pinzari. 2011. Hawaiian hoary bat occupancy at the Pacific Missile Range Facility (PMRF) and Satellite Facilities. Final Report. September 2011. 26 pp.

Bonaccorso, F. J. and L. P. McGuire. 2013. Modeling the colonization of Hawai'i by hoary bats (*Lasiurus cinereus*). In: R. Adams and S. Pedersen (eds.) Bat Evolution, Ecology, and Conservation. Springer, New York, NY.

Bonaccorso, F. J., C. M. Todd, A. C. Miles, and P. M. Gorresen. 2015. Foraging range movements of the endangered Hawaiian hoary bat, *Lasiurus cinereus semotus* (Chiroptera: Vespertilionidae). Journal of Mammalogy 96:64–71.

Bonaccorso, F. J., K. Montoya-Aiona, C. A. Pinzari, and C. M. Todd. 2016. Winter distribution and use of high elevation caves as foraging sites by the endangered Hawaiian hoary bat (Lasiurus cinereus semotus). Technical Report 68, Hawai'i Cooperative Studies Unit, University of Hawai`i at Hilo, Hi. 24 pp.

Corcoran, A.J. and T. J. Weller. 2018. Inconspicuous echolocation in hoary bats (*Lasiurus cinereus*). Proceedings of the Royal Society B 285: 20180441.

Cryan, P. M., P. M. Gorresen, C. D. Hein, M. R. Schirmacher, R. Diehl, M. Huso, D. T. S. Hayman, P. Fricker, F. Bonaccorso, D. H. Johnson, K. Heist, and D. Dalton. 2014. Behavior of bats at wind turbines. Proceedings of the National Academy of Sciences 111:15126–15131.

Downs, N. C. and L. J. Sanderson. 2010. Do bats forage over cattle dung or over cattle. Acta Chiropterologica 12:349–358.

Frick, W. F., E. F. Baerwald, J. F. Pollock, R. M. R. Barclay, J. A. Szymanski, T. J. Weller, A. L. Russell, S. C. Loeb, R. A. Medellin, and L. P. McGuire. 2017. Fatalities at wind turbines may threaten population viability of a migratory bat. Biological Conservation 209:172-177.

Giambelluca, T. W. and T. A. Schroeder. 1998. Climate. In: S. Juvik and J. Juvik (eds.) Atlas of Hawai'i. University of Hawai'i Press, Honolulu, HI.

Gorresen, M. P., F. J. Bonaccorso, C. A. Pinzari, C. M. Todd, K. Montoya-Aiona, and K. Brinck. 2013. A five-year study of Hawaiian hoary bat (*Lasiurus cinereus semotus*) occupancy on the Island of Hawai'i. Technical Report HCSU-041. Hawai'i Cooperative Studies Unit, University of Hawai'i at Hilo, Hawai'i. 48 pp

Gorresen, M. P., P. M. Cryan, M. Huso, C. Hein, M. Schirmacher, J. Johnson, K. Montoya-Aiona, K. W. Brinck and F. J. Bonaccorso. 2015. Behavior of the Hawaiian hoary bat at wind turbines and its distribution across the North Ko'olau Mountains, O'ahu. Technical Report HCSU-064, Hawai`i Cooperative Studies Unit, University of Hawai'i at Hilo, Hawai'i, 68 pp

Hawai'i Invasive Species Council. 2018. Coqui. http://dlnr.hawaii.gov/hisc/info/invasive-species-profiles/coqui/ assessed June 28, 2018.

Hein, C. D., J. Gruver, and E. B. Arnett. 2013. Relating pre-construction bat activity and post-construction bat fatality to predict risk at wind energy facilities: a synthesis. A report submitted to the National Renewable Energy Laboratory. Bat Conservation International, Austin, TX, USA.

Hosten, P. and R. Poland. 2018. How collaborative research has helped define Hawaiian hoary bat activity in Kalaupapa National Park, thus better informing park management strategies. 25th Annual Hawai'i Conservation Conference, July 24th 2018 - July 26th 2018. Honolulu, HI. Poster 119. http://www.hawaiiconservation.org/wp-content/uploads/Full-Abstract-Book_FINAL_7.6.2018.pdf. Abstract last accessed July 30, 2018.

H.T. Harvey, Consulting. 2013. Kawailoa Bat Mitigation Project at Ukoa Wetland. Report on Capture and Tracking of a bat from June 28, 2013 to July 5, 2013. 6 pp.

H.T. Harvey and Associates. 2016. Basic research of the home ranges, seasonal movements, habitat utilization, diet, and prey availability of the Hawaiian hoary bat on the island of Maui. Proposal submitted to Endangered Species Recovery Committee for Hawaiian hoary bat request for proposals, 2016. 31 pp.

H.T. Harvey and Associates Ecological Consultants/SWCA Environmental Consultants. 2014. 'Uko'a wetland Hawaiian hoary bat mitigation management plan. Prepared for First Wind. 31 pp.

Jacobs, D. S. 1996. Morphological divergence in an insular bat, *Lasiurus cinereus semotus*. Functional Ecology 10:622-630.

Jacobs, D. S. 1999. The diet of the insectivorous Hawaiian hoary bat (*Lasiurus cinereus semotus*). Canadian Journal of Zoology 77:1603–1607.

Jantzen, M.K. 2012. Bats and the Landscape: The influence of edge effects and forest cover on bat activity. Master's Thesis in the Graduate Program in Biology with Environmental and Sustainability. The University of Western Ontario, London, Ontario, Canada.

Johnston, D., K. Jonasson, and B. Yuen. 2018. Ecology of ʻōpeʻapeʻ (Hawaiian hoary bat on Maui. 25th Annual Hawaiʻi Conservation Conference, July 24th 2018 - July 26th 2018. Honolulu, HI. Poster 141. http://www.hawaiiconservation.org/wp-content/uploads/Full-Abstract-Book_FINAL_7.6.2018.pdf. Abstract last accessed July 30, 2018.

[KIRC] Kahoʻolawe Island Reserve Commission. 2017. Ko Hema Lamalama: Newsletter of the Kahoʻolawe Island Reserve June 2017.

Kaheawa Wind Power I. 2017. Kaheawa Wind Power I Habitat Conservation Plan Annual Report FY 2017. Submitted to USFWS. 52 pp

Kaheawa Wind Power II. 2017. Kaheawa Wind Power II Habitat Conservation Plan Annual Report FY 2017. Submitted to USFWS. 47 pp.

Kahuku Wind Power. 2017. Kahuku Wind Power Habitat Conservation Plan Annual Report FY2017. Submitted to USFWS. 46 pp.

Kawailoa Wind Power. 2017. Kawailoa Habitat Conservation Plan FY 2017 Annual Report. October 2017. Submitted to USFWS. 44 pp.

Kraus, F. and E. W. Campbell. 2002. Human-mediated escalation of a formerly eradicable problem: the invasion of Caribbean frogs in the Hawaiian Islands. Biological Invasions 4:327–332.

Menard, T. 2001. Activity patterns of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) in relation to reproductive time periods. Master's Thesis in Zoology, University of Hawaiʻi, Manoa.

Morales, J. C. and J. W. Bickham. 1995. Molecular systematics of the genus Lasiurus (Chiroptera: Vespertilionidae) based on restriction-site maps of the mitochondrial ribosomal genes. Journal of Mammalogy 76:730-749.

Moura, S., K. Montoya-Aiona, and F. Bonaccorso. 2018. Investigating roosting behaviors of the Hawaiian hoary bat (*Lasiurus cinerus semotus*) on Hawaiʻi Island. 25th Annual Hawaiʻi Conservation Conference, July 24th 2018 - July 26th 2018. Honolulu, HI. Presentation 137. http://www.hawaiiconservation.org/wp-content/uploads/Full-Abstract-Book_FINAL_7.6.2018.pdf. Abstract last accessed July 30, 2018.

Oʻahu Army Natural Resource Program, Annual Reports. 2016. 2016 status report on the Makua and Oʻahu Implementation Plans. Report 281 pp + Appendices 512 pp.

Pinzari, C. 2014. Hawaiian Hoary Bat Seasonal Acoustic Monitoring Study on Oʻahu Army Installations 2010-2014. Prepared for CSU. Available at: http://manoa.hawaii.edu/hpicesu/DPW/2014_YER/appendices_edited.pdf.

Pinzari, C.A. and Bonaccorso, F.J., 2018, Hawaiian Islands Hawaiian Hoary Bat Genetic Sexing 2009-2018 (ver. 2.0, November 2018): U.S. Geological Survey data release, https://doi.org/10.5066/P9R7L1NS.

Pinzari, C. A., F. J. Bonaccorso, and K. Montoya-Aiona. 2014. Hawaiian hoary bat occupancy at Kaloko-Honokōhau National Historic Park. Technical Report 51, Hawai`i Cooperative Studies Unit, University of Hawai`i at Hilo, HI. pp. 15.

Reeves, M. K. F. Amidon. 2018. Habitat Species Assessment Methods-Hawaii, Current condition summaries. Report from United States Fish and Wildlife Service, Honolulu, HI. August 2018.

Russell, A.L., C.A. Pinzari, M.J. Vonhof, K.J. Olival, and F.J. Bonaccorso. 2015. Two tickets to paradise: multiple dispersal events in the founding of hoary bat populations in Hawaiʻi. PLoS ONE 10(6): e0127912. [doi:10.1371/journal.pone.0127912]

Schuster, E., L. Bulling, and J. Köppel. 2015. Consolidating the state of knowledge: a synoptical review of wind energy's wildlife effects. Environmental Management 56:300-331.

Shiel, C. B., C. M. McAney, and J. S. Fairley. 1991. Analysis of the diet of Natterer's bat, *Myotis nattereri*, and the common long-eared bat, *Plecotus auritus*, in the west of Ireland. Journal of Zoology (London): 223:299–305.

Starcevich, L.A., J. Thompson, T. Rintz, E. Adamcyzk, D. Solick. 2019. Oahu Hawaiian hoary bat occupancy and distribution study. Project update and first year analysis prepared for the Hawaii Endangered Species Recovery Committee by Western EcoSytems Technology, Inc. 33 pp.

State of Hawai'i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2015. Hawai`i's comprehensive wildlife conservation strategy. Available at: http://dlnr.hawaii.gov/wildlife/hswap/. Accessed 21 June 2017.

State of Hawai`i, Division of Forestry and Wildlife. 2015. Nakula Natural Area Reserve Management Plan. 2015b. Available at: http://dlnr.hawaii.gov/ecosystems/nars/maui/nakula-2/. Accessed 21 June 2017.

Tetra Tech EC, Inc, and R.M. Towill Corporation. 2008. Environmental Assessment/Environmental Impact Statement Preparation Notice Lanai Wind Farm Project Lanai, Hawaii. Prepared for Castle & Cooke Resorts, LLC. September 19, 2008. 76 pp.

Todd, C. M. 2012. Effects of prey abundance on seasonal movements of the Hawaiian hoary bat (*Lasiurus cinereus semotus*). Master's Thesis. Department of Tropical Conservation Biology and Environmental Science. University of Hawai`i at Hilo, Hawai`i, 61pp.

Todd, C. M., C.A. Pinzari, and F.J. Bonaccorso. 2016. Acoustic surveys of Hawaiian hoary bats in Kahikinui Forest Reserve and Nakula Natural Area Reserve on the island of Maui. Technical Report HCSU-078. 26 pp.

[USFWS] U.S. Fish and Wildlife Service. 1998. Recovery Plan for the Hawaiian Hoary Bat. U.S. Fish and Wildlife Service, Portland, OR. 50 pp

[USFWS] U.S. Fish and Wildlife Service. 2011. Ōpe`ape`a or Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service, Portland, OR. 13 pp

[USFWS] U.S. Fish and Wildlife Service. 2018. Endangered and threatened wildlife and plants; initiation of 5-year status reviews of 18 species in Hawai'i, Oregon, Washington, Montana, and Idaho. Federal Register 83(14): 3014–3015.

[USGS-NWHC] U.S. Geological Survey National Wildlife Health Center. 2018. White-Nose Syndrome (WNS). https://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/ Accessed July 20 2018.

[USGS-PIERC] U.S. Geological Survey-Pacific Islands Ecosystems Research Center. 2016. Hawaiian hoary bat conservation biology: Movements, roosting behavior, and diet. Proposal submitted to Endangered Species Recovery Committee for Hawaiian hoary bat request for proposals, 2016. 18pp

[USGS-PIERC] U.S. Geological Survey-Pacific Islands Ecosystems Research Center. 2016. Hawaiian hoary bat conservation genetics. Proposal submitted to Endangered Species Recovery Committee for Hawaiian hoary bat request for proposals, 2016. 15 pp

[USGS-PIERC] U.S. Geological Survey-Pacific Islands Ecosystems Research Center. 2017a. Bat behavior and use of UV light to deter bats at wind turbines. Research Portfolio 2017. 40 pp.

[USGS-PIERC] U.S. Geological Survey-Pacific Islands Ecosystems Research Center. 2017b. Summary of field research on the Hawaiian hoary bat at Pu'u Makua Restoration Area, Maui. Research report from USGS-PIERC and Hawai'i Cooperative Studies Unit to Auwahi Wind Energy. 14 pp.

Weller, T.J. and J.A. Baldwin. 2012. Using echolocation monitoring to model bat occupancy and inform mitigations at wind energy facilities. Journal of Wildlife Management 76: 619–631. (doi:10.1002/jwmg.260

[WEST] Western EcoSystems Technology, Inc. 2015. Power analysis for trend detection in Hawaiian hoary bat occupancy in the Hawaiian Islands. November 11, 2015 report prepared by Western EcoSystems Technology, Inc, Corvallis, Oregon. 12pp.

[WEST] Western EcoSystems Technology, Inc. 2016. Hawaiian hoary bat. Proposal submitted to Endangered Species Recovery Committee for Hawaiian hoary bat request for proposals, 2016. Prepared by Western EcoSystems Technology, Inc, Corvallis, Oregon. 22 pp.

Whitaker, J. O., Jr. and P. Q. Tomich. 1983. Food habits of the hoary bat, *Lasiurus cinereus*, from Hawai'i. Journal of Mammalogy 64:151–152.

Wolfe, B. 2018. Presence of the endangered Hawaiian hoary bat on national wildlife refuges. 25th Annual Hawai'i Conservation Conference, July 24th 2018 - July 26th 2018. Honolulu, HI. Poster 208. http://www.hawaiiconservation.org/wp-content/uploads/Full-Abstract-Book_FINAL_7.6.2018.pdf. Abstract last accessed July 30, 2018.

Woolbright, L.L., A.H. Hara, C.M. Jacobsen, W.J. Mautz, and F.L. Benevides. 2006. Population densities of the coqui, *Eleutherodactylus coqui* (Anura:Leptodactylidae) in newly invaded Hawai'i and in native Puerto Rico. Journal of Herpetology 40: 122–126.

Personal communications

Corinna Pinzari to Dawn Bruns, et al. USFWS, September 3, 2015.
Frank Bonaccorso to Jeff Zimpfer, USFWS, May 2, 2011.

Summary of Impacts

List of Tables

Summary of impacts associated with the three alternatives for Auwahi Wind (Table H-1), Kawailoa Wind (Table H-2), KWP II (Table H-3) and Pakini Nui (Table H-4). Effects are limited to new impacts not previously analyzed in NEPA documents for Auwahi Wind (USFWS 2012), Kawailoa (USFWS 2011), and KWP II (Planning Solutions 2010, USFWS 2011) which are hereby incorporated into this PEIS by reference.

Table H-1. Summary of impacts associated with Alternative 1, 2, and 3 for the Auwahi Wind Project.

Auwahi Wind	**Alternative 1** **(No action)**	**Alternative 2** **(Proposed action)**	**Alternative 3** **(Increased curtailment)**
Geology and Soils	No impacts	Negligible impacts from soil disturbance during outplanting and water feature construction	Same as Alternative 2
Hydrology and Water Resources	No impacts or benefits from outplantings	Outplantings are expected to provide direct and indirect benefits to streams and to the Kamaole aquifer by improving water quality and increasing aquifer recharge; creation of two ponds is expected to have temporary adverse impacts to nearby surface water areas during pond construction; no change to hydrologic patterns or long term impact to groundwater are expected. Two existing springs will provide water for the ponds; water withdrawal represents a negligible volume from the aquifers and falls within the currently permitted water use	Same as Alternative 2
Natural Hazards (Flood/Wildfire)	No impacts or benefit of creation of ponds two dip tanks	Creation of two ponds with aerial fire-fighting dip tanks is expected to provide direct benefits to wildfire prevention and control.	Same as Alternative 2
Vegetation	No impacts or benefit from outplantings of natives or protection for perpetuity	Negligible, short-term adverse impacts due to ground disturbance; no impacts to rare or special status species; long-term beneficial impacts due to native forest restoration efforts and protection for perpetuity	Same as Alternative 2

Auwahi Wind	**Alternative 1** **(No action)**	**Alternative 2** **(Proposed action)**	**Alternative 3** **(Increased curtailment)**
Wildlife and Biodiversity	Provides the least risk to species that may fly at night through the turbine rotor sweep; no habitat-related beneficial impacts from mitigation	Collision risk to species that may fly at night through the rotor sweep zone Long-term beneficial impacts due to enhancement of native ecosystems, installation of year-round water resource, and protection of habitat for perpetuity and	Less risk of collision to species that fly at night than Alt. 2; same beneficial impacts as Alternative 2 but less acreage would be protected /restored
Hawaiian hoary bat	No impacts to Hawaiian hoary bats- no take and no mitigation benefits	Take of up to 119 Hawaiian hoary bats, through February 23, 2037; beneficial impacts for Tier 4 (up to 60 bats) include habitat enhancement, management, and protection into perpetuity of approximately 1,752 acres of 'Ulupalakua Ranch lands on leeward Haleakalā; for Tier 5 (up to 34 bats) mitigation would focus on restoration and management of at least 690 acres of land, protected into perpetuity, on Maui, and Tier 6 (up to 25 bats) mitigation would focus on restoration and management of at least 487 acres.	Take of up to 94 Hawaiian hoary bats; beneficial impacts from mitigation in Tiers 4 and 5 would be the same as Alt. 2. Tier 6 mitigation would not be implemented because of reduced take.
Hawaiian goose	No new impacts	Minor beneficial impacts to Hawaiian goose may be expected from Hawaiian hoary bat mitigation which includes installation of 2 ponds.	Same as Alternative 2

Auwahi Wind	**Alternative 1** **(No action)**	**Alternative 2** **(Proposed action)**	**Alternative 3** **(Increased curtailment)**
Hawaiian petrel	Negligible to beneficial impacts; complete curtailment of the turbines at night may decrease the risk of collision	Negligible impacts; low wind speed curtailment may reduce risk of collision	Negligible to beneficial impacts; curtailment of turbines for 5 months at night may reduce risk of collision; risks to the Hawaiian petrel may be slightly greater than Alternative 1 and less than Alternative 2, assuming a moving turbine blade poses more risk than a stationary turbine blade. However, there is not information available to quantify a difference.
Cultural Resources	No impacts to archeological resources or to Hawaiian hoary bat 'aumākua.	No impacts to archeological resources; adverse impacts are expected to individuals and families that identify Hawaiian hoary bats as 'aumākua	No impacts to archeological resources; adverse impacts are expected to individuals and families that identify Hawaiian hoary bats as 'aumākua but are expected to be less than alternative 2.

Auwahi Wind	**Alternative 1** **(No action)**	**Alternative 2** **(Proposed action)**	**Alternative 3** **(Increased curtailment)**
Public Services and Utilities	Adverse impact would be at least a 45% relative reduction in wind-generated energy output that would need to be replaced by another source; Daytime operations would provide beneficial impacts in the form of wind energy	Adverse impact would be up to a 20% relative reduction in energy production depending on wind speed	Adverse impact would be from 20- 40% relative reduction in energy production depending on wind speed

Table H-2. Summary of impacts associated with Alternative 1, 2, and 3 for the Kawailoa Wind Project.

Kawailoa Wind	**Alternative 1 (No action)**	**Alternative 2 (Proposed action)**	**Alternative 3 (Increased curtailment)**
Geology and Soils	No adverse or beneficial impacts	No adverse impacts would be expected from the land acquisition; beneficial impacts from protection of development; Negligible impacts could be expected in Tiers 5 and 6 associated with bat habitat restoration activities but would be short term; petrel burrow monitoring may cause short term soil compaction on marked paths	Same as Alternative 2
Hydrology and Water Resources	No adverse or beneficial impacts	Land acquisition of the HWA is expected to provide direct and indirect benefits to the water source that traverses the property and the aquifer below the parcels; Tier 5 and 6 mitigation could include restoration of terrestrial native vegetation and removal of invasive terrestrial and aquatic vegetation thereby improving water quality and wildlife access.	Same as Alternative 2 but with less restoration acreage
Natural Hazards (Flood/Wildfire)	No impacts	No impacts	Same as Alternative 2
Vegetation	No impacts or benefit from land acquisition or restoration	Long-term beneficial impacts would be expected from acquisition of lands for conservation and Tier 5 and 6 native forest restoration efforts	Same as Alternative 2 but no Tier 6 benefits
Wildlife and Biodiversity	Provides the least risk to species that may fly at night through the turbine rotor sweep; no habitat-related beneficial impacts from mitigation	Collision risk to species that may fly at night through the rotor sweep zone; long-term beneficial impacts due to acquisition of conservation lands; enhancement of native ecosystems	Less risk of collision to species that fly at night than Alt. 2; same beneficial impacts as Alternative 2 but less acreage would be protected /restored

Kawailoa Wind	**Alternative 1** **(No action)**	**Alternative 2** **(Proposed action)**	**Alternative 3** **(Increased curtailment)**
Hawaiian hoary bat	No impacts to Hawaiian hoary bats- no take and no mitigation benefits	Take of up to 205 Hawaiian hoary bats, through February 23, 2032; beneficial impacts of Tier 4 (up to 55 bats) acquisition of HWA conservation land (2882 acres) and bat habitat; for Tier 5 (up to 85 bats) mitigation would focus on restoration and management of at least 1725 acres of land, protected into perpetuity, on Maui, and Tier 6 (up to 65 bats) mitigation would focus on restoration and management of at least 1319 acres.	Take of up to 140 Hawaiian hoary bats; beneficial impacts from mitigation in Tiers 4 and 5 would be the same as Alt. 2. Tier 6 mitigation would not be implemented because of reduced take.
Hawaiian goose	No impacts	No impacts	Same as Alternative 2
Hawaiian petrel	Negligible to beneficial impacts; complete curtailment of the turbines at night may decrease the risk of collision	Take of up to 24 Hawaiian petrels; Benefits from predator control at at Hanakāpīʻai and Hanakoa are expected to more than offset take	

Kawailoa Wind	**Alternative 1** **(No action)**	**Alternative 2** **(Proposed action)**	**Alternative 3** **(Increased curtailment)**
Hawaiian petrel	Negligible to beneficial impacts; complete curtailment of the turbines at night may decrease the risk of collision	Take of up to 24 Hawaiian petrels; Benefits from predator control at at Hanakāpīʻai and Hanakoa are expected to more than offset take	Take of up to 24 Hawaiian petrels; Negligible to beneficial impacts from curtailment of turbines for 5 months at night may reduce risk of collision; risks to the Hawaiian petrel may be slightly greater than Alternative 1 and less than Alternative 2, assuming a moving turbine blade poses more risk than a stationary turbine blade. However, there is not information available to quantify a difference.

Kawailoa Wind	**Alternative 1** **(No action)**	**Alternative 2** **(Proposed action)**	**Alternative 3** **(Increased curtailment)**
Cultural Resources	No impacts to archeological resources or to Hawaiian hoary bat ʻaumākua.	No impacts to archeological resources; adverse impacts are expected to individuals and families that identify Hawaiian hoary bats as ʻaumākua	No impacts to archeological resources; adverse impacts are expected to individuals and families that identify Hawaiian hoary bats as ʻaumākua but are expected to be less than alternative 2.
Public Services and Utilities	Adverse impact would be at least a 45% relative reduction in wind-generated energy output that would need to be replaced by another source; Daytime operations would provide beneficial impacts in the form of wind energy	Adverse impact would be up to a 20% relative reduction in energy production depending on wind speed	Adverse impact would be from 20- 40% relative reduction in energy production depending on wind speed

Table H-3. Summary of impacts associated with Alternative 1, 2, and 3 for the Kaheawa Wind Phase II (KWP II) Project.

KWP II Wind	Alternative 1 (No action)	Alternative 2 (Proposed action)	Alternative 3 (Increased curtailment)
Geology and Soils	No impacts	Minor short-term soil compaction impacts form foot traffic at the Hawaiian goose pens may be expected	Same as Alternative 2
Hydrology and Water Resources	No impacts	No adverse or beneficial impacts	No adverse or beneficial impacts
Natural Hazards (Flood/Wildfire)	No impacts	No impacts	Same as Alternative 2
Vegetation	No impacts	Predator control and fence maintenance at the Piʻiholo Ranch Hawaiian goose pen or at Haleakalā Ranch on Maui are not expected to impact vegetation resources. Tier 4 mitigation on up to 640 acres would have minor impacts during invasive plant removal but restoration and outplanting of natives would provide long term beneficial impacts.	No impacts
Wildlife and Biodiversity	Provides the least risk to species that may fly at night through the turbine rotor sweep; no habitat-related beneficial impacts from mitigation	Collision risk to species that may fly at night through the rotor sweep zone; long-term beneficial impacts from knowledge gained from Tier 3 mitigation that will inform bat management and resources in the future; Tier 4 enhancement of native ecosystems	Less risk of collision to species that fly at night than Alt. 2; no beneficial impacts from habitat enhancement
Hawaiian hoary bat	No impacts to Hawaiian hoary bats- no take and no mitigation benefits	Take of up to 27 Hawaiian hoary bats, through January 2, 2032 would be approved; USGS Research project would have long-term benefits to bats from new biological knowledge; beneficial impacts of Tier 4 (up to 8 bats) would provide beneficial impacts from habitat restoration	Take of up to 15 bats would be approved; Research efforts would be reduced by about 44%

KWP II Wind	**Alternative 1 (No action)**	**Alternative 2 (Proposed action)**	**Alternative 3 (Increased curtailment)**
Hawaiian goose	Take of Hawaiian goose beyond approved take of 30 would not be authorized and mitigation for fatalities in excess of the authorized take would not be assured. Operations of the turbines during the daytime hours would be expected to pose a risk of fatality to Hawaiian geese and the operation would be expected to cease daytime operations if the existing authorized take was exceeded.	Take of up to 14 Hawaiian geese would be approved; predator control at Haleakala and Pi'iholo Ranch would have beneficial impacts	Same as Alternative 2

KWP II Wind	Alternative 1 (No action)	Alternative 2 (Proposed action)	Alternative 3 (Increased curtailment)
Hawaiian petrel	Negligible to beneficial impacts; complete curtailment of the turbines at night may decrease the risk of collision	Negligible impacts; low wind speed curtailment may reduce risk of collision	Negligible to beneficial impacts; curtailment of turbines for 5 months at night may reduce risk of collision; risks to the Hawaiian petrel may be slightly greater than Alternative 1 and less than Alternative 2, assuming a moving turbine blade poses more risk than a stationary turbine blade. However, there is not information available to quantify a difference.
Cultural Resources	No impacts to archeological resources or to Hawaiian hoary bat ʻaumākua.	No impacts to archeological resources; adverse impacts are expected to individuals and families that identify Hawaiian hoary bats as ʻaumākua	No impacts to archeological resources; adverse impacts are expected to individuals and families that identify Hawaiian hoary bats as ʻaumākua but are expected to be less than alternative 2.

KWP II Wind	Alternative 1 (No action)	Alternative 2 (Proposed action)	Alternative 3 (Increased curtailment)
Public Services and Utilities	Adverse impact would be at least a 45% relative reduction in wind-generated energy output that would need to be replaced by another source; Daytime operations would provide beneficial impacts in the form of wind energy	Adverse impact would be up to a 20% relative reduction in energy production depending on wind speed	Adverse impact would be from 20- 40% relative reduction in energy production depending on wind speed

Table H-4. Summary of impacts associated with Alternative 1, 2, and 3 for the Pakini Nui Project.

Pakini Nui	**Alternative 1 (No action)**	**Alternative 2 (Proposed action)**	**Alternative 3 (Increased curtailment)**
Geology and Soils	No impacts	Negligible impacts from soil disturbance during outplanting and water feature construction	Same as Alternative 2
Hydrology and Water Resources	No adverse or beneficial impacts	Bat mitigation activities are expected to provide direct and indirect benefits to surface water streams running through the mid and lower lands by improving water quality and increasing watershed groundwater recharge; the predator proof fence for Hawaiian goose would be expected to limit access of predators to two water reservoirs within the fenced area that cannot traverse the fence; the water reservoir would benefit from proposed repair and maintenance.	Same as Alternative 2 for the two water reservoirs; less bat habitat restoration acreage and benefits to water quality;
Natural Hazards (Flood/Wildfire)	Negligible; in the event of wildfire, the pastureland below and adjacent to project and the adjacent gulch would be expected to be vulnerable; a fire management plan in place for the turbine facility and the land is grazed reducing the fire load. No impacts related to flooding would be expected.	Habitat improvements, removal of invasive vegetation and fireload and replacement with natives is expected to provide direct and indirect benefits in the preventing or reducing the occurrence of natural hazards such as flooding or wildfire.	Same as Alternative 2 only reduced acreage of habitat improvements

Pakini Nui	**Alternative 1** **(No action)**	**Alternative 2** **(Proposed action)**	**Alternative 3** **(Increased curtailment)**
Vegetation	No impacts	Vegetation disturbance in bat mitigation area (HVNP) is expected to be temporary and localized, and over the long term habitat improvement would be expected to increase native vegetation cover, reduce competition with invasive plant species, improve habitat quality for rare plant species, as well as increase overall native forest recovery and resilience; negligible impacts would be expected at Piʻihonua	Same impacts as Alternative 2 with reduced acreage of native vegetation cover
Wildlife and Biodiversity	Provides the least risk to species that may fly at night through the turbine rotor sweep; no habitat-related beneficial impacts from mitigation; Impacts expected include fatalities of invasive and endemic avian wildlife species as a result of collision with turbines during daytime operation and stationary meteorological tower, and overhead transmission lines day or night; no authorized take of any federally listed species, no beneficial conservation mitigation activities would be assured	Collision risk to species that may fly at night through the rotor sweep zone; short-term impacts from disturbance of wildlife during outplanting and invasive species removal ;long-term beneficial impacts from habitat improvement; adverse impacts on predators of Hawaiian goose and Hawaiian petrel; predator control would provide benefits to the seabirds, Hawaiian goose, and other ground-nesting species nesting in the vicinity of the predator control. Fencing of the two reservoirs may cause localized displacement of species, (e.g. wild pigs, deer, goats) that cannot access the reservoirs.	May pose less risk of collision to species that fly at night than Alt. 2; Impacts from habitat restoration and predator control are the same as Alternative 2, but would involve less habitat restoration acreage at HVNP

Pakini Nui	**Alternative 1** **(No action)**	**Alternative 2** **(Proposed action)**	**Alternative 3** **(Increased curtailment)**
Hawaiian hoary bat	No impacts to Hawaiian hoary bats- no take and no mitigation benefits	Take of up to 26 Hawaiian hoary bats, through 2029, would be approved; Restoration of 1200 acres of native forest at HVNP would be expected to provide habitat benefits to bats;	Take of up to 16 bats would be approved; Restoration efforts would be reduced by about 44% and would be expected to have the same impacts as Alternative 2.
Hawaiian goose	Hawaiian geese may collide with the operating turbines during the day; no mitigation for take would be assured	Take of up to 3 Hawaiian geese would be approved; Short term disturbance during fence construction and reservoir repair could cause short-term disturbance to Hawaiian goose; fencing and predator control at Pi'ihonua would provide beneficial impacts to Hawaiian goose; Restoration at HVNP would be expected to have negligible to beneficial impacts the Hawaiian goose	Same as Alternative 2
Hawaiian petrel	Negligible to beneficial impacts; complete curtailment of the turbines at night may decrease the risk of collision	Negligible impacts; low wind speed curtailment may reduce risk of collision; fence maintenance and predator control and monitoring to protect endangered seabirds at HVNP is expected to have beneficial impacts	Negligible to beneficial impacts; curtailment of turbines for 5 months at night may reduce risk of collision; risks to the Hawaiian petrel may be slightly greater than Alternative 1 and less than Alternative 2, assuming a moving turbine blade poses more risk than a stationary turbine blade. However, there is not information available to quantify a difference. Benefits from fence maintenance and predator control at HVNP would be same as Alternative 2

Pakini Nui	**Alternative 1** **(No action)**	**Alternative 2** **(Proposed action)**	**Alternative 3** **(Increased curtailment)**
Cultural Resources	No impacts to archeological resources or to Hawaiian hoary bat ʻaumākua.	No impacts to archeological resources; adverse impacts are expected to individuals and families that identify Hawaiian hoary bats as ʻaumākua	No impacts to archeological resources; adverse impacts are expected to individuals and families that identify Hawaiian hoary bats as ʻaumākua but are expected to be less than alternative 2.
Public Services and Utilities	Adverse impact would be at least a 45% relative reduction in wind-generated energy output that would need to be replaced by another source; Daytime operations would provide beneficial impacts in the form of wind generated energy	Adverse impact would be up to a 20% relative reduction in energy production depending on wind speed	Adverse impact would be from 20- 40% relative reduction in energy production depending on wind speed

Table H-5. Summary of impacts associated with Alternative 1, 2, and 3 for the Projects.

All Projects	**Alternative 1** **(No action)**	**Alternative 2** **(Proposed action)**	**Alternative 3** **(Increased curtailment)**
Geology and Soils	No impacts	Minor short-term soil compaction impacts form foot traffic no long-term impacts expected	Same impacts as Alternative 2
Hydrology and Water Resources	No impacts	No adverse impacts; outplantings of native trees will provide long-term benefits to watersheds and water quality	Similar impacts as Alternative 2 but less acreage of outplantings
Natural Hazards (Flood/Wildfire)	No impacts	No adverse impacts; beneficial impacts from pond construction equipped with firefighting dip-tanks and reduction in fuel-load in forests through invasive plant removal and outplantings with natives	Similar impacts as Alternative 2 but less acreage of outplantings
Vegetation	No impacts	Mitigation would have minor impacts during invasive plant removal but restoration and outplanting of native plants would provide long term beneficial impacts to watersheds and wildlife.	Similar impacts as Alternative 2, but less acreage of outplantings and invasive plant removal
Wildlife and Biodiversity	Provides the least risk to species that may fly at night through the turbine rotor sweep; no habitat-related beneficial impacts from mitigation	Impacts to MBTA, native and non-native species that fly at night through the rotor sweep zone may be expected; long-term beneficial impacts from restoration, enhancement, and protection of native ecosystems for perpetuity may help these species, but actions do not specifically target the species' habitats.	May pose less risk of collision to MBTA, native and non-native species that fly at night than Alternative 2; less acreage of beneficial habitat restoration, enhancement, and protection of native ecosystems for perpetuity may help these species, but actions do not specifically target the species' habitats.

All Projects	**Alternative 1** **(No action)**	**Alternative 2** **(Proposed action)**	**Alternative 3** **(Increased curtailment)**
Hawaiian hoary bat	No impacts to Hawaiian hoary bats- no fatalities attributed to turbine blade collision would be expected. No Roosting, foraging, and drinking habitat for will be installed, restored, enhanced, and protected for perpetuity	Up to 377 fatalities, including dependent pups, may occur over the next 15 years across three islands. Fatalities are not expected to significantly impact the population of bats statewide, though local impacts may be expected to occur in the vicinity of the wind farms on O‘ahu, Maui, and Hawai‘i. Roosting, foraging, and drinking habitat for bats (10,555 ac) will be installed, restored, enhanced, and protected for perpetuity. Local impacts to the bat population may occur, but significant adverse impacts are not expected to occur statewide	Up to 265 bat fatalities over 15 years may occur; No loss of dependent young; Less roosting, foraging, and drinking habitat for bats (7,787 ac) will be installed, restored, enhanced, and protected for perpetuity. No significant adverse impacts are expected to occur.
Hawaiian goose	Non operation of the turbines at night may pose less risk of collision to Hawaiian geese; Operation of the turbines during the daytime hours would be expected to pose a risk of fatality but would not be expected to significantly impact the statewide population; No predator control to protect Hawaiian geese would be implemented	Up to 17 Hawaiian geese fatalities could occur over the next 15 years. Predator control at Haleakala and Pi‘iholo Ranch and Pi‘ihonua would have beneficial impacts by increasing survival rate of the Hawaiian geese. No impacts to the Hawaiian goose population on the islands of Maui and Hawai‘i or statewide would be expected under this alternative.	Similar impacts as Alternative 2 but may pose slightly less collision risk at night from April to September;

All Projects	Alternative 1 (No action)	Alternative 2 (Proposed action)	Alternative 3 (Increased curtailment)
Hawaiian petrel	Negligible to beneficial impacts; complete curtailment of the turbines at night may decrease the risk of collision. No protection of colonies from predators would be conducted	Up to 27 fatalities may be expected to occur over the next 15 years including loss of dependent young. Low wind speed curtailment may reduce risk of collision. Protection of seabird colonies at HVNP and at Hanakāpī'ai and Hanakoa from predators is expected to provide benefits to the entire resident sub colonies and improve survival and productivity. No adverse impacts are expected to the Hawaiian petrel population.	Curtailment of turbines for 5 months at night may reduce risk of collision; risks to the Hawaiian petrel may be slightly greater than Alternative 1 and less than Alternative 2, assuming a moving turbine blade poses more risk than a stationary turbine blade. Protection of colonies at HVNP and at Hanakāpī'ai and Hanakoa from predators is expected to provide benefits to the resident entire sub colonies. No adverse impacts are expected to the Hawaiian petrel colonies.
Cultural Resources	No impacts to archeological resources or to Hawaiian hoary bat 'aumākua.	No impacts to archeological resources; adverse impacts are expected to individuals and families that identify Hawaiian hoary bats and/or Hawaiian petrel as 'aumākua	No impacts to archeological resources; adverse impacts are expected to individuals and families that identify Hawaiian hoary bats as 'aumākua but are expected to be less than alternative 2.
Public Services and Utilities	Adverse impact would be up to a 50% relative reduction in wind-generated energy output that would need to be replaced by another source; Daytime operations would provide beneficial impacts in the form of wind energy	Adverse impact would be up to a 20% relative reduction in energy production depending on wind speed	Adverse impact would be up to a 40% relative reduction in energy production depending on wind speed

Known and Foreseeable Projects

List of Tables

Table I-1. Hawaiian Electric Companies renewable energy projects in development (HECO 2019) that are taken into consideration by the Service in Chapter 5 Cumulative Effects Analysis.

Utility (Island(s))	**Projects In Development (MW)**	**TOTAL (MW)**
Hawaiian Electric (O‘ahu)	Hoohana Solar (52 MW), Mililani I Solar (39 MW), NRG Solar (110 MW), Na Pua Makani Wind (24 MW), Palehua Wind (48 MW), Waiawa Solar (36 MW), West Loch Solar (20 MW), Community-Based Renewable Energy (5 MW)	**334**
Maui Electric (Maui, Moloka‘i, Lāna‘i)	Kuihelani Solar (60 MW), Molokai New Energy Partners Solar (2.7 MW), Paeahu Solar (15 MW), Community-Based Renewable Energy (1.5 MW)	**79.2**
Hawai‘i Electric Light (Hawai‘i)	Hale Kuawehi Solar (30 MW), Hu Honua Biomass (21.5 MW), Waikoloa Solar (30 MW), Community-Based Renewable Energy (1 MW)	**82.5**

Table I-2. Known and reasonably foreseeable future projects that have, or are expected to have, impacts to the Hawaiian hoary bat, Hawaiian goose, and Hawaiian Petrel that are taken into consideration by the Service in Chapter 5 Cumulative Effects Analysis.

Project Name	Permit or Project Term	Location	Current Take Authorization (Status of Impacts)[1]			Proposed Take Request (Expected Impacts)[2]		
			Hawaiian hoary bat	Hawaiian Goose	Hawaiian Petrel	Hawaiian hoary bat	Hawaiian Goose	Hawaiian Petrel
Coast Guard-Kalepa Comm. Tower (BiOp)	2013-2033	Kalepa, Kauaʻi	0	0	3/year (+)			
FCC- Kalaheo Communications Tower (BiOp)	2013-2033	Kalaheo, Kauaʻi	0	0	2/year (+)			
Kauaʻi Island Utility Coop. (Short-term HCP)	2011-2016	Kauaʻi Island	0	0	2/year (+)[3]			
Kauaʻi Seabird Recovery Project (DOFAW)		Kauaʻi Island			(+)			
Kauaʻi Island Utility Coop. (Long-term HCP)	Requesting 30 years	Kauaʻi Island				Not applicable	Not applicable	Not yet determined (-/+)
Kauaʻi Seabird (HCP)	Draft; 30 year request	Kauaʻi Island	Not applicable	Not applicable	Not applicable	0	0	60 (+)[3]
Kōkeʻe Air Force Station (BiOp)	2017-foreseeable future	Kōkeʻe, Kauaʻi	0	0	2/year (+)			
Tower Kauaʻi Lagoons (HCP)	2016-2042	Lihuʻe, Kaua`i	0	15 (+)	1 (+)			
DoD Military Radar		Oahu	(-)		(-)			

Project Name	Permit or Project Term	Location	Current Take Authorization (Status of Impacts)[1]			Proposed Take Request (Expected Impacts)[2]		
			Hawaiian hoary bat	Hawaiian Goose	Hawaiian Petrel	Hawaiian hoary bat	Hawaiian Goose	Hawaiian Petrel
James Campbell NWR (CCP)	Perpetuity	Kahuku, Oahu	+	+				
Kahuku Wind Power (BiOp/State HCP)	2010-2030	Kahuku, O‘ahu	32 (+)	0	12 (+)			
Kawailoa Wind Power (HCP)	2012-2032	Haleiwa, O’ahu	60 (+)	0	0	205 (+)	0	24 (+)
Na Pua Makani Wind (HCP)	2018-2038	Kahuku, O’ahu	51 (+)	6 (+)	0	Not applicable	Not applicable	Not applicable
Pearl Harbor NWR (CCP)	Perpetuity	Ewa, Oahu	+	+				
Palehua Wind (HCP)	No draft submitted	Makakilo, O’ahu	Not applicable	Not applicable	Not applicable	Not available	Not available	Not applicable
U.S. Army Kahuku Training Area Single Wind Turbine (BiOp)	2010-2030	Kahuku, O’ahu	4 (-)	0	0			
US Army (INRMP)		Oahu	(+)					
Auwahi Wind (HCP)	2012-2037	‘Ulupalakua, Maui	21 (+)	5 (+)	87 (+)	121 (+)	Not applicable	Not applicable
Auwahi II Wind (HCP)	No draft submitted	‘Ulupalakua, Maui	Not applicable	Not applicable	Not applicable	Not available (+)	Not available (+)	Not available (+)
Daniel K Inouye Telescope (BiOp; State HCP)	Ending 2019	Haleakalā, Maui			(+)			

Project Name	Permit or Project Term	Location	Current Take Authorization (Status of Impacts)[1]			Proposed Take Request (Expected Impacts)[2]		
			Hawaiian hoary bat	Hawaiian Goose	Hawaiian Petrel	Hawaiian hoary bat	Hawaiian Goose	Hawaiian Petrel
Haleakalā National Park		Haleakalā, Maui	(+)	(-/+)	(+)			
Haleakalā Ranch (SHA)	2019-2069	Kula, Maui		(+)				
Kahikinui Wind (HCP)	No draft submitted	Kahikinui, Maui	Not applicable	Not applicable	Not applicable	Not available (+)	Not available (+)	Not available (+)
Kaheawa Wind Phase I (HCP)	2006-2026	Maalaea, Maui	51 (+)	60 (+)	38 (+)			
Kaheawa Wind Phase II (HCP)	2012-2032	Maalaea, Maui	11 (+)	30 (+)	43 (+)	27 (+)	14 (+)	
Kalama Beach Park		Kalama, Maui			(-)			
Maui County		Maui (islandwide)			(-)			Not determined (+)
Maui Nui Seabird Recovery Project		Maui Nui			(+)			
Pi‘iholo (SHA)	Pending for 50 years	Pi‘iholo, Maui		(+)				
Island of Molokai (SHA)	2003-2033	Molokai (islandwide)		(+)				
Pu‘u O Hoku (SHA)	2001-2023; pending amendment	East Moloka‘i		(+)				
Pulama Lanai Seabird Project (MOU)	Perpetuity	Lanai Hale, Lanai			(+)			

Project Name	Permit or Project Term	Location	Current Take Authorization (Status of Impacts)[1]			Proposed Take Request (Expected Impacts)[2]		
			Hawaiian hoary bat	Hawaiian Goose	Hawaiian Petrel	Hawaiian hoary bat	Hawaiian Goose	Hawaiian Petrel
Big Island Beef Community Wind Project[4]	Not applicable	Paauilo, Hawai`i	0 (No impact)	0 (No impact)	0 (No impact)			
Hakalau NWR	Perpetuity	Hakalau, Hawai`i		(+)	(+)			
Hawaii Volcanoes NP	Perpetuity	Kīlaeua and Mauna Loa, Hawai`i	(+)	(+)	(+)			
Hawi Wind (HCP)	Draft pending	Upolu Point, Hawai`i	0 (unknown)	0 (unknown)	0 (unknown)	Not yet determined (+)	Not yet determined (+)	Not yet determined (+)
Kamehameha Schools-Keauhou and Kīlauea Forest (SHA)	2018-2068	East Mauna Kea, Hawai`i	(+)	(+)				
Lalamilo Wind Repowering (HCP)[5]	Not yet issued; 20 years	Lālāmilo, Hawai`i	0		0 (negligible)	6 (+)	0	3 (+)
North Kohala Microgrid Project[4]	Not applicable	North Kohala, Hawai`i	0 (No impact)	0 (No impact)	0 (No impact)			
Pakini Nui Wind (HCP)	Draft requests 10 years	Ka Lae, Hawai`i	0 (-)	0 (unknown)	0 (unknown)	26	3	3
Pelekane Bay Watershed Restoration Project (BiOp)	2010-2030	Pelekane, Hawai`i	16 (-)					

Project Name	Permit or Project Term	Location	Current Take Authorization (Status of Impacts)[1]			Proposed Take Request (Expected Impacts)[2]		
			Hawaiian hoary bat	Hawaiian Goose	Hawaiian Petrel	Hawaiian hoary bat	Hawaiian Goose	Hawaiian Petrel
Pohakuloa Training Area (BiOp)	Draft INRMP expected 2019	Pohakuloa, Hawai`i	(-/+)	(+)	(+)	(+)	(+)	(+)
Timber (HCP)	Pending	Hawai`i Island				Not yet determined (+/-)		
Waikoloa Water Community Wind Project[4]	Not applicable	Waikoloa, Hawai`i	0 (No impact)	0 (No impact)	0 (No impact)			
Hawaii Army National Guard (INRMP)		Kaua'i, O'ahu, Maui, Hawai'i	(+/-)	(+/-)	(+/-)			
USDA-NRCS Farm Bill (SHA)	2007-2057	State of Hawai`i		(+)				
USFWS National Wildlife Refuge Complex	Perpetuity	Kaua'i, O'ahu, Maui, Hawai'i	(+)	(+)	(+)			

1 Other species may also have incidental take authorizations not reported here. Number reflects federal authorized incidental take for the permit term; effects to the species shown parentheses (+) = take of, or impacts to, the species are offset with beneficial actions; (-) negative effects not mitigated or offset; (negligible) = minor, short-term effects only; (No impact) = no effects; (-/+) negative effects and beneficial effects both occurring, but benefits may be lagging

2 Proposed take request includes the previous authorized take

3 Take was higher than initially anticipated, KIUC continues to mitigate impacts while the Long term HCP is under development

4 Informal consultation completed with a "Not likely to adversely affect" determination-no incidental take (turbines inactive at night)

List of Preparers

Appendix J. List of Preparers

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