Kauaʻi Island Utility Cooperative Habitat Conservation Plan

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APPENDICES

Kauaʻi Island Utility Cooperative
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Appendix 1A

Data Used for Plan Development

Unless otherwise noted, each data type is collected for both Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu).
Data are not available for band-rumped storm-petrel (ʻakēʻakē) unless otherwise noted.
In the Data type and general methods column, the data sources referred to in Chapter 3, *Environmental Setting*, are bolded.

General data category	Data type and general methods	Who collected the data?	Where data were collected?	When data were collected?	What are the data limitations?	What is our level of confidence in the data?	What have we learned from the data?	How the data are used in the HCP?
Light Attraction/Fallout Monitoring	SOS Program Number of birds received and handled by SOS during fallout season and outcome of those birds (i.e., released after rehabilitation or mortality); **trends in birds grounded** and handled by SOS throughout the year.	SOS Program; presented in SOS annual reports	Seabirds found on the ground during fallout season that are turned into SOS for rehabilitation and release, or mortalities	Most seabirds are received during fallout season (Sept. 15–Dec. 15). Data collected annually starting ca. 1979 to present. Data from 2010 to present used to inform light attraction modeling and, secondarily, it corroborated the stable trend.	Sampling is opportunistic. Search effort (and any changes through time) is not quantified across years. Inconsistent level of effort in data collection and recordation in earlier years.	Medium. Longest dataset for seabirds available on Kauaʻi but sampling effort and data collection/recordation methods vary over time and are not systematic.	Rapid decline in recovered birds during 1990s and early 2000s. Flat trend in recovered birds since at least 2010. About 60% of covered species that are handled by the SOS Program are rehabilitated and released back into the wild, even though the HCP assumes 100% mortality from fallout,	Independent data source to corroborate seabird trends in relative abundance observed in radar survey data. Also used to track numbers of birds handled at SOS to determine adjustments to funding when triggered. Data used in modeling to estimate take associated with streetlights (See Appendix 5B, *Light Attraction Modeling for Covered Seabirds*). Data on percentage of SOS birds released also indicates that assumption of 100% mortality from fallout is conservative.
Light Attraction/Fallout Monitoring	Fallout KIUC facilities monitoring for seabirds.	KIUC	Port Allen Generating Station and Kapaia Generating Station	Data collected beginning in 2011. Annual take estimates calculated as the annual average of 8 years of data for Newell's shearwater (ʻaʻo) (2016–2023) and an annual average of 13 years of data for Hawaiian petrel (ʻuaʻu) and band-rumped storm-petrel (ʻakēʻakē) (2011–2023).	Data based on number of downed birds found at facilities. Some birds killed or injured as a result of facility lighting may have gone undetected.	High when applying assumption of 25% detectability. KIUC covered facilities are fenced and monitored for pests, which greatly reduces risk of predation of downed birds prior to detection. KIUC trains staff to identify and search for covered species and these trained staff conduct focused, dedicated searches for downed seabirds during the seabird fallout season twice daily (3–4 hours after sunset and 1 hour before sunrise)	See Tables 5-6, 5-10, and 5-12 for average annual amount of take at facilities.	To estimate the amount of take at covered facilities to occur during the permit term. All living seabirds found downed are sent to SOS for rehabilitation.
Seabird Abundance Trend Monitoring	Radar survey Fixed points throughout areas of Kauaʻi that are accessible by road (Wainiha to Kekaha), to determine **trends in relative abundance**.	DOFAW/KESRP; data and analysis provided in KESRP annual reports (e.g., Sahin 2023)	Wainiha to Kekaha: 15 fixed monitoring sites along Kaumualiʻi and Kūhiō Highways (radar unit is mounted on a truck)	Annually (May to mid-July) with some years skipped . Average annual survey frequency is 2 out of every 3 years. Data collected from 1993–Present. 30-year time series.	Trends measure change in relative abundance, i.e., an index of abundance (not a measure of absolute abundance). Not possible to survey areas without road access (e.g., Nā Pali Coast).	High. This is a systematic survey, monitoring the same sampling sites each year, with consistent measurements at each site within and between years. Statistical uncertainty is incorporated in trend estimates. Longest running systematic monitoring program for either seabird species.	Declining trend during 1990s and early 2000s consistent with rapid decline in abundance during that period. Since then, flat trend suggests stable (albeit relatively low) abundance levels since at least 2010.	Estimated trends form the basis for population dynamics model projections of abundance for both the worse case rate of decline and the more recent stable trend.
Seabird Abundance Trend Monitoring	At-sea strip transect survey	Spear et al. (1995) and Joyce (2016) analyzed at sea sightings data. Ainley et al. (2001)	Eastern Tropical Pacific Ocean. Not inclusive of the full at-sea range of Newell's shearwater (ʻaʻo) or	Data collected from 1980–1994 (Spear et al. 1995) and 1998–2011 (Joyce 2016). Data used for abundnace estimates is from 2001–2020.	The at-sea estimates include serious spatial deficiencies in geographical survey coverage, leading to uncorrected sources of statistical bias if the resulting	Low. Although the scientific merit and methodologies of both studies are sound, the published estimates are not a robust measure of total abundance in	Joyce (2016) provides an estimate of minimum abundance (ca. 2004, the mid-year of the annual survey time series), such that true	These data were considered for inclusion in population dynamics models, but ultimately not used, due to uncorrected sources of bias

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		and Griesemer and Holmes (2011) modeled abundance estimate from Spear et al. (1995), and Vorsino (2016) modeled trends based on more recent estimate of abundance from Joyce.	Hawaiian petrel (‘ua‘u)		estimates are assumed to represent total abundance of the species, as described in detail in Appendix 5D, Section 5D.2.1.1, *Estimates of Abundance on Kaua‘i*. Further, at-sea estimates alone, even if they could be corrected for these biases, provide only a single abundance estimate for the entire species. For the purpose of analyzing effects of the covered activities and developing an effective conservation strategy for the covered seabirds on Kaua‘i, important spatial differences in mortality risk in different breeding areas of Kaua‘i need to be considered.	light of the at-sea distribution data now available through tracking studies.	abundance was not qualitatively lower.	resulting from incomplete spatiotemporal at-sea survey coverage.
Powerline Monitoring	Powerline collision monitoring Remote monitoring by acoustic sensors recording **powerlines collisions for estimates of e.g. take.** Additionally, includes extensive observer monitoring, during the day and at night with infrared equipment.	KESRP under contract to KIUC (2011–2020) and ARC under contract to KIUC (2021–present); data and analyses in KESRP and ARC annual reports (e.g., Travers et al. 2020)	Sampling occurs across the KIUC transmission system and includes some sections of distribution with high risk	Data collected from 2011–present. ARC data from 2023 and KESRP data from 2021 used to estimate take from powerlines.	The fate of birds after collisions cannot be determined. Bird collisions recorded by acoustic sensor cannot be identified to species; species ID must be inferred from relatively small sample of observed collisions of identified birds. Additionally, species outcomes (injured, killed) must be inferred based on observed bird behaviors following collision.	High for number of strikes and minimization effectiveness. Acoustic detections are augmented and verified by independent visual survey data. Estimates integrate statistical uncertainty associated with sampling design and other factors. Sampling is extensive geographically and across multiple years. Moderate for mortalities: Based on post-collision behavior from small sample of observed collisions, assuming all grounded birds killed. Low for injury. Based on post-collision behavior from small sample of observed collisions: whether bird continues with strong flight, has labored flight, or drops in elevation.	Acoustic sensors are used to estimate powerline collision numbers before and after minimization, determining the effectiveness of minimization measures, and data have verified that minimization measures are effective. Visual surveys are used to estimate species ratios and post-collision outcomes (e.g., injury, mortality). Trend estimates using standardized data from both visual observations of passage rates and acoustic collision detections are consistent with a stable trend in relative abundance over the recent decade (2013–2023).	Estimated collision levels and effectiveness of minimization measures are used to inform the incidental take request. Powerline monitoring is used to track and report take, confirm reduction of collisions as a result of minimization and to inform minimization planning. Allocation of strikes by species and post-collision outcomes are used to estimate type of take by species and assess effects of the take on each species. Stable trends in standardized passage rates and collisions corroborate recent stable trend in radar survey and SOS data.
Seabird Colony Monitoring at Managed/Monitored Sites	Call rates Acoustic sensor monitoring of seabird colonies for **trends in relative abundance.**	KESRP (2011–2020), and ARC (2020–present); data and analysis provided in KESRP and ARC annual reports (ARC, e.g., Raine et al. 2023)	Managed sites (both KIUC and others) and Nā Pali Coast.	Data collected from 2011–present. ARC data from 2023 and KESRP data from 2021 used to estimate call rates. Sensors deployed in February through December annually at managed sites; data collected May–September. At social attraction sites, data	First year of monitoring varies by site (first site monitored in 2011). Only a qualitative index of trend in abundance. Data collection time at social attraction sites is limited, due to social attraction starting in 2022 and interference with broadcasted calls.	High. Raine et al. (2019) documented a statistically significant relationship between call rates and the number of breeding birds (both seabird species) present in a 820-foot (250-meter) radius around acoustic sensors. Data are collected through arrays of	Call rates have been shown to strongly correlate to numbers of breeding pairs and therefore remains an excellent monitoring technique. Along with other complementary data sets (e.g., auditory surveys, burrow checks, cameras), has demonstrated the benefits of	The data provide estimates of annual trends in call rates, including the four social attraction sites. Along with other complementary data sets (e.g., burrow monitoring), confirms efficacy of conservation site measures and supports monitoring of

General data category	Data type and general methods	Who collected the data?	Where data were collected?	When data were collected?	What are the data limitations?	What is our level of confidence in the data?	What have we learned from the data?	How the data are used in the HCP?
				are collected for approximately 1.5 months when recorded seabird calls for social attraction are not broadcasting over the sound system.		multiple acoustic sensors at the conservation sites each year, and annual call rates include statistical estimates of uncertainty.	predator control and shown rapid colony growth once predators are reduced. Comparisons of call rates also indicates effectiveness of predator control measures and helps in detecting barn owls through their calls.	conservation site benefits. The data is also used in the HCP to identify areas with high seabird activity and potential threats (barn owls) which helps focus management efforts.
Seabird Colony Monitoring at Managed/Monitored Sites	Auditory surveys Surveyors listening for birds and using night vision equipment, for determining breeding pair **abundance.**	KESRP (2011–2020), and ARC (2020–present)	KIUC conservation sites (Pihea, North Bog, Pōhākea, Pōhākea PF, Hanakāpīʻai, Upper Limahuli Preserve, Honopū, Honopū PF)	Data collected from 2011–present. ARC data from 2023 and KESRP data from 2021 used to estimate breeding pair abundance. Surveys are undertaken in the evening and the early morning, which are the peak periods of seabird movement to and from the sea and breeding colonies. Surveys are not conducted during the week of the full moon, as birds are not vocal during full moon nights. In the latest survey year of 2023, auditory surveys were taken in May (peak prospector activity) as well as July.	Because surveys are conducted by people in the field, there is a risk of human error. Burrows close to each other may be obscured. Lastly, surveys provide only a snapshot of specific seabird activity at specific times.	High. While the risk of human error exist, observers conducting the survey are experienced and well-trained, ensuring reliability of data observed. Moreover, methods used for data collection are standardized and have been consistently applied over time, which contributes to the reliability of results.	Auditory surveys confirm presence of seabird species at monitoring sites and can detect new burrow clusters, with higher call rates suggesting areas with critical habitats for seabirds. The surveys have also revealed temporal patterns in seabird vocal activity, with peaks during specific months corresponding to breeding season. Further, the surveys confirm positive abundance trends at sites with ongoing predator control.	The data is used in the breeding pair estimates and to determine the distribution of seabirds as well as to inform effectiveness of management practices.
Seabird Colony Monitoring at Managed/Monitored Sites	Burrow monitoring In-person checks and cameras to determine **reproductive success rates**, **breeding probability, and predation events/rates** at burrows.	KESRP (2011–2020), and ARC (2020–present)	Data collected across each KIUC conservation site.	Data collected from 2011–present. ARC data from 2023 and KESRP data from 2021 used to estimate reproductive success. Data collection occurs from March to December, with specific emphasis on the breeding season from May through September. Burrow checks and camera monitoring are conducted throughout this period.	Monitoring deep burrows where direct visual inspection is not possible. There can be inconsistencies in the number of burrows monitored across different sites due to challenges in locating burrows in steep topography and dense vegetation.	High. Burrow monitoring involves repeated direct observations of breeding pairs and their reproductive success, with decades of consistent monitoring. While recent approaches have improved data collection, the strong foundation of long-term data ensures reliability of the results.	There are positive trends for both species in reproductive success rates due to a reduction in predation events because of effective predator control measures. This is also consistent with breeding pairs at the conservation sites having low risk of take (e.g., from light attraction or powerline collisions).	The data is used in HCP to provide estimates of annual reproductive success rates and breeding probabilities, and assess the effectiveness of predator control measures and their impact on seabird populations. It also supports the creation of population estimates and seabird distribution mapping.
Seabird Colony Monitoring at Managed/Monitored Sites	Take monitoring from conservation activities Trapping records for seabirds incidentally caught in cat traps or are affected by other HCP conservation measures (i.e., colliding with weatherports).	KIUC (2011–present	Data collected across KIUC conservation sites.	Data collected from 2011–present. ARC data from 2023 and KESRP data from 2021 used to estimate take.	Birds could be hard to find if affected in other ways than caught in traps.	High. Monitoring and predator control staff visit the conservation sites routinely and will likely find birds that are grounded due to conservation efforts.	Incidental take of seabirds from conservation measures is low and usually impacted birds are found in good health and successfully released.	Take tracking/reporting. Incidents are tracked and reported on at the time of the incident and included in annual reports.

General data category	Data type and general methods	Who collected the data?	Where data were collected?	When data were collected?	What are the data limitations?	What is our level of confidence in the data?	What have we learned from the data?	How the data are used in the HCP?
Seabird Colony Monitoring at Managed/Monitored Sites	Flight paths Tracking the daily movements of birds to and from colonies by **tagging** them with GPS data loggers.	KESRP (Raine et al. 2017)	Data collected from seabirds at two KIUC conservation sites	Data collected from 2016–2017 (August–September) used to portray flight paths.	Only 2 years of data with a limited number of birds being tagged.	High level of confidence in the data generated, the loggers attain a high level of detail. Medium level of confidence in the conclusions drawn from the data due to relatively low number of birds tagged.	Seabird flight paths from and to the conservation sites are mostly in areas with no powerlines or streetlights. Newell's shearwater (ʻaʻo) flight paths had low variation, both outbound and inbound, and did not pass over any powerlines or streetlights. One of the two general Hawaiian petrel (ʻuaʻu) inbound flight paths crossed over powerlines and streetlights, while their outbound flights paths did not. Additionally, outbound flights for both species were high above the terrain, as opposed to inbound flights which were at a lower height.	Supporting data for evaluating threat levels for seabirds at the conservation sites.
Predator Monitoring at Managed/ Monitored Sites	Depredations of seabirds at burrows Cameras and visual observations, to determine **predation rates at burrows.**	KESRP (2011–2020), and ARC (2020–present)	Data collected at burrows across KIUC conservation sites.	Data collected from 2011–present. ARC data from 2023 and KESRP data from 2021 used to estimate depredation at burrows. Data collection occurred from March–December, with specific focus on the breeding season from May through September.	Limitations include challenges in detecting all predator activity due to camera placement and environmental conditions. There is also potential for cameras to fail, leading to gaps in data.	High level of confidence in the data based on systematic monitoring and validation through multiple methods. The use of cameras and visual observations has provided reliable data on predator activity and predation events.	Significant reduction in depredation events due to effective predator control measures near burrows. Predation events by rats, cats, and barn owls are carefully recorded and analyzed to understand their impact on seabird populations.	The data are used in the HCP to assess the effectiveness of predator control measures and their impact on seabird populations. It also provides insights into predator behavior. Detailed records of predator interactions and depredations help refine control techniques and improve predator management practices. Data have demonstrated the efficacy of dedicated predator control and the extensive benefits of reducing predation pressure on endangered seabird species at the conservation sites.
Predator Monitoring at Managed/ Monitored Sites	Predator presence and relative abundance estimates for cats, rodents, and ungulates at burrows Trail cameras and visual observation.	KESRP (2011–2020), and ARC (2020–present)	Data collected at burrows across KIUC conservation sites.	Data collected from 2011–present. ARC data from 2023 and KESRP data from 2021 used to estimate predator presence at burrows. Cameras were deployed from March to December.	Limitations include the potential to miss predator activity if the cameras malfunction or if predators avoid camera traps. Additionally, detection rates may vary based on camera placement and environmental conditions.	High level of confidence in the data due to the extensive use of cameras and the consistent methodology applied over multiple years.	Documentation of specific predator behaviors and patterns at seabird burrows, which can inform targeted management actions. There has been continued presence of predators at some sites, indicating the need for ongoing monitoring and control efforts near burrows. The data show a significant decrease in cat visits, with a 91.7% reduction at all sites combined since monitoring began. These	The presence estimates for predators help target and improve predator control efforts to reduce depredations and support seabird population recovery. The data are also used to inform and evaluate the effectiveness of predator control measures, which are crucial for the protection of endangered seabirds.

General data category	Data type and general methods	Who collected the data?	Where data were collected?	When data were collected?	What are the data limitations?	What is our level of confidence in the data?	What have we learned from the data?	How the data are used in the HCP?
							trends indicate the effectiveness of predator control measures.	
Predator Monitoring at Managed/ Monitored Sites	Predator capture and removal rates Number of trapped and removed predators.	Hallux (2018–2023), and NTBG (2012–present)	Data collected across KIUC conservation sites.	Data collected from 2012–present. NTBG data from 2023 and Hallux data from 2023 used to estimate predator abundance.	Limitations include potential biases in capture rates due to trap placement and environmental conditions, as well as the possibility of animals avoiding traps.	High level of confidence in the data due to systematic and consistent trapping methods used over multiple years.	The data indicate significant decreases in predator presence due to effective control measures.	The data are used to assess and enhance predator control measures, which are crucial for the protection of endangered seabirds. Capture and removal rates help inform the effectiveness of these measures and guide conservation strategies to support seabird population recovery. This includes evaluating trends in predator activity over time and using these insights to adjust and improve predator control efforts.
Predator Monitoring at Managed/ Monitored Sites	Barn owl call rates Acoustic sensor monitoring of call rates.	KESRP/ARC 2019–present	KIUC conservation sites and the Nā Pali Coast.	Data collected from 2019–present and used to estimate barn owl activity. Sensors deployed in February through December annually at conservation sites; data collected May–September.	Only a qualitative index of trend in abundance. Environmental factors like weather and vegetation interference could affect sensor performance.	High. Data are collected through arrays of multiple acoustic sensors at the conservation sites and Nā Pali Coast each year. Based on the long experience with acoustic sensor monitoring and the reliable results for seabird monitoring, we are confident in the data.	Barn owl calls are variable across sites and years, although patterns in call rates across locations are fairly consistent over the last 3 years.	The data are used to guide and prioritize predator control efforts. Identifying areas with higher barn owl activity helps focus management actions to protect endangered seabirds from predation.

ARC = Archipelago Research and Conservation
DOFAW = State of Hawaiʻi Division of Forestry and Wildlife
KESRP = Kauaʻi Endangered Seabird Recovery Project
NTBG = National Tropical Botanical Garden
SOS = Save Our Shearwaters

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Appendix 1B
Evaluation of Species Considered for Coverage

Pursuant to the federal Endangered Species Act (federal ESA) and Hawaiʻi Revised Statutes, incidental take authorizations may be required for species covered under the KIUC HCP (i.e., covered species) to implement the covered activities over the term of the KIUC HCP. Species KIUC considered for coverage were all state- or federally listed species that could be present in the Plan Area.

Table 1B-1 presents the evaluation process and results of the process for each of the species considered. As a result of this evaluation, KIUC identified nine species as meeting the criteria for inclusion as covered species in the KIUC HCP; Chapter 1, *Introduction and Background*, Table 1-1 lists these species. Attachments 1 and 2 to this appendix provide more detailed rationale for excluding particular species from the KIUC HCP covered species list. Where necessary, the attachments also include avoidance and minimization measures KIUC must implement to ensure take of listed species is avoided.

Attachment 1. Evaluation of Hoary Bat (ʻōpeʻapeʻa) Coverage in KIUC HCP

Attachment 2. Measures to Avoid Adverse Effects on Listed Plant Species

Table 1B-1. Evaluation of Special-Status Animals and Plants for Coverage under the KIUC HCP

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c]					Comments and Rationale
	Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	
Mammals						
Lasiurus cinereus semotu/Hawaiian hoary bat/ʻōpeʻapeʻa	E/E	+	±	+	No	Take unlikely with implementation of the avoidance and minimization measures described in Attachment 1.
Monachus schauinslandi/Hawaiian monk seal/ʻīlio-holo-i-ka-uaua	E/E	+	-	+	No	Take from covered activities unlikely.
Birds						
Puffinus newelli/Newell's shearwater/ ʻaʻo	T/T	+	+	+	Yes	Recommended for coverage under the Plan.
Pterodroma sandwichensis/Hawaiian petrel/ʻuaʻu	E/E	+	+	+	Yes	Recommended for coverage under the Plan.
Hydrobates castro/band-rumped storm-petrel/ʻakēʻakē	C/E	+	+	+	Yes	Recommended for coverage under the Plan.
Himantopus mexicanus knudseni/ Hawaiian stilt/aeʻo	E/E	+	+	+	Yes	Recommended for coverage under the Plan.
Anas wyvilliana/Hawaiian duck/koloa maoli	E/E	+	+	+	Yes	Recommended for coverage under the Plan.
Fulica alai/Hawaiian coot/ʻalae keʻokeʻo	E/E	+	+	+	Yes	Recommended for coverage under the Plan.
Gallinula galeata sandvicensis/ Hawaiian gallinule/ʻalae ʻula	E/E	+	+	+	Yes	Recommended for coverage under the Plan.
Branta sandvicensis/Hawaiian goose/ nēnē	E/E	+	+	+	Yes	Recommended for coverage under the Plan.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c]					Comments and Rationale
	Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	
Myadestes palmeri/Kauaʻi thrush/ puaiohi	E/E	+	-	+	No	Take from covered activities unlikely.
Oreomystis bairdi/Kauaʻi creeper/ ʻakikiki	E/E	+	-	+	No	Take from covered activities unlikely.
Loxops caeruleirostris/Kauaʻi akepa/ akekeʻe	E/E	+	-	+	No	Take from covered activities unlikely.
Drepanis coccinea/scarlet honeycreeper/ʻiʻiwi	T/E	+	-	+	No	Take from covered activities unlikely.
Reptiles						
Chelonia mydas/green sea turtle Central North Pacific distinct population segment/honu	T/T	+	+	+	Yes	Recommended for coverage under the Plan.
Eretmochelys imbricata/hawksbill turtle/ʻea	E/E	+	-	+	No	Take from covered activities unlikely.
Lepidochelys olivacea/olive ridley sea turtle	T/T	+	-	+	No	Take from covered activities unlikely.
Caretta caretta/loggerhead sea turtle	T/T	+	-	+	No	Take from covered activities unlikely.
Demochelys coriacea/leatherback sea turtle	E/E	-	-	+	No	Take from covered activities unlikely.
Invertebrates						
Adelocosa anops/Kauaʻi cave wolf spider/peʻe peʻe makaʻole	E/E	+	-	+	No	Take from covered activities unlikely.
Spelaeorchestia koloana/Kauaʻi cave amphipod/ʻuku noho ana	E/E	+	-	+	No	Take from covered activities unlikely.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c] Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	Comments and Rationale
Plants						
Adenophorus periens/pendant kihi fern/palai lāʻau	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Astelia waialeale/paʻiniu	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Bonamia menziesii/Hawaiʻi lady's nightcap	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Brighamis insignis/vulcan palm/ʻālula, hāhā	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Canavalia napaliensis/Mākaha Valley Jack-bean/ʻāwikiwiki, puakauhi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Centaurium sebaeoides/lavaslope centaury/ʻāwiwi	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
*Charpentiera densiflora/*Nā Pali Coast pāpala/pāpala	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyrtandra kealiae subsp. *kealiae* (formerly *C. limahuliensis*)/haʻiwale, kanawao keʻokeʻo	T/T	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c] Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	Comments and Rationale
Cyrtandra oenobarba/shaggystem cyrtandra/hā'iwale, kanawao ke'oke'o	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyanea eleeleensis/hāhā	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyanea kolekoleensis/ Kolekole cyanea/hāhā	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyanea kuhihewa/Limahuli Valley cyanea/hāhā	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyanea recta/upright cyanea/hāhā	T/T	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyanea remyi/Remy's cyanea/hāhā	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyanea rivularis (listed as Delissea)/ plateau cyanea/hāhā	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyrtandra cyaneoides/māpele/ kanawao ke'oke'o	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
*Delissea kauaiensis/*leechleaf delissea/ 'oha	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c] Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	Comments and Rationale
Delissea rhytidosperma/Kauaʻi delissea/ʻoha	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Doryopteris angelica/Kauaʻi digit fern	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Dryopteris crinalis var. *podosorus*/ serpent woodfern/palapalai ʻaumakua	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Dubautia imbricata subsp. *imbricata*/ bog dubautia/naʻenaʻe, kūpaoa	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Dubautia kalalauensis/naʻenaʻe, kūpaoa	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Dubautia kenwoodii/Kalalau rim dubautia/naʻenaʻe, kūpaoa	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Dubautia waialealae/Waiʻaleʻale dubautia/naʻenaʻe, kūpaoa	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Euphorbia haeleeleana/Kauaʻi spurge/ ʻakoko	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Euphorbia eleanoriae/Nā Pali sandmat/ʻakoko	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c] Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	Comments and Rationale
Euphorbia remyi var. *kauaiensis*/ Remy's sandmat/ʻakoko	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Euphorbia remyi var. *remyi*/Remy's sandmat/ʻakoko	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Exocarpos luteolus/leafy ballart/heau, au	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Flueggea neowawraea/mēhamehame	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Hesperomannia lydgatei/Kauaʻi island-aster	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Hibiscadelphus woodii/Wood's hau kuahiwi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Hibiscus waimeae subsp. *hannerae*/ Hibiscus waimeae/aloalo, kokiʻo keʻokeʻo, kokiʻo kea	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Ischaemum byrone/Hilo murainagrass, Hilo ischaemum	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Isodendrion longifolium/longleaf isodendrion/aupaka	T/T	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c] Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	Comments and Rationale
Kadua cookiana/Cook’s bluet/‘āwiwi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Kadua st-johnii/Nā Pali beach starviolet	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Keysseria erici/Alaka‘i Swamp island-daisy	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Keysseria helenae/Mt. Wai‘ale‘ale island-daisy	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Labordia helleri/Nā Pali Coast labordia/kāmakahala	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Labordia lydgatei/Wahiawa Mountain labordia/kāmakahala	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Labordia pumila/Kaua‘i labordia/ kāmakahala	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Lobelia niihauensis/Ni‘ihau lobelia	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Lysimachia daphnoides/Pacific loosestrife/ehua makanoe, kolokolo kuahiwi, kolekole lehua, kolokolo lehua	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c] Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	Comments and Rationale
Lysimachia scopulensis/ shiny-leaf yellow loosestrife/ehua makanoe, kolokolo kuahiwi, kolekole lehua, kolokolo lehua	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Melicope degeneri/Kōke'e Stream melicope/alani, alani kuahiwi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Melicope pallida/pale melicope/alani, alani kuahiwi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Melicope paniculata/Līhu'e melicope/ alani, alani kuahiwi	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Melicope puberula/hairy melicope/ alani, alani kuahiwi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Myrsine linearifolia/narrowleaf colicwood/kōlea	T/T	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Myrsine mezii/ Hanapēpē River colicwood/kōlea	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Peucedanum sandwicense/makou	T/T	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Phyllostegia renovans/red-leaf phyllostegia	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c]					Comments and Rationale
	Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	
Phyllostegia wawrana/fuzzystem phyllostegia	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Pittosporum napaliense/royal cheesewood/hō‘awa, hā‘awa	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Plantago princeps var. *anomola*/ale/ laukahi kuahiwi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Plantago princeps var. *longibracteata*/ ale/laukahi kuahiwi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Plantanthera holochila/Hawai‘i bog orchid	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Platydesma rostrata/pilo kea lau li‘i	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Poa manii/Olokele Gulch bluegrass	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Poa sandvicensis/Hawaiian bluegrass	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Polyscias bissattenuata/‘ohe‘ohe	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c]					Comments and Rationale
	Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	
Polyscias flynii/ʻoheʻohe	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Polyscias racemosum/Munroidendron	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Pritchardia hardyi/Hardy's loulu/loulu	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Pritchardia napaliensis/Nāpali loulu/ kōpiko	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Psychotria hobdyi/Hobdy's wild-coffee/kōpiko	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Pteralyyxia kauaiensis/kaulu	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Remya montgomeryi/Kalalau Valley remya	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Scheidea kauaiensis/Kauaʻi schiedea	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Schiedea lychnoides (listed as *Alsinidendron lychnoides*)/ kuawāwaenohu	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c] Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	Comments and Rationale
Stenogyne kealiae/Keal's stenogyne	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Stenogyne campanulata/Kalalau Valley stenogyne	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Tetraplasandra kavaiensis/ʻoheʻohe	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Wilkseya hobdyi/dwarf iliau	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

[a] When available, all three names are listed in order from scientific name, common, and Hawaiian name.

[b] **Federal**

E = listed as endangered under the ESA

T = listed as threatened

C = candidate for listing under ESA

[b] **State**

E = listed as endangered

T = listed as threatened

[c] **Criteria met or not**

\+ = Yes, the species meets the selection criteria

– = No, the species does not meet the selection criteria

U = Uncertain whether species meets selection criteria. More investigation required.

Attachment 1. Evaluation of Hawaiian Hoary Bat (ʻōpeʻapeʻa) Coverage in KIUC HCP

Memorandum

Date:	August 13, 2020
To:	Dawn Huff, Kauaʻi Island Utility Cooperative (KIUC)
From:	Dave Johnston, Paul Conry, Ron Duke, and Scott Terrill (HT Harvey) David Zippin, Torrey Edell, Ellen Berryman (ICF)
Subject:	**Evaluation of Hawaiian hoary bat (ʻōpeʻapeʻa) coverage in KIUC HCP**

The purpose of this memorandum is to document KIUC's evaluation to determine whether listed Hawaiian hoary bats (ʻōpeʻapeʻa) (*Lasiurus cinereus semotus*) should be included as covered species in the KIUC Habitat Conservation Plan (KIUC HCP).

Criteria for Coverage

KIUC used the following criteria to evaluate potential covered species in the HCP. KIUC decided to cover species in the HCP if they met all four of the criteria described below.

1. **Listing status.** The species is currently listed under the federal Endangered Species Act (federal ESA) or the Hawaiʻi ESA (Hawaiʻi Revised Statute [HRS] 195D-4).
2. **Geographic range**. The species is currently known to occur throughout the Plan Area (Island of Kauaʻi) based on knowledge of the species' geographic range and the presence of suitable habitat.
3. **Effects of covered activities.** The species has a reasonable likelihood of "take" as defined by the federal ESA and Hawaiʻi ESA by HCP covered activities that are currently occurring within the Plan Area or are likely to occur over the life of the permits.
4. **Adequacy of existing data on the species.** Sufficient data is available regarding the species' life history, habitat requirements, and presence in the Plan Area to adequately evaluate effects on the species and develop appropriate conservation measures to satisfy the permit issuance criteria of the ESA Section 10 and HRS Section 195D-2.

The Hawaiian hoary bat (ʻōpeʻapeʻa) was state- and federally listed as endangered on October 13, 1970 (U.S. Fish and Wildlife Service 1970). No critical habitat has been designated for the Hawaiian hoary bat (ʻōpeʻapeʻa). This species is widespread on the island of Kauaʻi (U.S. Fish and Wildlife Service 1998). Based on data from the islands of Hawaiʻi (Bonaccorso et al. 2015) and Maui (H.T. Harvey and Associates 2019), bat activity occurs in many habitats and females nursing young are generally expected at lower elevations (less than 1,000 feet [304.8 meters] in elevation) during summer months. Thus, the species is expected to raise young throughout much of the lowland areas with appropriate larger trees with dense foliage.

The Hawaiian hoary bat (‘ōpe‘ape‘a) meets the first two criteria described above because it is both listed and known to occur on Kaua‘i. Additionally, the species meets the fourth criteria because sufficient data is available to evaluate effects on the species and develop appropriate conservation measures to satisfy permit issuance criteria. The remainder of this memo focuses on the third criterion: the effects of covered activities on the Hawaiian hoary bat (‘ōpe‘ape‘a) and the likelihood of take, and commitments from KIUC to avoid take of this species.

Effects of Covered Activities

The only KIUC activity with the potential to affect Hawaiian hoary bats (‘ōpe‘ape‘a) is the pruning or removal of trees, but KIUC can avoid take of Hawaiian hoary bats (‘ōpe‘ape‘a) resulting from this activity through the implementation of avoidance measures. While the operation of streetlights may influence Hawaiian hoary bats (‘ōpe‘ape‘a) behavior by attracting bats, no adverse effects of the streetlights are anticipated. Each of these covered activities is detailed below.

Tree Pruning and Removal

Nursing females typically leave their pups in the roost tree while they forage (Barclay 1989), leaving young Hawaiian hoary bat (‘ōpe‘ape‘a) pups unable to leave a tree that is being trimmed or removed. Non-flying pups are therefore vulnerable until they can fly on their own. To avoid and minimize impacts on endangered Hawaiian hoary bats (‘ōpe‘ape‘a), the U.S. Fish and Wildlife Service (USFWS) recommends that projects: (1) do not disturb, remove or trim woody plants more than 15 feet (4.6 meters) tall during the bat birthing and pup rearing season of June 1 through September 15; and (2) do not use barbed wire for fencing (U.S. Fish and Wildlife Service 2020). Similarly, the State of Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) provides guidance that site clearing should be timed to avoid disturbance during the bat birthing and pup rearing season from June 1 through September 15. However, if site clearing cannot be avoided, including for emergency work, woody plants more than 15 feet (4.6 meters) tall should not be disturbed, removed, or trimmed without consulting DOFAW (Appendix A; State of Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife 2015, 2020).

Take of Hawaiian hoary bats (‘ōpe‘ape‘a) pups is more likely when dense vegetation is trimmed along lightly traveled roads, because this species is much more likely to use these areas than heavily travelled roadways with sparse vegetation (H.T. Harvey and Associates 2014). Based on recent radio-tracking data from Maui, bats roosted occasionally along quiet neighborhood streets with large densely foliated trees, but did not roost in trees under 15 feet (4.6 meters) tall or in trees that had relatively sparse leaves (e.g., albizia [*Falcataria moluccana*]) (H.T. Harvey and Associates 2019). During 2 years of data collection, on only a single night was a male bat observed roosting in a tree along a busy two-lane highway (Kula Highway); a Chinese elm (*Ulmus parvifolia*) with large mats of vines making a very densely foliated tree (i.e., a tree with foliage too dense to be able to see light coming through the tree) (H.T. Harvey and Associates 2019). Females, on the other hand, were never observed roosting along busy two-lane highways (H.T. Harvey and Associates 2019).

To evaluate the potential for Hawaiian hoary bats (‘ōpe‘ape‘a) take from vegetation trimming and removal, KIUC commissioned and implemented a pre-trimming bat monitoring program during the bat pup rearing seasons between 2013 and 2015, using thermal imaging. Tree trimmers were trained by KIUC’s consulting biologist on the use and methodology for searching vegetation on a daily basis in areas to be trimmed during the bat pup rearing season prior to vegetation clearing. The tree trimmers were trained using live mice in small cages that were hidden in vegetation along typical line-clearing segments by KIUC and its biologist. Training and blind searcher efficiency trials were conducted each year. During 3 years of monitoring during the bat pup rearing season (June 1 through September 15), KIUC and its contractors failed to find a single bat in over 662 tree-trimming unit-days. Even though no bats had been detected during tree-trimming activities, at the end of the 2015 season KIUC agreed to refrain from trimming in potential habitat during the pup rearing season. USFWS agreed that, with implementation of this measure and additional measures outlined below under *Avoidance Measures,* KIUC will avoid take of Hawaiian hoary bats (ʻōpeʻapeʻa) (Appendix A; U.S. Fish and Wildlife Service 2015).

Street Light Attraction

The Hawaiian hoary bat (ʻōpeʻapeʻa) regularly forages at streetlights (Belwood and Fullard 1984), and concentrations of moths around streetlights likely reduces the foraging time for bats (Acharya and Fenton 1999). Thus, these streetlights concentrate large moths, which also maximizes energy returns for the bats (Acharya and Fenton 1999).

Currently no data exist on the predation of the Hawaiian hoary bat (ʻōpeʻapeʻa) by owls or other predators (State of Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife 2015). Based on the ecology of other fast-flying open aerial foragers that forage at streetlights (Rydell et al. 1996), predation by owls at streetlights is unlikely. Rydell et al. (1996) found that smaller bats tend to begin foraging later than larger bats, possibly to avoid avian predation that is likely a greater risk with more available light. However, larger and therefore faster flying insectivorous bats, such as the Hawaiian hoary bat (ʻōpeʻapeʻa), start foraging earlier than slower bats, even when differences in diet and foraging habitat are controlled for (Jones and Rydell 1994). Because the Hawaiian hoary bat (ʻōpeʻapeʻa) often begins foraging at or just prior to sunset (Bonaccorso et al. 2015) while light values are relatively high compared to an hour or more later, this species does not appear to be avoiding predation. Therefore, it is unlikely that predation on the Hawaiian hoary bat (ʻōpeʻapeʻa) occurs when light values are high, such as is the case at streetlights.

Even though the Hawaiian hoary bat (ʻōpeʻapeʻa) is widely distributed on Kauaʻi, there are no data suggesting that bats have collided, or will likely collide, with utility structures on Kauaʻi. Currently, the only documented risk to the Hawaiian hoary bat (ʻōpeʻapeʻa) from anthropogenic structures are bats having been caught on barbed wire fencing and colliding with rotating wind turbines.

Avoidance Measures

During the KIUC HCP permit term, KIUC will commit to the following measures to avoid take of Hawaiian hoary bat (ʻōpeʻapeʻa).

1. KIUC will refrain from vegetation trimming or removal during the pup rearing season (June 1 to September 15) where vegetation is over 15 feet (4.6 meters) tall.[1]

2. Based on results from 3 years of comprehensive bat search protocols, vegetation maintenance in areas along heavily traveled roadways that lack vegetation over 15 feet (4.6 meters) tall may be trimmed during the Hawaiian hoary bat (ʻōpeʻapeʻa) bat pupping season (June 1 to September 15) (U.S. Fish and Wildlife Service 2015).

[1] This measures excludes grasses over 15 feet (4.6 meters) tall (i.e., Guinea grass) that are characterized by the lack of overhanging foliage (Willis and Brigham 2005).

3. In the very rare circumstances when removing/trimming/disturbing trees is necessary to correct a location-specific service problem (such as a trouble call reporting that a tree limb had fallen against lines or due to wind repeatedly striking a line, causing light flickering or breaker openings) during the bat pup rearing season, KIUC will only perform the minimum amount of tree trimming absolutely necessary to alleviate the immediate service problem. These very rare situations are not expected to involve take by removing only the minimum amount of vegetation necessary to correct the service problem and avoid imminent danger to lives and property. DOFAW and USFWS will be consulted via email with information on the event (e.g., location, date of removal, type of vegetation) before any vegetation more than 15 feet (4.6 meters) tall is disturbed, removed, or trimmed during the pup rearing season (June 1 through September 15).
4. No barbed wire will be used for conservation fencing.

Conclusion

The Hawaiian hoary bat (ʻōpeʻapeʻa) does not meet all four criteria for coverage under the KIUC HCP. Although the species is federally listed and occurs in the HCP permit area, and sufficient information exists to assess effects on the species and develop a conservation strategy, KIUC activities will avoid take of Hawaiian hoary bat (ʻōpeʻapeʻa). Vegetation trimming or removal will not result in take of Hawaiian hoary bats (ʻōpeʻapeʻa) with implementation of the avoidance measures described above. Furthermore, streetlights are not expected to result in take of Hawaiian hoary bat (ʻōpeʻapeʻa) for the reasons described above. Therefore, the KIUC HCP will not cover Hawaiian hoary bat (ʻōpeʻapeʻa).

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Appendix A. Agency Guidance Regarding Avoidance and Minimization Measures for Hawaiian Hoary Bat (ʻōpeʻapeʻa)

1. U.S. Fish and Wildlife Service December 16, 2015 letter regarding bat monitoring.
2. Division of Forestry and Wildlife August 6, 2020 email regarding guidance on bat take avoidance.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122
Honolulu, Hawai'i 96850

In Reply Refer To:
01EPIF00-2016-TA-0119

DEC 16 2015

Mr. Carey Koide
Transmission and Distribution Manager
Kaua'i Island Utility Cooperative
4463 Pahe'e Street, Suite 1
Līhu'e, HI 96766

Subject: Kaua'i Island Utility Cooperative Request to Forego Further Bat Monitoring

Dear Mr. Koide:

This responds to your December 2, 2015 letter requesting to modify avoidance measures to prevent take of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) during Kaua'i Island Utility Cooperative's (KIUC) maintenance operations. The KIUC has implemented comprehensive bat search protocols over the course of three bat pupping seasons (each June through September) in order to prevent the take of bats during tree trimming operations, as a component under KIUC's 2011 Service-approved Short Term Habitat Conservation Plan (ST HCP). The comprehensive bat monitoring protocols, approved by the Service in 2013 (Service File 2013-TA-0306) include the use of thermal imaging devices to scan for the absence of non-volant young in tree canopies prior to trimming, as well as annual field training for all personnel involved and blind searcher efficiency trials to test the ability for tree-trimming crews to accurately detect and avoid take of bats.

The Service received KIUC's 2015 bat monitoring report on December 1, 2015. Reviewing KIUC's monitoring data reports for 2013, 2014, and 2015 indicates that the tree-trimming teams have completed a total of 662 tree-trimming unit-days of monitoring of lowland vegetation clearing without encountering a single bat. Results from the searcher efficiency trials shows that tree-trimming teams have a very high likelihood of detecting a bat, if a bat were present.

Based on this information, the Service agrees with KIUC's decision to modify bat avoidance measures and forego comprehensive bat search protocols and instead limit tree-trimming during the bat pupping season (June through September) to areas along heavily traveled roadways that lack dense vegetation. The rationale behind that decision was based on the concern that in areas of very dense vegetation and along lightly traveled back roads there is a greater likelihood that bats might use that vegetation for roosting, and therefore the KIUC would not perform tree-trimming operations in these areas during the bat pupping season.

Mr. Carey Koide 2

This modified bat avoidance measure, supported by three years of monitoring data, should be considered in the development of any new KIUC-proposed habitat conservation plan. If actions proposed by KIUC are reasonably certain to result in any take of a Hawaiian hoary bat, then KIUC is recommended to seek incidental take authorization. We thank you for your efforts to conserve and protect Kaua'i's threatened and endangered species. If you have any questions regarding this letter, please contact Lasha Salbosa, Fish and Wildlife Biologist (phone: 808-792-9400 or email: Lasha-Lynn_Salbosa@fws.gov).

Sincerely,

Aaron Nadig
Island Team Manager:
O'ahu, Kaua'i, Northwestern Hawaiian Islands, and American Samoa

From: Taylor, Lauren
To: Ilana Nimz
Cc: Phil Taylor; Siddiqi, Afsheen A; tkoike@honolulu.gov; Aloha Arborist Association; Angela Liu-kelly; john_vetter@fws.gov; Steve; Dave Johnston; Bookless CIV Lance; william.grannis@us.af.mil; angela.kieranvast@navy.mil; dayna.fujimoto@navy.mil; Matthew Burt; Tyler Bogardus; keith.roberts1@usmc.mil; Stan Oka; kevin_donmoyer@fws.gov; joy_browning@fws.gov; nanea_valeros@fws.gov; Berry, Lainie; Matsuoka, Koa; Montoya-Aiona, Kristina; KAWELO, Hilary K (Kapua) CIV (US); Craig.Gorsuch@colostate.edu; angelia.binder@us.af.mil; matthew.welsh.2.ctr@us.af.mil; Moura, Sean; Katie Temple
Subject: RE: [EXTERNAL] Notes from HHB in Urban Forest meeting
Date: Thursday, August 6, 2020 4:44:09 PM

Aloha all,

Since this meeting DOFAW has had some inquiries about tree trimming during the bat pupping season. I would like to reiterate the State's current guidance on bat take avoidance and am happy for you to disseminate to your colleagues.

The State endangered Hawaiian Hoary Bat or ʻOpeʻapeʻa (*Lasiurus cinereus semotus*) has the potential to occur throughout the islands and roosts in a variety of trees. If any trees must be removed during the bat breeding season there is a risk of injury or mortality to juvenile bats. Site clearing should be timed to avoid disturbance during the bat birthing and pup rearing season (June 1 through September 15). If this cannot be avoided, including for emergency work, woody plants greater than 15 feet (4.6 meters) tall should not be disturbed, removed, or trimmed without consulting DOFAW at (808) 587-0160.

Currently we do not have data or research to support a method for reliably detecting roosting bats in trees. Therefore, to avoid the potential for take, the State recommends avoiding trimming during the pupping season.

Hawaii Revised Statutes Chapter 195D prohibits take of State listed species except when accompanied by an Incidental Take License and Habitat Conservation Plan. Our first priority in all instances is to assist in avoiding take of listed species. For take that cannot be avoided, we will work with the project proponent to minimize and mitigate the impacts of take. For anyone interested in pursuing an Incidental Take License, you may contact Koa Matsuoka (koa.matsuoka@hawaii.gov) or me for a consultation.

Respectfully,

Lauren Taylor
Protected Species Habitat Conservation Planning Coordinator
Endangered Species Biologist

Pacific Cooperative Studies Unit in cooperation with
Department of Land and Natural Resources
Division of Forestry and Wildlife
1151 Punchbowl Street, Room25
Honolulu, HI 96813
(808) 587-0010

Attachment 2. Measures to Avoid Adverse Effects on Listed Plant Species

KIUC will implement the following avoidance measures to ensure the KIUC HCP conservation measures do not adversely affect state- and federally listed plant species.

1. Prior to implementation of covered activities in potentially suitable habitat for listed plant species, including implementation of the conservation strategy minimization and conservation actions, a qualified botanist will conduct a botanical survey for listed plant species within the work area defined as the area where direct and indirect effects are likely to occur. Botanical surveys should optimally be conducted during the wettest part of the year (typically October to April) when plants and identifying features are more likely to be visible, especially in drier areas. If surveys are conducted outside of the wet season, plant presence will be assumed. If observed, listed plant locations will be mapped. The botanist should mark the boundary of the area occupied by listed plants with flagging.
2. KIUC will coordinate with a qualified botanist to implement measures ensuring the covered activities will avoid adverse effects on listed plants. KIUC will time their activities to occur when the listed plant species are less vulnerable to impacts (e.g., after seed has set), to the maximum extent possible. Buffer distances will be implemented for the actions listed in Table A2-1. The buffer distances will reduce direct and indirect impacts on listed plants from management actions. However, where covered activities occur within the recommended buffer distances, additional consultation with USFWS and DOFAW will be conducted. Impacts on the listed plant species within the buffer area may be reduced by placing temporary fencing or other barriers at the boundary of the disturbance, as far from the affected plants as practicable. KIUC may also implement erosion or siltation control measures to ensure listed plants in the vicinity of the management area are not adversely affected.
3. Prior to any work activities within management areas near or within a listed plant species buffer, the qualified botanist will conduct a worker environmental awareness training for all staff. The training will cover the listed plant species and their habitats. The training will cover the natural history, appearance (using representative photographs), and legal status of species, regulatory protections, benefits of compliance, as well as the avoidance and minimization measures that must be implemented to avoid impacts. Participants will be required to sign a form that states they have received and understand the training.
4. All activities, including surveys and monitoring, risk introducing invasive species into work areas. All equipment, personnel and supplies will be properly checked to ensure they are free of contamination (weed seeds, organic matter, or other contaminants) before entering work areas. Quarantines and or management activities occurring on specific priority invasive species proximal to project areas need to be considered or adequately addressed. This information will be obtained by contacting local experts such as those on local invasive species committees (Kaua'i: https://www.kauaiisc.org/). To avoid the potential spread of Rapid 'Ōhi'a Death (ROD), ROD decontamination protocols will be followed.

Table A2-1. Buffer Distances to Avoid and Minimize Potential Adverse Impacts on Listed Plant Species

Action		Buffer Distance (feet (meters))—Keep Work Activity This Far Away from Listed Plant: Grasses/Herbs/Shrubs and Terrestrial Orchids	Buffer Distance (feet (meters))—Keep Work Activity This Far Away from Listed Plant: Trees and Arboreal Orchids
Walking, hiking, surveys/monitoring		3 ft (1 m)	3 ft (1 m)
Cutting and removing vegetation by hand or hand tools (e.g., weeding)		3 ft (1 m)	3 ft (1 m)
Mechanical removal of individual plants or woody vegetation (e.g., chainsaw, weed eater)		3 ft up to height of removed vegetation (whichever greater)	3 ft up to height of removed vegetation (whichever greater)
Removal of vegetation with heavy equipment (e.g., bulldozer, tractor, “bush hog”)		2x width equipment + height of vegetation	820 ft (250 m)
Use of approved herbicides (following label)	Ground-based spray application; hand application (no wand applicator; spot treatment)	10 ft (3 m)	Crown diameter
	Ground-based spray application; manual pump with wand, backpack	50 ft (15 m)	Crown diameter
	Ground-based spray application; vehicle-mounted tank sprayer	50 ft (15 m)	Crown diameter
	Aerial spray (ball applicator)	250 ft (76 m)	250 ft (76 m)
	Aerial application – herbicide ballistic technology (individual plant treatment)	100 ft (30 m)	Crown diameter
	Aerial spray (boom)	Further consultation required	Further consultation required
Ground/soil disturbance/outplanting/fencing (hand tools, e.g., shovel, ʻōʻō; small mechanized tools, e.g., auger)		20 ft (6 m)	2x crown diameter
Ground/soil disturbance (heavy equipment)		328 ft (100 m)	820 ft (250 m)
Surface hardening/ soil compaction	Trails (e.g., human, ungulates)	20 ft (6 m)	2x crown diameter
	Roads/utility corridors, buildings/structures	328 ft (100 m)	820 ft (250 m)

Appendix 3A
Species Accounts

Appendix 3A
Species Accounts

3A.1 Newell's Shearwater (ʻaʻo) (*Puffinus newelli*)

3A.1.1 Listing Status and Taxonomy

The Newell's shearwater (ʻaʻo) (*Puffinus newelli*), listed as threatened under the federal Endangered Species Act (federal ESA) in 1975, is endemic to the Main Hawaiian Islands (MHI) (Niʻihau, Kauaʻi, Oʻahu, Molokaʻi, Maui, Lānaʻi, Kahoʻolawe, and Hawaiʻi). This species is in the seabird family Procellariidae (Ainley et al. 1997a, 2020). The Newell's shearwater (ʻaʻo) was until recently considered by both the U.S. Fish and Wildlife Service (USFWS) and the North American Classification Committee (NACC) as a *super species* containing the Townsend's shearwater (*P. auricularis townsendi*) and Newell's shearwaters (ʻaʻo) collectively treated as *Puffinus auricularis newelli.* In 2015, NACC decided that both were full species (Chesser et al. 2015), given their non-overlapping breeding and foraging ranges, and morphological and phenological differences (Ainley et al. 2020). USFWS, however, continues to treat both Townsend's shearwater and Newell's shearwater (ʻaʻo) as subspecies of *Puffinus auricularis* (U.S. Fish and Wildlife Service 2016a). Newell's shearwaters (ʻaʻo) and Townsend's shearwaters separate based on breeding phenology and distribution, behavior, and plumage (Ainley et al. 1997a, 2020). The species is also listed as threatened under Hawaiʻi Revised Statutes (HRS), Chapter 195D, Section 195D-4, Endangered and Threatened Species. The species is ranked as critically endangered under the International Union for Conservation of Nature (IUCN) Red List (BirdLife International 2019). No critical habitat has been designated for the Newell's shearwater (ʻaʻo) (50 Code of Federal Regulations 17.11).

3A.1.2 Life History

The Newell's shearwater (ʻaʻo) breeds only in the southeastern Hawaiian Islands (Pyle and Pyle 2017a). As summarized in Ainley et al. (2020), when not at breeding colonies, the Newell's shearwater (ʻaʻo) is highly pelagic, frequenting tropical and subtropical waters overlying depths greater than 6,562 feet (ft) (2,000 meters [m]), mostly east and south of the Hawaiian Islands. It captures prey by pursuit-plunging, an uncommon foraging method among warm-water seabirds (Ainley 1977) and can regularly reach depths of 164 ft (50 m) in pursuit of prey (Ainley et al. 2020). Flight is strong, with rapid wing beats interspersed with short glides, a style requiring predictable prey availability; thus, this flight style is also uncommon among warm-water seabirds (Spear and Ainley 1997a, 1997b). These shearwaters rely heavily on tuna, especially yellowfin tuna (*Thunnus albacares*) and other large, predatory fish that drive prey (predominantly ommastrephid squid) toward the ocean surface (Spear et al. 2007; Ainley et al. 2014).

Newell's shearwaters (ʻaʻo) arrive on colonies in early April, exhibit a pre-laying exodus from late April to mid-May (typical of procellarids), and lay eggs from late May to early June, with chicks fledging late September to mid-November, predominantly in October (Ainley et al. 2020). Females lay a single egg in a chamber at the end of a deep burrow. Incubation is 52–55 days; the chick-rearing period lasts approximately 92 days (Telfer 1986; Ainley et al. 2020).

3A.1.3 Habitat Requirements and Ecology

This species breeds in burrows or deep rock crevices, within dense vegetation at higher elevations, or on sheer coastal cliffs and slot canyons (i.e., long, narrow, deep canyon) (Troy et al. 2016; Ainley et al. 2020; Raine et al. 2021a). On the Island of Kauaʻi, Newell's shearwaters (ʻaʻo) breed at locations between 525 and 3,927 ft (160 and 1,197 m) above sea level (mean 1,509 ft [460 m] ± 394 ft [120 m] SD, *n* = 17; Ainley and Holmes 2011), and in Puna District on Hawaiʻi, at 620–1,083 ft (189–330 m) above sea level (Reynolds and Ritchotte 1997). Newell's shearwaters (ʻaʻo) no longer breed in lowlands, where wedge-tailed shearwaters (ʻuaʻu kani) (*Ardenna pacifica*) are abundant—a species that does not breed at higher elevations (Brattstrom and Howell 1956; Harrison 1990). One exception is a small Newell's shearwater (ʻaʻo) colony established artificially at Kīlauea Point, Kauaʻi, as part of a cross-fostering experiment (Byrd et al. 1984; Telfer 1986; Haber et al. 2010); this population consisted of six to nine breeding pairs in 2017 and nine pairs in 2019 (Raine et al. 2018a, 2020a). While Newell's shearwaters (ʻaʻo) and wedge-tailed shearwaters (ʻuaʻu kani) can co-occur, wedge-tailed shearwaters (ʻuaʻu kani) regularly evict breeding Newell's shearwater (ʻaʻo) pairs (Ainley et al. 2020; Raine et al. 2020a).

The Newell's shearwater (ʻaʻo) is absent in the Leeward Hawaiian Islands where other species of shearwaters, such as the wedge-tailed (ʻuaʻu kani) and Christmas (*Puffinus nativitatus*) shearwaters breed abundantly. These islands, however, are low in elevation, with sparse vegetation, which are factors not typical of Newell's shearwater (ʻaʻo) habitat (Troy et al. 2016; Young et al. 2019).

Due in part to the presence of pigs (*Sus scrofa*), rats (*Rattus* spp.), and cats (*Felis catus*), Newell's shearwaters (ʻaʻo) now nest on steep slopes ranging 28° to 48° on Kauaʻi (median = 39°; Troy et al. 2016), but also on near-vertical volcanic crater walls on Hawaiʻi (Reynolds and Richotte 1997; Ainley et al. 2020). Newell's shearwater (ʻaʻo) usually nest where terrain is vegetated by an open canopy of ʻōhiʻa lehua (*Metrosideros polymorpha*) and other native, wet, montane forest species, with an understory of densely matted false staghorn (uluhe) ferns (*Dicranopteris linearis*) (Troy et al. 2016). Raine et al. (2021a) documented that the three most important microhabitat variables for Newell's shearwater (ʻaʻo) are ʻōhiʻa lehua in the canopy, elevation, and percentage of false staghorn (uluhe) in the understory. The species also breeds, or at least recently bred, in the dry cliff faces of the Waimea Canyon and slot canyons of the Nā Pali Coast, Kauaʻi, both areas of sparse vegetation (Ainley et al. 2020). These birds may occasionally climb nearby trees or rock outcrops to take flight because they have difficultly taking off from flat ground (Telfer et al. 1987; Ainley et al. 2020); however, they have been observed to fly away on flat, unobstructed areas (shopping center parking lots) after becoming grounded when winds were adequately strong (Ainley et al. 1995).

Nesting colonies are situated inland from the coast—as much as 8.7 miles (mi) (14 kilometers [km]) on Kauaʻi. Inland-breeding Newell's shearwaters (ʻaʻo) on Kauaʻi repeatedly use the same routes when flying between breeding areas and the sea. Based on tracking work conducted by Raine et al. (2017a), key features the birds use to route to nesting colonies on Kauaʻi are terrain (specifically ridge tops) and prevailing wind, and while they have a few defined key routes, they appear to choose which route to take depending on prevailing wind direction and wind speed. On the other hand, outbound flights follow a broad swath out to sea, generally using the shortest possible distance between burrow and sea level.

Rainfall in Kauaʻi mountains, where Newell's shearwater (ʻaʻo) nest, is among the heaviest anywhere on Earth. Mean annual rainfall at Mount Waiʻaleʻale is 450 inches (1,143 centimeters [cm]); mean annual rainfall in Puna District and Waipiʻo Valley, on the windward east side of the island of

Hawaiʻi, is 108–213 inches (274–541 cm) (Encyclopedia Britannica 2020; Carlquist 1980; Giambelluca et al. 2013). Heavy rainfall facilitates dense vegetation growth.

3A.1.4 Distribution and Population Trends

3A.1.4.1 Current and Historic Distribution

As noted in Ainley et al. (2020), Newell's shearwaters (ʻaʻo) occur year-round in the eastern tropical Pacific Ocean, especially in the Equatorial Countercurrent, from equatorial waters lying south of the Hawaiian Islands east to about 120°W and north to the subtropical waters surrounding the MHI (22°N). During breeding season, low densities occur short distances west and north of Hawaiʻi to about 25°N (King and Gould 1967; Spear et al. 1995a; Joyce et al. 2011). Also, during that time of year, the central part of the marine range projects slightly northward, likely an artifact of more adults and subadults commuting to and from breeding colonies (Ainley et al. 2020). Telemetry work conducted by the Kauaʻi Endangered Seabird Recovery Project (KESRP) shows that during the breeding season, Newell's shearwaters (ʻaʻo) predominately use water north of Kauaʻi, up to 93.2 mi (150 km), while non-breeding or failed breeders can range more widely (Raine et al. 2021b). Nesting pairs engage in a short-long alteration of foraging trips, with one member of each pair making daily trips while the other is farther at sea for about a week; then they switch routines (Ainley et al. 2020).

Within the Hawaiian Islands, Newell's shearwaters (ʻaʻo) are found in the fossil and subfossil deposits of Oʻahu and other islands, and are believed, or are known, to have colonized Hawaiʻi, Maui, Molokaʻi, Oʻahu, and Kauaʻi Islands (Pyle and Pyle 2017a; Ainley et al. 2020). While the early Hawaiians knew the seabird well, naming it ʻaʻo after its distinctive call, the species was thought to be extinct after 1908, due largely to habitat loss and predation (Pyle and Pyle 2017a). Since then, Newell's shearwaters (ʻaʻo) have been detected on Kauaʻi, Oʻahu, Hawaiʻi, and Maui. Currently, breeding is only known to occur on Kauaʻi, Maui and Hawaiʻi, but song meter recordings made in 2016 and 2017 indicate that a small number of Newell's shearwaters (ʻaʻo) regularly prospect on Oʻahu (Young et al. 2019).

3A.1.4.2 Within the Plan Area

The majority of the Newell's shearwater (ʻaʻo) breeding areas are in the northwestern portion of Kauaʻi (Figure 1). These breeding populations are found primarily in mountainous areas within deep valleys and along the edges of steep ridges (Ainley and Holmes 2011; Ainley et al. 2020). The only current coastal nesting site, established artificially, is at Kīlauea Point National Wildlife Refuge; as of 2017, a total of 25 burrows have been located at this site; 9 of these burrows were active in 2019 (Raine et al. 2020a). This population is the result of an egg swap project during 1978–1980 when approximately 100 Newell's shearwater (ʻaʻo) eggs from burrows in the Anahola Mountains and Kaluahonu were moved to Kīlauea Point and Mokuʻaeʻae Islet (Byrd et al. 1984). The current distribution of Newell's shearwaters (ʻaʻo) can in part be explained not only by the birds' preferred locations, but also range restrictions caused by predation by introduced mammals (Ainley et al. 2020) and other factors discussed above and further in Section 3A.1.5, *Threats*.

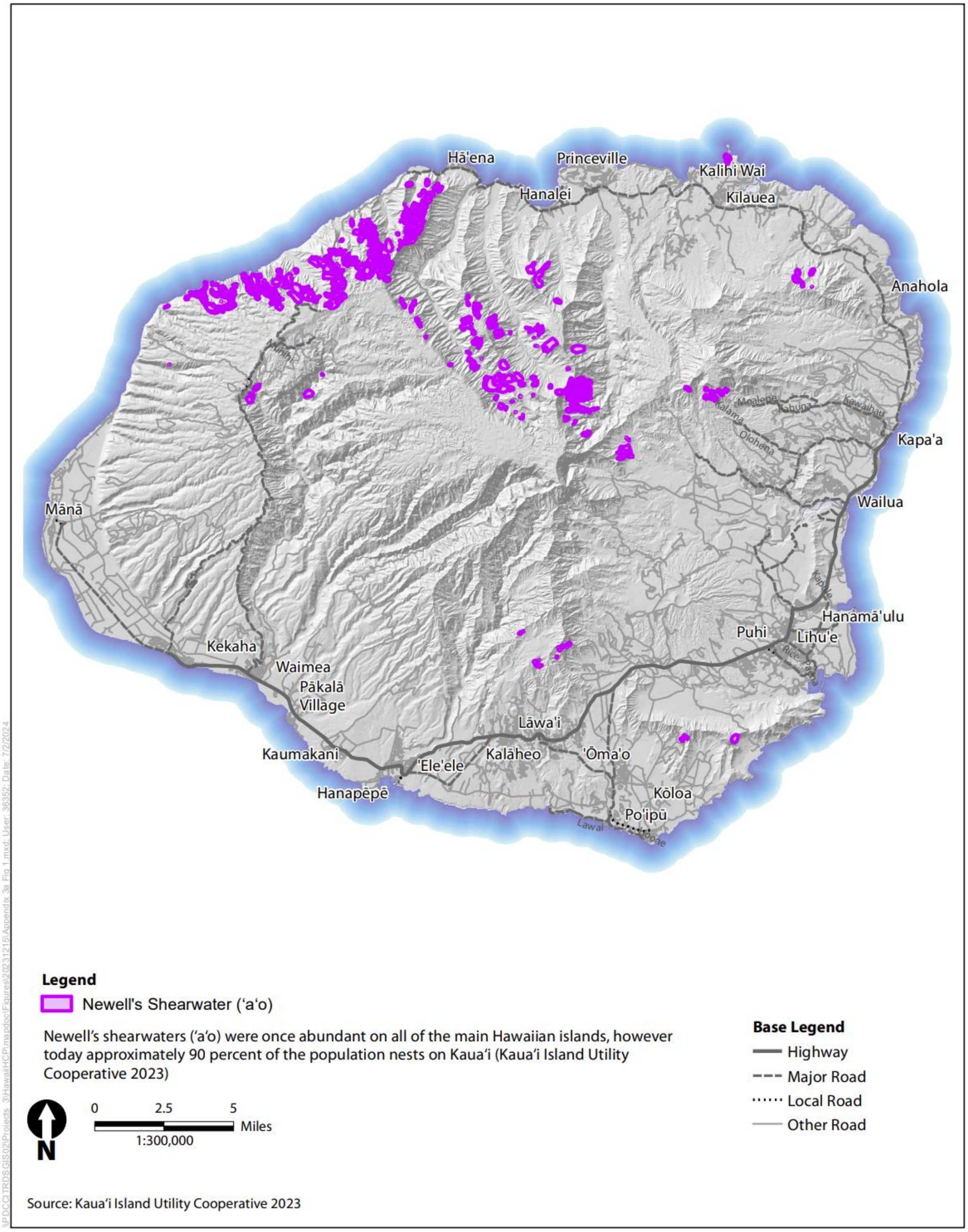

Figure 1. Current Confirmed Distribution of the Newell's Shearwater (ʻaʻo) Based on Contemporary Auditory Surveys

Since 2006, KESRP has been using auditory surveys to locate contemporary breeding areas of this species. USFWS has estimated that the suitable breeding habitat range represents roughly 2,634 acres (1,066 hectares; U.S. Fish and Wildlife Service 2016b) that occurs predominantly in the northwestern portion of Kauaʻi. Included are Wainiha Valley, Lumahaʻi Valley, Hanalei Valley, Upper Limahuli Valley, Upper Mānoa Valley, and in the valleys along the Nā Pali Coast from Hanakāpiʻai to Nuʻalolo (Raine et al. 2018b). Habitat suitability modeling by Troy et al. (2014) indicates that a moderate portion of the sloped interior of Kauaʻi could potentially be suitable nesting habitat for Newell's shearwater (ʻaʻo); however, in combination with a habitat/threat-isolation index (Troy et al. 2014), is much more restricted to portions of Kauaʻi isolated from anthropogenic factors. The bulk of the known active Newell's shearwater (ʻaʻo) burrows are in the Hono o Nā Pali Natural Area Reserve and Upper Limahuli Preserve (Raine et al. 2019a).

3A.1.4.3 Population

Kauaʻi supports approximately 90 percent of the known total Newell's shearwater (ʻaʻo) population (Pyle and Pyle 2009; Ainley et al. 2020). An assessment based on at-sea survey data collected by the National Marine Fisheries Service (NMFS) Southwest Fisheries Science Center from 1998 to 2011, estimated the total Newell's shearwater (ʻaʻo) population at 27,011 (95 percent CI = 18,254–37,125), which would include juveniles, sub-adults, and adults (Joyce et al. 2016). An updated assessment by Joyce et al. (2019) largely confirmed the 2016 estimate, concluding there to be 28,779 Newell's shearwaters (ʻaʻo) (95 percent CI = 17,574–43,011) (Joyce et al. 2019). However, these estimates are incomplete because the at-sea survey data analyzed by Joyce et al. (2016, 2019) only partially covered the full oceanic range of the species. Satellite-tagged Newell's shearwaters (ʻaʻo) from Kauaʻi have been tracked beyond the two at-sea survey boundaries, and the observed locations of tagged birds indicate that the available at-sea survey effort missed a substantial percentage of the population/at-sea range (Raine et al. 2021b). For example, those surveys did not include Newell's shearwaters (ʻaʻo) seen more than 300 mi (482.8 km) north of Kauaʻi (Joyce et al. 2016). Covering approximately the same ocean area, as well as decades earlier, Newell's shearwater (ʻaʻo) population estimates made based on 1986–1998 at-sea surveys are somewhat higher at 16,700–19,300 breeding pairs (Spear et al. 1995a), although as Joyce et al. (2016) stated the two estimates were not directly comparable due to different survey areas and methods. The lower population estimate of Joyce et al., compared to Spear et al., nevertheless is consistent with the decrease seen both by long-term radar studies by KESRP and the Save Our Shearwaters (SOS) fledgling fallout data (Raine et al. 2017b).

Given there is no correction factor to account for the negative bias in the at-sea survey estimates of abundance, Archipelago Research and Conservation (ARC) has developed island-based spatial estimates for the number of Newell's shearwater (ʻaʻo) breeding pairs in different areas of Kauaʻi. These estimates expand on previous studies (Raine et al. 2019b), which developed methods to estimate breeding pairs in acoustically monitored conservation sites in northwestern Kauaʻi (i.e., Upper Limahuli Preserve, Pihea, Pōhākea, North Bog, Hanakāpiʻai, and Hanakoa). In 2017, the first estimates of breeding pair abundance were produced at monitored management areas using a combination of survey data, based on two independent approaches: (1) auditory survey data (including night vision equipment) was used to map the perimeters of areas occupied by breeding colonies, and the habitat suitability model presented in Troy et al. (2014, 2017) was overlayed to further refine the spatial distribution of breeding pairs. Then, the nearest neighbor distance from known burrows at monitored colonies was used to apply an expected nesting density in the suitable habitat within the breeding colony perimeter, resulting in an estimate of breeding pair abundance;

and (2) a regression analysis of acoustic monitoring data, which provides an estimate of active burrows (i.e., breeding pairs) as a function of call detections given previous studies comparing paired visual and acoustic data in the same nesting areas. Based on the outputs of the two models, it was decided that the auditory survey data and habitat suitability modeling was the most appropriate way of providing population estimates and that the acoustic call rate method would need to be further refined before it could be used for this metric (e.g., Raine et al. 2019b).

For other areas of Kauaʻi, ARC has also used available auditory survey data to estimate breeding pair abundance, including a modified version of the Troy et al. (2014) habitat suitability model for Newell's shearwater (ʻaʻo) on Kauaʻi. The habitat suitability model was modified in several respects for this purpose, including filtering the estimated suitable habitat to reflect that, in areas without predator mitigation measures, the remaining breeding pairs are currently restricted to nesting in less accessible areas than those found in the conservation sites. Likewise, a correction factor was applied to account for active burrows being more dispersed in unmanaged areas (i.e., a reduction in densities of breeding pairs), due to (1) a lack of invasive predator control, resulting in higher predation rates on nesting birds in colonies outside the conservation sites, and (2) greater vulnerability to powerline collisions and light attraction in areas outside the more remote and undeveloped northwestern region of the island. However, in these unmanaged areas, available auditory survey data is relatively sparse and opportunistic (i.e., the auditory survey data have spatial coverage gaps and surveys have not been systematically performed each year, unlike the auditory surveys at the conservation sites).

This approach, based on available auditory survey data and the habitat suitability model, resulted in a minimum estimate of 10,186 breeding pairs on Kauaʻi and a minimum island-wide population of 34,546, and as stated above, assuming the Kauaʻi population is 90 percent of the entire population, a minimum total of 11,318 breeding pairs and a minimum population of 38,384 in the State of Hawaiʻi.

3A.1.4.4 Decline/Trend

Based on radar and SOS data collected between 1993 and 2013 the Newell's shearwater (ʻaʻo) population exhibited a significant decline in numbers commuting to and from montane breeding areas (Raine et al. 2017b; Ainley et al. submitted); in the last decade the trend flatlined (Raine and Rossiter 2020; Ainley et al. 2020; Ainley et al. submitted). Ornithological radar was first used to detect prevalence of Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu) (*Pterodroma sandwichensis*) in the various parts of Kauaʻi during 1992–1993 from May through mid-July (i.e., during the incubation and early chick-rearing stage) (Day et al. 2003a, 2003b). The effort was based on methods developed to monitor marbled murrelets (*Brachyramphus marmoratus*) in the Pacific Northwest (Cooper et al. 2001). The radar effort continued, and Day et al. (2003b) reported a mean annual decrease of 11.2 percent in the Newell's shearwater (ʻaʻo) population between 1993 and 2001.

Radar surveys have only been conducted in coastal areas of eastern, southern, and portions of northern Kauaʻi, which are the sections of coast accessible to vehicle-mounted radar equipment. Therefore, these radar data do not apply to the Nā Pali Coast, where the population is now concentrated (Figure 1). The study found an overall decrease in passage rates of 94 percent in 20 years. All the 13 monitored sites showed a substantial decrease in movement rates, with movement rates at 12 (92 percent) of the 13 sites showing statistically significant decreases (Raine et al. 2017b). Based on the radar data as a proxy for the breeding population, the Newell's shearwater (ʻaʻo) population was deemed to have decreased at an annual mean rate of approximately 13 percent over the 20-year period between 1993 and 2013 (Raine et al. 2017b). This updated rate of decrease is comparable to the mean annual rate of 11.2 percent between 1993 and 2001 reported by Day et al. (2003b).

Parallel to the radar data, the number of Newell's shearwater (ʻaʻo) fledglings retrieved by the SOS Program on Kauaʻi has also decreased significantly. These fledglings are predominantly grounded due to light attraction, a phenomenon called "fallout", which affects primarily hatch year juveniles. Fledglings may fly into elevated structures (i.e., buildings) or land on the ground. On the ground they have difficulty regaining flight unless the area is open and there is sufficient wind (Section 3A.1.3, *Habitat Requirements and Ecology*). On the ground they become vulnerable to further injury or death caused by vehicles on roadways, exhaustion and dehydration, and predation by feral animals. Prior to Hurricane ʻIniki in 1992, annual numbers of fledglings collected by SOS were on average 1,511 ± 79, but from 1992 (the year of Hurricane ʻIniki) to 2015, numbers declined strongly, from 955 to 157 annually (Raine et al. 2017b). The order-of-magnitude drop in SOS Program retrievals mirrored the decrease observed in radar-based counts of Newell's shearwaters (ʻaʻo) made in the same portion of Kauaʻi monitored by SOS (Raine et al. 2017b). The shearwaters that nest in areas in northern Kauaʻi (Nā Pali Coast) do not appear to be flying where radar (limited to locations accessible by vehicle) would detect them, nor are they flying near civilization where citizens might encounter any that are grounded by light attraction (Raine et al. 2017a). Similarly, the SOS Program is concentrated in the same portions of the island that are surveyed by radar. Troy et al. (2011) suggest that there are very few portions of Kauaʻi from which young Newell's shearwaters (ʻaʻo) could successfully fledge without potentially viewing artificial light along their post-natal nocturnal flights to the ocean. And although it is not known how these birds respond to viewing lights on land once they are at sea, studies indicate that the birds can be attracted by light back to shore (Podolsky et al. 1998). Indeed, nesting only along the beach, seaward of any lights or on offshore islets, wedge-tailed shearwaters (ʻuaʻu kani) are attracted back to land from the sea (Urmston et al. 2022).

Raine and Rossiter (2020) and Ainley et al. (submitted) have shown that the trends in both radar and SOS data have leveled out since about 2009, indicating that after a very large population decline the population trend appears over the last decade to be flat. Although data from the most recent radar survey in 2020 did not change the overall significant downward trajectory on Kauaʻi of Newell's shearwater (ʻaʻo) over the entire period since 1993 (93 percent decline in overall numbers with an average rate of 6.9 percent a year), the regression for the last decade (2010–2020) is flat, with no significant change (Raine and Rossiter 2020). It is thought that with the rise in human population, along with its domestic animals added to the rats and pigs already present on Kauaʻi as well as infrastructure collisions, populations of areas surveyable by radar are now much reduced. At the same time, the impact of recent conservation efforts (i.e., reduced coastal lighting) may also have contributed to reducing the rate of decline (Ainley et al. 2020; Raine et al. 2017c; Raine and Rossiter 2020). At conservation sites that have been acoustically monitored, and at which predators have been reduced or eliminated, there have been statistically significant increases in call rates between the first year of monitoring (either 2014 or 2015, depending on the site) and 2020. The rates of increase in call rates range between 8.23 percent at Hanakoa and 18.29 percent per year at North Bog (Archipelago Research and Conservation 2022).

Consistent with these observations indicating an overall population decrease at least for eastern and southern Kauaʻi, several historical breeding sites have been depleted to the point of extirpation over the past decade (Griesemer and Holmes 2011; U.S. Fish and Wildlife Service 2016b; Raine and Rossiter 2020). The Makaleha breeding site in northeastern Kauaʻi, into which predators have access, has been regularly monitored using auditory surveys performed from an adjacent ridge overlooking the colony. A decade ago, the Makaleha breeding site had high call rates like the Upper Limahuli Preserve–managed breeding site; today, call rates are sporadic at best (Raine in litt.). Elsewhere, decreasing numbers have occurred in breeding areas that border, or are contained in, the more urban portions of Kauaʻi. Formerly well-recognized breeding sites at Sleeping Giant, Kāhili/Kalāheo, North Fork Wailua, and Kaluahonu have similarly exhibited reduction to near extirpation levels (Raine in litt.).

3A.1.5 Threats

Threats to the Newell's shearwater (ʻaʻo) include collision with powerlines, attraction to artificial lighting and subsequent grounding, predation from introduced species, habitat loss and degradation, and threats at sea which, while poorly known presumably include depletion of predatory fish (e.g., yellowfin tuna), bycatch, ocean pollution, and in general ocean alteration due to climate change. All told, the effects of these various factors have resulted in a significant decline of approximately 13 percent per year over the period of 1993 to 2013 (Raine et al. 2017b; U.S. Fish and Wildlife Service 2017), with a rapid decline of the species from 2003 to 2007 (U.S. Fish and Wildlife Service 2016c). In addition to human-caused factors, stochastic events, such as storms, and ecologically disruptive processes driven by climate change are likely to have an effect on metapopulation numbers (U.S. Fish and Wildlife Service 2016c). The following subsections describe each known threat.

3A.1.5.1 Powerline Collisions

Collisions with utility lines have been shown to have a significant impact on endangered seabirds on Kauaʻi, and data collection since the 1990s has provided robust documentation of the mortality for this species due to powerline collisions in the Plan Area (Cooper and Day 1998; Podolsky et al. 1998; Ainley et al. 2001; Travers and Raine 2016, 2020; Travers et al. 2019). Birds moving to and from the ocean and montane breeding sites in the dark may not see the powerlines and as a result may collide with them (Travers et al. 2014, 2019; Travers and Raine 2020). Extensive studies conducted by KESRP since 2011 as part of the Kauaʻi Island Utility Cooperative (KIUC) Short-Term Habitat Conservation Plan (HCP) using acoustic monitoring devices and direct observations, indicate that every powerline construction type and every region with powerlines on Kauaʻi has resulted in seabird mortality due to collisions (Travers et al. 2020). As a result of collision, seabirds may be killed upon impact or may become grounded with life-threatening injuries. Once grounded, birds can succumb to their injuries and are at risk for vehicular collision, predation, starvation, or dehydration. Collisions with powerlines and their effect on Newell's shearwaters (ʻaʻo) are discussed in detail in Chapter 5, *Effects*, and therefore are only summarized here.

As mentioned above, one method to track powerline strikes is to directly observe nighttime seabird collisions using night vision goggles. Avian powerline morality initially was quantified through ground searches (Podolsky et al. 1998); however, this does not account for birds that become grounded but are not located (whether because they are able to crawl away, they are quickly depredated, or they glide and become grounded later) or are not mortally injured but may also suffer from reduced reproductive success. It is also very difficult to search underneath many powerlines on Kauaʻi due to the rugged terrain (Travers et al. 2020). From 2012 to 2020, Travers et al. (2021) documented 112 Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) (30 percent/70 percent) collisions, of which 29 percent had negative impacts on flight capabilities.

To better understand strikes from powerlines in remote, unsearchable areas, KESRP developed a novel method to acoustically detect powerline collisions using autonomous recording devices.

Increased monitoring coverage resulted in, for the first time, data collection rates that allowed for rapid quantification of the scale of seabird powerline collisions. Several models were then created by KESRP using this data, with the most recent being a Bayesian model (Travers et al. 2020). When seabirds collide with powerlines the grounding rate has been calculated as 28.8 percent (Travers et al. 2021). When this grounding rate is applied to the total number of acoustic strikes, it provides the number of grounded birds. This sampling method provided evidence that powerline strikes represent a serious threat to Newell's shearwater (ʻaʻo) (and other Hawaiian seabirds) on Kauaʻi. For more information on KESRP's powerline strike modeling, please see Appendix 5C, *Bayesian Acoustic Strike Model.*

3A.1.5.2 Light Attraction

Newell's shearwaters (ʻaʻo) fly to and from their breeding sites only at night. Artificial lighting causes disorientation, especially in fledglings during their first journey from their breeding site to the sea. They tend to circle lights and, in the process, may collide with structures or may land. This is called *fallout*. Furthermore, some portion of fledglings that successfully reach the sea are attracted back toward land by coastal lights, where they may be then susceptible to fallout (Troy et al. 2013).

Fledglings are the most susceptible to fallout on Kauaʻi (Telfer et al. 1987). Attraction to bright lights also occurs inland but seems to have a limited/negligible effect compared to coastal areas (Raine et al. 2019c). Even Newell's shearwaters (ʻaʻo) in northwestern Kauaʻi, where there are few lights, can be attracted back to land by bright lights (Troy et al. 2013).

Since the issue was first identified in the 1970s and 1980s, efforts have been implemented on Kauaʻi to minimize effects of light attraction–related fallout. Problematic light sources once identified were altered (e.g., Reed et al. 1985). Otherwise, most of the information available on the effect of light attraction on Newell's shearwaters (ʻaʻo) comes from the SOS Program, which was developed to minimize the effects of fallout on Kauaʻi's seabird populations through resident collection and delivery of downed birds to SOS stations for rehabilitation and release (Rauzon 1991; Telfer et al. 1987).

During the last 5 years of the SOS Program (2014–2018), SOS received 179 downed Newell's shearwaters (ʻaʻo) annually on average (Anderson 2019), 83 percent of which were released and observed flying to sea. Observations indicate that, in the absence of debilitating injuries or other threats, once grounded, shearwaters may be able to reorient themselves and are able to fly away if there is sufficient slope, sufficient wind to provide lift and an unobstructed pathway (Ainley et al. 1995, 2001). Unfortunately, it is thought that most grounded birds, if not found and recovered, are unable to gain flight and die from predation, vehicle strikes, or starvation and dehydration (Raine et al. 2020b).

Although it is not known what proportion of downed seabirds are discovered and turned in to SOS, or that fly away by themselves, previous studies have used several discovery or detection rates (Podolsky et al. 1998; Travers et al. 2012). The KIUC HCP assumes a detectability rate of 50 percent for areas that are systematically searched (i.e., facilities) (Ainley et al. 2001; U.S. Fish and Wildlife Service 2018a; State of Hawaiʻi Division of Forestry and Wildlife 2020), and a much lower rate of 10.4 percent for areas that are not systematically searched (i.e., streetlights). Please refer to Appendix 5B, *Light Attraction Modeling for Covered Seabirds*, for a detailed discussion of detectability rates.

To assess whether birds released from SOS survived, a comparison was made using satellite tags affixed to SOS-released shearwater fledglings and those that naturally fledged from the Upper Limahuli Preserve. The results found that some birds that are released after rescue and rehabilitation by SOS do survive (thus highlighting the importance of SOS); however, the survival rates of birds released from SOS were lower than those that fledged naturally and flew directly out to sea (Raine et al. 2020b).

3A.1.5.3 Predation

Predation by introduced predators is likely the most significant threat to the Newell's shearwater (ʻaʻo) and has been since Kauaʻi was first settled by Polynesians (Ainley et al. 2001; Griesemer and Holmes 2011; Raine et al. 2019a, 2019c–g, 2020c). Being burrow nesters, Newell's shearwaters (ʻaʻo) are particularly vulnerable, as eggs, chicks, or adults, to predation by introduced species (Ainley et al. 2019; Raine et al. 2019a, 2019d–h, 2020c). Predation has been documented at all existing management sites (Nagendra et al. 2019; Raine et al. 2019a, 2019d–h). Predation on Newell's shearwaters (ʻaʻo) by feral cats, feral pigs, rats (particularly black rats [*Rattus rattus*]), dogs (*Canis familiaris*), barn owls (*Tyto alba*), and feral honeybees (*Apis* spp.), have all been documented as having serious impacts on this species (Raine et al. 2019a, 2019d–h). Although not confirmed as present on Kauaʻi (U.S. Fish and Wildlife Service 2019), predation by Indian mongoose (*Herpestes auropunctatus*) continues to be an issue on other islands with devastating effects on seabirds in the absence of ongoing predator control (Simons 1985; VanderWerf and Young 2014). Mongoose have been caught on Kauaʻi in recent years (Kauaʻi Invasive Species Committee 2021) and would become a serious threat if they become established. The same would be true of brown tree snakes (*Boiga irregularis*), which are rampant on several Southwestern Pacific islands such as Guam.

Observations made during the implementation of KIUC's Short-Term HCP and early implementation for this HCP have revealed how each predator affects the Newell's shearwater (ʻaʻo) population (see Raine et al. 2020c). Rats mainly target eggs and chicks; cats target chicks, subadults, and adults; and barn owls target subadults and adults. Burrow destruction and depredation by pigs has been documented as a significant source of mortality, including substantial adult mortality at unfenced breeding sites (Raine and McFarland 2014). Predation by owls is also an important issue and likewise particularly difficult to control (Raine et al. 2019c).

Limited research has been conducted on feral cat movement in Hawaiʻi. The Hono o Nā Pali Natural Area Reserve has been the focus of cat tracking efforts (Pias et al. 2017). Frequently, individual cats are detected on multiple camera traps within a monitored seabird breeding site and some cats have been observed on cameras at multiple breeding sites. For example, one cat was detected reliably across three breeding areas, at six camera traps, eight times over 53 days (Pias and Dutcher 2018). Information from studies conducted within Hono o Nā Pali Natural Area Reserve indicate that cats inhabiting the Natural Area Reserve move among adjacent seabird breeding sites and travel over large areas estimated to exceed 1,500 acres (607 hectares).

3A.1.5.4 Habitat Modification

Habitat loss, conversion, and modification historically presumably has had a major negative effect on Newell's shearwaters (ʻaʻo) as civilization has expanded into wild lands where it breeds, along with its accompanying pets, farm animals, vehicles, and other infrastructure (U.S. Fish and Wildlife Service 2016c). Among the MHI, 75 percent of native forest has been lost to agriculture and human growth (Cuddihy and Stone 1990). Human activities associated with agriculture contribute to the exposure and increased predation of ground-nesting birds (Reynolds and Ritchotte 1997). Recently it has become evident that habitat modification via invasive plant species or natural catastrophic events (e.g., hurricane, wildfire) facilitates predation because the reduction in dense native vegetation can provide access for predators into breeding areas (U.S. Fish and Wildlife Service 2016b). Further, pigs and goats modify the habitat by eating and trampling native vegetation and spreading invasive plants (such as guava [*Psidium cattleianum*] and ginger [*Hedychium gardnerianum*]) that modify the habitat, making it impenetrable to breeding seabirds (U.S. Fish and Wildlife Service 2016c). Troy et al. (2014) showed that Newell's shearwaters (ʻaʻo) nesting habitat is covered more by native vegetation than random sites, suggesting invasive vegetation might provide less suitable habitat. Asner et al. (2008) suggest invasive vegetation such as, but not limited to, strawberry guava and ginger, can affect seabird habitat use. Invasive vegetation including young strawberry guava can form nearly impenetrable stands of vegetation, limiting physical access to the ground and to burrows and potential nest sites (Duffy 2010; Van Zandt et al. 2014), and has been associated with at least one abandoned Newell's shearwater (ʻaʻo) colony on Kauaʻi (Raine in litt.). Extreme weather events such as hurricanes ʻIniki (1992) and ʻIwa (1982) have caused significant disruptions in forest habitat and, coupled with colonization of invasive plants, have resulted in permanent habitat loss for forest birds (Pratt 1994), though the magnitude of these effects on Newell's shearwater (ʻaʻo) have not been documented.

3A.1.5.5 Fisheries

Newell's shearwaters (ʻaʻo) depend on tuna (*Thunnuss* spp.) and other predatory fish to force prey within reach of seabirds (Harrison 1990; Spear et al. 2007; Ainley et al. 2014). The commercial tuna longline fishery is an important economic industry in Hawaiʻi, as well as in other nations, whose fleets fish within the Newell's shearwater (ʻaʻo) range. Several tuna species are now depleted, with possible secondary adverse effects on Newell's shearwater (ʻaʻo) feeding patterns (Ainley et al. 2014). A particular target of the tuna industry is yellowfin tuna, to which Newell's shearwaters (ʻaʻo) are especially attracted (Spear et al. 2007). More studies are needed to estimate the extent and magnitude of the effect on Newell's shearwater (ʻaʻo). Climate change is expected to shift the migratory home ranges of many tuna and other predatory fish species, which may or may not have additional implications for Newell's shearwater (ʻaʻo) food availability. While bycatch is important to scavenging seabirds, it is likely less of an issue for Newell's shearwater (ʻaʻo) (and other bird species that eat only live prey). Likewise, ingestion of plastics, a significant issue for scavengers and surface-feeding species (see Spear et al. 1995b), is unknown for Newell's shearwaters (ʻaʻo); the inspection of stomachs of downed SOS birds found no plastic (Ainley et al. 2014). Plastic ingestion was found to be the cause of death for three translocated Hawaiian petrel (ʻuaʻu) fledglings (U.S. Fish and Wildlife Service 2022); however, more research is needed to determine if this was an anomaly or a widespread threat.

3A.1.5.6 Stochastic Weather Events

Because many Hawaiian plant and animal species persist in low numbers or in restricted ranges, natural disasters such as hurricanes, volcanic eruptions, or tsunamis can be particularly devastating (Mitchell et al. 2005). Volcanic eruptions, which in 1984 destroyed forest bird habitat on Mauna Loa (Mitchell et al. 2005), occur only on the newer, easternmost islands of the chain (Hawaiʻi, Maui), and tsunamis would not be an issue given their upland nesting of Newell's shearwater (ʻaʻo). Among the MHI, hurricanes rarely reach Kauaʻi. Nevertheless, hurricanes ʻIwa (November 1982) and ʻIniki (September 1992) reached Kauaʻi, the last ones to do so, and were implicated in the extinction of several highly endangered forest birds (Pratt 1994). These storms downed a significant number of trees in Kauaʻi's forests, likely affecting breeding attempts for Newell's shearwaters (ʻaʻo) (Day and Cooper 1995; Ainley et al. 1997b; Mitchell et al. 2005; Griesemer and Holmes 2011). Raine et al. (2017b) referred to a drop in the Newell's shearwater (ʻaʻo) population, as indexed by SOS data, after Hurricane ʻIniki, and reasoned that while the hurricane itself caused no direct mortality of adults—because it struck the island during the day while adults were at sea—it caused the removal of considerable amounts of vegetation that, prior to the storm, shielded powerlines, and this reduction in shielding subsequently led to an increase in powerline collisions (and subsequent reduction in Newell's shearwater [ʻaʻo] population). Ainley et al. (2001), on the other hand, also noted the decrease in SOS birds following impacts associated with Hurricane ʻIniki but ascribed the decrease to a documented reduction of human activity on the island, along with a reduction in associated urban lighting, leading to lower rates of fallout. Additionally, many native-dominated areas on Kauaʻi now contain smaller pockets of invasive species that became established following these hurricanes (Mitchell et al. 2005). Given that the majority of the Newell's shearwater (ʻaʻo) population breeds on Kauaʻi, catastrophic events like hurricanes represent a significant threat to the species (Mitchell et al. 2005).

3A.1.5.7 Climate Change

According to the Intergovernmental Panel on Climate Change (IPCC), human activities have caused a 1.8 degrees Fahrenheit (°F) (1 degree Celsius [°C]) increase in tropospheric temperature above pre-industrial levels, and with the current rate of warming, could reach an increase of 2.7°F (1.5°C) by the year 2030 (Intergovernmental Panel on Climate Change 2019).

With increasing atmospheric temperature, the size and intensity of large-scale storms, which differ in many respects from the normal stochastic weather events discussed in Section 3A.1.5.6, *Stochastic Weather Events*, are expected to increase in coming years in various parts of the globe. Although Kauaʻi is quite used to heavy rainfall, these large-scale storms such as Kona storms may well result in greater landscape-scale damage to habitat (e.g., landslides, flooding) and subsequent loss of burrows/individuals and their future reproductive capacity. In 2021, a Hawaiian petrel (ʻuaʻu) chick was rescued from a flooded burrow in the Natural Area Reserve (Archipelago Research and Conservation 2021). Additional examples include hurricanes ʻIwa and ʻIniki, which devastated forests in 1982 and 1992, dramatically reducing available nesting habitat (Day and Cooper 1995). Large-scale storms also facilitate the incursion of invasive plants and animals (e.g., feral pigs, goats) to native habitat, altering and degrading the forest's ability to support native biota (Mitchell et al. 2005; U.S. Fish and Wildlife Service 2011a). Existing climate zones on high islands are generally projected to shift upslope in response to climate change. Some invasive plants may outcompete native species, as some invasive plants disproportionately benefit from increased carbon dioxide, disturbances from extreme weather and climate events, and an ability to invade higher-elevation habitats as the climate warms (Bradley et al. 2010). Climate change may also result in reduced rainfall that will additionally stress native Pacific Island flora and fauna, especially in high-elevation ecosystems with increasing exposure to invasive species (Leong et al. 2014).

Climate change brings rising sea levels, and this will seriously affect seabirds nesting among the low, northwestern Hawaiian Islands (e.g., Reynolds et al. 2015). However, seabirds confined to nesting in the uplands of coastal environments and mountainous interior of the MHI would not be affected by coastal inundation caused by rising sea levels. Other at-sea issues resulting from climate change that may also arise include effects on the distribution of prey species and ocean acidification due to increased ocean temperatures.

3A.2 Hawaiian Petrel (ʻuaʻu) (*Pterodroma sandwichensis*)

3A.2.1 Listing Status and Taxonomy

The Hawaiian petrel (ʻuaʻu) (*Pterodroma sandwichensis*), is endemic to the MHI, and was listed under the federal ESA as endangered in 1967 (U.S. Fish and Wildlife Service 1967). It is a member of the seabird family Procellariidae. The Hawaiian petrel (ʻuaʻu) and Galápagos petrel (*Pt. phaeopygia*) were initially considered to be subspecies of the dark-rumped petrel (*Pt. phaeopygia*), but 20 years ago were split into two separate species, on the basis of differences in vocalizations, morphology, behavior, disjunct nesting and at-sea distributions (Banks et al. 2002; Tomkins and Milne 1991), and genetics (Browne et al. 1997; see also Spear et al. 1995a; U.S. Fish and Wildlife Service 2011b). The species is also listed as endangered under HRS, Chapter 195D, Section 195D-4, Endangered and Threatened Species. No critical habitat has been listed for the Hawaiian petrel (ʻuaʻu) (U.S. Fish and Wildlife Service 2020a). The Hawaiian petrel (ʻuaʻu) is listed as endangered on the IUCN Red List (BirdLife International 2018).

3A.2.2 Life History

Hawaiian petrels (ʻuaʻu) are long-lived, reaching 35 years of age; average age of first breeding is 6 years (Simons and Hodges 1998). In addition to physiological maturation, it is likely that competition for nest sites plays a role when an individual first breeds. It is also likely that nest-site availability can play an important role in the number of breeding birds in a colony, as seen in other burrow and cavity-nesting species—there could be a "floating population" composed of mature birds that have not yet found a nesting cavity (Warham 1997).

The Hawaiian petrel (ʻuaʻu) breeding cycle is synchronous with egg-laying spread over just about a month (Simons 1985). An estimated 89 percent of the adult population breeds in a given year (Simons and Hodges 1998). Phenology differs between the islands, with birds on Kauaʻi, arriving a month later than those on Maui and 2 weeks later than those on Lānaʻi (Judge et al. 2014). On Kauaʻi birds arrive to breeding grounds in mid-March and start pair formation. After pairing, nest building, and burrow maintenance, a distinct pre-laying exodus occurs in April, when breeding adults leave the colony just ahead of egg-laying, presumably to allow females time to acquire the reserves necessary for egg production and males to store energy for incubation. Egg-laying occurs in early May to mid-June. Incubation continues until mid-July. The chick-rearing period runs from mid-July until the end of the September, when the first chicks start to fledge. Fledging peaks in November with the last birds fledging towards the middle of December (Archipelago Research and Conservation 2021). Once the chicks leave they do not return to land again for a few years. Breeding colonies are generally empty by the end of November or early December.

3A.2.3 Habitat Requirements and Ecology

Hawaiian petrels (ʻuaʻu) forage widely in the North Pacific Ocean (Pitman 1986; Warham 1990; Spear et al. 1995a; Adams 2007; Wiley et al. 2012), using a long-trip, short-trip foraging strategy. Satellite-tagged birds from Maui and Lānaʻi have been tracked traveling more than 6,000 mi (10,000 km) on a single foraging trip to and from their breeding colonies, moving northwestward to the Kuroshio Current/Transition Zone then eastward to the California Current before returning to

Hawaiʻi (Adams and Flora 2010). Birds from Kauaʻi follow the same long-trip foraging routes, although for short trips they forage a few hundred kilometers north of Kauaʻi (Raine et al. 2017a). They are among the group of seabirds known as *tuna birds*, owing to their association with tuna that drive prey to the surface. The satellite tracking indicates some affinity to the realm of albacore (*Thunnus alalunga*). Assuming equivalence to the closely related Juan Fernandez petrel (*Pterodroma externa*), whose foraging has been extensively investigated (Spear et al. 2007), Hawaiian petrels (ʻuaʻu) feed mainly during daylight hours, but to a lesser degree at night. In summary, their diet consists of flying squid, flying fish, goatfish, lantern fish, hatchetfish, and similar species (see also Ballance et al. 1997; Simons 1985).

The species' nesting habitat is variable, as described by Simons and Hodges (1998). On Hawaiʻi and Maui, Hawaiian petrels (ʻuaʻu) nest in the cavities of lava flows in xeric conditions at high altitude (summit slopes of Mauna Loa and Haleakalā). On the lower islands of Lānaʻi and Kauaʻi, however, breeding areas are in dense, montane wet forest, mainly along valley headwalls, particularly those of steep slopes covered with uluhe fern (*Dicranopteris* spp.; Troy et al. 2016; see Figure 2). Raine et al. (2021a) documented that the three most important microhabitat variables for Hawaiian petrels (ʻuaʻu) are ʻōhiʻa lehua in the canopy, elevation, and maximum canopy height. Such attributes are consistent with the habitat suitability model of Young et al. (2019) developed to search for potential nesting colonies on Oʻahu, as well as the studies of Van Zandt et al. (2014) on Lānaʻi. Raine et al. (2021) found that Hawaiian petrels (ʻuaʻu) tend to utilize habitat at higher elevations but that were less steep and less vegetated than Newell's shearwater (ʻaʻo).

3A.2.4 Distribution and Population Trends

3A.2.4.1 Current and Historic Distribution

Based on current distribution and subfossil remains, Hawaiian petrels (ʻuaʻu) are thought to have once been prevalent on all of the high islands in the Hawaiian Archipelago including Hawaiʻi, Maui, Lānaʻi, Kahoʻolawe, Molokaʻi, Oʻahu, and Kauaʻi (Ainley et al. 1997c; Olson and James 1982a, 1982b; Telfer 1983; Pyle and Pyle 2017b). Historic accounts reveal abundant Hawaiian petrel (ʻuaʻu) presence on the Hawaiian Archipelago since the late 1800s and/or early 1900s (Banko 1980; Simons and Simons 1980), including on low-elevation coastal plains on Oʻahu, Kauaʻi (e.g., Makauwahi Cave), and other islands (Olson and James 1982a, 1982b). By at least the mid-20th century, Hawaiian petrel (ʻuaʻu) colonies were restricted to high elevations (Pyle and Pyle 2017b).

It appears that the historic decrease in Hawaiian petrel (ʻuaʻu) populations on all of the Hawaiian Islands and the historic extirpation of Oʻahu populations were initiated by Polynesians, especially with the introduction of invasive predatory species they brought to the islands (pigs, rats; Banko 1980; Olson and James 1982a, 1982b; Simons 1985). The Hawaiian petrel (ʻuaʻu) decline was accelerated with the introduction of cats by Europeans (Simons 1985).

Extant Hawaiian petrel (ʻuaʻu) breeding sites are known to exist at five high-elevation regions on Maui, Hawaiʻi, Kauaʻi and Lānaʻi. A large proportion of the Hawaiian petrel (ʻuaʻu) population breeds on the island of Maui within Haleakalā National Park (~27 percent; Pyle and Pyle 2017b). Presence there is aided by a long-standing commitment to predator control by the park. Some fragmented breeding locations with fewer than 10 burrows have been reported in areas outside the main known breeding sites (Simons and Hodges 1998), and radar studies indicate that breeding may occur on Molokaʻi (Day and Cooper 2002). Reportedly, the number of Hawaiian petrels (ʻuaʻu) in breeding areas on Lānaʻi and Maui are significantly greater than previously inferred. Survey work conducted at a rediscovered breeding site on Lānaʻi in 2005 and 2008 indicated that thousands of birds are present, rather than hundreds of birds as first thought (State of Hawaiʻi Department of Land and Natural Resources 2015), and in 2019, KESRP and Pūlama Lānaʻi monitored a total of 311 Hawaiian petrel (ʻuaʻu) burrows at multiple managed colonies (Raine et al. 2020d). Recent habitat suitability modeling indicates that 8,000–10,000 individuals and 4,000–5,000 breeding pairs reside in Haleakalā National Park (National Parks Service 2021). A recent study based on historical records, acoustic monitoring, and habitat suitability modeling suggests that a small number of Hawaiian petrels (ʻuaʻu) may be breeding on Oʻahu (Young et al. 2019).

3A.2.4.2 Within the Plan Area

The current breeding population of Hawaiian petrels (ʻuaʻu) on Kauaʻi is confined to higher elevations, especially ridge crests, in the northwest portion of the island (Figure 2).

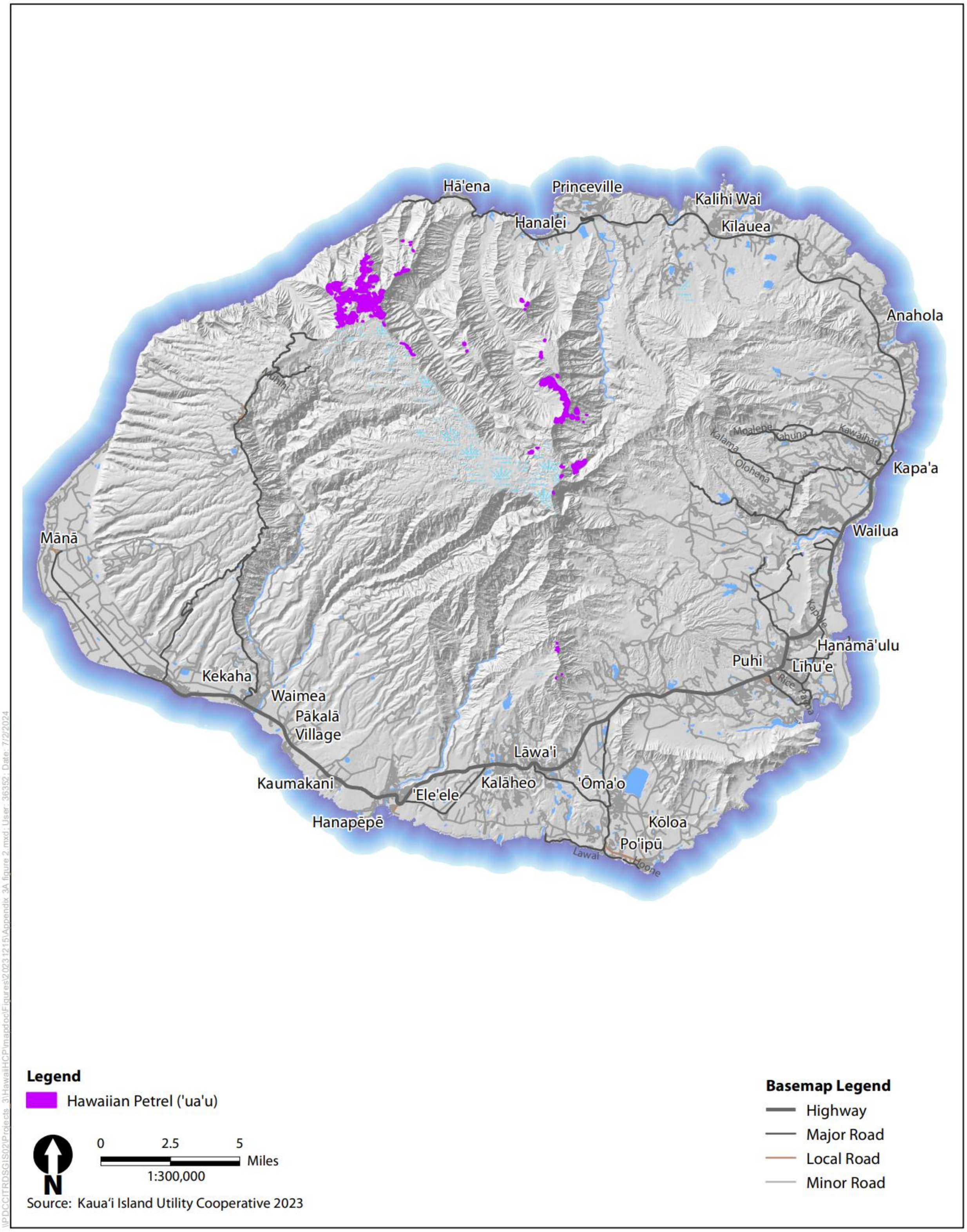

Figure 2. Current Confirmed Distribution of the Hawaiian Petrel (ʻuaʻu) Based on Contemporary Auditory Surveys

3A.2.4.3 Population

Kauaʻi supports approximately 33 percent of the total Hawaiian petrel (ʻuaʻu) population (Raine in litt.). An assessment based on at-sea survey data collected by the NMFS Southwest Fisheries Science Center from 1998 to 2011 estimated the total Hawaiian petrel (ʻuaʻu) population within the study area at 71,496 birds with lower and upper 95 percent confidence intervals of 58,010 and 85,645 (Joyce et al. 2016). The estimate includes juveniles, subadults and adults. More recently, Joyce et al. (2019) estimated the Hawaiian petrel (ʻuaʻu) population to be 65,856 individuals (Bootstrap 95 Percentile, 19,717 to 91,097) also based on surveys at sea. This largely confirmed the estimate from the Joyce et al. 2016 study and is significantly higher than previous assessments based on pelagic surveys in the same general region, where the Hawaiian petrel (ʻuaʻu) population was estimated at 19,000 (95 percent confidence interval = 11,000–34,000) including juveniles, subadults, and adults, and 4,500–5,000 breeding pairs (Spear et al. 1995a). As stated above for Newell's shearwater (ʻaʻo) (Section 3A.1.4.3, *Population*), the observations of both Joyce et al. (2016, 2019) and Spear et al. (1995a) cover a major portion but not the entire at-sea range and so are underestimates. Further, Ainley et al. (1997b) posited that Spear et al. (1995a) had underestimated the population by about 5 percent due to seasonal patterns of spatial occurrence. Nevertheless, the higher estimate of Joyce et al. (2019), with at-sea surveys conducted a couple of decades later, might well reflect the successful conservation efforts at Haleakalā National Park over the past 40 years.

In 2020, to remedy the gaps in the at-sea abundance data, ARC developed a theoretical population estimate for Hawaiian petrel (ʻuaʻu) that does not rely on the at-sea survey data analyzed by Joyce or Spear. The general approach used for estimating breeding pairs of Hawaiian petrel (ʻuaʻu) follows that used for Newell's shearwater (ʻaʻo)(Section 3A.1.4.3, *Population*). Briefly, this approach involves a combination of auditory survey data and habitat suitability modeling (Troy et al. 2017), as well as correction factors to account for lower densities of breeding pairs in colonies outside managed conservation sites (Raine in litt.). This approach resulted in a minimum estimate of 8,051 breeding pairs on Kauaʻi, which equates to a minimum island-wide population of 25,277 and, assuming the Kauaʻi population is 33 percent of the entire population, a maximum total of 24,396 breeding pairs and total minimum population of 76,598 in the State of Hawaiʻi.

3A.2.4.4 Decline/Trend

The Hawaiian petrel (ʻuaʻu) population decreased severely over the past few centuries, since the arrival of humans on the islands (Olson and James 1982a). Genetic analysis conducted within the last decade has revealed strong genetic differentiation among Hawaiian populations on separate islands (Welch and Fleischer 2011), underlining the importance of understanding population trends for this species on an island-by-island basis (Stiebens et al. 2013).

As with the Newell's shearwater (ʻaʻo), between 1993 and 2013 the Hawaiian petrel (ʻuaʻu) population declined steeply (Raine et al. 2017b). The study found an overall decrease in passage rates of 78 percent in 20 years, and 62 percent of the 13 sites showed a statistically significant decrease in movement rates over the entire period (Raine et al. 2017b). Based on the radar data as a proxy for the breeding population, the Hawaiian petrel (ʻuaʻu) population has decreased at an annual mean rate of 6 percent over the 20-year period (Raine et al. 2017b).

Radar surveys have only been conducted from May through mid-July, i.e., during the incubation and early chick-rearing stage, in coastal areas of northeastern, eastern, and southern Kauaʻi, or those areas accessible to vehicle-mounted radar equipment. Therefore, these radar data do not apply to the Nā Pali Coast where the Hawaiian petrel (ʻuaʻu) population is concentrated on Kauaʻi (Figure 2).

Following on from the population crash between 1993 and 2013, Raine and Rossiter (2020) and Ainley et al. (submitted) have shown that the trends in both radar and SOS data have been level for approximately the last decade. Although data from the more recent radar surveys through 2020 did not change the overall significant downward trajectory on Kauaʻi of Hawaiian petrel (ʻuaʻu) over the entire period since 1993 (72.8 percent decline in overall numbers with an average rate of 4.7 percent per year), the trend during the last decade (2010 to 2020) has been flat with no significant change (Raine and Rossiter 2020). Similar to Newell's shearwater (ʻaʻo), call rates at acoustically monitored conservation sites in which predators have been excluded or controlled have shown statistically significant increases between the first year of monitoring (either 2014 or 2015, depending on the site) and 2020, ranging from 16.23 percent at Pihea to 26.22 percent at North Bog (Archipelago Research and Conservation 2021).

Unlike Newell's shearwater (ʻaʻo), because so few Hawaiian petrels (ʻuaʻu) are grounded by light attraction on Kauaʻi every year, it is not possible to use SOS data to chart population declines (as was undertaken for Newell's shearwater [ʻaʻo]) (Raine et al. 2017b).

3A.2.5 Threats

Most of the threats facing Hawaiian petrels (ʻuaʻu) are like those faced by Newell's shearwaters (ʻaʻo) and are explained in detail in Section 3A.1.5, *Threats*. Compared to the Newell's shearwater (ʻaʻo), very few Hawaiian petrels (ʻuaʻu) have been found grounded and turned in to SOS during the fledging season, likely related to a recent historical much lower population size, and long-time relegation to the North Shore away from coast lights in developed areas of Kauaʻi. For example, on average, 9.6 Hawaiian petrels (ʻuaʻu) were received by the SOS Program annually between 2014 and 2018 in comparison to 179 Newell's shearwaters (ʻaʻo) during the same time period on Kauaʻi.

3A.2.5.1 Climate Change

Threats related to climate change would be the same for Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu), and are discussed in Section 3A.1.5.7, *Climate Change.*

3A.3 Band-Rumped Storm-Petrel (ʻakēʻakē) (*Hydrobates castro*)

3A.3.1 Listing Status and Taxonomy

The Hawaiʻi distinct population segment (HDPS) of the band-rumped storm-petrel (ʻakēʻakē) (*Hydrobates castro*) (hereafter band-rumped storm-petrel), a member of the seabird family Hydrobatidae, was listed as an endangered species under the federal ESA in 2016 (U.S. Fish and Wildlife Service 2016d). The species is also listed as endangered under HRS, Chapter 195D, Section 195D-4, Endangered and Threatened Species. No critical habitat has been designated for the band-rumped storm-petrel (ʻakēʻakē) (U.S. Fish and Wildlife Service 2016d). Recent genetic studies have found that the Hawaiian population of this species is genetically distinct from other populations throughout its global range (Taylor et al. 2019). The band-rumped storm-petrel (ʻakēʻakē) is listed as Least Concern on the IUCN Red List (BirdLife International 2018), as a function of the global occurrence of this species on dozens of nesting islands. However, the IUCN list does not consider the HDPS.

3A.3.2 Life History

On land, at least in the Hawaiian Islands, band-rumped storm-petrels (ʻakēʻakē) are nocturnal. The only nests that have been found are on the Island of Hawaiʻi (Galase 2019; Antaky et al. 2019). Based on auditory data, both on Kauaʻi and offshore Lehua Islet, the species arrives at breeding colonies on Kauaʻi in late May, with birds fledging from late September to mid-November (Raine et al. 2017d). Other information on the breeding biology of this species can only be approximated from the Galápagos Islands, where it has been relatively well studied. The species probably does not breed until 3 years of age, and likely lives to 20 years (Ainley 1984). The nesting season in the Galápagos also occurs during the boreal summer, with adults establishing nesting territories in April or May. A single, white egg is laid. The incubation period averages 42 days (Harris 1969) and the young reach fledging stage in 64–70 days (Allan 1962; Harris 1969). In the Hawaiian Islands evidence of their presence, either vocalizations or specimens, are spread from April to November; calling is most intense at Mauna Loa between June and August (Banko et al. 1991; Galase 2019). On the basis of auditory surveys, it arrives on Kauaʻi in late May and chicks fledge from late September to mid-November (Raine et al. 2017d).

At sea, this species forages at the surface by dipping and surface seizing. Diet consists mainly of small fish, squid, and crustaceans, as well as material scavenged from floating carcasses and surface slicks (Harris 1969; Slotterback 2002, 2020). More so than the above two species, it forages at night (Spear et al. 2007).

3A.3.3 Habitat Requirements and Ecology

The band-rumped storm-petrel (ʻakēʻakē) is a tropical/subtropical species occurring in the Atlantic, Indian, and Pacific Oceans; Pacific populations breed on the Galápagos Islands, Japan, and the Hawaiian Islands (Howell 2012). At sea, the band-rumped storm-petrel (ʻakēʻakē) has been observed off the coast of the Americas from 24.80°N to 23.27°S, but not beyond 1,123 mi (1,807 km) from the mainland (Spear et al. 2007), and birds have been seen 600 mi (966 km) north of Hawaiʻi, 1,000 mi (1,609 km) south of Hawaiʻi, and between Japan and Hawaiʻi (Raine et al. 2017d; U.S. Fish and Wildlife Service 2016d). More specifically, this species has been detected in very low numbers in waters between 10°N and 10°S south and west of Hawaiʻi, particularly during fall (Crossin 1974; Pitman 1986; Spear et al. 1999, 2007). In summer they have been detected in waters immediately south of the Hawaiian Islands (Crossin 1974; Spear et al. 1999; Banko et al. 1991). Banko et al. (1991) reported that early Hawaiians found them common off the windward coasts of the islands.

Nests are placed in crevices, holes, and protected ledges along cliff faces, well above the base and well below the top (Allan 1962; Harris 1969; Galase 2019). As noted by Raine et al. (2017d), breeding colonies on Kauaʻi, based on auditory surveys, are concentrated along the Nā Pali Coast, particularly within canyons from the Kalalau Valley to Polihale, as well as the Waimea Canyon. Habitat consists of sparsely vegetated, very steep cliffs, where the species has been relegated to such habitat by invasive mammalian predators. Small pockets of these birds also occur in some of the wetter and heavily vegetated valleys that contain exposed rocky cliff faces. A large concentration of storm-petrel activity was also recorded on the southeastern slopes of Lehua Islet (Raine et al. 2017d).

3A.3.4 Distribution and Population Trends

3A.3.4.1 Current and Historic Distribution

When Polynesians arrived in Hawaiʻi about 1,500 years ago, the band-rumped storm-petrel (ʻakēʻakē) probably was common on all the MHI (Harrison 1990; Raine et al. 2017d). As indicated by bones found in middens on the island of Hawaiʻi (Harrison 1990) and in excavation sites on Oʻahu and Molokaʻi (Olson and James 1982a, 1982b; Raine et al. 2017d), it appears the band-rumped storm-petrel (ʻakēʻakē) was once numerous enough to be harvested for food and possibly for their feathers (Harrison 1990).

The current distribution of the band-rumped storm-petrel (ʻakēʻakē) in Kauaʻi and the other Hawaiian Islands is poorly known (Raine et al. 2017d; Ainley et al. submitted). Evidence of nesting band-rumped storm-petrel (ʻakēʻakē) is based on detection of adult birds during the breeding season and on retrieval of downed fledglings in the fall, acoustic monitoring, and recovery of carcasses. Potential breeding sites have been recorded on Hawaiʻi (Banko et al. 1991; Galase et al. 2016), Maui (Banko et al. 1991), Kahoʻolawe (Hawaiʻi Heritage Program 1992), Lehua Islet (VanderWerf et al. 2007), and Kauaʻi (Raine et al. 2017d; Wood et al. 2002). Recently, a colony of band-rumped storm-petrel (ʻakēʻakē) was discovered at 6,932.4 ft (2,113 m) elevation on the northern slope of Mauna Loa within the U.S. Army's Pōhakuloa Training Area on the Island of Hawaiʻi (Galase 2019). A breeding population of this species has also been recently identified on the island of Lānaʻi (Raine et al. 2020d). Genetic analysis reveals little differentiation among islands, as judged from specimens obtained historically from various locations (Antaky et al. 2020).

On Kauaʻi, presumed band-rumped storm-petrel (ʻakēʻakē) nesting areas are located predominantly along the northwestern coastal cliffs of the Nā Pali Coast, and in the cliff walls of Waimea Canyon in the southwestern portion of the island (Figure 3). Other small breeding sites are suspected within more vegetated areas in the northern valleys such as Lumahaʻi and Wainiha (Raine et al. 2017d; VanderWerf et al. 2007; Wood et al. 2002).

On Lehua Islet, the band-rumped storm-petrel (ʻakēʻakē) detections over land are mainly concentrated on the southeastern slopes, with very little activity elsewhere (Raine et al. 2017d; VanderWerf et al. 2007). On the Island of Hawaiʻi, presumed nesting birds have been found in the Pōhakuloa Training Area (Galase et al. 2016), and remains of birds have been found along the southwest rift, and in Kūlani (Banko et al. 1991). Vocalizations have been heard in Haleakalā Crater on Maui in 1992 (Wood et al. 2002), on Lānaʻi (U.S. Fish and Wildlife Service 2016d; Raine et al. 2020d), and in Hawaiʻi Volcanoes National Park (U.S. Fish and Wildlife Service 2016d). The band-rumped storm-petrel (ʻakēʻakē) is regularly observed in coastal waters around Kauaʻi, Niʻihau, and Hawaiʻi (Joyce and Holmes 2010; U.S. Fish and Wildlife Service 2016b; Harrison 1990; Spear et al. 1999; Pyle and Pyle 2017c).

3A.3.4.2 Within the Plan Area

The current breeding population of the band-rumped storm-petrel (ʻakēʻakē) on Kauaʻi appears to be confined primarily to steep terrain such as ridge crests in the northwest portion of the island (Figure 3).

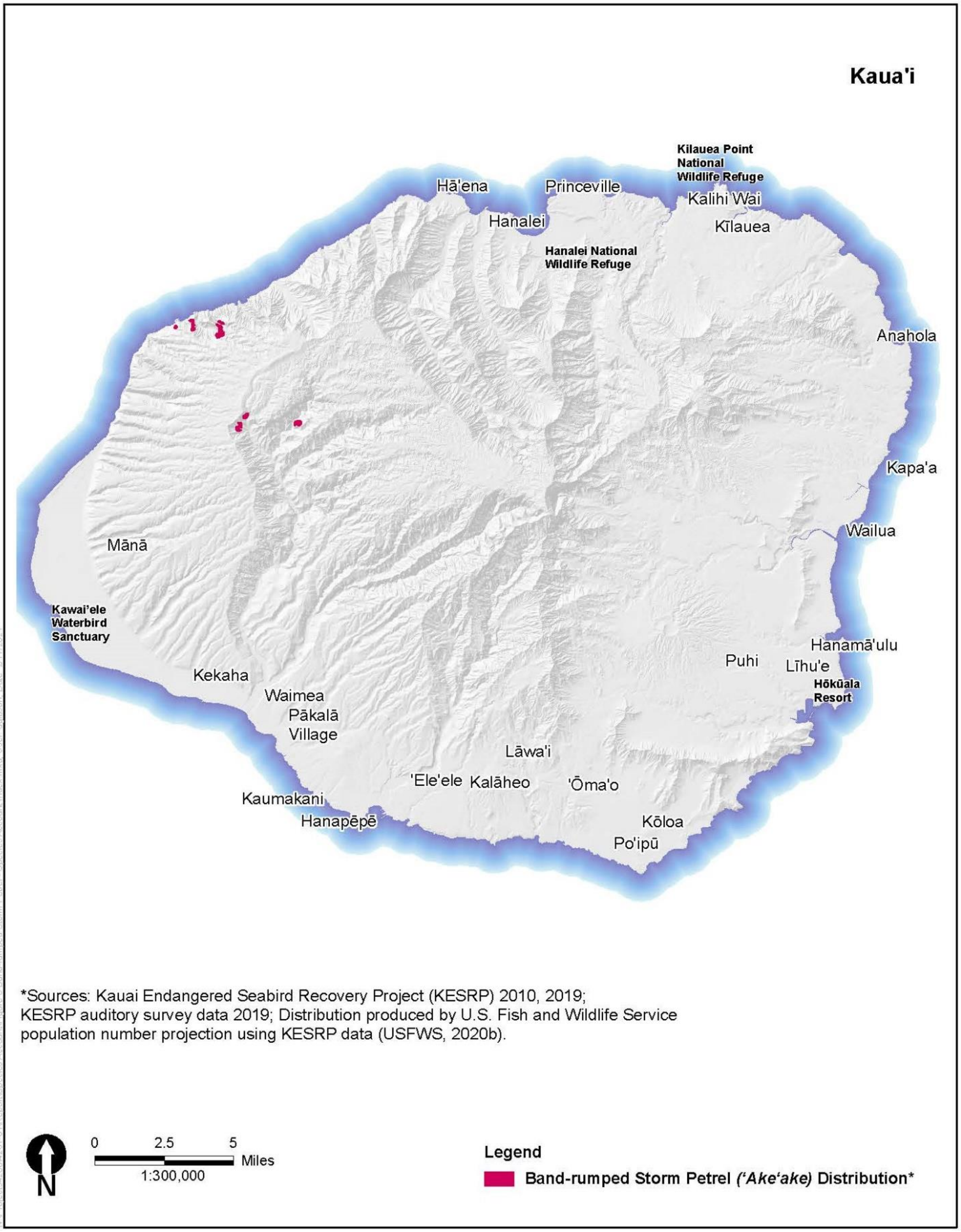

Figure 3. Current Confirmed Distribution of the Band-Rumped Storm-Petrel (‘akē‘akē) Based on Contemporary Auditory Surveys

3A.3.4.3 Population

There are significant differences in the various Pacific populations of band-rumped storm-petrels (ʻakēʻakē). Populations in Japan and the Galápagos are comparatively large, ranging from 30,000 to 50,000 birds, respectively (Coulter 1984; Enticott and Tipling 1997; Hasegawa 1984), while the Hawaiian population size is largely unknown. A study from 2002 estimated the Kauaʻi population to be 171 to 221 breeding pairs (Wood et al. 2002), and Pyle and Pyle (2017c) estimated 250 pairs as of the mid-2010s. Extensive at-sea surveys of the Pacific have revealed a broad gap in distribution of the band-rumped storm-petrel (ʻakēʻakē) east and west of Hawaiʻi (Pitman 1986; Spear and Ainley 2007). The worldwide population of the species is uncertain but is most likely around 150,000 birds (Brooke 2004). Recent genetic studies have found that the Hawaiian population of this species is genetically distinct from other populations throughout its global range, hence its classification as the HDPS (Taylor et al. 2019).

3A.3.4.4 Decline/Trend

Based on the scarcity of known breeding sites in Hawaiʻi; the remote, inaccessible locations where they are suspected to occur today; and compared to historic population levels and distribution, the band-rumped storm-petrel (ʻakēʻakē) appears to be significantly reduced in numbers and range compared to before colonization by the Polynesians (Raine et al. 2017d; U.S. Fish and Wildlife Service 2016d).

3A.3.5 Threats

The threats facing the band-rumped storm-petrel (ʻakēʻakē), including environmental stressors associated with climate change, are thought to be comparable to those faced by Newell's shearwaters (ʻaʻo) and are explained in detail in Section 3A.1.5, *Threats*. However, it is not a "tuna bird" and so changes in the distribution/abundance of tuna would not directly affect it. Also, because it picks at small items floating at the sea surface it is more likely to ingest plastic, which in some storm-petrels has been found to have significant implications (Spear et al. 1995b). As a much smaller seabird species, predation by rats is presumably an even larger problem for this species, and rats are probably capable of taking adult birds as well as chicks and eggs (Raine et al. 2017d).

3A.3.5.1 Climate Change

Threats related to climate change are the same for all three federal ESA–listed seabirds in Hawaiʻi and are discussed in Section 3A.1.5.7, *Climate Change*.

3A.4 Hawaiian Stilt (aeʻo) (*Himantopus mexicanus knudseni*)

3A.4.1 Listing Status and Taxonomy

The Hawaiian stilt (aeʻo) (*Himantopus mexicanus knudseni*) is a subspecies of the black-necked stilt (*Himantopus mexicanus*). It is a long-legged, slender shorebird (*Charadriiformes*, *Recurvirostridae*), 15 inches (38 cm) in length, with a long, thin beak. It was listed under the federal ESA as an endangered species on October 13, 1970 (U.S. Fish and Wildlife Service 1970). The species is also listed as endangered under HRS Chapter 195D, Section 195D-4, Endangered and Threatened Species. The second revision of the recovery plan for Hawaiian waterbirds was approved in October 2011. A 5-year status review was completed in 2020, at which time USFWS recommended the downlisting of the Hawaiian stilt (aeʻo) to threatened (U.S. Fish and Wildlife Service 2020b). USFWS proposed downlisting to threatened in March 2021 but no final rule has been published yet regarding this proposal. Critical habitat has not been designated.

3A.4.2 Life History

Hawaiian stilt (aeʻo) are semi-colonial nesters, but intensely territorial, with average inter-nest distances ranging from 53 to 262 ft (16–80 m) (Coleman 1981; Robinson et al. 1999). Their loose colonies occur in marshes near mudflats close to the water, especially marsh islands. They are found in that mudflat/marsh habitat year-round. Nests are shallow depressions lined with stones, twigs, and debris; nesting season extends from mid-February through August, with the peak of laying varying among years (Robinson et al. 1999). Hawaiian stilt (aeʻo) usually lay a clutch of three to four eggs incubated for 23–26 days (Coleman 1981; Chang 1990). Both parents take turns incubating day and night (U.S. Fish and Wildlife Service 2011c). Chicks are precocial, and are able to walk and swim within a few hours of hatching (U.S. Fish and Wildlife Service 2011c); they accompany adults on their daily foraging and may remain with both parents as late as February of the year after hatch (Robinson et al. 1999, 2020). Adult Hawaiian stilt (aeʻo) are aggressive against ground predators, as well as other Hawaiian stilts (aeʻo), and routinely approach humans within 15 ft (4.6 m); they use their legs to strike predators (as well as humans) from behind (Robinson et al. 1999, 2020). Adults also feign injury to distract potential predators from their nest sites and young (Dougherty et al. 1978; Robinson et al. 1999).

Stilts most commonly walk or wade over short distances rather than fly. During normal flight, stilts flap their wings continuously with an average wing-beat of approximately 40.8 beats per minute (Hamilton 1975). When flying in flocks, rapid changes of direction with complicated maneuvers are common (Hamilton 1975).

3A.4.3 Habitat Requirements and Ecology

Hawaiian stilt (aeʻo) are opportunistic feeders, and use a variety of aquatic habitats but are limited by water depth (shallow) and vegetation cover. Foraging habitat is early successional marshland or aquatic habitat with a water depth less than 9 inches (22.9 cm) (U.S. Fish and Wildlife Service 2011c). Breeding habitat differs from foraging habitat, and individuals move between the two habitats daily. Movement among wetland habitats in search of food is frequent. Hawaiian stilt (aeʻo) are known to use ephemeral lakes, alkaline ponds, anchialine pools, prawn farm ponds, marshlands, and tidal flats. They eat a wide variety of invertebrates and other aquatic organisms.

3A.4.4 Distribution and Population Trends

No historical estimate of Hawaiian stilt (aeʻo) population size is available, but by the early 1940s, the statewide population was estimated to be between 200 and 1,000 birds (U.S. Fish and Wildlife Service 2011c). These population estimates did not include any Niʻihau populations. Niʻihau can potentially support a large Hawaiian stilt (aeʻo) population when the extensive ephemeral lakes are flooded.

Hawaiian stilt (aeʻo) is currently found in wetland habitats below 660 ft (201 m) elevation on all of the MHI except Kahoʻolawe. Statewide census of the Hawaiian stilt (aeʻo) population shows moderate year-to-year variability (U.S. Fish and Wildlife Service 2020b). Long-term census data indicate that the statewide population of Hawaiian stilt (aeʻo) increased from 1985 to 2004 and has been roughly stable since then with approximately 1,500 to 2,000 individuals statewide (U.S. Fish and Wildlife Service 2020; Paxton et al. 2021; Gorresen et al. 2024). Populations have been increasing on Kauaʻi over the last 38 years. From 2019 to 2023, total population average in the State of Hawaiʻi was estimated at 1,511 (1,317–1,718 individuals), with 336 (229–483) individuals on Kauaʻi alone (Gorresen et al. 2024). A population viability analysis has been conducted by Reed and van Rees (2019) to update the findings of Reed et al. (1998) and reassess the population size necessary for long-term viability of the species. USFWS formally proposed downlisting the species from endangered to threatened in May 2021 (U.S. Fish and Wildlife Service 2021).

On Kauaʻi, Hawaiian stilt (aeʻo) are numerous in large river valleys such as Hanalei, Wailua, and Lumahaʻi, and on Mānā. Hawaiian stilt (aeʻo) also frequent Kauaʻi's reservoirs, particularly during drawdown periods, as well as sugarcane effluent ponds in Kekaha and Waimea (Figure 4). Considerable movement of the Hawaiian stilt (aeʻo) occurs between Kauaʻi and Niʻihau, apparently in response to rainfall patterns and the flooding and drying of ephemeral lakes on Niʻihau (Engilis and Pratt 1993). From 2008 to 2018, on average, the State of Hawaiʻi Division of Forestry and Wildlife (DOFAW) documented approximately 400 individuals in the Hanalei National Wildlife Refuge and approximately 100 individuals in other wetlands in Hanalei annually during winter counts. During the same time period in Mānā approximately 15 individuals were documented at the Kawaiʻele Sanctuary and approximately 34 individuals annually at other wetlands (State of Hawaiʻi Division of Forestry and Wildlife 2021). Long-term (1986–2023) trends indicate increasing population sizes for the Hawaiian stilt (aeʻo) population on Kauaʻi (Gorresen et al. 2024).

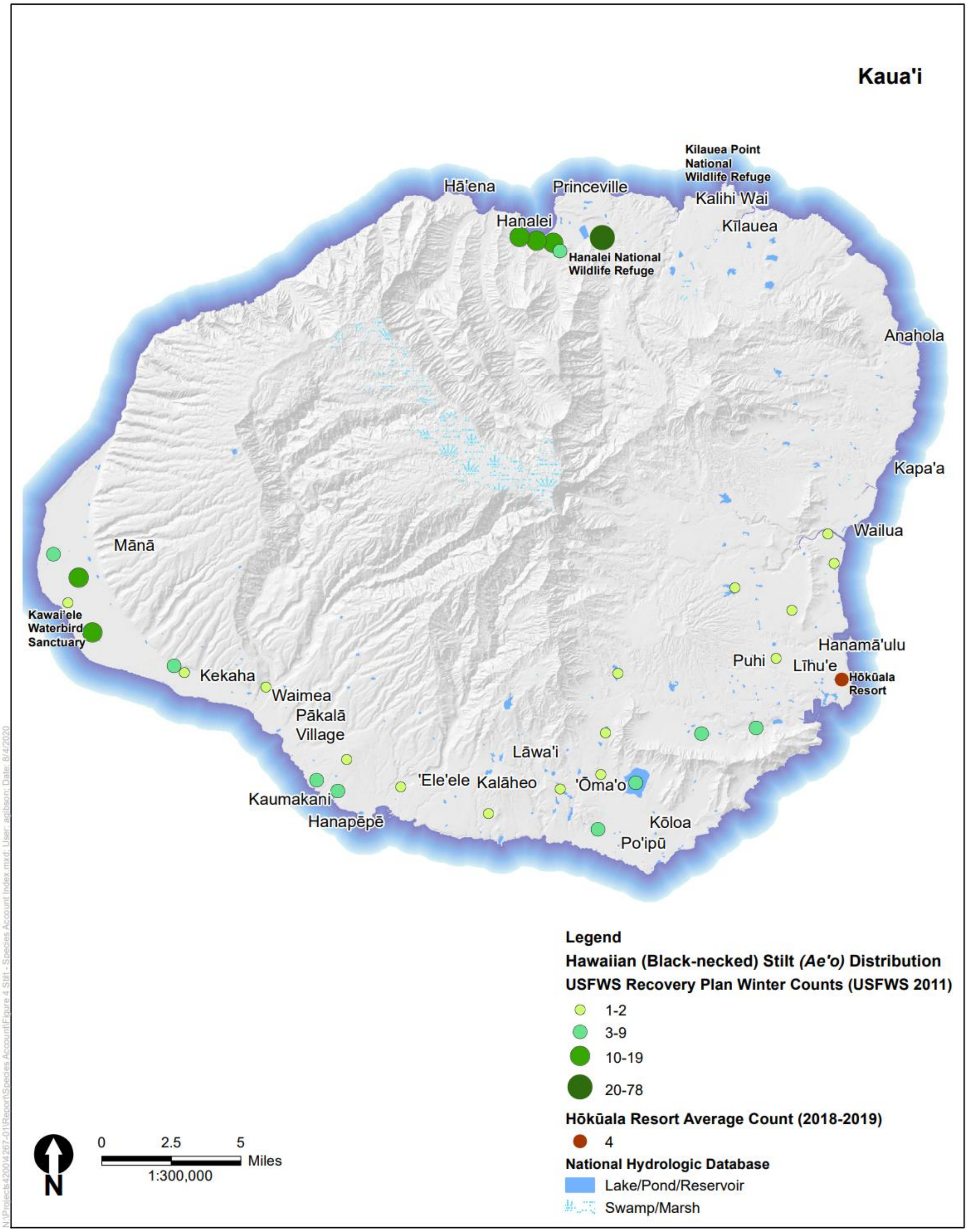

Figure 4. Distribution of the Hawaiian Stilt (ae‘o) on the Island of Kaua‘i

3A.4.5 Threats

The primary causes of the decline of Hawaiian waterbirds, including Hawaiian stilt (aeʻo), are predation by invasive animals, loss of wetland habitat, disease, and environmental contaminants. Depredation and habitat loss, however, are likely the greatest threats to the species. Human activities have led to the loss of many Hawaiian wetlands through filling and draining for agriculture, housing developments, hotels, and golf courses. Most remaining wetlands are degraded by altered hydrology, invasive species, human encroachment, and contaminants. Hydrologic alterations of wetlands, including flood control and channelization, often make wetland habitat less suitable by altering water depth and timing of water level fluctuations. The depletion of freshwater aquifers can cause saltwater intrusion into coastal groundwater, altering the salinity of associated wetlands, and reducing habitat suitability (U.S. Fish and Wildlife Service 2011b). Predation by invasive animals including rats, feral dogs, feral cats, and bullfrogs (*Lithobates catesbeianus*) also threaten the recovery of the Hawaiian stilt (aeʻo). Rats mainly target eggs and chicks, whereas feral cats and dogs target chicks, subadults, and adults. Other birds such as the black-crowned night heron (aukuʻu) (*Nycticorax nycticora*), cattle egret (*Bubulcus ibis*), Hawaiian short-eared owl (pueo) (*Asio flammeus sandwichensis*), and common mynas (*Acridotheres tristis*) have been observed preying on eggs, chicks, and subadults (U.S. Fish and Wildlife Service 2020b). Although not present on Kauaʻi (U.S. Fish and Wildlife Service 2019), predation by Indian mongoose of waterbirds including the Hawaiian stilt (aeʻo) continues to be an issue on other islands.

The most prevalent avian disease that continues to be a threat to the Hawaiian stilt (aeʻo) and other waterbirds is avian botulism. The disease can reappear annually in wetland habitats with stagnant water. The deadly effect, which includes flaccid paralysis and eventual leg paralysis, is caused by a toxin produced by the anaerobic bacteria known as *Clostridium botulinum* (type C). Wetlands with no prior history of avian botulism are less likely to experience an outbreak due to the low levels or absence of the *Clostridium botulinum* spores in the immediate environment. However, these spores can be introduced into areas with no botulism history by an infected bird (U.S. Fish and Wildlife Service 2020b). Avian botulism has been documented in the following locations: ʻŌhiʻapilo Pond on Molokaʻi, Hanalei National Wildlife Refuge on Kauaʻi, ʻŌpaeʻula Pond and ʻAimakapā Pond on Hawaiʻi, Keālia Pond National Wildlife Refuge and Kanahā Pond Wildlife Sanctuary on Maui, and at the lake on Laysan Island (U.S. Fish and Wildlife Service 2020b).

Two emerging avian diseases pose significant threats to the Hawaiian stilt (aeʻo): West Nile virus and avian influenza H5N1 or "bird flu". Both diseases have yet to be identified in Hawaiian bird populations (U.S. Fish and Wildlife Service 2011b). A surveillance program for these diseases has been established to identify infected birds; however, eradication measures have not yet been proposed if detection occurs.

3A.4.5.1 Climate Change

According to IPCC, human activities have caused a 1.8°F (1°C) increase in tropospheric temperature above pre-industrial levels, and with the current rate of warming, could reach an increase of 2.7°F (1.5°C) by the year 2030 (Intergovernmental Panel on Climate Change 2019). With increasing atmospheric temperature, the size and intensity of large-scale storms are expected to increase in coming years, and recent data demonstrates Category 4 and 5 hurricanes have increased globally at a rate of 25–30 percent per °C increase in global warming (Holland and Bruyere 2014). Temperature increases may also allow avian disease, pathogens, and vectors to expand their ranges and severity. Changes in temperature, precipitation, and sea level, and the effects of these changes will be greatly exacerbated by existing non-climate-related stressors, such as predation by invasive species, fragmentation of habitat resulting from expanding land uses, and disease. Studies examining the effects of sea level rise on low-lying coastal wetlands in the MHI indicate that increased water levels, erosion, salinity, and unprecedented flooding cycles associated with sea level rise threaten habitats of endangered waterbirds. Hawaiian waterbirds are particularly sensitive to sea level rise due to the proximity of their wetland habitat to the coast and the fact that most Hawaiian Island wetlands are groundwater dependent (Hunt and DeCarlo 2000; U.S. Fish and Wildlife Service 2011c, 2011d in Kane 2014). It is unclear how groundwater flooding will affect endangered waterbird habitat, but reduction of this habitat would negatively affect the species (U.S. Fish and Wildlife Service 2018b). Marine flooding and inundation from storm surge, marine overwash (i.e., waves overtopping sand dunes), and tidal waves, also have the potential to destroy active waterbird nests and their habitat (U.S. Fish and Wildlife Service 2018b). The rate of impact caused by sea level rise–induced flooding is modeled to rapidly accelerate once the height of the sea surface exceeds a critical elevation. Estimating the critical elevation marking the end of slow flooding and the onset of rapid flooding will help wetland decision makers to plan and develop management strategies to meet the challenges presented by climate change (State of Hawaiʻi Department of Land and Natural Resources 2015). In combination with habitat loss and degradation, sea level rise could severely limit available habitat for Hawaiian waterbirds (Clausen and Clausen 2014). In addition to sea level rise, the Hawaiian Islands are projected to experience more severe annual wave-driven flooding events, during which seawater overtops coastal berms, resulting in increased inland flooding (U.S. Fish and Wildlife Service 2018b). Climate change analyses in the Pacific Islands currently lack sufficient spatial resolution to make specific predictions concerning the effects of climate-related changes on waterbirds on Kauaʻi (University of Hawaiʻi at Mānoa 2014). Sea level rise in Hawaiʻi will not be uniform across the island chain due, in part, to local land subsidence resulting from the active growth of the Island of Hawaiʻi (Polhemus 2015).

3A.5 Hawaiian Duck (koloa maoli) (*Anas wyvilliana*)

3A.5.1 Listing Status and Taxonomy

The Hawaiian duck (koloa maoli) (*Anas wyvilliana*) is endemic to the MHI. Taxonomically, Hawaiian duck (koloa maoli) is in the family Anatidae (*Anseriformes*) and closely allied with the mallard (*Anas platyrhynchos*). The Hawaiian duck (koloa maoli) was listed under the federal ESA as an endangered species in 1967 (U.S. Fish and Wildlife Service 1970). The species is also listed as endangered under HRS, Chapter 195D, Section 195D-4, Endangered and Threatened Species. The second revised Hawaiian waterbird recovery plan was approved in October 2011 (U.S. Fish and Wildlife Service 2011c). Critical habitat has not been designated for the Hawaiian duck (koloa maoli).

3A.5.2 Life History

Hawaiian ducks (koloa maoli) tend to congregate in fall and winter in lowland wetlands in flocks of 5 to 15 birds. Pairs usually form in fall and winter but can form at any time of year depending on rainfall and habitat availability. Hawaiian ducks (koloa maoli) breed year-round, with the majority of nesting occurring March–June (Engilis et al. 2002). In the Kauaʻi lowlands, they form pair bonds between November and May, with pairs dispersing to stream and marshland nesting locations (U.S. Fish and Wildlife Service 2011c). Nests are made of vegetation, lined with feathers, on the ground in tall grass. Clutch size averages eight eggs; incubation lasts about 4 weeks. Young take to the water soon after hatching but cannot fly until about 9 weeks old. Offspring become sexually mature enough to reproduce after a year. Hawaiian ducks (koloa maoli) are wary of humans, especially when nesting or during the flightless period while molting, which peaks between June and August. During the winter, Hawaiian ducks (koloa maoli) may gather in larger numbers to exploit abundant food resources, though most typically they are found in pairs (U.S. Fish and Wildlife Service 2011c).

3A.5.3 Habitat Requirements and Ecology

Hawaiian ducks (koloa maoli) are found from sea level to 9,900 ft (3,017.5 m), in a wide variety of natural and artificial wetland habitats including freshwater marshes, flooded grasslands, montane stock ponds, streams, forest swamplands, taro patches, lotus (*Nelumbo nucifera*) farms, irrigation ditches, reservoirs, and mouths of larger streams. Hawaiian ducks (koloa maoli) typically forage in water less than 6 inches (15.2 cm) deep and are opportunistic feeders, having a diet including snails, fish, aquatic insects, earthworms, grass seeds, green algae, and seeds and leaves of wetland plants (U.S. Fish and Wildlife Service 2011c). They are strong flyers and usually fly at low altitudes. Birds on open wetlands are particularly skittish, and when flushed readily burst from water's surface making sharp turns, flying within 50 m of the ground and circling the disturbance before moving off (Engilis et al. 2020). Flight speed has been clocked from a moving automobile at approximately 44–50 miles per hour (72–80 km per hour) for over a third of a mile (half a kilometer) (Swedberg 1967). Hawaiian ducks (koloa maoli) are non-migratory, although some seasonal, altitudinal, and inter-island movements occur, the timing and mechanics of which are not well understood (Engilis and Pratt 1993). On Kauaʻi, seasonal movement of birds occurs from lowland wetlands to more secluded habitats in summer (U.S. Fish and Wildlife Service 2011c). In addition, there is evidence they may travel between Kauaʻi and Niʻihau in response to above-normal precipitation, and the flooding and drying of Niʻihau's ephemeral lakes (Engilis and Pratt 1993).

3A.5.4 Distribution and Population Trends

Hawaiian ducks (koloa maoli) were historically common across most of the Hawaiian Islands. Factors such as predation, agricultural and urban development, hybridization with feral mallards, and overhunting caused a decrease in the population in the early 20th century. At that time, Hawaiian ducks (koloa maoli) were common in the coastal marshes of all the MHI except for Lānaʻi and Kahoʻolawe (Pyle and Pyle 2017d). By the mid-20th century, the species had been reduced to 500 birds on the island of Kauaʻi, and a few isolated pairs on other islands (Schwartz and Schwartz 1953). Starting in the mid-1950s and continuing to 1990, the State of Hawaiʻi began a captive propagation and release program. During that time period, 757 captive-bred Hawaiian ducks (koloa maoli) were released on the islands of Oʻahu (326), Maui (12), and Hawaiʻi (419).

Since the species' listing under the federal ESA in 1967, the population has increased on Kauaʻi, though it is declining on other islands. The Hawaiian duck (koloa maoli) population was estimated in 2002 to be about 2,200 individuals, with 2,000 true (non-hybrid) Hawaiian ducks (koloa maoli) on Kauaʻi and Niʻihau, and 200 on the Island of Hawaiʻi (Engilis et al. 2002). The Hawaiian duck (koloa maoli) population on Kauaʻi is substantially larger than on all other islands combined. Gorresen et al. (2024) estimated a 5-year average population size between 2019 and 2023 on Kauaʻi of 516 to 854 individuals. This comparatively large population size on Kauaʻi is probably due to the lack of an established population of mongooses and low occurrence of hybridization unlike the other Hawaiian Islands (U.S. Fish and Wildlife Service 2011c). Hawaiian duck (koloa maoli) survey counts on Oʻahu, Maui, and Hawaiʻi are confounded by the difficulty in distinguishing Hawaiian duck (koloa maoli) from mallards and hybrids in the field. Populations on Kauaʻi have remained relatively free of mallard genes (Pyle and Pyle 2017d).

The State's biannual surveys typically do not include remote wetlands and streams (Engilis et al. 2002), where an estimated 50 to 80 percent of Hawaiian ducks (koloa maoli) are believed to reside on Kauaʻi (Schwartz and Schwartz 1953). Therefore, because DOFAW's biannual counts only provide estimates for lowland wetlands (Figure 5), they are useful for long-term trends analysis but are not used as an estimate for the Hawaiian duck (koloa maoli) population. Global long-term (1986–2023) trends indicate increasing population sizes for the Hawaiian duck (koloa maoli) population on Kauaʻi (Gorresen et al. 2024).

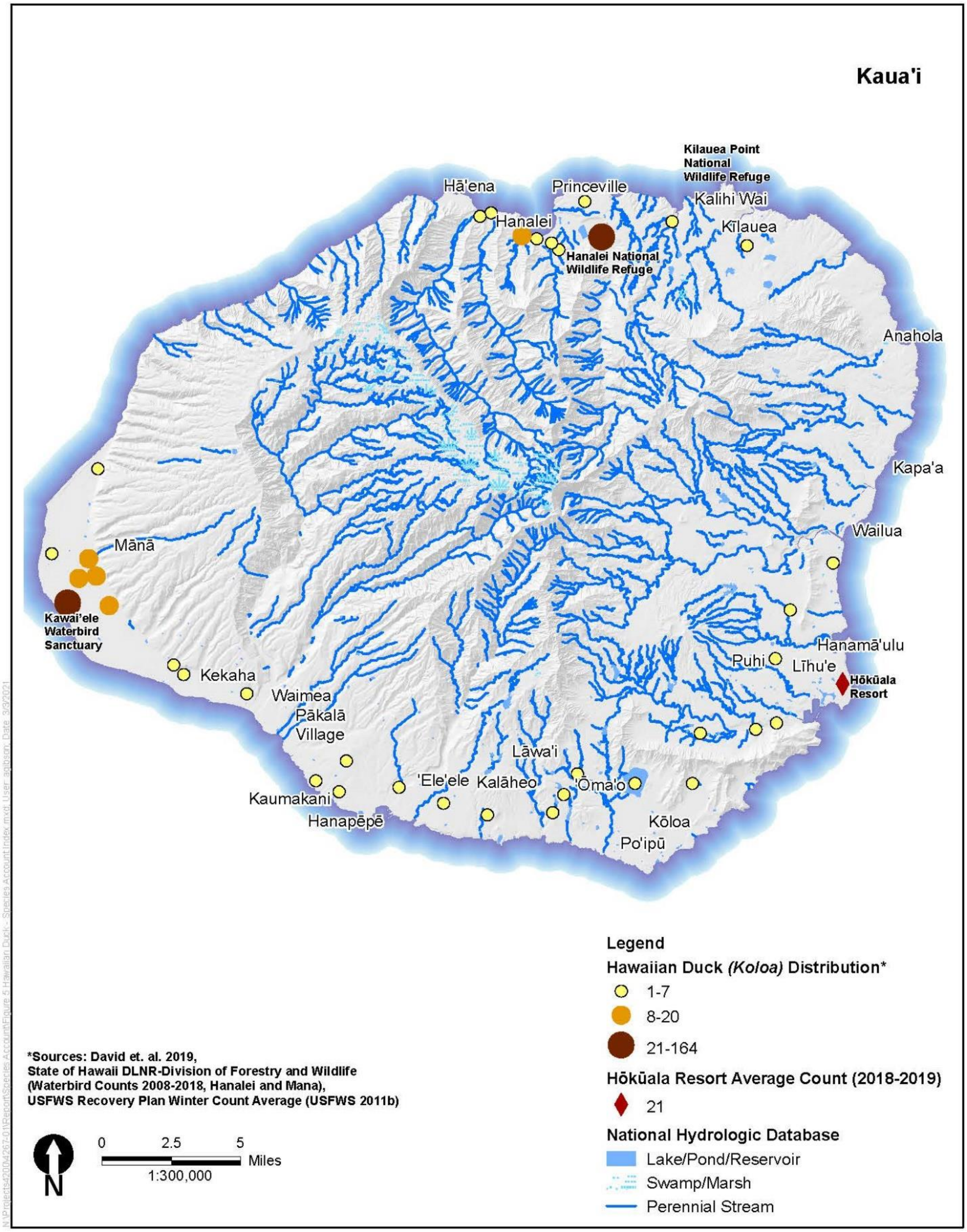

Figure 5. Distribution of the Hawaiian Duck (koloa maoli) on the Island of Kaua'i

3A.5.5 Threats

Threats to the Hawaiian duck (koloa maoli) are generally the same as those for other Hawaiian waterbirds—loss of wetland habitat, predation by invasive animals, disease, and environmental contaminants. In addition, threats to Hawaiian duck (koloa maoli) include hybridization with invasive mallards that were introduced to Hawaiʻi for farming, sport hunting, and pond beautification (Uyehara et al. 2007; U.S. Fish and Wildlife Service 2011c). Hybridization is considered the largest threat to the species (U.S. Fish and Wildlife Service 2011c). This is especially problematic on the islands of Oʻahu and Maui where most of the individuals are now mallard-Hawaiian duck (koloa maoli) hybrids (U.S. Fish and Wildlife Service 2011c; Pyle and Pyle 2017d). Although instances exist of ducks, geese, and rails colliding with powerlines (Bevanger 1998; Travers et al. 2019), there is little evidence that collisions with utility structures are having a large impact on Hawaiian waterbirds on Kauaʻi. During the period of 2007 to 2019, one Hawaiian duck (koloa maoli) turned into the SOS Program (Bache 2020) was found in the vicinity of powerlines, but the cause of death was unknown.

3A.5.5.1 Climate Change

Threats related to climate change are similar for all Hawaiian waterbirds and are discussed in Section 3A.4.5.1, *Climate Change*, for Hawaiian stilt (aeʻo). Climate change analyses in the Pacific Islands currently lack sufficient spatial resolution to make specific predictions concerning the effects of climate-related changes on Hawaiian duck (koloa maoli) on Kauaʻi (University of Hawaiʻi at Mānoa 2014).

3A.6 Hawaiian Coot (ʻalae keʻokeʻo) (*Fulica alai*)

3A.6.1 Listing Status and Taxonomy

The Hawaiian coot (ʻalae keʻokeʻo) (*Fulica alai*), is a member of the rail family, Rallidae, and is endemic to Hawaiʻi. It is 13–16.1 inches (33–41 cm) in size, and plumage is similar to the American coot (*Fulica america*). The Hawaiian coot (ʻalae keʻokeʻo) was listed as endangered under the federal ESA in 1967 (U.S. Fish and Wildlife Service 1970). The species is also listed as endangered under HRS, Chapter 195D, Section 195D-4, Endangered and Threatened Species. The latest recovery plan for the species was published in 2011 (U.S. Fish and Wildlife Service 2011c). The last 5-year review was published in 2015. Critical habitat has not been designated for the Hawaiian coot (ʻalae keʻokeʻo).

3A.6.2 Life History

Hawaiian coot (ʻalae keʻokeʻo) are mostly sedentary, making localized flights around existing wetland habitats based on rainfall (Pratt and Brisbin 2020). Their flight is strong and direct, requiring an extended period of running along the water's surface to become airborne (Brisbin and Mowbray 2020). Flight height is typically ≤16 ft (5 m) above the water surface except over land when additional altitude is needed to clear obstacles such as trees (Brisbin and Mowbray 2020). At times, the species travels long distances, including between islands, when local food sources are depleted (Engilis and Pratt 1993). Floating nests are constructed of aquatic vegetation, and found in open water or anchored to emergent vegetation (Byrd et al. 1985). Open water nests usually consist of mats of water hyssop (*Bacopa monniere*) and Hilo grass (*Paspalum conjugatum*) (Byrd et al. 1985; Pratt and Brisbin 2020). Nests in emergent vegetation are typically platforms constructed from buoyant stems of species such as bulrush (*Scirpus* spp.) (Byrd et al. 1985). Average depth of water at Hawaiian coot (ʻalae keʻokeʻo) nest sites was 13 inches (33 cm) in natural habitats (Byrd et al. 1985).

Hawaiian coot (ʻalae keʻokeʻo) are somewhat gregarious and non-breeding birds may form large flocks. Nesting occurs primarily March through September, although some nesting occurs in all months of the year (Shallenberger 1977; Pratt and Brisbin 2020). The timing of nesting appears to correspond with seasonal weather conditions (Byrd et al. 1985; Engilis and Pratt 1993). Nest initiation corresponds to rainfall, as appropriate water levels are critical to nest success. Clutch size ranges from one to ten eggs, and young hatch after a 25-day incubation period (Byrd et al. 1985). Chicks swim from the nest soon after hatching, remaining close to parents; immature birds have been seen with parents several weeks after hatching (Pratt and Brisbin 2020). There is no information on the lifespan and survivorship of this species; however, banding records indicate the oldest American coot was at least 22 years old (Klimkiewicz and Futcher 1989).

3A.6.3 Habitat Requirements and Ecology

Hawaiian coots (ʻalae keʻokeʻo) generally occur within wetland habitats having emergent plants interspersed with open water, especially freshwater wetlands, freshwater reservoirs, cane field reservoirs, sewage treatment ponds, taro loʻi, and brackish wetlands; they exhibit limited use of saltwater habitats (Shallenberger 1977; Byrd et al. 1985; Pratt and Brisbin 2020). Ephemeral wetlands support large numbers of Hawaiian coots (ʻalae keʻokeʻo) during the non-breeding season. Habitat elevation ranges from the coastal plains at sea level to 850 ft (259 m), rarely to 3,500 ft (1,067 m) (Byrd et al. 1985). On Kauaʻi, however, some birds occur in plunge pools above 4,900 ft (1,493.5 m) and on Hawaiʻi, birds occur in stock ponds at 6,600 ft (2,012 m) in elevation (U.S. Fish and Wildlife Service 2011c).

Hawaiian coots (ʻalae keʻokeʻo) are generalists and feed on land, grazing on grass adjacent to wetlands, or in the water (U.S. Fish and Wildlife Service 2011c). The species typically forages in water less than 12 inches (30.5 cm) deep, but dives in water up to 48 inches (121.9 cm) deep. Hawaiian coots (ʻalae keʻokeʻo) prefer to forage in water that is somewhat open (U.S. Fish and Wildlife Service 2011c). They use logs, rafts of vegetation, narrow dikes, mud bars, and artificial islands for resting. Food items include seeds and leaves, snails, crustaceans, insects, tadpoles, and small fish (U.S. Fish and Wildlife Service 2011c; Pratt and Brisbin 2020).

3A.6.4 Distribution and Population Trends

The Hawaiian coot (ʻalae keʻokeʻo) population was estimated to be 1,500–2,800 birds (U.S. Fish and Wildlife Service 2011c). The survey data from the biannual waterbird counts imply that the population has an overall slightly increasing trend (U.S. Fish and Wildlife Service 2011c). Surveys of the statewide Hawaiian coot (ʻalae keʻokeʻo) population between 2019 and 2023 resulted in a total population estimate of 1,306 to 1,858 birds, with approximately 552 individuals on Kauaʻi alone (Gorresen et al. 2024). Survey data from biannual waterbird counts suggest that the population on Kauaʻi increased from 1986 to 2023 (Gorresen et al. 2024).

The Hawaiian coot (ʻalae keʻokeʻo) historically occurred on all of the MHI except Lānaʻi and Kahoʻolawe. Hawaiian coots (ʻalae keʻokeʻo) have historically been most numerous on the islands of Oʻahu, Maui, and Kauaʻi (U.S. Fish and Wildlife Service 2011c). Approximately 80 percent of the current population occurs on Kauaʻi (Hanalei, Hulēʻia, ʻŌpaekaʻa), Oʻahu, and Maui (U.S. Fish and Wildlife Service 2011c). The remaining 20 percent occurs in coastal ponds and playa wetlands, including breeding populations on the islands of Hawaiʻi, Lānaʻi, Molokaʻi, and Niʻihau (U.S. Fish and Wildlife Service 2011c).

Surveys indicate that migration events between Kauaʻi and Niʻihau occur only when annual precipitation is above normal and ephemeral lakes on Niʻihau become flooded (Engilis and Pratt 1993). Numbers of Hawaiian coots (ʻalae keʻokeʻo) counted on Niʻihau during wet winters include 949 birds in 1986 and 803 birds in 1996, but Niʻihau has not been surveyed since 1999 (U.S. Fish and Wildlife Service 2005). Population trends specific to Kauaʻi have been monitored by annual surveys of Mānā from 1986 to 2004 and monthly counts in the Hanalei National Wildlife Refuge in 2010 through 2015. Between 0 and 87 Hawaiian coots (ʻalae keʻokeʻo) were observed each year in Mānā, whereas 45 to 641 individuals were detected in Hanalei (State of Hawaiʻi Division of Forestry and Wildlife 2021). Trend data collected over three decades (up to 2008) show that Hawaiian coots (ʻalae keʻokeʻo) are either stable or increasing statewide. Distribution of the Hawaiian coot (ʻalae keʻokeʻo) on Kauaʻi is shown in Figure 6. Global long-term (1986–2024) trends indicate increasing population sizes for the Hawaiian coots (ʻalae keʻokeʻo) population on Kauaʻi (Gorresen et al. 2024).

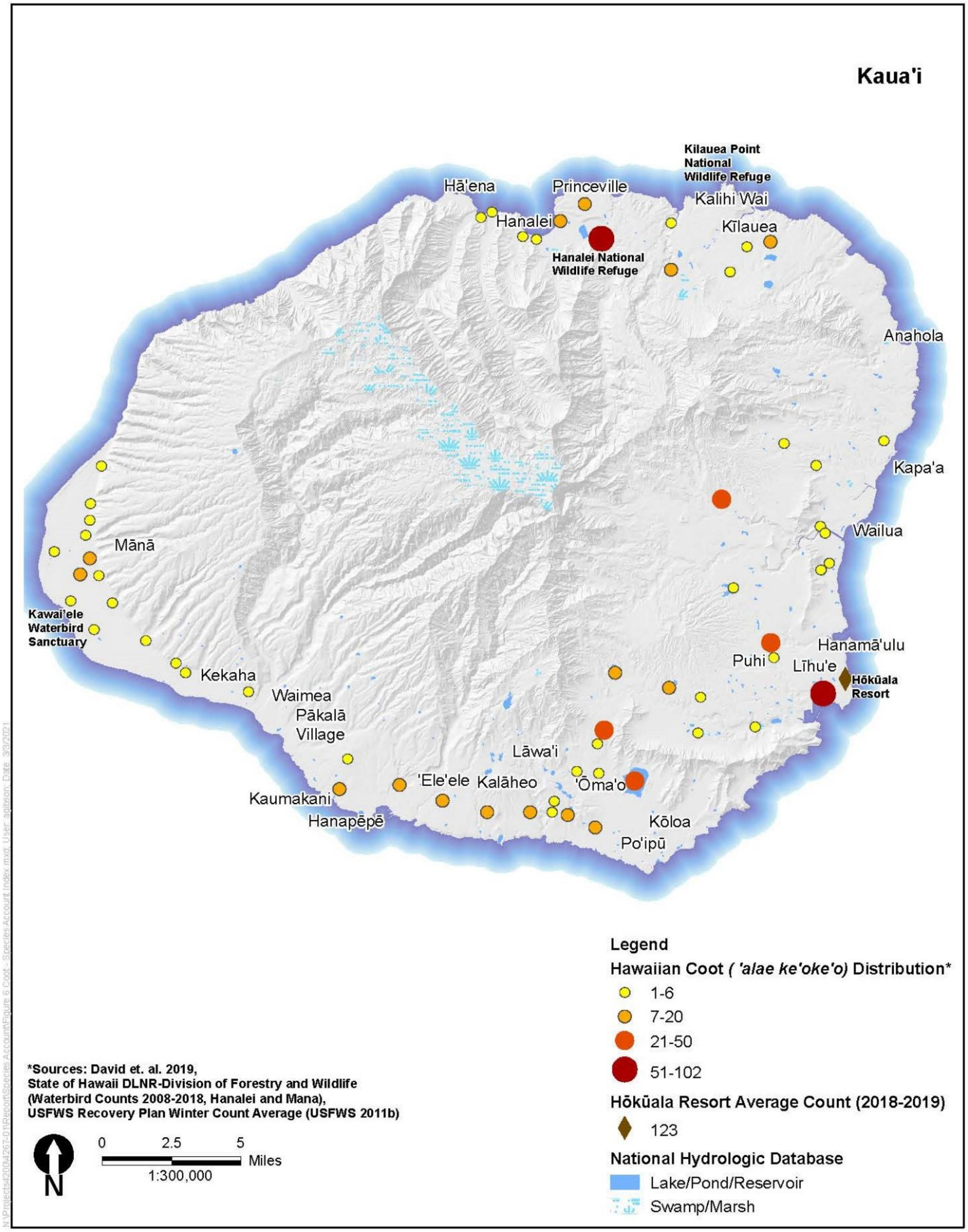

Figure 6. Distribution of the Hawaiian Coot (ʻalae keʻokeʻo) on the Island of Kauaʻi

3A.6.5 Threats

Threats to Hawaiian coots (ʻalae keʻokeʻo) are generally the same as those outlined in the Hawaiian stilt (aeʻo) account (Section 3A.4.5, *Threats*). In addition, Hawaiian coot (ʻalae keʻokeʻo) nest and forage at wastewater treatment plants across the islands, increasing their exposure to toxins. Bumblefoot (ulcerative pododermatitis), a bacterial infection that causes foot inflammation and swelling in birds, may be a chronic condition in the population. This infection has been found on 45 percent of the Hawaiian coot (ʻalae keʻokeʻo) banded at the Kaunakakai Wastewater Reclamation Facility on Molokaʻi (U.S. Fish and Wildlife Service 2011c). The incidence in birds on Kauaʻi is unknown.

There is no indication that this species interacts to a great extent with powerlines. However, studies in Europe have shown members of the Rallidae to be susceptible to high numbers of casualties in sensitive habitats where there are thin, low-hanging lines (Haas et al. 2005). During the period of 2007–2019, five individuals were turned into the SOS Program, reportedly found under powerlines. The precise cause of death is unknown but is assumed to be powerline collisions (Bache 2020).

3A.6.5.1 Climate Change

Threats related to climate change are similar for all Hawaiian waterbirds and are discussed in Section 3A.4.5.1, *Climate Change*, for Hawaiian stilt (aeʻo). Climate change analyses in the Pacific Islands currently lack sufficient spatial resolution to make specific predictions concerning the effects of climate-related changes on Hawaiian coot (ʻalae keʻokeʻo) on Kauaʻi (University of Hawaiʻi at Mānoa 2014).

3A.7 Hawaiian Common Gallinule (ʻalae ʻula) (*Gallinula galeata sandvicensis*)

3A.7.1 Listing Status and Taxonomy

The Hawaiian common gallinule (ʻalae ʻula) (*Gallinula galeata sandvicensis*), previously called the Hawaiian common moorhen and the Hawaiian gallinule, is a subspecies of the common gallinule (Griiformes, Rallidae). Hawaiian common gallinule (ʻalae ʻula) was listed as endangered under the federal ESA in 1967 (U.S. Fish and Wildlife Service 1970). The species is also listed as endangered under HRS, Chapter 195D, Section 195D-4, Endangered and Threatened Species. The latest recovery plan for the species was published in 2011 (U.S. Fish and Wildlife Service 2011c). The last 5-year review was published in 2015. Critical habitat has not been designated for the Hawaiian common gallinule (ʻalae ʻula).

3A.7.2 Life History

Hawaiian common gallinules (ʻalae ʻula) are non-migratory and it is unknown whether they are capable of inter-island movement. They characteristically swim or walk on aquatic vegetation or soil and are seldom seen flying (Bannor and Kiviat 2020). They nest year-round, though concentrated nesting is March–August (Shallenberger 1977; Byrd and Zeillemaker 1981; Chang 1990). Nesting phenology appears to be related to wetland late-succession vegetation and water levels. The Hawaiian common gallinule (ʻalae ʻula) clutch averages five to six eggs (Byrd and Zeillemaker 1981;

Chang 1990); incubation ranges from 19 to 22 days (Byrd and Zeillemaker 1981). Re-nesting and multiple broods during one season often occur (Byrd and Zeillemaker 1981). Platform nests are constructed in dense vegetation over water or near the edge of a marsh. Hawaiian common gallinule (ʻalae ʻula) hatchlings are precocial; chicks are covered with down and are able to walk but are dependent on parents for several weeks (U.S. Fish and Wildlife Service 2011c). Hawaiian common gallinule (ʻalae ʻula) are secretive, preferring to forage, nest, and rest in dense wetland vegetation. When feeding along the water's edge or in open water, they quickly seek cover when disturbed.

3A.7.3 Habitat Requirements and Ecology

Hawaiian common gallinules (ʻalae ʻula) predominantly occur in wetlands below 410 ft (125 m) in elevation on Kauaʻi and Oʻahu, with a few observations reported from Keʻanae Peninsula, Maui, and also from the Island of Hawaiʻi. The preferred habitat is low-elevation freshwater marshes (Engilis and Pratt 1993). Key habitat features include scattered dense stands of robust vegetation near open water, floating or barely emergent mats of vegetation, and water depth less than 3 ft (0.9 m). Hawaiian common gallinules (ʻalae ʻula) are opportunistic feeders and their diet varies with habitat, but includes algae, grass seeds, insects, snails, fish, crustaceans, mollusks, grasses, and wetland plants (U.S. Fish and Wildlife Service 2011c).

3A.7.4 Distribution and Population Trends

No historical population estimates are available prior to the first biannual waterbird count by DOFAW in 1977. It is believed that in the 19th century Hawaiian common gallinule (ʻalae ʻula) were common on all of the Hawaiian Islands, except Lānaʻi and Kahoʻolawe. The population exhibited a precipitous decline in numbers through the mid-20th century. Currently Hawaiian common gallinules (ʻalae ʻula) are only known to inhabit the islands of Kauaʻi and Oʻahu. Surveys of the statewide population between 2019 and 2016 were small but relatively stable, with an average of 712 birds (573–870) over 5 years (2019–2023) (Gorresen et al. 2024). On Kauaʻi alone, the population is estimated to be 485 (383–611) for the same time period.

On Kauaʻi, the largest populations occur in the Hanalei and Wailua River valleys, Waiakalua Reservoir, and Wilcox Ponds. However, they also occur in low numbers within the irrigation canals in Mānā in western Kauaʻi and in taro fields (Figure 7) (U.S. Fish and Wildlife Service 2011c). Between 2008 and 2018, DOFAW conducted monthly counts at Hanalei National Wildlife Refuge and other wetlands in Hanalei and observed approximately 648 individuals and 100 individuals, respectively, on an annual basis (State of Hawaiʻi Division of Forestry and Wildlife 2021). Annual counts in Mānā at the Kawaiʻele Waterbird Sanctuary averaged approximately 18 individuals and in other Mānā wetlands 34 individuals, on an annual basis (State of Hawaiʻi Division of Forestry and Wildlife 2021). While these surveys provide an estimation of population status, the methodology for the counts may be flawed and final totals are thought to be underestimated because of the species' secretive behavior (U.S. Fish and Wildlife Service 2011c). Global long-term (1986–2023) trends indicate increasing population sizes for the Hawaiian common gallinule (ʻalae ʻula) population on Kauaʻi (Gorresen et al. 2024).

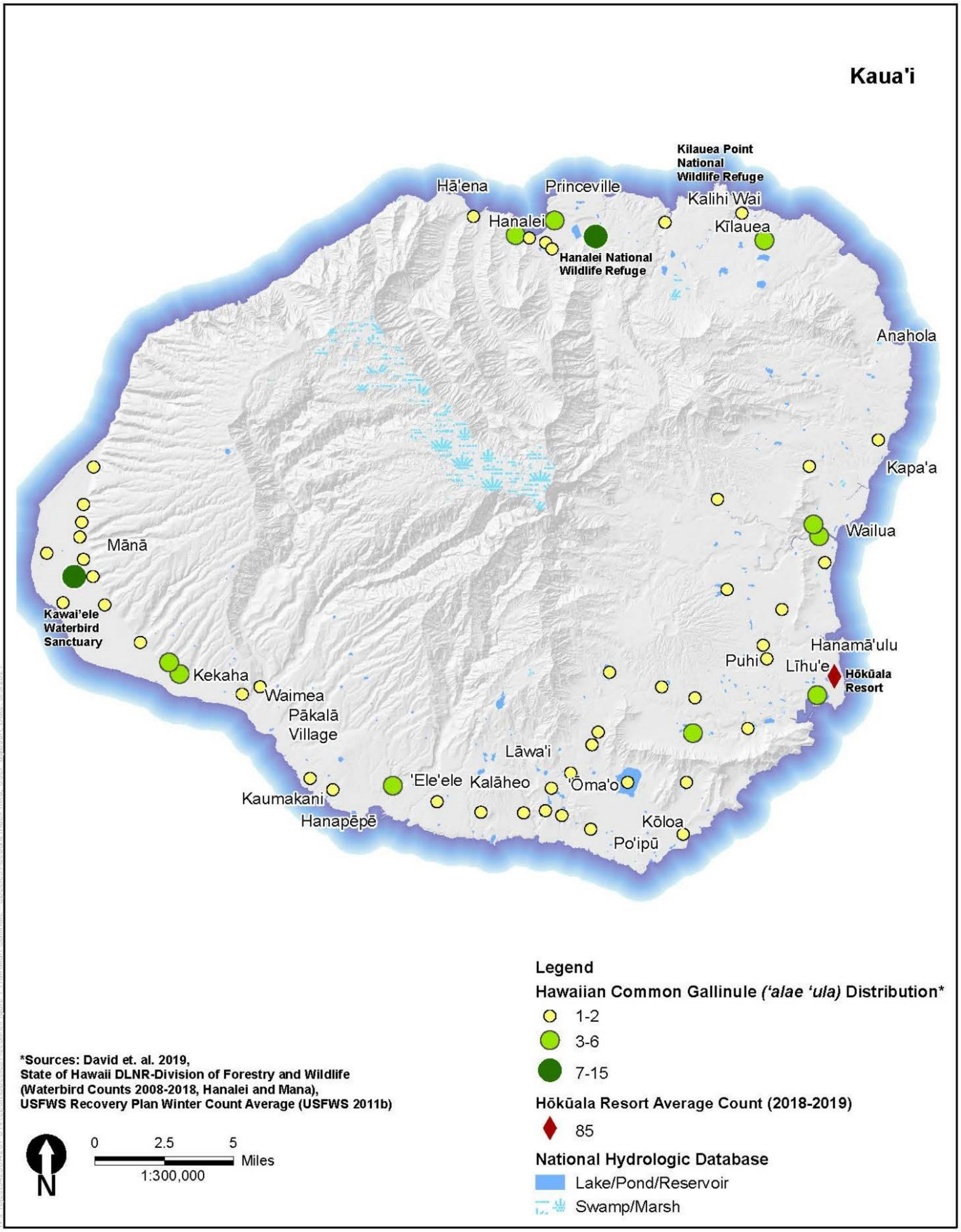

Figure 7. Distribution of the Hawaiian Common Gallinule (ʻalae ʻula) on the Island of Kauaʻi

3A.7.5 Threats

Most of the threats to the Hawaiian common gallinule (ʻalae ʻula) are also common to the other Hawaiian waterbirds. See the discussion of threats for these species in Section 3A.4.5, *Threats*. Habitat loss and degradation and predation are likely the main threats to an increasing or stable population of Hawaiian common gallinule (ʻalae ʻula). There is no indication that Hawaiian common gallinules (ʻalae ʻula) interact with powerlines, although instances exist of ducks, geese, and rails colliding with powerlines (Bevanger 1998; Travers et al. 2019), particularly in sensitive habitats (Haas et al. 2005). During the period of 2007 through 2019, three Hawaiian common gallinules (ʻalae ʻula) were found in the vicinity of powerlines but the cause of death was unknown (Bache 2020).

3A.7.5.1 Climate Change

Threats related to climate change are similar for all Hawaiian waterbirds and are discussed in Section 3A.4.5.1, *Climate Change*, for Hawaiian stilt (aeʻo). Climate change analyses in the Pacific Islands currently lack sufficient spatial resolution to make specific predictions concerning the effects of climate-related changes on Hawaiian gallinule (ʻalae ʻula) on Kauaʻi (University of Hawaiʻi at Mānoa 2014).

3A.8 Hawaiian Goose (nēnē) (*Branta sandvicensis)*

3A.8.1 Listing Status and Taxonomy

The Hawaiian goose (nēnē) (*Branta sandvicensis*) is a medium-sized goose (16.1 inches [41 cm] tall) and a member of the avian family Anatidae. The Hawaiian goose (nēnē) was listed as endangered under the federal ESA in 1967. The species is also listed as endangered under HRS, Chapter 195D, Section 195D-4, Endangered and Threatened Species. In 2019, USFWS downlisted Hawaiian goose (nēnē) from endangered to threatened (83 *Federal Register* [FR] 13919). This change went into effect on January 21, 2020 (U.S. Fish and Wildlife Service 2019). Critical habitat has not been developed for this species by USFWS.

3A.8.2 Life History

The Hawaiian goose (nēnē) is non-migratory with daily, local flights typically in early morning and late afternoon, between nesting and feeding areas. Although they are capable of interisland flight, their wings are reduced in size and they are non-migratory. When taking off and landing, their long, low flight path makes them vulnerable to collisions with stationary structures and moving objects such as vehicles and aircraft (Banko et al. 2020). Historically, flocks moved between high-elevation feeding habitats and lowland nesting areas. Hawaiian geese (nēnē) reach sexual maturity after 1 year, but usually do not form pair bonds until the second year. Females are highly philopatric and nest near their natal area, while males more often disperse (U.S. Fish and Wildlife Service 2018c). Today, many Hawaiian geese (nēnē) nest in mid- and high-elevation sites, although it is believed that they once nested primarily in leeward lowlands (Banko et al. 1999; U.S. Fish and Wildlife Service 2004). Lowland areas are used by Hawaiian goose (nēnē) populations on Kauaʻi year-round (Banko et al. 1999; U.S. Fish and Wildlife Service 2004, 2019).

Hawaiian geese (nēnē) nest on the ground in a shallow scrape, shaded by shrubs or other vegetation. They have an extended breeding season, laying eggs from August to April, peaking in December (October–March); the majority of eggs hatch in December and January (Banko et al. 1999; U.S. Fish and Wildlife Service 2004, 2018c). A Hawaiian goose (nēnē) clutch typically contains three to five eggs, and incubation ranges from 29 to 32 days. Once hatched, the young may remain in the nest for 1–2 days; all hatchlings depart the nest after the last egg is hatched (U.S. Fish and Wildlife Service 2004, 2018c). Goslings are flightless for 10–12 weeks and adults are flightless (owing to wing molt) for a period of 4–6 weeks, at about the same time. From June to September, after molting and fledging, family groups congregate in post-breeding flocks, often far from nesting areas (U.S. Fish and Wildlife Service 2004, 2018c). Hawaiian geese (nēnē) are highly social within their family units and moderately social with other geese, typically associating in small local flocks that are limited in size because of small population sizes (Banko et al. 2020).

3A.8.3 Habitat Requirements and Ecology

Hawaiian geese (nēnē) exhibit seasonal movements to grasslands when the production of fruiting bodies associated with shrubland foraging habitat is low, and when wet conditions produce grass with a high water and protein content. Hawaiian goose (nēnē) grazing is opportunistic, with variation in their grazing allowing the species to survive in marginal habitats (Banko et al. 1999). Historical reports from the Island of Hawaiʻi indicate that Hawaiian geese (nēnē) bred and molted primarily in the lowlands during winter and moved upslope in the hotter and drier summer (U.S. Fish and Wildlife Service 2004, 2018c). Reproductive success is relatively low in highland habitats on Hawaiʻi and Maui, and higher in lowland habitat on Kauaʻi (Banko et al. 1999).

On Kauaʻi, where the largest population now occurs, Hawaiian geese (nēnē) typically use lowland habitats including golf courses, coastal wetlands including taro loʻi (ponds), farmlands, pastures and fallow grassy and shrubby fields; they are also found along roadsides, and in established and maintained Hawaiian goose (nēnē) release sites and wildlife sanctuaries (Banko et al. 1999). Most Hawaiian geese (nēnē) on Kauaʻi occur in coastal wetlands at Hanalei and Huleʻia National Wildlife Refuges, along the Nā Pali Coast, and in maintained wetlands and water features at resorts and golf courses in and around Līhuʻe. The range has expanded considerably as the population has increased, and Hawaiian geese (nēnē) have adapted to many urban settings (U.S. Fish and Wildlife Service 2004; David et al. 2019).

3A.8.4 Distribution and Population Trends

Hawaiian geese (nēnē) were once widely distributed among the MHI (Niʻihau, Kauaʻi, Oʻahu, Molokaʻi, Maui, Lānaʻi, Kahoʻolawe, and Hawaiʻi); for a detailed history, see Pyle and Pyle 2017e). Before 1778, the distribution of Hawaiian goose (nēnē) was much broader than what it became after colonization by Europeans (Banko et al. 1999). However, estimating the population size both pre-Polynesian and pre-European contact is difficult because of limited understanding of species composition or even the gross structure of the vegetation before human occupation (U.S. Fish and Wildlife Service 2004). By 1952, the world population totaled 30 Hawaiian geese (nēnē), confined to the Island of Hawaiʻi (Smith 1952). It is thought that Hawaiian goose (nēnē) populations on the higher islands, Hawaiʻi and Maui, persisted longest owing to those islands' remote rugged upland areas, where hunting and predation by introduced mammals were less intense (Banko et al. 1999).

The 2023 statewide population estimate for the Hawaiian goose (nēnē) was 3,797 individuals, with 1,048 on Hawaiʻi; 429 on Maui; 6 on Molokaʻi; 2,314 on Kauaʻi; and 0 on Oʻahu (Nēnē Recovery

Action Group 2025). Kauaʻi has the greatest amount of lowland habitat available, and it is believed that this, in combination with the lack of an established mongoose population, has resulted in the largest population of Hawaiian geese (nēnē) among the MHI (Banko et al. 1999; U.S. Fish and Wildlife Service 2004).

There are currently four areas on Kauaʻi where Hawaiian geese (nēnē) are concentrated. The current distribution of birds on all islands, including Kauaʻi, is largely due to the locations captive-bred or translocated birds were released (Banko et al. 1999). With the exception of the Nā Pali Coast population, all Kauaʻi populations occur at low elevations, ranging from sea level to 600 ft (182.9 m). Approximately 25 captive Hawaiian geese (nēnē) were released by Kīpū Kai Ranch in 1985 on the southeast coastline of Kauaʻi. These birds were originally obtained from the Shipman Estates on Hawaiʻi in the late 1960s. Another 38 captive-bred Hawaiian geese (nēnē) were released at the Kīlauea Point National Wildlife Refuge located on the northeast coastline of Kauaʻi beginning in 1991. These birds have bred successfully, and together these two populations increased to more than 350 birds (U.S. Fish and Wildlife Service 2004). In 2012, it was estimated that 650 Hawaiian geese (nēnē) occurred on lands between Hanalei and Mōkōlea Point at Kīlauea Point. This was significantly higher than the record count of 91 individuals observed at the Kawaiʻele wetlands of Mānā along the southwestern coastline of Kauaʻi that same year. A third population was initiated on the Nā Pali Coast with the release of 62 captive Hawaiian geese (nēnē) in 1995–1996. Release was at 330 ft (100.6 m) elevation with the birds subsequently moving to breed at 1,650 ft (502.9 m). This population numbered about 61 birds in 2004 (U.S. Fish and Wildlife Service 2004). Twenty-four Hawaiian geese (nēnē) were introduced to the Hanalei National Wildlife Refuge in April 2000 (U.S. Fish and Wildlife Service 2004). Monthly counts at the Hanalei National Wildlife Refuge ranged between 40 and 211 Hawaiian geese (nēnē) from 2010 to 2015 (State of Hawaiʻi Division of Forestry and Wildlife 2021).

In 2011, an increase to 400 Hawaiian geese (nēnē) at Kauaʻi Lagoons (now Hōkūala Resort) along the southeast coast of Kauaʻi adjacent to Līhuʻe International Airport prompted DOFAW to initiate a translocation plan to reduce risk to aircraft operations (State of Hawaiʻi Division of Forestry and Wildlife 2012). Between 2011 and 2016, 652 birds were translocated to Maui and Hawaiʻi (U.S. Department of Agriculture-Wildlife Services 2019). Since 2016, Hawaiian geese (nēnē) resumed nesting at the resort, and in 2019, over 100 Hawaiian geese (nēnē) were recorded at the facility (David et al. 2019). Even with the translocation of birds to Maui and Hawaiʻi, Hawaiian goose (nēnē) are increasing on Kauaʻi (Figure 8; Nēnē Recovery Action Group 2017, 2025).

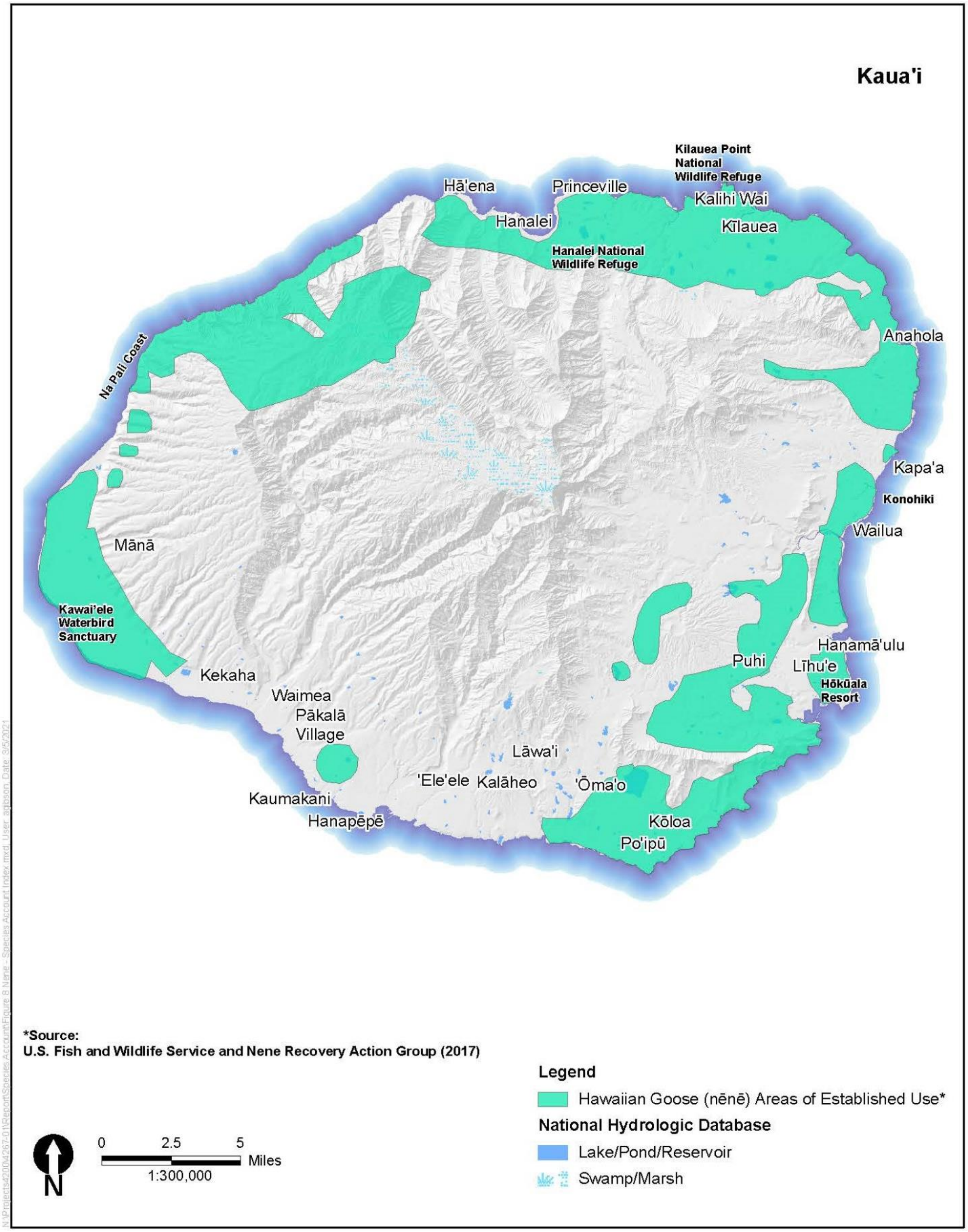

Figure 8. Hawaiian Goose (nēnē) Established Use Areas

3A.8.5 Threats

As with the other Hawaiian waterbirds, the primary causes of the decline of the Hawaiian goose (nēnē) are predation by introduced animals, loss of habitat, over-hunting in the late 19th century and early 20th century, disease, and environmental contaminants (U.S. Fish and Wildlife Service 2011c). During periods of flightlessness (while growing flight feathers and molting; February–May), Hawaiian goose (nēnē) goslings and adults are both extremely vulnerable to predation by invasive mammals. Introduced predators such as dogs, cats, and, on other islands, mongoose pose a serious threat to the Hawaiian goose (nēnē) by taking eggs, young birds, and even adults (U.S. Fish and Wildlife Service 2011c; State of Hawaiʻi Division of Forestry and Wildlife 2012).

Human activities have led to loss of lowland habitat for development of cultivated agriculture, housing developments, hotels, and golf courses. Habitat loss has also resulted from ungulate grazing and browsing, increased frequency of fire, and invasive plant species invasion (U.S. Fish and Wildlife Service 2004, 2019). However, palatable grasses and other plants in some pastureland, golf courses, lawns, and roadsides allow Hawaiian goose (nēnē) to forage and nest where it otherwise could not (Banko et al. 1999). In light of this information and the fact that the Hawaiian goose (nēnē) population in the lowland Kauaʻi sites have been the most successful, managers have expanded efforts to find lowland areas for potential Hawaiian goose (nēnē) reintroduction (U.S. Fish and Wildlife Service 2004). The threat of destruction and modification of habitat, particularly in lowland areas, by urbanization and land use conversion, including agriculture, is ongoing and expected to continue to limit the amount of Hawaiian goose (nēnē) foraging and nesting habitat, which may lead to reduced reproductive success and population declines (U.S. Fish and Wildlife Service 2019).

Increased use of urban, agricultural, and human built environments exposes Hawaiian geese (nēnē) to injury or death from collisions with vehicles, aircraft, construction or agricultural equipment, and golf balls or golf carts (Banko et al. 1999; David et al. 2019; U.S. Fish and Wildlife Service 2004). Although instances exist of ducks, geese, and rails colliding with powerlines (Bevanger 1998; Travers et al. 2019), there is little evidence that collisions with utility structures are having a large impact on Hawaiian geese (nēnē) (or other waterbird species) on Kauaʻi. During one seabird season of powerline monitoring, KESRP reported bird collisions that involved two cattle egrets, one black-crowned night heron (aukuʻu), and one Hawaiian goose (nēnē) (Travers and Raine 2020). During the period from 2007 to 2019, five Hawaiian geese (nēnē) were turned in to the SOS Program, found in the vicinity of powerlines, but the cause of death was not determined (Bache 2020).

Diseases could also render local habitats unsuitable for sustaining life history requirements. Avian botulism type C, introduced by humans, is the most prevalent disease affecting all Hawaiian waterbirds (U.S. Fish and Wildlife Service 2011c). It is caused by a neurotoxin produced by a common bacterium (*Clostridium botulinum*). Normally dormant, avian botulism spores only release toxins when certain conditions occur, including warm temperatures, high pH, low dissolved oxygen, and stagnant waters. By eating invertebrates containing the toxin, birds can be infected. The disease causes flaccid paralysis, the eventual loss of use of legs, and death (U.S. Fish and Wildlife Service 2011c). Since 2013, avian botulism outbreaks have been documented at 10 locations on Kauaʻi (Pratt and Brisbin 2020). Omphalitis, an infection of the umbilical stump, has been found to cause mortality in both wild and captive Hawaiian goose (nēnē) goslings (U.S. Fish and Wildlife Service 2004).

The possibility of West Nile virus or avian influenza reaching the Hawaiian Islands from the U.S. mainland or Asia currently is not a concern, but the potential for the future introduction of this pathogen in the Hawaiian waterbird populations remains a concern.

3A.8.5.1 Climate Change

Threats related to climate change that are discussed in Section 3A.4.5.1, *Climate Change*, for Hawaiian stilt (aeʻo) are similar for the Hawaiian goose (nēnē), including habitat loss due to flooding and sea level rise, the spread of invasive plant species, and disease. Climate change analyses in the Pacific Islands currently lack sufficient spatial resolution to make specific predictions concerning the effects of climate-related changes on Hawaiian goose (nēnē) on Kauaʻi (University of Hawaiʻi at Mānoa 2014).

3A.9 Central North Pacific Distinct Population Segment of the Green Sea Turtle (honu) (*Chelonia mydas)*

3A.9.1 Listing Status and Taxonomy

The green sea turtle (honu) is the largest marine turtle in the family Cheloniidae, second in maximum size only to the leatherback sea turtle (*Dermochelys coriacea*), and the sole species within the genus *Chelonia*. Green sea turtles (honu) grow to have a carapace length of 4 ft (1.2 m) and to weigh more than 400 pounds (181 kilograms). Its carapace has an olive-to-black color pattern and is composed of five scutes (or plates) running down its center, with four on either side. Other notable morphological distinctions are the species' yellow undersides and the two scales between its eyes. This species and other members of the Cheloniidae inhabit tropical and subtropical seas around the world.

All green sea turtles (honu) were listed under the federal ESA on July 28, 1978 (43 FR 32800). At that time, breeding populations in Florida and along the Pacific Coast of Mexico were listed as endangered and all other populations were listed as threatened. Major factors contributing to its status included human encroachment and associated activities on nesting beaches; commercial harvest of eggs, subadults, and adults; predation; lack of comprehensive and consistent protective regulations; and incidental take in fisheries. The federal recovery of the species is administered jointly between USFWS and NMFS (collectively referred to as "the Services") (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2015).

On February 16, 2012, the Services received a petition from the Association of Hawaiian Civic Clubs to identify the Hawaiian green sea turtle (honu) population as a distinct population segment (DPS) and delist it. On August 1, 2012, NMFS—with USFWS concurrence—determined that the petitioned action might be warranted, on the basis of the substantial information presented (77 FR 45571). After conducting a status review, the Services determined on April 6, 2016, that the Hawaiian population of the green sea turtle (honu) met the definition of threatened and identified it as the Central North Pacific distinct population segment (CNPDPS) (81 FR 20057). The status review analysis determined there were 11 DPSs for the species globally. All other green sea turtle (honu) populations remain federally protected, with three DPSs listed as endangered and eight DPSs listed as threatened, including the CNPDPS. Critical habitat for the CNPDPS of the green sea turtle (honu) has not been designated; however, the Services have agreed to identify and propose critical habitat for the five DPSs (including the CNPDPS) within U.S. jurisdictional lands and waters by 2023.

The CNPDPS of the green sea turtle (honu) is also protected by Chapter 195D of the HRS and Section 13-124 of Hawaiʻi Administrative Rules. Both adopt the same definitions, status designations, and prohibitions as the federal ESA, with the exceptions of some additional critical habitat designations and protections under the federal ESA, and additional penalties for violations at the state government level.

3A.9.2 Life History

Seminoff et al. (2015) published the status review as a NOAA Technical Memorandum entitled *Status Review of the Green Turtle (*Chelonia mydas*) under the U.S. Endangered Species Act*. This work serves as the most contemporary and comprehensive published repository of information for the species globally. As such, it forms the basis for most of the detail in this section.

Green sea turtle (honu) is migratory, and requires shoreline, neritic (nearshore), and oceanic habitats to satisfy different parts of its life cycle. Green sea turtles (honu) become sexually mature at 25–35 years. During the nesting season (April through September), females come ashore to lay eggs within a few weeks of mating. After making their way above the high-tide line, they use their front flippers to dig a large depression called a *body pit*. Females then use their back flippers to dig a smaller hole at the posterior end of the body pit called an *egg chamber*, into which they deposit between 50 and 200 soft-shelled eggs. After refilling and covering their nests with sand, they return to the ocean to forage before returning to shore approximately 14 days later to nest again. The female will nest approximately three to four times in a nesting season. Upon laying the final nest, the female returns to the ocean, taking up to several months to reach marine foraging grounds in the MHI. Females return to these specific, generally neritic feeding areas, to replenish energy stores for the next reproductive season. This typically takes more than a year; while males can mate annually, on average, females mate every 2 to 4 years to accommodate the energetic requirements of reproduction.

After about 2 months, hatchlings break through the eggshell and slowly dig their way to the surface, typically en masse, and head to the ocean. This movement generally occurs at night or in the early predawn hours to avoid detection on the beach or in nearshore waters by predators. Hatchlings initially orient to the brightest horizon, naturally occurring over the moonlit ocean, in areas devoid of artificial lighting (Daniel and Smith 1947; Limpus 1971; Salmon et al. 1992; Witherington and Martin 1996; Witherington 1997). After reaching the water, hatchlings exhibit a multi-day *swimming frenzy*, during which they swim almost continuously, fueled only by leftover egg yolk, to reach deeper water away from shore.

Young turtles are transported by strong currents to oceanic habitats, where they live among flotsam, such as Sargassum (brown algae) and flotsam mats. During this part of the green sea turtle's (honu) life cycle, which can last years to decades, the animals are omnivorous. This period is often referred to as "the lost years." Because it is difficult to study the turtles during this period, relatively little is known about this phase of the turtle's life cycle. Once juvenile turtles reach a certain size and age range, around 10 to 15 years old, the animals return to the highly productive neritic feeding areas to finish growing, a process that can take as little as a few years and as long as a few decades.

Adult turtles also occupy neritic foraging areas while traveling between nesting and breeding locations. After acquiring sufficient resources, adult males and females migrate to breeding areas to mate and, in the case of females, to nest. Females exhibit strong natal homing, meaning that to lay their own eggs, they return to the coastline where they had hatched. The distance between feeding and breeding areas can be hundreds to tens of thousands of miles.

3A.9.3 Habitat Requirements and Ecology

Seminoff et al. (2015) state that most green sea turtles (honu) spend most of their lives in neritic foraging grounds. These areas of shallow waters include both open coastline and protected bays and lagoons. While in these areas, green sea turtles (honu) rely on marine algae and seagrass as their primary food, although some populations also forage heavily on invertebrates during different parts of their life cycle. This is the case for the CNPDPS during its oceanic life stage as detailed below. These coastal habitats are often highly dynamic with annual fluctuation in salinity and air temperature, which can cause the distribution and abundance of potential green sea turtle (honu) food items to vary substantially between seasons and years (Carballo et al. 2002). Conditions at coastal foraging areas have been shown to affect the timing of green sea turtle (honu) reproduction (Limpus and Nicholls 1988; Solow et al. 2002). Therefore, even though foraging areas are usually separated from nesting areas by hundreds to thousands of miles, they have a profound influence on population dynamics. Annual and decadal oscillations in marine climate likely play a large role in these large-scale movements, because winds and currents are affected, but additional research is required to understand how environmental variability triggers or limits green sea turtle (honu) migration and reproduction.

Oceanic habitats are used by juveniles as noted in Section 3A.9.2, *Life History*, migrating adults, and, on some occasions, by green sea turtles (honu) that reside in the oceanic zone for foraging. Despite these uses of the oceanic zone, much remains unknown about how oceanography affects juvenile survival, adult migration, and prey availability in this species.

On shore, green sea turtles (honu) rely on safe and "healthy" beaches characterized by intact dune structure, native vegetation, lack of artificial lighting, and normal beach temperatures for nesting (Limpus 1971; Salmon et al. 1992; Ackerman 1997; Witherington 1997; Lorne and Salmon 2007). Research has shown that higher sand temperatures result in disproportionate sex ratios in sea turtles (higher temperatures result disproportionately more females produced and vice versa for males), which in turn can lead to lower fecundity rates and ultimately population declines (Blechschmidt et al. 2020). Coastal areas denuded of vegetation or where development is occurring can also affect the quality of nesting habitat by disrupting normal thermal regimes but also lead to the potential for tidal inundation associated with lack of vegetation. Nests laid in these areas are at a higher risk than those on more pristine beaches (Schroeder and Mosier 2000).

As noted above, green sea turtles (honu) have been shown to consume a wide variety of seagrass, marine algae, and invertebrates (Bjorndal 1997). Limited studies of oceanic adults have shown them to be primarily carnivorous (Arthur et al. 2008; Parker et al. 2011). Parker et al. (2011) conducted one of the few diet analyses of oceanic green sea turtles (honu). The authors studied ten animals opportunistically obtained as fisheries bycatch within the CNPDPS. Analysis indicated that green sea turtles (honu) of the CNPDPS during the oceanic life stage were "carnivorous with some omnivorous tendencies, foraging within the first 100 m of the water column." Neritic-stage juvenile and adult green turtles have been found to be generally herbivorous, foraging on seagrasses and marine algae, although some populations appear to forage heavily on invertebrates (Bjorndal 1997; Jones and Seminoff 2013). Additionally, some populations may exhibit one or more ontogenetic dietary shifts (i.e., developmental events that occur during the existence of a living organism) after recruitment to the neritic zone (Arthur et al. 2008; Howell et al. 2013). The CNPDPS of the green sea turtle (honu) is distinct in that this population segment has integrated invasive plant species into its diet (Russell and Balazs 2009). Seminoff et al. (2015) noted a scarcity of detailed diet information among the various life stages for this species globally.

3A.9.4 Distribution and Population Trends

3A.9.4.1 Current and Historic Distribution

The range of the CNPDPS of the green sea turtle (honu) includes the Hawaiian Archipelago and Johnston Atoll. The Hawaiian Archipelago represents the most geographically isolated chain of islands globally and the CNPDPS distribution reflects that isolation. The Hawaiian Archipelago consists of the MHI: Niʻihau, Kauaʻi, Oʻahu, Molokaʻi, Maui, Lānaʻi, Kahoʻolawe, and Hawaiʻi, and the Northwestern Hawaiian Islands which extend to Kure Atoll and are within Papahānaumokuākea Marine National Monument (Papahānaumokuākea). From 1965 to 2013, 17,536 individuals of the CNPDPS of the green sea turtle (honu) have been tagged, an effort that has involved all post-pelagic size classes from juveniles to adults. With only three exceptions, the 7,360 recaptures of these tagged turtles have been made within the Hawaiian Archipelago. The outliers involved one recovery each in Japan, the Marshall Islands, and the Philippines (Seminoff et al. 2015).

The principal nesting site for the CNPDPS of the green sea turtle (honu) where approximately 95 percent of all nesting occurs is French Frigate Shoals (Lalo), an atoll in Papahānaumokuākea (islands that make up the northwestern portion of the Hawaiian Archipelago) (Figure 9). Based on data collected from 1973 to 2005, East Island is where approximately 50 percent of the nesting occurs within French Frigate Shoals (Lalo) (Balazs and Chaloupka 2004, 2006). Since nesting surveys of the CNPDPS of the green sea turtle (honu) were initiated in 1973, there has been a marked increase in numbers nesting at East Island. The other islands within French Frigate Shoals (Lalo) include Tern, Trig, Gin, and Little Gin, all of which combined, account for the remainder of CNPDPS green sea turtle (honu) nesting at the atoll.

At East Island, the mean annual nesting abundance was 83 females during the first 4 years of monitoring (1973–1977) which increased to 464 females during the monitoring period of 2009–2012 (Seminoff et al. 2015). This trend represents an annual increase of 4.8 percent for the CNPDPS of the green sea turtle (honu) since monitoring began (Seminoff et al. 2015). Information on at-sea abundance trends is consistent with the increase in nesting (Balazs et al. 1996, 2005; Balazs 2000; Seminoff et al. 2015).

In 2018, East Island was dramatically altered by a Category 3 Hurricane, Walaka. The storm shrank the roughly 11-acre island by 94 percent. As sand re-accreted over time, the island moved offshore from its pre-Walaka position. In 2019, the island grew by nearly 600 percent and as of 2020, East Island had returned to nearly 60 percent of its pre-Walaka size (Kane et al. 2020) and appears to have shifted slightly from its pre-Walaka position.

Surveys were conducted in 2019 (National Oceanic and Atmospheric Administration 2019) at both East and Tern Islands. In 2019, 106 females were identified on at East Island (National Oceanic and Atmospheric Administration 2020a) and 251 females were identified at Tern Island (National Oceanic and Atmospheric Administration 2019). Relative to recent years, abundances of nesting females had increased at Tern Island and decreased at East Island in 2019. It is unclear if this increase is due solely to habitat loss and displacement from East and Trig islets or if there were additional factors facilitating increased abundance of nesting females at Tern Island (National Oceanic and Atmospheric Administration 2019). At both islands, additional ecological changes were observed. At Tern Island, the loss of vegetation due to Walaka and increased entrapment of nesters nesting over a larger area within overall suboptimal habitat has been observed. At East Island, surveys found that nests were frequently washed out, including the loss of an important index site that had been used to monitor trends in abundance for CNPDPS of the green sea turtle (honu) over the last 30 years (National Oceanic and Atmospheric Administration 2020a). In 2020, normal survey efforts were interrupted by COVID-19 but opportunistic surveys were able to be completed by Papahānaumokuākea Marine National Monument Co Trustee Agency partner staff already deployed prior to COVID-19 restrictions; these data were not publicly available (National Oceanic and Atmospheric Administration 2020b).

3A.9.4.2 Within the Plan Area

Seminoff et al. (2015) calculated and summarized abundance of nesting individuals across all locations within the CNPDPS of the green sea turtle (honu). Estimated total nester abundance was calculated as [(total counted females / year of monitoring) x remigration interval]. For Kauaʻi, green sea turtle (honu) monitoring data collected from 2010 to 2012 were used to calculate an estimated nester abundance of 16 females. This represents only 0.39 percent of the total estimate of 3,864 breeding females calculated for the CNPDPS of the green sea turtle (honu).

In addition, Parker and Balazs (2015) documented 20 nesting sites[1] from 1976 to 2012 around Kauaʻi. All but two were described as having intermittent or indeterminate use (Figure 9). The two locations regularly used by nesting females are Lāwaʻi Kai and Kīpū Kai on the south side of the island. Average annual nesting density of green sea turtles (honu) at all Kauaʻi sites is very low, ranging from less than one (i.e., one nest every several years) to one to two nests per year between 2015 and 2020 (State of Hawaiʻi Division of Aquatic Resources 2020). Lāwaʻi Kai and Kīpū Kai averaged one to two nests per year during the same time period (State of Hawaiʻi Division of Aquatic Resources 2020). Although nesting density is low, observations of nesting have increased over the past 5 years (State of Hawaiʻi Division of Aquatic Resources 2020).

[1] Nesting data reported from Kauaʻi are speculative due to the lack of systematic surveys. Estimates may also be skewed toward high-use beaches and beaches that regularly have resting seals (as this is how green sea turtle [honu] nests have been opportunistically found).

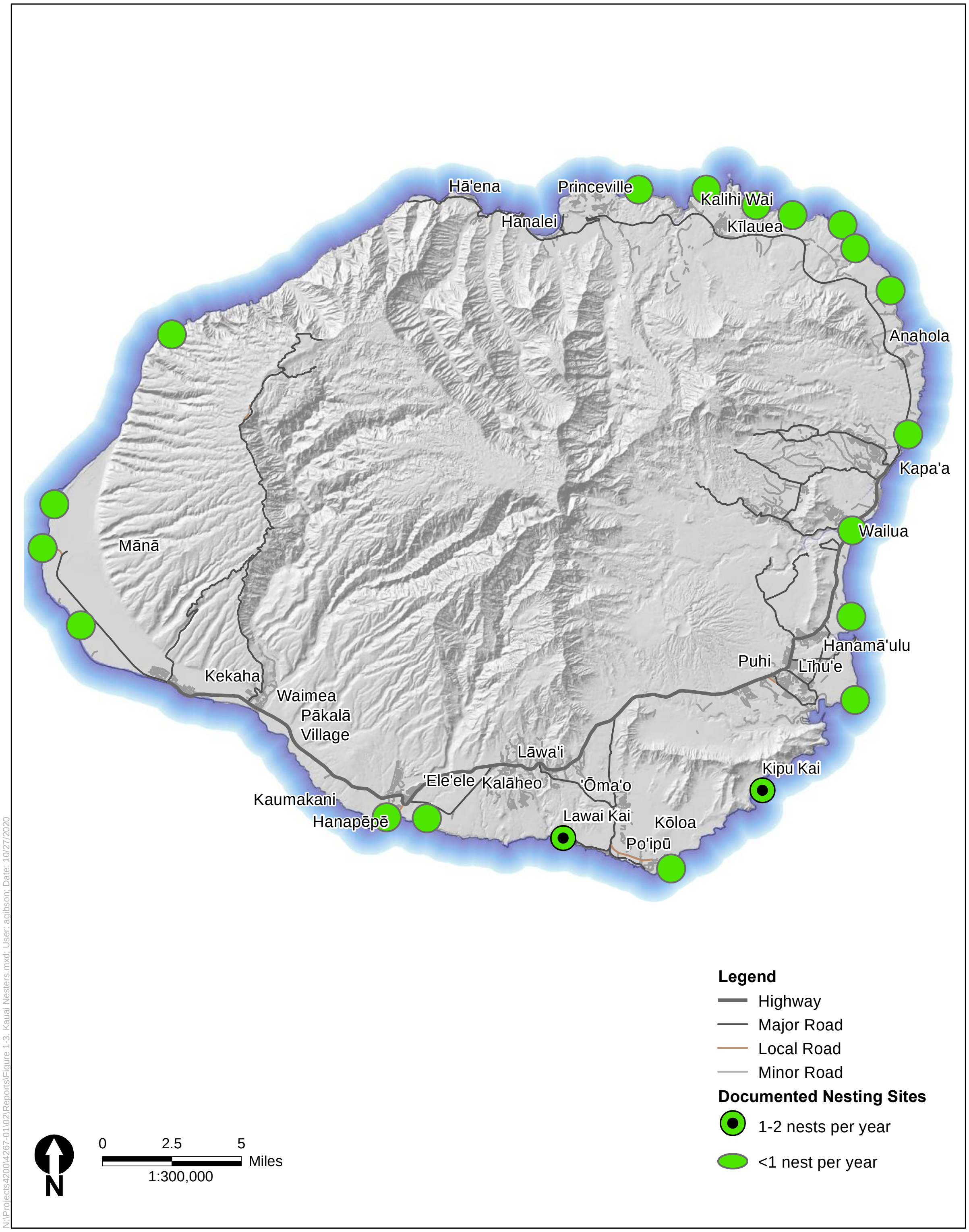

Figure 9. Location and Estimated Abundance of Central North Pacific Distinct Population Segment of the Green Sea Turtle (honu) Nests on Kauaʻi

3A.9.5 Threats

Seminoff et al. (2015) present the status review of the green sea turtle (honu) across the global range and document threats as part of the overall evaluation of each DPS. Consistent with the overall global threats, the primary causes of the decline of the CNPDPS of the green sea turtle (honu) are attributed to a variety of anthropogenic threats. Threats, such as bycatch in fishing gear (the incidental capture of non-target species), pollution, interactions with recreational and commercial vessels, development and public use of beaches, climate change, artificial lighting, predation, disease, beach driving, and major storm events all negatively affect green sea turtles (honu) in this DPS. Three of the most common reasons for sea turtle strandings in Hawaiʻi are entanglement in fishing lines, interactions with fishing hooks, and interaction with marine debris (usually entanglement in nets) (Francke et al. 2013).

Coastal development and construction, artificial lighting, vehicular and pedestrian traffic, beach pollution, tourism, and other human-related activities are increasing threats to the basking and nesting population in the MHI (currently very limited) and negatively affect hatchling and nesting turtles on beaches where these threats are present. Climate change effects, especially sea level rise, is a threat to the terrestrial and neritic-oceanic zones in both the MHI and Papahānaumokuākea; potential effects on green sea turtle (honu) life stages that rely on other zones are less certain.

3A.9.5.1 Development

Human populations are growing rapidly in many areas of the insular Pacific and this expansion is exerting increased pressure on limited island resources. The most valuable land on most Pacific islands is often located along the coastline, particularly when it is associated with a sandy beach. Construction is occurring at a rapid rate in some areas and is resulting in loss or degradation of green sea turtle nesting habitat (honu). Construction-related threats to the region's nesting beaches include construction of buildings (e.g., hotels, houses, restaurants) and recreational facilities (e.g., golf courses) on or directly adjacent to the beach; clearing of stabilizing beach vegetation, which accelerates erosion; and use of heavy construction equipment on the beach, which can cause sand compaction or beach erosion. Lighting associated with coastal development also degrades nesting habitat (Section 3A.9.5.5, *Artificial Light Attraction*).

3A.9.5.2 Public Use of Beaches

Increased public use of nesting beaches is a threat to green sea turtle (honu) nesting habitat in Kauaʻi. Public use of beaches includes a variety of recreational activities, such as picnicking (which can include beach camping and fires), swimming, surfing, playing sports, scuba diving, use of watercraft in the nearshore environment, and snorkeling access (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998). Public use of beaches can also increase litter and other refuse on the beach, which can attract destructive nonnative animals such as pigs. Although driving on Kauaʻi's beaches is illegal, there is extensive vehicle traffic in suitable green sea turtle (honu) nesting habitat (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998).

3A.9.5.3 Vessel Strikes

Various types of watercraft can strike green sea turtles (honu) when they are at or near the surface. Vessel strikes are a major threat to large juveniles at sea and adults in nearshore areas. High boat traffic areas such as marinas present a high risk to this species, and nesting females are vulnerable to vessel strikes when making reproductive migrations or while they are near shore during the nesting season (National Marine Fisheries Service 2021). Sea turtles can also be struck and seriously injured by boat propellers, hydrofoils and jet skis. From 2005 to 2009, 18.2 percent of all stranded green turtles (695 of 3818) in the U.S. Atlantic (Northeast, Southeast, and Gulf of Mexico) were documented as having sustained some type of propeller or collision injuries (Seminoff et al. 2015).

Green sea turtles (honu) have been documented as occasionally being hit by boats in Kauaʻi. In December 2020, a green sea turtle (honu) was struck by a boat and stranded on the shoreline. The individual had to be euthanized due the extent of its injuries. The turtle is just one of 22 that were injured in the NMFS Pacific Islands Region since March 2020 (Wu 2020).

3A.9.5.4 Climate Change

Global climate change will lead to alterations of green sea turtle (honu) nesting habitat. For example, sea level rise will result in increased erosion of nesting beaches and significant loss of habitat (Baker et al. 2006; Intergovernmental Panel on Climate Change 2007). The extent to which green sea turtles (honu) can adapt to these changes in nesting beach location and quality is unknown. Climate change will likely also cause higher sand temperatures leading to increased feminization of surviving hatchings (i.e., changes in sex ratio); and some beaches will also experience lethal incubation temperatures that will result in complete losses of hatchling cohorts (Glen and Mrosovsky 2004; Fuentes et al. 2010, 2011; Booth et al. 2020). Increased sea surface temperatures may alter the timing of nesting for some stocks (Weishampel et al. 2004), although the implications of changes in nesting timing are unclear. Changes in sea temperatures will also likely alter seagrass, macroalgae, and invertebrate populations in coastal habitats in many regions (Scavia et al. 2002). Climate forecasts are needed in population models to understand the impacts of rising temperatures (e.g., sand temperatures) on hatchling sex ratios and hatching success.

East and Tern islands of French Frigate Shoals (Lalo), the center of the CNPDPS range, are vulnerable to sea level rise (Baker et al. 2006). High-resolution digital elevation data and models are necessary to describe observed sea level rise and its future modeled potential at French Frigate Shoals (Lalo) and other nesting sites to assess green sea turtle (honu) vulnerability.

Changing storm dynamics and intensity because of climate change are emerging concerns for habitat in both the MHI and the Papahānaumokuākea (Baker et al. 2006; Keller et al. 2009). Storms and seasonal changes in current patterns can reduce or eliminate sandy beaches, degrade turtle nesting habitat, and cause barriers to adult and hatchling turtle movements on affected beaches.

One such notable event occurred in early October 2018 when Hurricane Walaka, a category 3 storm, directly affected French Frigate Shoals (Lalo). Satellite imagery documented dramatically altered shoreline habitat on East and Tern islands. East Island was almost completely claimed by the ocean. Unhatched turtle nests were severely affected by the storm at French Frigate Shoals (Lalo) as reported to USFWS by personal observations. One observation reported the runway at Tern Island was littered with turtle eggs destroyed from the storm. Consequently, the impacts of the hurricane affected nesting rates for 2018 and subsequent years following the event (U.S. Fish and Wildlife Service in litt.).

Some islands in French Frigate Shoals (Lalo) had already become submerged and were lost prior to Hurricane Walaka. As is common in sand-dominated ecosystems, Whale and Skate Islands were lost to erosion during the 1990s and Trig Island eroded earlier in 2018. Observations have led scientists to believe that, when these events occur, animals adapt by changing breeding locations (Papahānaumokuākea Marine National Monument 2018).

3A.9.5.5 Artificial Light Attraction

The presence of artificial lights on or adjacent to sea turtle nesting beaches alters the behavior of nesting adults (Witherington 1992); it is often fatal to emerging hatchlings, as they are attracted to light sources and drawn away from the water (Witherington and Bjorndal 1991; Nelson Sella et al. 2006). Light pollution has also been shown to affect females by deterring them from coming ashore to nest or drawing them away from the ocean after they are done nesting. These impacts have been well documented along coastal stretches of Florida and MHI. Based on hatchling orientation index surveys at nests located on 23 representative beaches in six Florida counties in 1993 and 1994, Witherington and Martin (1996) found approximately 10–30 percent of all sea turtle nests in each county showed evidence of hatchlings disoriented by artificial lighting.

Despite Seminoff et al. (2015) attempts to provide detailed analysis of all known threats to the species and relevant DPSs, light pollution is absent from the analysis for the CNPDPS. Although there is scant documentation for negative impacts from artificial lighting related to nesting on Kauaʻi, it is well known that artificial lighting affects sea turtles in the MHI. On Kauaʻi, there is recent documentation (2020) of one incident of more than one hatchling from a single nest being run over by vehicles near Kekaha Beach, resulting from disorientation due to artificial lighting emitted by a nearby streetlight adjacent to the main highway (Kauaʻi Hawaiian Monk Seal Conservation Hui in litt.). In addition, at least two known disorientation incidents also have occurred at a hotel in Poʻipū and one at Salt Pond County Park (Reiss in litt.). There are also numerous examples of hawksbill sea turtle (honuʻea) (*Eretmochelys imbricata*) disorientation of both hatchlings and nesting females from artificial lighting on Maui and the Island of Hawaiʻi. For example, on Maui in 1993 and 1996, two female hawksbills (honuʻea) with eggs and numerous hatchlings were killed by cars while trying to cross North Kīhei Road from the adjacent nesting beach (Hawaiʻi Wildlife Fund 2021).

3A.9.5.6 Disease

Fibropapilloma disease affects green sea turtles (honu) found in the MHI (Francke et al. 2013). This disease results in internal and external tumors (fibropapillomas) that may grow large enough to hamper swimming, vision, feeding, and potential escape from predators. In 2012 alone, 36 green turtle strandings in the MHI involved fibropapilloma tumors (Francke 2013). The exact numbers of animals affected by fibropapilloma is unknown because reported stranding data availability is limited and only represent a fraction of all CNPDPS of the green sea turtle (honu) mortalities. Depending on the area of Hawaiʻi, fibropapilloma disease appears to have peaked, remained the same, or increased (Van Houtan et al. 2010). Environmental factors may be significant in promoting fibropapilloma incidence; eutrophication (increase in nutrients) of coastal marine ecosystems also may promote this disease (Van Houtan et al. 2010). Fibropapilloma remains an important concern, particularly given the continued (and possibly future increasing) human impacts, including eutrophication of coastal marine ecosystems. Spirorchid (blood fluke) infections are reported for the CNPDPS of the green sea turtle (honu) (Greenblatt et al. 2005; Work et al. 2005); however, the extent to which this is a threat to the population is unknown.

3A.9.5.7 Predation

Predation of green sea turtle (honu) hatchlings by native species is normal and is something to which green sea turtles (honu) have adapted. Ghost crabs (*Ocypode* spp.) prey on hatchlings at French Frigate Shoals (Lalo) (Niethammer et al. 1997). The exact number of hatchlings lost is unknown but is estimated at approximately 5 percent (Balazs 1980). Hatchlings may also be eaten by fish when they enter the ocean. Large grouper (*Epinephelus tauvina*) are documented predators of post-hatchling green turtles in Hawaiʻi; however, the extent of grouper depredation is unknown (Balazs 1995). Seabirds, primarily the great frigatebird (ʻiwa) (*Fregatta minor*), an opportunistic predator of other seabird nestlings and known to prey on sea turtle hatchlings elsewhere, may also prey on sea turtle hatchlings at French Frigate Shoals (Lalo) (Balazs and Kubis 2007). Stranding records from Papahānaumokuākea and MHI (e.g., Francke 2013) show shark predation of CNPDPS of the green sea turtle (honu), predominantly adult turtles. The exact numbers of animals taken by sharks is unknown because reported strandings only represent a fraction of all CNPDPS of the green sea turtle (honu) mortalities.

Depredation of green sea turtle (honu) hatchlings by introduced species can exert additional pressure on the population in the cumulative context of additional anthropogenic sources. Mongoose, rats, dogs, feral pigs, and cats—all introduced species—exist on the MHI and are known to prey on eggs and hatchlings, although the exact impact on the current low level of nesting is unclear. If nesting in the MHI increases, it is likely the threat from these predators would increase.

3A.9.5.8 Illegal Harvest

While the harvesting of eggs and turtles was likely the major contributing factor to the historical decline of the population globally, current illegal harvest of green sea turtles (honu) for human consumption is limited. Harvest of CNPDPS of the green sea turtle (honu) has been illegal since it was listed under the federal ESA in 1978; furthermore, federal and state cooperative efforts and existing legislation appear to be minimizing the threat from illegal harvest. It is possible that human take today is underreported: anecdotal information suggests that some degree of illegal take continues to occur throughout the MHI.

3A.9.5.9 Marine Pollution, Fisheries Direct and Fisheries Indirect Interactions

Marine pollution includes the ingestion of, and entanglement in, marine debris, is another anthropogenic threat to CNPDPS of the green sea turtle (honu) throughout their range. Turtles ingest plastic, monofilament fishing line, and other marine debris (Bjorndal et al. 1994). Although direct effects may or may not be lethal, they result in varying side effects that could increase the probability of death (Balazs 1985a; Carr 1987; McCauley and Bjorndal 1999). CNPDPS of the green sea turtle (honu) can also be affected by contamination from herbicides, pesticides, oil spills, and other chemicals; as well as impacts on water quality (e.g., increases in water column sediments) resulting from structural degradation associated with excessive boat anchoring, dredging, and other sources (Francour et al. 1999; Lee Long et al. 2000; Waycott et al. 2005).

Historic military-related activities within the area covered by CNPDPS of green sea turtle (honu) have been a legacy of modification of offshore and onshore habitat at French Frigate Shoals (Lalo), including contamination (e.g., point sources of polychlorinated biphenyls because of former Long Range Navigation stations). Elevated levels of contamination remain in soils and nearshore sediment and biota; and sea and land pollution related to past and present human activities continues to stress the Papahānaumokuākea ecosystem (Wedding et al. 2008). During the 20th century, Johnston Atoll was the location of significant human and military activities such as guano mining, missile launching, airplane operations, nuclear testing, and chemical weapons incineration. The lingering effects of these activities include soil contamination, such as petroleum contamination of turtle foraging habitat (Balazs 1985b). However, the current effects of these activities on the marine environment and sea turtles are unclear.

Marine debris is a known threat for the CNPDPS of the green sea turtle (honu) in both terrestrial and marine environments. In 1996, it was estimated that between 750 and 1,000 tons of marine debris were on reefs and beaches in the Papahānaumokuākea, with fishing nets discarded or lost in the northeastern Pacific Ocean contributing the most (Keller et al. 2009). Keller et al. (2009) explain that even if no new debris were to enter the ocean, existing debris in the ocean will continue to accumulate in the Papahānaumokuākea for years. Such debris poses a major entanglement threat to sea turtles in the Papahānaumokuākea and can result in serious injury or mortality; it also can cause damage to habitat (Wedding et al. 2008). Balazs and Kubis (2007) describe entanglement and ingestion of marine debris as a potential threat to CNPDPS of the green sea turtle (honu), specifying discarded or abandoned fishing gear (nets and lines), as well as plastics (bags, six-pack rings, tar balls, polystyrene or other items that could ensnare or be eaten). Stranding information shows that fishing line and gill net gear entanglement is one of the causes of CNPDPS of the green sea turtle (honu) strandings and mortality in the MHI (Francke 2013, 2014). For example, 36 strandings in 2012 (Francke 2013) and 42 strandings in 2013 were related to entanglement in or ingestion of fishing line (Francke 2014). This number is a subset of the total number of animals possibly affected by this threat.

Interactions between the CNPDPS of green sea turtles (honu) and commercial and recreational fisheries in the Exclusive Economic Zone of the MHI can result in entanglement, injury, and mortality.

In addition, hook-and-line fishing from shore or boats hook and entangle individuals from the CNPDPS of the green sea turtle (honu) (National Marine Fisheries Service 2012; Francke et al. 2013). Interactions with nearshore recreational fisheries are identified in the NMFS stranding database as those turtles that strand as a result of interactions with fishhooks and fishing line. These include turtles that were hooked externally, ingested hooks, became entangled in fishing line, or exhibited intestinal prolapses due to line ingestion. Hook-and-line interactions have increased over time, with more than 60 turtles in 2011 and 46 turtles in 2012 stranded (Francke 2013; Francke et al. 2013; Ikonomopoulou et al. 2013). While current public outreach efforts by NMFS and its partners are attempting to reduce the magnitude of impact on CNPDPS of the green sea turtle (honu) from hook-and-line fishing, injury or mortality from the hooking or from the effects of line remaining on turtles that are cut free or break the line remains an issue (National Oceanic and Atmospheric Administration 2013).

Net and gill net entanglement cases include unidentified nearshore and pelagic nets, including cargo nets, trawl nets, lobster nets, and monofilament gill nets. Each year, individuals from the CNPDPS of the green sea turtle (honu) are incidentally entangled in net gear and some of these result in mortality (e.g., Francke 2013); however, the reported stranding is believed to be a smaller subset of the actual level of interaction with this gear. Henderson et al. (1987) documented sea turtle mortality resulting from entanglement in fishing gear in Hawaiʻi. Chaloupka et al. (2008) reported that between 1982 and 2002 approximately 7 percent of stranding related to gear-induced trauma were attributed to hook-and-line fishing; 5 percent for gill-net fishing. While gill nets are regulated by the State of Hawaiʻi, fishers are only required to inspect them completely every 2 hours, so entanglement and drowning do occur (National Marine Fisheries Service 2012).

Hawaiʻi-based pelagic longline fisheries use baited lines up to several miles long that have thousands of hooks and lures that inadvertently catch turtles, resulting in death by drowning (as they are unable to rise to the surface for air) or digestive debilitation (line and hook gets lodged in the stomach) (Sea Turtle Conservancy 2020). These fisheries are expected to take up to seven individuals from the CNPDPS of the green sea turtle (honu) annually (National Marine Fisheries Service 2005, 2012). Sea turtle bycatch rates in foreign fisheries are estimated to be at least 10 times and perhaps 20 times greater than Hawaiʻi-based fisheries (Bartram and Kaneko 2004; Kaneko and Bartram 2008), given the much greater fishing effort among foreign vessels (National Marine Fisheries Service 2012). While exact numbers are not available, at a minimum, an estimated 100 individuals of the CNPDPS of the green sea turtle (honu) are captured and killed annually as longline bycatch (National Marine Fisheries Service 2012).

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Appendix 4A

Conservation Site Selection

4A.1 Introduction

The purpose of this appendix is to describe the conservation site selection process for the Kaua‘i Island Utility Cooperative (KIUC) Habitat Conservation Plan (HCP). The conservation sites are the locations where Conservation Measure 4, *Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites* (hereafter Conservation Measure 4), will be implemented. Management actions under Conservation Measure 4 include intensive predator control at all sites. At some sites, predator exclusion fencing, social attraction, and invasive plant species control will also occur. Intensive monitoring will also occur at all sites (see Chapter 6, *Monitoring and Adaptive Management Program*, for details). This appendix describes the conservation site selection process and the conservation sites for the KIUC HCP.

4A.2 Conservation Site Selection

Selection and implementation of the conservation sites described in this HCP has been occurring for over 20 years, since 2002. This section describes the methods used to select the conservation sites and the scoring process used to identify the best conservation sites. The following section describes in more detail the selected conservation sites.

4A.2.1 Site Selection Methods

4A.2.1.1 Identification of Potential Conservation Sites

The U.S. Fish and Wildlife Service (USFWS), the State of Hawai‘i Division of Forestry and Wildlife (DOFAW), KIUC, other stakeholders, and species experts have been working collaboratively since 2002 to identify and evaluate potential conservation sites to contribute to viable metapopulations of the covered seabird species on Kaua‘i (Kaua‘i Island Utility Cooperative 2011). Initially, potential sites were identified through a desktop assessment using selection criteria that were developed in consultation with DOFAW, USFWS, and species experts from Pacific Rim Conservation and Hallux Ecosystem Restoration LLC.

During the evaluation process, DOFAW and USFWS worked with KIUC to narrow the list of potential sites and review new sites as they were proposed. Raine et al. (2020) provided key information on the current status of the covered seabird populations, practicability of implementing the conservation measures, and site constraints, to inform the site selection process. KIUC coordinated with USFWS and DOFAW staff and Dr. Andre Raine along with Lindsay Young of Pacific Rim Conservation for suggestions on appropriate sites and the practicability of implementing conservation measures at those sites. In 2020, Lindsey Young of Pacific Rim Conservation was contracted to conduct a feasibility analysis on potential conservation sites to further inform conservation site selection (Young 2020).

In addition, USFWS and DOFAW provided extensive input into the selection of the proposed conservation sites. During the planning process, USFWS published two important reports that recommended conservation actions to enhance breeding colonies of Newell’s shearwater (‘a‘o) be focused in northwestern Kaua‘i (U.S. Fish and Wildlife Service 2017a, 2019). These studies were based on spatially-explicit modeling that considered similar factors to the qualitative feasibility assessment (Young 2020), including topography, presence of existing breeding colonies, and threats of light attraction.

In 2023, KIUC contracted with Archipelago Research and Conservation (ARC) and Hallux Ecosystem Restoration to conduct additional site evaluations (Raine et al. 2023; Hallux Ecosystem Restoration 2023) after landowner negotiations failed on Upper Mānoa Valley, a site KIUC had been using as a conservation site from 2018 to 2022. Although Upper Mānoa Valley was added back into the HCP 2024, the five additional sites evaluated were added to this summary appendix.

4A.2.1.2 Habitat Suitability Models and Population Estimation

An important determinant of conservation sites is the presence of suitable breeding habitat for the two primary covered seabirds, Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu). Habitat distribution models were used to determine the location of suitable breeding habitat as a starting point to identify possible suitable conservation sites. Troy et al. (2014, 2016, 2017) developed habitat suitability models for both Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) using abiotic and biotic environmental parameters (e.g., elevation, wind speed, slope, vegetation cover) that are key nesting habitat characteristic of these species. These parameters were presented in a digital raster layer representing independent variables to produce the model in a GIS framework at a 164-foot (ft) by 164-ft (50-meter [m] by 50-m) pixel resolution representing categorical values of habitat suitability from 1 to 10. The output of the model is the predicted probability that each pixel supports (or could support) the nesting activities of Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) based on the environmental conditions of the pixel.

In 2018, Raine et al. used the Troy et al. (2014, 2016, 2017) habitat suitability models to estimate population sizes of endangered seabird colonies on Kauaʻi. Pixels valued 8 or higher were extracted from the habitat suitability models and used to identify areas of suitable habitat for each species within each conservation site. Areas of suitable breeding habitat were refined using current seabird activity for each species, as determined from the result of the Kauaʻi Endangered Seabird Recovery Project's auditory surveys. The average minimum area between burrows was then used to calculate an average density (burrow per m). Then, the minimum burrow densities for each species were multiplied by the total area of regions identified as occupied suitable breeding habitat (i.e., area with suitable breeding habitat in an area within constant intensive activity, as determined by auditory surveys) allowing the calculation of a total population estimate for each site (Raine et al. 2018).

The suitability models for both Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) and auditory survey[1] coverage are shown in Figures 4A-1 and 4A-2, respectively. Suitable habitat for Newell's shearwater (ʻaʻo) not covered by auditory surveys are either privately owned and inaccessible (e.g., the large block in the middle of the island), have low suitability for the species based on the Troy et al. (2014) model for the species, or both. Nearly all suitable nesting habitat of Hawaiian petrel (ʻuaʻu) has been covered by auditory surveys to verify presence or absence of breeding colonies (Figure 4A-2). As a result, there has been full auditory survey coverage for over 10 years (2011–2022) of all or almost all of the known and accessible breeding habitat of these species on Kauaʻi. The results of auditory surveys of both species were an important data source to select the

[1] Auditory surveys are performed by observers listening for calls before sunrise and after sunset during peak nesting season to estimate burrow densities. See Section 3.2.1.6, *Kauaʻi Metapopulation Distribution, Abundance, and Trends*, for more information.

conservation sites for the KIUC HCP, and they remain an important data source in annual monitoring of breeding pair abundance at those sites.

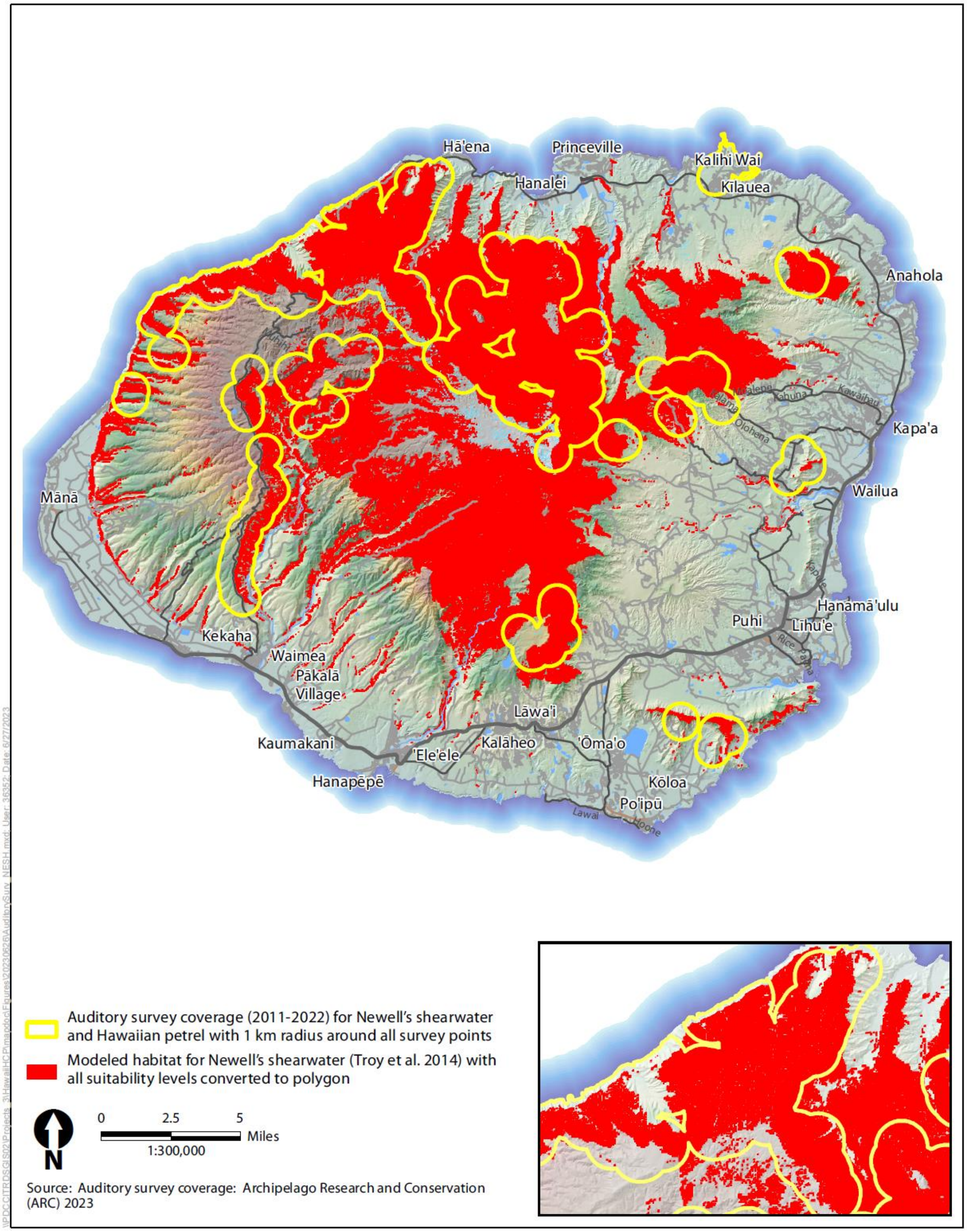

Figure 4A-1. Auditory survey coverage overlaying the habitat suitability model for Newell's shearwater ('a'o). Inset highlights northwestern Kaua'i where the conservation sites are located.

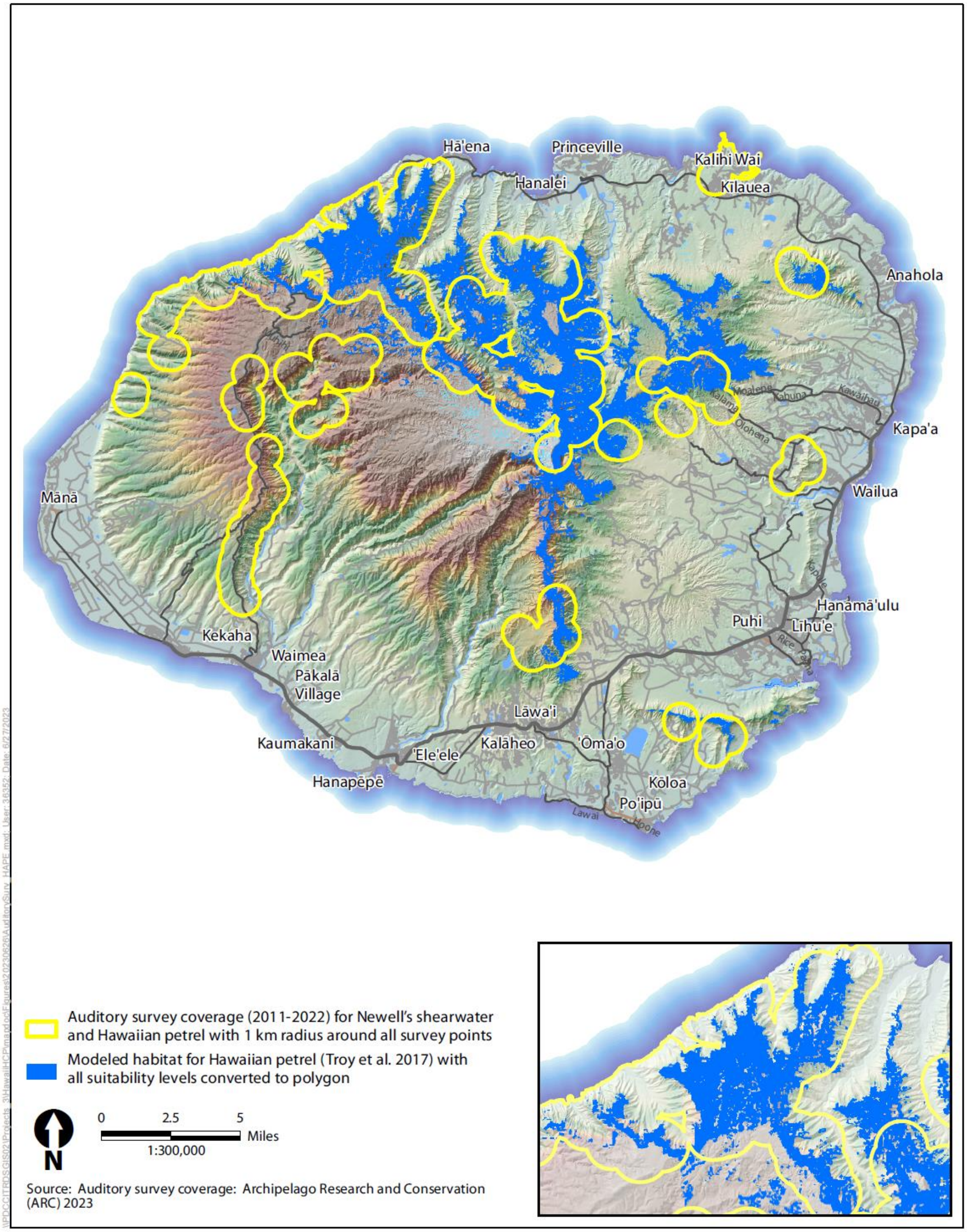

Figure 4A-2. Auditory survey coverage overlaying the habitat suitability model for Hawaiian petrel (ʻuaʻu). Inset highlights northwestern Kauaʻi where the conservation sites are located.

4A.2.1.3 Evaluation of Conservation Site Selection Criteria

The conservation site selection criteria listed in the following sections were developed by Raine et al. (2020) as a way of prioritizing known endangered seabird colonies that would be most suitable for long-term conservation under the KIUC HCP. Each conservation site is assessed against 14 criteria, with each criterion given a score from 0 to 5 or 1 to 5. Conservation sites are ranked independently for each covered seabird species and are not limited to those with more than one species present. However, a criterion for the presence of multiple species is included to increase the value of a conservation site with more than one covered seabird species.[2]

A description of the relative scores is outlined at the beginning of each criterion for ease of reference. Once each criterion was summed to a total score, the conservation sites with the highest scores were those that were selected as conservation sites for the HCP. A perfect score would total 96 points[3] (Raine et al. 2020).

Covered Species Occupancy

Criterion 1. Presence of a covered seabird breeding colony

Criterion 1 is defined as nesting within a conservation site by the covered seabird species. This criterion requires occurrence data (i.e., auditory surveys and/or burrow monitoring) to determine whether the site is occupied.

The criterion scores for presence of a covered species breeding colony are as follows:

- 0—No colony present
- 1—Species recorded at least once during auditory surveys
- 2—Auditory surveys confirm areas of activity identified as hotspot light (i.e., '*localized aerial activity, sporadic calling*')
- 3—Auditory surveys confirm areas of activity identified as hotspot heavy (i.e., '*localized aerial activity, continuous calling*')
- 4—Auditory surveys confirmed ground calling (highest level of evidence that a breeding colony exists at the site below the discovery of an actual burrow)
- 5—Confirmed breeding colony (through the discovery of active burrows)

The covered species occupancy criterion score is multiplied by a factor of two if a breeding colony is present to increase its weight. Conservation sites that contain a covered species breeding colony should be weighted more heavily than sites where social attraction is required to initiate a breeding colony. The criterion score is multiplied by a factor of three if the density of breeding birds at the site is high (i.e., for Newell's shearwater [ʻaʻo], the density at the Upper Limahuli Preserve [average nearest neighbor distance 62.7 ft {19.1 m}] and for and Hawaiian petrel [ʻuaʻu] the density at North Bog [average nearest neighbor distance 45.6 ft {13.9 m}]).

[2] The multiple species criterion score only goes from 1 to 3 because there are only 3 covered seabird species.
[3] The perfect score is over 70 because a few criteria are doubled or tripled to weight (i.e., increase their significance) for conservation site selection.

Sites with a criterion score of 0 for covered species occupancy were only included as a conservation site in the KIUC HCP if they met Criterion 2 or Criterion 3. If one or both of these criteria are met, then these sites could be considered if social attraction was planned to be used as a management tool to create a new breeding colony within the conservation site.

Criterion 2. Presence of a covered species breeding colony adjacent to the conservation site

Criterion 2 is defined as nesting by one or more of the covered species adjacent to the conservation site (within 0.62 mile [mi] [1 kilometer {km}]). This criterion requires occurrence data (i.e., auditory surveys and/or burrow monitoring) to determine whether the adjacent habitat is occupied.

The criterion scores for presence of a breeding colony adjacent to the conservation site are as follows:

- 0—No colony present
- 1—Species recorded at least once during auditory surveys
- 2—Auditory surveys confirm areas of activity identified as hotspot light (i.e., '*localized aerial activity, sporadic calling*')
- 3—Auditory surveys confirm areas of activity identified as hotspot heavy ('*localized aerial activity, continuous calling*')
- 4—Auditory surveys confirmed ground calling
- 5—Confirmed nest site

Conservation sites with adjacent breeding colonies would be ranked higher than conservation sites with little to no adjacent covered species activity.

Criterion 3. Presence of covered species transiting over the site

Criterion 3 is defined as presence of one or more of the covered species transiting over the conservation site. Conservation sites that are on a known flyway would be ranked higher than conservation sites that are not. This criterion requires auditory surveys and song meters to determine if the covered species pass over the conservation site.

The criterion scores for covered species occupancy are as follows:

- 0—No seabirds transiting over the site
- 1—Occasional covered seabirds transiting over the site, but not nightly
- 2— Occasional covered seabirds transiting over the site, on a nightly basis
- 3—Small numbers (<30) of covered seabirds transiting over the site during peak movement hours on a nightly basis
- 4—Moderate (31–75) numbers of covered seabirds transiting over the site during peak movement hours on a nightly basis
- 5—High numbers (76+) of covered seabirds transiting over the site during peak movement hours on a nightly basis

Social attraction in the conservation sites that are located within the nocturnal flyway is more likely to successfully attract breeding adults than in conservation sites with little or no covered seabird activity.

Criterion 4. Presence of multiple covered species at the conservation site

Criterion 4 is defined as occupancy of a conservation site by multiple covered species. This criterion requires occurrence data (i.e., auditory surveys and/or burrow monitoring) to determine whether the site is occupied.

The criterion scores for covered species occupancy are as follows (because there are three covered seabird species the maximum score is 3).

- 1—One species present
- 2—Two species present
- 3—Three species present

Conservation sites with multiple covered species increase the cost-benefit of the conservation measures because the same conservation actions can affect multiple covered species. The criterion score is multiplied by a factor of two if multiple species are present to increase its weight. Conservation sites with multiple covered species are of higher value than conservation sites with only one covered species colony.

Habitat Quality

Criterion 5. Presence of Invasive Plant Species

Criterion 5 requires an assessment of the quality of the habitat for breeding seabirds within the conservation site. On Kauaʻi, Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) nest in wet montane forests with a high proportion of native trees (particularly ʻōhiʻa lehua [*Metrosideros polymorpha*] in the canopy and native plants in the understory (particularly false staghorn [uluhe; *Dicranopteris linearis*]) (Raine et al. 2021). Newell's shearwater (ʻaʻo) are also found in the sheer cliffs of the Nā Pali Coast (where band-rumped storm-petrel [ʻakēʻakē]) are also found).

This criterion should, however, be considered with the following proviso in mind: the requirement that plants are native species is less important than the structural composition of the vegetation and the topography of the conservation site. That can be seen in the presence of Newell's shearwater (ʻaʻo) in the coastal habitat present at Kīlauea Point National Wildlife Refuge, which is vastly different from other breeding colonies on the island. Habitat quality should primarily be considered in terms of the presence of invasive plant species that alter habitat structure to impede burrowing and nesting behavior (e.g., strawberry guava [*Psidium littoralei*], Australian tree fern [*Sphaeropteris cooperi*], Himalayan ginger [kāhili ginger] [*Hedychium gardnerianum*]) and the level of ongoing habitat management within the conservation site. Conservation sites with high levels of invasive plants are assigned a low score. If positive habitat modification can occur in the conservation site after the fence enclosure is created (i.e., the terrain is easy to work in), then this was reflected in the scoring system. Good-quality native habitat was assigned the highest possible score.

- 1—Predominantly nonnative invasive plant species with no invasive plant species management
- 2—Native plant species mixed with a higher proportion of nonnative invasive plant species and no invasive plant management

- 3—Native plant species mixed equally with nonnative invasive plant species and sporadic invasive plant species control
- 4—High-quality native habitat with a lower proportion of nonnative invasive species and moderate invasive plant species management
- 5—Predominantly native plant species with intensive invasive plant species management

Predators

Criterion 6. Terrestrial predators

Criterion 6 is defined as the abundance of terrestrial predators in the conservation site and the level of ongoing predator control. Various factors can be used to infer whether or not the conservation site is likely to have high or low densities of terrestrial predators, such as proximity to urban areas, presence of roads or trails leading to the breeding site, degree of human traffic in the area (i.e., more humans leads to more trash and direct feeding), and topography and natural barriers that prevent predator movement.

- 1—High density of terrestrial predators, no ongoing predator control
- 2—High density of terrestrial predators, sporadic predator control
- 3—Moderate density of terrestrial predators, ongoing predator control
- 4—Low density of terrestrial predators, ongoing intensive predator control
- 5—No terrestrial predators (only applicable to areas where eradication has already occurred [e.g., Lehua Islet, fenced social attraction sites])

The greater the abundance of terrestrial predators present within a conservation site, the more difficult it will be to reduce or eradicate them and limit future incursion. While terrestrial predators are found throughout Kaua‘i, they are particularly prevalent in lowland areas near urban centers. Conservation sites with a high abundance of terrestrial predators would be ranked lower than conservation sites where predators are present in lower densities.

Criterion 7. Aerial introduced predators (barn owls [*Tyto alba*])

Criterion 7 is defined as the abundance of barn owls within the conservation site and the level of ongoing barn owl control. Various factors can be used to infer whether or not the conservation site is likely to have high or low densities of barn owls present, including proximity to rural areas and open fields (barn owls occur at higher densities in open areas), topography, and type of habitat in the conservation site.

- 1—High levels of barn owl activity or data deficient, no active barn owl control
- 2—Moderate levels of barn owl activity, no active barn owl control
- 3—Moderate levels of barn owl activity, sporadic barn owl control
- 4—Moderate levels of barn owl activity, regular barn owl control
- 5—Low levels of barn owl activity, intensive barn owl control

Conservation sites where barn owls are present in large numbers (particularly in the lowlands and near agricultural areas) will present significant management challenges. Barn owl control requires year-round targeted control efforts by well-trained professionals. As such, conservation sites with a lower density of barn owls would score higher than conservation sites with a high density of barn owls. For conservation sites where barn owl density is unknown, this criterion will score 3, which assumes that there are likely to be some barn owls within the conservation site given that this species is distributed across Kaua‘i.

Existing Management

Criterion 8. Existing management activities

Criterion 8 is defined as the status of management activities within the conservation site, including infrastructure to support management activities. Scores for this criterion are multiplied by a factor of two because the presence of existing management actions and infrastructure greatly reduce startup costs and reduce the time to realize covered species benefits.

- 0—No existing management
- 1—Very little existing management and infrastructure
- 2—Existing management but limited infrastructure
- 3—Existing management and infrastructure but they are not seabird-directed
- 4—Existing seabird-directed management and infrastructure ongoing for short-time (1–2 years)
- 5—Existing seabird-directed management has been ongoing for many years (3+ years) and infrastructure is present and in good condition

Scores for this criterion consider land ownership (i.e., federal, state, private), which may have relevance for whether or not the conservation site is already managed (e.g., within the Department of Land and Natural Resources System or has a private landowner who is supportive seabird management on their land), the conservation status of the parcel (i.e., if the land is already within a Conservation District or within a protected area such as a Hono O Nā Pali Natural Area Reserve [NAR], State Wilderness Park, or National Park), infrastructure present (e.g., fences, helicopter landing sites, weatherports), and the scope of any existing management activities. This criterion must also evaluate whether the current management regime on the conservation site is compatible with the biological goals and objectives of the KIUC HCP and is sustainable for the life of the permit term (i.e., due to land ownership/status/zoning). Conservation sites with existing covered seabird-directed management activities that are compatible with the biological goals and objectives of the KIUC HCP would score higher than locations without existing management.

Site Practicability

Criterion 9. Predator control operations

Criterion 9 is defined as the factors that limit predator control operations, such as steepness and slope, geographic scale, habitat structure, and substrate that directly affect the practicability of implementing the conservation measures within a conservation site. Sites with steep valleys, dense vegetation, or sites that are very large will all require significantly more effort in terms of predator control and would thus be less practicable than smaller areas or areas with gently undulating terrain and sparser vegetation. In addition, conservation sites where the topography results in fences with open ends (e.g., waterfalls, sheer cliffs) would be ranked lower than sites where fencing can be constructed without open ends (Young 2020).

- 0—Physical site conditions prevent predator control operations
- 1—Low practicability of predator control operations
- 2—Low to moderate practicability of predator control operations
- 3—Moderate practicability of predator control operations
- 4—High practicability of predator control operations
- 5—High practicability of predator control operations and predator eradication practicable if coupled with a predator exclusion fence or if an islet

The predator control operations criterion is multiplied by a factor of two to increase its weight in the total score, given that the physical site conditions can severely affect the feasibility of implementing the conservation measures within a conservation site. If no conservation measures were practicable, this criterion received a score of 0.

Criterion 10. Practicability of terrestrial predator exclusion fence construction

Criterion 10 is defined as the practicability of constructing a terrestrial predator exclusion fence within the conservation site. The factors that determine the practicability of constructing terrestrial predator exclusion fencing is the same as described for predator control operations above (Criterion 9). Installation of terrestrial predator exclusion fencing is challenging because it requires infrastructure (e.g., horizontal mesh skirt) to exclude both small mammals and ungulates. While a site may be practicable to fence, the landowners may not agree to have a predator exclusion fence on their land.

- 0—Terrestrial predator exclusion fence construction is impracticable
- 1—Terrestrial predator exclusion fencing is very difficult to construct in any portion of the site
- 2—Terrestrial predator exclusion fencing construction is practicable over a small portion of the site
- 3—Terrestrial predator exclusion fencing construction is practicable over between a quarter and half of the site
- 4—Terrestrial predator exclusion fencing construction is practicable over majority of site
- 5—Entire site can easily be fenced

The practicability of terrestrial predator exclusion fence construction criterion is multiplied by a factor of two to increase its weight in the total score. However, in the 2023 effort to locate a suitable final site, this criterion was multiplied by three due to being a critical component of the last conservation site (see footnote in Table 4A-1 to see which sites this applies to). Terrestrial predator exclusion fencing will further increase the effectiveness of open management predator control.

Criterion 11. Practicability of ungulate fence construction

Criterion 11 is defined as the practicability of constructing an ungulate exclusion fence within the conservation site.

- 0—Ungulate fencing construction is impracticable
- 1—Ungulate fencing is very difficult to construct in any portion of the site
- 2—Ungulate fencing construction is practicable over a small portion of the site
- 3—Ungulate fencing construction is practicable over between a quarter and half of the site
- 4—Ungulate fencing construction is practicable over majority of site
- 5—Entire site can easily be fenced

The factors that determine the practicability of constructing ungulate fencing include habitat structure, geographic scale, substrate, and topography. Large conservation sites with steep valleys, dense vegetation, drainages, or crumbly substrate would be ranked lower than smaller conservation sites with gently undulating terrain, sparser vegetation, no drainages, and a sturdy substrate. While a site may be practicable to fence, the landowners may not agree to have an ungulate exclusion fence on their land.

Criterion 12. Accessibility

Criterion 12 is defined as the existing site infrastructure (e.g., roads, trails, helicopter landing sites) that determine site accessibility and safety. Transportation to and from the site is a critical consideration, both in terms of the initial setup as well as follow-up monitoring and control efforts once the conservation measure is in place. For example, site infrastructure was reviewed to determine whether a site could be accessed by trails and/or roads not blocked with fencing or gates, or by helicopter.

- 1—Limited accessibility
- 2—Accessible by helicopter or boat, but weather may limit helicopter or boat access at certain times of the year
- 3—Accessible year-round by helicopter
- 4—Accessible by road vehicles, but weather may limit road access at certain time of the year
- 5—Accessible year-round by road vehicles

Conservation sites that are difficult to access, or are not practicable for road vehicles and require special transportation (i.e., helicopters or boats), will result in higher operational costs and may present logistical difficulties (e.g., if access is weather dependent this may result in fewer visits due to flight cancellations). Consequently, remote sites that require helicopters or boats would rank lower than those which can be easily accessed by roads or dirt tracks. Sites that could not be accessed by trails or roads, or by specialized transportation (e.g., no nearby landing site is practicable), were eliminated from further consideration.

Landowner Approval

Criterion 13. Landowner approval

Criterion 13 is defined as the degree of landowner willingness to allow implementation of the conservation measures on their land. For a site to be selected, landowner approval is necessary to implement the conservation measures as planned. The factors to consider under this criterion include: (1) who is the landowner, (2) are there multiple landowners, (3) are there socio-political factors that increase or decrease landowner willingness, and (4) is there political or social opposition to implementation of the conservation measures on the conservation site and if so, is appropriate outreach being conducted?

- 0—Access denied by landowner
- 1—Low likelihood of landowner approval
- 2—Moderate likelihood of landowner approval
- 3—Initial conversations with landowner have occurred but interest is not known
- 4—Landowner has expressed interest
- 5—Agreement with landowner in place or high likelihood of receiving landowner approval

It is necessary to secure agreements with landowners, whether state or private, for access to a conservation site for at least 50 years so that conservation measures could be implemented for at least the duration of the HCP permit term. Generally, landowner approval is accomplished through coordination and negotiation directly with the landowner. If the landowner is not willing, the conservation site would receive a score of 0 under this criterion.

Anthropogenic Threats

Criterion 14. Anthropogenic threats

Criterion 14 is defined as the presence of powerlines and lights on or adjacent to the site, or on the flyway for which birds would access the site. This criterion also considers if there are: (1) foreseeable development projects in the area (e.g., new housing developments) or (2) impending minimization actions (e.g., the removal of powerlines, use of diverters to reduce strikes, removal or dimming of known problem lights). The site selection process evaluates whether existing and future KIUC infrastructure and surrounding urbanization pose a threat to the covered seabird colony based on the location of the infrastructure and urban development in relation to the colony. This criterion was necessary to avoid compromising the conservation benefits generated by the HCP, especially as the seabird colonies increase in size with implementation of the conservation measures.

- 1—High levels of anthropogenic threats that are unlikely to be minimized
- 2—High level of anthropogenic threats, some of which can be minimized if sufficient funding is available
- 3—Moderate level of anthropogenic threats, some of which can be minimized if sufficient funding is available

- 4—Low level of anthropogenic threats or moderate/high level of anthropogenic threats, most of which can be minimized
- 5—Minimal anthropogenic threats

In the 2023 effort to locate a suitable final conservation site, this criterion was multiplied by two because it was of high importance for the last conservation site (see footnote in Table 4A-1 to see which sites this applies to).

4A.2.2 Site Selection Scores

A total of 32 sites were evaluated against the 14 criteria listed above. Each criterion was scored separately for Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu), as shown in Tables 4A-1 and 4A-2, respectively. Site selection scores are not included in this appendix for band-rumped storm-petrel (ʻakēʻakē) because at present the known impacts on this species are so low they are assumed to be mitigated by the conservation measures for the other two covered seabirds.

Table 4A-1. Conservation Site Selection Scores for Newell's Shearwater (ʻaʻo), Listed by Total Score (Highest to Lowest)

Site Selection Criterion	Criterion 1. Presence of a covered seabird breeding colony	Criterion 2. Presence of a covered seabird breeding colony adjacent to the conservation site	Criterion 3. Presence of a covered species transiting over the site	Criterion 4. Presence of multiple covered species at the conservation site	Criterion 5. Presence of invasive plant species	Criterion 6. Terrestrial predators	Criterion 7. Barn owls	Criterion 8. Existing management activities	Criterion 9. Predator control operations	Criterion 10. Practicability of terrestrial predator exclusion fence construction	Criterion 11. Practicability of ungulate fence construction	Criterion 12. Accessibility	Criterion 13. Landowner approval	Criterion 14. Anthropogenic threats	Total
Maximum Score	**10**	**5**	**5**	**6**	**5**	**5**	**5**	**10**	**10**	**10**	**10**	**5**	**5**	**5**	**96**
Pōhākea	10	5	5	4	4	4	4	10	8	10	10	3	5	5	87
Upper Limahuli Valley	10	5	5	4	5	4	3	10	8	10	10	3	5	5	87
Honopū—upper valley	10	5	5	4	3	3	3	8	8	10	10	4	3	5	81
Hanakoa	10	5	5	4	3	4	4	10	8	6	10	2	5	5	81
Hanakāpiʻai	10	5	5	4	3	4	4	10	8	6	10	2	5	5	81
North Bog	10	5	4	4	4	4	4	10	8	6	10	2	5	5	81
Upper Mānoa Valley	10	5	5	4	3	3	4	10	8	10	10	3	0	5	80
ʻAlēalau[a]	10	5	5	6	3	3	2	2	10	15	5	3	3	8	80
Pihea	4	5	4	4	4	4	4	10	8	2	10	5	5	5	74
Nuʻalolo Kai	8	5	5	4	3	3	2	8	8	6	8	3	4	5	72
Honopū—lower valley	8	5	5	4	2	3	2	8	8	8	8	3	3	5	72
Nuʻalolo Aina	8	5	5	4	2	3	3	8	8	6	8	3	3	5	71
Lumahaʻi Valley	8	5	5	4	3	1	1	6	8	8	10	3	4	4	70
"Connector"[a]	10	5	5	4	4	3	2	2	6	9	4	1	3	8	66
Hanalei Valley	8	5	5	4	3	1	1	3	8	6	10	4	4	3	65

Site Selection Criterion	Criterion 1. Presence of a covered seabird breeding colony	Criterion 2. Presence of a covered seabird breeding colony adjacent to the conservation site	Criterion 3. Presence of a covered species transiting over the site	Criterion 4. Presence of multiple covered species at the conservation site	Criterion 5. Presence of invasive plant species	Criterion 6. Terrestrial predators	Criterion 7. Barn owls	Criterion 8. Existing management activities	Criterion 9. Predator control operations	Criterion 10. Practicability of terrestrial predator exclusion fence construction	Criterion 11. Practicability of ungulate fence construction	Criterion 12. Accessibility	Criterion 13. Landowner approval	Criterion 14. Anthropogenic threats	Total
Waiʻahuʻakua[a]	8	5	5	4	2	2	3	10	6	0	4	4	3	8	64
Waimea Canyon	8	4	5	4	3	1	1	2	8	8	8	5	3	3	63
Awaʻawapuhi	8	5	5	4	2	2	2	6	8	2	8	3	3	5	63
Waiʻoli	8	5	5	2	2	1	1	10	8	4	8	3	2	3	62
HNP New	6	3	3	4	4	2	2	2	8	6	10	2	4	5	61
Nāmolokama	8	5	5	2	3	2	2	4	8	2	10	1	4	4	60
Lāʻau	8	4	5	4	3	1	2	4	8	2	10	1	3	4	59
Kalalau Valley	8	5	5	4	4	2	1	4	6	4	8	2	1	5	59
Lehua Islet	0	0	2	2	2	5	3	4	10	10	10	2	4	5	59
Moaʻalele[a]	8	5	3	4	4	3	2	2	8	0	3	3	3	10	58
Miloliʻi	4	2	3	4	2	2	1	2	8	2	6	3	2	5	46
Kāhili	10	3	4	4	2	1	1	4	8	2	4	5	1	1	50
Waipā	0	5	5	2	2	1	1	2	8	4	8	3	2	3	46
Wainiha Valley	4	5	4	3	3	2	2	2	2	3	5	4	0	3	42
Hāʻupu	4	2	3	4	3	1	1	2	8	4	4	3	1	1	41
Koluahonu	2	3	3	2	1	1	1	2	6	6	6	4	1	1	39
Sleeping Giant	4	2	3	2	1	1	1	2	6	2	6	5	1	1	37

[a] These sites were a part of a later ranking effort and have different maximum scores for Criterion 10 and 14 (Raine et al. 2023).

Table 4A-2. Conservation Site Selection Scores for Hawaiian Petrel (ʻuaʻu), Listed by Total Score (Highest to Lowest)

Site Selection Criterion	Criterion 1. Presence of a covered seabird breeding colony	Criterion 2. Presence of a covered seabird breeding colony adjacent to the conservation site	Criterion 3. Presence of a covered species transiting over the site	Criterion 4. Presence of multiple covered species at the conservation site	Criterion 5. Presence of invasive plant species	Criterion 6. Terrestrial predators	Criterion 7. Barn owls	Criterion 8. Existing management activities	Criterion 9. Predator control operations	Criterion 10. Practicability of terrestrial predator exclusion fence construction	Criterion 11. Practicability of ungulate fence construction	Criterion 12. Accessibility	Criterion 13. Landowner approval	Criterion 14. Anthropo-genic threats	Total
Maximum Score	**10**	**5**	**5**	**6**	**5**	**5**	**5**	**10**	**10**	**10**	**10**	**5**	**5**	**5**	**96**
Pōhākea	10	5	5	4	4	4	4	10	8	10	10	3	5	5	87
Upper Limahuli Preserve	10	5	5	4	5	4	3	10	8	10	10	3	5	5	87
North Bog	10	5	5	4	4	4	4	10	8	6	10	2	5	5	82
Pihea	10	5	5	4	4	4	4	10	8	2	10	5	5	5	81
Hanakoa	10	5	5	4	3	4	4	10	8	6	10	2	5	5	81
Hanakāpiʻai	10	5	5	4	3	4	4	10	8	6	10	2	5	5	81
Upper Mānoa Valley	0	5	5	4	3	3	4	10	8	10	10	3	0	5	70
Lumahaʻi Valley	8	4	5	4	3	1	1	6	8	8	10	3	4	4	69
Hanalei Valley	8	4	5	4	3	1	1	4	8	6	10	4	4	3	65
Lehua Islet	0	0	1	2	1	5	3	10	10	10	10	2	5	5	64
HNP New	6	3	3	4	4	2	2	4	8	6	10	2	4	5	63
Honopū—upper valley	0	0	1	4	3	3	3	8	8	10	8	4	3	5	60
Lāʻau	8	4	5	4	3	1	2	2	8	2	10	1	3	4	57
Nuʻalolo Kai	0	0	1	4	4	3	1	8	8	6	8	3	4	5	55
Honopū—lower valley	0	0	1	4	2	3	2	8	8	8	8	3	3	5	55

Site Selection Criterion	Criterion 1. Presence of a covered seabird breeding colony	Criterion 2. Presence of a covered seabird breeding colony adjacent to the conservation site	Criterion 3. Presence of a covered species transiting over the site	Criterion 4. Presence of multiple covered species at the conservation site	Criterion 5. Presence of invasive plant species	Criterion 6. Terrestrial predators	Criterion 7. Barn owls	Criterion 8. Existing management activities	Criterion 9. Predator control operations	Criterion 10. Practicability of terrestrial predator exclusion fence construction	Criterion 11. Practicability of ungulate fence construction	Criterion 12. Accessibility	Criterion 13. Landowner approval	Criterion 14. Anthropo-genic threats	Total
Waipā	8	5	5	2	2	1	1	2	8	4	8	3	2	3	54
Nuʻalolo Aina	0	0	1	4	2	3	3	6	8	6	8	3	3	3	50
Nāmolokama	0	4	5	2	3	2	2	2	8	2	10	1	4	4	49
Kalalau Valley	0	5	5	4	4	2	1	2	6	4	8	2	1	5	49
Waimea Canyon	0	0	2	4	3	1	1	4	8	8	8	5	2	3	49
Waiʻoli	0	4	5	2	2	1	1	2	8	4	8	3	2	3	45
Awaʻawapuhi	0	0	1	4	2	2	2	4	8	2	8	3	3	5	44
Miloliʻi	0	0	1	4	2	2	1	4	8	2	6	3	2	5	40
Kāhili	4	2	3	4	2	1	1	2	8	2	4	5	1	1	40
Hāʻupu	0	0	2	4	3	1	1	2	8	4	4	3	1	1	34
Koluahonu	0	1	2	2	1	1	1	2	6	6	6	4	1	1	34
Sleeping Giant	0	0	2	2	1	1	1	2	6	2	6	5	1	1	30

4A.3 KIUC HCP Conservation Site Descriptions

A total of 12 conservation sites with the highest site selection scores have been selected for the KIUC HCP. All of the selected conservation sites are located within the "no light conservation area" identified by the USFWS on the north shore of Kaua'i. The majority of the conservation sites that were selected for the KIUC HCP are the same sites where KIUC has been funding predator control and seabird monitoring (and invasive plant species control at two sites) annually since 2011 for the Short-Term HCP and in the interim period between the Short-Term HCP and commencement of this KIUC HCP. This provided KIUC, USFWS, and DOFAW with a large amount of data that was used to determine if management at these sites would continue to benefit the covered seabird species during HCP implementation. Because management had been occurring at these sites for such a long time, it also led to the decision to include these sites as conservation sites for the KIUC HCP rather than replace them with new sites. Other significant factors for selection of the conservation sites in the KIUC HCP included site adjacency and presence of existing fences. The location of all selected conservation sites is shown in Figure 4A-3. Table 4-8 in Chapter 4, *Conservation Strategy*, identifies the total size of each selected conservation site. Table 4-9 summarizes the history of management actions at each of the conservation sites. Table 4-10 describes the estimated number of Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) breeding pairs at each site, and Table 4-11 identifies the management action that will be implemented in each conservation site.

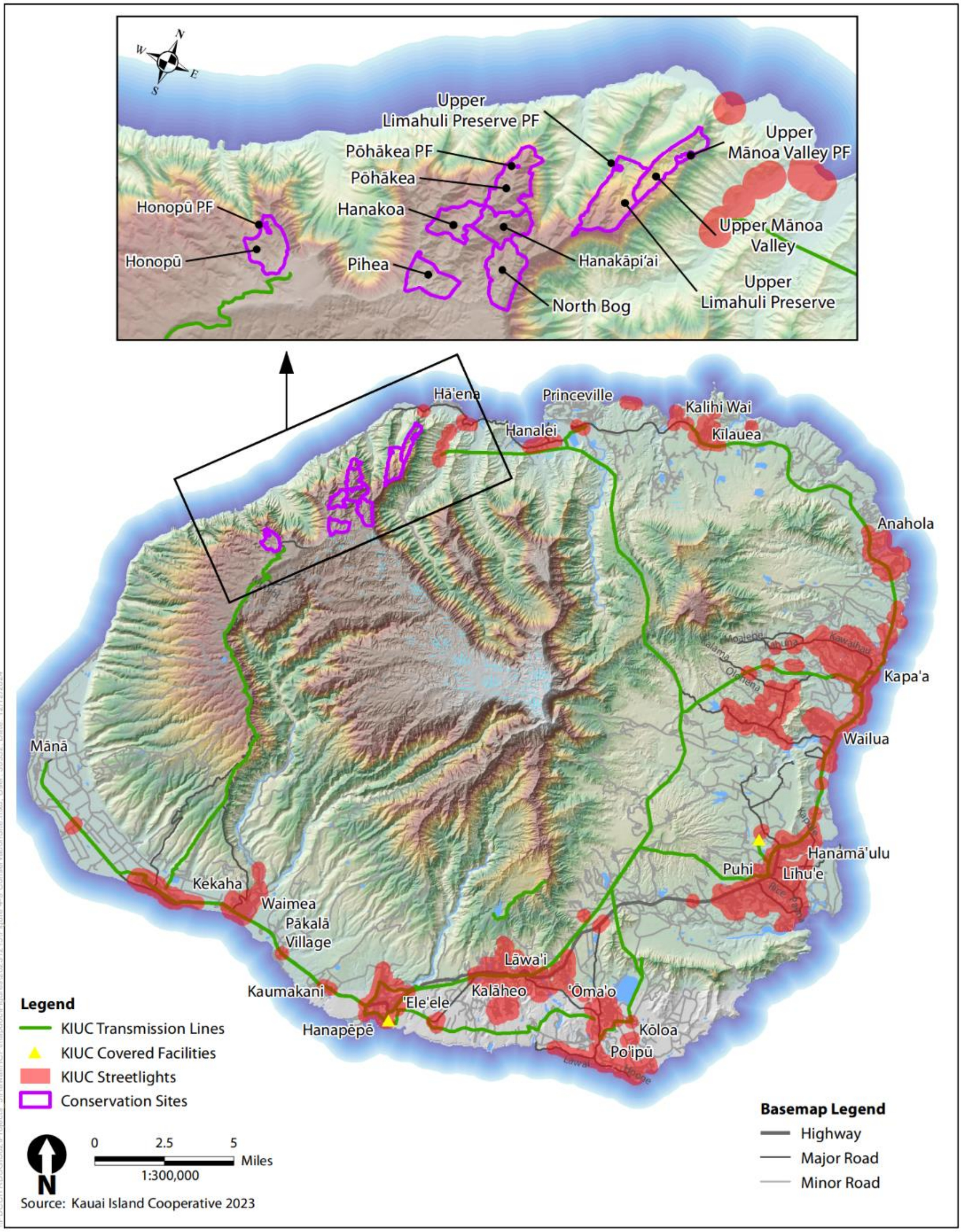

Figure 4A-3. Locations of HCP Conservation Sites Relative to KIUC Covered Activities

4A.3.1 Upper Limahuli Preserve

The Upper Limahuli Preserve (Preserve) is a 374-acre (ac) (151-hectare [ht]) conservation site ranging in elevation between 1,600 and 3,200 ft (488 and 975 m). The Preserve is owned and managed in perpetuity as a conservation area by the National Tropical Botanical Garden, who have agreed to include the Preserve as a conservation site in the HCP. The Preserve contains numerous steep ridgelines and cliffs that can only be accessed by helicopter.

Based on currently available data, 167 Newell's shearwater (ʻaʻo), 49 Hawaiian petrel (ʻuaʻu), and 38 unidentified burrows have been located at the Preserve (Raine et al. 2022) and the population estimate for the species within the site is between 498 and 617 Newell's shearwater (ʻaʻo) breeding pairs and between 112 and 135 Hawaiian petrel (ʻuaʻu) breeding pairs (Raine 2022). Table 4-10 in Chapter 4, *Conservation Strategy*, identifies the total size of each selected conservation site and the estimated number of breeding pairs for each species. Tracking of nesting adults indicates that most birds arrive and depart from the colony over the closely adjacent ocean, with only a few tracks showing birds flying high over existing powerlines (Raine et al. 2017). In 2009, work was completed on an ungulate exclusion fence that now protects the entire Preserve from ungulates. Other infrastructure includes several helicopter landing zones, two weatherports to support personnel and operations, and an extensive network of trails.

KIUC has funded predator control and monitoring efforts at this location since 2011, with predator control operations increasing in scope and personnel in recent years. Ongoing management activities at this site include invasive plant removal, maintenance of ungulate fencing, monitoring to keep the site ungulate-free, predator control (rats, cats, pigs, and barn owl), acoustic assessment of seabird activity, auditory surveys, and estimation of annual seabird reproductive success through nest monitoring.

The Preserve was included as a conservation site because it had a willing landowner and significant populations of both covered seabirds (particularly Newell's shearwater [ʻaʻo]). The large size of the site also suggests that the populations of both species can be expanded into new portions of the Preserve using social attraction techniques. The conservation site was also selected because of the substantial existing infrastructure, including the extensive ungulate exclusion fence that has been maintained successfully since 2009.

4A.3.2 Upper Limahuli Preserve PF

Upper Limahuli Preserve PF (which stands for predator exclusion fence) is an approximately 4.4 ac [1.8 ht] social attraction site located in the northern part of the greater Upper Limahuli Preserve conservation site (Figure 4A-3), described in Section 4A.3.1, *Upper Limahuli Preserve*. Upper Limahuli PF was chosen because the topography is well disposed for fence construction, the fact that there will be little disturbance to sensitive plan communities, and having only a few existing burrows means that there is room for growth when attracting new birds into the area. The predator exclusion fence around this site will be constructed in 2025, after which predators will be eradicated within the fenced area, any invasive plants will be removed, artificial burrows will be installed, and a sound system will be deployed inside the fenced area. Social attraction at this conservation site is expected to commence in 2027.

4A.3.3 Upper Mānoa Valley

The Upper Mānoa Valley conservation site is 228 ac (92 ht) and spans the width of the valley between about 1,000 and 2,600 ft (304.8 and 792.5 m) in elevation and shares its southwestern and southern borders with the Upper Limahuli Preserve. The private landowner has agreed to its inclusion as a conservation site in the HCP. Upper Mānoa Valley is a remote, undeveloped valley that is accessible only by foot or helicopter. Site access for fence construction, conservation, and monitoring activities is by helicopter.

Based on currently available data, nine Newell's shearwater (ʻaʻo) burrows and four unknown procellariids burrows have been located (Raine et al. 2020). The population estimate is between 199 and 283 Newell's shearwater (ʻaʻo) breeding pairs (Table 4-10). While Hawaiian petrel (ʻuaʻu) breeding has not been confirmed within Upper Mānoa Valley, large numbers of this species pass overhead on their way to the Upper Limahuli Preserve and Wainiha Valley (Raine et al. 2019). The species distribution model does not identify the Upper Mānoa Valley conservation site as currently occupied by Hawaiian petrels (ʻuaʻu); however, the site was identified as having suitable habitat for Hawaiian petrels (ʻuaʻu). Social attraction at the Upper Mānoa Valley PF for Newell's shearwater (ʻaʻo) may also attract Hawaiian petrels (ʻuaʻu).

KIUC funded predator control and monitoring efforts at this location from 2015 to 2022 when management was discontinued. Predator control and monitoring efforts at this location resumed in 2024. Upper Mānoa Valley is low in elevation, making it particularly vulnerable to cat incursion. This site also had the highest rat visitation rates at camera monitored burrows of all conservation sites in 2018 and second-highest in 2019. Current seabird conservation activities at Upper Mānoa Valley include nest site monitoring, predator control (rats, cats, pigs, and barn owl), invasive plant removal as needed, acoustic assessment of seabird activity, and estimation of annual seabird reproductive success. Artificial burrows were installed at the site in 2019 and outplantings of native species around the burrows were initiated in 2021. The southern boundary of the Upper Mānoa Valley site (uppermost in elevation) has a pig exclusion fence along the shared boundary with the Upper Limahuli Preserve.

4A.3.4 Upper Mānoa Valley PF

The Upper Mānoa Valley PF is an approximately 13.5 ac [5.5 ht] social attraction site located in the northeast portion of the Upper Mānoa Valley conservation site, described above. Upper Mānoa Valley PF was chosen due to its proximity to a major flyway for Newell's shearwater (ʻaʻo) making it a valuable location for social attraction. There are also several known Newell's shearwater (ʻaʻo) burrows adjacent to the PF site and within the rest of the Upper Mānoa Valley site which could be sources for social attraction. In addition, the site is at a relatively low elevation (1,800 to 2,000 ft [549 to 610 m]), making it vulnerable to cat incursion and thus likely to be substantially benefit from a predator exclusion fence. The predator exclusion fence around this site will be completed by the end of 2027, after which terrestrial predators will be eradicated within the fenced area and any invasive plants will be removed. Following construction of the predator exclusion fence, a sound system and additional artificial burrows will be installed within the social attraction site to broadcast calls during peak breeding season.

4A.3.5 North Bog

North Bog is part of the Hono O Nā Pali NAR, managed by DOFAW. DOFAW has approved inclusion of North Bog as a conservation site in the HCP. The North Bog conservation site, encompassing 257 ac (104 ht), is a site where seabird management has been ongoing. Site access for fence construction, predator control, and monitoring activities is by helicopter only, although in emergencies there is a trail to hike out. Given the site's remote location on the edge of Wainiha Valley, powerline collisions and light attraction are a lower risk to breeding birds. Site infrastructure consists of a helicopter landing zone, a weatherport to support personnel and operations, and an approximately 2-ac (0.8-ht) ungulate exclusion fence installed to protect rare native plants. A new ungulate exclusion fence was constructed by DOFAW in 2014 to protect the Hono O Nā Pali NAR. This fence extends from the Pihea lookout to the Kilohana lookout, preventing ingress by pigs from the Alakaʻi Swamp. A second ungulate exclusion fence was constructed in 2017 extending northward from the Pihea lookout, preventing ingress by pigs from the Kalalau Valley and further wing fences have been built on the Nā Pali Coast for the same reason.

Based on currently available data, a total of 2 Newell's shearwater (ʻaʻo), 235 Hawaiian petrel (ʻuaʻu), and 39 unidentified burrows have been located (Raine et al. 2022). The population estimate for the two species within the site is between 66 and 80 Newell's shearwater (ʻaʻo) breeding pairs and between 880 and 1,261 Hawaiian petrel (ʻuaʻu) breeding pairs (Raine 2022). Table 4-10 in Chapter 4, *Conservation Strategy*, identifies the total size of each selected conservation site and the estimated number of breeding pairs for each species.

Current seabird management actions include nest site monitoring, invasive plant removal, predator control (rats, cats, pigs, and barn owl), acoustic assessment of seabird activity, and estimation of annual seabird reproductive success. KIUC has funded predator control and monitoring efforts at this location since 2012 when the site was established. KIUC will also perform invasive plant control as needed.

4A.3.6 Pōhākea

Pōhākea is part of the Hono O Nā Pali NAR, managed by DOFAW. DOFAW has approved inclusion of Pōhākea as a conservation site in the HCP. Located in the northeastern corner of the Hono O Nā Pali NAR, Pōhākea is a 292-ac (118-ht) site bordered to the east by the Hanakāpiʻai drainage and to the south by the Hanakāpiʻai conservation site (Figure 4A-3). The Pōhākea site is on the Nā Pali Coast and as such is at low risk from existing powerlines and coastal lights. Site access for predator control and monitoring activities is by helicopter only.

Pōhākea is considered an important conservation site for seabirds. Based on currently available data, a total of 58 Newell's shearwater (ʻaʻo), 67 Hawaiian petrel (ʻuaʻu), and 33 unidentified burrows have been located (Raine et al. 2022). The population estimate for the two species within the site is between 290 and 464 Newell's shearwater (ʻaʻo) breeding pairs and between 161 and 611 Hawaiian petrel (ʻuaʻu) breeding pairs (Raine 2022). Table 4-10 in Chapter 4, *Conservation Strategy*, identifies the total size of each selected conservation site and the estimated number of breeding pairs for each species. Current seabird conservation activities include nest monitoring, predator control (rats, cats, pigs, and barn owls), invasive plant removal, acoustic assessment of seabird activity, and estimation of annual seabird reproductive success. All of the Pōhākea conservation site supports potential habitat for one or both of the covered seabirds (Troy et al. 2014, 2017). Construction of ungulate fencing associated with this conservation area has already been completed by the state Hono O Nā Pali NAR program. KIUC has funded predator control and monitoring efforts at this location since 2012 when the site was established. KIUC will also perform invasive plant control as needed.

4A.3.7 Pōhākea PF

Pōhākea PF is a small 0.4-ac (0.16-ht) area located within the northern portion of the larger Pōhākea conservation site, described in Section 4A.3.6, *Pōhākea*. A 0.4-ac (0.16-ht) predator exclusion fence was created by DOFAW and DOFAW partners around the site in 2021, and 50 artificial burrows and a sound system were deployed inside the fence area in early 2022 (prior to the start of the breeding season) to attract Newell’s shearwater (‘a‘o) to the fully protected area. The site was chosen for several reasons—(i) close proximity to a large breeding cluster of Newell’s shearwater (‘a‘o), (ii) located on a flyway for Newell’s shearwater (‘a‘o) transiting overhead to colonies in the back of Wainiha Valley, (iii) a steep bowl topography to allow nesting shearwaters to take off from without colliding with the fence and (iv) a high proportion of invasive vegetation (especially Himalayan ginger [kāhili ginger]), meaning that burrows could be dug into the site without disturbing significant amounts of native vegetation and no rare plant species. KIUC took control of the predator exclusion fenced area in 2022 and will maintain and manage it as a conservation site in accordance with this HCP.

4A.3.8 Honopū

The Honopū conservation site is part of the Nā Pali Coast State Wilderness Park managed by the Division of State Parks, Kōke‘e State Park managed by the Division of State Parks, and Nā Pali Kona Forest Reserve, managed by DOFAW. The site was established by the U.S. Navy Pacific Missile Range Facility. Development of this site involves a large ungulate fence and the establishment of predator control within the fenced area. It can be accessed via several trails from the main Koke‘e Road and has a scattered trail system and two helicopter landing zones. No weatherports or other infrastructure are currently present. Site access for fence maintenance, predator control, and covered species monitoring is predominantly on foot. The conservation site is located along the edge of the Kalalau Valley and the risk from powerlines and coastal lights is minimal.[4]

A 2.7-mi (4.4-km) ungulate fence was constructed by the State of Hawai‘i and partners in 2013 which tied off at the steep, impassable cliffs of Honopū Valley, resulting in a conservation site of 235 ac (95 ht). Within the Honopū conservation site a total of four Newell’s shearwater (‘a‘o) burrows have been located (Raine in litt.), two of which were active in 2020. While the conservation site contains suitable breeding habitat for Newell’s shearwater (‘a‘o), decades of predation from cats, rats, pigs, and barn owl have restricted the breeding population predominantly to the inaccessible Nā Pali cliffs. Therefore, while the current breeding population of Newell’s shearwater (‘a‘o) within the ungulate fenced area is 90 to 92 breeding pairs, the potential population estimate for the site is 396 to 487 pairs. Hawaiian petrels (‘ua‘u) are not known to breed in this area, although small numbers transit over. Band-rumped storm-petrels (‘akē‘akē) breed in good numbers on the cliffs adjacent to the conservation site, and this species is also often seen flying over the area. Table 4-10

[4] The site sits below the Kōke‘e Air Force Station, where a large fallout event of Newell’s shearwater (‘a‘o) and Hawaiian petrel (‘ua‘u) occurred in 2015. The Air Force Station has since changed its lights and—as long as this lighting protocol is maintained—presents minimal fallout risk to birds breeding in this area.

in Chapter 4, *Conservation Strategy*, identifies the total size of each selected conservation site and the estimated number of breeding pairs for each species.

4A.3.9 Honopū PF

The Honopū PF is a smaller 3.3-ac (1.3-ht) area located within the northern portion of the larger Honopū conservation site, described in Section 4A.3.8, *Honopū*. The Honopū PF is located entirely within the Nā Pali Kona Forest Reserve, managed by DOFAW. A 3.3-ac (1.3-ht) predator exclusion fence and social attraction site (i.e., Honopū PF) was constructed by the State and partners in 2021 inside the ungulate fence area, covering the northern edge of the conservation site overlooking the cliffs of Honopū Valley. In April 2021, 35 artificial burrows were installed in one section of the site for band-rumped storm-petrel (ʻakēʻakē) and 29 artificial burrows for both Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) in another section. The proximity of this conservation site to large breeding colonies of both Newell's shearwater (ʻaʻo) and band-rumped storm-petrel (ʻakēʻakē) in the cliffs of Honopū Valley make this an ideal social attraction site for these two species. KIUC began funding and implementing predator and invasive plant control and seabird monitoring at Honopū and Honopū PF in 2022. KIUC will also perform invasive plant control as needed.

4A.3.10 Pihea

Pihea is a 193-ac (78-ht) site that is part of the Nā Pali Coast State Wilderness Park managed by the Division of State Parks. State Parks has approved inclusion of this conservation site in the HCP. The Pihea conservation site can be accessed from the Pihea trail from Puʻu O Kila lookout, a scattered trail system, and there are two helicopter landing zones. No weatherports or other infrastructure are currently present. Several sections of strategic ungulate fence spanning 1.2 mi (1.9 km) have been installed by the Hono O Nā Pali NAR since 2014, resulting in regional conservation benefits that extend to the Pihea conservation site. The site is located along the edge of the Kalalau Valley and the risk from powerlines and coastal lights is minimal.[5] Site access for fence construction, maintenance, and predator control and monitoring is predominantly by helicopter. KIUC began funding and implementing predator control and seabird monitoring at Pihea in 2012. KIUC will also perform invasive plant control as needed.

Based on currently available data, a total of 144 Hawaiian petrel (ʻuaʻu) burrows and 27 unidentified burrows have been located (Raine et al. 2022) and the population estimate for this species within the site is between 645 and 815 Hawaiian petrel (ʻuaʻu) breeding pairs (Raine 2022). The lack of a robust Newell's shearwater (ʻaʻo) population at Pihea is likely because most Newell's shearwaters (ʻaʻo) nest along the edge of Kalalau Valley, which cannot be accessed safely for monitoring because of the steepness of the terrain. Table 4-10 in Chapter 4, *Conservation Strategy*, identifies the total size of each selected conservation site and the estimated number of breeding pairs for each species.

4A.3.11 Hanakoa

Hanakoa is part of the Hono O Nā Pali NAR managed by DOFAW. DOFAW has approved inclusion of Hanakoa as a conservation site in the HCP. The Hanakoa conservation site encompasses 179 ac (72

[5] The Pihea site points towards the Kōkeʻe Air Force Station, where a large fallout event of Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) occurred in 2015 due to night lighting. The Air Force Station has since changed its lights. the Air Force Station now presents minimal fallout risk to birds breeding in this area.

ht) within the Hono O Nā Pali NAR and is situated immediately adjacent and to the west of the Pōhākea and Hanakāpiʻai conservation areas (Figure 4A-3). The Hanakoa conservation site is in the interior mountainous region and thus at limited risk from existing powerlines and coastal lights. Site access for predator control and monitoring activities is by helicopter only.

Hanakoa is considered an important conservation site for seabirds. To date a total of 2 Newell's shearwater (ʻaʻo), 176 Hawaiian petrel (ʻuaʻu), and 36 unidentified burrows have been located (Raine et al. 2022). The population estimate for the two species within this site is between 45 and 74 Newell's shearwater (ʻaʻo) breeding pairs and between 171 and 455 Hawaiian petrel (ʻuaʻu) breeding pairs (Raine 2022). Table 4-10 in Chapter 4, *Conservation Strategy*, identifies the total size of each selected conservation site and the estimated number of breeding pairs for each species.

Construction of ungulate fences around the NAR borders was completed by the Hono O Nā Pali NAR program. These fences benefit the entire Hono O Nā Pali NAR area, including the Hanakoa conservation site. Funding for predator control efforts, between 2016 and 2019, was secured through the National Fish and Wildlife Foundation (via American Bird Conservancy) by D. E. Shaw Renewable Investments, LLC in partial fulfillment of Hawaiian petrel (ʻuaʻu) mitigation obligations under the HCP for Kawailoa Wind. KIUC began funding predator control and seabird monitoring at Hanakoa in 2021. KIUC will also perform invasive plant control as needed.

4A.3.12 Hanakāpiʻai

Hanakāpiʻai is part of the Hono O Nā Pali NAR managed by DOFAW. DOFAW approved inclusion of Hanakāpiʻai as a conservation site in the HCP. Bordered by North Bog to the east, Pōhākea to the west, and Hanakoa to the south (Figure 4A-3), Hanakāpiʻai is considered an important conservation site for seabirds, especially Hawaiian petrel (ʻuaʻu). The conservation site contains numerous steep ridgelines and cliffs that can only be accessed by helicopter. The Hanakāpiʻai site has three landing zones for helicopters and a scattered trail system. The conservation site is in the interior of the Hono O Nā Pali NAR and thus at limited risk from artificial lights and powerlines.

The Hanakāpiʻai conservation site encompasses 201 ac (81 ht) of potential habitat. To date a total of 19 Newell's shearwater (ʻaʻo), 316 Hawaiian petrel (ʻuaʻu), and 65 unidentified burrows have been located (Raine et al. 2022). The population estimate for the two species within this site is between 76 and 85 Newell's shearwater (ʻaʻo) breeding pairs and between 289 and 398 Hawaiian petrel (ʻuaʻu) breeding pairs (Raine 2022). Table 4-10 in Chapter 4, *Conservation Strategy*, identifies the total size of each selected conservation site and the estimated number of breeding pairs for each species.

Construction of ungulate fences around the NAR borders was completed by the Hono O Nā Pali NAR program. These fences benefit the entire Hono O Nā Pali NAR area, including the Hanakāpiʻai conservation site. Funding for predator control efforts was initially undertaken through funding from the National Fish and Wildlife Foundation (via American Bird Conservancy) between 2016 and 2019 and via D. E. Shaw Renewable Investments, LLC in partial fulfillment of Hawaiian petrel (ʻuaʻu) mitigation obligations under the Kawailoa Wind HCP on Oahu, which was amended in 2019. KIUC began funding and implementing predator control and seabird monitoring at Hanakāpiʻai in 2021. KIUC will also perform invasive plant control as needed.

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4A.4.2 Personal Communication

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Appendix 4B

KIUC Minimization Projects

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1	0.05	Mana sub to WKEP	57kV removal	06-2023	4.17	0.00	100%
2	0.07	Mana sub to WKEP	57kV removal	06-2023	5.20	0.00	100%
3	0.08	Mana sub to WKEP	57kV removal	06-2023	5.57	0.00	100%
4	0.08	Mana sub to WKEP	57kV removal	06-2023	6.22	0.00	100%
5	0.08	Mana sub to WKEP	57kV removal	06-2023	5.85	0.00	100%
6	0.08	Mana sub to WKEP	57kV removal	06-2023	3.84	0.00	100%
7	0.08	Mana sub to WKEP	57kV removal	06-2023	3.79	0.00	100%
8	0.05	Mana sub to WKEP	57kV removal	06-2023	0.46	0.00	100%
9	0.05	Mana sub to WKEP	57kV removal	06-2023	0.45	0.00	100%
10	0.05	Mana sub to WKEP	57kV removal	06-2023	2.25	0.00	100%
11	0.05	Mana sub to WKEP	57kV removal	06-2023	7.22	0.00	100%
12	0.05	Mana sub to WKEP	57kV removal	06-2023	5.45	0.00	100%
13	0.04	Mana sub to WKEP	57kV removal	06-2023	2.91	0.00	100%
14	0.05	Mana sub to WKEP	57kV removal	06-2023	3.41	0.00	100%
15	0.05	Mana sub to WKEP	57kV removal	06-2023	2.90	0.00	100%
16	0.05	Mana sub to WKEP	57kV removal	06-2023	2.69	0.00	100%
17	0.07	Mana sub to WKEP	57kV removal	06-2023	3.36	0.00	100%
18	0.05	Mana sub to WKEP	57kV removal	06-2023	2.68	0.00	100%
19	0.03	Mana sub to WKEP	57kV removal	06-2023	1.95	0.00	100%
20	0.07	Mana sub to WKEP	57kV removal	06-2023	3.88	0.00	100%
21	0.07	Mana sub to WKEP	57kV removal	05-2023	3.52	0.00	100%
22	0.04	Mana sub to WKEP	57kV removal	05-2023	1.86	0.00	100%
23	0.07	Mana sub to WKEP	57kV removal	05-2023	3.66	0.00	100%
24	0.07	Mana sub to WKEP	57kV removal	05-2023	3.50	0.00	100%
25	0.07	Mana sub to WKEP	57kV removal	05-2023	3.52	0.00	100%
26	0.07	Mana sub to WKEP	57kV removal	05-2023	5.30	0.00	100%
27	0.07	Mana sub to WKEP	57kV removal	05-2023	3.61	0.00	100%
28	0.08	Mana sub to WKEP	57kV removal	05-2023	4.24	0.00	100%
29	0.08	Mana sub to WKEP	57kV removal	05-2023	0.65	0.00	100%
30	0.04	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	0.39	0.22	42%
31	0.05	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	1.99	1.15	42%
32	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	2.81	1.63	42%
33	0.04	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	1.40	0.81	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
34	0.06	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	2.09	1.21	42%
35	0.05	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	2.07	1.20	42%
36	0.05	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	2.10	1.22	42%
37	0.06	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	2.26	1.31	42%
38	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	0.59	0.34	42%
39	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	0.58	0.33	42%
40	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	6.20	3.59	42%
41	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	6.17	3.58	42%
42	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	4.46	2.59	42%
43	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	1.27	0.73	42%
44	0.04	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	0.62	0.36	42%
45	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	2.95	1.71	42%
46	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	3.55	2.06	42%
47	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	1.07	0.62	42%
48	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	1.08	0.63	42%
49	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	1.05	0.61	42%
50	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	1.08	0.63	42%
51	0.04	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	1.73	1.00	42%
52	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	3.38	1.96	42%
53	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	0.76	0.44	42%
54	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	0.75	0.43	42%
55	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	4.29	2.49	42%
56	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	4.66	2.70	42%
57	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	4.45	2.58	42%
58	0.04	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	2.27	1.32	42%
59	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	4.23	2.45	42%
60	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	4.25	2.46	42%
61	0.06	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	2.44	1.42	42%
62	0.05	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	2.32	1.34	42%
63	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	3.97	2.30	42%
64	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	5.62	3.26	42%
65	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	0.64	0.37	42%
66	0.06	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	0.63	0.37	42%
67	0.04	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	0.35	0.21	42%
68	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	0.75	0.43	42%
69	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	3.29	1.91	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
70	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	3.21	1.86	42%
71	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	3.23	1.87	42%
72	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	3.15	1.83	42%
73	0.04	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	1.44	0.83	42%
74	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	2.93	1.70	42%
75	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	0.55	0.32	42%
76	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	0.55	0.32	42%
77	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	3.01	1.74	42%
78	0.12	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	5.22	3.03	42%
79	0.06	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	2.56	1.48	42%
80	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	3.83	2.22	42%
81	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	3.58	2.08	42%
82	0.04	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	1.59	0.92	42%
83	0.05	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	2.04	1.18	42%
84	0.04	WKEP to Kekaha sub	Diverter installation (Reflective)	05-2023	1.67	0.97	42%
85	0.04	WKEP to Kekaha sub	Diverter installation (Reflective)	06-2023	1.44	0.84	42%
86	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	06-2023	2.30	1.33	42%
87	0.06	WKEP to Kekaha sub	Diverter installation (Reflective)	06-2023	2.22	1.29	42%
88	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	06-2023	2.60	1.51	42%
89	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	06-2023	2.03	1.18	42%
90	0.06	WKEP to Kekaha sub	Diverter installation (Reflective)	06-2023	1.97	1.14	42%
91	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	06-2023	3.04	1.76	42%
92	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	06-2023	3.16	1.83	42%
93	0.04	WKEP to Kekaha sub	Diverter installation (Reflective)	06-2023	1.97	1.14	42%
94	0.04	WKEP to Kekaha sub	Diverter installation (Reflective)	06-2023	2.07	1.20	42%
95	0.03	WKEP to Kekaha sub	Diverter installation (Reflective)	06-2023	0.97	0.56	42%
96	0.06	WKEP to Kekaha sub	Diverter installation (Reflective)	01-2021	3.15	1.83	42%
97	0.05	WKEP to Kekaha sub	Diverter installation (Reflective)	01-2021	2.89	1.68	42%
98	0.06	WKEP to Kekaha sub	Diverter installation (Reflective)	01-2021	2.46	1.42	42%
99	0.03	WKEP to Kekaha sub	Diverter installation (Reflective)	01-2021	1.22	0.71	42%
100	0.05	WKEP to Kekaha sub	Diverter installation (Reflective)	01-2021	2.28	1.33	42%
101	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	01-2021	3.84	2.23	42%
102	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	01-2021	2.82	1.64	42%
103	0.08	WKEP to Kekaha sub	Diverter installation (Reflective)	01-2021	3.04	1.76	42%
104	0.07	WKEP to Kekaha sub	Diverter installation (Reflective)	08-2023	2.91	1.69	42%
105	0.04	WKEP to Kekaha sub	Diverter installation (Reflective)	02-2021	1.29	0.75	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
106	0.04	WKEP to Kekaha sub	Diverter installation (Reflective)	02-2021	0.44	0.25	42%
107	0.05	WKEP to Kekaha sub	Diverter installation (Reflective)	02-2021	0.65	0.38	42%
108	0.06	WKEP to Kekaha sub	Diverter installation (Reflective)	02-2021	1.57	0.91	42%
109	0.06	WKEP to Kekaha sub	Diverter installation (Reflective)	02-2021	0.91	0.53	42%
110	0.06	WKEP to Kekaha sub	Diverter installation (Reflective)	02-2021	0.91	0.53	42%
111	0.06	WKEP to Kekaha sub	Diverter installation (Reflective)	02-2021	1.63	0.95	42%
112	0.05	WKEP to Kekaha sub	Diverter installation (Reflective)	02-2021	1.45	0.84	42%
113	0.03	WKEP to Kekaha sub	Diverter installation (Reflective)	02-2021	0.77	0.45	42%
116	0.08	Kekaha sub to waimea bridge	Diverter installation (Reflective)	04-2022	7.16	4.15	42%
117	0.07	Kekaha sub to waimea bridge	Diverter installation (Reflective)	04-2021	4.88	1.32	73%
117	0.07	Kekaha sub to waimea bridge	Static wire removal	04-2021	4.88	1.32	73%
118	0.05	Kekaha sub to waimea bridge	Diverter installation (Reflective)	04-2021	5.46	1.48	73%
118	0.05	Kekaha sub to waimea bridge	Static wire removal	04-2021	5.46	1.48	73%
119	0.05	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	2.48	0.70	72%
119	0.05	Kekaha sub to waimea bridge	Static wire removal	04-2021	2.48	0.70	72%
120	0.06	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	2.63	0.75	72%
120	0.06	Kekaha sub to waimea bridge	Static wire removal	04-2021	2.63	0.75	72%
121	0.03	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	1.52	0.43	72%
121	0.03	Kekaha sub to waimea bridge	Static wire removal	04-2021	1.52	0.43	72%
122	0.04	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	3.87	1.10	72%
122	0.04	Kekaha sub to waimea bridge	Static wire removal	04-2021	3.87	1.10	72%
123	0.04	Kekaha sub to waimea bridge	Diverter installation (Reflective)	04-2022	2.22	0.67	70%
123	0.04	Kekaha sub to waimea bridge	Static wire removal	04-2021	2.22	0.67	70%
124	0.04	Kekaha sub to waimea bridge	Diverter installation (Reflective)	04-2022	2.28	0.73	68%
124	0.04	Kekaha sub to waimea bridge	Static wire removal	04-2021	2.28	0.73	68%
125	0.03	Kekaha sub to waimea bridge	Diverter installation (Reflective)	04-2022	2.91	0.93	68%
125	0.03	Kekaha sub to waimea bridge	Static wire removal	04-2021	2.91	0.93	68%
126	0.05	Kekaha sub to waimea bridge	Diverter installation (Reflective)	04-2022	3.25	0.85	74%
126	0.05	Kekaha sub to waimea bridge	Static wire removal	03-2021	3.25	0.85	74%
127	0.05	Kekaha sub to waimea bridge	Diverter installation (Reflective)	04-2022	2.39	0.69	71%
127	0.05	Kekaha sub to waimea bridge	Static wire removal	03-2021	2.39	0.69	71%
128	0.02	Kekaha sub to waimea bridge	Diverter installation (Reflective)	04-2022	1.96	0.55	72%
128	0.02	Kekaha sub to waimea bridge	Static wire removal	03-2021	1.96	0.55	72%
129	0.02	Kekaha sub to waimea bridge	Diverter installation (Reflective)	04-2022	2.88	0.83	71%
129	0.02	Kekaha sub to waimea bridge	Static wire removal	03-2021	2.88	0.83	71%
130	0.03	Kekaha sub to waimea bridge	Diverter installation (Reflective)	04-2022	4.31	1.22	72%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
130	0.03	Kekaha sub to waimea bridge	Static wire removal	03-2021	4.31	1.22	72%
131	0.03	Kekaha sub to waimea bridge	Diverter installation (Reflective)	04-2022	1.85	0.61	67%
131	0.03	Kekaha sub to waimea bridge	Static wire removal	03-2021	1.85	0.61	67%
132	0.05	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	3.81	1.19	69%
132	0.05	Kekaha sub to waimea bridge	Static wire removal	03-2021	3.81	1.19	69%
133	0.06	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	4.14	1.25	70%
133	0.06	Kekaha sub to waimea bridge	Static wire removal	03-2021	4.14	1.25	70%
134	0.07	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	5.48	1.28	77%
134	0.07	Kekaha sub to waimea bridge	Static wire removal	03-2021	5.48	1.28	77%
135	0.08	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	5.89	1.34	77%
135	0.08	Kekaha sub to waimea bridge	Static wire removal	03-2021	5.89	1.34	77%
136	0.07	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	5.88	1.41	76%
136	0.07	Kekaha sub to waimea bridge	Static wire removal	03-2021	5.88	1.41	76%
137	0.08	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	2.31	0.61	74%
137	0.08	Kekaha sub to waimea bridge	Static wire removal	03-2021	2.31	0.61	74%
138	0.08	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	2.30	0.55	76%
138	0.08	Kekaha sub to waimea bridge	Static wire removal	03-2021	2.30	0.55	76%
139	0.07	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	7.23	1.95	73%
139	0.07	Kekaha sub to waimea bridge	Static wire removal	03-2021	7.23	1.95	73%
140	0.08	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	2.37	0.67	72%
140	0.08	Kekaha sub to waimea bridge	Static wire removal	03-2021	2.37	0.67	72%
141	0.07	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	2.29	0.64	72%
141	0.07	Kekaha sub to waimea bridge	Static wire removal	03-2021	2.29	0.64	72%
142	0.08	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	6.86	1.64	76%
142	0.08	Kekaha sub to waimea bridge	Static wire removal	03-2021	6.86	1.64	76%
143	0.08	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	8.88	2.94	67%
143	0.08	Kekaha sub to waimea bridge	Static wire removal	03-2021	8.88	2.94	67%
144	0.07	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	7.35	1.93	74%
144	0.07	Kekaha sub to waimea bridge	Static wire removal	03-2021	7.35	1.93	74%
145	0.08	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	8.25	1.91	77%
145	0.08	Kekaha sub to waimea bridge	Static wire removal	03-2021	8.25	1.91	77%
146	0.08	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	9.58	2.26	76%
146	0.08	Kekaha sub to waimea bridge	Static wire removal	03-2021	9.58	2.26	76%
147	0.07	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	9.21	2.34	75%
147	0.07	Kekaha sub to waimea bridge	Static wire removal	03-2021	9.21	2.34	75%
148	0.07	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	7.88	1.78	77%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
148	0.07	Kekaha sub to waimea bridge	Static wire removal	03-2021	7.88	1.78	77%
149	0.08	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	6.95	1.55	78%
149	0.08	Kekaha sub to waimea bridge	Static wire removal	03-2021	6.95	1.55	78%
150	0.08	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	8.49	1.73	80%
150	0.08	Kekaha sub to waimea bridge	Static wire removal	03-2021	8.49	1.73	80%
151	0.07	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	7.23	1.82	75%
151	0.07	Kekaha sub to waimea bridge	Static wire removal	03-2021	7.23	1.82	75%
152	0.08	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	8.72	2.34	73%
152	0.08	Kekaha sub to waimea bridge	Static wire removal	03-2021	8.72	2.34	73%
153	0.08	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	6.82	1.56	77%
153	0.08	Kekaha sub to waimea bridge	Static wire removal	03-2021	6.82	1.56	77%
154	0.07	Kekaha sub to waimea bridge	Diverter installation (Reflective)	09-2022	4.99	1.16	77%
154	0.07	Kekaha sub to waimea bridge	Static wire removal	03-2021	4.99	1.16	77%
155	0.06	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	4.67	1.23	74%
155	0.06	Kekaha sub to waimea bridge	Static wire removal	03-2021	4.67	1.23	74%
156	0.06	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	5.32	1.56	71%
156	0.06	Kekaha sub to waimea bridge	Static wire removal	03-2021	5.32	1.56	71%
157	0.04	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	3.58	1.11	69%
157	0.04	Kekaha sub to waimea bridge	Static wire removal	03-2021	3.58	1.11	69%
158	0.06	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	4.16	1.11	73%
158	0.06	Kekaha sub to waimea bridge	Static wire removal	03-2021	4.16	1.11	73%
159	0.06	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	1.98	0.52	74%
159	0.06	Kekaha sub to waimea bridge	Static wire removal	03-2021	1.98	0.52	74%
160	0.05	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	1.18	0.31	73%
160	0.05	Kekaha sub to waimea bridge	Static wire removal	03-2021	1.18	0.31	73%
161	0.06	Kekaha sub to waimea bridge	Static wire removal	03-2021	0.57	0.33	43%
162	0.02	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	2.03	0.54	74%
162	0.02	Kekaha sub to waimea bridge	Static wire removal	03-2021	2.03	0.54	74%
163	0.03	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	2.28	0.65	71%
163	0.03	Kekaha sub to waimea bridge	Static wire removal	03-2021	2.28	0.65	71%
164	0.06	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	1.93	0.49	75%
164	0.06	Kekaha sub to waimea bridge	Static wire removal	03-2021	1.93	0.49	75%
165	0.06	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	2.03	0.68	66%
165	0.06	Kekaha sub to waimea bridge	Static wire removal	03-2021	2.03	0.68	66%
166	0.04	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	3.24	0.83	75%
166	0.04	Kekaha sub to waimea bridge	Static wire removal	03-2021	3.24	0.83	75%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
167	0.03	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	2.81	0.73	74%
167	0.03	Kekaha sub to waimea bridge	Static wire removal	03-2021	2.81	0.73	74%
168	0.03	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	2.79	0.76	73%
168	0.03	Kekaha sub to waimea bridge	Static wire removal	03-2021	2.79	0.76	73%
169	0.03	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	2.39	0.77	68%
169	0.03	Kekaha sub to waimea bridge	Static wire removal	03-2021	2.39	0.77	68%
170	0.03	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	1.12	0.31	72%
170	0.03	Kekaha sub to waimea bridge	Static wire removal	03-2021	1.12	0.31	72%
171	0.06	Kekaha sub to waimea bridge	Diverter installation (Reflective)	03-2022	2.11	0.58	73%
171	0.06	Kekaha sub to waimea bridge	Static wire removal	03-2021	2.11	0.58	73%
172	0.05	Kekaha sub to waimea bridge	Diverter installation (Reflective)	02-2022	3.52	1.14	68%
172	0.05	Kekaha sub to waimea bridge	Static wire removal	03-2021	3.52	1.14	68%
173	0.09	Kekaha sub to waimea bridge	Diverter installation (Reflective)	01-2022	6.46	2.36	64%
173	0.09	Kekaha sub to waimea bridge	Static wire removal	03-2021	6.46	2.36	64%
174	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	7.41	2.09	72%
174	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	7.41	2.09	72%
175	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	7.51	2.33	69%
175	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	7.51	2.33	69%
176	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	8.66	2.57	70%
176	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	8.66	2.57	70%
177	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	9.47	2.59	73%
177	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	9.47	2.59	73%
178	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	2.73	0.77	72%
178	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	2.73	0.77	72%
179	0.05	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	1.95	0.60	69%
179	0.05	Waimea Bridge to Kaumakani	Static wire removal	03-2021	1.95	0.60	69%
180	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	10.93	3.43	69%
180	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	10.93	3.43	69%
181	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	3.83	1.22	68%
181	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	3.83	1.22	68%
182	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	3.84	1.17	70%
182	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	3.84	1.17	70%
183	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	10.51	2.80	73%
183	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	10.51	2.80	73%
184	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	3.89	1.16	70%
184	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	3.89	1.16	70%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
185	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	3.37	1.05	69%
185	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	3.37	1.05	69%
186	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	5.66	1.86	67%
186	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	5.66	1.86	67%
187	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	5.00	1.53	69%
187	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	5.00	1.53	69%
188	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	4.63	1.36	71%
188	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	4.63	1.36	71%
189	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	05-2022	1.67	0.47	72%
189	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	1.67	0.47	72%
190	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	1.80	0.53	71%
190	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	1.80	0.53	71%
191	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	05-2022	4.17	1.32	68%
191	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	4.17	1.32	68%
192	0.03	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	06-2022	3.28	1.02	69%
192	0.03	Waimea Bridge to Kaumakani	Static wire removal	03-2021	3.28	1.02	69%
193	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	06-2022	2.59	0.83	68%
193	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	2.59	0.83	68%
194	0.03	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	06-2022	2.28	0.73	68%
194	0.03	Waimea Bridge to Kaumakani	Static wire removal	03-2021	2.28	0.73	68%
195	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	06-2022	2.05	0.59	71%
195	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	2.05	0.59	71%
196	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	05-2022	1.99	0.58	71%
196	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	1.99	0.58	71%
197	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	05-2022	5.90	1.53	74%
197	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	5.90	1.53	74%
198	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	5.29	1.42	73%
198	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	5.29	1.42	73%
199	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	7.04	2.11	70%
199	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	7.04	2.11	70%
200	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	8.54	2.44	71%
200	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	8.54	2.44	71%
201	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	8.81	2.62	70%
201	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	8.81	2.62	70%
202	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	1.79	0.57	68%
202	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	1.79	0.57	68%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
203	0.05	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	1.29	0.43	66%
203	0.05	Waimea Bridge to Kaumakani	Static wire removal	03-2021	1.29	0.43	66%
204	0.05	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	03-2022	6.15	2.14	65%
204	0.05	Waimea Bridge to Kaumakani	Static wire removal	03-2021	6.15	2.14	65%
205	0.06	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	05-2022	7.77	2.77	64%
205	0.06	Waimea Bridge to Kaumakani	Static wire removal	03-2021	7.77	2.77	64%
206	0.06	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	07-2022	3.93	1.37	65%
206	0.06	Waimea Bridge to Kaumakani	Static wire removal	03-2021	3.93	1.37	65%
207	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	05-2022	4.18	1.32	68%
207	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	4.18	1.32	68%
208	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	03-2022	7.10	2.36	67%
208	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	7.10	2.36	67%
209	0.06	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	03-2022	1.44	0.52	64%
209	0.06	Waimea Bridge to Kaumakani	Static wire removal	03-2021	1.44	0.52	64%
210	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	5.04	1.79	65%
210	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	5.04	1.79	65%
211	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	9.38	3.06	67%
211	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	9.38	3.06	67%
212	0.09	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	14.38	4.60	68%
212	0.09	Waimea Bridge to Kaumakani	Static wire removal	03-2021	14.38	4.60	68%
213	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	10.67	3.23	70%
213	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	10.67	3.23	70%
214	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	11.62	3.69	68%
214	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	11.62	3.69	68%
215	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	12.22	3.95	68%
215	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	12.22	3.95	68%
216	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	11.07	3.57	68%
216	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	11.07	3.57	68%
217	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	12.36	3.95	68%
217	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	12.36	3.95	68%
218	0.09	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	14.37	4.40	69%
218	0.09	Waimea Bridge to Kaumakani	Static wire removal	03-2021	14.37	4.40	69%
219	0.09	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	14.35	4.61	68%
219	0.09	Waimea Bridge to Kaumakani	Static wire removal	03-2021	14.35	4.61	68%
220	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	1.98	0.66	67%
220	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	1.98	0.66	67%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
221	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	1.73	0.57	67%
221	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	1.73	0.57	67%
222	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	12.66	4.66	63%
222	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	12.66	4.66	63%
223	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	13.06	4.16	68%
223	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	13.06	4.16	68%
224	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	12.09	3.91	68%
224	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	12.09	3.91	68%
225	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	05-2022	7.04	2.31	67%
225	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	7.04	2.31	67%
226	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	05-2022	6.77	2.01	70%
226	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	6.77	2.01	70%
227	0.06	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	04-2022	9.32	2.28	76%
227	0.06	Waimea Bridge to Kaumakani	Static wire removal	03-2021	9.32	2.28	76%
228	0.06	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	02-2022	9.07	2.26	75%
228	0.06	Waimea Bridge to Kaumakani	Static wire removal	03-2021	9.07	2.26	75%
229	0.05	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	02-2022	8.11	2.33	71%
229	0.05	Waimea Bridge to Kaumakani	Static wire removal	03-2021	8.11	2.33	71%
230	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	02-2022	9.18	5.33	42%
230	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	9.18	5.33	42%
231	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	02-2022	10.34	6.00	42%
231	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	10.34	6.00	42%
232	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	02-2022	1.61	0.59	63%
232	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	1.61	0.59	63%
233	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	2.96	0.93	69%
233	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	2.96	0.93	69%
234	0.06	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	9.31	2.66	71%
234	0.06	Waimea Bridge to Kaumakani	Static wire removal	03-2021	9.31	2.66	71%
235	0.05	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	7.47	2.19	71%
235	0.05	Waimea Bridge to Kaumakani	Static wire removal	03-2021	7.47	2.19	71%
236	0.10	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	13.92	3.78	73%
236	0.10	Waimea Bridge to Kaumakani	Static wire removal	03-2021	13.92	3.78	73%
237	0.10	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	14.97	3.78	75%
237	0.10	Waimea Bridge to Kaumakani	Static wire removal	03-2021	14.97	3.78	75%
238	0.05	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	7.81	1.82	77%
238	0.05	Waimea Bridge to Kaumakani	Static wire removal	03-2021	7.81	1.82	77%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
239	0.05	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	7.59	1.48	81%
239	0.05	Waimea Bridge to Kaumakani	Static wire removal	03-2021	7.59	1.48	81%
240	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	6.18	1.48	76%
240	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	6.18	1.48	76%
241	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	2.17	0.68	69%
241	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	2.17	0.68	69%
242	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	2.07	0.63	69%
242	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	2.07	0.63	69%
243	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	7.27	1.72	76%
243	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	7.27	1.72	76%
244	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	15.20	3.75	75%
244	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	10-2015	15.20	3.75	75%
245	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	16.00	4.43	72%
245	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	10-2015	16.00	4.43	72%
246	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	18.26	4.11	77%
246	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	10-2015	18.26	4.11	77%
247	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	17.03	3.23	81%
247	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	10-2015	17.03	3.23	81%
248	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	7.21	1.84	74%
248	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	7.21	1.84	74%
249	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	7.51	2.27	70%
249	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	7.51	2.27	70%
250	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	9.00	2.72	70%
250	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	9.00	2.72	70%
251	0.03	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	6.38	1.94	70%
251	0.03	Waimea Bridge to Kaumakani	Static wire removal	03-2021	6.38	1.94	70%
252	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	7.56	2.43	68%
252	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	7.56	2.43	68%
253	0.04	Waimea Bridge to Kaumakani	Static wire removal	03-2021	0.75	0.21	71%
253	0.04	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	10-2015	0.75	0.21	71%
254	0.07	Waimea Bridge to Kaumakani	Static wire removal	03-2021	1.42	0.32	78%
254	0.07	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	10-2015	1.42	0.32	78%
255	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	15.76	4.77	70%
255	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	15.76	4.77	70%
256	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	13.80	4.21	70%
256	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	13.80	4.21	70%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
257	0.08	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	01-2022	9.12	2.86	69%
257	0.08	Waimea Bridge to Kaumakani	Static wire removal	03-2021	9.12	2.86	69%
258	0.05	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	10-2022	5.79	1.51	74%
258	0.05	Waimea Bridge to Kaumakani	Static wire removal	03-2021	5.79	1.51	74%
259	0.05	Waimea Bridge to Kaumakani	Diverter installation (Reflective)	06-2022	4.27	1.21	72%
259	0.05	Waimea Bridge to Kaumakani	Static wire removal	03-2021	4.27	1.21	72%
260	0.03	Kaumakani to Port Allen	Diverter installation (Reflective)	09-2022	1.82	0.42	77%
260	0.03	Kaumakani to Port Allen	Static wire removal	03-2021	1.82	0.42	77%
261	0.05	Kaumakani to Port Allen	Diverter installation (Reflective)	09-2022	4.11	0.98	76%
261	0.05	Kaumakani to Port Allen	Static wire removal	03-2021	4.11	0.98	76%
262	0.08	Kaumakani to Port Allen	Diverter installation (Reflective)	01-2022	6.39	1.73	73%
262	0.08	Kaumakani to Port Allen	Static wire removal	03-2021	6.39	1.73	73%
263	0.07	Kaumakani to Port Allen	Diverter installation (Reflective)	01-2022	5.83	1.66	71%
263	0.07	Kaumakani to Port Allen	Static wire removal	03-2021	5.83	1.66	71%
264	0.08	Kaumakani to Port Allen	Diverter installation (Reflective)	01-2022	5.64	3.27	42%
264	0.08	Kaumakani to Port Allen	Static wire removal	03-2021	5.64	3.27	42%
265	0.04	Kaumakani to Port Allen	Diverter installation (Reflective)	01-2022	2.42	0.82	66%
265	0.04	Kaumakani to Port Allen	Static wire removal	03-2021	2.42	0.82	66%
266	0.05	Kaumakani to Port Allen	Diverter installation (Reflective)	01-2022	2.24	0.63	72%
266	0.05	Kaumakani to Port Allen	Static wire removal	03-2021	2.24	0.63	72%
267	0.05	Kaumakani to Port Allen	Diverter installation (Reflective)	12-2021	1.79	0.65	63%
267	0.05	Kaumakani to Port Allen	Static wire removal	03-2021	1.79	0.65	63%
268	0.08	Kaumakani to Port Allen	Diverter installation (Reflective)	02-2022	2.81	0.88	69%
268	0.08	Kaumakani to Port Allen	Static wire removal	03-2021	2.81	0.88	69%
269	0.05	Kaumakani to Port Allen	Diverter installation (Reflective)	12-2021	1.55	0.53	66%
269	0.05	Kaumakani to Port Allen	Static wire removal	03-2021	1.55	0.53	66%
270	0.06	Kaumakani to Port Allen	Diverter installation (Reflective)	12-2021	1.92	0.69	64%
270	0.06	Kaumakani to Port Allen	Static wire removal	03-2021	1.92	0.69	64%
271	0.08	Kaumakani to Port Allen	Diverter installation (Reflective)	12-2021	2.93	0.85	71%
271	0.08	Kaumakani to Port Allen	Static wire removal	03-2021	2.93	0.85	71%
272	0.02	Kaumakani to Port Allen	Diverter installation (Reflective)	12-2021	0.58	0.19	67%
272	0.02	Kaumakani to Port Allen	Static wire removal	03-2021	0.58	0.19	67%
273	0.02	Kaumakani to Port Allen	Diverter installation (Reflective)	12-2021	0.80	0.23	71%
273	0.02	Kaumakani to Port Allen	Static wire removal	03-2021	0.80	0.23	71%
274	0.01	Kaumakani to Port Allen	Diverter installation (Reflective)	12-2021	0.40	0.11	73%
274	0.01	Kaumakani to Port Allen	Static wire removal	03-2021	0.40	0.11	73%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
275	0.05	Kaumakani to Port Allen	Diverter installation (Reflective)	12-2021	1.15	0.35	70%
275	0.05	Kaumakani to Port Allen	Static wire removal	03-2021	1.15	0.35	70%
276	0.08	Kaumakani to Port Allen	Diverter installation (Reflective)	12-2021	1.93	0.64	67%
276	0.08	Kaumakani to Port Allen	Static wire removal	03-2021	1.93	0.64	67%
277	0.07	Kaumakani to Port Allen	Diverter installation (Reflective)	04-2021	2.33	0.62	73%
277	0.07	Kaumakani to Port Allen	Static wire removal	03-2021	2.33	0.62	73%
277	0.07	Kaumakani to Port Allen	Static wire removal	03-2021	2.33	0.62	73%
278	0.06	Kaumakani to Port Allen	Diverter installation (Reflective)	04-2021	1.84	0.48	74%
278	0.06	Kaumakani to Port Allen	Static wire removal	03-2021	1.84	0.48	74%
279	0.02	Kaumakani to Port Allen	Diverter installation (Reflective)	04-2021	0.70	0.20	71%
279	0.02	Kaumakani to Port Allen	Static wire removal	03-2021	0.70	0.20	71%
280	0.06	Kaumakani to Port Allen	Diverter installation (Reflective)	04-2021	2.67	0.78	71%
280	0.06	Kaumakani to Port Allen	Static wire removal	03-2021	2.67	0.78	71%
281	0.07	Kaumakani to Port Allen	Diverter installation (Reflective)	04-2021	3.50	1.04	70%
281	0.07	Kaumakani to Port Allen	Static wire removal	03-2021	3.50	1.04	70%
282	0.02	Kaumakani to Port Allen	Diverter installation (Reflective)	04-2021	1.28	0.40	68%
282	0.02	Kaumakani to Port Allen	Static wire removal	03-2021	1.28	0.40	68%
283	0.03	Kaumakani to Port Allen	Diverter installation (Reflective)	04-2021	2.01	0.57	72%
283	0.03	Kaumakani to Port Allen	Static wire removal	03-2021	2.01	0.57	72%
284	0.04	Kaumakani to Port Allen	Diverter installation (Reflective)	04-2021	2.10	0.62	71%
284	0.04	Kaumakani to Port Allen	Static wire removal	03-2021	2.10	0.62	71%
285	0.03	Kaumakani to Port Allen	Diverter installation (Reflective)	04-2021	1.12	0.33	71%
285	0.03	Kaumakani to Port Allen	Static wire removal	03-2021	1.12	0.33	71%
286	0.05	Kaumakani to Port Allen	Diverter installation (Reflective)	04-2021	2.08	0.56	73%
286	0.05	Kaumakani to Port Allen	Static wire removal	03-2021	2.08	0.56	73%
287	0.05	Kaumakani to Port Allen	Diverter installation (Reflective)	04-2021	2.77	1.61	42%
289	0.04	Kaumakani to Port Allen	Diverter installation (Reflective)	06-2022	2.62	1.52	42%
290	0.03	PAGS - Waialo Rd/Hwy intersection	Diverter installation (Reflective)	03-2021	1.55	0.36	77%
290	0.03	PAGS - Waialo Rd/Hwy intersection	Static wire removal	03-2021	1.55	0.36	77%
291	0.04	PAGS - Waialo Rd/Hwy intersection	Diverter installation (Reflective)	03-2021	1.75	0.42	76%
291	0.04	PAGS - Waialo Rd/Hwy intersection	Static wire removal	03-2021	1.75	0.42	76%
292	0.04	PAGS - Waialo Rd/Hwy intersection	Diverter installation (Reflective)	03-2021	2.55	0.63	75%
292	0.04	PAGS - Waialo Rd/Hwy intersection	Static wire removal	03-2021	2.55	0.63	75%
293	0.04	PAGS - Waialo Rd/Hwy intersection	Diverter installation (Reflective)	03-2021	2.74	0.63	77%
293	0.04	PAGS - Waialo Rd/Hwy intersection	Static wire removal	03-2021	2.74	0.63	77%
294	0.04	PAGS - Waialo Rd/Hwy intersection	Diverter installation (Reflective)	03-2021	2.35	0.57	76%

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294	0.04	PAGS - Waialo Rd/Hwy intersection	Static wire removal	03-2021	2.35	0.57	76%
295	0.04	PAGS - Waialo Rd/Hwy intersection	Diverter installation (Reflective)	03-2021	2.80	0.73	74%
295	0.04	PAGS - Waialo Rd/Hwy intersection	Static wire removal	03-2021	2.80	0.73	74%
296	0.04	PAGS - Waialo Rd/Hwy intersection	Diverter installation (Reflective)	03-2021	3.75	0.88	77%
296	0.04	PAGS - Waialo Rd/Hwy intersection	Static wire removal	03-2021	3.75	0.88	77%
297	0.02	PAGS - Waialo Rd/Hwy intersection	Diverter installation (Reflective)	03-2021	1.74	0.41	77%
297	0.02	PAGS - Waialo Rd/Hwy intersection	Static wire removal	03-2021	1.74	0.41	77%
298	0.03	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	03-2021	2.49	1.44	42%
298	0.03	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	2.49	1.44	42%
299	0.03	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	11-2021	2.31	1.34	42%
299	0.03	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	2.31	1.34	42%
300	0.03	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	11-2021	2.67	1.55	42%
300	0.03	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	2.67	1.55	42%
301	0.03	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	03-2021	1.73	1.00	42%
301	0.03	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	1.73	1.00	42%
302	0.03	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	03-2021	2.11	1.23	42%
302	0.03	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	2.11	1.23	42%
303	0.04	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	06-2022	2.98	1.73	42%
303	0.04	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	2.98	1.73	42%
304	0.03	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	06-2022	1.14	0.66	42%
304	0.03	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	1.14	0.66	42%
305	0.07	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	07-2022	2.09	1.21	42%
305	0.07	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	2.09	1.21	42%
306	0.07	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	07-2022	2.61	1.51	42%
306	0.07	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	2.61	1.51	42%
307	0.06	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	07-2022	2.92	1.69	42%
307	0.06	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	2.92	1.69	42%
308	0.04	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	12-2021	5.37	3.11	42%
308	0.04	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	5.37	3.11	42%
309	0.03	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	12-2021	2.50	1.45	42%
309	0.03	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	2.50	1.45	42%
310	0.07	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	12-2021	5.80	3.36	42%
310	0.07	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	5.80	3.36	42%
311	0.06	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	12-2021	8.21	4.76	42%
311	0.06	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	8.21	4.76	42%
312	0.04	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	12-2021	5.00	2.90	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
312	0.04	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	5.00	2.90	42%
313	0.03	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	07-2022	3.21	1.86	42%
313	0.03	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	3.21	1.86	42%
314	0.07	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	07-2022	10.03	5.82	42%
314	0.07	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	10.03	5.82	42%
315	0.07	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	10.40	1.04	90%
316	0.07	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	06-2022	0.97	0.56	42%
316	0.07	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	0.97	0.56	42%
317	0.08	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	04-2021	1.01	0.59	42%
317	0.08	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	1.01	0.59	42%
318	0.03	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	04-2021	1.76	1.02	42%
318	0.03	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	1.76	1.02	42%
319	0.05	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	04-2021	3.12	1.81	42%
319	0.05	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	3.12	1.81	42%
320	0.06	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	04-2021	8.78	5.09	42%
320	0.06	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	8.78	5.09	42%
321	0.06	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	04-2021	7.99	4.63	42%
321	0.06	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	7.99	4.63	42%
322	0.04	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	04-2021	1.65	0.96	42%
322	0.04	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	1.65	0.96	42%
323	0.07	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	04-2021	2.93	1.70	42%
323	0.07	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	2.93	1.70	42%
324	0.08	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	04-2021	3.12	1.81	42%
324	0.08	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	3.12	1.81	42%
325	0.05	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	04-2021	1.85	1.07	42%
325	0.05	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	1.85	1.07	42%
326	0.05	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	04-2021	6.02	3.49	42%
326	0.05	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	07-2019	6.02	3.49	42%
328	0.16	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	12-2016	5.30	5.30	0%
329	0.12	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	12-2016	3.83	3.83	0%
330	0.19	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	09-2021	12.78	7.41	42%
330	0.19	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	12-2016	12.78	7.41	42%
331	0.15	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	09-2021	10.21	5.92	42%
331	0.15	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	12-2016	10.21	5.92	42%
332	0.11	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	08-2021	5.45	3.16	42%
332	0.11	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	12-2016	5.45	3.16	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
333	0.13	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	09-2021	6.73	3.91	42%
333	0.13	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	12-2016	6.73	3.91	42%
334	0.32	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	12-2016	3.50	3.50	0%
335	0.12	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	09-2021	21.11	12.24	42%
335	0.12	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	12-2016	21.11	12.24	42%
336	0.12	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	09-2021	20.91	12.13	42%
336	0.12	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	12-2016	20.91	12.13	42%
337	0.12	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	12-2016	1.79	1.79	0%
338	0.15	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	12-2016	2.31	2.31	0%
339	0.14	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	09-2021	20.70	12.01	42%
339	0.14	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	12-2016	20.70	12.01	42%
340	0.14	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	08-2021	40.35	23.40	42%
340	0.14	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	12-2016	40.35	23.40	42%
341	0.10	Waialo Rd/Hwy intersection - Brydsewood	Diverter installation (Reflective)	08-2021	0.91	0.53	42%
341	0.10	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	12-2016	0.91	0.53	42%
342	0.16	Waialo Rd/Hwy intersection - Brydsewood	Static wire removal	12-2016	1.50	1.50	0%
343	0.27	Fujita Tap	Static wire removal	08-2023	3.88	1.13	71%
343	0.27	Fujita Tap	Diverter installation (Reflective)	04-2022	3.88	1.13	71%
344	0.11	Fujita Tap	Static wire removal	08-2023	1.66	0.33	80%
344	0.11	Fujita Tap	Diverter installation (Reflective)	04-2022	1.66	0.33	80%
345	0.10	Fujita Tap	Static wire removal	08-2023	1.24	0.60	52%
346	0.12	Fujita Tap	Static wire removal	08-2023	1.55	0.37	76%
346	0.12	Fujita Tap	Diverter installation (Reflective)	04-2022	1.55	0.37	76%
347	0.14	Fujita Tap	Static wire removal	08-2023	3.46	0.85	76%
347	0.14	Fujita Tap	Diverter installation (Reflective)	04-2022	3.46	0.85	76%
348	0.12	Fujita Tap	Static wire removal	08-2023	2.93	0.74	75%
348	0.12	Fujita Tap	Diverter installation (Reflective)	04-2022	2.93	0.74	75%
349	0.26	Fujita Tap	Static wire removal	08-2023	1.99	0.43	78%
349	0.26	Fujita Tap	Diverter installation (Reflective)	04-2022	1.99	0.43	78%
350	0.18	Fujita Tap	Static wire removal	08-2023	1.36	0.30	78%
350	0.18	Fujita Tap	Diverter installation (Reflective)	07-2022	1.36	0.30	78%
351	0.17	Fujita Tap	Static wire removal	08-2023	0.19	0.04	78%
351	0.17	Fujita Tap	Diverter installation (Reflective)	07-2022	0.19	0.04	78%
352	0.45	Fujita Tap	Static wire removal	08-2023	0.51	0.29	42%
352	0.45	Fujita Tap	Diverter installation (Reflective)	07-2022	0.51	0.29	42%
352	0.45	Fujita Tap	Static wire removal	12-2016	0.51	0.29	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
353	0.03	Fujita Tap	Diverter installation (Reflective)	07-2022	0.33	0.19	42%
354	0.18	Fujita Tap	Static wire removal	08-2023	2.24	0.55	75%
354	0.18	Fujita Tap	Diverter installation (Reflective)	04-2022	2.24	0.55	75%
355	0.15	Fujita Tap	Static wire removal	08-2023	2.17	0.55	74%
355	0.15	Fujita Tap	Diverter installation (Reflective)	04-2022	2.17	0.55	74%
356	0.12	Fujita Tap	Static wire removal	08-2023	1.72	0.40	76%
356	0.12	Fujita Tap	Diverter installation (Reflective)	04-2022	1.72	0.40	76%
357	0.12	Fujita Tap	Static wire removal	08-2023	4.64	1.12	76%
357	0.12	Fujita Tap	Diverter installation (Reflective)	04-2022	4.64	1.12	76%
358	0.20	Fujita Tap	Static wire removal	11-2022	5.06	1.32	74%
358	0.20	Fujita Tap	Diverter installation (Reflective)	04-2022	5.06	1.32	74%
359	0.56	Fujita Tap	Static wire removal	11-2022	8.36	1.93	77%
359	0.56	Fujita Tap	Diverter installation (Reflective)	05-2022	8.36	1.93	77%
360	0.27	Fujita Tap	Static wire removal	11-2022	1.10	0.49	55%
361	0.22	Fujita Tap	Static wire removal	11-2022	11.85	3.26	73%
361	0.22	Fujita Tap	Diverter installation (Reflective)	11-2021	11.85	3.26	73%
362	0.17	Fujita Tap	Static wire removal	11-2022	10.12	2.63	74%
362	0.17	Fujita Tap	Diverter installation (Reflective)	11-2021	10.12	2.63	74%
363	0.14	Fujita Tap	Static wire removal	11-2022	8.73	2.37	73%
363	0.14	Fujita Tap	Diverter installation (Reflective)	11-2021	8.73	2.37	73%
364	0.15	Fujita Tap	Static wire removal	11-2022	10.84	2.45	77%
364	0.15	Fujita Tap	Diverter installation (Reflective)	11-2021	10.84	2.45	77%
365	0.14	Fujita Tap	Diverter installation (Reflective)	08-2021	5.68	1.15	80%
365	0.14	Fujita Tap	Static wire removal	05-2021	5.68	1.15	80%
365	0.14	Fujita Tap	Static wire removal	04-2021	5.68	1.15	80%
366	0.13	Fujita Tap	Diverter installation (Reflective)	08-2021	5.32	1.08	80%
366	0.13	Fujita Tap	Static wire removal	05-2021	5.32	1.08	80%
366	0.13	Fujita Tap	Static wire removal	04-2021	5.32	1.08	80%
367	0.13	Fujita Tap	Diverter installation (Reflective)	08-2021	1.52	0.28	82%
367	0.13	Fujita Tap	Static wire removal	05-2021	1.52	0.28	82%
367	0.13	Fujita Tap	Static wire removal	04-2021	1.52	0.28	82%
368	0.15	Fujita Tap	Static wire removal	08-2023	1.74	0.36	79%
368	0.15	Fujita Tap	Diverter installation (Reflective)	04-2022	1.74	0.36	79%
369	0.19	Fujita Tap	Static wire removal	08-2023	13.40	2.42	82%
369	0.19	Fujita Tap	Diverter installation (Reflective)	04-2022	13.40	2.42	82%
370	0.16	Fujita Tap	Static wire removal	08-2023	1.68	0.37	78%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
370	0.16	Fujita Tap	Diverter installation (Reflective)	04-2022	1.68	0.37	78%
371	0.16	Fujita Tap	Diverter installation (Reflective)	08-2021	1.67	0.28	83%
371	0.16	Fujita Tap	Static wire removal	05-2021	1.67	0.28	83%
372	0.13	Fujita Tap	Diverter installation (Reflective)	08-2021	8.40	1.18	86%
372	0.13	Fujita Tap	Static wire removal	05-2021	8.40	1.18	86%
373	0.14	Fujita Tap	Diverter installation (Reflective)	12-2021	6.32	1.04	83%
373	0.14	Fujita Tap	Static wire removal	05-2021	6.32	1.04	83%
374	0.15	Fujita Tap	Diverter installation (Reflective)	05-2021	1.80	0.25	86%
374	0.15	Fujita Tap	Static wire removal	05-2021	1.80	0.25	86%
375	0.14	Fujita Tap	Diverter installation (Reflective)	05-2021	1.44	0.21	85%
375	0.14	Fujita Tap	Static wire removal	05-2021	1.44	0.21	85%
376	0.15	Fujita Tap	Diverter installation (Reflective)	05-2021	1.36	0.19	86%
376	0.15	Fujita Tap	Static wire removal	05-2021	1.36	0.19	86%
377	0.15	Fujita Tap	Diverter installation (Reflective)	05-2021	12.20	7.08	42%
378	0.16	Fujita Tap - Kilohana Tap	Static wire removal	12-2023	1.49	0.28	81%
378	0.16	Fujita Tap - Kilohana Tap	Diverter installation (Reflective)	04-2022	1.49	0.28	81%
379	0.18	Fujita Tap - Kilohana Tap	Static wire removal	12-2023	1.74	0.34	80%
379	0.18	Fujita Tap - Kilohana Tap	Diverter installation (Reflective)	04-2022	1.74	0.34	80%
380	0.18	Fujita Tap - Kilohana Tap	Static wire removal	12-2023	14.76	2.82	81%
380	0.18	Fujita Tap - Kilohana Tap	Diverter installation (Reflective)	12-2021	14.76	2.82	81%
381	0.20	Fujita Tap - Kilohana Tap	Static wire removal	12-2023	14.65	3.21	78%
381	0.20	Fujita Tap - Kilohana Tap	Diverter installation (Reflective)	12-2021	14.65	3.21	78%
382	0.10	Fujita Tap - Kilohana Tap	Static wire removal	12-2023	8.91	1.64	82%
382	0.10	Fujita Tap - Kilohana Tap	Diverter installation (Reflective)	04-2022	8.91	1.64	82%
383	0.21	Fujita Tap - Kilohana Tap	Static wire removal	08-2023	2.13	0.58	73%
383	0.21	Fujita Tap - Kilohana Tap	Diverter installation (Reflective)	04-2022	2.13	0.58	73%
384	0.15	Fujita Tap - Kilohana Tap	Static wire removal	08-2023	1.53	0.40	74%
384	0.15	Fujita Tap - Kilohana Tap	Diverter installation (Reflective)	04-2022	1.53	0.40	74%
385	0.17	Fujita Tap - Kilohana Tap	Static wire removal	08-2023	1.10	0.35	68%
385	0.17	Fujita Tap - Kilohana Tap	Diverter installation (Reflective)	04-2022	1.10	0.35	68%
386	0.14	Fujita Tap - Kilohana Tap	Static wire removal	08-2023	0.86	0.20	76%
386	0.14	Fujita Tap - Kilohana Tap	Diverter installation (Reflective)	11-2021	0.86	0.20	76%
387	0.18	Fujita Tap - Kilohana Tap	Static wire removal	08-2023	3.61	0.93	74%
387	0.18	Fujita Tap - Kilohana Tap	Diverter installation (Reflective)	11-2021	3.61	0.93	74%
388	0.19	Fujita Tap - Kilohana Tap	Static wire removal	08-2023	3.84	0.94	75%
388	0.19	Fujita Tap - Kilohana Tap	Diverter installation (Reflective)	11-2021	3.84	0.94	75%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
389	0.15	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	07-2021	4.77	0.54	89%
389	0.15	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	4.77	0.54	89%
390	0.22	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	07-2021	6.84	1.10	84%
390	0.22	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	6.84	1.10	84%
391	0.17	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	07-2021	12.60	1.93	85%
391	0.17	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	12.60	1.93	85%
392	0.15	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	07-2021	10.71	1.41	87%
392	0.15	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	10.71	1.41	87%
393	0.15	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	09-2021	4.30	0.82	81%
393	0.15	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	4.30	0.82	81%
394	0.39	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	11-2021	10.94	2.08	81%
394	0.39	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	10.94	2.08	81%
395	0.36	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	11-2021	17.61	2.67	85%
395	0.36	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	17.61	2.67	85%
396	0.26	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	11-2021	34.86	5.92	83%
396	0.26	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	34.86	5.92	83%
397	0.15	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	07-2021	19.73	2.63	87%
397	0.15	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	19.73	2.63	87%
398	0.16	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	07-2021	3.51	0.60	83%
398	0.16	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	3.51	0.60	83%
399	0.20	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	11-2021	4.41	0.73	83%
399	0.20	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	4.41	0.73	83%
400	0.21	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	09-2021	2.67	0.33	88%
400	0.21	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	2.67	0.33	88%
401	0.24	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	09-2021	3.07	0.43	86%
401	0.24	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	3.07	0.43	86%
402	0.22	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	09-2021	2.44	0.13	95%
402	0.22	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	2.44	0.13	95%
403	0.13	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	09-2021	1.44	0.07	95%
403	0.13	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	1.44	0.07	95%
404	0.25	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	09-2021	9.24	0.94	90%
404	0.25	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	9.24	0.94	90%
405	0.14	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	07-2021	1.55	0.06	96%
405	0.14	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	1.55	0.06	96%
406	0.18	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	08-2021	2.06	0.24	88%
406	0.18	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	2.06	0.24	88%

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407	0.14	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	07-2021	2.80	0.20	93%
407	0.14	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	2.80	0.20	93%
408	0.13	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	07-2021	2.43	0.16	93%
408	0.13	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	2.43	0.16	93%
409	0.09	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	07-2021	6.18	0.42	93%
409	0.09	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	6.18	0.42	93%
410	0.20	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	07-2021	15.77	1.15	93%
410	0.20	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	15.77	1.15	93%
411	0.19	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	07-2021	15.33	1.66	89%
411	0.19	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	15.33	1.66	89%
412	0.18	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	07-2021	11.40	1.34	88%
412	0.18	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	11.40	1.34	88%
413	0.28	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	08-2021	1.88	0.19	90%
413	0.28	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	1.88	0.19	90%
414	0.16	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	08-2021	1.07	0.09	92%
414	0.16	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	1.07	0.09	92%
415	0.16	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	08-2021	9.65	0.71	93%
415	0.16	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	9.65	0.71	93%
416	0.18	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	08-2021	8.14	0.48	94%
416	0.18	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	8.14	0.48	94%
417	0.14	Kilohana to Hanahanapuni (CP1 and CP2)	Diverter installation (Reflective)	08-2021	4.65	0.21	96%
417	0.14	Kilohana to Hanahanapuni (CP1 and CP2)	Static wire removal	05-2020	4.65	0.21	96%
420	0.15	PLT entrance Wailua	Static wire removal	10-2023	5.26	0.28	95%
420	0.15	PLT entrance Wailua	Diverter installation (LED)	08-2022	5.26	0.28	95%
421	0.22	PLT entrance Wailua	Static wire removal	10-2023	6.15	0.33	95%
421	0.22	PLT entrance Wailua	Diverter installation (LED)	08-2022	6.15	0.33	95%
422	0.22	PLT entrance Wailua	Static wire removal	10-2023	10.66	0.66	94%
422	0.22	PLT entrance Wailua	Diverter installation (LED)	09-2022	10.66	0.66	94%
423	0.30	PLT entrance Wailua	Static wire removal	10-2023	28.29	1.10	96%
423	0.30	PLT entrance Wailua	Diverter installation (LED)	09-2023	28.29	1.10	96%
424	0.31	Powerline Trail S2	Static wire removal	10-2023	28.74	1.94	93%
424	0.31	Powerline Trail S2	Diverter installation (LED)	09-2023	28.74	1.94	93%
425	0.35	Powerline Trail S2	Static wire removal	10-2023	79.37	5.01	94%
425	0.35	Powerline Trail S2	Diverter installation (LED)	09-2023	79.37	5.01	94%
426	0.57	Powerline Trail S2	Static wire removal	10-2023	128.09	5.37	96%
426	0.57	Powerline Trail S2	Diverter installation (LED)	12-2023	128.09	5.37	96%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
427	0.29	Powerline Trail S2	Static wire removal	10-2023	123.07	9.06	93%
427	0.29	Powerline Trail S2	Diverter installation (LED)	09-2023	123.07	9.06	93%
428	0.28	Powerline Trail S2	Static wire removal	10-2023	116.13	7.26	94%
428	0.28	Powerline Trail S2	Diverter installation (LED)	09-2023	116.13	7.26	94%
429	0.20	Powerline Trail S2	Static wire removal	10-2023	128.89	9.44	93%
429	0.20	Powerline Trail S2	Diverter installation (LED)	09-2023	128.89	9.44	93%
430	0.14	Powerline Trail S2	Static wire removal	10-2023	88.85	4.25	95%
430	0.14	Powerline Trail S2	Diverter installation (LED)	04-2021	88.85	4.25	95%
431	0.09	Powerline Trail S2	Static wire removal	10-2023	138.35	8.10	94%
431	0.09	Powerline Trail S2	Diverter installation (LED)	04-2021	138.35	8.10	94%
432	0.16	Powerline Trail S2	Static wire removal	10-2023	235.04	16.24	93%
432	0.16	Powerline Trail S2	Diverter installation (LED)	08-2023	235.04	16.24	93%
433	0.17	Powerline Trail S2	Static wire removal	10-2023	129.49	8.20	94%
433	0.17	Powerline Trail S2	Diverter installation (LED)	08-2023	129.49	8.20	94%
434	0.28	Powerline Trail N1	Static wire removal	10-2023	133.61	7.15	95%
434	0.28	Powerline Trail N1	Diverter installation (LED)	08-2023	133.61	7.15	95%
435	0.15	Powerline Trail N1	Static wire removal	10-2023	47.20	2.65	94%
435	0.15	Powerline Trail N1	Diverter installation (LED)	08-2023	47.20	2.65	94%
436	0.31	Powerline Trail N1	Static wire removal	10-2023	98.26	3.55	96%
436	0.31	Powerline Trail N1	Diverter installation (LED)	07-2023	98.26	3.55	96%
437	0.12	Powerline Trail N1	Static wire removal	10-2023	16.97	0.82	95%
437	0.12	Powerline Trail N1	Diverter installation (LED)	07-2023	16.97	0.82	95%
438	0.22	Powerline Trail N1	Static wire removal	10-2023	21.14	0.64	97%
438	0.22	Powerline Trail N1	Diverter installation (LED)	07-2021	21.14	0.64	97%
439	0.13	Powerline Trail N1	Static wire removal	10-2023	12.87	0.52	96%
439	0.13	Powerline Trail N1	Diverter installation (LED)	07-2021	12.87	0.52	96%
440	0.11	Powerline Trail N1	Static wire removal	10-2023	10.30	0.49	95%
440	0.11	Powerline Trail N1	Diverter installation (LED)	07-2023	10.30	0.49	95%
441	0.21	Powerline Trail N1	Static wire removal	10-2023	42.00	2.01	95%
441	0.21	Powerline Trail N1	Diverter installation (LED)	01-2023	42.00	2.01	95%
442	0.21	Powerline Trail N1	Static wire removal	10-2023	49.66	2.28	95%
442	0.21	Powerline Trail N1	Diverter installation (LED)	07-2021	49.66	2.28	95%
443	0.14	Powerline Trail N1	Static wire removal	10-2023	43.61	1.85	96%
443	0.14	Powerline Trail N1	Diverter installation (LED)	07-2021	43.61	1.85	96%
444	0.14	Powerline Trail N1	Static wire removal	10-2023	24.37	1.02	96%
444	0.14	Powerline Trail N1	Diverter installation (LED)	01-2023	24.37	1.02	96%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
445	0.17	Powerline Trail N1	Static wire removal	10-2023	20.66	0.91	96%
445	0.17	Powerline Trail N1	Diverter installation (LED)	01-2023	20.66	0.91	96%
446	0.20	Powerline Trail N1	Static wire removal	10-2023	62.80	2.81	96%
446	0.20	Powerline Trail N1	Diverter installation (LED)	10-2022	62.80	2.81	96%
447	0.15	Powerline Trail N1	Static wire removal	10-2023	48.88	1.93	96%
447	0.15	Powerline Trail N1	Diverter installation (LED)	07-2021	48.88	1.93	96%
448	0.12	Powerline Trail N1	Static wire removal	10-2023	167.13	10.64	94%
448	0.12	Powerline Trail N1	Diverter installation (LED)	01-2023	167.13	10.64	94%
449	0.12	Powerline Trail N1	Static wire removal	10-2023	174.21	9.29	95%
449	0.12	Powerline Trail N1	Diverter installation (LED)	01-2023	174.21	9.29	95%
450	0.20	Powerline Trail N1	Static wire removal	10-2023	44.71	1.05	98%
450	0.20	Powerline Trail N1	Diverter installation (LED)	07-2021	44.71	1.05	98%
451	0.22	Powerline Trail N1	Static wire removal	10-2023	45.25	1.79	96%
451	0.22	Powerline Trail N1	Diverter installation (LED)	07-2021	45.25	1.79	96%
452	0.17	Powerline Trail N1	Static wire removal	10-2023	54.46	2.41	96%
452	0.17	Powerline Trail N1	Diverter installation (LED)	01-2023	54.46	2.41	96%
453	0.13	Powerline Trail N1	Static wire removal	10-2023	27.63	1.36	95%
453	0.13	Powerline Trail N1	Diverter installation (LED)	01-2023	27.63	1.36	95%
454	0.27	Powerline Trail N1	Static wire removal	10-2023	5.83	0.28	95%
454	0.27	Powerline Trail N1	Diverter installation (LED)	01-2023	5.83	0.28	95%
455	0.17	Powerline Trail unminimized	Static wire removal	10-2023	17.66	0.98	94%
455	0.17	Powerline Trail unminimized	Diverter installation (LED)	01-2023	17.66	0.98	94%
456	0.18	Powerline Trail unminimized	Static wire removal	10-2023	10.28	0.37	96%
456	0.18	Powerline Trail unminimized	Diverter installation (LED)	01-2023	10.28	0.37	96%
457	0.19	Powerline Trail unminimized	Static wire removal	10-2023	4.13	0.85	79%
457	0.19	Powerline Trail unminimized	Diverter installation (Reflective)	08-2022	4.13	0.85	79%
458	0.29	Powerline Trail unminimized	Static wire removal	10-2023	10.58	2.85	73%
458	0.29	Powerline Trail unminimized	Diverter installation (Reflective)	09-2022	10.58	2.85	73%
459	0.21	Powerline Trail unminimized	Static wire removal	10-2023	25.53	8.05	68%
459	0.21	Powerline Trail unminimized	Diverter installation (Reflective)	09-2022	25.53	8.05	68%
460	0.15	Powerline Trail unminimized	Static wire removal	09-2023	11.37	3.60	68%
460	0.15	Powerline Trail unminimized	Diverter installation (Reflective)	08-2022	11.37	3.60	68%
461	0.18	Powerline Trail unminimized	Diverter installation (Reflective)	08-2022	10.30	5.98	42%
462	0.40	PLT to Hanalei Tap double circuit Transmission	Diverter installation (Reflective)	10-2022	35.60	20.65	42%
463	0.30	PLT to Hanalei Tap double circuit Transmission	Diverter installation (Reflective)	09-2022	19.60	11.37	42%
464	0.36	PLT to Hanalei Tap double circuit Transmission	Diverter installation (Reflective)	08-2022	1.03	0.60	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
466	0.32	PLT to Hanalei Tap double circuit Transmission	Diverter installation (Reflective)	10-2022	3.61	2.09	42%
467	0.53	PLT to Hanalei Tap double circuit Transmission	Diverter installation (Reflective)	07-2022	5.92	3.43	42%
468	0.18	Hanalei Tap to Hanalei Taro Fields	Diverter installation (Reflective)	06-2022	0.96	0.56	42%
469	0.18	Hanalei Tap to Hanalei Taro Fields	Diverter installation (Reflective)	06-2022	0.96	0.56	42%
470	0.11	Hanalei Tap to Hanalei Taro Fields	Diverter installation (Reflective)	06-2022	6.85	3.97	42%
471	0.07	Hanalei Tap to Hanalei Taro Fields	Diverter installation (Reflective)	06-2022	3.54	2.05	42%
472	0.09	Hanalei Tap to Hanalei Taro Fields	Diverter installation (Reflective)	06-2022	5.22	3.03	42%
473	0.04	Hanalei Tap to Hanalei Taro Fields	Diverter installation (Reflective)	06-2022	2.44	1.42	42%
474	0.04	Hanalei Tap to Hanalei Taro Fields	Diverter installation (Reflective)	06-2022	1.87	1.08	42%
475	0.09	Hanalei Tap to Hanalei Taro Fields	Diverter installation (Reflective)	06-2022	4.09	2.37	42%
476	0.17	Hanalei Tap to Hanalei Taro Fields	Diverter installation (Reflective)	06-2022	7.04	4.08	42%
477	0.10	Hanalei Tap to Hanalei Taro Fields	Diverter installation (Reflective)	03-2022	0.57	0.33	42%
478	0.52	Hanalei Taro Fields to Wainiha Sub	Diverter installation (Reflective)	06-2022	1.66	0.97	42%
486	0.08	Port Allen to Halewili Positron	Diverter installation (Reflective)	06-2022	2.00	0.63	68%
486	0.08	Port Allen to Halewili Positron	Static wire removal	01-2021	2.00	0.63	68%
487	0.08	Port Allen to Halewili Positron	Diverter installation (Reflective)	04-2021	1.99	0.68	66%
487	0.08	Port Allen to Halewili Positron	Static wire removal	01-2021	1.99	0.68	66%
487	0.08	Port Allen to Halewili Positron	Static wire removal	01-2021	1.99	0.68	66%
488	0.07	Port Allen to Halewili Positron	Diverter installation (Reflective)	04-2021	2.01	0.68	66%
488	0.07	Port Allen to Halewili Positron	Static wire removal	01-2021	2.01	0.68	66%
488	0.07	Port Allen to Halewili Positron	Static wire removal	01-2021	2.01	0.68	66%
489	0.07	Port Allen to Halewili Positron	Diverter installation (Reflective)	04-2021	1.94	0.63	68%
489	0.07	Port Allen to Halewili Positron	Static wire removal	01-2021	1.94	0.63	68%
489	0.07	Port Allen to Halewili Positron	Static wire removal	01-2021	1.94	0.63	68%
490	0.07	Port Allen to Halewili Positron	Diverter installation (Reflective)	04-2021	7.76	2.55	67%
490	0.07	Port Allen to Halewili Positron	Static wire removal	01-2021	7.76	2.55	67%
490	0.07	Port Allen to Halewili Positron	Static wire removal	01-2021	7.76	2.55	67%
491	0.07	Port Allen to Halewili Positron	Diverter installation (Reflective)	04-2021	8.61	2.79	68%
491	0.07	Port Allen to Halewili Positron	Static wire removal	01-2021	8.61	2.79	68%
491	0.07	Port Allen to Halewili Positron	Static wire removal	01-2021	8.61	2.79	68%
492	0.07	Port Allen to Halewili Positron	Diverter installation (Reflective)	04-2021	9.51	2.90	70%
492	0.07	Port Allen to Halewili Positron	Static wire removal	01-2021	9.51	2.90	70%
492	0.07	Port Allen to Halewili Positron	Static wire removal	01-2021	9.51	2.90	70%
493	0.07	Port Allen to Halewili Positron	Diverter installation (Reflective)	04-2021	10.13	3.17	69%
493	0.07	Port Allen to Halewili Positron	Static wire removal	01-2021	10.13	3.17	69%
493	0.07	Port Allen to Halewili Positron	Static wire removal	01-2021	10.13	3.17	69%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
494	0.07	Port Allen to Halewili Positron	Diverter installation (Reflective)	04-2021	10.56	3.61	66%
494	0.07	Port Allen to Halewili Positron	Static wire removal	01-2021	10.56	3.61	66%
494	0.07	Port Allen to Halewili Positron	Static wire removal	01-2021	10.56	3.61	66%
495	0.08	Port Allen to Halewili Positron	Diverter installation (Reflective)	04-2021	2.83	0.93	67%
495	0.08	Port Allen to Halewili Positron	Static wire removal	01-2021	2.83	0.93	67%
495	0.08	Port Allen to Halewili Positron	Static wire removal	01-2021	2.83	0.93	67%
496	0.03	Port Allen to Halewili Positron	Diverter installation (Reflective)	04-2021	1.12	0.33	70%
496	0.03	Port Allen to Halewili Positron	Static wire removal	01-2021	1.12	0.33	70%
496	0.03	Port Allen to Halewili Positron	Static wire removal	01-2021	1.12	0.33	70%
497	0.06	Port Allen to Halewili Positron	Diverter installation (Reflective)	04-2021	9.29	3.16	66%
497	0.06	Port Allen to Halewili Positron	Static wire removal	01-2021	9.29	3.16	66%
497	0.06	Port Allen to Halewili Positron	Static wire removal	01-2021	9.29	3.16	66%
498	0.06	Port Allen to Halewili Positron	Diverter installation (Reflective)	04-2021	2.08	0.69	67%
498	0.06	Port Allen to Halewili Positron	Static wire removal	01-2021	2.08	0.69	67%
498	0.06	Port Allen to Halewili Positron	Static wire removal	01-2021	2.08	0.69	67%
499	0.06	Port Allen to Halewili Positron	Diverter installation (Reflective)	04-2021	2.02	0.59	71%
499	0.06	Port Allen to Halewili Positron	Static wire removal	01-2021	2.02	0.59	71%
499	0.06	Port Allen to Halewili Positron	Static wire removal	01-2021	2.02	0.59	71%
500	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.84	0.61	42%
500	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	1.84	0.61	42%
501	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.79	0.65	42%
501	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	1.79	0.65	42%
502	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	4.21	1.42	42%
502	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	4.21	1.42	42%
503	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	8.18	2.72	42%
503	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	8.18	2.72	42%
504	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	5.97	2.11	42%
504	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	5.97	2.11	42%
505	0.08	Halewili Positron to Aepo sub	Static wire removal	01-2024	0.53	0.21	42%
505	0.08	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	0.53	0.21	42%
506	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	11.70	3.81	42%
506	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	11.70	3.81	42%
507	0.03	Halewili Positron to Aepo sub	Static wire removal	01-2024	6.31	2.21	42%
507	0.03	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	6.31	2.21	42%
508	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	12.31	4.27	42%
508	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	12.31	4.27	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
509	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	12.52	4.26	42%
509	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	12.52	4.26	42%
510	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	12.45	4.18	42%
510	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	12.45	4.18	42%
511	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	11.29	3.87	42%
511	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	11.29	3.87	42%
512	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	13.11	4.49	42%
512	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	13.11	4.49	42%
513	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	12.06	4.19	42%
513	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	12.06	4.19	42%
514	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	5.47	1.91	42%
514	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	5.47	1.91	42%
515	0.03	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.30	0.82	42%
515	0.03	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	2.30	0.82	42%
516	0.02	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.28	0.37	42%
516	0.02	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	1.28	0.37	42%
517	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	8.91	3.20	42%
517	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	8.91	3.20	42%
518	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	8.66	2.74	42%
518	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	8.66	2.74	42%
519	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.78	0.50	42%
519	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.78	0.50	42%
520	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.82	0.57	42%
520	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.82	0.57	42%
521	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.26	0.69	42%
521	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	2.26	0.69	42%
522	0.04	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.35	0.48	42%
522	0.04	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.35	0.48	42%
523	0.08	Halewili Positron to Aepo sub	Static wire removal	01-2024	9.94	3.54	42%
523	0.08	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	9.94	3.54	42%
524	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	8.03	2.75	42%
524	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	8.03	2.75	42%
525	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.43	0.91	42%
525	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	2.43	0.91	42%
526	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.34	0.91	42%
526	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	2.34	0.91	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
527	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	10.33	4.00	42%
527	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	10.33	4.00	42%
528	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.05	0.41	42%
528	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.05	0.41	42%
529	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.21	0.42	42%
529	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.21	0.42	42%
530	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	9.08	3.49	42%
530	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	9.08	3.49	42%
531	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	9.09	3.50	42%
531	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	9.09	3.50	42%
532	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.44	0.52	42%
532	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.44	0.52	42%
533	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	11.16	3.77	42%
533	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	11.16	3.77	42%
534	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	20.73	6.95	42%
534	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	20.73	6.95	42%
535	0.08	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.54	0.55	42%
535	0.08	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.54	0.55	42%
536	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.24	0.47	42%
536	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.24	0.47	42%
537	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	9.80	3.74	42%
537	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	9.80	3.74	42%
538	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	10.59	4.05	42%
538	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	10.59	4.05	42%
539	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.99	0.77	42%
539	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.99	0.77	42%
540	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.97	0.75	42%
540	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.97	0.75	42%
541	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	11.39	4.38	42%
541	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	11.39	4.38	42%
542	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.81	0.72	42%
542	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.81	0.72	42%
543	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.57	0.59	42%
543	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.57	0.59	42%
544	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.66	0.58	42%
544	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.66	0.58	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
545	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	4.68	1.55	42%
545	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	4.68	1.55	42%
546	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.51	0.49	42%
546	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.51	0.49	42%
547	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.72	0.58	42%
547	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.72	0.58	42%
548	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	5.27	1.80	42%
548	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	5.27	1.80	42%
549	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	5.12	1.85	42%
549	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	5.12	1.85	42%
550	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	5.06	1.76	42%
550	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	5.06	1.76	42%
551	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	4.83	1.73	42%
551	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	4.83	1.73	42%
552	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.00	0.76	42%
552	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	2.00	0.76	42%
553	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.98	0.72	42%
553	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.98	0.72	42%
554	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	4.91	1.87	42%
554	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	4.91	1.87	42%
555	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	4.96	1.79	42%
555	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	4.96	1.79	42%
556	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	5.24	1.87	42%
556	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	5.24	1.87	42%
557	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	5.36	1.88	42%
557	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	5.36	1.88	42%
558	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	4.23	1.32	42%
558	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	4.23	1.32	42%
559	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.01	0.67	42%
559	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	2.01	0.67	42%
560	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.23	0.82	42%
560	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	2.23	0.82	42%
561	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	4.75	1.76	42%
561	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	4.75	1.76	42%
562	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	11.39	4.20	42%
562	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	11.39	4.20	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
563	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	6.38	2.32	42%
563	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	6.38	2.32	42%
564	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.14	0.78	42%
564	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	2.14	0.78	42%
565	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.88	1.07	42%
565	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	2.88	1.07	42%
566	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	4.46	1.66	42%
566	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	4.46	1.66	42%
567	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.17	0.80	42%
567	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	2.17	0.80	42%
568	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.13	0.76	42%
568	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	2.13	0.76	42%
569	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.00	0.70	42%
569	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	2.00	0.70	42%
570	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.03	0.74	42%
570	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	2.03	0.74	42%
571	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	4.83	1.73	42%
571	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	4.83	1.73	42%
572	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	4.70	1.63	42%
572	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	4.70	1.63	42%
573	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	4.61	1.59	42%
573	0.07	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	4.61	1.59	42%
574	0.02	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.23	0.69	42%
574	0.02	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	2.23	0.69	42%
575	0.02	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.64	0.39	42%
575	0.02	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.64	0.39	42%
576	0.03	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.63	0.47	42%
576	0.03	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	1.63	0.47	42%
577	0.05	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.44	0.58	42%
577	0.05	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	2.44	0.58	42%
578	0.04	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.03	0.53	42%
578	0.04	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	2.03	0.53	42%
579	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.69	0.81	42%
579	0.06	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	2.69	0.81	42%
580	0.08	Halewili Positron to Aepo sub	Static wire removal	01-2024	4.64	0.73	42%
580	0.08	Halewili Positron to Aepo sub	Diverter installation (Reflective)	04-2021	4.64	0.73	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
581	0.24	Halewili Positron to Aepo sub	Static wire removal	07-2016	2.35	0.85	64%
582	0.08	Halewili Positron to Aepo sub	Diverter installation (Reflective)	06-2022	1.31	0.76	42%
583	0.08	Halewili Positron to Aepo sub	Static wire removal	01-2024	5.22	0.94	42%
583	0.08	Halewili Positron to Aepo sub	Diverter installation (Reflective)	03-2021	5.22	0.94	42%
584	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	3.45	0.13	90%
585	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	4.32	0.18	90%
586	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.93	0.08	90%
587	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.90	0.08	90%
588	0.04	Halewili Positron to Aepo sub	Static wire removal	01-2024	3.56	0.15	90%
589	0.05	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.20	0.05	90%
590	0.08	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.84	0.07	90%
591	0.05	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.32	0.05	90%
592	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.45	0.06	90%
593	0.07	Halewili Positron to Aepo sub	Static wire removal	01-2024	1.57	0.06	90%
594	0.06	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.12	0.08	90%
595	0.08	Halewili Positron to Aepo sub	Static wire removal	01-2024	2.48	0.51	42%
595	0.08	Halewili Positron to Aepo sub	Diverter installation (Reflective)	12-2021	2.48	0.51	42%
597	0.07	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	5.62	1.56	42%
597	0.07	Aepo sub to Kukuiula Riser	Diverter installation (Reflective)	12-2021	5.62	1.56	42%
598	0.10	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	9.26	3.00	42%
598	0.10	Aepo sub to Kukuiula Riser	Diverter installation (Reflective)	12-2021	9.26	3.00	42%
599	0.06	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	1.38	0.57	0%
600	0.08	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	1.87	0.68	0%
601	0.10	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	5.70	1.76	42%
601	0.10	Aepo sub to Kukuiula Riser	Diverter installation (Reflective)	06-2022	5.70	1.76	42%
602.1	0.10	Aepo sub to Kukuiula Riser	Static wire removal	12-2023	6.96	2.50	64%
602.1	0.14	Aepo sub to Kukuiula Riser	Diverter installation (Reflective)	12-2021	6.96	2.50	64%
602.2	0.13	Aepo sub to Kukuiula Riser	Diverter installation (Reflective)	12-2021	5.60	3.25	42%
603	0.09	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	4.19	1.07	42%
603	0.09	Aepo sub to Kukuiula Riser	Diverter installation (Reflective)	12-2021	4.19	1.07	42%
604	0.05	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	4.27	1.08	42%
604	0.05	Aepo sub to Kukuiula Riser	Diverter installation (Reflective)	12-2021	4.27	1.08	42%
605	0.05	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	4.82	1.23	42%
605	0.05	Aepo sub to Kukuiula Riser	Diverter installation (Reflective)	12-2021	4.82	1.23	42%
606	0.08	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	4.61	1.13	42%
606	0.08	Aepo sub to Kukuiula Riser	Diverter installation (Reflective)	12-2021	4.61	1.13	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
607	0.07	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	2.94	1.10	0%
608	0.06	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	2.54	1.05	0%
609	0.07	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	2.43	0.89	0%
610	0.08	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	2.04	0.58	0%
611	0.07	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	3.65	1.63	0%
612	0.06	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	5.60	1.33	42%
612	0.06	Aepo sub to Kukuiula Riser	Diverter installation (Reflective)	12-2021	5.60	1.33	42%
613	0.07	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	7.21	1.96	42%
613	0.07	Aepo sub to Kukuiula Riser	Diverter installation (Reflective)	12-2021	7.21	1.96	42%
614	0.10	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	8.44	2.46	42%
614	0.10	Aepo sub to Kukuiula Riser	Diverter installation (Reflective)	12-2021	8.44	2.46	42%
615	0.09	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	2.44	0.69	0%
616	0.06	Aepo sub to Kukuiula Riser	Static wire removal	03-2024	1.95	0.82	0%
619	0.06	Kiahuna Golf to Koloa Sub	Static wire removal	12-2023	1.99	0.98	51%
620	0.07	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	2.07	0.93	0%
621	0.07	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	1.57	0.71	0%
622	0.07	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	2.10	0.95	0%
623	0.07	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	2.29	1.13	0%
624	0.07	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	7.56	2.28	42%
624	0.07	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	11-2021	7.56	2.28	42%
625	0.07	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	2.01	1.11	0%
626	0.06	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	1.77	1.03	0%
627	0.07	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	8.30	2.87	42%
627	0.07	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	12-2021	8.30	2.87	42%
628	0.06	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	1.89	1.10	0%
629	0.07	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	2.06	0.60	42%
629	0.07	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	12-2021	2.06	0.60	42%
630	0.07	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	7.96	2.09	42%
630	0.07	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	11-2021	7.96	2.09	42%
631	0.07	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	7.93	2.25	42%
631	0.07	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	11-2021	7.93	2.25	42%
632	0.06	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	8.21	2.37	42%
632	0.06	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	11-2021	8.21	2.37	42%
633	0.06	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	7.72	2.19	42%
633	0.06	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	04-2021	7.72	2.19	42%
634	0.06	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	8.17	2.82	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
634	0.06	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	04-2021	8.17	2.82	42%
635	0.06	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	8.37	2.89	42%
635	0.06	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	04-2021	8.37	2.89	42%
636	0.06	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	2.75	0.94	42%
636	0.06	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	04-2021	2.75	0.94	42%
637	0.06	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	2.71	0.88	42%
637	0.06	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	04-2021	2.71	0.88	42%
638	0.06	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	8.79	2.83	42%
638	0.06	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	04-2021	8.79	2.83	42%
639	0.06	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	1.56	0.49	42%
639	0.06	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	04-2021	1.56	0.49	42%
640	0.06	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	1.59	0.53	42%
640	0.06	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	04-2021	1.59	0.53	42%
641	0.06	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	7.88	2.29	42%
641	0.06	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	04-2021	7.88	2.29	42%
642	0.03	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	3.87	1.23	42%
642	0.03	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	06-2022	3.87	1.23	42%
643	0.04	Kiahuna Golf to Koloa Sub	Static wire removal	03-2024	4.32	1.29	42%
643	0.04	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	10-2021	4.32	1.29	42%
644	0.04	Kiahuna Golf to Koloa Sub	Diverter installation (Reflective)	12-2021	N/A	N/A	N/A
645	0.06	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	12-2021	N/A	N/A	N/A
645	0.06	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	N/A	N/A	N/A
646	0.06	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	8.64	2.58	70%
646	0.06	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	04-2021	8.64	2.58	70%
647	0.07	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	9.69	2.87	70%
647	0.07	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	04-2021	9.69	2.87	70%
648	0.07	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	10.06	2.96	71%
648	0.07	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	04-2021	10.06	2.96	71%
649	0.07	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	11.54	3.63	69%
649	0.07	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	04-2021	11.54	3.63	69%
650	0.07	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	11.55	3.60	69%
650	0.07	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	04-2021	11.55	3.60	69%
651	0.09	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	14.66	3.96	73%
651	0.09	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	04-2021	14.66	3.96	73%
652	0.10	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	11-2021	12.08	3.23	73%
652	0.10	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	12.08	3.23	73%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
653	0.13	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	11-2021	15.44	4.58	70%
653	0.13	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	15.44	4.58	70%
654	0.11	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	11-2021	15.25	4.01	74%
654	0.11	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	15.25	4.01	74%
655	0.09	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	11-2021	8.37	2.07	75%
655	0.09	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	8.37	2.07	75%
656	0.10	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	11-2021	17.80	4.36	76%
656	0.10	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	17.80	4.36	76%
657	0.09	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	12-2021	8.58	1.75	80%
657	0.09	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	8.58	1.75	80%
658	0.10	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	12-2021	1.79	0.41	77%
658	0.10	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	1.79	0.41	77%
659	0.09	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	12-2021	6.38	1.25	80%
659	0.09	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	6.38	1.25	80%
660	0.09	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	12-2021	7.75	2.02	74%
660	0.09	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	7.75	2.02	74%
661	0.11	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	12-2021	6.88	1.63	76%
661	0.11	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	6.88	1.63	76%
662	0.19	Koloa Sub to Waita Reservoir	Diverter installation (Reflective)	12-2021	1.69	0.41	76%
662	0.19	Koloa Sub to Waita Reservoir	Static wire removal	04-2021	1.69	0.41	76%
667	0.40	Waita Reservoir - Knudsen Gap(hwy)	Diverter installation (Reflective)	12-2021	11.48	2.21	81%
667	0.40	Waita Reservoir - Knudsen Gap(hwy)	Static wire removal	05-2021	11.48	2.21	81%
668	0.35	Waita Reservoir - Knudsen Gap(hwy)	Static wire removal	05-2021	9.86	0.18	98%
669	0.15	Waita Reservoir - Knudsen Gap(hwy)	Static wire removal	05-2021	0.99	0.55	45%
670	0.14	Waita Reservoir - Knudsen Gap(hwy)	Static wire removal	05-2021	8.25	0.41	95%
671	0.26	Waita Reservoir - Knudsen Gap(hwy)	Static wire removal	04-2021	15.44	0.69	96%
672	0.24	Waita Reservoir - Knudsen Gap(hwy)	Static wire removal	04-2021	2.99	0.06	98%
674	0.18	Waita Reservoir - Knudsen Gap(hwy)	Diverter installation (Reflective)	01-2023	5.47	1.96	64%
674	0.18	Waita Reservoir - Knudsen Gap(hwy)	Static wire removal	05-2021	5.47	1.96	64%
675	0.44	Waita Reservoir - Knudsen Gap(hwy)	Diverter installation (Reflective)	01-2023	13.26	3.70	72%
675	0.44	Waita Reservoir - Knudsen Gap(hwy)	Static wire removal	05-2021	13.26	3.70	72%
676	0.29	Waita Reservoir - Knudsen Gap(hwy)	Diverter installation (Reflective)	09-2022	3.46	0.65	81%
676	0.29	Waita Reservoir - Knudsen Gap(hwy)	Static wire removal	04-2021	3.46	0.65	81%
677	0.10	Knudsen Gap(hwy) - Green Energy Sub	Diverter installation (Reflective)	09-2022	1.24	0.40	68%
677	0.10	Knudsen Gap(hwy) - Green Energy Sub	Static wire removal	04-2021	1.24	0.40	68%
678	0.11	Knudsen Gap(hwy) - Green Energy Sub	Diverter installation (Reflective)	12-2021	7.37	1.52	79%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
678	0.11	Knudsen Gap(hwy) - Green Energy Sub	Static wire removal	04-2021	7.37	1.52	79%
679	0.10	Knudsen Gap(hwy) - Green Energy Sub	Diverter installation (Reflective)	12-2021	6.97	4.04	42%
680	0.08	Green Energy Sub - Fujita Tap	Diverter installation (Reflective)	12-2021	8.94	5.18	42%
691	0.21	Fujita tap - Kilohana tap	Diverter installation (Reflective)	09-2022	15.97	9.26	42%
699	0.11	Fujita tap - Kilohana tap	Diverter installation (Reflective)	08-2021	14.26	8.27	42%
700	0.09	Fujita tap - Kilohana tap	Diverter installation (Reflective)	08-2021	9.98	5.79	42%
702	0.07	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	08-2021	22.25	1.96	91%
702	0.07	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	22.25	1.96	91%
703	0.09	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	07-2021	16.11	2.04	87%
703	0.09	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	16.11	2.04	87%
704	0.09	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	07-2021	10.39	1.37	87%
704	0.09	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	10.39	1.37	87%
705	0.09	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	07-2021	5.45	0.66	88%
705	0.09	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	5.45	0.66	88%
706	0.08	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	07-2021	61.22	7.19	88%
706	0.08	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	61.22	7.19	88%
707	0.18	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	09-2021	130.22	22.37	83%
707	0.18	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	130.22	22.37	83%
708	0.14	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	09-2021	150.44	25.46	83%
708	0.14	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	150.44	25.46	83%
709	0.09	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	09-2021	97.04	16.07	83%
709	0.09	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	97.04	16.07	83%
710	0.09	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	09-2021	31.87	4.73	85%
710	0.09	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	31.87	4.73	85%
711	0.16	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	09-2021	55.91	8.11	86%
711	0.16	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	55.91	8.11	86%
712	0.12	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	09-2021	20.43	2.08	90%
712	0.12	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	20.43	2.08	90%
713	0.11	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	09-2021	18.64	2.71	85%
713	0.11	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	18.64	2.71	85%
714	0.10	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	09-2021	62.81	6.88	89%
714	0.10	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	62.81	6.88	89%
715	0.20	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	03-2022	132.76	26.46	80%
715	0.20	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	132.76	26.46	80%
716	0.36	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	03-2022	25.16	4.90	81%
716	0.36	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	25.16	4.90	81%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
717	0.19	Kilohana tap - Lihue sub(a) (LC1)	Diverter installation (Reflective)	03-2022	9.49	1.78	81%
717	0.19	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	9.49	1.78	81%
718	0.31	Kilohana tap - Lihue sub(a) (LC1)	Static wire removal	05-2020	40.09	2.92	93%
719	0.15	Kilohana tap - Lihue sub(b)	Static wire removal	05-2020	34.23	2.42	93%
720	0.12	Kilohana tap - Lihue sub(b)	Static wire removal	05-2020	54.77	3.47	94%
721	0.18	Kilohana tap - Lihue sub(b)	Static wire removal	05-2020	82.32	4.27	95%
722	0.13	Kilohana tap - Lihue sub(b)	Diverter installation (Reflective)	03-2022	1.91	0.69	64%
722	0.13	Kilohana tap - Lihue sub(b)	Static wire removal	05-2020	1.91	0.69	64%
723	0.22	Kilohana tap - Lihue sub(b)	Diverter installation (Reflective)	03-2022	3.11	1.29	59%
723	0.22	Kilohana tap - Lihue sub(b)	Static wire removal	05-2020	3.11	1.29	59%
724	0.33	Kilohana tap - Lihue sub(b)	Static wire removal	05-2020	8.48	0.47	94%
725	0.30	Kilohana tap - Lihue sub(b)	Diverter installation (Reflective)	12-2021	7.88	2.39	70%
725	0.30	Kilohana tap - Lihue sub(b)	Static wire removal	05-2020	7.88	2.39	70%
726	0.09	Kilohana tap - Lihue sub(b)	Static wire removal	06-2023	15.88	0.94	94%
727	0.07	Kilohana tap - Lihue sub(b)	Static wire removal	06-2023	1.44	0.35	76%
727	0.07	Kilohana tap - Lihue sub(b)	Diverter installation (Reflective)	12-2021	1.44	0.35	76%
728	0.08	Kilohana tap - Lihue sub(b)	Static wire removal	06-2023	1.56	0.46	70%
728	0.08	Kilohana tap - Lihue sub(b)	Diverter installation (Reflective)	05-2022	1.56	0.46	70%
729	0.10	Kilohana tap - Lihue sub(b)	Static wire removal	06-2023	0.94	0.32	66%
729	0.10	Kilohana tap - Lihue sub(b)	Diverter installation (Reflective)	12-2021	0.94	0.32	66%
730	0.26	Kilohana tap - Lihue sub(b)	Static wire removal	06-2023	2.32	0.61	74%
730	0.26	Kilohana tap - Lihue sub(b)	Diverter installation (Reflective)	05-2022	2.32	0.61	74%
731	0.11	Kilohana tap - Lihue sub(b)	Static wire removal	06-2023	2.23	0.45	80%
731	0.11	Kilohana tap - Lihue sub(b)	Diverter installation (Reflective)	05-2022	2.23	0.45	80%
732	0.09	Kilohana tap - Lihue sub(b)	Static wire removal	06-2023	1.81	0.28	84%
732	0.09	Kilohana tap - Lihue sub(b)	Diverter installation (Reflective)	05-2022	1.81	0.28	84%
733	0.05	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	4.92	2.85	42%
734	0.04	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	3.57	2.07	42%
735	0.05	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	4.79	2.78	42%
736	0.04	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	7.11	4.13	42%
737	0.02	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	2.90	1.68	42%
738	0.02	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	2.75	1.59	42%
739	0.10	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	16.71	9.69	42%
740	0.04	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	11.57	6.71	42%
741	0.09	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	1.44	0.84	42%
742	0.06	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	1.34	0.78	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
743	0.05	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	13.36	7.75	42%
744	0.04	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	10.32	5.98	42%
745	0.04	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	10.53	6.11	42%
746	0.04	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	10.76	6.24	42%
747	0.05	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	15.01	8.71	42%
748	0.01	Lihue sub - Ehiku street	Diverter installation (Reflective)	05-2022	1.42	0.82	42%
748	0.01	Lihue sub - Ehiku street	Static wire removal	05-2022	1.42	0.82	42%
749	0.04	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	16.31	4.50	72%
749	0.04	Ehiku street - Kapaia sub	Static wire removal	01-2021	16.31	4.50	72%
750	0.06	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	1.49	0.27	82%
750	0.06	Ehiku street - Kapaia sub	Static wire removal	01-2021	1.49	0.27	82%
751	0.05	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	1.48	0.24	84%
751	0.05	Ehiku street - Kapaia sub	Static wire removal	01-2021	1.48	0.24	84%
752	0.05	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	16.51	2.73	83%
752	0.05	Ehiku street - Kapaia sub	Static wire removal	01-2021	16.51	2.73	83%
753	0.05	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	2.26	0.38	83%
753	0.05	Ehiku street - Kapaia sub	Static wire removal	01-2021	2.26	0.38	83%
754	0.04	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	1.90	0.32	83%
754	0.04	Ehiku street - Kapaia sub	Static wire removal	01-2021	1.90	0.32	83%
755	0.05	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	13.84	2.38	83%
755	0.05	Ehiku street - Kapaia sub	Static wire removal	01-2021	13.84	2.38	83%
756	0.05	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	14.26	2.44	83%
756	0.05	Ehiku street - Kapaia sub	Static wire removal	01-2021	14.26	2.44	83%
757	0.04	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	1.82	0.31	83%
757	0.04	Ehiku street - Kapaia sub	Static wire removal	01-2021	1.82	0.31	83%
758	0.05	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	2.08	0.34	83%
758	0.05	Ehiku street - Kapaia sub	Static wire removal	01-2021	2.08	0.34	83%
759	0.06	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	16.33	2.86	82%
759	0.06	Ehiku street - Kapaia sub	Static wire removal	01-2021	16.33	2.86	82%
760	0.04	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	17.54	3.01	83%
760	0.04	Ehiku street - Kapaia sub	Static wire removal	01-2021	17.54	3.01	83%
761	0.07	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	21.16	3.46	84%
761	0.07	Ehiku street - Kapaia sub	Static wire removal	01-2021	21.16	3.46	84%
762	0.06	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	21.97	3.58	84%
762	0.06	Ehiku street - Kapaia sub	Static wire removal	01-2021	21.97	3.58	84%
763	0.05	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	1.69	0.37	78%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
763	0.05	Ehiku street - Kapaia sub	Static wire removal	01-2021	1.69	0.37	78%
764	0.05	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	1.69	0.34	80%
764	0.05	Ehiku street - Kapaia sub	Static wire removal	01-2021	1.69	0.34	80%
765	0.05	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	12.00	2.43	80%
765	0.05	Ehiku street - Kapaia sub	Static wire removal	01-2021	12.00	2.43	80%
766	0.06	Ehiku street - Kapaia sub	Diverter installation (Reflective)	04-2021	6.53	1.01	85%
766	0.06	Ehiku street - Kapaia sub	Static wire removal	01-2021	6.53	1.01	85%
767	0.04	Ehiku street - Kapaia sub	Diverter installation (Reflective)	05-2022	10.62	6.16	42%
769	0.04	Ehiku street - Kapaia valley	Static wire removal	12-2023	11.48	6.66	42%
769	0.04	Ehiku street - Kapaia valley	Diverter installation (Reflective)	05-2022	11.48	6.66	42%
770	0.04	Ehiku street - Kapaia valley	Static wire removal	12-2023	13.34	7.74	42%
770	0.04	Ehiku street - Kapaia valley	Diverter installation (Reflective)	05-2022	13.34	7.74	42%
771	0.02	Ehiku street - Kapaia valley	Static wire removal	12-2023	1.18	0.69	42%
771	0.02	Ehiku street - Kapaia valley	Diverter installation (Reflective)	05-2022	1.18	0.69	42%
772	0.04	Ehiku street - Kapaia valley	Static wire removal	12-2023	3.01	1.74	42%
772	0.04	Ehiku street - Kapaia valley	Diverter installation (Reflective)	05-2022	3.01	1.74	42%
773	0.04	Ehiku street - Kapaia valley	Static wire removal	12-2023	12.94	7.51	42%
773	0.04	Ehiku street - Kapaia valley	Diverter installation (Reflective)	05-2022	12.94	7.51	42%
774	0.05	Ehiku street - Kapaia valley	Static wire removal	12-2023	13.52	7.84	42%
774	0.05	Ehiku street - Kapaia valley	Diverter installation (Reflective)	05-2022	13.52	7.84	42%
775.1	0.03	Ehiku street - Kapaia valley	Static wire removal	12-2023	13.16	7.63	42%
775.1	0.03	Ehiku street - Kapaia valley	Diverter installation (Reflective)	05-2022	13.16	7.63	42%
775.2	0.03	Ehiku street - Kapaia valley	Static wire removal	12-2023	13.32	7.73	42%
775.2	0.03	Ehiku street - Kapaia valley	Diverter installation (Reflective)	05-2022	13.32	7.73	42%
778	0.13	Ehiku street - Kapaia valley	Diverter installation (Reflective)	05-2022	2.28	1.32	42%
779	0.06	Ehiku street - Kapaia valley	Diverter installation (Reflective)	05-2022	1.17	0.68	42%
780	0.14	Ehiku street - Kapaia valley	Diverter installation (Reflective)	05-2022	27.17	15.76	42%
781	0.10	Ehiku street - Kapaia valley	Diverter installation (Reflective)	05-2022	17.92	10.39	42%
782	0.04	Ehiku street - Kapaia valley	Diverter installation (Reflective)	07-2022	2.85	1.65	42%
783	0.04	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	4.54	2.63	42%
784	0.02	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	3.51	2.04	42%
785	0.03	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	5.05	2.93	42%
786	0.08	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	9.70	5.63	42%
787	0.04	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	9.69	5.62	42%
788	0.04	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	10.51	6.10	42%
789	0.07	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	20.11	11.66	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
790	0.08	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	20.37	11.81	42%
791	0.06	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	14.08	8.17	42%
792	0.05	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	13.33	7.73	42%
793	0.06	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	12.10	7.02	42%
794	0.05	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	10.70	6.21	42%
795	0.04	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	9.84	5.71	42%
796	0.06	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	12.19	7.07	42%
797	0.03	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	1.55	0.90	42%
798	0.04	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	1.43	0.83	42%
799	0.08	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	14.05	8.15	42%
800	0.07	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	4.95	2.87	42%
801	0.06	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	4.45	2.58	42%
802.1	0.03	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	5.57	3.23	42%
802.2	0.03	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	05-2022	2.58	1.49	42%
803	0.06	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	05-2022	3.26	1.89	42%
804	0.07	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	2.82	1.63	42%
805	0.04	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	07-2022	1.48	0.86	42%
806	0.03	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	05-2022	4.71	2.73	42%
807	0.07	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	05-2022	9.65	5.60	42%
808	0.06	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	05-2022	3.81	2.21	42%
809	0.03	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	05-2022	1.85	1.08	42%
810	0.06	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	04-2023	3.64	2.11	42%
811	0.04	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	05-2022	2.68	1.56	42%
812	0.06	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	05-2022	9.53	5.53	42%
813	0.08	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	05-2022	2.82	1.63	42%
814	0.09	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	05-2022	3.18	1.85	42%
815	0.08	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	05-2022	3.46	2.01	42%
816.1	0.04	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	1.65	0.96	42%
816.2	0.04	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	6.77	3.93	42%
817	0.08	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	05-2022	3.26	1.89	42%
818	0.08	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	3.36	1.95	42%
819	0.09	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	13.46	7.81	42%
820	0.08	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	12.49	7.24	42%
821	0.08	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	9.33	5.41	42%
822	0.08	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	8.52	4.94	42%
823	0.03	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	1.40	0.81	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
824	0.06	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	3.36	1.95	42%
825	0.08	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	7.84	4.55	42%
826	0.08	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	7.90	4.58	42%
827	0.07	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	7.31	4.24	42%
828	0.06	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	4.44	2.57	42%
829	0.06	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	4.55	2.64	42%
830	0.06	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	05-2022	3.12	1.81	42%
831	0.07	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	3.51	2.04	42%
832	0.04	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	2.12	1.23	42%
833	0.07	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	3.06	1.78	42%
834	0.04	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	1.80	1.05	42%
835	0.03	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	2.12	1.23	42%
836	0.03	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	2.05	1.19	42%
837	0.02	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	2.14	1.24	42%
838	0.04	Kapaia Valley - Lydgate sub	Static wire removal	06-2023	4.72	1.38	71%
838	0.04	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	4.72	1.38	71%
839	0.05	Kapaia Valley - Lydgate sub	Static wire removal	06-2023	4.49	1.31	71%
839	0.05	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	4.49	1.31	71%
840	0.09	Kapaia Valley - Lydgate sub	Static wire removal	06-2023	7.54	2.35	69%
840	0.09	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	7.54	2.35	69%
841	0.09	Kapaia Valley - Lydgate sub	Static wire removal	06-2023	8.42	2.44	71%
841	0.09	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	8.42	2.44	71%
842	0.09	Kapaia Valley - Lydgate sub	Static wire removal	06-2023	8.87	2.77	69%
842	0.09	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	04-2023	8.87	2.77	69%
843	0.09	Kapaia Valley - Lydgate sub	Static wire removal	06-2023	4.41	1.47	67%
843	0.09	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	4.41	1.47	67%
844	0.10	Kapaia Valley - Lydgate sub	Static wire removal	06-2023	4.36	1.33	70%
844	0.10	Kapaia Valley - Lydgate sub	Diverter installation (Reflective)	08-2022	4.36	1.33	70%
846	0.06	Lydgate sub - Kuamoo Rd	Static wire removal	06-2023	9.30	2.95	68%
846	0.06	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	08-2022	9.30	2.95	68%
847	0.03	Lydgate sub - Kuamoo Rd	Static wire removal	06-2023	3.12	1.10	65%
847	0.03	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	08-2022	3.12	1.10	65%
848	0.04	Lydgate sub - Kuamoo Rd	Static wire removal	06-2023	4.73	1.66	65%
848	0.04	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	08-2022	4.73	1.66	65%
849	0.05	Lydgate sub - Kuamoo Rd	Static wire removal	06-2023	4.66	1.60	66%
849	0.05	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	08-2022	4.66	1.60	66%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
850	0.04	Lydgate sub - Kuamoo Rd	Static wire removal	06-2023	3.84	1.31	66%
850	0.04	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	08-2022	3.84	1.31	66%
851	0.05	Lydgate sub - Kuamoo Rd	Static wire removal	06-2023	2.59	0.88	66%
851	0.05	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	08-2022	2.59	0.88	66%
852	0.03	Lydgate sub - Kuamoo Rd	Static wire removal	06-2023	1.92	0.69	64%
852	0.03	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	08-2022	1.92	0.69	64%
853	0.04	Lydgate sub - Kuamoo Rd	Static wire removal	06-2023	5.90	2.06	65%
853	0.04	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	08-2022	5.90	2.06	65%
854	0.03	Lydgate sub - Kuamoo Rd	Static wire removal	06-2023	6.04	2.12	65%
854	0.03	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	08-2022	6.04	2.12	65%
855	0.05	Lydgate sub - Kuamoo Rd	Static wire removal	06-2023	7.77	2.78	64%
855	0.05	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	08-2022	7.77	2.78	64%
856	0.05	Lydgate sub - Kuamoo Rd	Static wire removal	06-2023	6.60	2.33	65%
856	0.05	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	08-2022	6.60	2.33	65%
857	0.04	Lydgate sub - Kuamoo Rd	Static wire removal	06-2023	5.26	1.84	65%
857	0.04	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	08-2022	5.26	1.84	65%
858	0.03	Lydgate sub - Kuamoo Rd	Static wire removal	06-2023	3.76	1.30	65%
858	0.03	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	10-2022	3.76	1.30	65%
859	0.03	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	10-2022	2.69	1.56	42%
860	0.05	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	10-2022	3.83	2.22	42%
861	0.08	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	08-2022	0.99	0.57	42%
862	0.10	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	04-2023	1.32	0.77	42%
863	0.04	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	04-2023	2.09	1.21	42%
864	0.04	Lydgate sub - Kuamoo Rd	Diverter installation (Reflective)	04-2023	2.17	1.26	42%
865	0.04	Kuamoo Rd - Kapaa Bypass Rd (Wailua widening project 2020-2021)	Diverter installation (Reflective)	04-2023	1.80	1.04	42%
866	0.05	Kuamoo Rd - Kapaa Bypass Rd (Wailua widening project 2020-2021)	Diverter installation (Reflective)	05-2022	1.89	1.09	42%
867	0.05	Kuamoo Rd - Kapaa Bypass Rd (Wailua widening project 2020-2021)	Diverter installation (Reflective)	05-2022	1.58	0.92	42%
868	0.04	Kuamoo Rd - Kapaa Bypass Rd (Wailua widening project 2020-2021)	Diverter installation (Reflective)	05-2022	1.32	0.76	42%
869	0.04	Kuamoo Rd - Kapaa Bypass Rd (Wailua widening project 2020-2021)	Diverter installation (Reflective)	05-2022	1.30	0.76	42%
870	0.04	Kuamoo Rd - Kapaa Bypass Rd (Wailua widening project 2020-2021)	Diverter installation (Reflective)	05-2022	1.48	0.86	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
871	0.04	Kuamoo Rd - Kapaa Bypass Rd (Wailua widening project 2020-2021)	Diverter installation (Reflective)	05-2022	1.70	0.98	42%
872	0.03	Kuamoo Rd - Kapaa Bypass Rd (Wailua widening project 2020-2021)	Diverter installation (Reflective)	05-2022	1.41	0.82	42%
873	0.04	Kuamoo Rd - Kapaa Bypass Rd (Wailua widening project 2020-2021)	Diverter installation (Reflective)	04-2023	2.57	1.49	42%
874	0.06	Kuamoo Rd - Kapaa Bypass Rd (Wailua widening project 2020-2021)	Diverter installation (Reflective)	05-2022	5.43	3.15	42%
875	0.06	Kuamoo Rd - Kapaa Bypass Rd (Wailua widening project 2020-2021)	Diverter installation (Reflective)	05-2022	5.94	3.44	42%
876	0.05	Kuamoo Rd - Kapaa Bypass Rd (Wailua widening project 2020-2021)	Diverter installation (Reflective)	05-2022	4.70	2.73	42%
877	0.04	Kuamoo Rd - Kapaa Bypass Rd (Wailua widening project 2020-2021)	Diverter installation (Reflective)	05-2022	4.89	2.84	42%
878	0.04	Kuamoo Rd - Kapaa Bypass Rd (Wailua widening project 2020-2021)	Diverter installation (Reflective)	05-2022	4.65	2.69	42%
879	0.04	Kuamoo Rd - Kapaa Bypass Rd (Wailua widening project 2020-2021)	Diverter installation (Reflective)	05-2022	3.99	2.31	42%
880	0.05	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	5.69	3.30	42%
881	0.04	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	4.77	2.77	42%
882	0.04	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	4.67	2.71	42%
883	0.04	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	4.30	2.49	42%
884	0.04	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	3.97	2.30	42%
885	0.04	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	3.88	2.25	42%
886	0.04	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	4.01	2.33	42%
887	0.04	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	4.33	2.51	42%
888	0.04	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	4.41	2.56	42%
889	0.02	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	2.33	1.35	42%
890	0.03	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	2.63	1.52	42%
891	0.03	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	2.58	1.50	42%
892	0.04	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	1.87	1.08	42%
893	0.03	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	1.55	0.90	42%
894	0.04	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	1.40	0.81	42%
895	0.03	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	2.12	1.23	42%
896	0.05	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	4.04	2.35	42%
897	0.04	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	4.49	2.60	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
898	0.04	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	4.93	2.86	42%
899	0.03	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	2.54	1.47	42%
900	0.03	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	09-2022	2.74	1.59	42%
901	0.03	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	05-2022	1.60	0.93	42%
902	0.03	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	05-2022	1.49	0.86	42%
903	0.03	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	05-2022	1.33	0.77	42%
904	0.05	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	05-2022	3.15	1.83	42%
905	0.06	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	05-2022	4.82	2.79	42%
906	0.02	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	06-2022	1.43	0.83	42%
907	0.02	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	06-2022	1.61	0.93	42%
908	0.03	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	06-2022	2.12	1.23	42%
909	0.03	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	06-2022	2.29	1.33	42%
910	0.03	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	06-2022	2.11	1.22	42%
911	0.06	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	06-2022	4.30	2.50	42%
912	0.06	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	06-2022	4.77	2.77	42%
913	0.06	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	06-2022	6.87	3.99	42%
914	0.06	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	06-2022	5.31	3.08	42%
915	0.06	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	06-2022	4.86	2.82	42%
916	0.02	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	06-2022	2.00	1.16	42%
917	0.03	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	06-2022	2.36	1.37	42%
919	0.01	Kapaa Bypass Rd - Kapaa sub	Diverter installation (Reflective)	06-2022	0.71	0.41	42%
920	0.04	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	3.75	1.56	59%
921	0.04	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	05-2021	5.27	1.63	69%
921	0.04	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	5.27	1.63	69%
922	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	05-2021	7.57	2.08	72%
922	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	05-2021	7.57	2.08	72%
922	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	7.57	2.08	72%
923	0.09	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	05-2021	10.52	3.11	70%
923	0.09	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	10.52	3.11	70%
924	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	2.48	0.41	83%
924	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	2.48	0.41	83%
925	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	2.60	0.45	83%
925	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	2.60	0.45	83%
926	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	3.95	0.77	81%
926	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	3.95	0.77	81%
926	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	3.95	0.77	81%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
927	0.06	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	01-2022	3.35	0.82	75%
927	0.06	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	3.35	0.82	75%
928	0.17	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	01-2022	2.45	1.42	42%
928	0.17	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	2.45	1.42	42%
929	0.09	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	01-2022	1.24	0.37	70%
929	0.09	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	1.24	0.37	70%
930	0.12	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	1.96	0.60	69%
930	0.12	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	1.96	0.60	69%
931	0.16	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	2.48	0.77	69%
931	0.16	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	2.48	0.77	69%
932	0.09	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	01-2022	1.61	0.47	71%
932	0.09	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	1.61	0.47	71%
933	0.11	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	01-2022	2.09	0.48	77%
933	0.11	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	2.09	0.48	77%
934	0.11	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	01-2022	6.00	1.66	72%
934	0.11	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	6.00	1.66	72%
935	0.16	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	01-2022	9.11	2.57	72%
935	0.16	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	9.11	2.57	72%
936	0.11	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	01-2022	1.95	0.46	76%
936	0.11	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	1.95	0.46	76%
937	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	1.24	0.30	75%
937	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	1.24	0.30	75%
938	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	1.52	0.33	78%
938	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	1.52	0.33	78%
939	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	1.54	0.35	77%
939	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	1.54	0.35	77%
940	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	6.58	1.51	77%
940	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	6.58	1.51	77%
941	0.06	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	5.22	1.27	76%
941	0.06	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	5.22	1.27	76%
942	0.09	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	7.26	1.64	77%
942	0.09	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	7.26	1.64	77%
943	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	6.22	1.46	77%
943	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	6.22	1.46	77%
944	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	7.11	1.57	78%
944	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	7.11	1.57	78%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
945	0.06	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	4.39	0.88	80%
945	0.06	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	4.39	0.88	80%
946	0.21	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	1.76	0.26	85%
946	0.21	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	1.76	0.26	85%
947	0.09	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	0.76	0.11	85%
947	0.09	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	0.76	0.11	85%
948	0.05	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	3.84	0.68	82%
948	0.05	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	3.84	0.68	82%
949	0.05	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	3.30	0.63	81%
949	0.05	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	3.30	0.63	81%
950	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	5.79	1.27	78%
950	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	5.79	1.27	78%
951	0.05	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	5.25	1.45	72%
951	0.05	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	5.25	1.45	72%
952	0.06	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	7.88	1.57	80%
952	0.06	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	7.88	1.57	80%
953	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	8.98	1.83	80%
953	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	8.98	1.83	80%
954	0.05	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	5.60	1.30	77%
954	0.05	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	5.60	1.30	77%
955	0.06	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	6.24	1.33	79%
955	0.06	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	6.24	1.33	79%
956	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	2.94	0.63	79%
956	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	2.94	0.63	79%
957	0.09	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	3.67	0.77	79%
957	0.09	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	3.67	0.77	79%
958	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	5.69	1.12	80%
958	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	5.69	1.12	80%
959	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	10-2021	6.94	1.32	81%
959	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	6.94	1.32	81%
960	0.06	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	09-2021	5.52	1.11	80%
960	0.06	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	5.52	1.11	80%
961	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	09-2021	8.41	1.63	81%
961	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	8.41	1.63	81%
962	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	09-2021	8.53	1.74	80%
962	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	8.53	1.74	80%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
963	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	09-2021	8.73	1.70	81%
963	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	8.73	1.70	81%
964	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	09-2021	2.40	0.38	84%
964	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	2.40	0.38	84%
965	0.06	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	09-2021	1.81	0.56	69%
965	0.06	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	1.81	0.56	69%
966	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	09-2021	1.43	0.48	67%
966	0.07	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	1.43	0.48	67%
967	0.10	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	09-2021	2.07	0.58	72%
967	0.10	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	2.07	0.58	72%
968	0.18	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	2.54	0.79	69%
968	0.18	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	2.54	0.79	69%
969	0.13	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	1.86	0.45	76%
969	0.13	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	1.86	0.45	76%
970	0.09	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	0.83	0.19	77%
970	0.09	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	0.83	0.19	77%
971	0.22	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	2.48	0.66	73%
971	0.22	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	2.48	0.66	73%
972	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	0.98	0.27	73%
972	0.08	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	0.98	0.27	73%
973	0.11	Kapaa sub - Olohena/Waipouli Rd Intersection	Diverter installation (Reflective)	11-2021	122.43	26.61	78%
973	0.11	Kapaa sub - Olohena/Waipouli Rd Intersection	Static wire removal	02-2021	122.43	26.61	78%
974	0.18	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	192.47	39.56	79%
974	0.18	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	192.47	39.56	79%
975	0.20	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	07-2022	6.35	1.70	73%
975	0.20	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	6.35	1.70	73%
976	0.22	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	6.97	1.99	71%
976	0.22	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	6.97	1.99	71%
977	0.13	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	4.49	0.95	79%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
977	0.13	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	4.49	0.95	79%
978	0.09	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	3.15	0.53	83%
978	0.09	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	3.15	0.53	83%
979	0.20	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	5.45	1.50	73%
979	0.20	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	5.45	1.50	73%
980	0.19	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	5.11	1.31	74%
980	0.19	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	5.11	1.31	74%
981	0.11	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	2.55	0.41	84%
981	0.11	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	2.55	0.41	84%
982	0.05	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	1.18	0.13	89%
982	0.05	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	1.18	0.13	89%
983	0.16	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	1.74	0.31	82%
983	0.16	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	1.74	0.31	82%
984	0.07	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	0.76	0.11	86%
984	0.07	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	0.76	0.11	86%
985	0.17	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	7.17	1.08	85%
985	0.17	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	7.17	1.08	85%
986	0.07	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	2.68	0.25	91%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
986	0.07	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	2.68	0.25	91%
987	0.14	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	6.42	1.17	82%
987	0.14	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	6.42	1.17	82%
988	0.15	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	1.77	0.55	69%
988	0.15	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	1.77	0.55	69%
989	0.23	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	3.00	0.96	68%
989	0.23	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	3.00	0.96	68%
990	0.11	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	1.49	0.26	83%
990	0.11	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	1.49	0.26	83%
991	0.11	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	1.97	0.44	78%
991	0.11	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	1.97	0.44	78%
992	0.12	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	2.31	0.55	76%
992	0.12	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	2.31	0.55	76%
993	0.08	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Diverter installation (Reflective)	02-2022	1.70	0.36	79%
993	0.08	Olohena/Waipouli Rd Intersection - Hanahanapuni Tap	Static wire removal	02-2021	1.70	0.36	79%
995	0.07	Kapaa sub - Mailihuna Rd	Static wire removal	08-2023	7.94	2.27	71%
995	0.07	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2021	7.94	2.27	71%
996	0.07	Kapaa sub - Mailihuna Rd	Static wire removal	08-2023	11.22	3.54	68%
996	0.07	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2021	11.22	3.54	68%
997	0.08	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	12.53	4.02	68%
997	0.08	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2021	12.53	4.02	68%
998	0.08	Kapaa sub - Mailihuna Rd	Static wire removal	08-2023	12.17	3.90	68%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
998	0.08	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2021	12.17	3.90	68%
999	0.09	Kapaa sub - Mailihuna Rd	Static wire removal	08-2023	14.74	4.74	68%
999	0.09	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2021	14.74	4.74	68%
1000	0.10	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	11.85	3.73	68%
1000	0.10	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2021	11.85	3.73	68%
1001	0.01	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	3.59	1.08	70%
1001	0.01	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2021	3.59	1.08	70%
1002	0.08	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	11.91	3.51	71%
1002	0.08	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2021	11.91	3.51	71%
1003	0.08	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	11.87	3.74	68%
1003	0.08	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2021	11.87	3.74	68%
1004	0.08	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	11.78	3.63	69%
1004	0.08	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2021	11.78	3.63	69%
1005	0.08	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	15.38	4.78	69%
1005	0.08	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2021	15.38	4.78	69%
1006	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	8.47	2.58	70%
1006	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2021	8.47	2.58	70%
1007	0.05	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	5.92	1.84	69%
1007	0.05	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	08-2022	5.92	1.84	69%
1008	0.03	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	5.77	1.95	66%
1008	0.03	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	01-2022	5.77	1.95	66%
1009	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	5.48	1.66	70%
1009	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	01-2022	5.48	1.66	70%
1010	0.03	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	2.77	0.73	74%
1010	0.03	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	01-2022	2.77	0.73	74%
1011	0.00	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	0.59	0.15	74%
1011	0.00	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	01-2022	0.59	0.15	74%
1012	0.02	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	1.84	0.49	74%
1012	0.02	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	03-2022	1.84	0.49	74%
1013	0.03	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	1.87	1.08	42%
1013	0.03	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	03-2022	1.87	1.08	42%
1014	0.03	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	1.75	1.02	42%
1014	0.03	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	03-2022	1.75	1.02	42%
1015	0.03	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	2.12	1.23	42%
1015	0.03	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	10-2022	2.12	1.23	42%
1016	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	2.40	1.39	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1016	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	10-2022	2.40	1.39	42%
1017	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	2.24	1.30	42%
1017	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	10-2022	2.24	1.30	42%
1018	0.02	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	1.69	0.98	42%
1018	0.02	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	10-2022	1.69	0.98	42%
1019	0.02	Kapaa sub - Mailihuna Rd	Static wire removal	05-2023	1.61	0.93	42%
1019	0.02	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	10-2022	1.61	0.93	42%
1020	0.03	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	2.24	1.30	42%
1020	0.03	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	10-2022	2.24	1.30	42%
1021	0.01	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	0.78	0.25	67%
1021	0.01	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	10-2022	0.78	0.25	67%
1022	0.03	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.89	0.65	66%
1022	0.03	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	10-2022	1.89	0.65	66%
1023	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.91	0.57	70%
1023	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	10-2022	1.91	0.57	70%
1024	0.03	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.43	0.39	73%
1024	0.03	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	10-2022	1.43	0.39	73%
1025	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.42	0.40	71%
1025	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	10-2022	1.42	0.40	71%
1026	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.37	0.41	70%
1026	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	07-2022	1.37	0.41	70%
1027	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.18	0.33	72%
1027	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	07-2022	1.18	0.33	72%
1028	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.29	0.31	76%
1028	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2022	1.29	0.31	76%
1029	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.35	0.33	75%
1029	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2022	1.35	0.33	75%
1030	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.29	0.34	73%
1030	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2022	1.29	0.34	73%
1031	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.54	0.42	73%
1031	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	05-2022	1.54	0.42	73%
1032	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.26	0.39	69%
1032	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	10-2022	1.26	0.39	69%
1033	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.69	0.48	71%
1033	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	10-2022	1.69	0.48	71%
1034	0.03	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.77	0.47	74%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1034	0.03	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	10-2022	1.77	0.47	74%
1035	0.05	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	2.01	0.50	75%
1035	0.05	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	09-2022	2.01	0.50	75%
1036	0.05	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	2.33	0.57	75%
1036	0.05	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	09-2022	2.33	0.57	75%
1037	0.03	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.79	0.43	76%
1037	0.03	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	09-2022	1.79	0.43	76%
1038	0.03	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.48	0.38	74%
1038	0.03	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	09-2022	1.48	0.38	74%
1039	0.03	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	2.05	0.46	77%
1039	0.03	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	09-2022	2.05	0.46	77%
1040	0.03	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.67	0.44	74%
1040	0.03	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	07-2022	1.67	0.44	74%
1041	0.03	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.31	0.32	76%
1041	0.03	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	09-2022	1.31	0.32	76%
1042	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.86	0.44	76%
1042	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	09-2022	1.86	0.44	76%
1043	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	2.02	0.45	78%
1043	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	09-2022	2.02	0.45	78%
1044	0.04	Kapaa sub - Mailihuna Rd	Static wire removal	06-2023	1.90	0.50	74%
1044	0.04	Kapaa sub - Mailihuna Rd	Diverter installation (Reflective)	10-2022	1.90	0.50	74%
1045	0.04	Kealia Transmission Minimization Project	Static wire removal	06-2023	2.35	0.68	71%
1045	0.04	Kealia Transmission Minimization Project	Diverter installation (Reflective)	10-2022	2.35	0.68	71%
1046	0.06	Kealia Transmission Minimization Project	Static wire removal	06-2023	2.44	0.63	74%
1046	0.06	Kealia Transmission Minimization Project	Diverter installation (Reflective)	05-2022	2.44	0.63	74%
1047	0.04	Kealia Transmission Minimization Project	Static wire removal	06-2023	1.11	0.18	84%
1047	0.04	Kealia Transmission Minimization Project	Diverter installation (Reflective)	05-2022	1.11	0.18	84%
1048	0.08	Kealia Transmission Minimization Project	Static wire removal	06-2023	2.66	0.36	86%
1048	0.08	Kealia Transmission Minimization Project	Diverter installation (Reflective)	04-2022	2.66	0.36	86%
1049	0.08	Kealia Transmission Minimization Project	Static wire removal	06-2023	3.38	0.49	85%
1049	0.08	Kealia Transmission Minimization Project	Diverter installation (Reflective)	04-2022	3.38	0.49	85%
1050	0.08	Kealia Transmission Minimization Project	Static wire removal	06-2023	3.27	0.76	77%
1050	0.08	Kealia Transmission Minimization Project	Diverter installation (Reflective)	04-2022	3.27	0.76	77%
1051	0.05	Kealia Transmission Minimization Project	Static wire removal	06-2023	2.69	0.86	68%
1051	0.05	Kealia Transmission Minimization Project	Diverter installation (Reflective)	05-2022	2.69	0.86	68%
1052	0.05	Kealia Transmission Minimization Project	Static wire removal	06-2023	3.41	1.03	70%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1052	0.05	Kealia Transmission Minimization Project	Diverter installation (Reflective)	05-2022	3.41	1.03	70%
1053	0.11	Kealia Transmission Minimization Project	Static wire removal	06-2023	6.79	2.04	70%
1053	0.11	Kealia Transmission Minimization Project	Diverter installation (Reflective)	05-2022	6.79	2.04	70%
1054	0.04	Kealia Transmission Minimization Project	Static wire removal	06-2023	4.03	1.02	75%
1054	0.04	Kealia Transmission Minimization Project	Diverter installation (Reflective)	08-2022	4.03	1.02	75%
1055	0.04	Kealia Transmission Minimization Project	Static wire removal	06-2023	5.30	1.81	66%
1055	0.04	Kealia Transmission Minimization Project	Diverter installation (Reflective)	03-2022	5.30	1.81	66%
1056	0.08	Kealia Transmission Minimization Project	Static wire removal	06-2023	10.14	2.34	77%
1056	0.08	Kealia Transmission Minimization Project	Diverter installation (Reflective)	03-2022	10.14	2.34	77%
1057	0.03	Kealia - Anahola sub	Static wire removal	06-2023	4.47	1.30	71%
1057	0.03	Kealia - Anahola sub	Diverter installation (Reflective)	03-2022	4.47	1.30	71%
1058	0.02	Kealia - Anahola sub	Static wire removal	06-2023	3.84	1.21	68%
1058	0.02	Kealia - Anahola sub	Diverter installation (Reflective)	03-2022	3.84	1.21	68%
1059	0.07	Kealia - Anahola sub	Static wire removal	06-2023	10.44	3.03	71%
1059	0.07	Kealia - Anahola sub	Diverter installation (Reflective)	03-2022	10.44	3.03	71%
1060	0.08	Kealia - Anahola sub	Static wire removal	06-2023	15.20	4.98	67%
1060	0.08	Kealia - Anahola sub	Diverter installation (Reflective)	03-2022	15.20	4.98	67%
1061	0.06	Kealia - Anahola sub	Static wire removal	06-2023	5.62	1.85	67%
1061	0.06	Kealia - Anahola sub	Diverter installation (Reflective)	03-2022	5.62	1.85	67%
1062	0.05	Kealia - Anahola sub	Static wire removal	06-2023	3.38	0.91	73%
1062	0.05	Kealia - Anahola sub	Diverter installation (Reflective)	03-2022	3.38	0.91	73%
1063	0.08	Kealia - Anahola sub	Static wire removal	06-2023	4.27	1.30	70%
1063	0.08	Kealia - Anahola sub	Diverter installation (Reflective)	03-2022	4.27	1.30	70%
1064	0.17	Kealia - Anahola sub	Static wire removal	06-2023	15.01	2.54	83%
1064	0.17	Kealia - Anahola sub	Diverter installation (Reflective)	03-2022	15.01	2.54	83%
1065	0.05	Kealia - Anahola sub	Static wire removal	06-2023	8.58	2.82	67%
1065	0.05	Kealia - Anahola sub	Diverter installation (Reflective)	08-2022	8.58	2.82	67%
1066	0.06	Kealia - Anahola sub	Static wire removal	06-2023	9.96	3.44	66%
1066	0.06	Kealia - Anahola sub	Diverter installation (Reflective)	03-2022	9.96	3.44	66%
1067	0.08	Kealia - Anahola sub	Static wire removal	06-2023	2.46	0.77	69%
1067	0.08	Kealia - Anahola sub	Diverter installation (Reflective)	03-2022	2.46	0.77	69%
1068	0.08	Kealia - Anahola sub	Static wire removal	06-2023	2.69	0.82	70%
1068	0.08	Kealia - Anahola sub	Diverter installation (Reflective)	03-2022	2.69	0.82	70%
1069	0.06	Kealia - Anahola sub	Static wire removal	06-2023	9.34	3.03	68%
1069	0.06	Kealia - Anahola sub	Diverter installation (Reflective)	03-2022	9.34	3.03	68%
1070	0.08	Kealia - Anahola sub	Static wire removal	06-2023	13.37	4.81	64%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1070	0.08	Kealia - Anahola sub	Diverter installation (Reflective)	05-2022	13.37	4.81	64%
1071	0.05	Kealia - Anahola sub	Static wire removal	06-2023	0.26	0.09	64%
1071	0.05	Kealia - Anahola sub	Diverter installation (Reflective)	05-2022	0.26	0.09	64%
1072	0.24	Kealia - Anahola sub	Static wire removal	06-2023	1.51	0.36	76%
1072	0.24	Kealia - Anahola sub	Diverter installation (Reflective)	03-2022	1.51	0.36	76%
1075.1	0.06	Kealia - Anahola sub	Static wire removal	06-2023	11.14	3.28	71%
1075.1	0.06	Kealia - Anahola sub	Diverter installation (Reflective)	05-2022	11.14	3.28	71%
1075.2	0.06	Kealia - Anahola sub	Static wire removal	06-2023	11.88	3.33	72%
1075.2	0.06	Kealia - Anahola sub	Diverter installation (Reflective)	05-2022	11.88	3.33	72%
1076	0.05	Kealia - Anahola sub	Static wire removal	06-2023	2.47	0.69	72%
1076	0.05	Kealia - Anahola sub	Diverter installation (Reflective)	05-2022	2.47	0.69	72%
1077	0.06	Kealia - Anahola sub	Static wire removal	06-2023	2.29	0.71	69%
1077	0.06	Kealia - Anahola sub	Diverter installation (Reflective)	05-2022	2.29	0.71	69%
1078	0.06	Kealia - Anahola sub	Static wire removal	06-2023	3.12	0.87	72%
1078	0.06	Kealia - Anahola sub	Diverter installation (Reflective)	04-2022	3.12	0.87	72%
1079	0.06	Kealia - Anahola sub	Static wire removal	06-2023	4.12	0.99	76%
1079	0.06	Kealia - Anahola sub	Diverter installation (Reflective)	03-2022	4.12	0.99	76%
1080	0.07	Kealia - Anahola sub	Static wire removal	12-2023	5.07	1.25	75%
1080	0.07	Kealia - Anahola sub	Diverter installation (Reflective)	07-2022	5.07	1.25	75%
1081	0.02	Kealia - Anahola sub	Static wire removal	12-2023	1.53	0.47	69%
1081	0.02	Kealia - Anahola sub	Diverter installation (Reflective)	07-2022	1.53	0.47	69%
1082	0.07	Anahola sub - Moloaa	Static wire removal	01-2021	13.96	7.09	49%
1083	0.08	Anahola sub - Moloaa	Static wire removal	01-2021	2.11	1.25	41%
1084	0.07	Anahola sub - Moloaa	Static wire removal	01-2021	1.86	1.09	41%
1085	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	9.14	5.11	44%
1086	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	7.94	4.23	47%
1087	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	8.03	4.32	46%
1088	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	10.00	5.43	46%
1089	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	3.48	1.89	46%
1090	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	3.44	1.90	45%
1091	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	9.94	5.58	44%
1092	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	2.47	1.26	49%
1093	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	2.44	1.25	49%
1094	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	8.59	4.70	45%
1095	0.03	Anahola sub - Moloaa	Static wire removal	01-2021	5.82	3.18	45%
1096	0.05	Anahola sub - Moloaa	Static wire removal	12-2023	2.07	1.27	39%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1097	0.06	Anahola sub - Moloaa	Static wire removal	12-2023	1.90	1.14	40%
1098	0.11	Anahola sub - Moloaa	Static wire removal	12-2023	16.24	10.17	37%
1099	0.10	Anahola sub - Moloaa	Static wire removal	12-2023	1.36	0.70	49%
1100	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	0.64	0.34	47%
1101	0.02	Anahola sub - Moloaa	Static wire removal	01-2021	3.11	1.71	45%
1102	0.07	Anahola sub - Moloaa	Static wire removal	01-2021	10.08	5.15	49%
1103	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	5.51	2.98	46%
1104	0.05	Anahola sub - Moloaa	Static wire removal	01-2021	4.87	2.75	43%
1105	0.03	Anahola sub - Moloaa	Static wire removal	01-2021	2.77	1.29	53%
1106	0.03	Anahola sub - Moloaa	Static wire removal	01-2021	1.96	0.85	57%
1107	0.03	Anahola sub - Moloaa	Static wire removal	01-2021	2.00	0.87	57%
1108	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	3.29	1.47	55%
1109	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	2.50	1.17	53%
1110	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	2.33	1.11	53%
1111	0.03	Anahola sub - Moloaa	Static wire removal	01-2021	3.34	1.74	48%
1112	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	4.35	2.33	46%
1113	0.03	Anahola sub - Moloaa	Static wire removal	01-2021	3.30	1.80	45%
1114	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	3.32	1.77	47%
1115	0.09	Anahola sub - Moloaa	Static wire removal	02-2021	8.27	4.89	41%
1116	0.04	Anahola sub - Moloaa	Static wire removal	02-2021	4.93	2.47	50%
1117	0.04	Anahola sub - Moloaa	Static wire removal	02-2021	6.60	3.11	53%
1118	0.04	Anahola sub - Moloaa	Static wire removal	02-2021	6.52	3.13	52%
1119	0.04	Anahola sub - Moloaa	Static wire removal	12-2023	7.10	3.15	56%
1120	0.04	Anahola sub - Moloaa	Static wire removal	12-2023	1.55	0.70	55%
1121	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	1.55	0.74	52%
1122	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	1.79	0.95	47%
1123	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	1.90	1.07	44%
1124	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	2.26	1.28	43%
1125	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	1.96	1.12	43%
1126	0.06	Anahola sub - Moloaa	Static wire removal	01-2021	1.84	1.07	42%
1127	0.06	Anahola sub - Moloaa	Static wire removal	01-2021	19.19	11.14	42%
1128	0.08	Anahola sub - Moloaa	Static wire removal	01-2021	2.71	1.55	43%
1129	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	1.40	0.81	42%
1130	0.08	Anahola sub - Moloaa	Static wire removal	01-2021	16.06	8.26	49%
1131	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	7.65	4.19	45%
1132	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	6.13	3.14	49%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1133	0.07	Anahola sub - Moloaa	Static wire removal	02-2021	13.19	7.87	40%
1134	0.11	Anahola sub - Moloaa	Static wire removal	02-2021	17.55	9.23	47%
1135	0.09	Anahola sub - Moloaa	Static wire removal	01-2021	14.65	8.50	42%
1136	0.09	Anahola sub - Moloaa	Static wire removal	01-2021	21.07	12.15	42%
1137	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	11.63	7.11	39%
1138	0.09	Anahola sub - Moloaa	Static wire removal	01-2021	19.54	10.38	47%
1139	0.08	Anahola sub - Moloaa	Static wire removal	01-2021	20.15	10.81	46%
1140	0.09	Anahola sub - Moloaa	Static wire removal	01-2021	21.75	12.46	43%
1141	0.08	Anahola sub - Moloaa	Static wire removal	01-2021	46.42	26.99	42%
1142	0.08	Anahola sub - Moloaa	Static wire removal	01-2021	23.72	13.34	44%
1143	0.03	Anahola sub - Moloaa	Static wire removal	01-2021	0.25	0.14	45%
1144	0.05	Anahola sub - Moloaa	Static wire removal	01-2021	40.52	21.58	47%
1145	0.07	Anahola sub - Moloaa	Static wire removal	01-2021	50.09	28.19	44%
1146	0.08	Anahola sub - Moloaa	Static wire removal	01-2021	10.38	4.64	55%
1147	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	8.35	4.02	52%
1148	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	7.76	3.58	54%
1149	0.05	Anahola sub - Moloaa	Static wire removal	01-2021	23.46	11.37	52%
1150	0.09	Anahola sub - Moloaa	Static wire removal	01-2021	41.02	20.79	49%
1151	0.04	Anahola sub - Moloaa	Static wire removal	01-2021	8.34	4.07	51%
1152	0.05	Anahola sub - Moloaa	Static wire removal	01-2021	9.75	5.40	45%
1153	0.08	Anahola sub - Moloaa	Diverter installation (Reflective)	12-2020	24.36	7.74	68%
1153	0.08	Anahola sub - Moloaa	Static wire removal	02-2020	24.36	7.74	68%
1154	0.08	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	24.12	8.09	66%
1154	0.08	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	24.12	8.09	66%
1155	0.08	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	23.13	7.56	67%
1155	0.08	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	23.13	7.56	67%
1156	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	23.23	7.76	67%
1156	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	23.23	7.76	67%
1157	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	22.06	6.84	69%
1157	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	22.06	6.84	69%
1158	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	19.52	5.39	72%
1158	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	19.52	5.39	72%
1159	0.10	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	39.12	9.99	74%
1159	0.10	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	39.12	9.99	74%
1160	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	13.67	4.38	68%
1160	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	13.67	4.38	68%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1161	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	13.88	4.37	69%
1161	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	13.88	4.37	69%
1162	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	14.31	4.59	68%
1162	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	14.31	4.59	68%
1163	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.12	0.66	69%
1163	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.12	0.66	69%
1164	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	1.96	0.59	70%
1164	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	1.96	0.59	70%
1165	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	13.45	4.01	70%
1165	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	13.45	4.01	70%
1166	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	28.94	8.59	70%
1166	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	28.94	8.59	70%
1167	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	29.97	8.65	71%
1167	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	29.97	8.65	71%
1168	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.95	0.90	69%
1168	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.95	0.90	69%
1169	0.09	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	22.38	7.16	68%
1169	0.09	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	22.38	7.16	68%
1170	0.10	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	39.14	13.10	67%
1170	0.10	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	39.14	13.10	67%
1171	0.09	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	24.92	8.20	67%
1171	0.09	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	24.92	8.20	67%
1172	0.10	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	3.02	0.98	68%
1172	0.10	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	3.02	0.98	68%
1173	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	1.36	0.50	63%
1173	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	1.36	0.50	63%
1173	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	1.36	0.50	63%
1174	0.08	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	2.11	0.75	64%
1174	0.08	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.11	0.75	64%
1174	0.08	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.11	0.75	64%
1175	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	31.52	12.31	61%
1175	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	31.52	12.31	61%
1176	0.08	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	08-2023	101.64	36.20	64%
1176	0.08	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	101.64	36.20	64%
1177	0.08	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	68.95	26.76	61%
1177	0.08	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	68.95	26.76	61%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1178	0.07	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	74.66	27.64	63%
1178	0.07	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	74.66	27.64	63%
1179	0.09	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	0.37	0.13	65%
1179	0.09	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	0.37	0.13	65%
1180	0.06	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	0.27	0.09	66%
1180	0.06	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	0.27	0.09	66%
1181	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	10.95	3.55	68%
1181	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	10.95	3.55	68%
1182	0.11	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	27.96	9.69	65%
1182	0.11	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	27.96	9.69	65%
1183	0.09	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	18.58	6.06	67%
1183	0.09	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	18.58	6.06	67%
1184	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	10.53	3.00	72%
1184	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	10.53	3.00	72%
1185	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	13.66	4.18	69%
1185	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	13.66	4.18	69%
1186	0.10	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	2.72	1.06	61%
1186	0.10	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.72	1.06	61%
1187	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	1.20	0.33	73%
1187	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	1.20	0.33	73%
1188	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	14.38	4.07	72%
1188	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	14.38	4.07	72%
1189	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	16.84	4.74	72%
1189	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	16.84	4.74	72%
1190	0.11	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	2.30	0.74	68%
1190	0.11	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.30	0.74	68%
1191	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	0.81	0.26	67%
1191	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	0.81	0.26	67%
1192	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	02-2021	14.37	4.92	66%
1192	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	14.37	4.92	66%
1193	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	13.74	8.10	41%
1194	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	4.29	1.38	68%
1194	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	4.29	1.38	68%
1195	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	4.18	1.05	75%
1195	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	4.18	1.05	75%
1196	0.06	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	15.90	5.14	68%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1196	0.06	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	15.90	5.14	68%
1197	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	7.90	2.64	67%
1197	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	7.90	2.64	67%
1198	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	9.89	3.46	65%
1198	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	9.89	3.46	65%
1199	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.59	0.92	64%
1199	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	2.59	0.92	64%
1200	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.43	0.85	65%
1200	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	2.43	0.85	65%
1201	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	15.64	5.53	65%
1201	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	15.64	5.53	65%
1202	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	13.72	4.89	64%
1202	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	13.72	4.89	64%
1203	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	55.34	19.98	64%
1203	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	55.34	19.98	64%
1204	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	30.63	10.74	65%
1204	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	30.63	10.74	65%
1205	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	5.91	1.95	67%
1205	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	5.91	1.95	67%
1206	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	9.71	3.19	67%
1206	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	9.71	3.19	67%
1207	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	12.92	3.82	70%
1207	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	12.92	3.82	70%
1208	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	10.97	3.05	72%
1208	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	10.97	3.05	72%
1209	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	8.65	2.50	71%
1209	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	8.65	2.50	71%
1210	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	10.36	3.39	67%
1210	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	10.36	3.39	67%
1211	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	6.68	2.15	68%
1211	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	6.68	2.15	68%
1212	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	6.62	2.17	67%
1212	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	6.62	2.17	67%
1213	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	10.92	3.80	65%
1213	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	10.92	3.80	65%
1214	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	10.27	3.44	66%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1214	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	03-2015	10.27	3.44	66%
1215	0.07	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	13.96	4.40	68%
1215	0.07	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	13.96	4.40	68%
1216	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	10.34	3.58	65%
1216	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	10.34	3.58	65%
1217	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	10.10	3.50	65%
1217	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	10.10	3.50	65%
1218	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	15.85	5.53	65%
1218	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	15.85	5.53	65%
1219	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	16.85	5.60	67%
1219	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	16.85	5.60	67%
1220	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	6.88	2.23	68%
1220	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	6.88	2.23	68%
1221	0.09	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	14.05	4.41	69%
1221	0.09	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	14.05	4.41	69%
1222	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	6.77	2.02	70%
1222	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	6.77	2.02	70%
1223	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	7.52	2.11	72%
1223	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	7.52	2.11	72%
1224	0.07	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	14.37	4.16	71%
1224	0.07	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	14.37	4.16	71%
1225	0.06	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.17	0.67	69%
1225	0.06	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.17	0.67	69%
1226	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	1.74	0.54	69%
1226	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	1.74	0.54	69%
1227	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	7.02	2.26	68%
1227	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	7.02	2.26	68%
1228	0.08	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	13.62	4.26	69%
1228	0.08	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	13.62	4.26	69%
1229	0.08	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	3.88	1.20	69%
1229	0.08	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	3.88	1.20	69%
1230	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.08	0.66	68%
1230	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.08	0.66	68%
1231	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	9.22	2.87	69%
1231	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	9.22	2.87	69%
1232	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	13.30	4.12	69%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1232	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	13.30	4.12	69%
1233	0.07	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	11.39	3.24	72%
1233	0.07	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	11.39	3.24	72%
1234	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.82	0.76	73%
1234	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.82	0.76	73%
1235	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.90	0.82	72%
1235	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.90	0.82	72%
1236	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	4.82	1.26	74%
1236	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	4.82	1.26	74%
1237	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	3.89	1.06	73%
1237	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	3.89	1.06	73%
1238	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	4.56	1.33	71%
1238	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	4.56	1.33	71%
1239	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	6.95	2.14	69%
1239	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	6.95	2.14	69%
1240	0.03	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	6.53	1.90	71%
1240	0.03	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	6.53	1.90	71%
1241	0.07	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	6.77	1.97	71%
1241	0.07	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	6.77	1.97	71%
1242	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	7.19	2.19	70%
1242	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	7.19	2.19	70%
1243	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	12.72	3.59	72%
1243	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	12.72	3.59	72%
1244	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	12.51	3.78	70%
1244	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	12.51	3.78	70%
1245	0.03	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.27	0.71	69%
1245	0.03	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.27	0.71	69%
1246	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	15.62	4.23	73%
1246	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	15.62	4.23	73%
1247	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	15.55	4.86	69%
1247	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	15.55	4.86	69%
1248	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	6.12	1.97	68%
1248	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	6.12	1.97	68%
1249	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	5.68	1.75	69%
1249	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	5.68	1.75	69%
1250	0.06	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	5.94	1.82	69%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1250	0.06	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	5.94	1.82	69%
1251	0.02	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.84	0.93	67%
1251	0.02	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.84	0.93	67%
1252	0.03	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.22	0.76	66%
1252	0.03	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.22	0.76	66%
1253	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.01	0.67	66%
1253	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.01	0.67	66%
1254	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.29	0.74	68%
1254	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.29	0.74	68%
1255	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	5.47	1.73	68%
1255	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	5.47	1.73	68%
1256	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	6.88	2.34	66%
1256	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	6.88	2.34	66%
1257	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	9.93	3.62	64%
1257	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	9.93	3.62	64%
1258	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.13	0.79	63%
1258	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.13	0.79	63%
1259	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.13	0.80	62%
1259	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.13	0.80	62%
1260	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.19	0.81	63%
1260	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.19	0.81	63%
1261	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.15	0.78	64%
1261	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.15	0.78	64%
1262	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.12	0.76	64%
1262	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.12	0.76	64%
1263	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	13.33	4.33	68%
1263	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	13.33	4.33	68%
1264	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	14.51	4.53	69%
1264	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	14.51	4.53	69%
1265	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	11.81	3.30	72%
1265	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	11.81	3.30	72%
1266	0.02	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	10.66	2.97	72%
1266	0.02	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	10.66	2.97	72%
1267	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	5.57	1.47	74%
1267	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	5.57	1.47	74%
1268	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	33.06	9.09	72%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1268	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	33.06	9.09	72%
1269	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	24.86	6.53	74%
1269	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	24.86	6.53	74%
1270	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	6.89	1.91	72%
1270	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	6.89	1.91	72%
1271	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	7.25	2.15	70%
1271	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	7.25	2.15	70%
1272	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	15.92	4.83	70%
1272	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	15.92	4.83	70%
1273	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	19.82	5.59	72%
1273	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	19.82	5.59	72%
1274	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	7.48	1.94	74%
1274	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	7.48	1.94	74%
1275	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.08	0.54	74%
1275	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.08	0.54	74%
1276	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.20	0.56	74%
1276	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.20	0.56	74%
1277	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	5.92	1.56	74%
1277	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	5.92	1.56	74%
1278	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	1.17	0.30	75%
1278	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	1.17	0.30	75%
1279	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	1.07	0.26	76%
1279	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	1.07	0.26	76%
1280	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	6.34	1.82	71%
1280	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	6.34	1.82	71%
1281	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.09	0.53	75%
1281	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.09	0.53	75%
1282	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.07	0.54	74%
1282	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.07	0.54	74%
1283	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	9.52	2.74	71%
1283	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	9.52	2.74	71%
1284	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	10.91	3.37	69%
1284	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	10.91	3.37	69%
1285	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	9.83	2.98	70%
1285	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	9.83	2.98	70%
1286	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.97	0.93	69%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1286	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.97	0.93	69%
1287	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.88	0.94	67%
1287	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.88	0.94	67%
1288	0.10	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	2.88	0.80	72%
1288	0.10	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	2.88	0.80	72%
1289	0.04	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	1.07	0.35	68%
1289	0.04	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	1.07	0.35	68%
1290	0.07	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	18.07	5.28	71%
1290	0.07	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	18.07	5.28	71%
1291	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	12.00	3.97	67%
1291	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	12.00	3.97	67%
1292	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	10.52	3.46	67%
1292	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	10.52	3.46	67%
1293	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	9.83	3.18	68%
1293	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	9.83	3.18	68%
1294	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	27.01	9.96	63%
1294	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	27.01	9.96	63%
1295	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	29.46	10.77	63%
1295	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	29.46	10.77	63%
1296	0.05	Moloaa - Kilauea end of xmission line	Diverter installation (Reflective)	12-2020	12.01	3.98	67%
1296	0.05	Moloaa - Kilauea end of xmission line	Static wire removal	02-2020	12.01	3.98	67%
1297	0.05	Hanalei tap to Hwy	Diverter installation (Reflective)	05-2023	2.70	1.56	42%
1298	0.04	Hanalei tap to Hwy	Diverter installation (Reflective)	05-2023	1.34	0.77	42%
1299	0.05	Hanalei tap to Hwy	Diverter installation (Reflective)	05-2023	1.67	0.97	42%
1300	0.05	Hanalei tap to Hwy	Diverter installation (Reflective)	05-2023	1.60	0.93	42%
1301	0.05	Hanalei tap to Hwy	Diverter installation (Reflective)	05-2023	1.58	0.92	42%
1302	0.05	Hanalei tap to Hwy	Diverter installation (Reflective)	05-2023	1.50	0.87	42%
1303	0.03	Hanalei tap to Hwy	Diverter installation (Reflective)	06-2023	1.02	0.59	42%
1304	0.06	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	05-2023	3.69	2.14	42%
1305	0.06	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	05-2023	3.34	1.94	42%
1306	0.00	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	05-2022	2.88	1.67	42%
1307	0.11	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	06-2023	23.14	13.42	42%
1310	0.03	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	06-2023	1.26	0.73	42%
1311	0.03	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	06-2023	1.04	0.60	42%
1312	0.04	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	06-2023	1.52	0.88	42%
1313	0.07	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	06-2023	1.84	1.07	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1314	0.05	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	06-2023	2.67	1.55	42%
1315	0.06	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	06-2023	2.41	1.40	42%
1316	0.06	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	05-2023	2.20	1.28	42%
1317	0.06	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	05-2023	2.03	1.18	42%
1318	0.05	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	06-2023	3.00	1.74	42%
1319	0.04	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	06-2023	2.39	1.39	42%
1320	0.10	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	06-2023	2.06	1.19	42%
1321	0.03	Hwy Hanalei - Princeville sub	Diverter installation (Reflective)	08-2021	N/A	N/A	N/A
1322	0.04	Port Allen	Diverter installation (Reflective)	06-2022	3.31	1.92	42%
1323	0.06	Port Allen	Diverter installation (Reflective)	06-2022	3.13	1.82	42%
1327	0.01	Hanalei Tap	Diverter installation (Reflective)	11-2022	0.27	0.15	42%
1328	0.01	Hanalei Tap	Diverter installation (Reflective)	11-2022	0.67	0.39	42%
1330	0.05	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	01-2021	15.83	9.18	42%
1331	0.06	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	07-2022	15.96	9.25	42%
1332	0.06	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	07-2022	13.70	7.94	42%
1333	0.05	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	07-2022	11.25	6.52	42%
1334	0.05	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	07-2022	13.27	7.70	42%
1335	0.05	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	07-2022	14.12	8.19	42%
1336	0.06	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	07-2022	13.20	7.66	42%
1337	0.06	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	07-2022	7.68	4.45	42%
1366	0.05	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	01-2023	15.85	9.19	42%
1367	0.05	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	01-2023	15.87	9.20	42%
1368	0.05	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	01-2023	16.95	9.83	42%
1370	0.05	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	01-2021	18.63	10.81	42%
1371	0.05	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	01-2021	18.78	10.89	42%
1372	0.05	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	01-2021	17.54	10.17	42%
1373	0.06	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	01-2021	19.42	11.27	42%
1374	0.06	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	01-2021	18.19	10.55	42%
1375	0.06	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	01-2021	19.46	11.29	42%
1376	0.04	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	01-2021	14.82	8.60	42%
1377	0.05	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	01-2021	23.96	13.90	42%
1378	0.06	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	01-2021	27.51	15.96	42%
1403	0.04	Kekaha Sub to Waimea Canyon Dr	Diverter installation (Reflective)	01-2021	15.34	8.90	42%
1404	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2021	17.85	10.35	42%
1405	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2021	21.79	12.64	42%
1406	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	08-2022	17.56	10.19	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1407	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	08-2022	18.76	10.88	42%
1408	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	08-2022	21.26	12.33	42%
1409	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	08-2022	18.32	10.62	42%
1410	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	08-2022	16.80	9.74	42%
1411	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	08-2022	23.14	13.42	42%
1412	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	08-2022	25.46	14.77	42%
1413	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	08-2022	16.01	9.29	42%
1414	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	08-2022	18.08	10.49	42%
1415	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	08-2022	12.72	7.38	42%
1416	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	08-2022	11.78	6.83	42%
1417	0.07	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2023	27.38	15.88	42%
1418	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2023	20.35	11.80	42%
1419	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2023	19.51	11.31	42%
1420	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2023	13.59	7.88	42%
1421	0.09	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2023	21.94	12.72	42%
1422	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	08-2022	18.94	10.98	42%
1423	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	08-2022	14.47	8.39	42%
1424	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2023	12.72	7.38	42%
1425	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2023	14.24	8.26	42%
1426	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2023	10.67	6.19	42%
1427	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2023	10.12	5.87	42%
1428	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2021	10.19	5.91	42%
1429	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2021	11.01	6.38	42%
1430	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	12-2022	8.60	4.99	42%
1431	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	03-2021	10.01	5.80	42%
1432	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2021	11.63	6.75	42%
1433	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	03-2021	14.16	8.21	42%
1434	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	03-2021	23.20	13.45	42%
1435	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	03-2021	21.47	12.45	42%
1436	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	03-2021	17.02	9.87	42%
1437	0.09	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	12-2022	23.65	13.72	42%
1438	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	11-2022	12.10	7.02	42%
1439	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	11-2022	10.41	6.04	42%
1440	0.12	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	11-2022	25.54	14.81	42%
1441	0.09	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2023	18.94	10.98	42%
1442	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	11-2022	17.65	10.24	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1443	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	11-2022	21.36	12.39	42%
1444	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	11-2022	18.15	10.52	42%
1445	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	11-2022	18.51	10.74	42%
1446	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	11-2022	21.98	12.75	42%
1447	0.07	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	11-2022	17.77	10.31	42%
1448	0.10	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	11-2022	29.09	16.87	42%
1449	0.07	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	11-2022	25.71	14.91	42%
1450	0.13	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	01-2023	34.35	19.93	42%
1453	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	12-2022	15.00	8.70	42%
1454	0.00	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	12-2022	1.24	0.72	42%
1455	0.01	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	12-2022	3.02	1.75	42%
1456	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	03-2021	10.49	6.08	42%
1457	0.07	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	15.16	8.79	42%
1458	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	09-2022	12.02	6.97	42%
1459	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	09-2022	11.35	6.59	42%
1460	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	16.60	9.63	42%
1461	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	17.21	9.98	42%
1462	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	7.97	4.63	42%
1463	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	12.72	7.38	42%
1466	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	25.29	14.67	42%
1467	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	09-2022	12.36	7.17	42%
1468	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	09-2022	12.47	7.23	42%
1469	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	09-2022	7.93	4.60	42%
1470	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	09-2022	7.30	4.24	42%
1471	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	09-2022	7.30	4.23	42%
1472	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	09-2022	9.58	5.56	42%
1473	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	09-2022	6.88	3.99	42%
1474	0.07	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	17.52	10.16	42%
1475	0.12	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	29.65	17.20	42%
1476	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	12.56	7.28	42%
1477	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	10.72	6.22	42%
1478	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	20.17	11.70	42%
1479	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	13.77	7.99	42%
1480	0.05	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	13.94	8.09	42%
1481	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	14.51	8.42	42%
1482	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	5.03	2.92	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1483	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	09-2022	6.05	3.51	42%
1484	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	09-2022	5.27	3.06	42%
1485	0.04	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	09-2022	6.17	3.58	42%
1486	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	09-2022	7.85	4.55	42%
1487	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	6.74	3.91	42%
1488	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	16.15	9.37	42%
1489	0.07	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	09-2022	8.35	4.84	42%
1490	0.06	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	09-2022	8.06	4.67	42%
1491	0.07	Waimea Canyon Dr to Canyon Overlook	Diverter installation (Reflective)	10-2022	19.08	11.06	42%
1492	0.07	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	8.20	4.76	42%
1493	0.04	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	6.03	3.50	42%
1494	0.03	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	3.73	2.16	42%
1495	0.05	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	7.25	4.21	42%
1496	0.05	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	7.52	4.36	42%
1497	0.08	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	19.25	11.17	42%
1498	0.07	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	30.21	17.52	42%
1499	0.06	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	11.89	6.90	42%
1500	0.04	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	09-2022	6.60	3.83	42%
1501	0.06	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	16.73	9.71	42%
1502	0.06	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	22.87	13.26	42%
1503	0.06	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	09-2022	7.06	4.10	42%
1504	0.05	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	12.11	7.02	42%
1505	0.05	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	12.82	7.44	42%
1506	0.04	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	5.06	2.94	42%
1507	0.05	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	13.51	7.84	42%
1508	0.10	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	11-2022	24.51	14.21	42%
1509	0.06	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	8.48	4.92	42%
1510	0.05	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	6.03	3.50	42%
1511	0.05	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	10.97	6.36	42%
1512	0.05	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	12.21	7.08	42%
1513	0.04	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	5.91	3.43	42%
1514	0.07	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	9.81	5.69	42%
1515	0.06	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	8.62	5.00	42%
1516	0.07	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	15.02	8.71	42%
1517	0.07	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	12.16	7.05	42%
1518	0.07	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	13.81	8.01	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1519	0.03	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	5.31	3.08	42%
1520	0.05	Canyon Overlook to Pua Lua	Diverter installation (Reflective)	10-2022	15.45	8.96	42%
1521	0.04	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	13.06	7.57	42%
1522	0.03	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	5.44	3.15	42%
1523	0.04	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	5.17	3.00	42%
1524	0.03	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	4.22	2.45	42%
1525	0.05	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	6.62	3.84	42%
1526	0.08	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	8.20	4.76	42%
1527	0.06	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	8.06	4.67	42%
1530	0.04	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	12.25	7.11	42%
1531	0.04	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	10.41	6.04	42%
1532	0.06	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	7.22	4.19	42%
1533	0.05	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	5.87	3.40	42%
1534	0.06	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	8.93	5.18	42%
1535	0.06	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	10.52	6.10	42%
1536	0.07	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	9.02	5.23	42%
1537	0.07	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	22.05	12.79	42%
1538	0.07	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	25.11	14.56	42%
1539	0.04	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	13.62	7.90	42%
1540	0.06	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	7.69	4.46	42%
1541	0.07	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	7.76	4.50	42%
1542	0.07	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	14.98	8.69	42%
1543	0.04	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	4.88	2.83	42%
1544	0.03	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	3.39	1.97	42%
1545	0.07	Pua Lua to NASA	Diverter installation (Reflective)	11-2022	18.19	10.55	42%
1546	0.07	Pua Lua to NASA	Diverter installation (Reflective)	11-2022	12.02	6.97	42%
1547	0.06	Pua Lua to NASA	Diverter installation (Reflective)	11-2022	11.27	6.53	42%
1548	0.10	Pua Lua to NASA	Diverter installation (Reflective)	11-2022	20.16	11.69	42%
1549	0.04	Pua Lua to NASA	Diverter installation (Reflective)	12-2022	8.47	4.91	42%
1550	0.04	Pua Lua to NASA	Diverter installation (Reflective)	11-2022	6.78	3.93	42%
1551	0.04	Pua Lua to NASA	Diverter installation (Reflective)	11-2022	6.81	3.95	42%
1552	0.04	Pua Lua to NASA	Diverter installation (Reflective)	11-2022	3.19	1.85	42%
1553	0.03	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	3.22	1.87	42%
1554	0.06	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	5.92	3.43	42%
1555	0.07	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	7.25	4.20	42%
1556	0.06	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	8.56	4.96	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1557	0.06	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	8.49	4.92	42%
1558	0.05	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	8.17	4.74	42%
1559	0.03	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	4.79	2.78	42%
1560	0.05	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	6.73	3.90	42%
1561	0.06	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	14.58	8.46	42%
1562	0.04	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	13.42	7.79	42%
1563	0.05	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	6.65	3.86	42%
1564	0.05	Pua Lua to NASA	Diverter installation (Reflective)	10-2022	9.93	5.76	42%
1565	0.04	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	9.96	5.78	42%
1566	0.05	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	5.18	3.01	42%
1567	0.04	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	4.80	2.78	42%
1568	0.05	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	5.74	3.33	42%
1569	0.07	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	11.99	6.95	42%
1570	0.05	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	10.27	5.95	42%
1571	0.04	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	4.60	2.67	42%
1572	0.03	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	3.59	2.08	42%
1573	0.05	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	5.14	2.98	42%
1574	0.05	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	4.70	2.72	42%
1575	0.05	NASA to Kokee Nature Center	Diverter installation (Reflective)	09-2022	3.99	2.32	42%
1576	0.05	NASA to Kokee Nature Center	Diverter installation (Reflective)	09-2022	3.92	2.27	42%
1577	0.06	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	9.49	5.50	42%
1578	0.05	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	8.88	5.15	42%
1579	0.06	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	4.87	2.83	42%
1580	0.06	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	4.46	2.58	42%
1581	0.06	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	4.97	2.88	42%
1582	0.04	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	3.55	2.06	42%
1583	0.06	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	4.14	2.40	42%
1584	0.06	NASA to Kokee Nature Center	Diverter installation (Reflective)	10-2022	4.79	2.78	42%
1585	0.05	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	4.23	2.45	42%
1586	0.05	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	4.98	2.89	42%
1587	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	5.22	3.03	42%
1588	0.07	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	6.06	3.52	42%
1589	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	5.91	3.43	42%
1590	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	6.46	3.75	42%
1591	0.07	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	10.11	5.87	42%
1592	0.08	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	15.89	9.22	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1593	0.03	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	2.58	1.50	42%
1594	0.05	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	6.99	4.06	42%
1595	0.05	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	6.58	3.82	42%
1596	0.05	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	3.65	2.11	42%
1597	0.04	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	2.96	1.71	42%
1598	0.05	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	10.23	5.93	42%
1599	0.07	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	11.50	6.67	42%
1600	0.05	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	6.56	3.81	42%
1601	0.04	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	7.94	4.60	42%
1602	0.04	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	5.99	3.48	42%
1603	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	9.23	5.35	42%
1604	0.07	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	8.96	5.20	42%
1605	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	7.37	4.28	42%
1606	0.05	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	6.44	3.73	42%
1607	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	8.18	4.75	42%
1608	0.07	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	10.86	6.30	42%
1609	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	9.92	5.76	42%
1610	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	8.61	4.99	42%
1611	0.03	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	3.47	2.01	42%
1612	0.03	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	3.65	2.12	42%
1613	0.05	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	5.47	3.17	42%
1614	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	5.45	3.16	42%
1615	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	8.17	4.74	42%
1616	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	6.84	3.97	42%
1617	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	8.69	5.04	42%
1618	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	7.47	4.33	42%
1619	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	8.16	4.73	42%
1620	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	7.65	4.44	42%
1621	0.05	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	6.17	3.58	42%
1622	0.04	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	6.43	3.73	42%
1623	0.04	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	10-2022	8.70	5.05	42%
1624	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	15.90	9.22	42%
1625	0.06	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	22.12	12.83	42%
1626	0.03	Kokee Nature Center to Makaha Ridge	Diverter installation (Reflective)	11-2022	14.43	8.37	42%
1627	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	06-2022	1.97	1.14	42%
1628	0.04	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	4.68	2.71	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1629	0.04	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	6.31	3.66	42%
1630	0.09	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	06-2022	12.75	7.40	42%
1631	0.04	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	06-2022	6.54	3.80	42%
1632	0.07	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	6.46	3.75	42%
1633	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	3.93	2.28	42%
1634	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	4.21	2.44	42%
1635	0.02	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	3.05	1.77	42%
1636	0.02	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	2.94	1.71	42%
1637	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	3.58	2.08	42%
1638	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	3.17	1.84	42%
1639	0.01	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	1.95	1.13	42%
1640	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	4.37	2.53	42%
1641	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	4.91	2.85	42%
1642	0.02	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	3.83	2.22	42%
1643	0.02	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	2.97	1.72	42%
1644	0.02	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	3.80	2.20	42%
1645	0.02	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	3.58	2.08	42%
1646	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	4.93	2.86	42%
1647	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	5.39	3.12	42%
1648	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	6.42	3.72	42%
1649	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	4.96	2.88	42%
1650	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	4.83	2.80	42%
1651	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	5.00	2.90	42%
1652	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	5.16	2.99	42%
1653	0.04	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	6.43	3.73	42%
1654	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	5.37	3.11	42%
1655	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	5.22	3.03	42%
1656	0.04	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	6.84	3.96	42%
1657	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	5.38	3.12	42%
1658	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	5.89	3.42	42%
1659	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	5.42	3.14	42%
1660	0.01	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	2.84	1.65	42%
1661	0.04	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	6.84	3.96	42%
1662	0.06	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	12.13	7.03	42%
1663	0.08	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	16.27	9.44	42%
1664	0.08	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	14.96	8.68	42%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
1665	0.21	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	20.57	11.93	42%
1666.1	0.08	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	4.79	2.78	42%
1666.2	0.08	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	10-2022	5.67	3.29	42%
1667	0.06	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	10-2022	5.32	3.09	42%
1670	0.04	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	10-2022	3.51	2.03	42%
1671	0.05	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	5.48	3.18	42%
1672	0.05	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	4.70	2.72	42%
1673	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	2.25	1.31	42%
1674	0.04	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	1.70	0.99	42%
1675	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	1.95	1.13	42%
1676	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	2.63	1.52	42%
1677	0.04	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	2.96	1.72	42%
1678	0.05	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	3.46	2.01	42%
1679	0.06	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	10-2022	2.62	1.52	42%
1680	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	10-2022	2.06	1.19	42%
1681	0.04	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	10-2022	2.37	1.38	42%
1682	0.04	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	10-2022	2.23	1.30	42%
1683	0.03	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	2.45	1.42	42%
1684	0.04	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	2.35	1.37	42%
1685	0.04	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	2.59	1.50	42%
1686	0.05	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	03-2022	3.19	1.85	42%
1689	0.05	Kekaha Mauka 57kV - Port Allen/Kapaa	Diverter installation (Reflective)	11-2022	4.65	2.70	42%
1691	0.04	Puu Lua Kokee	Diverter installation (Reflective)	10-2022	4.47	2.59	42%
2026	0.13	Kahili	Diverter installation (LED)	12-2023	32.33	3.23	90%
2027	0.09	Kahili	Diverter installation (LED)	12-2023	24.21	2.42	90%
2028	0.06	Kahili	Diverter installation (LED)	12-2023	16.95	1.69	90%
2029	0.27	Kahili	Diverter installation (LED)	12-2023	82.55	8.25	90%
2030	0.48	Kahili	Undergrounding	04-2015	18.74	0.00	100%
2032	0.12	Kahili	Diverter installation (LED)	10-2022	29.30	2.93	90%
6000	0.03	None	Undergrounding	04-2015	4.80	0.00	100%
6001	0.11	None	Undergrounding	05-2015	19.04	0.00	100%
6002	0.07	None	Undergrounding	05-2015	17.99	0.00	100%
6003	0.04	None	Undergrounding	05-2015	11.37	0.00	100%
6004	0.10	None	Undergrounding	05-2015	24.57	0.00	100%
6005	0.06	None	Undergrounding	05-2015	13.68	0.00	100%

Span	Length (mi)	Span Name	Minimization action	Date	Estimated Baseline strike rate for seabirds	Estimated 2024 strike rate for seabirds	Estimated % Strike Reduction for Seabirds
10731074	0.19	None	Static wire removal	06-2023	13.22	5.22	61%
13081309	0.06	None	Diverter installation (Reflective)	10-2022	23.99	13.92	42%
14641465	0.03	None	Diverter installation (Reflective)	10-2022	10.46	6.07	42%
15281529	0.03	None	Diverter installation (Reflective)	10-2022	3.66	2.12	42%

Appendix 4C

Protocols for Seabird Trap Interactions at Conservation Sites

PROTOCOLS FOR SEABIRD TRAP INTERACTIONS AT CONSERVATION SITES

Certain HCP measures conducted at KIUC managed conservation sites may result in occasional take of covered seabirds. Specifically, there is a risk that individual birds may be caught in predator control traps. The following protocols have been developed for situations where individual birds are caught in predator control traps or otherwise expected to have been impacted by any other HCP related action, and will be followed by KIUC's contractors that perform HCP measures at the conservation sites.

All colony monitoring and predator control staff not named on a banding permit and that implement HCP measures at the conservation sites, will have in-person hands on training at SOS on an annual basis. In-person training will include proper methods for approaching a bird found on the ground, proper handling and evaluation methods.

A bird box is located at each site, either at the campsite or in a lock box, and are lined with clean material (e.g. sheet, towel, pillowcase). Crews must always carry a clean pillowcase (not reused) contained in a Ziplock bag or drybag. Pillowcases used to transport grounded birds must be replaced with clean pillowcases to prevent transference of avian diseases between individuals. After each use, used pillowcases must be appropriately cleaned offsite. Always transport bird in a lined bird box except in emergency situations when obtaining a bird box from the weatherport is too far away or will take too long to appropriately respond to bird's condition. If a bird is transported in a clean pillow case instead of a bird box, cover with body or rain gear to protect the bird from rain to the degree possible.

SAVE OUR SHEARWATERS: The SOS Hotline is manned by a staff member 24/7. Call/text (808) 635-5117 as needed/able.

ARCHIPELAGO RESEARCH AND CONSERVATION: Andre Raine (808) 265-3723

1. INITIAL DETECTION

Upon detection of a seabird caught in a trap, always notify the field supervisor or field partner immediately. The field supervisor or project manager must always notify KIUC's HCP manager immediately. If detected on a camera and a crew is not onsite, the predator control crew that handles trapping at that site will get to the site as soon as possible to check on the status of the bird.

Note the following and report to field supervisor or project manager

a. Species
b. Trap location
c. Estimate of how long bird has been in trap or otherwise grounded

2. OBSERVE THE BIRD IN SITU

A. TRAP INTERACTIONS

◊ Take a photo of the bird in the trap or in situ, without touching the bird.

◊ Are there obvious signs of injury or illness?

Do you see blood on the bird ***or*** *the trap? Is the head drooped or moving in an abnormal way (scanning, torticollis)? Eyes squinting or obstructed? Wings splayed at sides or in an unnatural position?*

◊ Are there clear signs of contamination?

Is there noticeable mud, feces, oil, etc. on the feathers?

◊ Is bait or lure present in the trap?

IF YES TO ANY ⇨ PROCEED WITH STEP 3 AND 4.
IF NO TO ALL ⇨ CONTINUE TO STEP 5.

B. WEATHERPORT/ETC. COLLISIONS

◊ Take a photo of the bird in the trap or in situ, without touching the bird.

◊ As you approach the bird, take note of the bird's body posture and behavior.

Do you see any blood on the bird ***or*** *its surroundings? Is the head drooped or moving in an abnormal way (scanning, torticollis)? Eyes squinting or occluded? Wings splayed at sides or in an unnatural position?*

◊ Are there clear signs of contamination?

Is there noticeable mud, feces, oil, etc. on the feathers?

IF YES TO ANY ⇨ PROCEED WITH STEP 3 AND 4.
IF NO TO ALL ⇨ CONTINUE TO STEP 6.

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3. HANDLING BIRD FOR FLYOUT

A. REMOVAL FROM TRAP

◊ Prior to removal, notify the office and field partner that you are preparing to handle the bird. If weatherport is a relatively short hiking distance, get a bird box from the weatherport and return with it to the trap. A clean pillow case can be used in emergency situations or if weatherport is too far away to removal bird in a timely way.

◊ Prep yourself: Take off your bag and remove work gloves (handle birds with bare hands). Ensure your hands are free from any residue (including hand sanitizer) that could transfer to the bird's plumage.

◊ Prep your supplies: Have the bird box and/or clean pillow case ready and within reach.

◊ Lock open the trap door and block the door with your body to keep the bird in the trap.

◊ Reach into the trap and bring the bird's wings into the sides of its body to prevent it from hurting itself. Do not begin to pull the bird out until you are sure you have a secure hold of the wings and body. As you remove the bird from the trap, watch to make sure that no toenails/wing tips/etc get hooked on trap parts. The bird may bite, but do not release the bird. The bird's safety comes first so let it bite you and keep holding it firmly but gently.

◊ Place the bird inside the lined bird box or clean pillow case (in emergencies). Immediately close the lid of the bird box or tie the end of the pillow case to prevent the bird attempting to escape. In emergency situations when a bird box may not be accessible, use the clean pillowcase to contain the bird by gently inserting the bird inside and to the bottom of the pillow case and knot the end. The bag should tied off carefully so that no primaries or tail feathers are caught.

B. WEATHERPORT/ETC. COLLISIONS – PICKING UP BIRD

◊ Ensure that your hands are free from any residue (including hand sanitizer) that could transfer to the bird's plumage.

◊ Approach the bird slowly and carefully, placing yourself between the bird and any potential avenue for escape. Reach down to grab the bird. Bring the wings to the sides of its body. Do not move the bird until you are sure you have control of the wings and body. Even if the bird is not struggling, always maintain a safe and secure hold.

◊ Place the bird inside the lined bird box or clean pillow case (in emergencies) for immediate flyout. Immediately close the lid of the bird box or tie the end of the pillow case to prevent the bird attempting to escape.

4. FLYOUT PROTOCOL

◊ Notify your supervisor and the bird will be flown out following the transport instructions.

- ◊ Communicate with fellow crew or field supervisor to coordinate an immediate flight out.

- ◊ If you will be transiting using webbing or in unstable terrain, communicate with your field partner to meet you along the trail to transit the bird together.

- ◊ Transport the bird in a bird box back to the weatherport, except in emergency situations where bird box can't be obtained within a reasonable period of time. In emergency situation, use the clean pillowcase to transport bird back to the weatherport. Keep the bag pressed securely to your middle, but not so firm as to suffocate the bird. Hike with the bird in an upright position and maintain hold on bird to prevent movement. The darkness of birdbox/pillow case will help ensure the bird is calmer and more desensitized as you move. If it is raining, keep the bird sheltered as much as possible to prevent it from becoming wet.

- ◊ Once back at the weatherport, or closest station with a bird box, gently pat the bird dry if wet and muddy. If transporting via pillow case, place the bird in the bird box for helicopter transport. Line the box with a clean sheet, towel, or the pillowcase. Make sure the box is properly sealed, air holes are open/not blocked and place the box in a dark and cool location away from activity. Do not handle the bird, or attempt to provide food or water, while waiting on a helicopter.

- ◊ Once the helicopter arrives, hand the box to the pilot or whoever inside the helicopter that can safely position it for the flight out.

- ◊ Once helicopter arrives in Lihue, the lined bird box with bird inside will be immediately transported to SOS or handed off to SOS staff at a designated meeting place.

IN PREPARATION FOR TRANSPORT TO SOS, PLACE THE BIRD IN A QUIET, DARK, COOL AREA AWAY FROM ACTIVITY TO MINIMIZE STRESS UNTIL THE HELICOPTER ARRIVES.

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5. FLYOUT WEATHER DELAYS

- ◊ If weather prevents helicopter access to fly bird out and deliver to SOS on the day the bird is placed in bird box for transport and it is before mid-September for NESH and before mid-October for HAPE, field staff must contact Andre Raine and SOS to get feedback/recommendations on whether or not it is best to release birds at the site or continue waiting on extraction. If any signs of abnormality are present other than natural soiling, birds must always be extracted regardless of the time it takes for helicopter to access the site.

- ◊ If weather prevents helicopter access to fly bird out and deliver to SOS on the day the bird is placed in the bird box for transport and the bird has signs other than natural soiling, field staff must contact Andre Raine and SOS to get feedback/recommendations on when it's appropriate to hike the bird out or to a different weather port that is accessible by helicopter (for sites where hike out is an option).

6. REMOVAL AND EXAMINATION OF THE BIRD

◊ Before handling the bird for further examination, find a location nearby (hole or deep enclosed space that is no more than a few feet from trap) in the vegetation or under something other than a burrow that can serve as a shelter for the bird during the day. Make sure the location is not occupied and is dry, if possible. The hole or enclosed space where the bird is to be placed should be twice the length of the bird and protected from direct light. It will move back to its burrow at night, but will need cover during the day. Record GPS points of the location and send to it your field supervisor or project manager.

◊ Prior to removal from trap or retrieving the bird from ground, notify the office and field partner that you are preparing to handle and assess the bird. It is not necessary to wait for a response from the office or field partner.

◊ Prep yourself: Take off your bag and remove work gloves (handle birds with bare hands). Ensure your hands are free from any residue (including hand sanitizer) that could transfer to the bird's plumage.

◊ Prep your supplies: Pull out your clean pillowcase; have it ready and within reach. If possible, lay the pillowcase down to use as an examination surface. This will help avoid any additional contamination to the bird's plumage.

◊ Lock open the trap door and block the door with your body to keep the bird in the trap.

◊ Reach into the trap and bring the bird's wings into the sides of its body to prevent it from hurting itself. Do not begin to pull the bird out until you are sure you have a secure hold of the wings and body. As you remove the bird from the trap, watch to make sure that no toenails/wing tips/etc get hooked on trap parts. The bird may bite, but do not release the bird. The bird's safety comes first so let it bite you and keep holding it firmly but gently.

◊ Place the bird on the clean examination surface. Even if the bird is not struggling, always maintain a safe and secure hold.

◊ Check to see if the bird has a band. If band is present, document band number.

Note: Limit handling time to avoid unnecessary stress. Stress can exasperate existing issues and negatively impact the bird's health. Don't rely on the bird's behavior to show whether they are stressed or not, as wild animals commonly avoid showing any sign of weakness or vulnerability when faced with a threat. Assume a wild bird is experiencing stress even if it appears calm. Do your best to move efficiently through the exam while still being thorough. The bird should not be in hand for more than 5-10 minutes.

USE THE FOLLOWING PROMPTS TO GUIDE YOUR EXAM.
IF ANY ABNORMALITIES ARE FOUND, END EXAM AND PROCEED WITH IMMEDIATE FLY-OUT PROTOCOL.

Respiratory

◊ Breathing should not be audible or significantly labored. Respirations that sound wet are abnormal.

◊ The bird may or may not vocalize sporadically, both are normal. Mouth is typically kept closed, but the bird may begin open mouth breathing if stressed and/or hot.

Face/Mouth

◊ Assess the head/neck of the bird. Is it held upright (unless trying to hide)? Are eyes bright, open, and clear? Does the bird seem to react to its surroundings? Check the bill for chips or other abnormalities.

◊ To assess hydration, open the bill of the bird. Do this very carefully. Never pry open the mouth from the tip of the bill. The mucous membranes should be light pink/pink in color and moist. If saliva appears ropey or stringy, the bird is likely dehydrated.

Plumage

◊ Does the bird have any dirty or damaged feathers? Are the belly, chest, or vent feathers tinged with grime? Note that birds with small, seemingly insignificant amounts of dirt/etc. have required multiple poolings before they became fully waterproof.

Body Condition

◊ Use your fingers that are wrapped around either side of the bird's belly to examine the keel bone (breastbone). While this bone is easily felt, it should not be sharp to the touch. You should be able to feel muscle up either side of the keel.

Legs/Feet

◊ Examine the webbing and toes of both feet. Are there open sores, abrasions, or swelling?

◊ Do the legs show any physical injuries or signs of asymmetry? Do they lay flat when the bird sits? Does the bird avoid putting weight on its legs or feet?

Body posture/wings

◊ Loosen your hold on the bird to examine body posture. It should be centered and balanced.

- ◊ While your grip is loosened, take a moment to assess how the wings are sitting. Are they held into the body or are they splayed out to either side? Do they appear to be symmetrical? Are the flight feathers in good condition?

- ◊ If no abnormal findings have been observed, perform a flight test: Place your hands directly in front of the thighs along the belly of the bird with your thumbs wrapped around the back to maintain a secure hold of the body. Wings should be free of your grip. Raise the bird off the examination surface and tilt the body up ~80° so the chest faces forward. The bird should begin to flap in the air. Does the bird favor one wing during the flap test or have unequal wing beats?

IF NO ABNORMALITIES ARE OBSERVED, PROCEED TO STEP 7.
IF THE BIRD WILL BE TRANSPORTED TO SOS, PLACE THE BIRD BOX IN A QUIET, DARK, COOL AREA AWAY FROM ACTIVITY TO MINIMIZE STRESS UNTIL THE HELICOPTER ARRIVES.

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7. RELEASE

- ◊ If the bird is captured in a non-baited trap and is determined to be in good condition based on the examination, the bird can be release at the site.

- ◊ Gently place the bird, head first about half way inside the previously identified covered location near where the bird was found. Allow the bird a few second to acclimate to the dark before releasing your hold. After the bird has run forward into the covered location, keep your hands over the entrance to dissuade the bird from running back out.

- ◊ Any trap that captures a bird during the breeding season must be locked open with zip ties or moved for the remainder of the seabird season.

- ◊ If bird is thought to have collided with weatherport, is detected at night and is in good condition, release at weatherport unless it is raining. If it’s raining, contain bird in bird box inside weatherport until rain abates or until the next evening when it can be released in a burrow or protected area.

- ◊ After handling bird, sanitize hands to the best of your ability while in the field and more thoroughly after returning to the weatherport. Take proper care of your health and safety. Any injuries should be appropriately attended. Do not touch mouth or eyes after handling bird.

8. REPORTING

Field crew supervisors will report these incidences to KIUC's HCP Manager immediately upon detection, and will send a detailed report using the report form below to KIUC's HCP Manager within four days of the detection.

KIUC's HCP Manager will report seabird trap interactions to USFWS and DOFAW. Email notification of the incident will be made within 24 hours of detecting the incident followed by a detailed report within one week of detecting the incident.

A copy of the detailed reporting form is below.

KIUC Conservation Site Seabird Incident Report

Date	
Time	
Location (include GPS coordinates)	
Point of Contact (Name and Phone)	
Species of Bird/Age	
Summary of Event	
Status of Bird (healthy/ dead/injured etc.)	
Actions taken	
Additional information (optional)	

Map showing location of the incident, and photos of the site and affected bird insitu will accompany this report.

Appendix 4D

Best Management Practices for Invasive Plant Species Control

Australian Tree Ferns- ***Cyathea cooperi**,* ATF - ATF's are widespread throughout ULP and although control has been done for years, it is still common to encounter large ferns while doing weed work. It is most common to find them in disturbed areas such as clearings and landslides although they can be present anywhere. ATFs can be identified by having many stiff, upright/horizontal fronds covered in thick white scales. Generally the fronds are far more numerous than the native hapu'u fern and form a definitive round "helicopter" top. In areas where large ferns were killed in the past there will often be many regenerating seedlings and juveniles. ATF's can be very difficult to kill. Common knowledge is that you can cut the trees down without using herbicide and the trunk or remaining crown will not re-sprout. It has been found that this is not the case in the ULP, possibly due to the wet environment.

Herbicide Used- 30% Habitat.

Control Method-

- Seedlings- For seedlings of ATF's up to one foot tall it is best to pull the plant, and hike out the remaining meristem and root ball. Fronds can be removed.
- Juveniles- The main meristem on Juvenile ATF's can almost always be reached. If this is possible first remove all fronds so that you can access the top of the meristem where new croziers (curled fronds) are sprouting up. Using a saw, cut down into the stalk about 8 inches from both sides to remove a large V-shaped wedge. It is important that you have cut far enough down to reach the starchy heart of the fern. Remove the V-shaped wedge and apply Habitat to the main stem and the wedge piece then. Following this replace the wedge back in the main stem. Replacing the wedge assists in keeping rain from washing away the herbicide and also insures that the plant dies as one unit.
- Adults- For large ATF's where you cannot reach the meristem of the plant it will be necessary to cut down the tree somewhere along the trunk. Do this where it is easiest to access as sometimes large trees can fall abruptly causing a safety hazard and you may have to move out of the way. Once you have felled the tree apply herbicide to the starchy heart that you have exposed on both sides of the cut (pic below). Do this as quickly as possible! Then move up to the main mersitem and follow the same wedge procedure as outlined for Juvenile ferns. This insures that no part of the plant will regrow.

 

ATF cut down with herbicide applied and ATF in the forest w characteristic "helicopter shaped fronds".

Himalayan Ginger- *Hedychium gardnerianum,* HEDGAR - Himalayan Ginger is widely known as one of the top threats to native Hawaiian forests. The herbaceous shrub can grow upwards of 6' tall and can completely smother the ground with thick rhizomes and an even thicker layer of canopy produced by large waxy leaves. Observations have been made of these rhizomes growing over the entrance to seabird burrows. This species is one of the most widespread and persistent weed species in ULP. Eradication is not an option for ginger only holding back the tide. The plants are always vigorous, the seeds are bird dispersed, and seedlings can sprout up in pristine areas with no disturbance. Due to this fact, the only way to insure you are doing an effective job of mitigating the threat is to searchcover all areas where the plants will sprout up, searching methodically searching every square meter of suitable area at that site in the days work area. Ginger, although it will sprout up anywhere, prefers shady open areas under trees, and wet areas along streams and gulches. It seems the seeds get stuck in Uluhe and Uluhe lau nui and desiccate slowing down sprouting in these areas. In general once you have reached an area that is open, sunny and covered in Uluhe or uluhe lau nui your search is complete. However if you see a stand of trees up the slope that appears to have a shady open area underneath you must go and check for HEDGAR. This search method is a bit esoteric to explain but with experience and dedication to comprehensively searching an area it becomes clear with time where the plants tend to grow.

Herbicide Used- 1% Escort

Control Method-

- Cut stems a couple/several inches above rhizome (on Himalayan ginger; where the pink base of the stem begins to fade to a green color) and stack stalks on the side.
- Stack all of the fronds that you remove off to the side of the patch as you will need them after treating to cover your work.
- It is important to "Undress" the patch before applying herbicide so you can clearly see all the rhizomes that need to be treated. Scrape away all leaves, dirt and debris.
- Once you have cleaned the work area make cuts in all rhizomes including the ones that you just cut the fronds off of. Each section of rhizome should get 4-6 cuts up to ¼" deep with a machete or saw, with particular focus on the nodes where new growth will be

sprouting from. Make sure to look under and around the sides of the patch to make sure you make cuts and/or stabs in rhizomes that are hiding underneath the bulk of the patch. Also be careful not to cut chunks of rhizome and send them flying into the bushes as these will surely re-sprout.

- Liberally coat all rhizomes and cuts with Escort. Don't skimp on herbicide as under-treated patches can regrow.
- Once the patch has been treated it is time to cover it or "build a hale" to prevent rain from washing away all of your hard work. The best way to do this is to remove individual leaves from your largest fronds. The leaves can then be stacked, overlapping to reduce runoff. Sometimes it is necessary to build a scaffold using leafless stems to stack your overlapping leaves on.
- Seedlings up to 1' in height can be pulled, taken back to camp and thrown in the trash. The leaves and stems can be ripped off.


HEDGAR stems cut at the proper height and a large flower stalk.

Guava Trees *Psidium cattleianum*, Strawberry Guava, PSICAT and ***Psidium guajava*,** Common Guava, PSIGUA**-** Strawberry guava seems to be appearing more often in the ULP although relative to other areas on Kauai numbers are pretty low. Trees can be found anywhere and are generally scattered, solitary individuals. Common Guava is only found at lower elevations close to basecamp and has not been seen for years. Some sources recommend applying Garlon directly to the trunk on Common Guava trees but it is believed this treatment should be avoided in the ULP due to the wet environment.

Herbicide Used- 25% Garlon 4.

Control Method-

- Cut the tree down within 1' of the ground.
- Apply Garlon 4 to the trunk liberally.
- Apply to the cut on the tree and make sure to elevate the tree off the ground.
- Make sure to search the area for seedlings and juveniles if the tree you are treating is mature. These can usually be pulled with ease.

PPSICAT growth form, flowers, trunk and fruit.

PSIGUA fruit and smooth trunk bark.

Hardwood Trees- ***Melaleuca quinquenervia,*** Paperbark Tree, MELQUI; *and* ***Grevillea robusta,*** Silk Oak, GREROB- These trees are becoming less common in the ULP due to successful control and are mainly seen around Basecamp. They are somewhat difficult to spot. **Paperbark Tree-** This species has a very conspicuous straight trunk that is bright white with

dark olive green leaves. The bark is very papery and sheds off of the tree. Leaves have a pleasant herbal fragrance.
Grevillea- This species is rarely seen in the ULP. The leaves are very lacey and the round canopy is very different from the other trees in the *Metrosideros* dominated forest however, they it can be difficult to spot unless they are large trees. The wood of this species can be toxic, and so care must be taken for anyone who cuts down this species. The flowers are bright orange and spiky, very conspicuous, even from great distances.

Herbicide Used- 30% Habitat.

Control Method-

- Cut down the tree and directly apply Habitat to the cut stump and also to the cut on the part of the tree you have felled.
- It is very important to be mindful of how and where cut materials are being disposed. Most tree species in ULP will re-root from cut pieces and grow into full trees. It is best to prop the trees in the bushes or Uluhe in a site where they will desiccate in the sun.
- It is also important to apply the herbicide quickly (within 30 sec. or as soon as the applicator can safely apply the herbicide) after the tree has been cut since some of these species can close up their wounds shortly after being damaged.

Paperbark flowers and leaves, Natalia Tangalin cuts down a tree, and treated stump.

Grevillea robusta leaves and flowers.

Softwood Trees- *Spathodea campanulata*, African Tulip, SPACAM; ***Schefflera actinophylla*,** Octopus tree, SCHACT; ***Clusia rosea*,** Autograph Tree, CLUROS-

African Tulip although beautiful, is one of the most invasive species in Hawaii. The huge orange or yellow flowers can cover these trees and the large seed pods that follow are filled with papery wind dispersed seeds. When sterile and at a distance, this species can be confused with some *Polyscias* species. The large trees will have a straight white trunk and a sparse but contained canopy of dark bluish compound leaves. These trees are quite common in the lower sections of the ULP near Basecamp.

***Schefflera*,** a very common house plant throughout the nation, has taken over a large portion of the Lower Limahuli Preserve. The bird dispersed seeds can grow epiphytically. As the trees grow they will eventually strangle their host tree. These trees have very glossy leaves on relatively sparse (thick) branches with whitish bark. Seed heads and flower spikes are bright red and resemble the outstretched arms of an octopus. From a distance this species could be confused with native *Polyscias* species (which are in the same family). Although uncommon in the ULP as compared to other weed species, this is also a very problematic species.

Autograph Tree is yet to be spotted in the ULP, but it is known from the ridges in nearby Mānoa Valley and occurs hanging on the steep cliffs of Lower Limahuli preserve. It is a matter of when and not if the species will make it into the ULP and when it does it will be a formidable foe. *Clusea* is a medium to large terrestrial or epiphytic tree with a dense canopy of dark green, waxy stiff leaves. Flowers are white-pink, large and waxy, while the fruits are greenish-brown and fleshy. The dark brown bark can become very rough on the trunk and the trees often send down adventitious root suckers similar to Banyan.

Herbicide Used- 50% RounduUp.

Control Method-

- Although these species have softer wood they are generally much more difficult to kill. Felled branches have a much higher tendency to re-root and grow into a new tree.
- To effectively remove the species use a saw or drill to make 1/2'" deep cuts/holes around all parts of the trunk on the trunk (or all trunks if there are multiple).
- Cuts should be spaced every 2-3" and be as close to the base of the tree as possible.
- It is very important to make cuts in all aerial roots and suckers as well to insure all parts of the tree die.
- On larger trees it is necessary to stop after 5 cuts and apply herbicide so that the wounds don't heal over. Or get help from a co-worker.
- Liberally apply RounduUp to all holes and cuts.

- USE EXTRA caution as the chemical is very concentrated!!
- Autograph Tree can be much more difficult to kill than the other trees in this section. It is best to make more cuts and use more herbicide to be cautious.


SPACAM leaves and flowers and the small papery, wind dispersed seeds.


SCHACT octopus-like leaves and growth habit showing bright red flowers.

CLUROS growth habit and leaf, flower, fruit and seed capsule.

Mules Foot Fern- *Angiopteris evecta*, *ANGEVE*- Mules foot fern is a new arrival to the ULP only spotted within the last 3 years. The occurrence of this very large fern seems to be increasing although of yet only juvenile plants have been found. Native to SE Asia and Australia, *Angiopteris* can grow to become massive and when they mature they have with fronds up to 7 meters in length and 3 meters in width. The base of the frond stems (stipes) appear swollen and bear two flat, rounded, dark brown, leathery growths- this section of the fern is called the "mules foot". Look for Mules Foot Fern in and around shady wet gulches. The base of the plant closely resembles that of *Marratia douglasii,* a native fern, so it is important to be aware of which taxa you are looking at before making a kill.

Herbicide Used- 30% Habitat.

Control Method-

- Remove all fronds from the fern.
- Around the scaly base of the fern make ¼- ½" deep incisions with a machete or saw, every inch or so.
- Apply 30% Habitat to the wounds as quickly as possible.
- It is good to try and cover the treated area with a nearby HEDGAR leaf or Clidemia.

ANGEVE fronds and pinna and base with fleshy stipules or "Mules Foot".

Albizia- *Falcataria moluccana,* FALMOL-
Only a few individuals of this species are known to occur within Limahuli. Unfortunately, the locations are very difficult to access. The seeds disperse easily and the incredibly fast growing tree can be difficult to cut down. The white bark and large flat/layered canopy of this tree makes it easy to spot. It is good to keep an eye out for seedlings and juveniles in landslides and other disturbed areas.

Herbicide Used- 30% Habitat

Control Method-

- Albizia can be controlled by stripping the bark from the base of the tree however it is prudent to apply Habitat to the cuts as well.
- Use a hand saw and cut in through the bark and cambium layer (approx. 1-1.5") in a circle around the tree about 3' from the base.
- Go down the trunk 1' foot and cut another circle around the tree.
- Try to make a vertical cut in between your 2 previous cuts.
- With some work you can begin to pry the bark from the tree and it should come off with ease.
- Apply Habitat to the lower and upper exposed parts of the cambium.

Albizia's large spreading trunk and leaves and flowers.

Vines/Brambles (*Rubus sp., Passiflora sp., Lantana camara*)-

Rubus argutus is a relatively new species to the upper preserve. This prickly vine can rip rain jackets and cut skin. The large black fruit are tasty and hold lots of bird dispersed seeds. This fast growing species can form large thick patches quickly and should be viewed as a very high priority for incipient removal. When in fertile, the vines are covered in white flowers.

***Passiflora* sp**. (Lilikoi, Passion Fruit) – Any species of this genus that naturalizes in the ULP could pose a huge threat to the preserve. The long, fast growing vines can smother large areas and the edible fruit is will readily dispersed by birds. Although it has only been observed a few times in the ULP, staff should be on the look-out for a uniform mat of foliage on the canopy (or fruit on the ground).

Lantana camara- Lantana is a vigorously growing shrub with recurved prickles and a strong odor when crushed. Its root system is very strong, and it gives out a new flush of shoots even after repeated cuttings. The flowers are usually orange or yellow, but can also occur in a range from red to white. Seeds are bird dispersed.

Herbicide Used- 30% Habitat.

Control Method-

- As most of the vegetative parts of these plants are growing through and on top of surrounding plants, you must first identify where the stems are growing out of the ground.
- Cut the stem and liberally apply Habitat to the fresh cut.
- Look for any signs of aerial roots growing out of the vines, if they are present cut and treat as much stem as possible, ideally placing the treated parts off the ground so that there is little chance of them rooting down.
- For **Blackberry** it is best to leave the stem intact and girdle the base by stripping it of the bark. Apply habitat to the stripped area. Blackberry will often have to be re-treated and is very difficult to kill.

Invasive Species Best Management Practices

[Photo on website]

Caption: If project activities occur in natural areas or native habitat, or have a high risk of introducing invasive species, we recommend that the following best management practices for biosecurity be incorporated into the project design as applicable.

Recommended Best Management Practices to Minimize the Introduction/Spread of Invasive Species

(Updated August 2021)

Invasive species pose a significant worldwide threat to native plants and animals, resulting in economic, ecological, cultural, and human health impacts (Lowe et al. 2004; Global Invasive Species Database (GISD) 2021). These impacts often include habitat degradation and loss, agricultural impacts, altered landscapes, increased costs associated with management of impacts to human quality of life, and loss of biodiversity, sometimes resulting in extirpations and extinctions of native species (International Union for Conservation of Nature and Natural Resources (IUCN) 2017; Ebersole 2020). Beginning with the first inadvertent introductions of invasive species by humans hundreds of years ago, all of these impacts continue to affect native species and habitats in the Hawaiian (Staples and Cowie 2001; Duffy and Martin 2019; Hawaii Invasive Species Council (HISC) and Coordinating Group on Alien Pest Species (CGAPS) 2020; National Tropical Botanical Garden 2021) and Mariana Islands (Rogers et al. 2012; Dawson et al. 2017;; Ossola 2018; College of Natural and Applied Sciences,).

In general, project activities can increase the likelihood of introducing or spreading invasive species to new areas or islands. For example, seeds of invasive plant species can be inadvertently transported on equipment or gear from a previous work site to a new site where they are not present. Likewise, equipment used in an area infected with a pathogen (i.e., Rapid ʻŌhiʻa Death (ROD) or *Ceratocystis spp.*), if not properly decontaminated, can act as a vector to introduce the pathogen into a new area (College of Tropical Agriculture, University of Hawaii 2021). Likewise, vehicles must be properly inspected and cleaned to ensure vertebrate pests do not stowaway and spread to other areas. These are just a few examples of how even well-intended project activities may inadvertently introduce invasive species.

To improve biosecurity and prevent and minimize the introduction or spread of invasive species, projects should incorporate best management practices (BMPs). In particular, vigilance is necessary when project activities occur in natural areas, including National Parks, National Wildlife Refuges, and Hawaiʻi State Natural Areas; or habitat areas containing primarily native vegetation (referred to hereafter as native habitat). We recommend that all projects occurring in natural areas or native habitat adhere to the following procedures, termed the "General Invasive Species BMPs*.*" Activities involving a substantial amount of transportation of materials (i.e., construction materials or aggregate, etc.), vehicles, machinery, equipment, or personnel between sites have a higher risk of spreading invasive species, and should also follow the "General Invasive Species BMPs" to the extent practicable. Additional consultation is recommended if the project involves transportation of materials, equipment, vehicles, etc. between islands.

There are also a few select invasive species of concern in the Pacific Islands of which species-specific BMPs have already been developed in partnership with species experts. These species-specific BMPs are recommended for projects that occur in certain geographic areas, and / or involve an activity that is a known pathway for the spread of specific species or groups of species. Please refer to Table 1 for the current distribution of these invasive species. If your project occurs within the geographic area of any of these species, please review and incorporate the relevant species-specific BMP(s) into your project design. As new invasive species threats emerge that require development of species-specific BMPs, those may be added to this list.

General Invasive Species Best Management Practices

The following protocol is recommended to the extent practicable when the project activities occur in natural areas or native habitat. These procedures should also be applied to any project that involves a substantial amount of transportation of materials (i.e., construction materials or aggregate, etc.), vehicles, machinery, equipment, or personnel between multiple work sites. Additional consultation is recommended if the project involves transportation of materials, equipment, vehicles, etc. between islands.

1. Cleaning and treatment:

   Project applicants should assume that all project materials, vehicles, machinery, and equipment contain dirt and mud, debris, plant seeds, and other invasive species and therefore require thorough cleaning. Treatment for specific pests, for example, trapping and poison baiting for rodents, or baiting and fumigation for insects, should be considered when necessary. For effective cleaning we offer the following recommendations prior to entry into a project site:

   a. Project materials, vehicles, machinery, and equipment must be pressure washed thoroughly (preferably with hot water) in a designated cleaning area. Project materials, vehicles, machinery, and equipment should be visibly free of mud, dirt, seeds, plant debris, insects, spiders, frogs (including frog eggs), and other vertebrate species such as rats, and mice and rubbish. Areas of particular concern include bumpers, grills, hood compartments, wheel wells, undercarriage, cabs, and truck beds. Truck beds with accumulated material are prime sites for hitchhiking invasive species.

   b. The interior and exterior of vehicles, machinery, and equipment must be free of rubbish and food. The interiors of vehicles and the cabs of machinery should be vacuumed clean.

2. Inspection:

   a. Following cleaning and or treatment, project materials, vehicles, machinery, and equipment, must be visually inspected by its user, and be free of mud, dirt, debris, and invasive species prior to entry into a project site. For example, inspection for ants would include the use of ant bait attractants which could confirm the absence / presence of ants in a vehicle. Another example would be the careful visual inspection of a vehicle's tires and undercarriage for any remaining mud that could contain invasive plant seeds.

3. Re-treatment:

   a. Any project materials, machinery, vehicles, and equipment found to contain invasive species after initial cleaning including any plant material must be re-cleaned before entry to the project site. Likewise, if materials, vehicles, machinery, or any equipment contain ants, other invertebrates, or vertebrates, including rats and mice, after initial treatment, they must be re-treated for extermination (i.e., poison baiting, trapping, fumigation, etc.) before entry into the project site. Cleaning, treatment, and inspection are the responsibility of the equipment or vehicle owner and operator. However, it is ultimately the responsibility of the action agency to ensure that all project materials, vehicles, machinery, and equipment are free of mud and invasive species before entry to a project site with a natural area or native habitat site.

4. Base yards and staging areas:

   a. Base yards and staging areas should be inspected for invasive species at least weekly during the duration of the project. Invasive species found in the site must be immediately removed or treated. Vehicles should be parked within a 10 square meter buffer area free of debris and/or vegetation. Ideally, vehicles should be parked on pavement and not under trees or in tall grass and other vegetation.

   b. Temporary storage of project vehicles or equipment outside of a base yard or staging area, such as a private residence, is discouraged. If necessary, they should be kept in a pest free area.

5. For all project site personnel:

   a. Prior to departing your residence or place of employment to transit to the project site, visually inspect and clean your clothes, boots or other footwear, backpack, radio harness, tools and other personal gear and equipment for insects, seeds, soil, plant parts, , or other debris.

   b. Immediately prior to departing a project site, visually inspect and clean your clothes, boots, pack, radio harness, tools, and other personnel gear and equipment for insects, seeds, soil, plant parts, , or other debris. Seeds found on clothing, footwear, backpacks, etc., should be placed in a secure bag or similar container and discarded in the trash rather than being dropped to ground at the project site or elsewhere.

6. Additional considerations (if applicable):

   a. Conduct a risk evaluation for activities that involve an uncertain potential for invasive species introduction, and therefore require further assessment in order to determine additional prevention guidelines.

   b. When applicable, use pest-free or low-risk sources of plants, mulch, wood, animal feed or other materials to be transported to a project site.

   c. For projects involving plants from nurseries (e.g., outplanting activities, etc.), all plants should be inspected and, if necessary, appropriately cleaned or treated for invasive species prior to being transported to the project site.

   d. Avoid unnecessary exposure to invasive species at a particular site (to the extent practical) to reduce contamination and spread. For example, plan or organize timelines so that work commences in a less infested area and toward a more contaminated site as best as practical.

e. When applicable, limit ground disturbing activities while working in natural areas. For example, utilize existing trails or roadways to avoid creation of new corridors that may be exploited by opportunistic vertebrates.

f. Maintain good communication about invasive species risks between project managers and personnel working on the project site. Ensure prevention measures are communicated to the entire project team. Report any species of concern or possible introduction of invasive species to appropriate land managers.

Rapid ʻŌhiʻa Death (ROD)

Rapid ʻŌhiʻa Death (ROD) is a caused by a fungal pathogen (*Ceratocystis* spp.) that attacks and kills ʻōhiʻa trees (*Metrosideros polymorpha*). ʻŌhiʻa is endemic to the Hawaiian Islands and is the most abundant native tree species, comprising approximately 80% of Hawaiʻi's native forests.

The following decontamination protocol and BMPs are recommended for projects occurring in any natural area or native habitat where ʻōhiʻa is present on islands where ROD is currently found. If working directly with ʻōhiʻa trees (e.g., sampling suspected trees, clearing an area of ʻōhiʻa, etc.) or in area(s) known to be highly infested with ROD, additional consultation is recommended. Additional consultation is also recommended if the project involves transportation of materials, equipment, vehicles, etc. between islands.

Current Distribution of ROD: Hawaiʻi Island, Oʻahu, Kauaʻi

- For more information about ROD including current confirmed distribution, ROD science updates, and the latest on ROD protocol, please visit www.rapidohiadeath.org.

Best Management Practices for Projects on Islands with ROD

1. Never transport any part of an ʻōhiʻa tree between different areas of an island or to a different island.
2. Do not use equipment from ROD infected islands on another island unless it is very specialized equipment and follows the decontamination protocols described below.
3. Avoid wounding ʻōhiʻa trees and roots with mowers, chainsaws, weed eaters, and other tools. If an ʻōhiʻa receives a minor injury like a small broken branch, then give the injury a clean, pruning-type cut (close to the main part of the trunk or branch) to promote healing, and then spray the entire wounded area with a pruning seal.
4. Always report suspect ROD ʻōhiʻa trees. ROD is a wilt disease that cuts off the supply of water and nutrients to the tree. The primary symptom to look for is an entire canopy or a large branch with dying leaves or red discolored leaves. Please record the GPS coordinates and location and take a picture of the tree if possible. Please report suspected ROD ʻōhiʻa trees to the following agency:

a. KISC: 808-821-1490 (kisc@hawaii.edu)

ROD Decontamination Protocol Projects on Islands with ROD

1. Clothes, footwear, backpacks, and other personal equipment
   a. Before leaving the project site, remove as much mud and other contaminants as possible. Use of a brush with soap and water to clean gear is preferred. Footwear, backpacks, and other gear must be sanitized by spraying with a solution of >70% isopropyl alcohol or a freshly mixed 10% bleach solution.
2. Vehicles, machinery, and other equipment
   a. Vehicles, machinery, and other equipment must be thoroughly hosed down with water (pressure washing preferred) and visibly free of mud and debris, then sprayed with a solution of >70 isopropyl alcohol or a freshly mixed 10% bleach solution. Use of a "pump-pot" sprayer is recommended for the solution and a hot water wash is preferred. Be sure to thoroughly clean the undercarriage, truck bed, bumpers, and wheel wells.
   b. If non-decontaminated personnel or items enter a vehicle , then the inside of the vehicle (i.e., floor mats, etc.) must be subsequently decontaminated by removing mud and other contaminants and sprayed with the one of the same aforementioned sanitizing solutions.
3. Cutting tools
   a. All cutting tools, including machetes, chainsaws, and loppers must be sanitized to remove visible mud and other contaminants. Tools must be sanitized using a solution of >70% isopropyl alcohol or a freshly mixed 10% bleach solution. One minute after sanitizing, one may apply an oil-based lubricant to chainsaw chains or other metallic parts to prevent corrosion as bleach is corrosive to metal.

NOTE: When using a 10% bleach solution, surfaces should be cleaned with a minimum contact time of 30 seconds. Bleach must be mixed daily and used within 24 hours, as once mixed it degrades. Bleach will not work to disinfect surfaces that have high levels of organic matter such as sawdust or soil. Because bleach is also corrosive to metal, a water rinse after proper sanitization is recommended to avoid corrosion.

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Appendix 4E

Review of New Powerlines and Streetlights in Northwestern Kaua‘i

The following process is applied to this HCP to ensure that future KIUC infrastructure and infrastructure modifications covered by this HCP in a specifically defined area of northwestern Kauaʻi do not inhibit the ability of the HCP to achieve the biological goals and objectives defined in Chapter 4, *Conservation Strategy*.

4E.1 KIUC Activities within the Area of Additional Conservation Commitments

A. Under the KIUC proposed HCP, covered seabird populations on Kauaʻi would be concentrated in approximately 12 highly managed conservation sites within the northwestern portion of the island. The *Area of Additional Conservation Commitments* (AACC) (Figure 4E-1) is intended to ensure that activities covered by the HCP will not reduce the likelihood that the HCP biological goals and objectives will be met. This will be accomplished by evaluating any proposed new KIUC-operated streetlights or powerlines (i.e., transmission or distribution lines) within the AACC. Evaluations will be based on existing data, or new information or data that may be available at the time of the proposed new powerlines/lights. Data evaluated may include, without limitation, new information not included in the HCP on routes navigated by covered seabird species to and from the HCP conservation sites and data indicating the likelihood of collision with new proposed powerlines or light attraction to new proposed KIUC-operated streetlights.

B. For purposes of Appendix 4E, the term "infrastructure" means any KIUC constructed, installed, or operated overhead wire (transmission wire, distribution wire, or communication wire), supporting structure (poles, towers, lattice structure, or H-frame), or streetlight. Attachment 1 contains an inventory of existing infrastructure within the AACC.

C. Operation and modification of existing covered infrastructure within the AACC (Attachment 1) can occur under the HCP without further review by the U.S. Fish and Wildlife Service (USFWS) or State of Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) if there is no potential to increase take of the covered seabirds. It is assumed that any modification to existing covered infrastructure within the AACC will not increase the potential for take of covered seabirds as long as any of the following parameters are not increased: wire height, vertical wire profile, exposure of wires, number of streetlights, or intensity of streetlights.

D. KIUC may implement modifications of covered infrastructure in the AACC that measurably reduces take by, without limitation, decreasing the following: wire height, vertical wire profile, or the number or intensity of streetlights. KIUC may also implement take minimization measures, such as flight diverter installation, and adaptive management measures that are identified in the HCP and approved through the federal incidental take permit (ITP) and state incidental take license (ITL).

E. Except as provided in Paragraphs C and D above, as applicable, any proposal to add new powerline or streetlight infrastructure or modify existing covered infrastructure identified in Attachment 1 in the AACC requires case-by-case USFWS, DOFAW, and KIUC review of best available data to assess whether the impacts of the proposed new or modified infrastructure will impact the likelihood of the HCP biological goals and objectives being met. Where KIUC proposes new or modified infrastructure in accordance with this paragraph, KIUC will submit a detailed written proposal to the USFWS and DOFAW for review and discussion. Subject to the availability of resources, USFWS and DOFAW will each use reasonable effort to review a complete KIUC proposal for new infrastructure and provide in writing the initial findings of their review to KIUC within 60 days of receiving the proposal. Ultimately, it is the responsibility of USFWS and DOFAW to make the final determination of the likelihood of impact. The criteria used to evaluate the proposal would include the following:

i. the likelihood of timely attainment of biological goals and objectives for covered species identified in the HCP, federal ITP, and state ITL;

ii. the likelihood of exceedance of ITP or ITL authorized species take limits;

iii. the likelihood of conflict with ITP and/or ITL terms and conditions;

iv. the likelihood of the proposed new or modified infrastructure falling outside the scope of effects of the proposed action fully analyzed through the National Environmental Policy Act (NEPA) or Hawai'i Environmental Policy Act (HEPA) process;

v. the likelihood of the proposed new or modified infrastructure being inconsistent with the agencies' respective NEPA/HEPA record of decision and any associated findings;

vi. the likelihood of the proposed new or modified infrastructure falling outside the scope of covered activities and effects analyzed through Endangered Species Act section 7 intra-Service consultation process; and

vii. whether the proposed new or modified infrastructure would otherwise comply with applicable laws.

F. Best available scientific information will be used in assessing the effects of proposed new or modified infrastructure under subparagraph E.i. (biological goals and objectives) and subparagraph E.ii. (take exceedance), including, without limitation, information on the status of covered species and the effectiveness of HCP take minimization and mitigation measures.

G. Proposed new powerlines that do not exceed 30 feet in height and do not involve vertical profile configuration with more than two layers (transmission and distribution) are exempt from review under the process described in Paragraph E. For such exempt powerlines, KIUC will provide to USFWS and DOFAW as soon as the information is available documentation of the assessment by a qualified avian biologist that will occur during the planning process to determine the potential strike rate (strikes per year) per span. (This assessment process is described for all new powerlines in Chapter 4, Section 4.4.1.2, *Future Transmission and Distribution Lines*.)

H. Should an agency determine that KIUC's proposed new or modified infrastructure in the AACC would trigger one or more considerations in Paragraph E, the agency will notify KIUC in writing. KIUC would have the option of reviewing the agency determination and all data and information that formed the basis of the determination. If KIUC's data and findings do not concur with that of the agencies, KIUC would provide additional data and information and meet with the agencies to discuss and determine the most appropriate path forward in consideration of all the available information. KIUC would have the option of requesting a formal amendment to the HCP, federal ITP, and state ITL in accordance with Section 7.6 of the HCP (Revisions and Amendments) and then appliable laws, regulations, processes, and policies.

I. Should an agency determine that KIUC's proposed new or modified infrastructure in the AACC would not trigger one or more considerations in Paragraph E, the agency will notify KIUC in writing that the new or modified infrastructure would be considered covered under the existing federal ITP and state ITL.

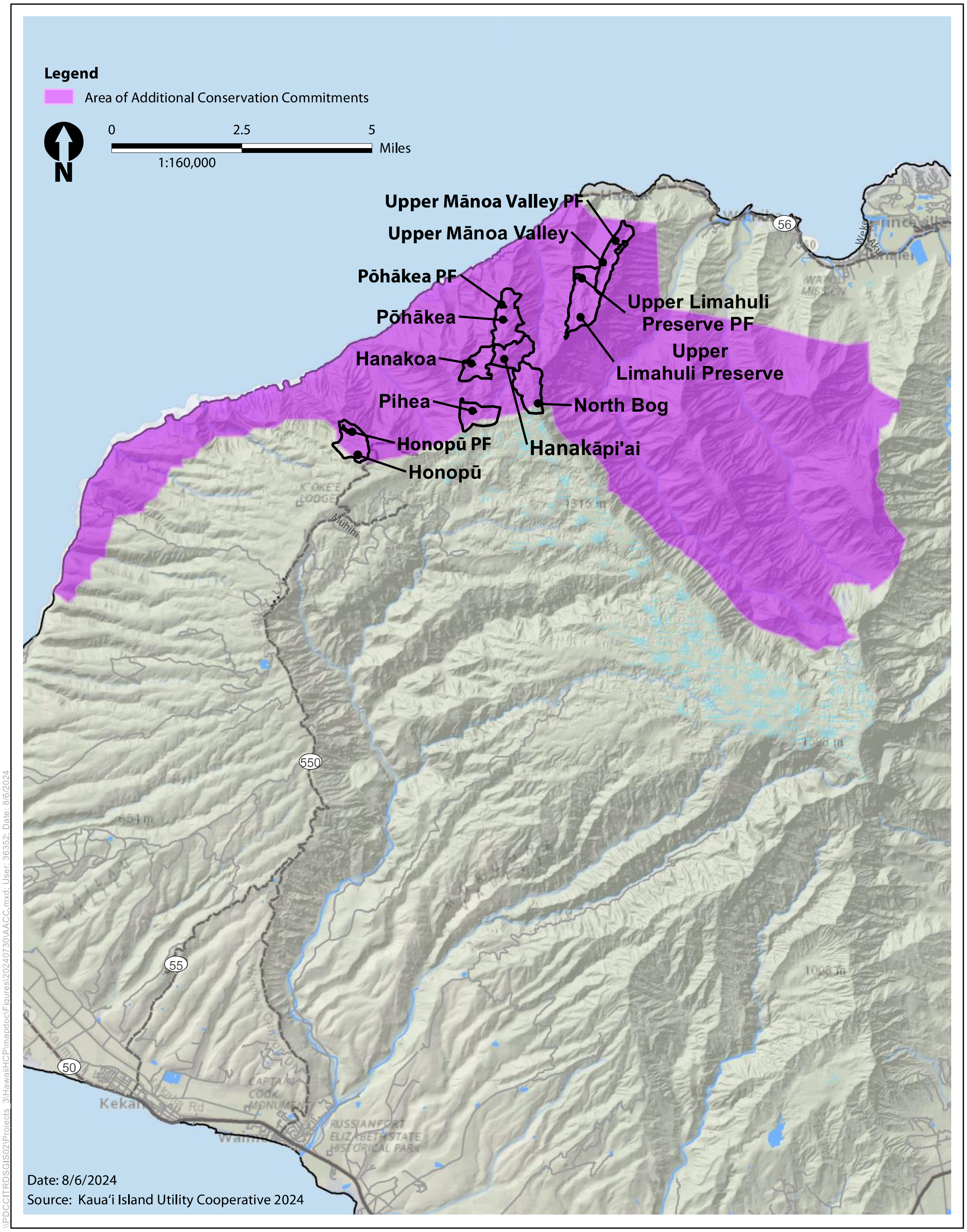

Figure 4E-1. Area of Additional Conservation Commitments with KIUC HCP Conservation Sites

Attachment 1

Inventory of Existing Infrastructure in the AACC

Pole Number	Configuration (horizontal/vertical)	Voltage	Pole Height[a] (ft)	Top Line Height (ft)	Total Height of Array (ft)	Distance of Span to Next Pole[b] (ft)	Next Pole Number
110-445-9900	horizontal	distribution	38	38.3	0	284	110-445-8801
110-445-9901	horizontal	distribution	34.3	34.4	0	247	110-445-9900
110-445-9902	horizontal	distribution	39.3	39	0	260	110-445-9901
110-445-0900	vertical	distribution	42	41.2	5	312	110-445-9902
110-445-0000	vertical	distribution	37.8	35.9	4.6	325	110-445-0900
110-445-0001	horizontal	distribution	33.5	33.5	0	178	110-445-0000
110-445-0002	horizontal	distribution	34	34	0	54	110-445-0001

[a] Above ground level

[b] Approximate, estimated with 3% sag.

Appendix 4F

Land Agreement with National Tropical Botanical Garden for Upper Limahuli Preserve Conservation Sites

Unforeseen issues developed in April 2025 between National Tropical Botanical Garden and KIUC regarding the Land Agreement with National Tropical Botanical Garden for Upper Limahuli Preserve Conservation Sites. KIUC has initiated a dispute resolution process to resolve these issues. If the dispute resolution process results in Upper Limahuli not being used as an HCP conservation site, KIUC will coordinate with USFWS and DOFAW to find an alternative site or sites, minimization, mitigation or a combination of these actions to make up for the site being withdrawn from the HCP.

MEMORANDUM OF UNDERSTANDING

THIS AGREEMENT, made this 9th day of August, 2023, by and between The National Tropical Botanical Garden with offices at 3530 Papalina Road, Kalaheo, Kauai, Hawaii 96741 (hereinafter "NTBG"), and the Kauai Island Utility Cooperative, with offices at 4463 Phaa Street, Suite #1, Lihue, Hawaii, 96766 (hereinafter "KIUC"), collectively referred to as the "Parties",

W I T N E S S E T H:

WHEREAS, NTBG is a 501(c)(3) nonprofit organization chartered by congress in 1964, and owns the real property described as "Limahuli Garden and Preserve", entirely located within the State of Hawaii's Conservation District and which includes the 400 acre Upper Limahuli Preserve ("Premises") located on TMK No. (4) 5-9-001-003 (the "Property"); and

WHEREAS, within the Upper Limahuli Preserve, wildlife biologists confirmed the presence of breeding colonies of Hawaiian petrels (Pterodroma sandwichensis), and Newell's shearwaters (Puffinus auricularis newellii) (collectively referred to as "listed seabirds"), both of which are federal and state listed species; and

WHEREAS, in 1993 the Board of Land and Natural Resources approved NTBG's Conservation District Use Application for Limahuli Valley Special Subzone (CDUP KA-2656) including the Master Plan for Limahuli Gardens and Preserve; and

WHEREAS, in accordance with NTBG's revised 2007 Master Plan, the Upper Limahuli Preserve is maintained as a natural area restricted from public access and with the following management objectives:

- preservation of flora and fauna native to the area including the listed seabirds,
- improve the habitat for the native flora and fauna through the control and removal of alien species including feral animals shown to be destructive to native flora and fauna including the listed seabirds and habitat needed for the success of breeding colonies, and
- to establish limited research/survey programs that will document and record the native flora and fauna species including the monitoring and tracking of the listed seabird colonies; and

WHEREAS, in 2009, with grant funds from USFWS, NTBG constructed an ungulate exclusion fence around the perimeter of the Upper Limahuli Preserve to restrict pigs and goats from the area, and

WHEREAS, KIUC is a not-for-profit electrical utility providing electrical services to the island of Kauai through electrical facilities, some of which are known to impact the Hawaiian petrel (Pterodroma sandwichensis), a species listed as endangered, and the Newell's shearwater (Puffinus auricularis newellii), a species listed as threatened, through powerline collisions and light attraction from streetlights.

WHEREAS, in 2011, KIUC completed a five-year Short Term Habitat Conservation Plan ("STHCP") and was issued a five-year Incidental Take Permit ("ITP") based on that plan;

WHEREAS, since issuance of the ITP and beyond the term of the STHCP and ITP, KIUC has been funding certain mitigation activities related to the protection of existing seabird colonies within the Upper Limahuli Preserve including the monitoring of seabird colonies, the control of seabird predators (i.e. cats, rats, mice, feral bees and barn owls) for the protection of those colonies, the control of invasive vegetation to improve seabird habitat and the maintenance of the ungulate exclusion fence; and

WHEREAS, KIUC has been working with US Fish and Wildlife Service and Hawaii's Department of Forestry and Wildlife on the development of a longer-term Habitat Conservation Plan ("HCP"), in which KIUC desires to continue funding the monitoring and protection as outlined in the HCP of seabird colonies located within the Upper Limahuli Preserve for the term of the HCP, including the construction of a predator exclusion fence or fences; and

WHEREAS, KIUC anticipates completion and approval of the HCP in 2024 and issuance of an ITP and a state Incidental Take License by the end of 2024 or in the first half of 2025, and thus requires the ability to access and implement HCP actions within the Upper Limahuli Preserve for the full term of the HCP.

NOW THEREFORE, in consideration of the terms and conditions contained herein and other good and valuable consideration, the Parties agree to the terms of the MOU presented in the following numbered sections:

1. Purpose
   KIUC, or KIUC's contractors, may enter the Premises for the term of the HCP for the purpose of implementing conservation actions as outlined by the HCP conservation strategy and utilize existing trails, temporary structures such as weatherports and wilderness areas.

   KIUC's conservation actions within the Premises are defined by the HCP conservation strategy and broadly include the following:
   A. Seabird colony monitoring.

   B. Predator control of cats, rats, mice, feral bees and barn owls, and other predators of seabirds that may occur in the area throughout the term.

   C. Construction of one or more predator exclusion fences within the existing ungulate exclusion fenced area.

   D. Maintenance of the existing ungulate exclusion fence.

   E. Control of invasive vegetation that diminishes suitable habitat for seabirds.

2. Trips into the Premises are expected to involve 2-5 individuals at any one time, and shall not exceed 5 individuals without prior written authorization from NTBG.

3. When KIUC's conservation actions fall within NTBG staff capabilities, NTBG will be given priority consideration as long as their rates are competitive with other service providers.

4. NTBG reserves the right to refuse access to any of KIUC's contractors who have violated Limahuli Garden and Preserve policies and procedures or pose a threat to native plants and animals, or cultural resources.

5. Special Requirements to Entry
   A. KIUC, or KIUC's contractors, shall give NTBG a written copy of all flight plans to the Premises. Except in cases of emergency or for legitimate health or safety reasons,

KIUC or KIUC's contractors will send written notice of projected trip dates to NTBG's Operations Manager at least one week in advance.

B. KIUC is required to abide by Limahuli Garden and Limahuli Preserve policies and procedures for coronavirus security, biosecurity (including protocols to prevent the spread of Rapid Ohia Death), and rare plant protection.
C. KIUC is required to abide by state and federal law and guidelines regarding rare plants and animals, and cultural resources.
D. KIUC is required to abide by best practices for protecting sensitive location information on rare plants and animals, and cultural resources.
E. KIUC trips will coordinate with and not interfere with NTBG activities (including its traps and cameras) in the Premises.

6. Research and Investigation
NTBG authorizes KIUC and KIUC's Agents to enter the Premises only for the purposes described in Paragraph 2 above, and to allow public access to the information gathered or obtained by KIUC within the scope of its activities on the licensed Premises to the degree authorized below.

KIUC is authorized to store the information collected in a private database and use the information in reports, maps, publications, project reviews, or to otherwise make the information available to the public in a manner that identifies the specific location of the private property owned by NTBG. The specific locations of threatened and endangered plants and animals or cultural resources will not be made publicly available.

7. Special Conditions
Prior approval by the Limahuli Conservation Operations Manager is required for any actions that involve: significant construction or installation of large equipment, disturbance to a cumulative area of greater than $1m^2$, potential harm to native plants, animals, or cultural resources, or any significant departure from prior approved techniques or actions. Prior approval by both Limahuli Garden Director and landowner NTBG is required for any actions that involve the construction of permanent and semi-permanent structures (intended lifespan of > 10 years), disturbance to a cumulative area of greater than $100m^2$, or may have an impact on downstream human communities. NTBG reserves the right to not approve fence construction activities that could cause serious or irreversible harm to threatened and endangered plants located within the Premises.

8. Ownership of Physical Structures
KIUC will maintain ownership of permanent and semi-permanent physical structures funded by KIUC and constructed by KIUC or KIUC's contractors through the term of the HCP. KIUC maintains the responsibility for upkeep, maintenance, and liability associated with these structures. Five years before the end of the Agreement the Parties will meet to discuss 1) if this MOU will be extended, 2) what will happen to the improvements made under this Agreement, and 3) if KIUC intends to continue with the HCP efforts within the Premises. At the end of the term, KIUC will conduct a survey to determine the status of the fence and identify any repairs necessary for the ongoing integrity of the fence. Based on the results of the survey, KIUC will: 1) make the identified necessary repairs as agreed to by the Parties, or 2) KIUC will pay a one-time fee to NTBG to compensate for the identified necessary repairs.

9. Insurance
At all times during the term of this Agreement, KIUC, will maintain, at its sole expense, the following insurance coverages:

1. Workers compensation and employer's liability to include statutory Workers Compensation, Temporary Disability and other similar insurance required by state or federal laws. Employer's liability coverage must be no less than $1,000,000 for each accident.
2. Commercial General Liability – limits of liability must not be less than $1,000,000 for each occurrence and not less than $2,000,000 in the aggregate. Any additional insurance coverage related to ARC's use of helicopters for access to the Licensed Premises shall be included in the commercial general liability insurance coverage if available.

All insurance policies required under this MOU (except Workers Compensation) must name NTBG as additional insured. KIUC shall provide NTBG with certificates of insurance upon signing of this Agreement.

10. <u>No Partnership</u>
No party to this agreement is an agent, employee, or partner of the other. This agreement shall not be construed to create a financial partnership or joint venture between the parties. This agreement binds no party to the financial obligation(s) of any other.

11. <u>Waivers and Release, and Indemnification</u>
To the fullest extent permitted by law, KIUC does hereby waive and release any and all claims against NTBG and its directors, officers, employees and affiliates (together, the "Landowner Parties") for all liability, loss, damage, expenses and attorneys' fees resulting from (i) death or injury to any person or (ii) loss, theft or damage to property of KIUC caused by or arising from KIUC's presence or activities on the Premises, regardless of the cause and even if caused by negligence, active or passive. KIUC agrees not to bring any claim or to sue NTBG on the basis of these waived and released claims.

KIUC shall defend, indemnify and hold NTBG and the other Landowner Parties harmless from and against any and all claims, liabilities, losses, damages and attorney's fees that may be suffered by or made against NTBG or the Landowner Parties (i) as a result of a claim by KIUC or any of KIUC's employees, contractors, collaborators, volunteers or other persons who enter the Premises with KIUC's permission ("KIUC's Agents"), or any other third party, arising directly or indirectly from KIUC's presence and activities on the Premises or otherwise under this Agreement, or (ii) from any breach by KIUC or KIUC's Contractors' obligations under this Agreement, except to the extent that the liability is caused by NTBG's or the Landowner Parties' gross negligence or willful misconduct. Without limiting the generality of the foregoing, KIUC shall be strictly liable for any and all losses, damages, costs, claims, liabilities and attorney's fees resulting directly or indirectly from or related to the use of helicopters for access to the Premises including but not limited to personal injury, death or property damage and shall defend, indemnify and hold NTBG and the other Land owner Parties harmless from all such losses, damages, costs, claims, liabilities and attorney's fees.

12. <u>Term</u>
The term of this agreement shall commence on the date this MOU is executed and continue for the term of KIUC's HCP.

13. <u>Termination</u>

NTBG has the right to terminate this MOU if KIUC violates Limahuli Garden and Preserve policies and procedures, fails to abide by the terms of this agreement, or pose a threat to native plants and animals, or cultural resources without remediation.

KIUC has the right to terminate this MOU if the Premises, for any reason, loses its value and capacity to be a seabird conservation site and is no longer considered a viable mitigation site for KIUC's HCP.

In addition, this Agreement may be terminated by mutual written agreement of the Parties. If either party fails to observe or perform any of the covenants herein contained and such default shall continue for thirty days after written notice thereof is given to the defaulting party, then the non-defaulting party may terminate this Agreement by providing written notice thereof to the defaulting party, which written notice shall specify the effective date of such termination, and exercise such other remedies as are available to the non-defaulting party at law or in equity.

14. Governing Law and Action or Suit
This Agreement shall be governed by and construed in accordance with the laws of the State of Hawaii. In the event of any action or proceeding brought by either KIUC or NTBG against the other based upon or arising out of any breach of the terms and conditions of this Agreement, the prevailing party shall be entitled to recover all costs, including reasonable attorneys' fees from the other.

15. Dispute Resolution
The Parties shall use their good faith efforts to resolve any dispute arising out of or relating to this Agreement. The Parties agree, at the request of either party, to attempt to resolve any such dispute by mediation attended by the principals of each party with authority to settle the dispute. Upon request by either party for resolution of a matter by mediation, the Parties shall jointly select a neutral person, with at least ten years' experience as a commercial mediator, to act as mediator. The fees of the mediator shall be shared equally by both Parties. The mediation shall be conducted in accordance with the commercial mediation rules of Dispute Resolution, Inc. or another dispute resolution entity agreed upon by the Parties. In the event that they are unable to resolve any such dispute using good faith efforts and mediation, then such dispute shall be settled by binding arbitration before a single arbitrator, and judgment upon the award rendered by the arbitrator may be entered in any court having jurisdiction thereof. The arbitrator shall be the person agreed to in writing by the {arties or, failing such agreement, as appointed by Dispute Prevention and Resolution, Inc. or another dispute resolution entity agreed upon by the Parties.

IN WITNESS WHEREOF, the parties, by their duly authorized representatives, have signed below on the date first written above.

NTBG

BY Janet Mayfield
Janet Mayfield (Apr 30, 2024 12:53 HST)
Janet Mayfield, Director and CEO

ATTEST:

BY ____

KIUC

BY David J. Bissell
David Bissell, President and CEO

ATTEST:

BY ____

NTBG Upper Limahuli HCP Agreement 08-09-23 execution version

Final Audit Report 2024-04-30

Created:	2024-04-26
By:	Chris Yuh (cyuh@kiuc.coop)
Status:	Signed
Transaction ID:	CBJCHBCAABAAR2tdCDUBEZUU6rVA4chIiThLZ2YB-3CA

"NTBG Upper Limahuli HCP Agreement 08-09-23 execution version" History

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Agreement completed.

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Appendix 4G

Land Agreement with Ric Berry for Upper Mānoa Valley Conservation Sites

LONG-TERM EASEMENT AND
CONSERVATION MEASURES COOPERATIVE AGREEMENT
with respect to the
UPPER MĀNOA VALLEY

This Long-Term Easement and Conservation Measures Cooperative Agreement ("Agreement") is made and entered into this 28th day of February, 2024 by and among Ric Berry ("Berry") and the Kaua'i Island Utility Cooperative ("KIUC"), collectively referred to as the "Parties," concerning long-term conservation measures to be funded and implemented by KIUC on real property owned by Berry and referred to as the Upper Mānoa Valley.

RECITALS

A. Berry owns fee title to that certain real property on the Island of Kaua'i, State of Hawai'i, known and referred to as the Upper Mānoa Valley ("UMV" or "Premises"). A map depicting the location and approximate boundaries of the UMV is attached to this Agreement as Exhibit A.

B. KIUC is a not-for-profit electrical generation, transmission and distribution utility cooperative owned by the members it serves. Headquartered in Līhu'e, Hawai'i, KIUC serves approximately 33,000 electric accounts on the island of Kaua'i.

C. The UMV is a remote, undeveloped valley located in the interior of Kaua'i, which is only accessible by foot or by helicopter. The UMV contains valuable natural resources, and is occupied by numerous species of plants and animals, including one or more species of seabirds that are listed as threatened or endangered under the federal Endangered Species Act ("ESA") and the analogous State of Hawai'i statute (Hawai'i Revised Statutes Chapter 195D ("HRS 195D")), including the Newell's Shearwater (collectively, "listed seabirds"). These seabirds breed within the UMV and elsewhere on Kaua'i, but spend the majority of their lives at sea.

D. Berry has a strong and long-standing interest in facilitating the implementation of conservation actions within the UMV, including but not limited to actions which will benefit listed seabirds. As part of that interest, Berry established the "UMV Working Group" which consists of persons and organizations (including KIUC) with specialized expertise and/or interest in conservation actions in the UMV, who participate on a voluntary basis and provide advice to Berry and other participants.

E. KIUC owns and/or operates multiple power lines and lights, which can adversely affect listed seabird species, including the Newell's Shearwater. KIUC completed a Short Term Habitat Conservation Plan (STHCP) in 2011. KIUC was issued an ESA Incidental Take Permit by the U.S. Fish and Wildlife Service ("USFWS"), which authorized KIUC to "take" listed seabirds incidental to the presence and operation of KIUC's covered facilities. The STHCP expired in 2016 but KIUC has continued to implement the conservation measures under the STHCP (see below). KIUC is now preparing a long-term Habitat Conservation Plan ("HCP") which will support its application to the USFWS for a new longerterm incidental take permit ("ITP"), and its application to the Hawai'i Department of Land and Natural Resources ("DLNR") for a longer term Incidental Take License ("ITL") under HRS 195D. The draft HCP and associated Environmental Impact Statement will undergo both state and federal environmental review according to the requirements of Hawaiʻi Environmental Policy Act ("HEPA") and National Environmental PolicyAct (NEPA") prior to ITP and ITL issuance.

F. Pursuant to an Interim Cooperative Agreement between the Parties (signed in April 2017, and extended in April 2019), KIUC has since 2017 conducted seabird monitoring, predator control and vegetation management within the UMV as a voluntary continuation of the STHCP conservation plan and, since 2020, as early implementation for the proposed long-term HCP. As part of its efforts to minimize, mitigate, and offset the effects of its unavoidable take of listed seabirds pursuant to the HCP, KIUC desires to implement certain additional conservation actions within the UMV that will benefit, and increase the numbers of, listed seabirds which breed in the UMV. More specifically, KIUC desires to conduct predator control and colony monitoring throughout the UMV, construct and maintain a predator exclusion fence within the UMV, and to construct and maintain two weatherports in support of fence construction and ongoing conservation work. After construction is complete, KIUC also desires to then implement measures intended to (i) reduce or eliminate seabird predators (e.g., rats, cats and pigs) within the fence, (ii) attract additional breeding seabirds to the fenced area using "social attraction" techniques, (iii) manage non-native, invasive vegetation in seabird breeding areas that can impair the ability of seabirds to create and maintain breeding burrows, and (iv) regularly monitor and report to USFWS and DOFAW on the performance of these measures.

G. KIUC's ongoing and proposed future conservation actions in the UMV, while designed specifically to benefit listed seabird species, will also provide other ancillary conservation benefits to other UMV flora and fauna, and the overall UMV ecosystem. They will also likely enhance other, complementary conservation actions that Berry desires to pursue in the UMV.

I. The USFWS and DLNR Division of Forestry and Wildlife ("DOFAW"), which are not parties to this Agreement, worked in collaboration with KIUC on developing the HCP and are aware of and support the draft HCP actions proposed in the UMV. After the state and federal review processes, the approved final HCP will determine actions that occur in the UMV.

J. The Parties desire to enter into this Agreement in order to express their commitment to the mutually beneficial implementation of these conservation actions in the UMV, and to establish the framework for their long-term cooperative effort immediately and without waiting for the completion of the HCP. This Agreement also ensures KIUC has the landowner's authorization to implement the UMV conservation activities that are included within the approved final HCP.

K. The Parties agree that a separate perpetual Conservation Easement in accordance with Hawaii Revised Statutes Chapter 198 will be prepared consistent with the requirements of USFWS and DLNR and recorded against the UMV (the "Conservation Easement"), and this Agreement will likely be incorporated into the terms the Conservation Easement.

L. Berry has been advised to seek private counsel prior to executing this Agreement and confirms he has reviewed and signed this Agreement after such consultation.

NOW, THEREFORE, for and in consideration of the facts recited above, the mutual covenants set forth in this Agreement, and other consideration, the receipt and adequacy of which are hereby acknowledged, the Parties agree as follows:

1. <u>Grant of Use and Right to Implement Permitted Uses</u>

A. Berry hereby grants to KIUC and its contractors a non-exclusive easement in gross, for the term of this Agreement, to enter the UMV via foot and by helicopter for the purposes of implementing certain types of "Permitted Uses", which uses are related to the conservation of listed seabird species summarized in Section F above. A list of the types of Permitted Uses is attached as Exhibit B. Permitted uses will be outlined in the approved final HCP and the final site management plan attached to the Conservation Easement.

B. Until such time as the USFWS and DLNR approve the HCP and issue the ITP and ITL, KIUC intends to continue conducting seabird-related conservation measures consistent with those proposed in the longer term HCP. The types and locations of these measures are detailed in KIUC's draft HCP, which is currently under review by USFWS, DLNR DOFAW and ESRC, and which is subject to revision. A description of the types of seabird conservation measures is included in attached Exhibit B.

C. All improvements constructed by KIUC in accordance with this Agreement shall be constructed in accordance with prevailing good construction practices and shall be maintained in a good and safe condition during the term of this Agreement.

2. <u>Reservation of Uses</u>

Subject to the terms of the Conservation Easement upon its recordation, any lawful uses not specifically granted to KIUC and which do not adversely affect or compromise the success of conservation measures implemented by KIUC are reserved to Berry, and Berry may conduct such uses subject to the restrictions in this Agreement.

3. <u>Non-Interference with Seabird Conservation Work</u>

A. The draft HCP identifies currently known areas of seabird presence and activity ("Seabird Areas") in the UMV, within which KIUC is conducting and would continue to conduct seabird monitoring, predator control and weed control activities to benefit listed seabirds through the term of the HCP. It also identifies the location of the seabird social attraction site.

B. The draft HCP also identifies the anticipated location of the future predator exclusion fence. After the fence is constructed, KIUC would then implement seabird conservation measures (e.g., predator control) throughout the fenced area and within the larger UMV management area outside of the fenced area and maintain the predator exclusion fence as as defined by the final, approved HCP.

C. In conjunction with construction and maintenance of the predator exclusion fence, KIUC also intends to install and maintain two weatherport structures (to provide shelter to conservation work crews), and two helicopter Landing Zones ("LZ"), which were developed as part of the STHCP activities. The weatherport(s) will have a capacity to house four individuals for overnight stays. Consistent with guidance provided by DLNR's Office of Conservation and Coastal Lands, the weatherport(s) and LZ are to be used to support conservation work (including related visits by Berry and KIUC personnel), and are not to be used for commercial purposes (e.g., commercial tours). The weatherport facilities and landing zones would be utilized for the purpose of KIUC or its agents to conduct listed species field work to implement the HCP, and the facilities will be removed by KIUC if no longer necessary for this purpose.

The fences and weatherport structures are owned by KIUC for the term of this Agreement; thereafter, ownership will be transferred to Berry or the Conservation Easement. The fences and weatherports will be transferred in good condition with all identified repairs completed prior to the transfer.

D. Berry, and any other individual or other organization acting on his behalf or with his permission, may implement other conservation measures within the wider UMV seabird conservation area, so long as (i) such other measures do not adversely affect or compromise the success of KIUC's seabird conservation measures, (ii) Berry notifies KIUC well in advance of implementing such measures in order to provide an opportunity to identify and resolve any potential conflicts or issues, and (iii) Berry, or those acting on his behalf or with his permission, comply fully with appropriate biosecurity protocols.

E. KIUC and its contractors will not take any actions which will adversely affect or compromise the success of conservation measures implemented by Berry or any other individual or other organization acting on his behalf or with his permission, and Berry will not take any actions which will adversely affect or compromise the success of conservation measures implemented by KIUC.

4. <u>Pre-entry Notice and Coordination</u>.

A. KIUC or its contractors shall provide written notice to Berry not less than 96 hours prior to their entry into the UMV except in situations requiring rapid response to protect seabird species. Any particular notification can specify multiple entries on multiple dates. The notice shall generally describe the nature, location, and duration of the entry.

B. Berry, or other individuals or organizations acting on his behalf or with his permission, shall provide written notice to KIUC not less than 24 hours prior to their entry into the seabird conservation area or their entry into the fenced area. The Parties shall confer prior to any such entry to determine what precautions or measures are necessary to avoid adversely affecting or compromising the success of KIUC's seabird conservation activities. Each Party shall comply with such mutually acceptable precautions and measures. In addition, if Berry, or other individuals or organizations acting on his behalf or with his permission, wish to utilize the weatherport(s), they shall provide written notice to KIUC not less than two weeks in advance. The Parties shall then confer and determine whether adequate weatherport space will be available.

C. Actions for which no objection has been raised during such 24 hour period, or actions that are otherwise in conformance with any approved terms and conditions of entry agreed to by the Parties, shall be deemed approved and in conformance with the goals and objectives of this Agreement.

5. Vegetation Removal

Prior to removing any vegetation within the UMV for the construction of the predator exclusion fence and weatherports, KIUC or its contractors shall conduct a basic field review to verify whether rare or endangered plants are present and shall take such measures as necessary to avoid injury to such plants. Such locations shall be marked on a reference map and conveyed to Berry.

6. KIUC Conservation Obligations

A. Until such time as KIUC receives its ITP and ITL KIUC shall continue to perform the conservation activities as described in the draft HCP. Upon issuance of such ITP and ITL the affirmative conservation obligations of KIUC shall be governed by such ITP and ITL, the terms of which will be reflected in the HCP and the Conservation Easement.

B. KIUC will proceed with the construction of the predator exclusion fence, and implementation of predator eradication, post-eradication predator control and social attraction efforts, irrespective of the timing of USFWS and DLNR approval of the HCP, and issuance of the ITP and ITL, respectively. KIUC shall initiate construction of the fence as soon as is practicable after execution of this Agreement, receipt of State Conservation District permits and a fencing contractor has been selected . The Parties understand and acknowledge that construction must be avoided in some areas during certain times of the year so as not to harm seabirds or compromise their breeding.

7. Berry Conservation Obligations

A. Berry agrees the Premises will be dedicated, in perpetuity, for seabird conservation efforts consistent with this Agreement through a Conservation Easement in accordance with Hawaii Revised Statutes Chapter 198. Details of the Conservation Easement will be determined by USFWS, DLNR DOFAW, the easement holder, KIUC and Berry, but will at least include the following:

1. A Conservation Easement is an interest in real property created by deed, restrictions, convenants, or conditions, the purpose of which in this case is to preserve and protect land for seabird conservation (HRS 198-1).
2. The Conservation Easement will be perpetual (HRS 198-2).
3. The particular characteristics of a Conservation Easement shall be those granted or specified in the instrument creating or transferring the easement.
4. A 501(c) organization or government entity may aquire or hold Conservation Easements (HRS 198-3).
5. Instruments creating, assigning, or otherwise transferring Conservation Easements shall be recorded in the bureau of conveyances, or land court and such

instruments shall be subject to the requirements of HRS chapters 501 and 502 (HRS 198-4).

6. All Conservation Easements shall be considered to run with the land (HRS 198-5).
7. A site management plan for UMV that reflects seabird conservation measures as outlined in the approved final HCP.

Berry has reviewed HRS Chapter 198 and is aware of how a Conservation Easement is defined and regulated by by Hawaii state law. Berry will file a Conservation Easement for the Premises to be recorded with the Bureau of Conveyances to memorialize such an easement within six months of execution of this Agreement.

As part of the HCP, KIUC will fund the Conservation Easement at Upper Manoa. Funding assurances for the Conservation Easement at Upper Manoa will be addressed in the HCP, the details of which are not included in the landowner agreement.

B. Within 45 days of written request by KIUC, Berry agrees to (i) grant to a qualified third party identified by KIUC a perpetual Conservation Easement (as defined above, the "Conservation Easement"), which Conservation Easement shall become effective upon approval of the HCP and issuance of the Permit and the License; provided, however the KIUC shall be required to post any and all endowments or performance security that may be required by USFWS or DOFAW to secure KIUC's obligations under the Permit and License and which are incorporated into the Conservation Easement and (ii) enter into such modifications to this Agreement as may be necessary to reflect the terms of the HCP and the Conservation Easement.

7. UMV Working Group

A. As described in Recital E, above, Berry intends for the UMV Working Group to continue. The UMV Working Group shall consist of Berry, KIUC, and the voluntary participation of such other persons, agencies, and organizations as determined by Berry that have an interest in the conservation work conducted in UMV, ideally including representatives of the USFWS, DLNR, Achipelago Research and Conservation, LLC, and National Tropical Botanical Garden.

B. Berry intends to convene the Working Group at least annually on Kaua'i. Prior to such meeting, Berry and KIUC shall prepare and distribute brief written summaries of all activities conducted and information collected in the UMV since the prior Working Group meeting. Other attending Working Group members will also be asked to prepare written summaries of any activities they have conducted in or information they have collected regarding the UMV since the prior Working Group meeting.

8. Information Sharing

KIUC shall promptly provide Berry and/or his designee with a copy of annual reports for conservation work conducted by KIUC and/or its agents at Upper Manoa. Also, KIUC or its agents will provide Berry and/or his designee with written monthly updates on conservation activities conducted by KIUC and/or its agents.

9. Dispute Resolution

Should a dispute arise between the Parties concerning this Agreement, the Parties shall exercise their good-faith best efforts to resolve such dispute within sixty (60) days through direct negotiations. If the Parties are unable to resolve the dispute through direct negotiation, the Parties shall promptly submit the dispute to confidential mediation using a professional Hawaii mediator. The mediator must have professional experience involving natural resources, conservation or environmental issues. If the Parties are unable to agree on the selection of such mediator, each Party will designate a proposed mediator, and such proposed mediators will meet and confer and select a third mediator who will then serve as the sole mediator of the dispute. The Parties shall share the cost of the mediator(s) equally. A good-faith attempt by the Parties to resolve a dispute through direct negotiation, and then mediation, is a mandatory pre-condition to pursuing any other remedy or adversarial proceeding of any kind.

10. Compliance with Law

KIUC shall, at all times during the term hereof, comply with all applicable laws, rules and regulations, whether state, county or federal, including but not limited to, the laws applicable to the use of the Premises and the terms of any permits.

11. Due Care and Diligence/No Construction.

KIUC and its contractors will use due care and diligence in entering upon the Premises. KIUC agrees that under no circumstances will it (a) grade, cut, remove vegetation, or otherwise alter the Premises except as is necessary in connection with the Permitted Uses and with Berry's approval, or (b) make any improvements other than those contemplated by this Agreement.

12. Liability.

KIUC shall own the predator exclusion fence or any other seabird conservation fencing installed at Upper Manoa consistent with KIUC's HCP, and will retain liability for this fencing through the term of the HCP. KIUC shall be responsible for injury to persons or property caused by its employees, agents, and contractors in the course and scope of their work upon the Premises. KIUC shall indemnify, hold harmless, and defend Berry from any liability or claim arising from such work upon the Premises.

13. Condition of Premises/Assumption of Risk.

KIUC hereby agrees and acknowledges Berry has not made and will not make any representation or warranty, implied or otherwise, with respect to the condition of the Premises, including any dangerous or defective conditions existing upon the Premises, whether or not such conditions are known to Berry or reasonably discoverable by KIUC. KIUC accepts each entry upon the Premises with full assumption of the risks, and consequences thereof, of said conditions. KIUC agrees all property, approved improvements and equipment of KIUC kept or stored on the Premises shall be so kept or stored at the sole risk of KIUC.

14. Permits.

KIUC, at no cost or expense to Berry, shall be responsible for obtaining any and all governmental permits and approvals which may be necessary for it to conduct any work or activities under this Agreement.

15. Liens and Claims.

KIUC will not permit any mechanics', materialmen's, or other similar liens or claims to stand against the Premises for labor or material furnished in connection with any work performed by KIUC under this Agreement.

16. Nonexclusive Rights.

The rights granted to KIUC by this Agreement are nonexclusive. Berry reserves all rights to use the Premises, and to authorize other persons or entities to access the Premises and implement other conservation actions, subject to the applicable restrictions in this Agreement.

17. Reimbursement of Berry Expenses. [INTENTIONALLY OMITTED]

18. Compensation.

As compensation for the herein grant of easement, KIUC shall pay Berry the sum of twenty thousand ($20,000) per year prior to the ITP and ITL issuance, and forty thousand ($40,000) per year for the remainder of the HCP term. The payment amount after ITP and ITL issuance shall be increased every 12 months by one percent (1%).

Payments shall commence on the first of the month following the effective date of this Agreement (when signed by all the parties) and shall be due on the twentieth day of the January annually thereafter. Payment may be prorated for any partial annual period.

19. Term.

This Agreement will remain in effect for the term of the HCP. The Agreement cannot be terminated without the written consent of both Parties, and without good cause, unless KIUC is not issued an ITP and ITL for the longer term HCP, in which case this Agreement is terminated.

At the end of the Term, if KIUC desires to continue seabird conservation activities at Upper Manoa, both parties will mutually work towards either amending the Term of this Agreement or enter into a new agreement. Regardless of the length of time KIUC performs seabird conservation activities in Upper Manoa, Berry intends for the seabird conservation area to remain dedicated to seabird protection and conservation.

20. Agreement Binding Upon Heirs and Assigns

This Agreement, and the terms, conditions, rights and obligations contained herein, extend to, are binding upon, and inure to the benefit of the Parties and their respective heirs, personal representatives, successors, assigns, and/or acquirers, including any subsequent fee title owner of the Premises.

21. Insurance

KIUC shall, within thirty (30) days of the date of execution of this Agreement, provide Berry with evidence of a comprehensive general liability insurance policy covering the Upper Manoa Valley property and any improvements constructed by KIUC thereon, with minimum limits of not less than $1,000,000 for bodily injury to one or more persons in any one occurrence, and not less than $100,000 for property loss or damages, naming Berry as additional insured. The Parties contemplate that KIUC will be authorizing access to the Property by its employees, agents, and contractors for the purpose of conducting the work contemplated by this Agreement. The conduct of such parties shall be within the scope of the herein insurance and indemnification requirements.

22. Counterparts

This Agreement may be executed in counterparts, each of which shall be an original and have the same effect as if all of the Parties executing the counterparts had executed a single instrument.

IN WITNESS WHEREOF, the Parties have executed this Agreement as of the date first set forth above.

Ric Berry
Owner, Upper Mānoa Valley

By: Richard Langwith Berry (Feb 28, 2024 11:36 PST)

Date: 02/28/24

Kaua'i Island Utility Cooperative

By:

Title: CEO

Date: 02/28/24

<u>**Exhibit A – Map of Upper Manoa Valley, Island of Kaua'i**</u>

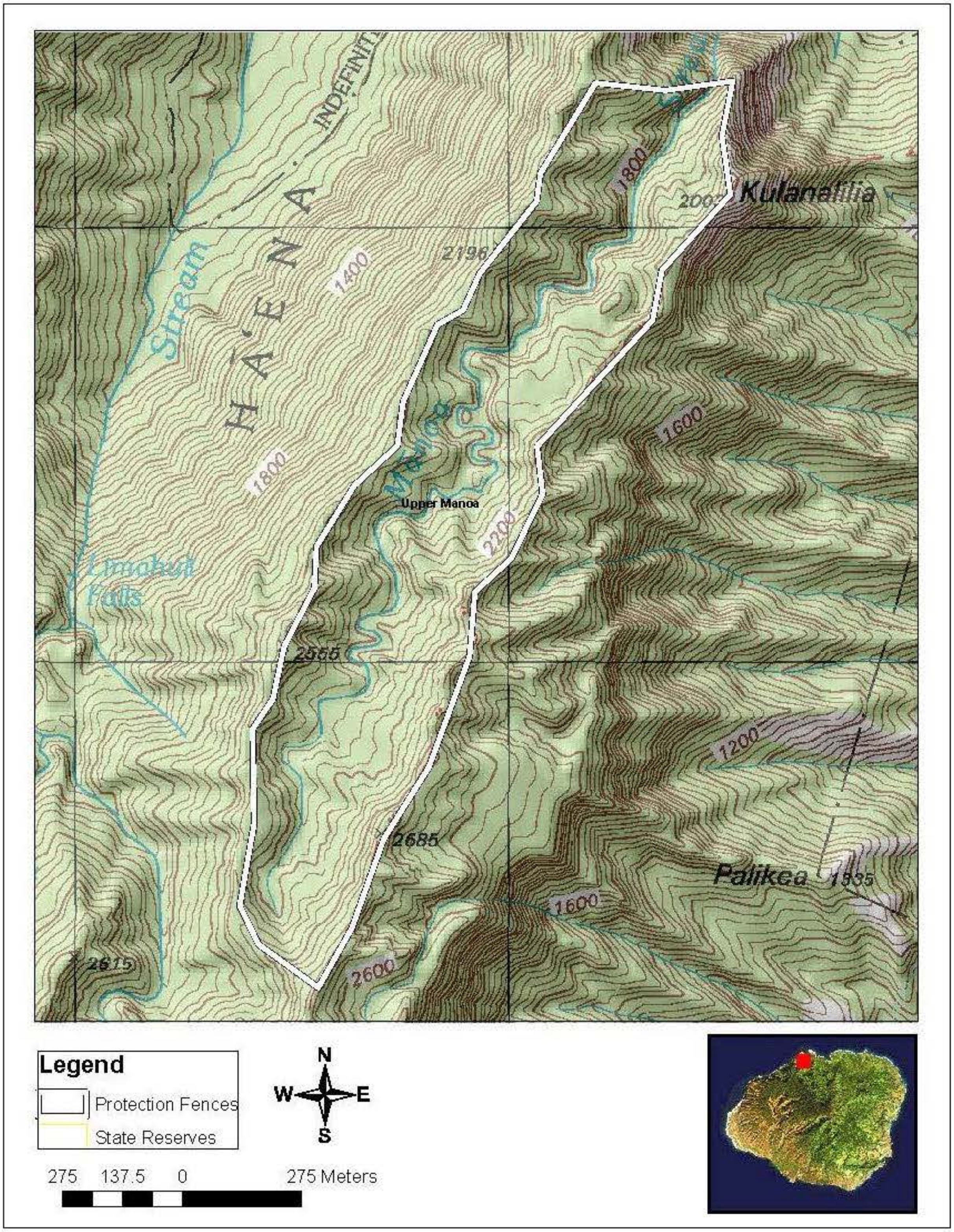


Exhibit B – Types of Permitted Uses in the Draft HCP

Final Permitted Uses will be determined by the approved final HCP and will be outlined in a site management plan attached to the Conservation Easement.

Use/Purpose	Location	Terms and Conditions
General Uses		
Helicopter access: construction of one or more helicopter Landing Zone ("LZ") platforms, and helicopter landings in UMV	See Exhibit C, Figure 1 for approximate locations	Helicopter landings permitted only in designated LZ location(s), plus any designated fencing material construction drop areas
Pedestrian access to conduct conservation activities	Entire UMV easement area	General access, subject to restrictions necessary to avoid adverse effects on conservation measures. Pedestrian access only - no motorized equipment may be used except with the written consent of the Grantor
Overnight camping, construction of weatherport shelter(s)	Camping in designated (pre-weatherport) camping areas, then in constructed weatherport(s). Weatherport(s) to be constructed in approximate locations shown in Exhibit C, Figure 1	Camping allowed in designated interim areas or weatherport(s) only, except in emergencies
Seabird-related mitigation work, as part of the early implementation and the HCP.	Entire UMV easement area	Type of work described below and to be superseded by HCP.
Use of equipment	Entire UMV easement area	Hand tools (including chain saws) only
Archeological/Cultural surveys	Entire UMV easement area	Pedestrian access, hand tools only
Rare and endangered plant surveys	Entire UMV easement area	Pedestrian access, hand tools only
Seabird Monitoring		

Install, check and extract monitoring devices	Entire UMV easement area	
General pedestrian field inspection of conservation conditions and scientific research	Entire UMV easement area	
Predator Control		
Installation and checking of predator monitoring devices and traps	Entire UMV easement area	
Use of firearms to eradicate predators	Entire UMV easement area	
Pedestrian field inspection	Entire UMV easement area	
Predator Control Fence and Potential for Cat/Ungulate Fence*		
Vegetative clearing, site preparation for fence installation	Along and adjacent to fence route (generally consists of perimeter of entire UMV easement area)	Hand tools only (including chain saws and other hand-operated power equipment)
Fence construction staging area(s), for delivery and storage of construction materials and associated equipment	Agreed-upon locations necessary for helicopter drops of fencing materials and associated construction equipment	Staging areas to be cleaned and stabilized following completion of fence construction
Fence construction	Along and adjacent to fence route as shown in Exhibit C, Figure 1	Hand tools only (including chain saws and other hand-operated power equipment)
Fence inspection and maintenance	Along and adjacent to fence route as shown in Exhibit C, Figure 1	Hand tools only (including chain saws and other hand-operated power equipment)
Social Attraction		
Clear existing vegetation	Social Attraction area depicted in Exhibit C, Figure 1	Hand tools only (including chain saws and other hand-operated power equipment). Vegetation clearing may only occur after an inspection confirms that rare or endangered plants are not present
Planting of native plant species	Social Attraction area depicted in Exhibit C, Figure 1	Hand tools only (including chain saws and other hand-operated power equipment)

Installation of artificial burrows and social attraction sound devices	Social Attraction area depicted in Exhibit C, Figure 1	Hand tools only (including chain saws and other hand-operated power equipment)
Operate and maintain social attraction equipment	Social Attraction area depicted in Exhibit C, Figure 1	Hand tools only (including chain saws and other hand-operated power equipment)
Monitor field conditions and performance of social attraction project	Social Attraction area depicted in Exhibit C, Figure 1	Monitoring results to be provided to Grantor
Weed Control		
Mechanical weed removal	Priority weed control areas depicted in Exhibit c, Figure 1	Hand tools only (including chain saws and other hand-operated power equipment)
Herbicide application	Treatment of invasive plants Priority weed control areas depicted in Exhibit c, Figure 1	Specific allowable herbicides, and manner and amount of application, are subject to advance approval by Grantor

*Cat/ungulate exclusion fencing at Upper Manoa Valley will be options considered as part of the HCP adaptive management when triggered.

<u>Exhibit C – KIUC's Draft HCP Conservation Strategy and Early Implementation</u>

Upper Mānoa Valley
KIUC's Draft HCP Conservation Strategy and Early Implementation

The state published draft HCP was published in January 2023 and the federal public draft is anticipated to be published in the third quarter of 2024. Issuance of the associated ITP and ITL, respectively, is anticipated in 2025. Conservation measures at Upper Manoa Valley will be determined by the approved final HCP, the ITP and ITL and outlined in the site management plan attached to the Conservation Easement. The draft HCP seabird-focused conservation measures at Upper Manoa include the construction of two weatherports and landing zones, a predator exclusion fence and implementation of predator eradication/control and social attraction efforts in the UMV. Draft HCP conservation efforts also include colony monitoring inside and outside the predator exclusion fence and intensive predator control in the the management site outside the predator exclusion fence.

Over the last several years, KIUC has been conducting extensive preparatory work in the UMV, including site evaluations, fence line surveys, seabird monitoring, and predator and weed control. KIUC intends to move forward with weatherport and predator exclusion fence construction in anticipation of issuance of the ITP and ITL in 2025, but irrespective of the timing of issuance. UMV landowner Ric Berry has requested that KIUC define the conservation work KIUC will implement during the term of the HCP. Among other things, Mr. Berry desires to pursue additional conservation work in the UMV that would not interfere with or compromise KIUC's seabird-focused conservation work.

KIUC Conservation Work for the Draft HCP

The following activities are identified in the draft HCP as conservation measures that KIUC (acting through its contractors and conservation partners) intends to implement as early implementation for the HCP and for the term of the HCP irrespective of the issuance date of the ITP/ITL, and are subject to change based on the approved final HCP:

<u>Continuation of Baseline Seabird Monitoring</u>. KIUC will continue to fund baseline monitoring of seabird activity in UMV. Monitoring will be at the same level and in generally the same locations as is being done in previous years. The work will include

deployment of cameras at active seabird burrows to record seabird and predator activity. 8 song meters will also continue to be deployed at static sites already in place at Upper Manoa to provide a site wide aural net to allow for call rate trend monitoring. Seven (7) trips will be undertaken each year, bi-monthly between February (when equipment will be set up prior to seabird arrival) and November, with one trip being an auditory survey trip focused on the social attraction site. ARC will provide oral reports on a monthly, or more frequent, basis and a written Annual Report.Seabird monitoring will continue after completion of the predator exclusion fence.

Initiation of Social Attraction Site. KIUC will continue to fund baseline monitoring at the social attraction site. To date, 26 artificial nest boxes have been deployed in the area and 263 native plants planted around the boxes to provide ground and canopy cover. Although social attraction will not occur until the predator proof fence is up, boxes will be monitored on all Upper Manoa monitoring trips and cameras deployed throughout the site. This will allow for an assessment of seabird activity prior to attraction and the prevalence of non-native predators. Once social attraction is initiated, 24 new nest boxes will be deployed and all nest boxes will continue to be checked on each monitoring visit

Continuation of Pre-Fencing Predator Control. KIUC will continue to fund monthly 1-day predator control visits to the UMV using a 2-person Hallux Ecosystem Restoration LLC (HER) team, plus rapid response visits when warranted. The team will install and operate traps for cats and rats, snares for pigs, barn owl control and monitoring cameras. The predator-control work will be focused along the ridgelines and immediately around identified seabird burrows. HER will provide monthly oral reports and a written Annual Report.

Intensive Predator Control Outside the Predator Exclusion Fence. Intensive predator control would be conducted in the larger portion of the management site that is not fenced (shown in Figure 2). This effort would involve two full time staff that would visit the site two times per month during the seabird season and one time per month outside the seabird season. Cat trapping along the eastern ridge of the valley would continue to be maintained. Additional cat trapping would be devoted to around the outside of the predator exclusion fence, in the stream drainage and along the western edge of the valley. The cat trapping effort along both ridge lines will be monitored with cellular transmitting cameras, allowing traps to remain open and active between trips.This cat trapping effort would cover the most likely paths of the intrusion into the valley by cats given the slopes of the surrounding landscape. Additional Goodnature A24 traps would be deployed at 50m intervals along the stream and western ridge. Any areas with accessible slopes in the stream drainages or on the interior slopes would be placed with Goodnatures in a 50m x 50m grid. The intensive predator control effort at

UMV is expected to change and expand over the term of the HCP as new burrows are discovered and new areas become accessible.

Continuation of Pre-Fencing Weed Control. KIUC will continue funding bi-monthly invasive weed control efforts by the Kōkeʻe Resource Conservation Program (KRCP) using two-person teams. The purpose of weed control is to reduce and/or prevent the spread of invasive weed species (for examples of weed species see **Error! Reference source not found.** below) which can degrade or destroy seabird breeding habitat. KRCP will provide a written report following each 1-day, bi-monthly visit to UMV.

Table 1 Presence of Weeds in KIUC Weed Control Areas[a]

Polygon	*Size*	*Weed Presence*
A	19.3 acres	Paperbark tree, African tulip tree, bushy beardgrass, others
B	9.7 acres	Paperbark tree, African tulip tree, others
A, B, C[b]	63.9 acres	Himalayan ginger, paperbark tree, Australian tree fern, albizia, others
A, B, C	63.9 acres	Guava

a Weed presence was established based on a limited survey and should not be considered a comprehensive list of weeds in the respective areas.
b Weed inventory surveys were only conducted in a portion of the area.

The weed-control team will focus its efforts in areas identified in Figure 1, below, and along trails used to access those areas. The three polygons together represent 63.9 acres or 41 percent of the proposed 157.4 acre UMV fenced area. The polygon areas were selected based on the following:

- They capture most of the area where active NESH burrows have so far been located based on KESRP/ARC seabird monitoring to date. By concentrating weed control within the main seabird monitoring area, target invasive weed species can be kept under control.
- Polygon A includes the social attraction site (where the initial set of artificial burrows were installed in late 2019) and an area where active burrows and ground calling have been identified by KESRP/ARC.
- Polygon B is an area where KESRP/ARC has reported seabird ground calling but has not yet located active burrows.
- Polygon C has numerous confirmed breeding burrows and seabird ground calling.

- Most areas within the designated polygons are believed to be accessible for weed control purposes, however some areas are too steep or are otherwise unsafe for weed control efforts.

The polygons were generated at the landowner's request, and are based on the best available information. Although the polygons were generated as a guide for the STHCP weed control work, KIUC anticipates they will be carried over into the 30 year HCP and thus will continue to provide focus for the weed control work.

The specific areas worked on within the polygons will be a function of the weed control priorities detailed below, in combination with such factors as accessibility, location-specific circumstances, weather, input from project partners, seabird activity, etc.:

Priority 1: Social Attraction Site. KIUC has initiated the establishment of a seabird social attraction site in the location of the proposed predator exclusion fence as shown on Figure 1. Ultimately this site will be approximately 13 acres in size. Work to date includes the installation of a set of artificial burrows in 2019 on a 1-acre portion along with out-planting 263 native plant species for understory and canopy in 2021. Substantial weed control work focused on this 1-acre area will be necessary to ensure the ultimate success of the installed burrows and to prevent outplantings from being over-run by non-native species.

Goals:

For the 1-acre initial burrow installation area, extensive weed control will be conducted in order to allow for the successful establishment of existing outplanted native or endemic species deemed compatible with social attraction efforts Further outplanting of native species will occur as the social attraction project evolves around all additional artificial nest boxes that are deployed..

Cut down large paperbark trees within the larger approximate 13 acre site.

Given these goals, it is anticipated that some weed control work will be conducted in the social attraction site during every weed control trip during the interim period.

Priority 2: Ridge Trail.

Goal: treat weeds along the travelled portion of the ridge trail in a fashion that reduces the spread of seeds by predator control, seabird monitoring personnel and weed control personnel utilizing the trail. Weeds that have the potential to produce seeds in the next 3 months will be targeted.

Priority 3: Seabird Breeding Areas (both known and suspected).

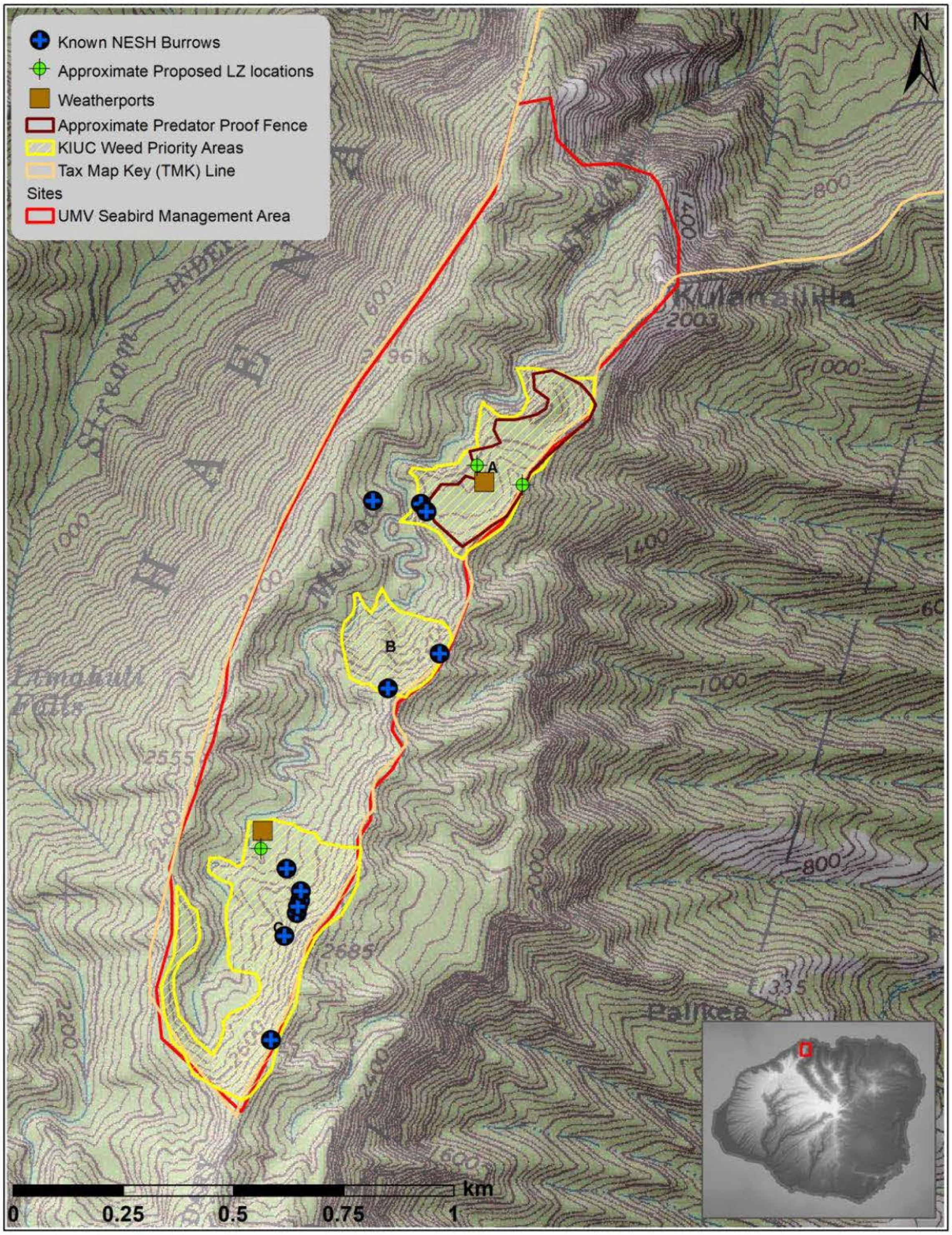
Goal: "hold the line" to prevent the advancement of weeds with the greatest likelihood to adversely affect seabird breeding over the next 5 years, in select areas.

When not working at the social attraction site, the weed control crew will preferentially address the densest stands of the worst weeds (ginger, guava, and Australian tree fern) that (a) are observed by KRCP or reported to KRCP by the seabird monitoring or predator control teams, (b) are within the Figure 1 polygons, and (c) are located closest to known or suspected active seabird burrows. The areal extent of this work during the interim period will depend upon the extent of KRCP work involved in addressing Priority 1 and 2 work.

Efforts will focus on the fringes of active burrow areas when birds are present during the breeding season, and will focus on the heart of active burrow areas when seabirds are at sea (winter). At all times, KRCP will take care not to disturb known burrows and be vigilant for as yet un-identified burrows that may be in weed control areas. KRCP will communicate with ARC to ensure KRCP personnel are up to date on seabird breeding ecology and the location of all known burrows. If KRCP staff find a burrow or suspected burrow, they will flag it, photograph it and take a GPS point to share with ARC. ARC staff will then check the suspected burrow on the next trip.

The known locations of active breeding areas will likely evolve over time as seabird monitoring efforts continue. KRCP will be informed of new findings and will adjust the location of their efforts as deemed appropriate.

Figure 1 Locations of New Infrastructure and Weed Control Priority areas in Upper Manoa Valley



Permits for Predator Exclusion Fence and Weatherports. The fence and support facilities will all be within the Protective subzone of the State Conservation District and will be subject to the State Conservation District Rules (HAR §11-5). KIUC submitted to Offic of Conservation and Coastal Lands (OCCL) a permit determination in mid-2021 and a Conservation District Use Application in October 2021 to received required authorizations for construction of weatherports and the predator exclusion fence. This permit application process was paused when work stopped at UMV at the end of 2023. Pursuit of completion of the permit application will be re-initiated upon execution of this agreement.

Construction of Two Weatherports in UMV. KIUC intends to initiate construction of two weatherports, the approximate locations of which are identified in Figure 1, as soon as the Conservation District Use Permit is issued by OCCL. It is anticipated that permit issuance will occur by the end of 2024 and construction of these facilities will commence in the first quarter of 2025. Because construction may precede issuance of the ITP and ITL, it will be part of KIUC's early implementation work for the HCP.

Construction of Predator Exclusion Fence. Prepatory work for the construction of a predator exclusion fence in UMV has been underway for a number of years. A fencing feasibility assessment conducted by Pono Pacific in 2022 determined an approximate size and location for a predator exclusion fence at Upper Manoa Valley. The approximate location is shown on Figure 1, and is subject to alignment adjustments at the time of construction to address terrain issues, and to avoid rare, threatened and endangered plants and sebird burrows. The estimated size is approximately 13 acres and would encompass the social attraction site. Construction activities will commence as soon as practicably feasible after issuance of the Conservation District Use Permit and the fencing team is available. It is anticipated that permit issuance will occur by the end of 2024 and the fencing team will be available in 2026. Because commnencment of construction may likely precede issuance of the ITP and ITL, it will be part of KIUC's early implementation work for the HCP. It is estimated that completion of construction of the predator exclusion fence will occur at the end of 2026 or 2027.

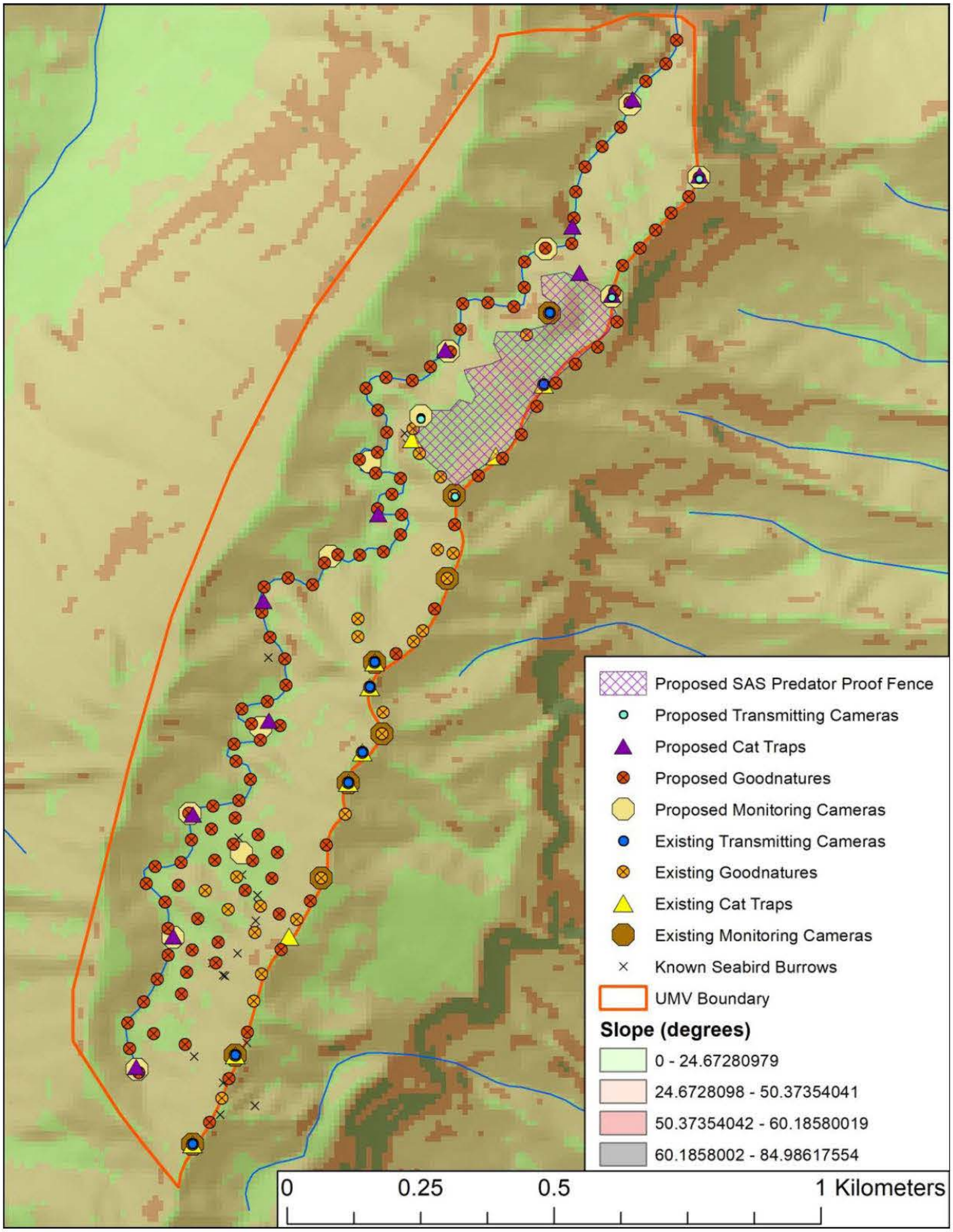
Install Additional Artificial Burrows for the Seabird Social Attraction Site. The design of the initial artificial burrows is complete, and KIUC installed approximately 20-25 burrows within an approximately 1-acre portion of the ultimate social attraction site in 2019. After construction of the predator exclusion fence is completed, KIUC will install additional artificial burrows within the social attraction site. The number of additional burrows and specific locations will be determined at the time of installation.

UMV Preliminary Cultural Impact Assessment. KIUC has contracted Cultural Surveys Hawaii to prepare a Cultural Impact Assessment (CIA) for the EIS being conducted by USFWS for the HCP. The CIA scope includes the UMV. The study does not require any on-ground work within the UMV. The results will be included in the Chapter 343 and NEPA EIS that supports the ITP and ITL.

Predator Eradication and Control After Predator Exclusion Fence Construction. After completion of the predator exclusion fence, predator eradication within the the predator will occur within the predator exclusion fenced area with the goal of complete eradication of terrestrial predators (cats, mice, rats, pigs, goats). This process may take from 3 – 12 months depending on terrestrial predator abundance within the fenced area. After the fenced area has been confirmed predator free, ongoing predator control for the site will involve predator trapping in the event of a fence breach. Also, barn owl and invasive bee control will continue at the site for the term of the HCP.

Social Attraction Set Up, Initiation and Monitoring. After completion of the predator exclusion fence and predator eradication within the fenced area, a solar-powered sound system will be installed within the social attraction site to broadcast calls over the area where artificial burrows are located. The calls will broadcast throughout the peak breeding season (April through September) and stop prior to the emergence of fledgings.

Figure 2 Intensive Predator Control Plan



Non-KIUC Conservation Activities

KIUC supports the landowner's desire to perform (or have other third parties perform on his behalf) other conservation activities in the UMV, so long as those activities don't adversely affect or compromise KIUC's seabird-focused conservation efforts.

For any such work in the UMV, inside or outside the fence, KIUC requests the following:

1. KIUC should be informed when the landowner or other third parties will enter the UMV so that information can be exchanged and logistics addressed. This is important for all work in UMV, including work outside of the fenced area because it is likely that any visit to UMV will involve helicopter landings within the seabird conservation site.
2. Third parties entering the UMV should be educated about the presence of and the need to avoid adversely affecting KIUC seabird conservation equipment (i.e., traps, cameras, and song meters).

Conservation activities by the landowner or third parties can occur anywhere in the UMV. A greater level of coordination and planning will need to occur for work inside the fenced area relative to outside the fenced area. Due to the sensitivities regarding conservation actions within the fenced area, the landowner and any involved third parties should engage in extensive consultations and coordination with KIUC first in order to ensure there will be no adverse impacts to KIUC's seabird-focused conservation work in the fenced area.

KIUC_Berry_Upper Manoa Long Term Agreement USFWS Final for Signature

Final Audit Report 2024-02-28

Created:	2024-02-28
By:	Chris Yuh (cyuh@kiuc.coop)
Status:	Signed
Transaction ID:	CBJCHBCAABAAvrpc8mZGfO0qhONG5yLtjRXfUKXXIvGJ

"KIUC_Berry_Upper Manoa Long Term Agreement USFWS Final for Signature" History

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Signer langwith@gmail.com entered name at signing as Richard Langwith Berry
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Appendix 4H

State Lands Access Package

June 17, 2025

Kauaʻi Island Utility Cooperative
c/o David Bissell
4463 Pahee Street #1
Lihue, Hawaiʻi 96766

Re: KIUC's Habitat Conservation Plan (HCP) and Proposed Use of State Lands

Aloha Mr. Bissell,

Mahalo for taking the time to meet with me and Department of Land and Natural Resources (DLNR) staff on March 25, 2025, to discuss KIUC's proposed HCP. The HCP is necessary to comply with both federal and state Endangered Species Acts and the issuance of a federal incidental take permit (ITP) and a state incidental take license (ITL). It is our understanding that KIUC's conservation strategy for a successful HCP seeks to utilize State lands to manage and enhance seabird breeding habitat and colonies on approximately eight (8) State land sites, as well as four (4) sites on private land. This letter has been revised to address some of USFWS concerns.

After discussions with the Division of Forestry and Wildlife (DOFAW), the DLNR supports the KIUC's use and occupancy of State lands for its HCP conservation strategy. *See* Hawaii Revised Statutes (HRS) Chapter 171. KIUC's use of State lands is intended to enable KIUC to carry out long-term mitigation and conservation activities for the benefit of federally and state-listed threatened and endangered seabird species, particularly the Newell's shearwater (*Puffinus newelli*) and the Hawaiian petrel (*Pterodroma sandwichensis*). The use and occupancy of state lands, for any purpose, needs prior Board of Land and Natural Resources (Board) approval at a publicly noticed meeting.
As part of its HCP, KIUC has committed to offsetting the incidental take of these protected seabirds associated with utility infrastructure, especially power lines. The disposition of State lands may provide the necessary legal and operational foundation for KIUC to implement habitat restoration, predator control, monitoring, and other long-term conservation measures essential to the recovery and protection of these species.

The Department recognizes KIUC's proactive role and long-term investment in endangered species mitigation on Kauaʻi. We believe a land disposition exemplifies a strong public-private partnership model for habitat conservation on State lands. The DLNR supports KIUC's continued collaboration with DOFAW and other relevant DLNR divisions to ensure that the implementation of mitigation actions is consistent with applicable management plans, best available science, and adaptive conservation practices.

The eight proposed conservation sites on State lands will require coordination and an application process with other DLNR divisions, including the following:

1. The sites in the Hono O Nā Pali Natural Area Reserve may require a special use permit, which is issued by the Board. *See* HRS Chapter 195; Hawai‘i Administrative Rules (HAR) Title 13, Chapter 209.

2. The draft HCP indicates that KIUC would like to conduct conservation actions on State lands in the conservation district. The proposed conservation actions in conservation district land may require a conservation district use permit, which is issued by the Board. *See* HRS Chapter 183C; HAR Title 13, Chapter 5.

3. The sites in the Nā Pali Kona Forest Reserve may require a special use permit, which is issued by the Board. *See* HRS Chapter 183; HAR Title 13, Chapter 104.

4. The sites in the Nā Pali Coast State Wilderness Park may require a special use permit, which is issued by the Board. *See* HRS Chapter 184; HAR Title 13, Chapter 146.

5. Some of the above-referenced sites may be appropriate for a non-exclusive easement for longer-term dispositions. Non-exclusive easement(s) for the use and occupancy of State lands are issued by the Board. *See* HRS Chapter 171.

For KIUC's reference and planning considerations, the standard terms and conditions of the above-referenced special use permits and a non-exclusive easement are attached hereto.

The DLNR understands that KIUC's draft HCP proposes a 50-year term for both the HCP and ITL. Given that KIUC's proposed mitigation obligations and conservation obligations are expected to be implemented over the full term of the HCP, any request for long-term use and occupancy of State lands must be clearly stated in KIUC's applications to the DLNR. The DLNR acknowledges that any final land use dispositions to KIUC must provide a reasonable expectation that KIUC will be able to carry out the conservation actions in the HCP. However, the DLNR cannot provide any assurances regarding access to or use of the referenced State lands unless and until the matter is formally considered and approved by the Board. The lands referenced above include some of Hawai‘i's most ecologically sensitive and significant areas on the island of Kaua‘i, which the DLNR holds in trust for the people of Hawai‘i. Uses of these public trust lands are subject to DLNR's regulatory processes (chapter 195D, HRS) and strict public scrutiny.

We encourage KIUC to coordinate with its legal counsel and the respective DLNR staff to ensure compliance with all applicable regulations, including environmental compliance pursuant to HRS Chapter 343, if KIUC wishes to apply for the use of State lands for its conservation actions. If you have any questions or require further assistance, please contact Jason Omick at jason.d.omick@hawaii.gov.

Mahalo,

Dawn N.S. Chang
Director
Department of Land and Natural Resources

C: Danica Swenson, Deputy Attorney General
David Smith, Administrator Division of Forestry and Wildlife
Ian Hirokawa, Acting Administrator Land Division
Michael Cain, Administrator Office of Conservation and Coastal Lands
Curt Cottrell, Administrator Division of State Parks

(20) To use or possess narcotics or drugs except as provided by Federal or State laws. No person shall enter or remain within the premises when under the influence of alcohol or illegal narcotics or drugs;

(21) To use or possess alcohol, except with the written permission of the board or its authorized representative. [Eff 6/29/81; am 12/9/02; am 7/3/03; am 1/26/07; am](Auth: HRS § 195-5) (Imp: HRS § 195-5)

§ 13-209-4.5 Closing of areas. The board or its authorized representative, with the approval of the commission, may close or restrict the public use of all or any portion of a natural area reserve for up to two years, when deemed necessary by the commission for the protection of the natural, geological, or cultural resources of the area or the safety and welfare of persons or property, by the posting of appropriate signs indicating the duration, extent, and scope of closure. Closures may be renewed with the approval of the board or its authorized representative and the commission. All persons shall observe and abide by the officially posted signs designating closed areas. [Eff 1/26/07] (Auth: HRS § 195-5) (Imp: HRS § 195-5)

§ 13-209-4.6 Visiting hours. The board or its authorized representative, with the approval of the commission, may establish a reasonable schedule of visiting hours for all or portions of a natural area reserve by the posting of appropriate signs indicating the hours during which the natural area reserve may be accessed. All persons shall observe and abide by the officially posted signs designating visiting hours. [Eff: 1/26/07] (Auth: HRS § 195-5) (Imp: HRS § 195-5)

§ 13-209-5 Special-use permits. (a) The board or its authorized representative, with the approval of the commission or its authorized representative, may issue permits to conduct activities otherwise prohibited by section 13-209-4 for research, education, management, or for any other purpose consistent with chapter 195, Hawaii Revised Statutes.

(b) No permit may be valid for more than one year from date of issuance. The board may waive this restriction for permits where the board determines such a waiver to be in the best interest of the State.

(c) All special-use permits shall be subject to standard conditions, as approved by the board, including but not limited to the following:

(1) The permittee shall adhere to specifications given in the permit application;

(2) Disturbance of vegetation and wildlife shall be avoided as much as possible;

(3) Precautions shall be taken to prevent introductions of plants or animals not naturally present in the area. The permittee is responsible for making sure that participants' clothes, equipment, and vehicles are free of seeds or dirt to lessen the chance of introducing any non-native plants or soil animals. Should an infestation develop attributable to permittee, the permittee is responsible for eradication by methods specified by the department;

(4) This permit is not transferable;

(5) This permit does not exempt the permittee from complying with any other applicable rule or statute;

(6) The State of Hawaii shall be released and held harmless from any and all liability for injuries or death, or damage or loss of property however occurring during any activity related to this permit.

(d) The board or its authorized representative may attach special conditions on the special-use permit, including but not limited to reporting requirements, limitations on the size of groups or the length of time for which the permit is valid. Failure to comply with any of these conditions shall render a permit void.

(e) All permittees shall carry the permit with them at all times while in the reserve and shall, upon request, show the permit to any law enforcement officer or the board or its authorized representative.

(f) Permits are not transferable. If the permittee is a partnership, joint venture, or corporation, the sale or transfer of 25 percent or more of ownership interest or stocks by dissolution, merger, or any other means, shall be deemed a transfer for purposes of this subsection and subject to the right of the department to terminate this permit effective the date of the sale or transfer.

(g) The board or its authorized representative may revoke or cancel a permit without prior notice when an emergency is declared by the department or other proper authority or when the special-use poses an immediate threat to the health, safety, and welfare of the public or natural, geological, or cultural resources of the reserve.

(h) The board or its authorized representative may revoke or cancel any permit with thirty days written notice:

(1) For any infraction of the terms and conditions of the permit;
(2) Upon a finding that the special-use threatens to damage the integrity or condition of the natural, geological, or cultural resources in the reserve;
(3) Upon a finding that the special-use poses a threat to the health, safety, or welfare of the general public or otherwise negatively impacts the general public's use and enjoyment of the reserve; or
(4) Upon closure of a reserve pursuant to section 13-209-4.5.

(i) The provisions of this section shall not exempt the applicant from complying with any other applicable rule or statute.[Eff 6/29/81; am 1/26/07; am] (Auth: HRS § 195-5)(Imp: HRS § 195-5)

§ 13-209-5.5 <u>Applications for special-use permits.</u> (a) All applications for special-use permits shall be submitted in writing to the board or its authorized representative on the form prescribed by the department. The application shall contain the following information:

(1) Name of applicant, and if relevant, affiliation and title;
(2) Contact information, including name of primary contact, mailing address, phone number, and if available, email address;
(3) The period of time for which the permit is requested, not to exceed one year unless seeking a waiver pursuant to section 13-209-5(b);
(4) The reserve(s) involved;
(5) A map illustrating the reserve and the location within the reserve of the proposed special-use;
(6) A description of the proposed special-use;
(7) A discussion of how the proposed special-use satisfies subsections (b)(1) through (b)(6);
(8) An assessment of the potential environmental impact the special-use may have on the reserve or the surrounding area;
(9) Signature of the applicant;
(10) Any other information as determined by the department.

(b) In evaluating the merits of an application for a special-use permit, the board or its authorized representative shall apply the following criteria:

(1) The proposed special-use cannot be conducted elsewhere;
(2) The proposed special-use is consistent with the purpose and objectives of the natural area reserve system;

am 11/14/05; am and comp] (Auth: HRS §183C-3) (Imp: HRS §183C-4)

§13-5-41.1 Fire buffer zone. Where requested by the department, fire buffer zones shall be established and shall include the requirements listed in Exhibit 5, entitled "Fire Buffer Zone Standards: August 12, 2011", which is located at the end of this chapter and made a part of this section. [Eff and comp] Auth: HRS §183C-3) (Imp: HRS §183C-4)

§13-5-42 Standard conditions. (a) Any land use permitted within the conservation district is subject to the following standard conditions:

(1) The permittee shall comply with all applicable statutes, ordinances, rules, and regulations of the federal, state, and county governments, and applicable parts of this chapter;

(2) The permittee, its successors and assigns, shall indemnify and hold the State of Hawaii harmless from and against any loss, liability, claim, or demand for property damage, personal injury, and death arising out of any act or omission of the applicant, its successors, assigns, officers, employees, contractors, and agents under this permit or relating to or connected with the granting of this permit;

(3) The permittee shall obtain appropriate authorization from the department for the occupancy of state lands, if applicable;

(4) The permittee shall comply with all applicable department of health administrative rules;

(5) The single family residence shall not be used for rental or any other commercial purposes unless approved by the board. Transient rentals are prohibited, with the exception of wilderness camps approved by the board;

(6) The permittee shall provide documentation (e.g., book and page or document number) that the permit approval has been placed in recordable form as a part of the deed instrument, prior to submission for approval of subsequent construction plans;

(7) Before proceeding with any work authorized by the department or the board, the permittee shall submit four copies of the construction plans and specifications to the chairperson or an authorized representative for approval for consistency with the conditions of the permit and the declarations set forth in the permit application. Three of the copies will be returned to the permittee. Plan approval by the chairperson does not constitute approval required from other agencies;

(8) Unless otherwise authorized, any work or construction to be done on the land shall be initiated within one year of the approval of such use, in accordance with construction plans that have been signed by the chairperson, and shall be completed within three years of the approval of such use. The permittee shall notify the department in writing when construction activity is initiated and when it is completed;

(9) All representations relative to mitigation set forth in the accepted environmental assessment or impact statement for the proposed use are incorporated as conditions of the permit;

(10) The permittee understands and agrees that the permit does not convey any vested right(s) or exclusive privilege;

(11) In issuing the permit, the department and board have relied on the information and data that the permittee has provided in connection with the permit application. If, subsequent to the issuance of the permit such information and data prove to be false, incomplete, or inaccurate, this permit may be

modified, suspended, or revoked, in whole or in part, and the department may, in addition, institute appropriate legal proceedings;

(12) When provided or required, potable water supply and sanitation facilities shall have the approval of the department of health and the county department of water supply;

(13) Provisions for access, parking, drainage, fire protection, safety, signs, lighting, and changes on the landscape shall be provided;

(14) Where any interference, nuisance, or harm may be caused, or hazard established by the use, the permittee shall be required to take measures to minimize or eliminate the interference, nuisance, harm, or hazard;

(15) Obstruction of public roads, trails, lateral shoreline access, and pathways shall be avoided or minimized. If obstruction is unavoidable, the permittee shall provide alternative roads, trails, lateral beach access, or pathways acceptable to the department;

(16) Except in case of public highways, access roads shall be limited to a maximum of two lanes;

(17) During construction, appropriate mitigation measures shall be implemented to minimize impacts to off-site roadways, utilities, and public facilities;

(18) Cleared areas shall be revegetated, in accordance with landscaping guidelines provided in this chapter, within thirty days unless otherwise provided for in a plan on file with and approved by the department;

(19) Use of the area shall conform with the program of appropriate soil and water conservation district or plan approved by and on file with the department, where applicable;

(20) Animal husbandry activities shall be limited to sustainable levels in accordance with good

soil conservation and vegetation management practices;

(21) The permittee shall obtain a county building or grading permit or both for the use prior to final construction plan approval by the department;

(22) For all landscaped areas, landscaping and irrigation shall be contained and maintained within the property, and shall under no circumstances extend seaward of the shoreline as defined in section 205A-1, HRS;

(23) Artificial light from exterior lighting fixtures, including but not limited to floodlights, uplights, or spotlights used for decorative or aesthetic purposes, shall be prohibited if the light directly illuminates or is directed to project across property boundaries toward the shoreline and ocean waters, except as may be permitted pursuant to section 205A-71, HRS. All exterior lighting shall be shielded to protect the night sky;

(24) Where applicable, provisions for protection of beaches and the primary coastal dune shall be established by the permittee, to the satisfaction of the department, including but not limited to avoidance, relocation, or other best management practices;

(25) The permittee acknowledges that the approved work shall not hamper, impede, or otherwise limit the exercise of traditional, customary, or religious practices of native Hawaiians in the immediate area, to the extent the practices are provided for by the Constitution of the State of Hawaii, and by Hawaii statutory and case law; and

(26) Other terms and conditions as prescribed by the chairperson.

(b) Failure to comply with any of these conditions shall render a permit void under the chapter, as determined by the chairperson or board.

(c) Deviation from any of the conditions, standards, or criteria provided in this chapter may be considered by the board, only when supported by a satisfactory written justification stating:

(1) The deviation is necessary because of the lack of practical alternatives;
(2) The deviation shall not result in any substantial adverse impacts to natural resources;
(3) The deviation does not conflict with the objective of the subzone; and
(4) The deviation is not inconsistent with the public health, safety, or welfare.

Failure to secure board approval for a deviation before the deviation occurs constitutes cause for permit revocation. [Eff 12/12/94; am and comp] Auth: HRS §183C-3) (Imp: HRS §§183C-4, 183C-6)

§13-5-43 Time extensions. (a) Permittees may request time extensions for the purpose of extending the period of time to comply with the conditions of a permit.

(b) Time extensions may be granted as determined by the chairperson on all departmental permits and on the first request for extension of a board permit of up to two years to initiate or complete a project, based on supportive documentation from the applicant.

(c) Time extensions may be granted by the board upon the second or subsequent request for a time extension on a board permit, based on supportive documentation from the applicant.

(d) Unless otherwise authorized, all time extensions shall be submitted to the department prior to the expiration deadline.

(e) If a time extension request is received after the expiration deadline, it shall be forwarded to the board for review. If a request for a time extension is not received within one year after the expiration deadline, the permit shall be void.

SUBCHAPTER 3

PERMITS

§13-104-18 General provisions for permits. (a) The board or its authorized representative may issue the following types of permits:

(1) Camping;
(2) Special use;
(3) Collecting;
(4) Commercial; and
(5) Access.

(b) All permits are subject to the following provisions:

(1) Permits are subject to denial, cancellation, or termination at any time by the board or its authorized representative upon violation of these rules or any conditions of the permit or any federal, state, or county statutes, ordinances, and rules or for danger to the public or because of natural causes. Persons who have violated permit conditions or the rules may be ordered by the department to leave the forest reserve. Permittees who have violated permit conditions or the rules may be denied future permits for forest reserves or subject to the imposition of additional permit restrictions;
(2) Permits shall not be transferable;
(3) Persons or organizations to whom permits are issued shall be held responsible for all conditions on the permit;
(4) All persons eighteen years of age or older shall be eligible to secure a permit and all minors shall be allowed use of the premises; provided that they are under the direct supervision of one adult for every ten minors;
(5) The size of groups as well as the length of time any permit may be in effect may be

limited by the board or its authorized representative;

(6) The board or its authorized representative may require the permittee, at the permittee's own cost, to provide police protection in the interest of the public safety and welfare and for the protection of property when the number of persons using the forest reserve is one hundred or more;

(7) Fees and charges as set by the board may be assessed when permits are granted for the exclusive use of areas or facilities, or when charges are necessary to defray the cost of special facilities, services, or supplies provided by the State, or as otherwise determined by the board or its authorized representative when necessary to carry out the provisions of chapter 183, Hawaii Revised Statutes. Fees and charges contained in this chapter may be waived or reduced by the board or its authorized representative if the waiver or reduction is in the public interest;

(8) The board may set and approve a forest product price list. Charges may be assessed when permits are granted for forest products. The forest product price list shall reasonably reflect fair market value and be periodically updated by the board;

(9) All permittees, upon request, shall show the permit to any law enforcement officer, the board, or its authorized representative;

(10) By signing the permit and entering into the forest reserve, all persons included on the permit agree to comply with all the terms and conditions of the permit, as well as applicable laws and regulations; and consent to present the permit to a duly authorized representative of the department upon request; and

(11) Persons applying for a permit shall provide, if requested, identification for all persons included on a permit, satisfactory to the

board or its authorized representative. The board or its authorized representative may require the names, addresses, and telephone numbers of all persons included on a permit. [Eff 9/28/81; comp 10/15/93; am and comp JAN 16 2021] (Auth: HRS §183-2) (Imp: HRS §§183-1.5, 183-2)

§13-104-19 Camping permits. (a) All persons, groups, organizations, or associations wishing to camp within a forest reserve shall obtain a camping permit authorizing the use of the specific area and facilities for camping purposes for the stated date or dates.

(b) Each camping permit will reserve the use of a designated area for the stated date or dates of use. Camping is permitted only in designated areas or sites.

(c) No person, group, organization, or association shall remain at any one specific camping site for longer than seven days; provided that the board or its authorized representative may extend the length of stay for good cause.

(d) After issuance of a camping permit, a period of at least thirty days shall pass before another camping permit for the same designated area may be issued to any person listed on any previously valid or current camping permit. The board or its authorized representative may waive a portion of the thirty-day period for good cause.

(e) Camping permits may be denied, canceled, or terminated for the following reasons:

(1) When the size of the group will exceed or exceeds the capacity of the existing site or facilities;
(2) When there are inadequate facilities to meet the immediate needs of the camper or campers;
(3) When repairs or improvements are being made at the campsite; or

(4) When a state of emergency is declared or for other reasons involving the health, safety, and welfare of the applicants or permittees;

upon the declaration of the board' or its authorized representative. [Eff 9/28/81; am and comp 10/15/93; am and comp JAN 16 2021] (Auth: HRS §183-2) (Imp: HRS §183-2)

§13-104-20 Special use permits. (a) Special use permits are only issued by the board or its authorized representative. Special uses are those provided for in this section and which are considered compatible with the functions and purposes of each individual area, facility, or unit within a forest reserve. Special uses include but are not limited to community activities, such as meetings, weddings, concerts, shows, and other community events; and the scientific collection of plants and animals.

(b) Applications for special use permits shall be received by the board or its authorized representative at least fifteen working days in advance of the date the permit is to be in effect, however, the deadline may be waived by the board or its authorized representative upon a showing of good cause.

(c) A request for a special use permit shall be considered on its own merits, including its potential effect on forest reserve resources and the public's use and enjoyment of the forest reserve. [Eff 9/28/81; am and comp 10/15/93; am and comp JAN 16 2021] (Auth: HRS §183-2) (Imp: HRS §183-2)

§13-104-21 Collecting permits. (a) Persons wishing to collect forest products for personal use and at no charge shall obtain a collecting permit authorizing the collection in a specific area.

(b) Each application for a collecting permit

Standard Conditions for State Park System Special Use Permits

SUBCHAPTER 3

PERMITS

§13-146-50 General provisions. (a) Permits governing the use of public facilities and areas within the premises shall consist of the following types:

(1) Camping
(2) Lodging
(3) Group use
(4) Special use

(b) The board or its authorized representative may issue permits. The following conditions shall apply to all permits:

(1) Permits shall be issued on a first-come first-served basis. The board or its authorized representative may withhold a portion of the available permits to be issued to walk-in applicants on a first-come first-served basis.
(2) All responsible persons eighteen years of age or older shall be eligible to secure permits.
(3) Permits shall be obtained by the means determined by the board, including, but not limited to, from the district offices of the department, through concessionaires, telephone or electronically through the Internet.
(4) Permits obtained at the district offices shall be obtained between the hours of 8 a.m. and 3:30 p.m. on regular working days of the department.
(5) Permits are not transferable.
(6) Persons or organizations to whom permits are issued are bound by the permit conditions stipulated on or attached to the permit and any applicable federal, state,

and county laws, ordinances, rules and regulations.

(7) The size of groups as well as the length of time any permit may be in effect may be limited by the board or its authorized representative.

(8) Fees and charges as set by the board shall be assessed for permits to defray the cost of special facilities, services, or supplies provided by the State, or to meet other conditions as the board or its authorized representative may prescribe to carry out the provisions of chapter 184, HRS. Charges may be waived by the board if, in their opinion, the waiver is in the public interest and benefits the State.

(9) All payments of fees and charges shall be in U.S. funds, and by credit card, in cash, cashier's check, certified check, traveler's check, postal money order, or bank money order, provided that personal or business checks may be used to pay for events that will occur thirty or more days after the date of the payment.

(10) All permittees shall, upon request, show the permit to any law enforcement officer, the board or its authorized representative.

(11) Other procedures, terms and conditions deemed by the board or its authorized representative necessary to carry out the provisions of chapter 184, HRS, this chapter, or any applicable federal, state, or county statute, ordinance, or rule.

(c) Permits may be denied when:

(1) The premises or park facilities are closed or will be closed because of damages, or because of scheduled or ongoing construction, repairs, or maintenance activities, or because of other reasons.

(2) A state of emergency is declared by the

board or other proper authorities.

(3) Natural or civil disturbances occur or threaten to occur, including, but not limited to, tsunamis, floods, earthquakes, storms, riots, demonstrations, and employee strikes.

(4) There are inadequate facilities to meet the needs of the applicant for the permit.

(5) The premises or facilities will be used by other permittees.

(6) The applicant has a prior record of noncompliance with permit conditions or violations of this chapter.

(d) Permits may be denied, canceled or terminated at any time without advance notice when:

(1) A state of emergency is declared by the board or other proper authorities.

(2) Natural or civil disturbances occur or threaten to occur, including, but not limited to, tsunamis, floods, earthquakes, storms, riots, demonstrations, and employee strikes.

(3) Permittees violate or have previously violated permit conditions or provisions of this chapter within a year of a permit application.

(4) Fees, as required, are not paid. [Eff 4/16/90; am and comp 6/8/99; am 1/22/10; comp OCT 08 2020] (Auth: HRS §184-5) (Imp: HRS §184-5)

§13-146-51 Camping permits. (a) The following provisions shall apply to camping:

(1) Camping and the use of recreational trailers or other camper units is only permitted at locations designated by the board or its authorized representative.

the same family, who are accompanied by at least one of their parents, shall be allowed to remain in the area past the 7 p.m. deadline, where permitted, without regard to the adult-minor ratio.

(d) The board or its authorized representative may require the permittee at the permittees own cost, to provide licensed security services or protection in the interest of public safety and welfare and for the protection of property, when the number of persons under the permit is one hundred or more. [Eff 4/16/90; am and comp 6/8/99; comp OCT 0 8 2020] (Auth: HRS §184-5) (Imp: HRS §184-5)

§13-146-54 Special use permits. (a) Special uses shall be permitted only with a special use permit issued by the board or its authorized representative. Special uses are all types of uses other than camping, lodging, group use and activities permitted under chapter 13-7 which are considered compatible with the functions and purposes of each individual area, facility, or unit of the premises.

(b) Requests for permits for special uses shall each be considered on its own merits, including its effect on the park area, facilities, and the public=s use and enjoyment.

(c) Special uses include but are not limited to:

(1) Day use permits, commercial tours, and weddings; and

(2) Such activities as assemblies, carnivals, celebrations, concerts, demonstrations, festivals, gatherings, meetings, pageants, parades, and other community or ethnic oriented events, or activities, or other spectator attractions that are open to the general public or to restricted groups. [Eff 4/16/90; am and comp 6/8/99;

THIS IS A DRAFT NON-EXCLUSIVE EASEMENT FOR USE OF STATE LANDS. THIS DRAFT DOES NOT PROVIDE ACCESS TO STATE LANDS. THE EXECUTION OF THIS NON-EXCLUSIVE EASEMENT IS CONTINGENT UPON THE APPLICANT FOLLOWING ALL APPLICATION PROCEDURES AND ULTIMATELY THE BOARD OF LAND AND NATURAL RESOURCES' APPROVAL OR DENIAL AT A REGULARLY SCHEDULED BOARD OF LAND AND NATURAL RESOURCES MEETING PURSUANT TO HAWAIʻI REVISED STATUTES SECTION 171-13(b).

LAND COURT SYSTEM	REGULAR SYSTEM

Return by Mail ( ) Pickup ( ) To:

Total Number of Pages:

Tax Map Key No. (Portions of (4) 5-9-001:001 and(4) 5-9-001:016)
**One easement issued per TMK.*

GRANT OF NON-EXCLUSIVE EASEMENT S-______

THIS INDENTURE, made and entered into this _______ day of _______________, 20____, by and between the STATE OF HAWAII, by its Board of Land and Natural Resources, hereinafter referred to as the "Grantor," and [*Kauaʻi Island Utility Cooperative*], whose address is ____, hereinafter referred to as the "Grantee."

WITNESSETH THAT:

The Grantor, pursuant to Sections 171-13 and Section 183C-5, Hawaii Revised Statutes, to the extent applicable, for and in consideration of the rent to be paid and of the terms, conditions, and covenants herein contained, all on the part of the Grantee to be kept, observed, and performed, does hereby grant unto the Grantee, the following non-exclusive and term easement rights:

> Right, privilege, and authority to construct, use, maintain, and repair predator-proof fencing, seabird colony management to include monitoring, invasive species control and monitoring, vegetation removal, any associated adaptive management, and maintenance of weatherports or other infrastructure, subject to the terms and conditions herein,

in, over, under and across that/those certain parcel(s) of land(s) ("easement area"), also referred to as "premises," situate at *[Na Pali Kona Forest Reserve] [Hono o Na Pal Natural Area Reserve] [Kokee State Park]*, being identified as "___________," containing an area of [AREA TO BE DETERMINED BY BOARD], more or less, more particularly described in Exhibit "A" and delineated on Exhibit "B," both of which are attached hereto and made parts hereof, said exhibits being respectively, a survey description and survey map prepared by the Survey Division, Department of Accounting and General Services, State of Hawaii, designated C.S.F. No. ____________ and dated ______________, TOGETHER WITH the rights of ingress and egress to and from the easement area for all purposes in connection with the rights hereby granted.

TO HAVE AND TO HOLD the easement rights unto the Grantee, its successors and assigns, SUBJECT, HOWEVER, to the following terms, conditions and covenants:

1. The term of this easement shall be [*KIUC'S DRAFT HCP PROPOSES 50 YEARS; # OF YEARS TO BE DETERMINED AT THE BOARD OF LAND AND NATURAL RESOURCES' DISCRETION*] years, commencing on the ___ day of ___________, ____, up to and including the ___ day of ______________, ____, unless sooner terminated as hereinafter provided, the Grantor reserving and the Grantee yielding and paying to the Grantor at the Office of the Department of Land and Natural Resources, Honolulu, Oahu, State

of Hawaii, [*EITHER A ONE TIME PAYMENT, PAYABLE IN ADVANCE OR AN ANNUAL RENTAL AS PROVIDED HEREIN, PAYABLE IN ADVANCE, WITHOUT NOTICE OR DEMAND IN EQUAL MONTHLY/QUARTERLY/SEMI-ANNUAL/ANNUAL PAYMENTS, AS DETERMINED BY THE BOARD OF LAND AND NATURAL RESOURCES*] installments on _______th of each and every year during the term as follows:

A. For the first [*# OF YEARS, AS DETERMINED BY THE BOARD OF LAND AND NATURAL RESOURCES*] the sum of [*AMOUNT TO BE DETERMINED BY THE BOARD OF LAND AND NATURAL RESOURCES*] per annum.

B. The annual rental reserved shall be reopened and redetermined as of the day following the expiration of the [*YEAR OF TERM TO BE DETERMINED BY THE BOARD OF LAND AND NATURAL RESOURCES*] of the term.

C. The rental for any ensuing period shall be the fair market rental at the time of reopening. At least six months prior to the time of reopening, the fair market rental shall be determined by:

(1) An employee of the Department of Land and Natural Resources qualified to appraise lands; or

(2) A disinterested appraiser whose services shall be contracted for by the Board of Land and Natural Resources. Grantee shall be promptly notified of the determination by certified mail, return receipt requested, and provided with the complete appraisal prepared by the Board of Land and Natural Resources or the Board of Land and Natural Resources' appraiser. The determination shall be deemed received by Grantee on the date the Grantee signs the return receipt or three (3) days after mailing, whichever occurs first. Provided that if the Grantee does not agree upon the fair market rental as determined by the Board of Land and Natural Resources' appraiser, the Grantee must notify the Grantor in writing within thirty (30) days after receipt of the determination, and the Grantee shall appoint the Grantee's own appraiser whose name and address shall be stated in the notice. The Grantee shall provide the Board of Land and Natural Resources with the complete appraisal prepared by the Grantee's appraiser. Each party shall pay for its own appraiser. If the Board of Land and Natural Resources' and the Grantee's appraisers do not agree upon the easement rental, the

Grantee and the Board of Land and Natural Resources shall, subject to section 171-17, Hawaii Revised Statutes, as may be amended from time to time, resolve the matter. The costs of mediation and arbitration shall be borne equally by the Grantee and the Board of Land and Natural Resources.

In the event that the fair market rental is not finally determined before the reopening date, the Grantee shall pay the rental as determined by the Board of Land and Natural Resources' appraiser until the new rent is determined, and the rental paid by Grantee shall then be subject to retroactive adjustments as appropriate.

Should the Grantee fail to notify Grantor in writing within thirty (30) days after receipt of the determination that Grantee disagrees with the fair market rental as determined by the Board of Land and Natural Resources' appraiser and that Grantee has appointed its own appraiser, then the fair market rental as determined by the Board of Land and Natural Resources' appraiser shall be deemed to have been accepted by Grantee and shall be the fair market rental as of the date of reopening.

D. The interest rate on any and all unpaid or delinquent rentals shall be at one percent (1%) per month, plus a service charge of FIFTY AND NO/100 DOLLARS ($50.00) a month for each delinquent payment.

THE GRANTOR AND THE GRANTEE COVENANT AND AGREE AS FOLLOWS:

1. The Grantee shall at all times with respect to the easement area use due care for public safety and agrees to release, indemnify, defend, and hold the Grantor harmless from and against any claim or demand for loss, liability, or damage, including claims for bodily injury, wrongful death, or property damage, arising out of or resulting from: a) any act or omission on the part of the Grantee relating to the Grantee's use, occupancy, maintenance, or enjoyment of the easement area; b) any failure on the part of the Grantee to maintain the easement area and sidewalks, roadways, and parking areas adjacent thereto in the Grantee's use and control, and including any accident, fire or nuisance, growing out of or caused by any failure on the part of the Grantee to maintain the easement area in a safe condition; and c) from and against all actions, suits,

damages, and claims by whomsoever brought or made by reason of the Grantee's non-observance or non-performance of any of the terms, covenants, and conditions of this grant of non-exclusive easement or the rules, regulations, ordinances, and laws of the federal, state, municipal or county governments.

2. The Grantor reserves unto itself, its successors and assigns, and the public, the full use and enjoyment of the easement area and the authority and right to grant to others rights and privileges for any and all purposes affecting the easement area, provided, however, that the rights herein reserved shall not be exercised by the Grantor and similar grantee(s) in any manner which interferes unreasonably with the Grantee in the use of the easement area for the purposes for which this easement is granted.

3. The Grantee shall not construct, place or maintain any building or structure over or upon the easement area, except for the purposes described in this grant and in accordance with plans and specifications submitted by the Grantee to and approved in writing by the Chairperson of the Board of Land and Natural Resources and in full compliance with all applicable laws, ordinances, rules and regulations.

4. The placement of all improvements in or upon the easement area by the Grantee shall be done without cost or expense to the Grantor and shall remain the property of the Grantee, subject to the terms of paragraphs 11 and 15; provided, that the removal shall be accomplished with minimum disturbance to the easement area which shall be restored to its original condition, or as close thereto as possible, within a reasonable time after removal.

5. Upon completion of any work performed in or upon the easement area, the Grantee shall remove therefrom all equipment and unused or surplus materials, if any, and shall leave the easement area in a clean and sanitary condition satisfactory to the Grantor.

6. This easement or any rights granted herein shall not be sold, assigned, conveyed, leased, mortgaged, or otherwise transferred or disposed of, directly or by operation of law, except with the prior written consent of the Grantor.

7. The Grantee shall keep the easement area and the

improvements thereon in a safe, clean, sanitary, and orderly condition, and shall not make, permit or suffer, any waste, strip, spoil, nuisance or unlawful, improper, or offensive use of the easement area.

8. The Grantee covenants, for itself, its successors and assigns, that the use and enjoyment of the land herein granted shall not be in support of any policy which discriminates against anyone based upon race, creed, sex, color, national origin, religion, marital status, familial status, ancestry, physical handicap, disability, age or HIV (human immunodeficiency virus) infection.

9. The Grantee, in the exercise of the rights granted herein, shall comply with all of the requirements of the federal, state, and county authorities and shall observe all county ordinances and state and federal laws, rules and regulations, now in force or which may hereinafter be in force.

10. These easement rights shall cease and terminate, and the easement area shall automatically be forfeited to the Grantor, without any action on the part of the Grantor, in the event of non-use or abandonment by the Grantee of the easement area, or any portion thereof, for a consecutive period of one (1) year.

11. The Grantee shall, at the expiration, termination or revocation of this easement, peaceably deliver unto the Grantor possession of the premises, together with all improvements existing or constructed thereon or Grantee shall remove such improvements and shall restore the premises to their original state, at the option of the Grantor. The Grantor may agree to take ownership of said improvements and shall notify the Grantee in writing if it wishes to retain the improvements in the easement area. If the Grantee does not remove the improvements or restore the premises to the satisfaction of the Grantor, the Grantor may effect such action and the Grantee agrees to pay all costs and expenses for such action. Furthermore, upon the expiration, termination, or revocation of this easement, should the Grantee fail to remove any and all of Grantee’s personal property from the premises, after notice thereof, the Grantor may remove any and all of Grantee’s personal property from the premises, and either deem the property abandoned and dispose of the property or place the property in storage at the cost and expense of Grantee and the

Grantee does agree to pay all costs and expenses for disposal, removal, or storage of the personal property. This provision shall survive the expiration, termination or revocation of the easement.

12. The Grantee shall procure and maintain, at its own cost and expense, in full force and effect throughout the term of this easement, general liability insurance, or its equivalent, with an insurance company or companies licensed or authorized to do business in the State of Hawaii with an AM Best rating of not less than "A-VIII" or other comparable and equivalent industry rating, in an amount of at least $1,000,000.00 for each occurrence and $2,000,000.00 aggregate, and with coverage terms acceptable to the Chairperson of the Board of Land and Natural Resources. The policy or policies of insurance shall name the State of Hawaii as an additional insured. A copy of the policy or other documentation required by the Grantor shall be filed with the State of Hawaii, Department of Land and Natural Resources. The insurance shall cover the entire easement area, including all buildings, improvements, and grounds and all roadways or sidewalks on or adjacent to the easement in the use or control of the Grantee.

The Grantee, prior to entry and use of the easement area or within fifteen (15) days after the effective date of this easement, whichever is sooner, shall furnish the Grantor with a policy(s) or other documentation required by the Grantor showing the policy(s) to be initially in force, keep the policy(s) or other documentation required by the Grantor on deposit during the entire easement term, and furnish a like policy(s) or other documentation required by the Grantor upon each renewal of the policy(s). This insurance shall not be cancelled, limited in scope of coverage, or nonrenewed until after thirty (30) days written notice has been given to the Grantor. The Grantor may at any time require the Grantee to provide Grantor with copies of the insurance policy(s) that are or were in effect during the easement term or other documentation required by the Grantor.

The Grantor shall retain the right at any time to review the coverage, form, and amount of the insurance required by this easement. If, in the opinion of the Grantor, the insurance provisions in this easement do not provide adequate protection for the Grantor, the Grantor may require Grantee to obtain insurance sufficient in coverage, form, and amount to provide adequate protection. The Grantor's requirements shall be reasonable but shall be designed to assure protection for and against the kind and extent of the risks which exist at the time a change in insurance is required. The Grantor shall notify Grantee in writing of changes in the insurance requirements and Grantee shall deposit copies of acceptable insurance policy(s) or other documentation required by the Grantor thereof, with the Grantor incorporating the changes within thirty (30) days after receipt of the notice.

The procuring of the required policy(s) of insurance shall not be construed to limit Grantee's liability under this easement nor to release or relieve the Grantee of the indemnification provisions and requirements of this easement. Notwithstanding the policy(s) of insurance, Grantee shall be obligated for the full and total amount of any damage, injury, or loss caused by Grantee's or the Grantee's employees, agents, officers, or invitees' negligence or neglect connected with this easement.

It is agreed that any insurance maintained by the Grantor will apply in excess of, and not contribute with, insurance provided by Grantee's policy.

13. Grantor reserves the right to withdraw the easement for public use or purposes, at any time during the term of this easement upon the giving of reasonable notice to Grantee. Upon withdrawal of the easement, Grantor shall return to Grantee a portion of the one-time payment described in paragraph 1. For purposes of determining the amount to be returned to the Grantee, the term "net payment" shall mean the one-time payment described in paragraph 1 reduced by any non-refundable portion of the one-time payment, if any, that Grantor was required by statute to pay to any other entity or body. The amount returned to Grantee shall be the net payment prorated for the unused term of the easement.

14. The Grantee shall not mortgage, hypothecate, or pledge the premises, any portion, or any interest in this easement without the prior written approval of the Chairperson of the Board of Land and Natural Resources and any mortgage, hypothecation, or pledge without the approval shall be null and void.

15. Time is of the essence in this agreement and if the Grantee shall abandon the premises, or if this easement and premises shall be attached or taken by operation of law, or if any assignment is made of the Grantee's property for the benefit of creditors, or if Grantee shall fail to observe and perform any of the covenants, terms, and conditions contained in this easement and on its part to be observed and performed, and this failure shall continue for a period of more than sixty (60) calendar days after delivery by the Grantor of a written notice of breach or default, by personal service, registered mail or certified mail to the Grantee at its last known address and to each mortgagee or holder of record having a security interest in the premises, the Grantor may, subject to the provisions of section 171-21, Hawaii Revised Statutes, at once re-enter the premises, or any part, and upon or without the entry, at its option, terminate this easement without prejudice to any other remedy or right of action for any preceding or other breach of contract; and in the event of termination, at the option of Grantor, all improvements shall remain and become the property of the Grantor or shall be removed by Grantee.

16. In the event the Grantor seeks to forfeit the privilege, interest, or estate created by this easement, each recorded holder of a security interest may, at its option, cure or remedy the default or breach within sixty (60) calendar days, from the date of receipt of the Grantor's notice, or within an additional period allowed by Grantor for good cause, and add the cost to the mortgage debt and the lien of the mortgage. Upon failure of the holder to exercise its option, the Grantor may: a) pay to the holder from any moneys at its disposal, including the special land and development fund, the amount of the mortgage debt, together with interest and penalties, and secure an assignment of the debt and mortgage from the holder or if ownership of the privilege, interest, or estate shall have vested in the holder by way of foreclosure, or action in lieu thereof, the Grantor shall be entitled to the conveyance of the privilege, interest, or estate upon payment to the holder of the amount of the mortgage debt, including interest and penalties, and all reasonable expenses incurred by the holder in connection with the foreclosure and preservation of its security interest, less appropriate credits, including income received from the privilege, interest, or estate subsequent to the foreclosure; or b) if the property cannot be reasonably reassigned without loss to the State, then terminate the outstanding privilege,

interest, or estate without prejudice to any other right or remedy for any preceding or other breach or default and use its best efforts to redispose of the affected land to a qualified and responsible person free and clear of the mortgage and the debt secured; provided that a reasonable delay by the Grantor in instituting or prosecuting its rights or remedies shall not operate as a waiver of these rights or to deprive it of a remedy when it may still otherwise hope to resolve the problems created by the breach or default. The proceeds of any redisposition shall be applied, first, to reimburse the Grantor for costs and expenses in connection with the redisposition; second, to discharge in full any unpaid purchase price or other indebtedness owing the Grantor in connection with the privilege, interest, or estate terminated; third, to the mortgagee to the extent of the value received by the State upon redisposition which exceeds the fair market value of the land as previously determined by the State's appraiser; and fourth, to the owner of the privilege, interest, or estate.

17. In case the Grantor shall, without any fault on its part, be made a party to any litigation commenced by or against the Grantee as a result of this grant of non-exclusive easement (other than condemnation proceedings), the Grantee shall pay all costs, including reasonable attorney's fees and expenses incurred by or imposed on the Grantor; furthermore, the Grantee shall pay all costs, including reasonable attorney's fees and expenses, which may be incurred by or paid by the Grantor in enforcing the covenants and conditions of this grant of non-exclusive easement, or in the collection of delinquent rental, fees, taxes, and any and all other applicable charges attributed to said easement area.

18. The Grantee shall not cause or permit the escape, disposal or release of any hazardous materials except as permitted by law. Grantee shall not allow the storage or use of such materials in any manner not sanctioned by law or by the highest standards prevailing in the industry for the storage and use of such materials, nor allow to be brought onto the easement area any such materials except to use in the ordinary course of Grantee's business, and then only after written notice is given to Grantor of the identity of such materials and upon Grantor's consent which consent may be withheld at Grantor's sole and absolute discretion. If any lender or governmental agency shall ever require testing to ascertain whether or not there has been

any release of hazardous materials by Grantee, then the Grantee shall be responsible for the reasonable costs thereof. In addition, Grantee shall execute affidavits, representations and the like from time to time at Grantor's request concerning Grantee's best knowledge and belief regarding the presence of hazardous materials on the easement area placed or released by Grantee.

The Grantee agrees to release, indemnify, defend, and hold Grantor harmless, from any damages and claims resulting from the release of hazardous materials on the easement area occurring while Grantee is in possession, or elsewhere if caused by Grantee or persons acting under Grantee. These covenants shall survive the expiration or earlier termination of this easement.

For the purpose of this easement "hazardous material" shall mean any pollutant, toxic substance, hazardous waste, hazardous material, hazardous substance, or oil as defined in or pursuant to the Resource Conservation and Recovery Act, as amended, the Comprehensive Environmental Response, Compensation, and Liability Act, as amended, the Federal Clean Water Act, or any other federal, state, or local environmental law, regulation, ordinance, rule, or bylaw, whether existing as of the date hereof, previously enforced, or subsequently enacted.

19. Should future development necessitate a relocation of the easement granted herein, or any portion thereof, the relocation shall be accomplished at the Grantee's own cost and expense; provided, however, that if other lands of the Grantor are available, the Grantor may, in the Grantor's sole and absolute discretion grant to the Grantee without payment of any money, a substitute easement of similar width within the reasonable vicinity of the original alignment, which substitute easement shall be subject to the same terms and conditions as that herein granted and as required by law.

20. The introduction of noxious, invasive, or exotic plant and animal species to the easement area shall not be permitted. The Grantee shall be solely responsible for the removal, at no cost to the Grantor, of any and all noxious, invasive, or exotic plant and animal species on the easement area. This provision shall not apply to native species.

21. If there is more than one Grantee under this

grant of easement, then the obligation of each Grantee shall be joint and several such that each Grantee is jointly and severally liable for all obligations under this grant of easement.

22. The Grantee shall, at its own cost and expense, within thirty (30) calendar days after the date of receipt of this easement document, procure and deposit with the Grantor and thereafter keep in full force and effect during the term of this easement a good and sufficient surety bond, conditioned upon the full and faithful observance and performance by Grantee of all the terms, conditions, and covenants of this easement, in an amount equal to two times the annual rental then payable. This bond shall provide that in case of a breach or default of any of the easement terms, covenants, conditions, and agreements, the full amount of the bond shall be paid to the Grantor as liquidated and ascertained damages and not as a penalty.

23. The Grantee shall comply with all applicable federal and state environmental impact regulations.

24. The Grantee shall coordinate with and comply with requests from the Division of Forestry and Wildlife, Department of Land and Natural Resources to avoid conflicts with public uses of the easement area and other management objectives.

25. The Grantee shall submit detailed annual work plans and reports about mitigation activities and outcomes in the easement area to the Division of Forestry and Wildlife, Department of Land and Natural Resources.

26. The public shall have access across the easement area at all times.

27. The easement area shall not be used at any time by the Grantee, its guests or invitees for parking purposes.

28. The Grantee shall at all times during the term of this easement keep trim all vegetation growing within, over, or onto the easement area so that it does not present a threat to public safety by creating or contributing to roadway, waterway, or pedestrian obstruction, visual obstruction to operators of vehicles, fire hazards, or interference with or downing of power lines.

29. The easement area is encumbered by Governor's Executive Order Nos. 1509, 2293, 2724, 3087, 3088, 3156, 3161, 3239, 3240, 3241, 3243, 4269, and 4270 to the State of Hawaii, Department of Land and Natural Resources, and therefore this grant of easement may be subject to the State of Hawaii Governor's and the Department of Land and Natural Resources' approval. Said approval was obtained on ________ and ___________ .

[SIGNATURE LINES]

Appendix 4I

Conservation Easement for Upper Mānoa Valley and Upper Mānoa Valley PF Conservation Sites

LAND COURT | REGULAR SYSTEM

AFTER RECORDATION, RETURN BY MAIL [X] PICK-UP [ ] RS

Total No. of Pages: _________

TITLE OF DOCUMENT:

CONSERVATION EASEMENT DEED

PARTIES TO DOCUMENT:

GRANTOR: **RICHARD BERRY**

____

____

GRANTEE: ________________________________

____

____

TMK No. (4) 5-9-001-021

CONSERVATION EASEMENT DEED

THIS CONSERVATION EASEMENT DEED ("Conservation Easement") is made as of ____________, 2024, by **RICHARD BERRY** ("Grantor"), in favor of ____________________, a Hawaiʻi nonprofit corporation ("Grantee"). Grantee and Grantor are hereinafter referred to individually as "Party" and collectively as "Parties."

For good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, and the foregoing Recitals and mutual covenants, terms, conditions, and restrictions contained herein, and pursuant to the laws of the State of Hawaiʻi, including Chapter 198, HRS, Grantor hereby voluntarily grants and conveys to Grantee a conservation easement in perpetuity over the Easement Area. Grantor expressly intends that this Conservation Easement run with the land, including all duties, obligations, and rights conferred herein, and it shall be binding upon Grantor, and Grantee and their respective successors, assigns, and heirs and executors in perpetuity.

I. RECITALS

1. This Easement includes three main parts: (1) the Recitals, which provide a general description of the Property, its important Conservation Values, and the existing zoning and land use classification affecting the Property; (2) Covenants and Restrictions, which describe the respective rights and obligations of Grantor and Grantee; and (3) the Exhibits, which identify and describe the Property and identify site-specific conservation measures.

2. Kauaʻi Island Utility Cooperative ("KIUC") owns and/or operates multiple power lines and lights ("Utilities") throughout the County, which adversely affect as the ʻaʻo ("Newell's Shearwater"), the ʻuaʻu ("Hawaiian petrel"), and the ʻakēʻakē ("band-rumped storm-petrel") (collectively, the "Listed Seabirds"). The Listed Seabirds are protected under both the federal Endangered Species Act, 16 U.S.C. § 1531 et seq. ("ESA") and the Hawaiʻi Endangered Species Act ("HESA") (Chapter 195D of the Hawaiʻi Revised Statutes ("HRS").

3. KIUC drafted and committed to implement the [insert name] Habitat Conservation Plan ("HCP") dated [insert]. On ___________, KIUC was issued an ESA Incidental Take Permit [insert #] ("Permit") by the United States Fish and Wildlife Service ("USFWS") and HESA Incidental Take License [insert #]] ("ITL") ("License") by the Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife ("DOFAW"). The Permit and License authorize the incidental "take" (as "take" is defined in the ESA and HESA and their respective implementing regulations) of HCP covered species (including Listed Seabirds) resulting from KIUC activities covered by the HCP. Copies of these documents may be obtained from the USFWS and DOFAW upon request.

4. Grantor is the sole owner in fee simple of certain real property consisting of approximately 391.8620 acres (the "Property"). The property subject to this Conservation Easement includes approximately 256.6 acres of land located in the County of Kauaʻi (the "County"), State of Hawaiʻi, commonly referred to as "Upper Manoa Valley" and shown on Exhibit [#] (the "Property" or the "Easement Area"). Grantor is the sole owner of the Property.

5. Pursuant that certain Long-Term Easement and Conservation Measures Cooperative Agreement with respect to the Upper Manoa Valley ("UMV Agreement") dated February 28, 2024, by and between Grantor and KIUC (Exhibit insert), Grantor agreed to dedicate use of the Easement Area to conservation of the Listed Seabirds through issuance of an in-perpetuity conservation easement in accordance with Chapter 198, HRS. This Conservation Easement implements that requirement of the UMV Agreement. On even date herewith, Grantor and KIUC agreed to subordinate the UMV Agreement to this Conservation Easement provided Grantee agrees to recognize and respect the terms and provisions of the UMV Agreement as more fully set forth herein. The Parties acknowledge and agree that the terms of this Conservation Easement and the UMV Agreement are consistent and that KIUC shall have the right to conduct any and all conservation and related activities within the Easement Area as anticipated by the UMV Agreement and as outlined in the HCP.

6. Conservation Values. The Easement Area possesses wildlife and habitat values of great importance to Grantor, Grantee, the United States of America, through its Department of the Interior, USFWS, the people of the State of Hawaiʻi, and the people of the United States of America. Further, the Property contains valuable natural resources, without limitation, montane habitat, native plant species, Listed Plant species (i.e., Endangered *Bonamia menziesii, Euphorbia eleanoriae* [ʻakoko], *Kadua fluviatilis* [kamapuaʻa], *Santalum involutum, and Schiedea kauaiensis*, and Threatened *Isodendrion longifolium* [aupaka]), and the Listed Seabird species, which have either been identified in the area or are known to nest within this habitat. Individually and collectively, this habitat and all native wildlife and native plants that may be found within the Easement Area, comprise the "Conservation Values" of the Easement Area. Maintaining, protecting, and, as appropriate, enhancing all Conservation Values in the Easement Area assists in ensuring that the Easement Area will remain available for current and future Listed Seabird use, and that HCP biological goals and objectives for Listed Seabirds can be obtained and maintained in perpetuity.

7. Grantee is [insert name, address, and description of the Grantee]. Grantee is authorized to hold conservation easements pursuant to Chapter 198, HRS. Specifically, Grantee is a public body which qualifies for and holds an income tax exemption under Section 501(c) of the Internal Revenue Code of 1954, as amended, and whose organizational purposes are designed to facilitate the purposes of Chapter 198, HRS.

8. Grantor desires that the Conservation Values of the Easement Area be preserved and maintained in perpetuity by permitting only those uses of and activities within the Easement Area that do not impair or interfere with the Conservation Values, including those uses and activities anticipated by the UMV Agreement, which shall be deemed to further and not to impair or interfere with the Conservation Values provided those activities are carried out in a manner consistent with the UMV Agreement and as outlined in the "Site Management Plan" (defined below). Grantee desires to accept this Conservation Easement to preserve and protect in perpetuity the Conservation Values of the Easement Area for the benefit of this generation, and the generations to come.

9. The USFWS has jurisdiction over the conservation, protection, restoration, and management of fish, wildlife, native plants, and the habitat necessary for biologically sustainable populations of these species within the United States pursuant to the ESA, the Fish and Wildlife

Coordination Act, 16 U.S.C. §§ 661–666c, the Fish and Wildlife Act of 1956, 16 U.S.C. § 742(f) *et seq*., and other provisions of federal law.

10. The DOFAW's mission includes taking positive actions to enhance the prospects for survival and perpetuation of all indigenous species of aquatic life, wildlife, and land plants that are integral parts of Hawai‘i's native ecosystems and comprise the living heritage of Hawai‘i pursuant to Chapter 195D, HRS.

11. KIUC is defined in Section 2 above.

12. Chapter 4, Section 4.4.4 of the HCP contains detailed management prescriptions for the Easement Area and other conservation sites proposed for conservation on Kaua‘i under the HCP. These provisions collectively shall serve as the site management plan ("Site Management Plan" or "SMP") for the Easement Area under this Conservation Easement. The SMP is intended to ensure that the Easement Area is used, managed, monitored, and maintained in perpetuity for the benefit of the Listed Seabirds and their habitat in accordance with the HCP and this Conservation Easement.

13. Baseline Documentation. The status of the Conservation Values and any existing improvements within the Easement Area at the time of the execution of the Conservation Easement are further documented in an inventory of relevant features called the "Baseline Documentation Report." The Baseline Documentation Report is a pre-acquisition assessment of the property that summarizes the baseline biological conditions including, without limitation, the presence and condition of habitat of Covered Species in the HCP; any agricultural activities in the Easement Area; a map of the parcel which identifies the Easement Area and any designated Development Envelopes, a description of the property's physical conditions (e.g., roads, buildings, fences, wells, other structures); and ground and aerial photographs documenting the condition of the entire Easement Area including the Conservation Values found. Both Parties acknowledge, as described in Exhibit [insert]] attached hereto and incorporated herein by reference, that each has received a copy of the Baseline Documentation Report, and that it provides a comprehensive and accurate representation of the Easement Area and its resources as of the date of execution of this Conservation Easement. The Baseline Documentation Report is intended to serve as an objective informational baseline for monitoring compliance with the terms of this Conservation Easement.

14. The Parties intend and agree that this Conservation Easement and the SMP shall survive suspension expiration, or termination of either or both the License and Permit; provided, however, that KIUC shall have no further obligations relative to the management or conservation of the Easement Area following the expiration or termination of the License and the Permit. In such event, the management of the Easement Area will continue to be informed by best available scientific information and the goals and objectives of the SMP. Notwithstanding the foregoing, KIUC may voluntarily choose to continue its conservation activities within the Conservation Area following expiration of the License or the Permit in its sole discretion including, without limitation, in accordance with the terms of new or amended incidental take authorizations from DOFAW or the USFWS

15. The Parties each confirm that they have reviewed and signed this Conservation Easement after consulting their respective legal counsel.

II. COVENANTS, TERMS, CONDITIONS AND RESTRICTIONS

1. Recitals**.** The Recitals set forth in Article I (above) are incorporated into this Article II for all intents and purposes as though they were fully written out herein, and all substantive requirements and understanding stated in the Recitals shall be binding on the parties.

2. Conservation Easement Purposes. The purpose of this Conservation Easement is to ensure that the Easement Area will be retained forever in its natural, restored, or enhanced condition consistent with the protection and enhancement of the Listed Seabirds as set forth in the SMP (the "Conservation Purpose" or "Purpose"). The Conservation Purpose includes, without limitation, the prevention of any use of the Easement Area that will impair or interfere with the Conservation Values of the Property. Grantor intends that this Conservation Easement will confine the use of the Easement Area to activities that are consistent with the Conservation Purposes. Any and all activities occurring under the SMP or in accordance with the UMV Agreement shall be deemed to be consistent with, and not to impair or interfere with, the Conservation Purpose.

3. Grantee's Rights. To accomplish the Conservation Purpose, and subject to the terms and provisions of the SMP and the UMV Agreement, Grantor hereby grants and conveys the following rights to Grantee:

(a) To preserve and protect the Conservation Values of the Easement Area;

(b) To enter the Easement Area at any reasonable time in order to monitor compliance with and otherwise enforce the terms of this Conservation Easement, and for scientific research and interpretive purposes by Grantee or its designees, provided that Grantee shall not unreasonably interfere with Grantor's authorized use and quiet enjoyment of the Property;

(c) To prevent any activity on or use of the Easement Area that is inconsistent with the Conservation Purpose and to require the restoration of such areas or features of the Easement Area that may be damaged by any act, failure to act, or any use or activity that is inconsistent with the Conservation Purpose;

(d) (To require that all mineral, air and water rights as Grantee deems necessary to preserve, protect, and sustain the biological resources and Conservation Values of the Easement Area shall remain a part of and be put to beneficial use upon the Easement Area consistent with the Conservation Purpose and the laws of the State of Hawaiʻi; and

(e) All present and future development rights appurtenant to, allocated, implied, reserved or inherent in the Easement Area; such rights are hereby terminated and extinguished, and may not be used on or transferred to any portion of the Easement Area, nor any other property adjacent or otherwise.

4. Grantee's Duties. The Grantee shall:

(a) Actively work to ensure that the requirements and objectives of this Conservation Easement are met through, without limitation, undertaking one or more site visits annually; regularly reviewing available site monitoring information throughout each year (such information may include, without limitation, KIUC and Grantor reports, aerial and satellite photograph, and remote sensing information); actively participating in discussions related to SMP implementation and modifications; and, when appropriate, enforcing the terms and conditions of the Conservation Easement;

(b) Promptly report any actual or reasonably foreseeable threats to Conservation Values and recommendations for addressing those threats to Grantor, KIUC, DOFAW and USFWS;

(c) Promptly report any obstacles to its faithfully and timely accomplishing its duties, together with plans or recommendation for addressing such obstacles, to Grantor, KIUC, DOFAW and USFWS;

(d) Generate an annual report documenting discharge of its duties and any reasonably foreseeable issues or concerns for Grantor KIUC, DOFAW, and USFWS, which shall be delivered by [insert date] of each calendar year; and

(e) Make itself available at reasonable times for calls and meetings requested by Grantor, KIUC, DOFAW or USFWS, to discuss Conservation Easement related matters.

5. Third-Party Beneficiaries. Grantor and Grantee each acknowledge that USFWS**,** DOFAW and KIUC each is a third-party beneficiary of this Conservation Easement. The USFWS, DOFAW and KIUC and their respective successors, assigns, contractor, and agents shall have the right of access to the Property at all reasonable times for purposes related to their rights under this Conservation Easement and, in the case of KIUC, the UMV Agreement. USFWS, DOFAW and KIUC each shall have the right, but not the obligation, to enforce the terms and conditions of this Conservation Easement as if it is the Grantee hereunder. These enforcement rights are in addition to, and do not limit, those rights of enforcement under the Permit and License, as applicable, held by USFWS and DOFAW. USFWS, DOFAW and KIUC are each entitled to the same remedies as the Parties. Additionally, the Parties acknowledge and agree that USFWS, DOFAW and KIUC are expressly granted certain additional rights under this Conservation Easement including, but not limited to, prior written notice of certain specified actions and a right of approval of certain specified actions. The Parties do not intend to transfer any property interest in the Easement Area to the Third-Party Beneficiaries; provided, however, that this Conservation Easement shall not be deemed to affect or modify any property interest held by KIUC under the UMV Agreement.

6. KIUC Conservation Actions. Grantor and Grantee acknowledge that pursuant to the UMV Agreement, KIUC (including its contractors, subcontractors, consultants, and representatives) have a non-exclusive easement in gross to enter the Property and Easement Area for the purpose of implementing certain types of permitted uses which relate to the conservation of Listed Seabirds as set forth in the HCP, Permit, License, and SMP. Notwithstanding the subordination of the UMV Agreement to this Conservation Easement, nothing in this Conservation Easement shall be deemed to limit or impair KIUC’s rights or obligations under the UMV Agreement.

7. Grantor Prohibited Uses. Any activity on or use of the Easement Area that is inconsistent with the Conservation Purpose is prohibited. Without limiting the generality of the foregoing, and subject to and expect as otherwise provided or authorized in the terms and provisions of the SMP and the UMV Agreement, the following uses and activities by Grantor, Grantor's agents, and any third-parties are expressly prohibited:

(a) Unseasonable watering; use of chemical fertilizers, pesticides, biocides, herbicides, rodenticides, fungicides or other agents for non-native predator control or invasive plant control; weed abatement activities for invasive plant control; and any and all other activities and uses which may adversely affect the Conservation Values of the Easement Area or otherwise interfere with the Conservation Purpose;
(b) Use of off-road vehicles and use of any other motorized vehicles except on existing roadways;
(c) Agricultural activity of any kind;
(d) Recreational activities including, but not limited to, horseback riding, biking, hunting or fishing;
(e) Commercial, industrial, institutional, or residential structures or uses;
(f) Any legal or de facto division, subdivision or partitioning of the Easement Area;
(g) Construction, reconstruction, expansion, location, relocation, installation, or placement of any building, billboard or sign, or any other structure or improvement of any kind, except signs for safety/security, structures necessary for safe access by helicopter, structures necessary for equipment storage to support conservation activities, and access control or education that will not impair or interfere with the Conservation Values and are consistent with the Purposes of this Conservation Easement;
(h) Deposit or accumulation of soil, trash, ashes, refuse, waste, bio-solids or any other materials;
(i) Planting, introduction, or dispersion of non-native or exotic plant or animal species;
(j) Filling, dumping, excavating, draining, dredging, mining, drilling, removing or exploring for or extracting minerals, loam, soil, sand, gravel, rock or other material on or below the surface of the Easement Area, or granting or authorizing surface entry for any such purpose;
(k) Altering the surface or general topography of the Easement Area, including building roads or trails, or paving or otherwise covering any portion of the Easement Area, except as necessary to support safe access to the Easement Area for activities necessary to support Conservation Values;
(l) Removing, disturbing, altering, destroying, or cutting of trees, shrubs or other vegetation, except as required by law, or to address imminent threats to human health, safety or property, or in furtherance of the Conservation Purpose. Such activities shall be addressed in the SMP;
(m) Manipulating, impounding or altering any natural water course, body of water, or water circulation on the Easement Area, and activities or uses detrimental to water quality, including but not limited to degradation or pollution of any surface or sub-surface waters;
(n) Without the prior written consent of KIUC, Grantee, USFWS, and DOFAW, which may withhold for any reason, transferring, encumbering, selling, leasing, or otherwise separating the air or water rights for the Easement Area; changing the place or purpose

of use of the water rights; abandoning or allowing the abandonment of, by action or inaction, any water or water rights, wells, ground water rights, or other rights in and to the use of water historically used on or otherwise appurtenant to the Easement Area, including but not limited to: (1) riparian water rights; (2) rights to waters which are secured under contract with any irrigation or water district, to the extent such waters are customarily applied to the Easement Area; and (3) any water from wells that are in existence or may be constructed in the future on the Easement Area; and

(o) Any activity or use that may violate or fail to comply with relevant federal, state, or local laws, regulations, or policies applicable to Grantor, the Easement Area, or the activity or use in question.

8. Grantor's Reserved Rights. Grantor reserves to itself, and to its personal representatives, heirs, successors, and assigns, all rights accruing from its ownership of the Property, including the right to engage in or to permit or invite others to engage in uses of the Easement Area that are are (1) consistent with the requirements and Purposes of this Conservation Easement and (2) are, to ensure consistency with the Purposes, expressly described in detail and authorized in the SMP.

9. Grantor's Duties. The Grantor shall:

(a) Undertake all reasonable actions to prevent the unlawful entry and trespass by persons whose activities may degrade or harm the Conservation Values of the Easement Area or that are otherwise inconsistent with this Conservation Easement;

(b) Undertake all necessary actions to perfect the rights of Grantee under this Conservation Easement; and

(c) Work cooperatively with KIUC to ensure that the UMV Easement is modified to conform to the requirements of this Conservation Easement.

10. Adaptive Management. The HCP, License, and Permit require Adaptive Management for the protection of Listed Seabirds in the Easement Area, recognizing that Adaptive Management is a key element of implementing effective conservation programs. Adaptive Management combines data from monitoring species and natural systems with new information from management and targeted studies to continually assess the effectiveness of the conservation program and adjust conservation actions. Adaptive Management may include re-prioritizing monitoring efforts as well as corrective actions where (a) current management activities are not adequate or effective, or (b) enforcement difficulties are identified. Actions that are part of Adaptive Management of the Easement Area in accordance with the Permit, License, and HCP, including but not limited to monitoring and corrective actions, are consistent with the Conservation Purpose.

11. Remedies.

(a) Grantee determines that a violation of the terms of this Conservation Easement has occurred or is threatened, Grantee shall give written notice to Grantor of such violation and demand in writing the cure of such violation ("Notice of Violation"). At the time of giving any such Notice of Violation, Grantee shall also give a copy of the Notice of Violation to the third party beneficiaries (i.e., USFWS, DOFAW and KIUC) in accordance with the terms of this Conservation Easement.

(b) If Grantor fails to cure the violation within fifteen (15) days after receipt of the Notice of Violation, or if the cure reasonably requires more than fifteen (15) days to complete and Grantor fails to begin the cure within the fifteen (15)-day period or fails to continue diligently to complete the cure, Grantee may bring an action at law or in equity in a court of competent jurisdiction to enforce the terms of this Conservation Easement for any or all of the following: to recover any damages to which Grantee may be entitled for violation of the terms of this Conservation Easement or for any injury to the Conservation Values of the Easement Area; to enjoin the violation, ex parte as necessary, by temporary or permanent injunction without the necessity of proving either actual damages or the inadequacy of otherwise available legal remedies; to pursue any other legal or equitable relief, including, but not limited to, the restoration of the Easement Area to the condition in which it existed prior to any such violation or injury; or to otherwise enforce this Conservation Easement. Without limiting the liability of Grantor, Grantee may apply any damages recovered Grantee to the cost of undertaking any corrective action on the Easement Area.

(c) If Grantee determines that circumstances require immediate action to prevent or mitigate injury to the Conservation Values of the Easement Area, Grantee, may pursue its remedies under this Conservation Easement without prior notice to Grantor or without waiting for the period provided for cure to expire. Grantee's and KIUC's rights under this section apply equally to actual or threatened violations of the terms of this Conservation Easement.

(d) Grantor agrees that Grantee's, remedies at law for any violation of the terms of this Conservation Easement are inadequate and that Grantee shall be entitled to the injunctive relief described in this Section 11, both prohibitive and mandatory, in addition to such other relief to which Grantee may be entitled, including specific performance of the terms of this Conservation Easement, without the necessity of proving either actual damages or the inadequacy of otherwise available legal remedies. Grantee's remedies described in this Section shall be cumulative and shall be in addition to all remedies now or hereafter existing at law or in equity. The failure of Grantee to discover a violation or to take immediate legal action shall not bar Grantee from taking such action at a later time.

(e) If at any time in the future Grantor or any subsequent transferee uses or threatens to use the Easement Area for purposes inconsistent with this Conservation Easement (including, without limitation, that are inconsistent with the approved in the SMP), then any person and any entity with a justiciable interest in the preservation of this Conservation Easement each has standing as an interested party in any proceeding affecting this Conservation Easement.

12. Costs of Enforcement. Grantor shall bear all costs incurred by Grantee, KIUC, DOFAW, or USFWS, where it is a prevailing party in enforcing the terms of this Conservation Easement against Grantor. These costs may include, but are not limited to, the following: costs of suit and attorneys' and experts' fees, and any costs for restoration necessitated by Grantor's actions, negligence or breach of this Conservation Easement.

13. Discretion of Grantee and KIUC. Enforcement of the terms of this Conservation Easement by Grantee or KIUC shall be at the discretion of the enforcing party, and any forbearance

by Grantee or KIUC to exercise its rights under this Conservation Easement in the event of any breach of any term of this Conservation Easement shall not be deemed or construed to be a waiver by Grantee, or KIUC of such term or of any subsequent breach of the same or any other term of this Conservation Easement or of any rights of Grantee, or KIUC under this Conservation Easement. No delay or omission by Grantee or KIUC in the exercise of any right or remedy shall impair such right or remedy or be construed as a waiver.

14. Acts Beyond Grantor's Control. Nothing contained in this Conservation Easement shall be construed to entitle Grantee (or any third party beneficiary) to bring any action against Grantor for any injury to or change in the Easement Area resulting from any natural cause beyond Grantor's control, including, without limitation, fire not caused by Grantor, flood, storm, and earth movement, or any prudent action taken by Grantor under emergency conditions to prevent, abate, or mitigate significant injury to persons or the Easement Area resulting from such causes. Notwithstanding, where mitigation of injury to persons is not a concern, whenever practicable, Grantor will promptly consult the Grantee, USFWS, DOFAW and KIUC before taking emergency remedial action. As soon as possible after taking any emergency remedial action, Grantor will notify the Grantee, USFWS, DOFAW and KIUC, in writing. The notification will explain of the need for the action and specific action taken. Thereafter, the parties will meet, as needed, to determine whether subsequent action is needed to redress impacts to Conservation Purpose.

15. Construction, Maintenance and Disposition of Predator Control Fence, Weatherports, and Landing Zones. Notwithstanding anything to the contrary contained herein, KIUC shall have the right to construct and maintain a fence, two weatherports, and two landing zones UMV Agreement to protect the Conservation Values of the Easement Area. Grantee, USFWS, DOFAW and KIUC shall have an ongoing right to use the Weatherport and Landing Zones at any reasonable time in association with their rights under this Conservation Easement. Grantee's, USFWS's, and DOFAW's right to use the Weatherport and Landing Zones shall survive suspension, expiration, or termination or the Permit and the License. KIUC will own and maintain the predatory control fence, weatherport and landing zones for the term of Permit and the term of the License. Upon expiration or termination of the Permit and the License, the predator control fences, weatherport, and landing zones will be transferred to Grantor for continued use in achieving and maintaining the Purposes of this Conservation Easement; provided, however, that USFWS and DOFAW (and KIUC should it elect to continue its management activities within the Easement Area following the expiration of the current terms of the Permit and the License) shall have an ongoing right to use such facilities during the life of this Conservation Easement.

16. Supplemental Access Provision. In addition to Grantee, USFWS, and DOFAW access rights provided herein, their respective consultants, contractors, subcontracts, and agents are granted a right of access at all reasonable times to assist Grantee, USFWS, and DOFAW in exercising their respective rights and duties under this Agreement. Any financial institution retained by KIUC or Grantee that requires site access, such as a surety, insurer, bank, or endowment manager, shall be considered a contractor for purposes of this provision. This Conservation Easement does not convey a general right of access to the public.

17. Costs and Liabilities. Grantor retains all responsibilities and shall bear all costs and liabilities of any kind related to the ownership, operation, upkeep, and maintenance of the Easement Area to the extent that such responsibilities and costs are not borne by KIUC under the

UMV Agreement. Grantor agrees that neither Grantee, USFWS, DOFAW, nor KIUC shall have any duty or responsibility for the operation, upkeep or maintenance of the Property, the monitoring of hazardous conditions thereon, or the protection of Grantor, the public or any third parties from risks relating to conditions on the Property. Grantor, Grantee, and KIUC each remains solely responsible for obtaining any applicable governmental permits and approvals required for any activity or use permitted by this Conservation Easement, and any activity or use shall be undertaken in accordance with all applicable federal, state, local and administrative agency statutes, codes, ordinances, rules, regulations, orders and requirements.

18. Taxes; No Liens. Grantor shall pay before delinquency all taxes, assessments (general and special), fees, and charges of whatever description levied on or assessed against the Property by competent authority (collectively "Taxes"), including any Taxes imposed upon, or incurred as a result of, this Conservation Easement, and shall furnish Grantee, USFWS, DOFAW, and KIUC with satisfactory evidence of payment upon request. Grantor, Grantee and KIUC each shall keep the Property free from any liens (other than a security interest that is expressly subordinate to this Conservation Easement as provided in Sections 27(k) and (l)), including those arising out of any obligations incurred for any labor or materials furnished or alleged to have been furnished to or for Grantor or Grantee, at or for use on the Property.

19. Hold Harmless.

(a) Grantor shall hold harmless, protect, and indemnify Grantee and its directors, officers, employees, agents, contractors, and representatives and the heirs, personal representatives, successors and assigns of each of them (each a "Grantee Indemnified Party" and, collectively, "Grantee's Indemnified Parties") from and against any and all liabilities, penalties, costs, losses, damages, expenses (including, without limitation, reasonable attorneys' fees and experts' fees), causes of action, claims, demands, orders, liens or judgments (each a "Claim" and, collectively, "Claims"), arising from or in any way connected with: (1) injury to or the death of any person, or physical damage to any property, resulting from any act, omission, condition, or other matter related to or occurring on or about the Easement Area, regardless of cause, except that this indemnification shall be inapplicable to Grantee's Indemnified Parties with respect to any Claim due solely to the negligence or willful misconduct of Grantee's Indemnified Parties; (2) the obligations specified in Sections 6, 15, and 16; and (3) the existence or administration of this Conservation Easement.

(b) Grantor shall hold harmless, protect, and indemnify USFWS, DOFAW, and KIUC and their respective directors, officers, employees, agents, contractors and representatives, and the heirs, personal representatives, successors and assigns of each of them (each a "Other Indemnified Party" and, collectively, "Other Indemnified Parties") from and against any and all Claims arising from or in any way connected with: (1) injury to or the death of any person, or physical damage to any property, resulting from any act, omission, condition, or other matter related to or occurring on or about the Property, regardless of cause; and (2) the existence or administration of this Conservation Easement. Provided, however, that this indemnification shall be inapplicable to an Other Indemnified Party with respect to any Claim due solely to the negligence or willful misconduct of that Other Indemnified Party. If any action or proceeding is brought against any of Other Indemnified Parties by reason of any Claim to which the indemnification in this Section 19 applies, then Grantor shall, at the election of and upon written notice from the Other Indemnified Party, defend such action or proceeding by counsel reasonably acceptable to the Other Indemnified Party or reimburse the Other Indemnified Party for all charges incurred for legal services in defending the action or proceeding.

20. Highest and Best Use. In granting this Conservation Easement, Grantor has considered the fact that any use of the Easement Area that is prohibited by this Conservation Easement, or any other use as determined to be inconsistent with the Purpose of this Conservation Easement, may become economically more valuable than permitted uses. It is the intent of Parties that such circumstances shall not justify the modification, termination, or extinguishment of this Conservation Easement. Grantor's inability to carry on any or all of the permitted uses, or the unprofitability of doing so, shall not impair the validity of this Conservation Easement or be considered grounds for its termination or extinguishment. Additionally, changes in the value or use of the property on lands adjacent to or in the vicinity the Easement Area shall not justify the modification, termination, or extinguishment of this Conservation Easement. The Parties Agree that it is their intent to preserve the condition of the Easement Area and each of the Conservation Values protected herein, notwithstanding economic, or other hardship or changes in circumstances or conditions. The Parties recognize that protection of Conservation Values in accordance with the requirements of this Conservation Easement is the intended best and most productive use of the Easement Area.

21. Extinguishment. This Conservation Easement constitutes a property right. It is the Parties' intention that the terms and conditions of this Conservation Easement shall be carried out in perpetuity. Liberal construction is expressly required for attaining and maintaining in perpetuity Conservation Values and the Purposes of this Conservation Easement. If circumstances arise in the future that render the Conservation Purpose impossible to accomplish, this Conservation Easement can only be terminated or extinguished, in whole or in part, by judicial proceedings in a court of competent jurisdiction. Grantor shall provide written notice to Grantee, KIUC, DOFAW and USFWS at least forty-five (45) days prior to taking any action to extinguish this Conservation Easement, and each may oppose the extinguishment in the proceeding should they choose. No such extinguishment shall affect the value of Grantee's interest in the Easement Area, and if the Easement Area, or any interest therein, is sold, exchanged, or taken after such extinguishment, Grantee shall be entitled to receive its pro-rata share of the proceeds of such sale, exchange or taking. The amount of the compensation to which Grantee shall be entitled from any sale, exchange, or taking of all or any portion of the Easement Area subsequent to such extinguishment shall be based on the respective fair market values of the interests of Grantee and Grantor extinguished as determined in the judicial extinguishment proceedings, and Grantee shall use any proceeds received in a manner determined in writing by USFWS and DOFAW to be consistent with meeting KIUC's mitigation obligations under the Permit and License.

22. Condemnation. If all or any part of the Easement Area is proposed to be taken under the power of eminent domain, Grantor and Grantee shall join in appropriate proceedings at the time of such proposed taking to recover the full value of the interests in the Easement Area subject to the taking and all incidental or direct damages resulting from the taking. All expenses

reasonably incurred by the parties to this Easement in connection with such taking shall be paid out of the recovered proceeds. The Parties shall be respectively entitled to compensation from the balance of the recovered proceeds in a manner determined by USFWS or DOFAW in writing to be consistent with the Purposes of this Conservation Easement and Grantor's mitigation obligations under the Permit.

23. Transfer of Easement. Grantee may transfer or assign this Conservation Easement only to an entity or organization approved in advance in writing by Grantor, USFWS, and KIUC that is authorized to acquire and hold conservation easements pursuant to HRS § 198.3 (and any successor or other provisions then applicable) or the laws of the United States. Grantee shall require the transferee to record the assignment in the county where the Property is located. The failure of Grantee to perform any act provided in this Section shall not impair the validity of this Conservation Easement or limit its enforcement in any way.

24. Transfer of Property. Grantor agrees to incorporate the terms of this Conservation Easement by reference in any deed or other legal instrument by which Grantor divests itself of any interest in all or any portion of the Easement Area (to the extent such divestiture is not otherwise prohibited by this Agreement). Grantor agrees that the deed or other legal instrument shall also incorporate by reference, applicable provisions of the Permit and any amendments thereto. Grantor further agrees to give written notice to Grantee, USFWS, DOFAW, and KIUC of the intent to transfer any interest at least sixty (60) days prior to the date of such transfer. Grantee, USFWS, DOFAW, and KIUC shall have the right to prevent any transfer in which prospective subsequent claimants or transferees are not given notice of the covenants, terms, conditions and restrictions of this Conservation Easement, including the documents incorporated by reference in it. The failure of Grantor or Grantee to perform any act provided in this Section shall not impair the validity of this Conservation Easement or limit its enforceability in any way.

25. No Merger. The doctrine of merger is not intended to apply and shall not operate to extinguish this Conservation Easement if the Conservation Easement and the Property become vested in the same party. If, despite this intent, the doctrine of merger applies to extinguish the Conservation Easement then, unless Grantor, Grantee, USFWS and KIUC otherwise agree in writing, a replacement conservation easement or restrictive covenant containing the same protections embodied in this Conservation Easement shall promptly be recorded against the Property by Grantee, or its successor in interest, in favor of a third party approved in writing by USFWS to ensure that the mitigation obligations required under the Permit identified in Recital C, which include conservation of the Property in perpetuity through execution and recordation of a conservation easement or equivalent legal mechanism, and the Purposes of Chapter 198, HRS, are fulfilled. Until such replacement conservation easement or equivalent legal mechanism is executed and recorded, Grantee or its successor in interest shall continue to protect the Property in accordance with the terms of the original Conservation Easement. Any and all terms and conditions of this Conservation Easement shall be deemed covenants and restrictions upon the Property, which shall run with the land according to the laws of the State of Hawaiʻi and otherwise exist in perpetuity.

26. Notices. Any notice, demand, request, consent, approval, or other communication that a Party desires or is required to give to the other Party shall be in writing, and be served personally or sent by recognized overnight courier that guarantees next-day delivery or by first class United States mail, postage fully prepaid, and addressed as follows:

To Grantor: Richard Berry
[Address]
[City, State Zip]

To Grantee: [Name]
[Address]
[City, State Zip]
[Attn:]

To USFWS: Pacific Islands Fish and Wildlife Office
300 Ala Moana Blvd # 5231
Honolulu, Hawaii 96850
[Attn:]

To DOFAW:

To KIUC: Kauaʻi Island Utility Cooperative
4463 Pahee St #1
Lihue, Hawaii 96766
[Attn:]

or to such other address as Grantor, Grantee, USFWS, DOFAW, and KIUC may designate by written notice to the other Parties. Notice shall be deemed effective upon delivery in the case of personal delivery or delivery by overnight courier or, in the case of delivery by first class mail, three (3) business days after deposit into the United States mail.

27. Amendment. This Conservation Easement may be amended by the Parties only by mutual written agreement and subject to the prior written consent of USFWS and KIUC. Any such amendment shall be consistent with the Purposes of this Conservation Easement, the HCP, the Permit and the License, and the laws of the State of Hawaiʻi governing conservation easements and shall not affect its perpetual duration. Any such amendment shall be recorded in the Bureau of Conveyances of the State of Hawaiʻi (the "Bureau"), and Grantee shall promptly provide a conformed copy of the recorded amendment to Grantor, USFWS and DOFAW.

28. Additional Provisions.

(a) Controlling Law and Venue. The interpretation and performance of this Conservation Easement shall be governed by applicable State of Hawaiʻi and federal law. Where the USFWS is a party in litigation, the appropriate venue shall be a federal court with competent jurisdiction.

(b) Liberal Construction. Despite any general rule of construction to the contrary, this Conservation Easement shall be liberally construed to accomplish the Conservation Purpose and the policy and purpose of Chapter 198, HRS. If any provision in this instrument is found to be ambiguous, an interpretation consistent with the Conservation Purposes that would render the provision valid shall be favored over any interpretation that would render it invalid.

(c) Severability. If a court of competent jurisdiction voids or invalidates on its face any provision of this Conservation Easement, such action shall not affect the remainder of this Conservation Easement. If a court of competent jurisdiction voids or invalidates the application of any provision of this Conservation Easement to a person or circumstance, such action shall not affect the application of the provision to any other persons or circumstances.

(d) Entire Agreement. This instrument, including the documents incorporated by reference in it, sets forth the entire agreement of the Parties with respect to the Conservation Easement and supersedes all prior discussions, negotiations, understandings, or agreements relating to the Conservation Easement. No alteration or variation of this instrument shall be valid or binding unless contained in an amendment in accordance with Section 27.

(e) No Forfeiture. Nothing contained in this Conservation Easement will result in a forfeiture of Grantor's title in any respect.

(f) Successors. The covenants, terms, conditions, and restrictions of this Conservation Easement shall be binding upon, and inure to the benefit of, the Parties and their respective personal representatives, heirs, successors, and assigns and shall constitute a servitude running in perpetuity with the Easement Area.

(g) Covenant Running with the Land. This Conservation Easement and covenants contained herein (1) are imposed upon the Easement Area; (2) shall run with and against the same and shall be a charge and burden thereon for the benefit of Grantee, or any successor in interest; and (3) are perpetual and irrevocable.

(h) Termination of Rights and Obligations. A Party's rights and obligations under this Conservation Easement terminate upon transfer of the Party's interest in the Conservation Easement or Easement Area, except that liability for acts, omissions, or breaches occurring prior to transfer shall survive transfer.

(i) Captions. The captions in this instrument have been inserted solely for convenience of reference and are not a part of this instrument and shall have no effect upon its construction or interpretation.

(j) No Hazardous Materials Liability.

(1) Except as disclosed in any Phase 1 report provided to Grantee prior to the recordation of this Conservation Easement, Grantor represents and warrants to Grantee, USFWS, DOFAW, and KIUC that it has no knowledge or notice of any Hazardous Materials (defined below) or underground storage tanks existing, generated, treated, stored, used, released, disposed of, deposited or abandoned in, on, under, or from the Easement Area, or transported to or from or affecting the Easement Area.

(2) Without limiting the obligations of Grantor under Section 17 of this Conservation Easement, Grantor hereby releases and agrees to indemnify, protect and hold harmless Grantee's Indemnified Parties and Other Indemnified Parties (each as defined in Section 17) from and against any and all Claims (as defined in Section 17) arising from or connected with any Hazardous Materials or underground storage tanks present, alleged to be present, released in, from, or about, or otherwise associated with the Easement Area at any time, except that this release and indemnification shall be inapplicable to the Grantee's Indemnified Parties or Other Indemnified Parties with respect to any Hazardous Materials placed, disposed, or released by Grantee's Indemnified Parties or Other Indemnified Parties. This release and indemnification includes, without limitation, Claims for (a) injury to or death of any person or physical damage to any property; and (b) the violation or alleged violation of, or other failure to comply with, any Environmental Laws (defined below). If any action or proceeding is brought against any of Grantee's Indemnified Parties or Other Indemnified Parties by reason of any such Claim, Grantor shall, at the election of and upon written notice from the Grantee Indemnified Party or Other Indemnified Party, defend such action or proceeding by counsel reasonably acceptable to the Grantee Indemnified Party or Other Indemnified Party or reimburse the Grantee Indemnified Party or Other Indemnified Party for all charges incurred for legal services in defending the action or proceeding.

(3) Despite any contrary provision of this Conservation Easement, the Parties do not intend this Conservation Easement to be, and this Conservation Easement shall not be, construed such that it creates in or gives to Grantee, USFWS, DOFAW, or KIUC any of the following:

(A) The obligations or liability of an "owner" or "operator," as those terms are defined and used in Environmental Laws (defined below), including, without limitation, the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended (42 U.S.C. § 9601 *et seq*.; hereinafter, "CERCLA"); or

(B) The obligations or liabilities of a person described in 42 U.S.C. § 9607(a)(3) or (4); or

(C) The obligations of a responsible person under any applicable Environmental Laws; or

(D) The right or duty to investigate and remediate any Hazardous Materials associated with the Property; or

(E) Any control over Grantor's ability to investigate, remove, remediate or otherwise clean up any Hazardous Materials associated with the Property.

(4) The term "Hazardous Materials" includes, without limitation, (a) material that is flammable, explosive or radioactive; (b) petroleum products, including by-products and fractions thereof; and (c) hazardous materials, hazardous wastes, hazardous or toxic substances, or related materials defined in CERCLA, the Resource Conservation and Recovery Act of 1976 (42 U.S.C. § 6901 et seq.; hereinafter "RCRA"); the Hazardous Materials Transportation Act (49 U.S.C. § 5101 et seq.; hereinafter "HTA"); Chapter 342J, HRS, governing hazardous waste management (hereinafter "HWM") and in the regulations adopted and publications promulgated pursuant to them, or any other applicable Environmental Laws now in effect or enacted after the date of this Conservation Easement.

(5) The term "Environmental Laws" includes, without limitation, CERCLA, RCRA, HTA, HWM, and any other federal, state, local or administrative agency statute, code, ordinance, rule, regulation, order or requirement relating to pollution, protection of human health or safety, the environment or Hazardous Materials. Grantor represents, warrants and covenants to Grantee, USFWS, and DOFAW that activities upon and use of the Easement Area by Grantor, its agents, employees, invitees and contractors will comply with all Environmental Laws. Grantee represents, warrants and covenants to Grantor, USFWS, and DOFAW that activities upon and use of the Easement Area by Grantee, its agents, employees, invitees and contractors will comply with all Environmental Laws.

(k) Warranty. Grantor represents and warrants that Grantor is the sole owner of fee simple title to the Easement Area; that the Easement Area is not subject to any other conservation easement; and that there are no outstanding mortgages, liens, encumbrances or other interests in the Easement Area that may conflict or are otherwise inconsistent with this Conservation Easement and which have not been expressly subordinated to this Conservation Easement by a written, recorded Subordination Agreement approved by KIUC and Grantee, USFWS, and DOFAW. The Easement Area is in compliance with all federal, state, and local laws, regulations, and requirements applicable to the Easement Area and its use. There is no pending or threatened litigation affecting the Easement Area or any portion of the Easement Area that may materially impair the Conservation Purpose.

(l) Additional Easements. Grantor shall not grant any additional easements, rights of way, or other interests in the Easement Area (other than a security interest that is expressly subordinated to this Conservation Easement), or grant, transfer, abandon, or relinquish any, air, or water right, or any water associated with the Property.

(m) Recording. Grantee shall record this Conservation Easement, together all exhibit and attachments hereto, in the Bureau and may re-record it at any time as Grantee deems necessary to preserve its rights in this Conservation Easement.

(n) Interpretation. In interpreting this Conservation Easement and exhibits hereto, any provisions which are alleged to be ambiguous shall not be construed against the drafter. The Parties intend that this Conservation Easement be interpreted in a manner consistent with the Conservation Purpose. In the unlikely event of a conflict between the primary purpose of Listed Seabird conservation and the Conservation Purpose, the Conservation Easement and associated documents will be interpreted to promote Listed Seabird conservation to the extent permissible by law. The captions in this instrument have been inserted solely for convenience and ease of reference and are not a part of this instrument and shall have no effect upon construction or interpretation.

(o) Counterparts. The Parties may execute this instrument in two or more counterparts, which shall, in the aggregate, be signed by both Parties; each counterpart shall be deemed an original instrument as against any party who has signed it. In the event of any disparity between the counterparts produced, the recorded counterpart shall be controlling.

IN WITNESS WHEREOF, the Parties have executed this Conservation Easement as of the day and year first set forth above.

GRANTOR:

____

RICHARD BERRY

Date: ___________________________

GRANTEE:

[NAME],
a Hawai‘i nonprofit corporation

By: _______________________________
Name:_____________________________
Title: ______________________________

Date: _____________________________

STATE OF ________________)
) ss.
COUNTY OF ______________)

On _______________________, 20___, before me,_________________________, a Notary Public in and for the State of _______________, personally appeared ____, personally known to me (or proved to me on the basis of satisfactory evidence) to be the person whose name is subscribed to the within instrument and acknowledged to me that he/she executed the same in his/her authorized capacity, and that by his/her signature on the instrument, the person, or the entity upon behalf of which the person acted, executed the instrument.

WITNESS my hand and official seal.

____
Notary Public in and for the State of _________________

(SEAL)

STATE OF HAWAIʻI)
) ss.
CITY AND COUNTY OF HONOLULU)

On this day, ________________, before me personally appeared ____________________, to me known to be the persons described in and who executed the foregoing ___-page instrument, dated _______________, and acknowledged that they executed the same as their free act and deed, First Circuit of the State of Hawaiʻi.

Witness my hand and official seal.

____
Name: ____________________________
Notary Public, State of Hawaiʻi

My commission expires: ______________

Date of Doc: ______________________	# Pages: __________
Name of Notary: ______________________	__________ Circuit
Doc. Description: ______________________	
______________________	(stamp or seal)
______________________	
______________________	
Notary Signature Date	
NOTARY CERTIFICATION	

EXHIBIT A

LEGAL DESCRIPTION OF PROPERTY

<u>EXHIBIT B</u>

SITE MAP

EXHIBIT C

EASEMENT AREA

EXHIBIT D

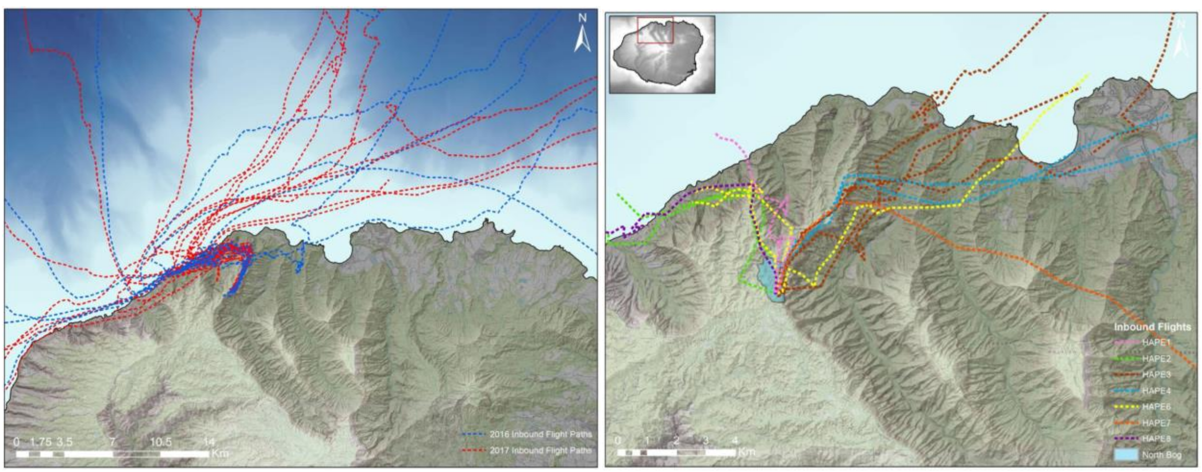
SITE MANAGEMENT PLAN

Appendix 5A

Variables Influencing Powerline Strikes

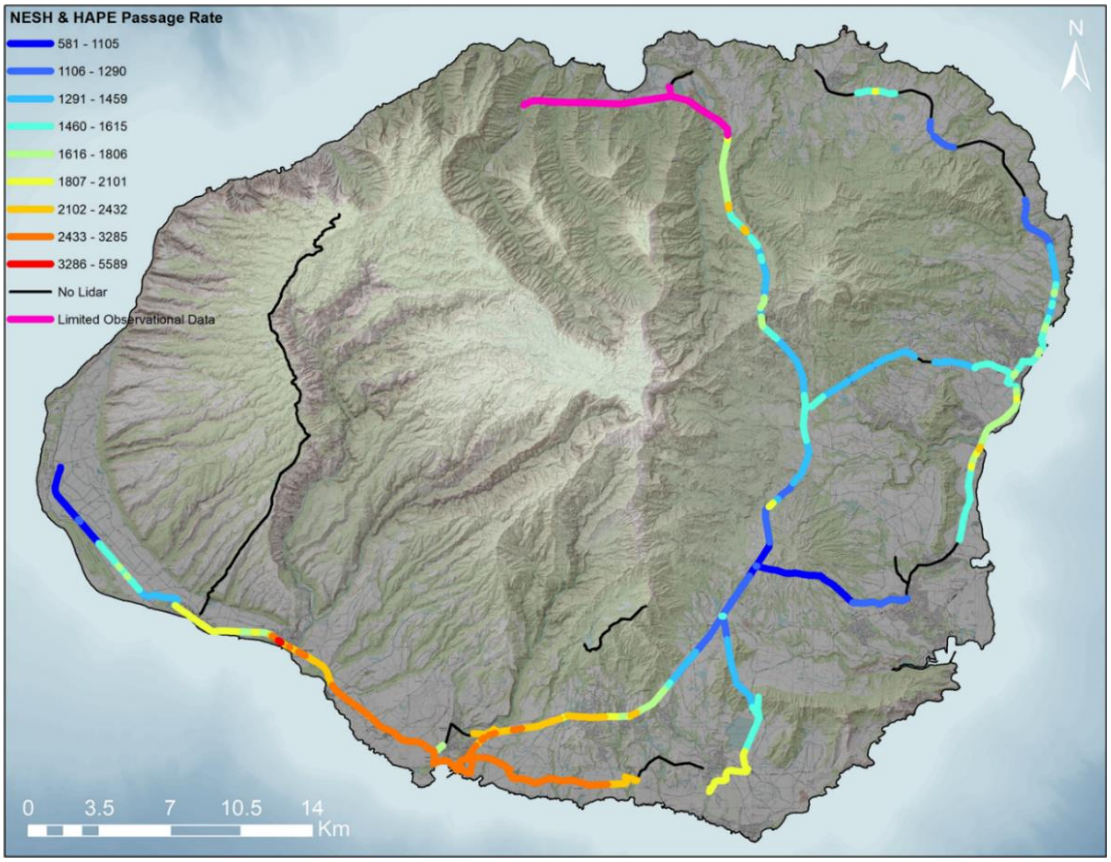
5A.1 Powerline Location

Seabirds in the colonies in the northwestern portion of Kauaʻi are thought to be relatively safe from powerline collisions because there is a lack of powerlines in that part of Kauaʻi. Recent tracking data are consistent with this assumption; most observed flight paths from colonies take relatively direct routes to and from sea that do not cross powerlines in other parts of Kauaʻi (Figure 5A-1; Raine et al. 2017). However, during the tracking study, an adult Hawaiian petrel (ʻuaʻu) breeding in North Bog was tracked crossing over the interior of Kauaʻi from the ocean back to its colony, making multiple crossings while en route of the powerlines along one of the highest collision hot spots on Kauaʻi on the Powerline Trail (Raine et al. 2017). It is not clear if this is a regular route for this bird since only one inbound route was collected, but it does indicate that some seabirds from colonies in the northwestern portion of Kauaʻi may also be at risk from powerline collisions (Figure 5A-1 lower right map; Raine et al. 2017). The tracking data indicate, therefore, that the risk of powerline collision mortalities for breeding colonies in northwestern Kauaʻi is relatively low, but not zero. Figures 5A-2 and 5A-3 show the combined passage rates and annual strikes rates for Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu) in the Plan Area, respectively. The results clearly show that birds in relatively safe areas such as the northwest of Kauaʻi may still have some risk of powerline collision.



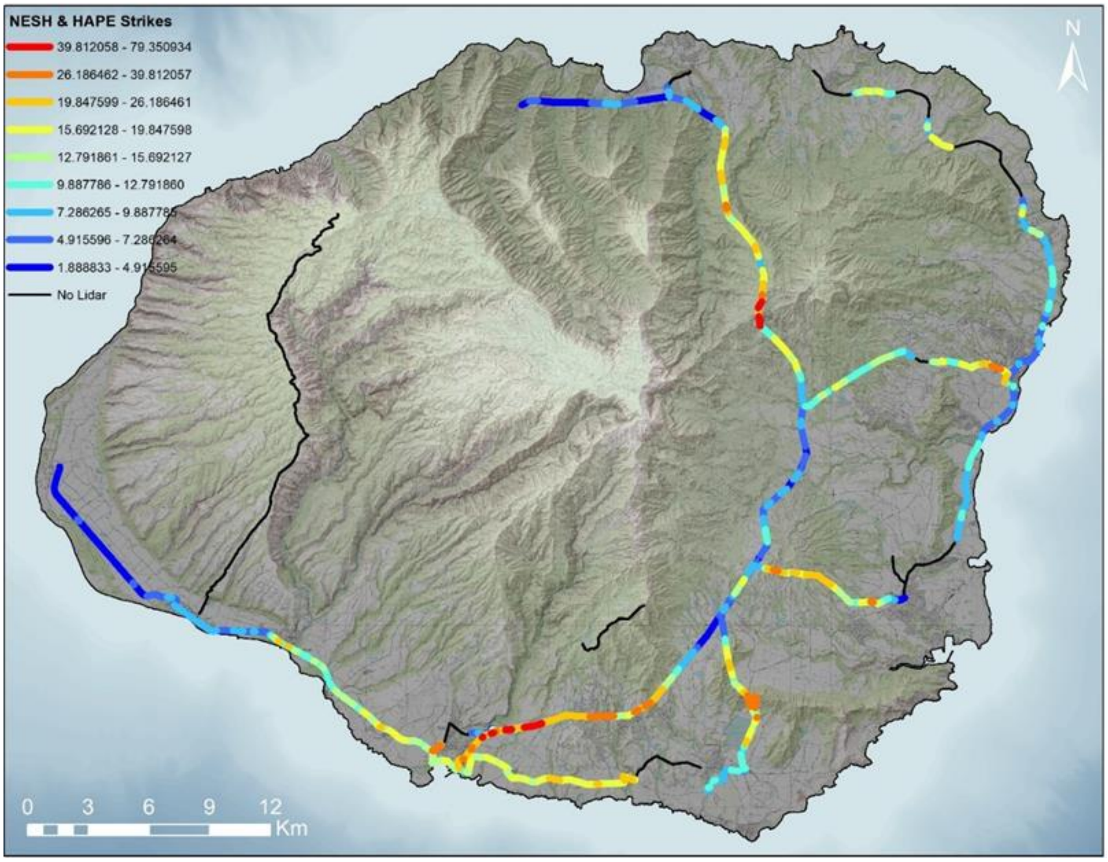
Source: Raine et al. 2017

Figure 5A-1. All recorded tracks recorded in 2016 and 2017 for Newell's shearwater (ʻaʻo) (left two maps) and Hawaiian petrel (ʻuaʻu) (right two maps). Outbound tracks are shown in the top two maps and inbound tracks are shown in the bottom two maps. Inbound tracks for Hawaiian petrel (ʻuaʻu) are only from 2017; no inbound tracks were recorded for this species in 2016.



Source: Travers et al. 2019

Figure 5A-2. Combined Passage Rates for Newell's Shearwaters ('a'o) (NESH) and Hawaiian Petrels ('ua'u) (HAPE) for Monitored Powerlines for One Season



Source: Travers et al. 2019

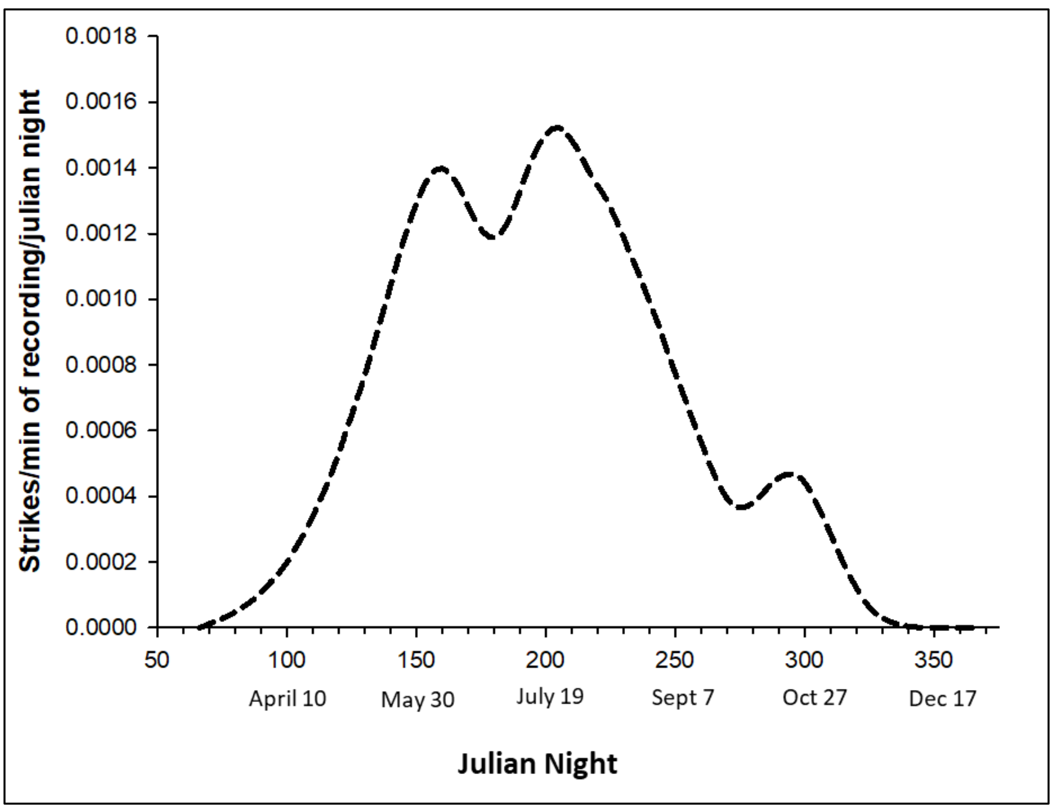
Figure 5A-3. Annual Estimated Strike Rates of Newell's Shearwaters (ʻaʻo) (NESH) and Hawaiian Petrels (ʻuaʻu) (HAPE) Colliding with Monitored Powerlines

5A.2 Seasonality

Powerline collisions occur annually in conjunction with the covered seabird breeding season and times of transition between breeding colonies and the sea. Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu) are at risk of powerline collisions from March to the end of December (Travers et al. 2018). This time period coincides with the Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) breeding season. The majority of powerline collisions occur from April to the end of November (Travers et al. 2018).

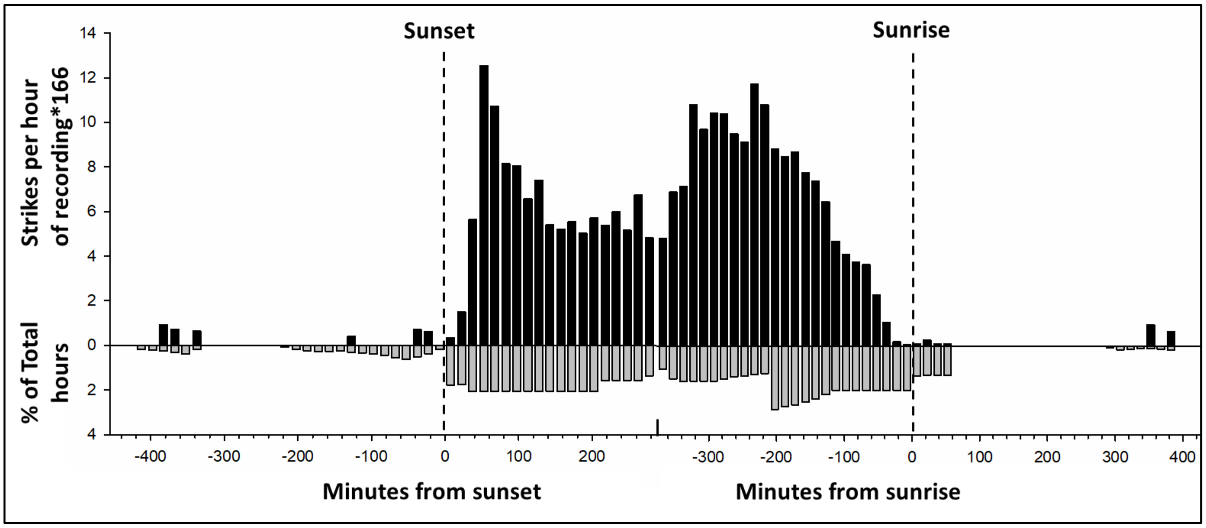
The amount of powerline collisions fluctuates throughout the breeding season. As seabirds return to their breeding grounds in March, detection of powerline collisions commences. Powerline detections fluctuate throughout the various stages of the breeding season, which on Kauaʻi is as follows; arrival (mid-April), exodus (May), incubation (May–mid July), chick rearing (late July–September), fledging (late September–mid-November for Newell's shearwaters [ʻaʻo] and November–mid-December for Hawaiian petrels [ʻuaʻu]), and ends when seabirds have left for the winter (Raine et al. 2019; Travers et al. 2014, 2019). Figure 5A-4 shows the distribution of powerline strike detection rates in relation to the time of year, with a peak during the middle of the Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) breeding season (as described above). Thus, detection rates of powerline collisions begin to increase as Newell's shearwaters (ʻaʻo) and Hawaiian petrels ('ua'u) arrive at the breeding colonies, peak in the middle of the seabird breeding season, and then decline to zero after chicks have fledged and seabirds have left for the winter (Travers et al. 2019).

Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) movement between breeding colonies and the sea takes place during crepuscular periods (sunset to sunrise) and full darkness (Travers et al. 2019). Based on acoustic monitoring of powerline strikes and observations of the covered seabirds at monitored powerline spans, the pattern of collisions corresponds to the daily movement of Newell's shearwaters ('a'o) and Hawaiian petrels ('ua'u). As seen in Figure 5A-5, strike detections start to increase when seabirds transit powerlines during crepuscular periods and reach their high point during the peak movement of seabirds, which occurs during full darkness (Travers et al. 2019). Visual observations and monitoring of burrows with cameras have observed movement patterns of Newell's shearwaters ('a'o) and Hawaiian petrels ('ua'u) to and from breeding colonies on Kaua'i. Breeding adult Newell's shearwater ('a'o) movement is primarily restricted to near crepuscular periods, while Hawaiian petrels ('ua'u) arrive and depart throughout the night (Travers et al. 2017). Newell's shearwaters ('a'o) have been estimated to account for approximately 70 percent of powerline passages, compared to 30 percent of Hawaiian petrel ('ua'u) (Travers et al. 2020). This observed proportion is a function of the increased frequency with which Newell's shearwaters ('a'o) visit their burrows compared to Hawaiian petrels ('ua'u), as well as the portion of the night during which monitoring occurred (Travers et al. 2019).



Source: Travers et al. 2019

Figure 5A-4. Seasonal Pattern of Acoustically Detected Nocturnal Powerline Strike Sounds



Source: Travers et al. 2019

Figure 5A-5. Timing of Powerline Strikes Acoustically Detected Throughout a 24-hour Period Based Upon Information Collected from 2013 to 2017

5A.3 Topography

Topography surrounding powerlines varies and may increase or decrease powerline collision risks. For example, powerlines strung across valleys increase their aboveground height. Though power poles are 75 feet (ft) (23 meters [m]) tall, placing these poles up a valley can result in powerlines 279 ft (85 m) above the ground, in the middle of seabird flight heights (Travers et al. 2019). Additionally, ridgelines above deep valleys can cause birds to fly very low as they come up and over the ridges, increasing the risk of seabirds colliding with powerlines located at ridgelines.

5A.4 Vegetation Height

The height of vegetation surrounding powerlines may increase or decrease seabird powerline collision risks. For example, trees taller than the powerlines force birds to fly over the powerlines (Travers et al. 2019), thereby reducing the risk of collision. If trees are lower than the powerlines, the lines are exposed to birds flying at the height of those wires, thereby potentially exposing them to risk of collision. For vegetation to result in an entire powerline span having zero risk of a bird collision, tall trees must shield the full length of the span to prevent a seabird from flying at the height of the wires. If there are any gaps in the tree line that expose a portion of the powerline, seabirds may fly lower and thus be exposed to the space occupied by the powerlines (Travers et al. 2019). This applies to areas where birds are flying to or from colonies. If powerlines are strung up through colonies, tree cover will not necessarily reduce collisions because birds may be flying through the trees to land at their burrows.

5A.5 Wires

Wire height and covered seabird flight height can affect the potential for a powerline collision. Wires that are taller (higher above ground) are more likely to be positioned within the bird flight height distribution (Travers et al. 2019). Therefore, within a wire array, the top wire has greater risk than the second highest wires, and the second wire has greater risk than the third wire. This factor is important for minimization planning.

The height of a powerline depends, in part, on the type of powerline: static wire, transmission line, distribution line, or communication line. Figure 2-2a and 2-2b in Chapter 2, *Covered Activities*, displays the major wire types and their relative positions on the pole. Sometimes in place of a standard static wire, there is a fiber-optic cable. Fiber-optic cable is important to identify and map because, unlike standard static wires, fiber-optic cable does not produce a strike sound when hit (Travers et al. 2014). The covered bird species may collide with any of these lines.

Wire configuration influences collision risk. For example, vertically arrayed wires have greater risk than if those same wires were constructed horizontally because the vertical array takes up more physical airspace in which birds transit, increasing the probability that birds will be flying at wire height.

Wire thickness can affect the wire's visibility to a bird transiting the area, as well as the rate of mortality if struck. Bundling wires or using thicker wires are potential minimization tools, but it is not clear what effect this would have on reducing powerline collisions (i.e., birds may see thicker wires better and thus would be more likely to avoid them, or depending on the array, bundled wires could increase collisions because it reduces the chance of avoidance) (Raine in litt.). Using insulated wires does, however, allow the wires to be lowered closer to the ground (because they have different regulations than uninsulated wires), which in many scenarios would reduce collision risk.

The greater the number of wires the more objects that occur in the birds' flight path, thereby increasing the risk of a seabird colliding with a powerline.

5A.6 Seabird Flight Height

For the tracking study done on Kauaʻi by Raine et al. (2017), described above, regarding the flight height of these species to and from two colonies in the northwest portion of the island, birds were outfitted with global positioning system (GPS) tracking tags, which recorded the location, height, distance, and speed at they traveled. A GPS-tagged Hawaiian petrel (ʻuaʻu) was recorded crossing powerlines multiple times at low altitude, in a known high-strike area along the Powerline Trail (Raine et al. 2017). For Newell's shearwaters (ʻaʻo) flying from their breeding colonies out to sea, birds flew high as they left the colony until they reached the sea. When coming in from the sea to the breeding colony, birds flew low over the sea until turning inland, then increased sharply in altitude and departed from sea level about 0.6 mile (mi) (1 kilometer [km]) from the coast. When flying from their breeding colony out to sea, Hawaiian petrels (ʻuaʻu) flew high, gradually losing height and reaching sea level about 4.5 mi (7.3 km) from the coast. As they returned from the sea to their breeding colony, they flew low over the sea until approaching land and then increased sharply in altitude, departing sea level 2.5 mi (4.1 km) from the coast.

5A.7 Flight Speed and Maneuverability

Flight speed of the covered seabirds at powerlines is a function of bird direction (inland or seaward) and flight direction relative to wind direction and speed. Radar studies at powerlines indicated that seabirds transit at rates of 30 km/hour (18.6 mi/hour) to 100 km/hr (62.1 mi/hour) (Travers et al. 2014). The information herein is based on limited data available regarding movement patterns of

Newell’s shearwaters (‘a‘o) and Hawaiian petrels (‘ua‘u) from a study by Raine et al. (2017), including flight speed of these species to and from two colonies in the northwest portion of Kaua‘i.

Table 5A-1 provides the average speed of each species as it flew over land and water on the way from its breeding colony to sea and from sea back to its breeding colony (Raine et al. 2017). The speed at which seabirds fly puts them at an increased likelihood of collision with powerlines. An observed trend is that Hawaiian petrels (‘ua‘u) have a higher avoidance of powerline collisions, likely due to their increased flight maneuverability and sometimes slower flight speed than Newell’s shearwaters (‘a‘o) (Travers et al. 2018).

Table 5A-1. Average speed of Newell’s shearwater (‘a‘o) and Hawaiian petrel (‘ua‘u) as it flies over land and water from its breeding colonies to the sea and from the sea to its breeding colonies.

	Outbound (breeding colony to sea)	Inbound (sea to breeding colony)
Newell’s shearwater (‘a‘o)		
Land	42.9 km/hr	35.7 km/hr
Water	56.6 km/hr	42.4 km/hr
Hawaiian petrel (‘ua‘u)		
Land	51 km/hr	34 km/hr
Water	61.4 km/hr	27.3 km/hr

Hawaiian petrels have increased flight maneuverability due to lower wing loading (weight to wing surface area ratio) and in some instances a slower flight speed than the Newell’s shearwater (‘a‘o) (Travers et al. 2018). Direct observations of powerline interactions show that Hawaiian petrels (‘ua‘u) are better able to make large correcting maneuvers such as stalling or flaring upwards to avoid powerlines, when the wires are detected. Newell’s shearwaters (‘a‘o) struggle to make large correcting maneuvers unless flying with a steady head wind (Travers et al. 2018).

5A.8 Flight Path

The flight path of seabirds varies by the side of island and inland and seaward directions of flight as well as other factors such as wind direction and speed. For example, for inland flights seabirds on the north, east, and south to southwest shores of the island tend to take a direct flight path (Travers et al. 2019). Seabirds breeding in the Nā Pali, Waimea Canyon, and Makaweli/Olokele drainages use the lee of the island to gain elevation using calm areas or the wind that circles inland and upslope (Travers et al. 2019). Flight paths that result in lower aboveground flight height increase powerline collision risk. For example, when a flight path forces them to fly into a strong head wind, the birds fly lower. This occurs typically on the seaward flight on the east side of the island and on the inland flight on the south/west side of the island.

5A.9 Wind- and Weather-Related Factors

Seabird flight heights and flight path are influenced by wind and topography (Travers et al. 2019). Seabirds flying into a headwind fly slower and have greater lift and maneuverability, but it also causes seabirds to fly lower increasing the likelihood of flying at wire height (Travers et al. 2018). Seabirds flying with a tailwind fly higher (Travers et al. 2019) and have less maneuverability and less ability to gain elevation (Travers et al. 2013). Thereby, a seabird flying with a tailwind may fly over land at greater altitudes to avoid obstacles (Travers et al. 2013). Typically, the wind is light to moderate from the northeast direction in the summer (Travers et al. 2018), which is the peak breeding season for Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu). This results in varied flight directions relative to wind for the north/east, south/west, and Nā Pali Coast, further resulting in varied flight height and behaviors in these three large regions.

Heavy mist or rain may obscure powerlines from flying birds, reducing the bird's ability to detect them, and increasing the risk of collision with powerlines.

5A.10 References

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Appendix 5B

Light Attraction Modeling for Covered Seabirds

5B.1 Introduction

5B.1.1 Purpose

The purpose of this document is to describe the process for quantifying take of the covered seabirds, Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu), and band-rumped storm-petrel (ʻakēʻakē), on Kauaʻi resulting from attraction to Kauaʻi Island Utility Cooperative (KIUC) streetlights and facility lights for the KIUC Habitat Conservation Plan (HCP). The methods to quantify take resulting from KIUC streetlights are different from the methods used to quantify take resulting from lights associated with KIUC facilities. The methods and outcomes for both types of lights are discussed in this appendix.

5B.1.2 Mechanism of Take

Artificial lighting can attract various species in the family *Procellaridae*, including the covered seabirds. When fledglings leave their nest for the first time in the hours following sunset, they have the propensity to become attracted to artificial lights. After flying around the lights, birds attracted to artificial light can tire or inadvertently hit a structure and may become grounded, an event referred to as *fallout* (Imber 1975; Telfer et al. 1985). If the light-attracted individuals that become grounded are not rescued, they are at risk for succumbing to injury or mortality due to starvation, predation, collisions with cars, or a combination thereof. This attraction often occurs after young fledglings reach the ocean and are then attracted inland by coastal lights, which explains why they are frequently grounded in coastal areas that are quite distant from their colony (Troy et al. 2013; Rodríguez et al. 2015). There is also a potential for attraction to occur on their outbound journey prior to reaching the ocean (Troy et al. 2013). In uncommon events, adults can also exhibit light attraction (Center for Biological Diversity 2016).

Despite lacking knowledge of the exact mechanism causing attraction, it is understood that observed patterns of fallout on Kauaʻi are complex and result from various independent conditions (Troy et al. 2013). The primary source of attraction is bright lights; An early study on Kauaʻi showed that the shielding of bright lights can reduce fallout by 40 percent (Reed et al. 1985), and recent studies continue to indicate that the reduction of lateral light spillage is beneficial to reducing light-induced fallout (Rodríguez et al. 2017a, 2017b). While efforts to shield lights can effectively reduce fallout, these efforts do not appear to eliminate it. Several studies have shown that fallout patterns are also influenced by the location and brightness of artificial lights relative to seabird colonies, the proximity of lights to the coastline, and the wavelengths emitted by different light types (Troy et al. 2011, 2013; Rodrigues et al. 2012; Rodríguez et al. 2015, 2017a, 2017b, 2017c; Longcore et al. 2018).

5B.1.2.1 Streetlights

KIUC owns and operates approximately 4,100 streetlights located along roadways and in residential developments, primarily along the developed southern, eastern, and northern perimeter of Kauaʻi up to 5 miles (8.1 kilometers) inland and generally coinciding with urban centers and residential areas. KIUC streetlights are 3000K light-emitting diode (LED) bulbs that have been retrofitted with full-cutoff luminaries to minimize lateral light spillage (Kauaʻi Island Utility Cooperative 2017). It is estimated that an additional 1,754 streetlights will be installed in the Plan Area over the 50-year permit term.

5B.1.2.2 Facility Lights

KIUC owns and operates only two facilities which maintain nighttime lights for safety and visibility; the Port Allen Generating Station and the Kapaia Generating Station. Due to the location of Port Allen Generating Station along the southern coastline of Kaua'i, the risk of grounding is greater than at Kapaia Generating Station, which is located 2.2 miles (3.5 kilometers) inland from the nearest coastline. At the Port Allen Generating Station, KIUC installed green LED 41- and 90-watt lights (Kaua'i Island Utility Cooperative 2017). Before the fallout season in 2019, dimming capabilities were also enabled on these facility lights (Kaua'i Island Utility Cooperative 2019). Based on the significantly reduced number of birds found at the Port Allen Generating Station and Kapaia Generating Station in 2019 and 2020 relative to previous years at KIUC facilities, dimming the lights appears to have minimized light attraction.

Nighttime Lighting for Repairs

Any potential impacts related to nighttime lighting used for KIUC facility repairs are addressed in Chapter 5, *Effects*, but are not discussed in this appendix since they did not require any modeling. See Chapter 5, *Effects*, for the assessments of nighttime light for repairs and the associated take estimate.

5B.2 Assessment of Fallout from Streetlights

5B.2.1 Existing Streetlights

The streetlight assessment used a novel approach, developed in collaboration with the U.S. Fish and Wildlife Service, to assign fallout documented by the Save our Shearwater (SOS) Program to streetlights based on the proportional contribution of those lights to the lightscape of Kaua'i (Figure 1). This proportional assessment was developed using remotely sensed radiance, often casually called "brightness", collected by a sensor that is designed to provide global measurement of the intensity of nocturnal visible and near-infrared light on a daily basis (Cao et al. 2017); measurements of radiance made by this sensor were in units of nanowatts per square-centimeter per steradian. The process used to estimate fallout due to streetlights included the following steps:

- Partition all data associated with this assessment according to the existing spatially explicit SOS sectors that encompass all areas of the island with streetlights (Section 5B.2.1.1, *Partitioning Data by Sector*).
- Assess island-wide satellite data of the lightscape on Kaua'i (Section 5B.2.1.2, *Assessing the Lightscape on Kaua'i*).
- Estimate the radiance generated by a single streetlight (Section 5B.2.1.3, *Estimating the Radiance Generated by a Single Streetlight*).
- Estimate the proportional contribution of streetlights to radiance by sector (Section 5B.2.1.4 *Estimating the Proportional Contribution of Streetlights to Radiance by Sector*).

- Derive an estimate of fallout occurring due to streetlights in each sector (Section 5B.2.1.5, *Uncorrected Fallout Estimate for Streetlights*).
- Apply a correction factor to account for seabirds that were grounded but not detected (Section 5B.2.1.6, *Detectability Correction Factor for Streetlight Fallout*).

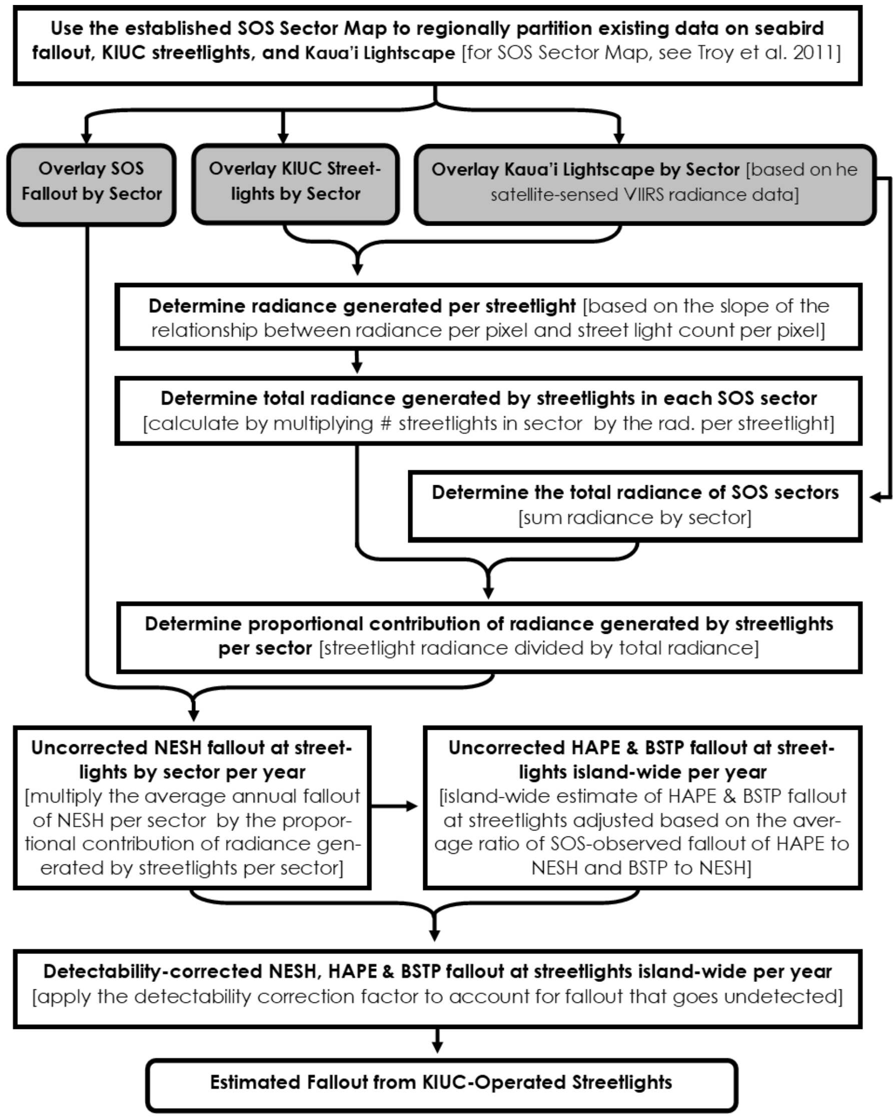

Figure 1. Conceptual schematic of the approach used to determine the proportional contribution of KIUC streetlights to the radiance of Kauaʻi on a regional basis as a proxy for the proportion of annual seabird fallout resulting from these streetlights.

The assessment included 641 SOS database records of grounded hatch-year and unknown age Newell's shearwaters (ʻaʻo) documented from September 1 to December 31 of each year from 2015 to 2019. This assessment conservatively included all reported fallout regardless of the source of the light attraction.[1] Ideally, all birds that could not be assigned to a specific, non-streetlight light source would have been removed from this analysis. However, the radiance associated with these non-streetlight light sources could not be partitioned out of the Visible Infrared Imaging Radiometer Suite (VIIRS) radiance measures due to the coarse resolution of these data (discussed in Section 5B.2.1.2, *Assessing the Lightscape on Kaua'i*) and, therefore, it was mathematically inappropriate to remove birds without also removing the corresponding radiance.

5B.2.1.1 Partitioning Data by Sector

All streetlights, lightscape, and fallout data used for this assessment were partitioned according to SOS sector (Figure 2) (SOS Program unpublished data, as described by Troy et al. 2013). There are 35 sectors[2] that vary in size, ranging from 1,237 to 98,926 square kilometers, and cover developed areas as well as areas with no development and no artificial lighting. The benefits of partitioning fallout, lightscape, and streetlight data by SOS sector is that these sectors have been used since the 1990s to understand long-term patterns of fallout across Kaua'i (Troy et al. 2011, 2013), and partitioning data by SOS sector enables this assessment to account for spatial heterogeneity of fallout across the Plan Area.

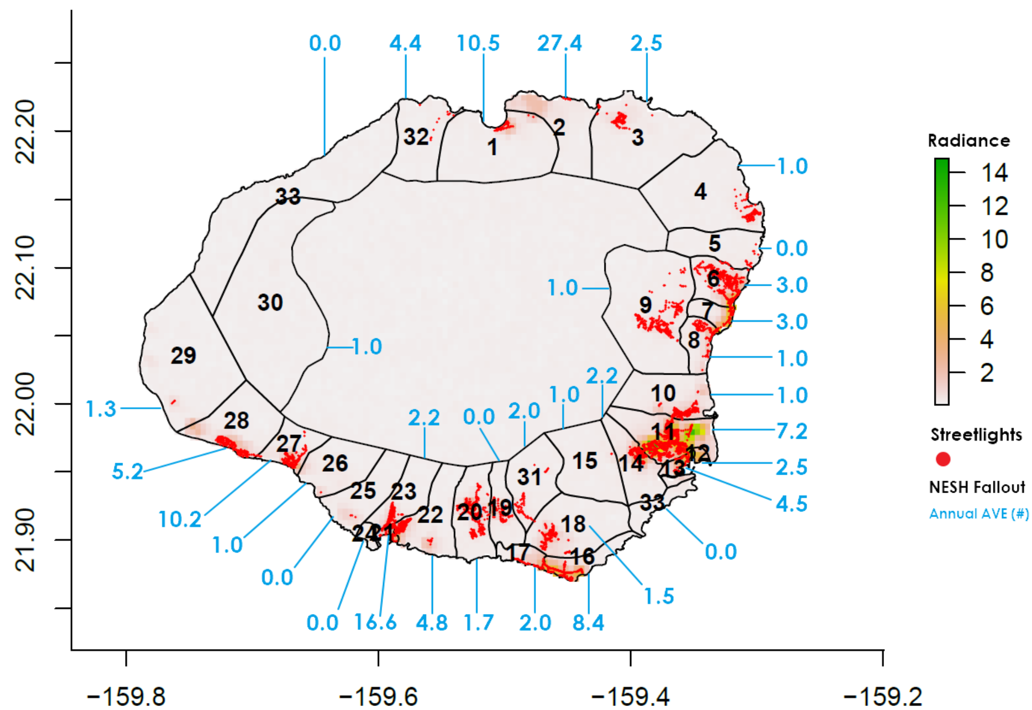

Figure 2. SOS sectors (delineated with black outlines and identified with black numbers) and the annual average (AVE) fallout of Newell's shearwater ('a'o) reported by SOS over the previous 5 years (blue numbers) with the radiance and streetlights across the Plan Area. The radiance data was derived from October 2018 measurements.

[1] Over half of the 641 Newell's shearwater ('a'o) fallout records in the SOS database could be assigned to non-streetlight sources (e.g., KIUC facility lights, fallout claimed by participants in the Kaua'i Seabird Habitat Conservation Plan, and other lights) (DOFAW 2020).

[2] A sector is a geographic area varying in size.

5B.2.1.2 Assessing the Lightscape on Kauaʻi

The lightscape of Kauaʻi was assessed using radiance data collected via satellite, which is the only data available at an island-wide scale. Globally, radiance produced by lights at night have been remotely sensed on a daily basis by the Day-Night Band (DNB) sensor on the VIIRS installed on the Suomi National Polar-Orbiting Partnership Satellite (Cao and Bai 2014). The DNB sensor is one of 23 sensors on the VIIRS. The purpose of the DNB sensor is to measure radiance (nanowatt [nW] per square centimeters [cm^2] per steradian [sr]) from as low as a quarter moon illumination to the brightest daylight in the 0.5 to 0.9 micrometer range of the electromagnetic spectrum (Cao and Bai 2014). For this assessment, both the October and November[3] 2018 stray-light corrected composite maps of Kauaʻi's radiance were used. These maps were compiled by the National Oceanic and Atmospheric Administration's (NOAA) Earth Observation Group (2020), and provided by NOAA's National Center for Environmental Information (2018a, 2018b).

The resolution of radiance measures derived from the DNB were much lower than what would be needed to directly measure the contribution of a single streetlight. The on-board aggregation scheme allows the DNB sensor to maintain a nearly constant 0.46-mile (742-meter) resolution over the entire 186-mile (300-kilometer) sampling swath for raw images (Cao and Bai 2014; Cao et al. 2017) and NOAA's National Geophysical Data Center's Earth Observation Group uses these raw images to make monthly composites of radiance data. Due to the way the daily images are gridded using a 15 arc-second resolution, these monthly composites have greater resolution than can be measured by the DNB sensor (on the order of 430 by 460 meters [hereafter, pixel] at the latitude of Kauaʻi) (Baugh et al. 2013). While this is an improvement in resolution from the DNB radiance measurements, monthly composites of radiance data are still too coarse to estimate the radiance generated by a single streetlight (e.g., a single radiance pixel can contain as many as 41 KIUC streetlights as well as numerous other light sources that inflate and/or mask the actual radiance emitted by the streetlights). Therefore, since it is not possible to directly measure the radiance generated by a single streetlight, the contribution of streetlights to radiance has been inferred by relating the degree to which radiance increased as a function of increased counts of streetlights per pixel using methods described in Section 5B.2.1.3, *Estimating the Radiance Generated by a Single Streetlight*.

5B.2.1.3 Estimating the Radiance Generated by a Single Streetlight

To estimate the contribution of streetlights to radiance, a regression was used to describe the degree to which radiance increased as a function of increasing numbers of streetlights per pixel. Because the light generated by streetlights is difficult to separately identify when contributing to light associated with commercial and urban centers, using all radiance data in the Plan Area would not provide a meaningful estimate of the relationship between streetlights and radiance. Thus, it was necessary to restrict the data to include only the minimum radiance per streetlight count, as these darker pixels were more likely to represent areas where the light generated only by streetlights and not additional lights associated with commercial areas and urban centers. The approach to estimate the radiance generated by a single streetlight included the following steps:

- Isolate the radiance data needed to assess how radiance per pixel varied as a function of streetlight count (see *Radiance Data Subset*).

[3] Over the last 5 years (2015-2019), 72 percent of the fallout on Kauaʻi happened during the months of October and November, with 41.2 percent occurring in October and 30.8 percent occurring in November.

- Produce a probabilistic estimate of radiance generated per streetlight that incorporates uncertainty into the estimate of slope (see *Radiance Generated per Streetlight*).
- Extrapolate the proportional contribution of streetlights to total radiance by sector (Section 5B.2.1.4, *Estimating the Proportional Contribution of Streetlights to Radiance by Sector*).

Radiance Data Subset

Visualizing the radiance for all pixels on Kauaʻi in October (Figure 3A) and November (Figure 3B) as a function of streetlight count per pixel showed that there were many situations where the radiance of a particular pixel was unrelated to the radiance produced by streetlights. For example, in areas where there were no streetlights (streetlight count equal to zero), non-streetlight lights present in those pixels produced large radiance measures. Including radiance measures from pixels where streetlights were not present would not facilitate estimation of radiance added by streetlights. Furthermore, for pixels with the same streetlight count, the range of associated radiance per pixel varied from relatively dark to very bright; these bright pixels were associated with commercial areas that had lights that produced more radiance than streetlights, and thus masked the streetlight signal. Because of this, inclusion of radiance measures from all pixels with streetlights would have inappropriately introduced measures of various confounding light sources that mask the streetlight signal. Thus, to isolate the streetlight signal for individual streetlight radiance, the data used for this assessment was restricted to consider only the darker rural or residential areas (i.e., locations where there are relatively few non-streetlight light sources).

Assumptions were made to isolate pixels that could inform an estimate of the radiance added by streetlights. A single datapoint, the pixel with the lowest radiance, was selected for each category of streetlight count (Figure 4). For each streetlight count, the pixel with the lowest radiance was assumed to be derived from an area where there was minimal presence of non-streetlight light sources, thus there was minimal masking of the streetlight signal by other lights.

When looking at the minimum radiance for each streetlight count, there was a strong and consistent linear pattern between radiance added per increase in streetlight count (Figure 4). Notably, this strong and consistent relationship was evident for lower streetlight counts but appeared to breakdown once the count of streetlights exceeded 21 streetlights per pixel (Figure 4); this pattern was similar in both October (Figure 4A) and November (Figure 4B). We hypothesized that this apparent breakdown in the relationship was artificial, resulting in part from the fact that these larger streetlight counts per pixel were relatively rare (generally three or fewer instances on the island for a given streetlight count; Figure 3) and in part because greater densities of streetlights were more likely to be associated with urban centers and commercial areas rather than darker, residential-only areas. Thus, each pixel presented in Figure 4 with a streetlight count greater than 20 was manually reviewed using satellite imagery in Google Earth to assess if the pixel was overlapping a darker residential area or if the pixel was overlapping a brighter commercial area. Pixels characterized as residential were assumed to have a radiance that was generated primarily by streetlights (and to a lesser extent, households); all pixels categorized as residential were included in the regression (black dashes in Figure 4). Pixels characterized as commercial were assumed to have a radiance that was generated by a variety of non-streetlight light sources that likely masked the streetlight signal; all pixels categorized as commercial were excluded from the regression (red dashes in Figure 4).

In both October (Figure 4A) and November (Figure 4B), the manual review classified 8 of 15 pixels as commercial and the remaining 7 of 15 pixels as residential. The commercial pixels were brighter than the residential pixels (October: t=4.6, df=7.2, p=0.001; November: t=5.1, df=7.4, p< 0.001) and were located primarily in Līhuʻe adjacent to the airport (the brightest spot on the island) whereas the residential areas contained between 75 and 150 houses per pixel and were distributed across multiple towns including Hanapēpē, Kapaʻa, Wailua Homesteads, Lāwaʻi, and Kīlauea.

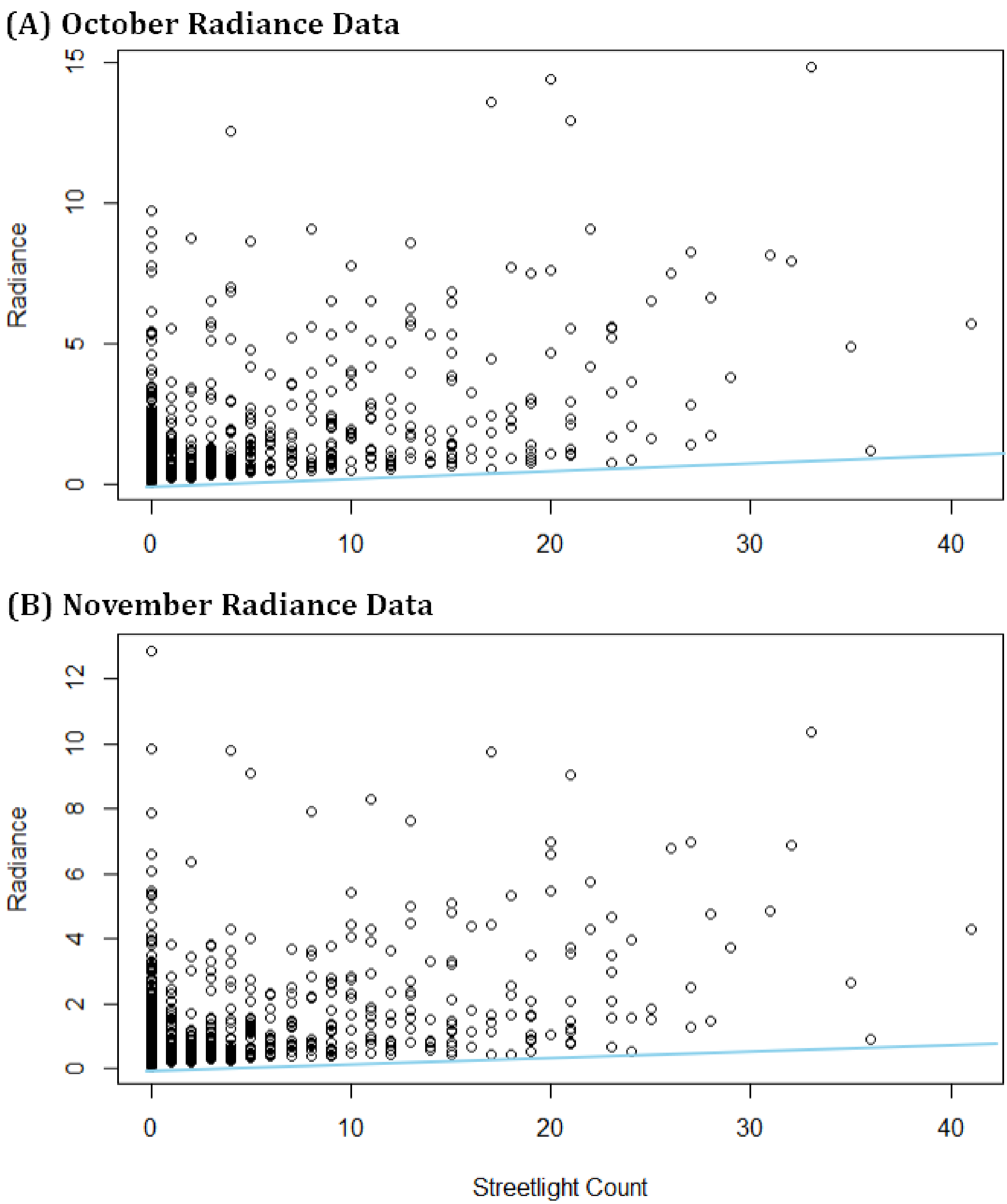

Figure 3. Radiance and streetlight count for all pixels on Kaua'i using the October (A) and November (B) based on 2018 VIIRS satellite radiance data.

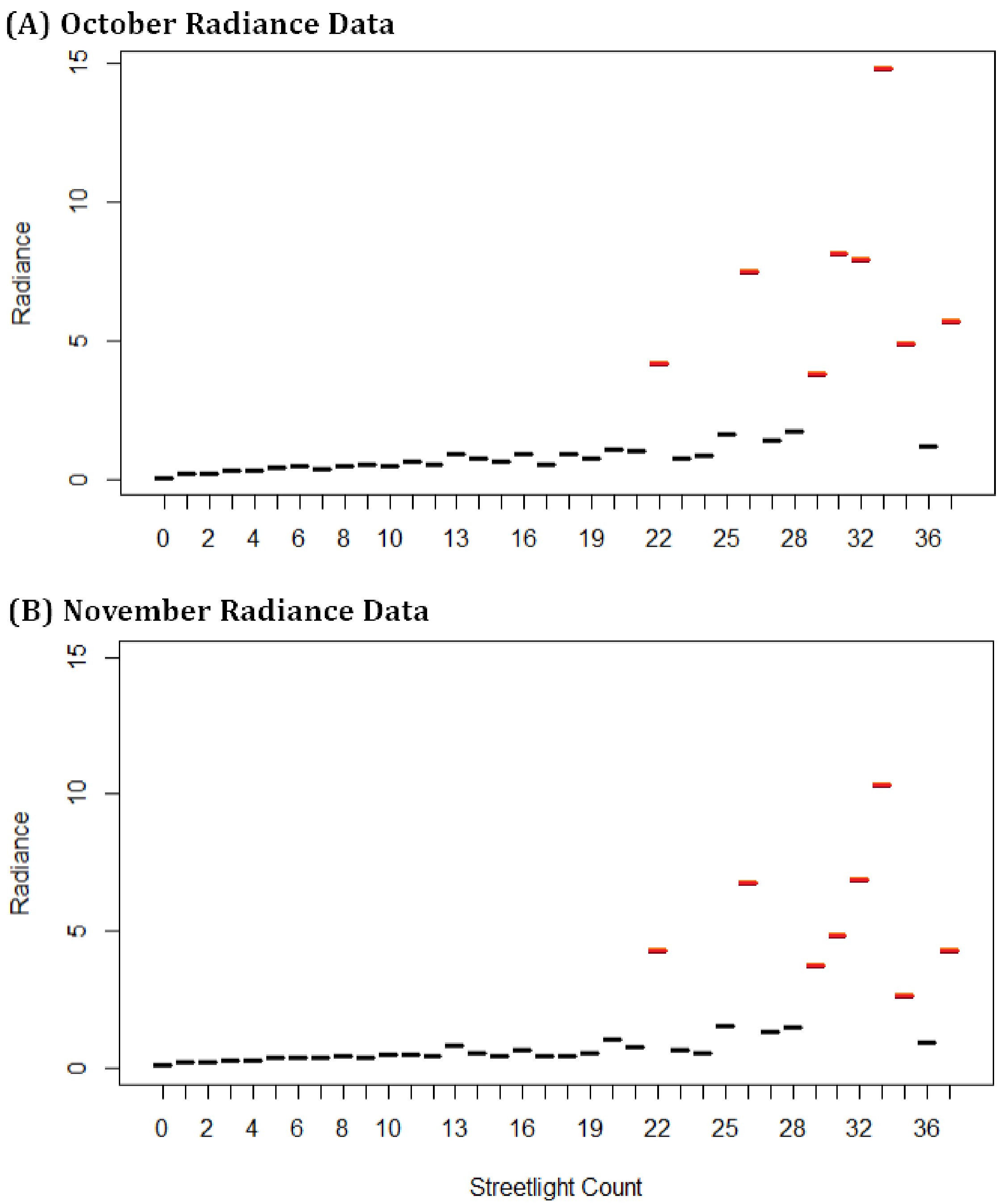

Figure 4. Subset of Plan Area radiance that includes only the darkest pixel per streetlight count for October (A) and November (B) based on 2018 VIIRS satellite radiance data. Black dashes represented pixels categorized as residential and were therefore included in the assessment of radiance added by streetlights. Red dashes represented pixels categorized as commercial and were therefore considered

to be unrepresentative of radiance generated by streetlights and were excluded in the assessment of radiance added by streetlights.

Radiance Generated per Streetlight

Once the dataset relevant for quantifying the functional relationship between radiance and streetlight count was compiled, a linear regression was used to estimate how much radiance increased as the streetlight count per pixel increased. This rate of increase is also known as the slope.

Comparison of Three Analytical Approaches

Three analytical approaches for estimating the variance in radiance added by a single streetlight were explored: bootstrapping, Bayesian regression, and cross-validation. All three approaches were implemented to assess variance in radiance added per additional streetlight (i.e., the slope). Cross-validation was also used to determine model fit metrics as a means of assessing whether the predictive power of the relationship between radiance and streetlight count was similar using data from October relative to November. Below is a brief description of each approach:

- Bootstrapping, which falls under the broader class of resampling methods, uses random sampling with replacement to assign measures of accuracy (bias, variance, confidence intervals, etc.) to sample estimates (Mooney and Duval 1993).
- A linear regression within the context of Bayesian inference was also implemented for comparative purposes (Kruschke 2015).
- Cross-validation, sometimes called rotation estimation or out-of-sample testing, is a suite of similar model validation techniques generally used to assess how well the results of a statistical analysis will generalize to an independent data set (Stone 1974); specifically, leave-one-out cross-validation was used (Fushiki 2011). The most common goal of cross-validation is to estimate the expected level of fit of a model to data that is independent of the data used to create or train the regression.

Bootstrapping, Bayesian, and cross-validation approaches each have their advantages and drawbacks, but in this context were generally complimentary. Each were used to estimate the variance about the regression parameters (e.g., intercept and slope). Cross-validation had the added benefit of providing insight into how well the model predicted out-of-sample data.

Radiance and Streetlight Count

Based on the regression using October satellite imagery, the radiance emitted by a single streetlight was estimated to be 0.04 nW/cm^2/sr (95% HDI: 0.03–0.05) (Figure 5A). For comparison, Bayesian and cross-validation methods produced similar estimates of slope (Bayesian Approach: 0.04 (0.03-0.05 nW/cm^2/sr; Cross Validation Approach: 0.04 (0.03-0.05 nW/cm^2/sr). Based on the regression using November satellite imagery, the radiance emitted by a single streetlight was estimated to be 0.03 nW/cm^2/sr (95% HDI: 0.02–0.04) (Figure 5B). Again, Bayesian and cross-validation methods produced similar estimates of slope (Bayesian Approach: 0.03 (0.02-0.04 nW/cm^2/sr; Cross Validation Approach: 0.03 (0.02-0.04 nW/cm^2/sr). Thus, the estimate of radiance produced per streetlight was similar using data from October and November (i.e., overlapping confidence intervals), with the mean estimate being 0.01 nW/cm^2/sr greater in October relative to November.

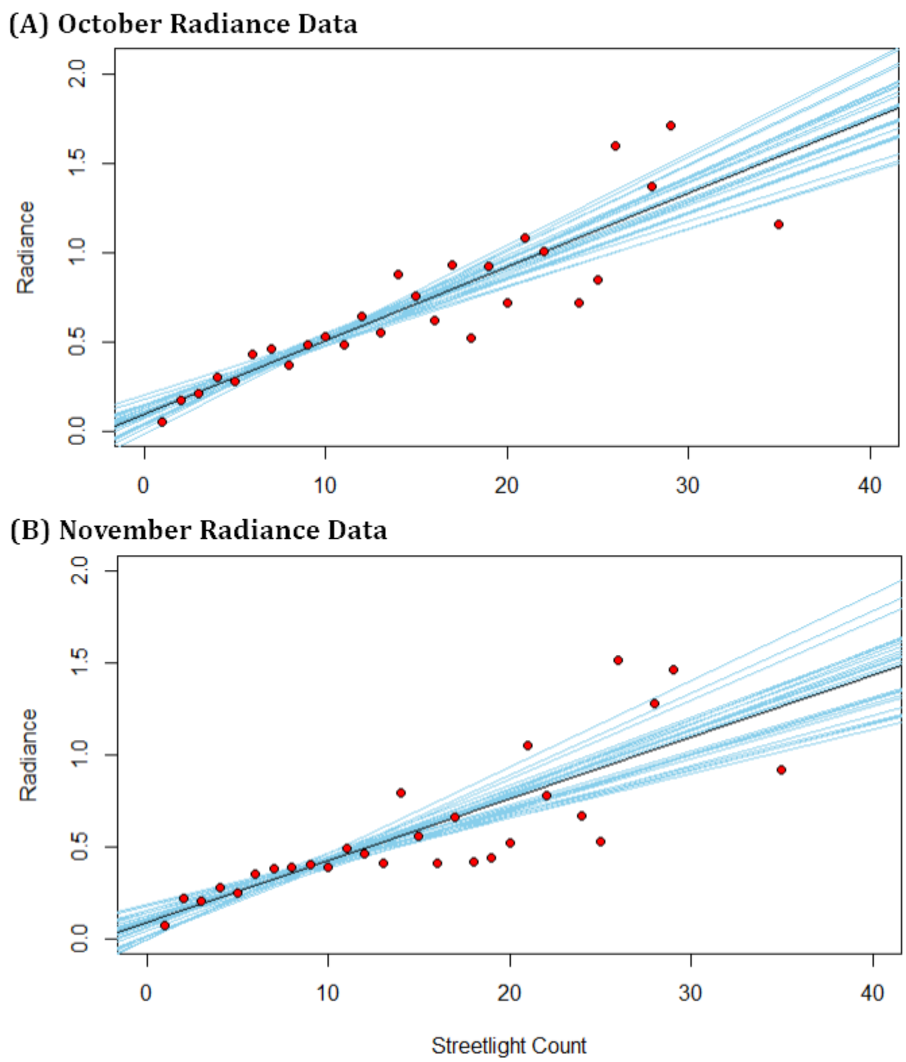

Figure 5. Radiance regressed against streetlight count per pixel using 2018 VIIRS satellite radiance data from October (A) and November (B). The black line represents the average relationship between radiance and streetlight count and the blue lines are examples of credible regression lines generated via bootstrapping.

Cross-validation was also used to determine model fit metrics and assess whether the predictive power of the relationship between radiance and streetlight count was similar using data from October relative to November. Leave-one-out cross-validation indicated that model fit metrics were relatively good in both months but slightly better in October (root-mean-square error = 0.21, mean absolute error = 0.15, R-squared = 0.73) relative to November (root-mean-square error = 0.23, mean absolute error = 0.17, R-squared = 0.58).

Since the October 2018 data produced a larger point estimate of the light added per streetlight and the predictive relationship between streetlight count and radiance was stronger, all estimates of streetlight take presented in Section 5B.4.2, *Take Estimates for Covered Seabird Species*, were derived using the October 2018 radiance data.

5B.2.1.4 Estimating the Proportional Contribution of Streetlights to Radiance by Sector

Once radiance per streetlight was determined, the proportional contribution of streetlights to the total radiance was determined on a sector-by-sector basis by:

1. Extrapolating the radiance of a single streetlight to the total number of streetlights in each sector;
2. Summing the radiance of each pixel within an SOS sector; and
3. Dividing the total radiance generated by streetlights by the sum of the radiance in each sector.

Across all sectors, the proportional contribution of streetlights to sector radiance averaged 6.1 percent but the proportion of radiance added in individual sectors was variable, ranging from sectors without streetlights (and therefore having a 0 percent contribution to radiance) to sectors with streetlights intermixed non-streetlight light types (e.g., residential, commercial, etc.). Both Kapaʻa and Hanapēpē were found to have the greatest proportional contribution of streetlights to overall radiance at 13.2 percent. There are no sectors that have areas of lighting that were only contributed to by a streetlight, and no sectors where the streetlights' contribution to overall radiance was greater than that of the non-streetlight sources.

5B.2.1.5 Uncorrected Fallout Estimate for Streetlights

Newell's Shearwater (ʻaʻo)

The average annual fallout for Newell's shearwater (ʻaʻo) was summarized by sector and multiplied by the proportional contribution of streetlights in each sector to derive an estimate of fallout attributable to KIUC streetlights. The majority (89.75 percent) of Newell's shearwater (ʻaʻo) fallout between 2015 and 2019 could be assigned to an SOS sector. The sector of fallout was not known for the remaining 10.25 percent of Newell's shearwater (ʻaʻo) because the location information was not provided by the citizen collector and not included in the SOS records. For birds where the sector of fallout was unknown, the proportional contribution of streetlights to sector radiance was averaged across all land-based sectors to proportionally assign fallout of birds with unknown locations to KIUC streetlights.

Hawaiian Petrel (ʻuaʻu) and Band-Rumped Storm-Petrel (ʻakēʻakē)

Fallout of Hawaiian petrel (ʻuaʻu) and band-rumped storm-petrel (ʻakēʻakē) was too infrequent to develop a robust assessment of sector-by-sector patterns following the method used for Newell's shearwater (ʻaʻo). Due to the very limited fallout data for Hawaiian petrel (ʻuaʻu) and band-rumped storm-petrel (ʻakēʻakē), the sector-by-sector patterns determined using Newell's shearwater (ʻaʻo) were applied to these other seabird species. The total fallout estimated for Newell's shearwater (ʻaʻo) was adjusted using the ratio of each species to Newell's shearwater (ʻaʻo). For Hawaiian petrel (ʻuaʻu), these ratios were determined using the total observed fallout of Newell's shearwater (ʻaʻo) relative to Hawaiian petrel (ʻuaʻu) annually from 2015 to 2019 (Table 2) and then calculating the 5-year average. For band-rumped storm-petrel (ʻakēʻakē), the analysis used a 15-year timeseries of fallout. A single value for the annual average of Newell's shearwater (ʻaʻo) to band-rumped storm-petrel (ʻakēʻakē) fallout was calculated. The average annual ratio indicated that for every Newell's shearwater (ʻaʻo) take, an additional 0.061 Hawaiian petrel (ʻuaʻu) and 0.01 band-rumped storm-petrel (ʻakēʻakē) are estimated to occur.

Table 2. Annual number of Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu), and Band-rumped storm-petrel (ʻakēʻakē) reported in the SOS database

YEAR	NESH[a]	HAPE[b]	BSTP[c]	HAPE:NESH	BSTP:NESH
2005	*	*	0	-	-
2006	*	*	1	-	-
2007	*	*	6	-	-
2008	*	*	2	-	-
2009	*	*	2	-	-
2010	*	*	2	-	-
2011	*	*	1	-	-
2012	*	*	1	-	-
2013	*	*	0	-	-
2014	*	*	3	-	-
2015	154	4	0	0.026	-
2016	100	1	1	0.010	-
2017	142	14	0	0.099	-
2018	161	4	0	0.025	-
2019	84	12	0	0.143	-
AVE	**128.2****	**7**	**1.3**	**0.061**	**0.01**

[a] NESH = Newell's shearwater (ʻaʻo)
[b] HAPE = Hawaiian petrel (ʻuaʻu)
[c] BSTP = Band-rumped storm-petrel (ʻakēʻakē)
*For Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu), a 5-year timeseries of data were used for these species and therefore data were only summarized for the previous 5 years (but there was fallout of both species prior to 2015.)
**Annual fluctuations in SOS numbers occur based on the moon phase during peak fallout, as well as the size of the breeding population, annual variation in breeding effort, annual variation in reproductive success, inconsistencies in observer effort, and changes to the lightscape across Kauaʻi.

5B.2.1.6 Detectability Correction Factor for Streetlight Fallout

Not all grounded birds are located and turned into SOS for rehabilitation and, therefore, the SOS database does not fully represent the total number of birds that are attracted by lights in the Plan Area each year. Therefore, an estimate of detectability is needed to adjust the estimated fallout resulting from using the SOS database to account for the additional birds that were not turned into SOS.

The exact probability of a grounded Newell's shearwater (ʻaʻo) being located and turned into SOS has not been previously quantified for birds grounded at streetlights and there is a paucity of data to support making such an estimate. An accurate estimate would require specific data on the number of grounded birds that are not turned into SOS because they were not located opportunistically at their grounding location, hid in nearby bushes where they could not be found, were removed from the site and/or consumed by predators, or were hit by vehicles and not retrieved. There are no data to inform any of these specific components that contribute to fallout.

Given the lack of data on the necessary metrics, the literature related to searching for dead and grounded seabirds on Kauaʻi was reviewed to provide additional insight into the potential lower limit of detectability. Specific studies reviewed were Podolsky et al. (1998), and Travers et al. (2012), which documented similar patterns described by Podolsky et al. (1998).

Podolsky et al. (1998) compared the findings of two parallel programs that located dead birds.

- searches conducted by Podolsky et al. (1998), which relied on trained biologists to intensively search for dead birds
- searches associated with the SOS program, which relied on citizens to opportunistically discover and turn in dead birds.

Podolsky et al. (1998) searched intensively for dead birds in proximity to powerlines in urban and suburban areas, inconspicuously marked all dead individuals, and coordinated with the SOS program to determine if any of these dead birds were subsequently turned in by citizens. Although Podolsky et al. (1998) did not examine the efficacy of SOS in detecting birds, information provided by the findings of these overlapping searches can inform an estimate of the lower limit of detectability.

For the purposes of calculating the efficacy of SOS searchers in locating birds, it was assumed that all the dead birds available to be found by these two concurrent efforts were located by the overlapping intensive surveys and opportunistic observations (an assumption that is uncertain and has not been investigated). In total, 50 dead birds were located, 8 of which were found by citizens and turned into SOS (Podolsky et al. 1998). Based on the assumption that all dead birds were located, this would indicate that SOS had a 16 percent (8 SOS birds/50 total dead birds) discovery rate of dead birds. Given that the detection probabilities reported by Podolsky et al. (1998) only applied to dead birds, this detectability is likely a worst-case scenario for the detectability of live birds because the literature indicates that citizens are more inclined to turn in live birds to SOS. Travers et al. (2012) specifically noted that "residents are extremely unlikely to pick up a dead bird and pass it on to [SOS] thus resulting in an underestimate of this cohort". Podolsky et al. (1998) reached a similar conclusion regarding residents' preference to submit live birds to the SOS program. Thus, a minimum detection rate of 16 percent for live birds (as determined using dead birds) was the best conservative estimate that could be empirically derived at this time.

However, it is important to note that there are confounding factors that may interfere with the estimation of detectability of live birds (i.e., their mobility and ability to hide) relative to dead birds, which cannot be quantified based on the information available to date. Thus, we attempted to further adjust the discovery rate downwards as a way of accounting for these additional confounding factors.

To do this, we assumed that the 50 dead birds described in Podolsky et al. (1998) were actually alive and that there were an unknown number of additional dead birds that would remain undiscovered and would never be turned into SOS (equivalent to a detectability of zero percent). The percent of grounded birds that were found dead when trained searchers intensively surveyed for all grounded birds (live or dead) was used to calculate the number of additional dead birds that would go undiscovered. Podolsky et al. (1998) reported that 43 percent of the birds they located when searching for grounded birds were dead and more recent data from Travers et al. (2012) indicated that 35 percent of the grounded birds were dead. In both cases, Travers et al. (2012) noted that these percentages of dead birds were likely an overestimate of the actual proportion of the cohort that was dead versus alive because residents collect live birds prior to searchers arriving.

Knowing the number of documented live birds (50) and the ratio of birds that are alive (100 percent minus 43 percent based on Podolsky et al. 1998, or 100 percent minus 35 percent based on Travers et al. 2012) allows the additional number of grounded birds that are dead and will remain undetected by SOS searcher to be calculated using the following equation:

$$count\ of\ dead\ birds\ = \frac{count\ of\ live\ birds * percent\ of\ birds\ found\ dead}{percent\ of\ birds\ found\ live}$$

Using the percent of dead birds reported by Podolsky et al. (1998), an estimated 37.7 dead birds in addition to the 50 live birds would go undetected by searchers associated with the SOS Program.

$$count\ of\ dead\ birds\ = \frac{50\ live\ birds * 43\ percent\ of\ birds\ found\ dead}{57\ percent\ of\ birds\ found\ live} = 37.7$$

In this hypothetical scenario, there would be a total of 87.7 birds (live (50) and dead (37.7)) available to be discovered and submitted to SOS with just 8 ultimately being turned into SOS; thus, the overall detectability rate for SOS at streetlights would be 9.2 percent. If we do the same calculation using the more recent information from Travers et al. (2012), an estimated 26.9 dead birds in addition to the 50 live birds would go undetected by searchers associated with the SOS Program.

$$count\ of\ dead\ birds\ = \frac{50\ live\ birds * 35\ percent\ of\ birds\ found\ dead}{65\ percent\ of\ birds\ found\ live} = 26.9$$

In this hypothetical scenario, there would be a total of 76.9 birds (live (50) and dead (26.9)) available to be discovered and submitted to SOS, with just 8 ultimately being turned into SOS; thus, the overall detectability rate for SOS at streetlights would be 10.4 percent (8 found birds divided by 76.9 grounded birds). Given the conservative nature of these calculations, for purposes of correcting the detectability estimate of SOS estimated fallout resulting from KIUC streetlights, the light attraction model used a detectability rate of 10.4 percent as the worst-case estimate for all three covered seabird species.

5B.2.1.7 Sensitivity Analysis

To assess if the output of this assessment was stable across months, separate estimates of the radiance added per streetlight were made for October and November. All other inputs used to estimate the proportional contribution of radiance to streetlights were multiplicative processes and are thus scaled 1:1 input to output at the level of the SOS sector. Thus, on a sector-by-sector basis, a 10 percent change in one input (e.g., streetlight count per sector, detectability correction factor, etc.) would result in a 10 percent change in the output (e.g., estimated fallout per sector).

5B.2.2 Future Streetlights

In addition to quantifying the annual fallout occurring at the existing streetlights, quantifying the anticipated additional fallout associated with the estimated 1,754 future streetlights over the 50-year permit term of the HCP was also necessary. These future streetlights will not be uniformly distributed across the island, but rather are expected to be installed in a manner that is proportional to the growth expected in Kauaʻi's Planning Districts (Figure 6, copied from the Kauaʻi General Plan; County of Kauaʻi 2018). So, for example, if there were 1,050 future streetlights, then 2 percent (or a total of 20 streetlights) would be installed in the North Shore Planning District, 13 percent (or a total of 130 streetlights) would be installed in the East Kauai Planning District, and so on.

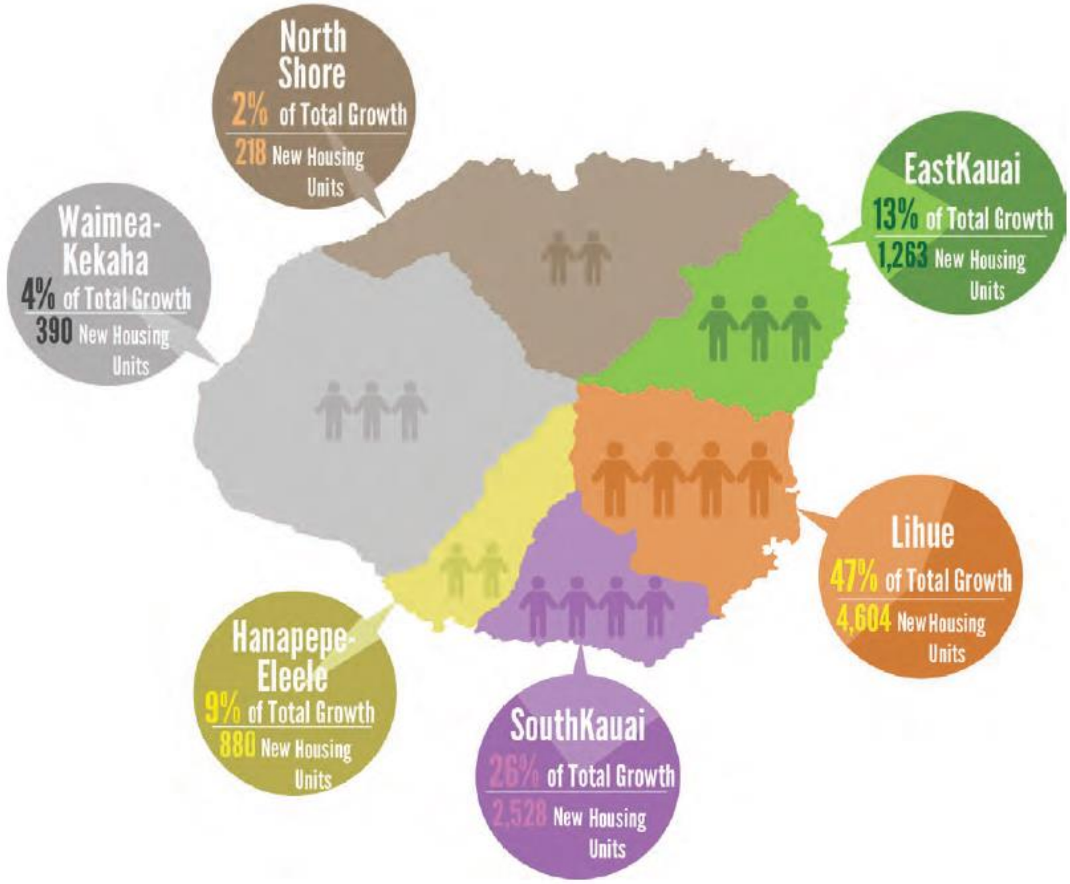

Figure 6. Growth allocations by Planning District from the Kaua'i General Plan (Kaua'i County 2018)

However, these Planning Districts are large and encompass multiple SOS sectors (Figure 2). Thus, for a given Planning District, future streetlights were further partitioned to SOS sectors based on the proportion of streetlights currently present in each SOS sector. So, for example, in the North Shore Planning District there are four SOS sectors that currently have a total of 161 streetlights; 24.8 percent (n=40) of these streetlights are in SOS sector 1, 3.1 percent (n=5) are in SOS sector 2, 64.6 percent (n=104) are in SOS sector 3, and 7.5 percent (n=12) are in SOS sector 32. Thus, of the 20 future streetlights expected in the North Shore Planning District, 24.8 percent were added to SOS sector 1, 3.1 percent were added to SOS sector 2, 64.6 were added to SOS sector 3, and 7.5 percent were added to SOS sector 32. These calculations were repeated for each Planning District on Kaua'i to determine the number of estimated streetlights to be added to each SOS sector in the future.

Once the number of estimated future streetlights to be added to each SOS sector were identified using the method described above, the estimate of radiance generated by a single streetlight could be scaled up to estimate the total radiance added to each SOS sector by the addition of these future streetlights. Similar to the assessment of fallout occurring at existing streetlights, the proportional contribution of future streetlights to SOS sector radiance was used to partition observed fallout into streetlights and non-streetlight and then corrected for detectability using the same logic presented in Section 5B.2.1, *Existing Streetlights* (e.g., assuming a detectability rate of 10.4 percent at streetlights).

Although we can project the total number and general location of future streetlights with some accuracy based on the existing distribution of streetlights and future growth projections summarized in the Kauaʻi General Plan, the same is not true for projecting the magnitude and distribution of future fallout and radiance on the island. It is unknown if and to what extent fallout and overall radiance will change in the future. As such, for purposes of this assessment, we assumed that the current patterns of fallout and radiance will persist into the future.

5B.2.3 Limitations

There were several limitations related to the estimation of fallout occurring at current and future streetlights that should be considered:

- Although the resolution of the radiance data was too coarse to directly measure the radiance added by single streetlight, recently published study (Kyba et al. 2020) successfully measured the proportional contribution of streetlights to nighttime radiance in Tucson, Arizona using the VIIRS DNB radiance data, providing support for validity the approach described here to estimate the proportional contribution of streetlights.
- For purposes of this assessment, it was assumed that the proportional contribution of streetlights to radiance was equal to the proportional contribution of streetlights to the annual rate of fallout. Light intensity and region are the only factors that can be accounted for using the approach presented here and it does not account for other factors known to contribute to patterns in fallout such as differential attraction by different wavelengths or distance from the coastline. It is possible that the intensity of the various light sources on Kauaʻi as sensed from space may not match the perceived attractiveness of these light sources to newly fledged seabirds.
- Certain bulb types may be more attractive to shearwaters than others due to the spectrum of wavelengths emitted. Based on preliminary reports, the visual system of Newell's shearwaters (ʻaʻo) may be sensitive to violet and ultraviolet wavelengths (Moon et al. 2019), and these attractive wavelengths are more prevalent in "cool" light (e.g., 5000K LED) and less prevalent in "warm" light (e.g., 3000K LED) (Figure 1 in Longcore et al. 2018). There have been two recent studies that specifically characterized the attractiveness of LED lights to shearwaters relative to other light types. Rodríguez et al. (2017c) experimentally attracted shearwaters using unshielded 5000K LED, high-pressure sodium, and metal halide bulbs. They recorded average fallout rates of 1.7 birds per hour at high pressure sodium lights, 2.1 birds per hour at LED lights and 3.3 birds per hour at metal halide lights and concluded that "metal halide multiplied the mortality risk by a factor of 1.6 and 1.9 respectively in comparison with LED and high-pressure sodium lights". Despite having observed fallout of 125 birds in 66 hours at 5000K LED and high-pressure sodium lights, the variability in fallout rates at these two light types overlapped enough that it was not possible to conclude that there were differences in the attractiveness of LEDs and high pressure sodium lights (Rodríguez et al. 2017c). Longcore et al. (2018) created a model that inferred potential attractiveness of a more extensive list of lights based on the visual sensitivity of Newell's shearwater (ʻaʻo) reported by a thesis (Reed 1986). Results presented in Longcore et al. (2018) represent predictions rather than actual data on attractiveness of lights to shearwaters, and shortcomings were highlighted in their discussion. Furthermore, the re-

analysis of Rodríguez et al. (2017c) by Longcore et al. (2018) showed that using actinic power per lux to predict attraction may overestimate the attractiveness of LED lights based on findings reported by Rodríguez et al. (2017c) (see Figure 5, Longcore et al. 2018). Importantly, the Longcore et al. (2018) assessment lacked critical information needed to understand if apparent differences presented for various light types were statistically significant.

- The SOS database did not provide sufficient detail regarding fallout location to conclusively link fallout to streetlights. Therefore, the SOS data could not be used to validate the outcome of the analysis. In addition, the surrounding urban lightscape prohibits isolating a single light source as the cause of fallout. Since light attraction likely results from multiple light sources, directly quantifying the true contribution of streetlights to fallout would require an experimental study where various light sources are manipulated and the impact on fallout is measured.
- Data on detectability of seabirds grounded under streetlights does not exist. The 10.4 percent used here is intentionally conservative and lower than what has been documented for other situations. A review of 294 infrastructure-driven mortality studies based on carcass searches found that body mass was the most important variable influencing the detectability of a carcass to searchers (Barrientos et al. 2018); Newell's shearwaters (ʻaʻo) range in mass from 342 to 425 grams (Ainley et al. 2020) and the review by Barrientos et al. (2018) suggested that a bird of that size would have an overall detectability rate of about 80 percent for trained observers across the habitat types of interest (fences, powerlines, roads, solar plants, and wind farms).
- The actual distribution of future streetlights may not match what was projected in the Kauaʻi General Plan (County of Kauaʻi 2018). Further, future fallout and radiance patterns are unknown. If future fallout and radiance patterns are determined to differ from what has been projected by this assessment, differences can be addressed through adaptive management.

5B.3 Assessment of Fallout from Facility Lights

For the two covered facilities in the KIUC HCP, Port Allen Generating Station and the Kapaia Generating Station, take was directly enumerated using the average number of downed birds located at each facility, as documented in KIUC monitoring logs (Kauaʻi Island Utility Cooperative 2019) and the SOS database. KIUC staff have monitored and maintained inspection logs for these facilities during the seabird fallout season (September 15 through December 15) since 2011.

The take estimate for KIUC facilities is based on 8-year average (2016–2023) for Newell's shearwater (ʻaʻo) and) a 13-year average (2011–2023) for rarer species (i.e., Hawaiian petrel [ʻuaʻu] and band-rumped storm-petrel [ʻakēʻakē]). The take estimate that encompassed observations prior to and following full minimization was calculated to be consistent with methods used to estimate facility take elsewhere on the island by participants in the Kauaʻi Seabird HCP (DOFAW 2020).

The take estimate for fallout from facility lights used a detectability factor of 25 percent. While this detectability factor is greater than the detectability factor for streetlights, it is half the detectability rate used for facilities covered in the Kauaʻi Seabird HCP (DOFAW 2020) as their annual reports have indicated that a detectability rate of 50 percent is likely too optimistic. Also, KIUC facilities, Port Allen Generating Station and Kapaia, are fenced and monitored for pests. Regular pest control methods such as traps and pest control services are used for rats and mice. Any stray cats that make it into the fenced facilities are captured using live traps and removed from the property. KIUC trains staff to identify and search for covered species and these trained staff conduct searches for downed seabirds during the seabird fallout season twice daily (see Chapter 6, *Monitoring and Adaptive*

Management Program). Searchers are equipped with Oppenheimer Seabird Recovery Kit and recovered birds are transported to an SOS Aid Station.

5B.4 Conclusions

5B.4.1 Summary of Streetlight, Lightscape, and Fallout by Sector

A complete summary of the proportional contribution of 4,150 streetlights, used for this assessment, to radiance and the average annual fallout for Newell's shearwater (ʻaʻo) was summarized on a sector-by-sector basis (Table 3). This is based on radiance data from October 2018.

Table 3. Model Output for Each SOS Sector

Sector ID	Sector Name	Streetlight count (#)	Total streetlight radiance	Sector radiance	Proportional contribution of streetlights	AVE Total NESH[a] fallout (#/year)	AVE Streetlight NESH[a] fallout (#/year)
1	Hanalei	40	1.6	87.5	0.018	10.5	0.20
2	Princeville	5	0.2	83.8	0.002	27.4	0.06
3	Kīlauea	104	4.1	82.7	0.050	2.5	0.13
4	Anahola	91	3.6	69.6	0.052	1.0	0.05
5	Kealia	19	0.7	29.9	0.023	0.0	0.00
6	Kapaʻa	368	14.5	110.2	0.132	3.0	0.40
7	Waipouli	49	1.9	89.9	0.021	3.0	0.06
8	Wailua	115	4.5	61.4	0.073	1.0	0.07
9	Wailua Homesteads	278	10.9	98.6	0.111	1.0	0.11
10	Hanamaulu-Kapaia	180	7.1	94.0	0.076	1.0	0.08
11	Līhuʻe	1000	39.3	473.6	0.083	7.2	0.60
12	Marriott	0	0.0	46.8	0.000	2.5	0.00
13	Nāwiliwili	56	2.2	78.5	0.028	4.5	0.13
14	Puhi	290	11.4	99.6	0.115	2.2	0.25
15	Kipu	2	0.1	46.4	0.002	1.0	0.00
16	Poʻipū	146	5.7	115.6	0.049	8.4	0.41
17	Kukuiula	37	1.5	37.5	0.040	2.0	0.08
18	Kōloa	151	5.9	85.7	0.069	1.5	0.10
19	Lāwaʻi	103	4.0	40.5	0.099	0.0	0.00
20	Kalaheo	266	10.4	71.0	0.147	1.7	0.25
21	Port Allen	43	1.7	44.7	0.038	16.6	0.63
22	ʻEleʻele	211	8.3	81.2	0.102	4.8	0.49
23	Hanapēpē	149	5.9	44.7	0.132	2.2	0.29
24	Salt Ponds	0	0.0	6.6	0.000	0.0	0.00
25	Olokele-Kaumakani	3	0.1	40.9	0.002	0.0	0.00

Sector ID	Sector Name	Streetlight count (#)	Total streetlight radiance	Sector radiance	Proportional contribution of streetlights	AVE Total NESH[a] fallout (#/year)	AVE Streetlight NESH[a] fallout (#/year)
26	Pakala	1	0.0	45.8	0.000	1.0	0.00
27	Waimea	155	6.1	57.6	0.106	10.2	1.08
28	Kekaha	169	6.6	86.0	0.077	5.2	0.40
29	PMRF[b]	5	0.2	84.0	0.002	1.3	0.003
30	Kōkeʻe	0	0.0	103.4	0.000	1.0	0.00
31	Omao-Maluhia	57	2.2	39.4	0.056	2.0	0.11
32	Haena-Wainiha	12	0.5	34.4	0.015	4.4	0.07
33	Kipukai, Nā Pali	0	0.0	90.9	0.000	2.0	0.00
34	At sea	0	0.0	0.0	0.000	1.0	0.00
35	Unknown[c]	(124.4)	(4.9)	(80.7)	0.061	15.2	0.93
Total	**--**	**4,105[d]**	**161.2[d]**	**2662.4[d]**	**1.72**	**135.1**	**6.1[f]**

[a] NESH = Newell's shearwater (ʻaʻo)

[b] PMRF = Pacific Missile Range Facility

[c] Sector 35 is called "unknown" and as not all birds turned into SOS are assigned to sector, and the only way to account for birds in this category is to calculate island-wide averages. See *Newell's shearwater (ʻaʻo)* for more information.

[d] Streetlight count, streetlight radiance, and sector radiance totals exclude the numbers in parenthesis from Sector 35 (Unknown) as the values, while they are included in the model and calculations, are in addition to the real island-wide totals.

[e] The proportional contribution of streetlights column cannot be summed because they are proportions and as such, are not additive. Rather the value in the row titled Total represents the island-wide average which is calculated by dividing the streetlight radiance for the entire island by the sector radiance for the entire island (161.2/2662.4)=0.061.

[e] The AVE Streetlight NESH Fallout (#/year) is the summed total of all the rows, including unknown.

5B.4.2 Take Estimates for Covered Seabird Species

5B.4.2.1 Existing Streetlights

Assuming a detectability scenario of 10.4 percent, annual fallout by Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu) and band-rumped storm-petrel (ʻakēʻakē) attributed to the 4,150 streetlights used for this assessment are summarized in Table 4. These estimates are based on the proportional contribution of radiance estimated for existing streetlights to the radiance of all night-time lights on Kauaʻi.

Below is the equation used to calculate the total fallout of Newell's shearwater (ʻaʻo) using the total fallout observed per year that is attributable to streetlights. This number is equal to 6.957 without rounding errors and is derived by adding up the annual average of Newell's shearwater (ʻaʻo) fallout at streetlights in each sector (Table 3; the total value of Newell's shearwater (ʻaʻo) fallout at streetlights calculated from sector-specific numbers presented in Table 3 is 6.983 due to compounding rounding errors). This total of Newell's shearwater (ʻaʻo) fallout is then corrected using a detection probability of 10.4 percent.

$$\frac{6.957\ birds\ found}{0.104\ detectability\ correction\ factor} = 66.9\ birds\ after\ correcting\ for\ detectability$$

The estimates for Hawaiian petrel (‘ua‘u) and band-rumped storm-petrel (‘akē‘akē) are then derived from the detectability corrected estimate of Newell’s shearwater (‘a‘o) using the ratios of occurrence in the fallout database averaged over 5 years for Hawaiian petrel (‘ua‘u) and 10 years for band-rumped storm-petrel (‘akē‘akē). Per Table 2, for every Newell’s shearwater (‘a‘o) in the SOS database, there has been a long-term average of 0.061 Hawaiian petrel (‘ua‘u) and 0.01 band-rumped storm-petrel (‘akē‘akē). Thus, the estimated fallout for Newell’s shearwater (‘a‘o) is multiplied by these ratios resulting in an estimated 4.05 Hawaiian petrel (‘ua‘u) (=66.9 x 0.061) and 0.669 band-rumped storm-petrel (‘akē‘akē) (=66.9 x 0.01) fallout at streetlights per year.

Table 4. Estimates of take per year for Newell’s shearwater (‘a‘o), Hawaiian petrel (‘ua‘u), and band-rumped storm-petrel (‘akē‘akē) assuming that the SOS data includes only 10.4 percent of birds that fallout at streetlights.

Species	Estimate	Lower 95% CI	Upper 95% CI
NESH[a]	66.9	51.7	86.8
HAPE[b]	4.0	3.1	5.3
BSTP[c]	0.7	0.5	0.8

[a] NESH = Newell’s shearwater (‘a‘o)
[b] HAPE = Hawaiian petrel (‘ua‘u)
[c] BSTP = band-rumped storm-petrel (‘akē‘akē)

5B.4.2.2 Future Streetlights

Assuming a detectability scenario of 10.4 percent, additional annual fallout anticipated with the addition of 1,754 future streetlights by Newell’s shearwater (‘a‘o), Hawaiian petrel (‘ua‘u) and band-rumped storm-petrel (‘akē‘akē) are summarized in Table 5. These estimates are based on the proportional contribution of radiance estimated for existing streetlights to the radiance of all night-time lights on Kaua‘i.

Table 5. Estimates of take per year for Newell’s shearwater (‘a‘o), Hawaiian petrel (‘ua‘u), and band-rumped storm-petrel (‘akē‘akē) if the SOS data includes only 10.4 percent of birds that will fallout at future streetlights.

Species	Estimate[d]	Lower 95% CI	Upper 95% CI
NESH[a]	20.5	15.9	26.7
HAPE[b]	1.2	1.0	1.7
BSTP[c]	0.2	0.1	0.3

[a] NESH = Newell’s shearwater (‘a‘o)
[b] HAPE = Hawaiian petrel (‘ua‘u)
[c] BSTP = Band-rumped storm-petrel (‘akē‘akē)
[d] These are the additional birds that will be taken each year once all the 1,754 estimated streetlights are added.

5B.4.2.3 Facility Lights

Following a similar approach of the Kaua‘i Seabird HCP (DOFAW 2020), included in this assessment is an 8-year average for Newell’s shearwater (‘a‘o) and the 13-year average (the extent of the data available) for the rarer Hawaiian petrel (‘ua‘u) and band-rumped storm-petrel (‘akē‘akē) (Table 7).

All fallout of covered seabirds reported in Table 7 occurred at the Port Allen Generating Station. After applying the detection correction of 25 percent to the annual average fallout over the full time period the annual take is estimated to be 12.5 Newell's shearwater ('a'o), 0.3 Hawaiian petrel ('ua'u), and 0 band-rumped storm-petrel ('akē'akē).

Table 7. Fallout of covered seabirds documented at covered KIUC facilities. Note that light minimization efforts occurred at the Port Allen Generation Facility prior to the fallout season in 2019 and less birds were found in the two fallout seasons after these measures were implemented.

Year	NESH[a]	HAPE[b]	BSTP[c]
2023	1	0	0
2022	1	0	0
2021	1	0	0
2020[d]	2	0	0
2019[d]	0	0	0
2018	10	0	0
2017	4	0	0
2016	6	0	0
2015	*	0	0
2014	*	0	0
2013	*	0	0
2012	*	1	0
2011	*	0	0
AVE	**3.1**	**0.1**	**0**
25% detectability	**12.5**	**0.3**	**0**

[a] NESH = Newell's shearwater ('a'o)
[b] HAPE = Hawaiian petrel ('ua'u)
[c] BSTP = Band-rumped storm-petrel ('akē'akē)
[d] Light minimization measures were fully implemented in 2019 and 2020

5B.4.2.4 Combined Take Estimate

Combining the take estimates for existing streetlights, future streetlights, and KIUC's covered facilities from Tables 4, 5, and 6, results in an estimated annual take of 99.9 Newell's shearwater ('a'o) (=66.9+20.5+12.5), 5.5 Hawaiian petrel ('ua'u) (=4.0+1.2+0.3), and 0.9 band-rumped storm-petrel ('akē'akē) (=0.7+0.2+0.0) for the KIUC HCP.

5B.5 References

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Appendix 5C

Bayesian Acoustic Strike Model

Underline Monitoring Project
Review Draft- Bayesian Acoustic Strike Model

Marc Travers, M. Tim Tinker, Scott Driskill, André F. Raine

Provided June 16, 2020

The Underline Monitoring Project (UMP) is part of the Kauaʻi Endangered Seabird Recovery Project (KESRP), which is a joint project of the Pacific Cooperative Studies Unit of the University of Hawaiʻi and the Division of Forestry and Wildlife (DOFAW)/State of Hawaiʻi Department of Land and Natural Resources.

Estimating rates of power line collisions for seabirds using acoustic monitoring

This document outlines the method and results for a Bayesian model created to assist in the development of the KIUC Long Term Habitat Conservation Plan to estimate rates of power line collisions of two endangered seabirds on the island of Kaua'i – the Newell's Shearwater *Puffinus newelli* and the Hawaiian Petrel *Pterodroma sandwichensis* - using acoustic monitoring. The document has been created with the intention of helping reviewers of the model understand the parameters, decision points and results of the model and accompanies the R code and data for the model. We assume that reviewers already have a high level of understanding of the acoustic monitoring process that has formed the backbone of take monitoring on Kauai since 2011, so have truncated a description of portions of the methodologies – we encourage readers to review any of the Underline Monitoring Project Annual Reports for a full description of field methods and previous key results.

This model was created by KESRP (a project administered by the Research Corporation of the University of Hawaii's Pacific Co-operative Studies Unit) and Tim Tinker of Nhydra and should be considered the intellectual property of its creators. The R code, data, and any other materials will be sent to other parties for the explicit purposes of review only, and the use of this model is bound by the terms of the data sharing agreement, which are that reviewers will not seek to publish the model or aspects of it themselves, nor use it for their own financial gain.

Methods

Study Area

Power lines occur around the perimeter of Kaua'i as well as along inland roads or valleys in several areas. For the purpose of this study we divided the landscape up into 8 regions (*reg*), which we used as a spatial random effect in statistical analyses (Figure 1). We also further divide power lines in into areas within the regions. These regions and areas were delineated based on power line construction type and environment type. Power lines within each region are divided into spans that occur between two sets of adjacent poles, and for this study each span received a unique identifier, or spanID. A span consists of an array of wires, which can be further divided into one or more "levels" of wires (wires within a single level are at the same approximate height above ground, ABG). Birds that fly through an array of wires can potentially strike a wire; however, the likelihood of a bird flying at the same height of the wires depends on several factors, including the presence of "obstacles" (e.g. trees, buildings) which birds must fly above. For example, in a coastal area with tall trees, if the height of the entire wire array is lower than the height of the treetops, birds will in all likelihood fly above the treetop obstacle and thus above the wire array, leading to a near zero likelihood of collision.

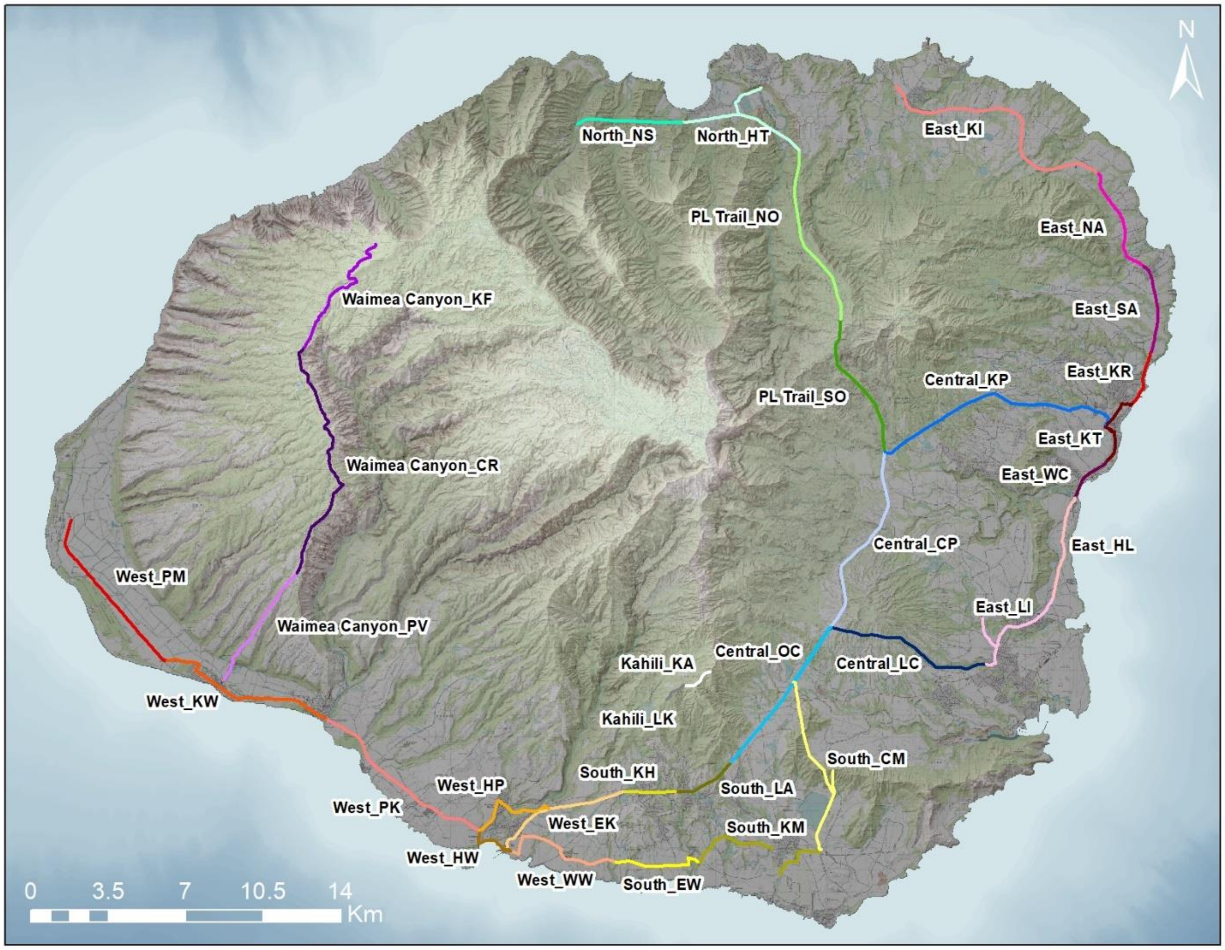


Figure 1. UMP power line regions and areas.

Spans are of varying length, depending on landscape configuration, and have several other defining characteristics or attributes. The structural attributes recorded for a given span include the distance (m) between poles or span length (*Lng*), variance in wire exposure (exsd), percent of span exposed (pcex), space between wire layers (sbwl), and number of wire layers (wlyr).

In addition to structural attributes, each span is associated with several geographic and environmental attributes that can affect bird passage rates or collision likelihood. Geographic and environmental attributes include distance from ocean (*dstoc*) and landscape gradient (grad).

Data Collection

To acoustically record power line strike sounds, Song Meter SM2+ (Wildlife Acoustics, Boston, MA) sensors were deployed at either 1) the base of power poles in quiet soundscapes (typically higher elevation sites) or 2) were mounted on the power pole just below the lowest transmission lines when the pole was near traffic sounds. Units deployed at the base of the poles had two SMX-II microphones positioned on the side of the unit, and the units were placed beneath vegetation to protect the microphone from wind and to reduce the likelihood that units would be tampered with by the public. The pole-mounted units had one Night Flight Microphone mounted on the pole as close to the lowest transmission wire as possible. We had five recording schedules, 1) peak time recording, 2) off-peak recording, 3) check time recording, 4) all3, and 5) every night (see Table 1). These recording schedules were as follows:

- "Peak" time units record acoustic data during two periods, starting at sunset and running for 3.5 hours and then starting again 3.5 hours before sunrise and ending at sunrise, for a total of 7 hours each night. This time period was named "peak" because it includes the peak pulse of passage rates observed at power lines (Travers et al. 2012 and 2013).
- "Off-peak" units record throughout the portion of the night not covered by the peak time units outlined above. They also recorded for 2.5 hours during the day (1 hour before and after sunset and sunrise, respectively, and for one half hour during midday).
- "Check" units recorded all night and thus covered the full nocturnal collision monitoring period (half hour after sunset to half hour before sunrise) every second night. Note to be conservative, the period encompassing the first half hour after sunset and the first half hour before sunrise, was removed from consideration. Although the target seabirds do fly during these periods, their likelihood of colliding with wires during day light is low compared to darker periods.
- "All3" units record every third night for the entire night.
- "Every night" units record every night for the entire night.

These schedules allowed us to deploy each unit type for one month before the batteries and SD cards needed to be changed.

Table 1. UMP Acoustic recording strategy and schedules

Recording Strategy	Recording Schedule	Frequency	PM Night Monitoring	AM Night Monitoring	Day Light Monitoring
Static (Seasonal)	Peak	Every Night	SS to 3.5 h after	-3.5 to SR	None
Static (Seasonal)	Off-peak	Every Night	SS+3.5 h to 23:59	00:00 to SR-3.5 h	SR to 1 h, 12:00 to 12:30, -1 h to SS
Static (Seasonal) Reduced Cost	All 3	Every 3rd Night	SS to 23:59	00:00 to SR	None
Static (Minimization)	Every	Every Night	SS to 23:59	00:00 to SR	None
Check (Re-sampling)	Check	Every 2nd Night	SS to 23:59	00:00 to SR	None
Rover (Randomized)	Peak	Every Night	SS to 3.5 h after	-3.5 to SR	None

We had three sampling strategies that employed the above recording schedules. First, we had seasonal monitoring which typically covered the full seabird breeding season from March 1 to January 1. In order to reduce costs to KIUC, from 2016 we began reducing some of the seasonal monitoring to April 1-November 1. Seasonal monitoring sites typically had two Song Meter units at each location: one for peak time recording and one for off-peak recording.

The seasonal units were deployed at 'static' sites (sites monitored every year) to measure the variation of strikes across the season, which includes identifying the start and end of the strike season and the increase and decrease in the strike rate which coincides with the seasonal variation in passage rates of the target seabirds[1]. The off-peak units were deployed to identify the frequency of strikes in the middle portion of the night and variation across the season. The ratio of off-peak strikes to peak strikes measured at full season monitoring sites is used to develop correction factors or model middle of the night strikes for locations that only had partial night monitoring (i.e. rover peak monitoring described below). For seasonal monitoring locations we deliberately selected sites with the highest known strikes. The consistently elevated strike rates are required to reliably detect the seasonal patterns.

Secondly, we deployed 'check' units at sites that recorded strikes in previous seasons (see previous UMP Annual Reports for details) or areas that had high collision risk characteristics. Check units record all night every second night. This schedule was designed to provide data on the full night without the need for increased equipment and analysis time (i.e. to lower monitoring costs). Firstly, these units are used to provide additional information on the variation in strike across the night. Again, this allows for development of correction multipliers for locations that only had partial night monitoring (i.e. rover peak monitoring described below). Secondly, check units being deployed at sites with previously detected strikes allow for measuring strike change across years and at different times of the season.

Thirdly, we employed a random stratified sampling protocol for all other acoustic monitoring (May 15 to September 15). This type of monitoring had one unit recording on the peak schedule per site. Our random stratified protocol, described in detail below, was designed to ensure 1) equal monitoring across the different regions while 2) forcing equal monitoring of varying exposure heights within each region and ensuring 3) that there was equal spread across the existing exposure heights over the entire sampling period. To accomplish equal sampling across regions, we allocated equal monitoring effort (number of units) to a region based on the number of spans present within that region. Within each region, we looked at the range of exposure heights present (height of wires relative to local vegetation; see Travers et al. 2013 & 2014 for details) and classified spans into the categories of low, medium, or high exposure height specific for that region (e.g. the range for low exposure in one region may be different than another region). We then assigned random numbers to each span and selected equal numbers from each exposure category. We conducted this sampling without replacement each month. Thus, every month's acoustic monitoring was balanced across regions and the exposure heights were balanced within each region.

[1] Seabird passage rates vary across the season as birds have different burrow visitation rates as they advance through different breeding stages.

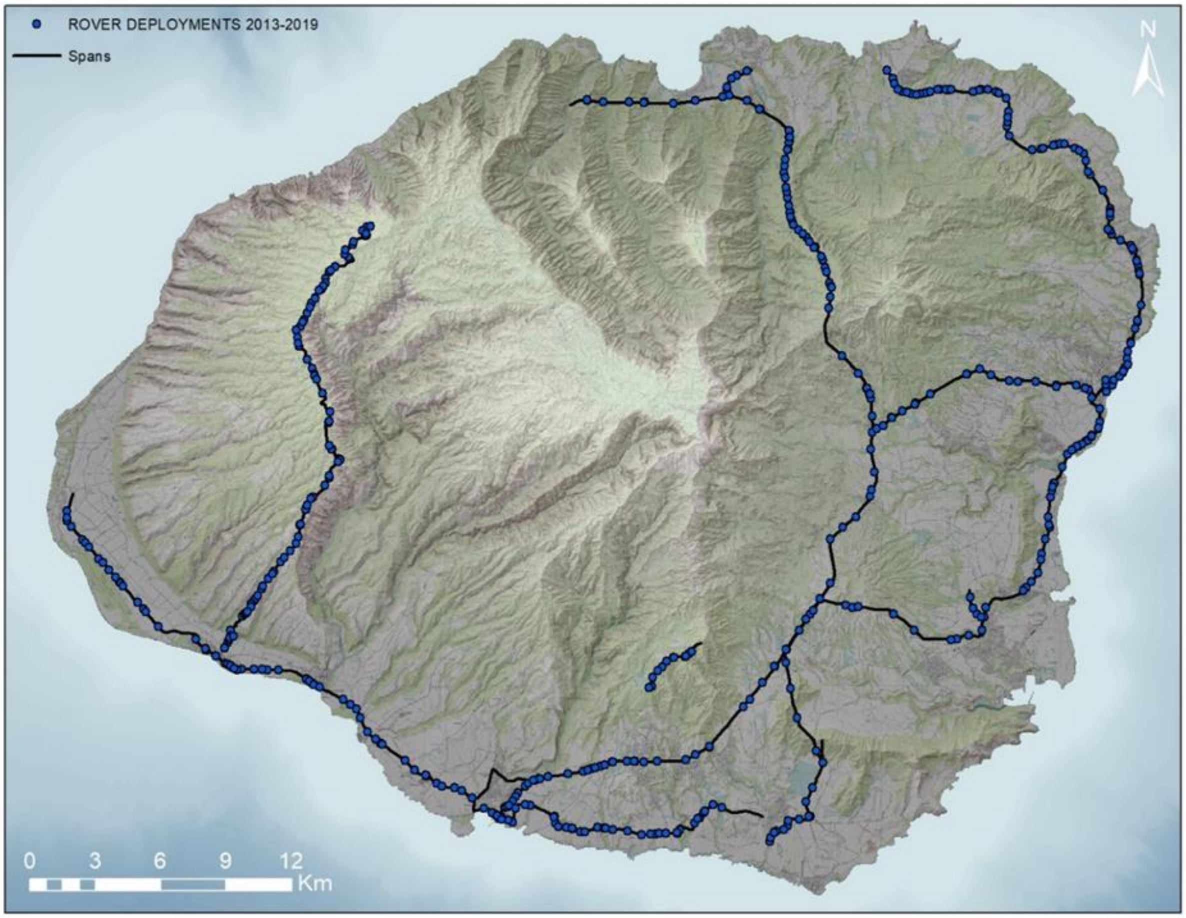


Figure 2. Distribution of rovers monitoring effort 2013-2019 with site selection based on the KESRP simple random stratified sampling design. We have not displayed monitoring effort because rover sites have a uniform effort of one month (20-30 days) on the peak schedule. We have shown that our rover monitoring effort does bias the result towards undercounting strikes. The undercounting of strikes is due the fact that a short window of monitoring effort (20-30 days) has a reduced likely hood of detecting any strikes even if the seasonal strike total is as high as 20 (Travers et al. 2017b). Furthermore, strikes are undercounted when fiberoptic cable is present (because Fiber does not produce a strike sound) and at sites with high ambient noise from vehicle traffic and wind (Travers et al. 2019a).

Conservation Metrics Inc.. Automated detection and classification of acoustic strike sounds

Automated acoustic analysis of all field recordings was carried out with custom detection and classification software developed by Conservation Metrics, Inc. (CMI). We applied a machine learning technique, Deep Neural Networks (DNNs), to detect sounds on field recordings that had spectro-temporal properties similar to those measured from examples of strike sounds. Deep Neural Networks are a powerful tool for detection and classification of events used in many fields such as speech recognition, image recognition, and other pattern recognition tasks (Deng et al. 2013, Schmidhuber 2015, Cichy et al. 2016, Min et al. 2016).

Our workflow splits the stereo acoustic files into two datasets, one for each microphone channel (right and left). Spectro-temporal measurements are extracted from these recordings in discrete time windows (2-seconds long), and discrete frequency bins (256 frequency bins per time step). The Underline Monitoring Project acoustic effort results in the collection of hundreds of millions of discrete 2-second clips every monitoring season, and billions of spectro-temporal measurements.

Feature measurement scores were used to train DNN classification models to detect powerline strikes. Specifically, we developed training and cross-validation datasets with examples of "positive" sound clips containing the sound of interest (i.e. 2-second clips containing powerline strike sounds) and a representative sample of "negative" sound clips (i.e. examples of 2-second clips containing sounds from the soundscapes at all survey sites that are not powerline strikes). The neural networks optimize a combination of spectro-temporal feature values that best differentiates positive sounds from negative sounds in the environment. Trained DNN classification models can then be applied to predict events of interest on acoustic data from future surveys, returning a likelihood that any given 2-second clip contains a sound produced by a powerline strike.

CMI Model performance

There is an inherent trade-off between accuracy (proportion of true positives in the set of possible events identified by the model) and sensitivity (proportion of true positives detected out of total available for detection in the data) in any signal detection problem. An increase in the sensitivity of a detector will usually lead to decrease in accuracy and vice versa. The signal detection challenge for the Underline Monitoring Project is the need to optimize classification model sensitivity for a rare signal, while maintaining accuracy levels that produce a manageable amount of potential events for manual review (*see below*). Collision sounds are rare, in a typical season acoustic surveys collect 60-70,000 hours of acoustic recordings (~7 years in aggregate), and we have typically detected only 1 to 2 hours per season containing collision sounds.

Our current DNN model was developed in 2015. It was trained using example data collected through 2015 and optimized to process large datasets more efficiently than previous detection models. The training data included 1,193 examples of strike sounds and 192,645 randomly selected samples of other background sounds from the soundscape. We evaluated model performance using a standard test dataset developed from KESRP Underline Monitoring Project recordings. Specifically, the test dataset contained recordings from field survey periods when KESRP staff were monitoring for seabird collisions at acoustic monitoring sites in 2013. The test dataset included 216 hours of recordings from 7 sites made on 16 survey nights. Human observers detected a total of 32 strikes during these survey periods. CMI manually reviewed and labeled the test dataset by navigating to each timestamp for a strike observed in the field and finding the strike in the test dataset. There were 9 strikes that could not be located on the sound data, so the test dataset on which we evaluated performance included 23 strike sounds. The DNN model returns a confidence score between 0-1 that a strike is present for each window. Model performance metrics vary based on the confidence threshold selected for an analysis. A receiver operating characteristic (ROC) curve was used to evaluate model performance at different confidence thresholds, and we selected a confidence threshold for our analysis based on a value that balanced the desire for high sensitivity (detection of a high percentage of strike sounds available for detection) and high accuracy (a low number of sounds incorrectly identified as strike sounds). At the chosen threshold of 0.006, the DNN model detected 16 of 23 (sensitivity: 69.6%, accuracy: 0.6%) collisions in the test data. At that threshold, the model classifies 99.29% of the test dataset (over 386,000 2-second clips) as not containing a collision sound, with an accuracy of 99.998%. If the performance of the acoustic method was evaluated as a whole (DNN Detections/Total Observed Strikes) the survey method identifies 16 of 32 strikes (sensitivity: 50%).

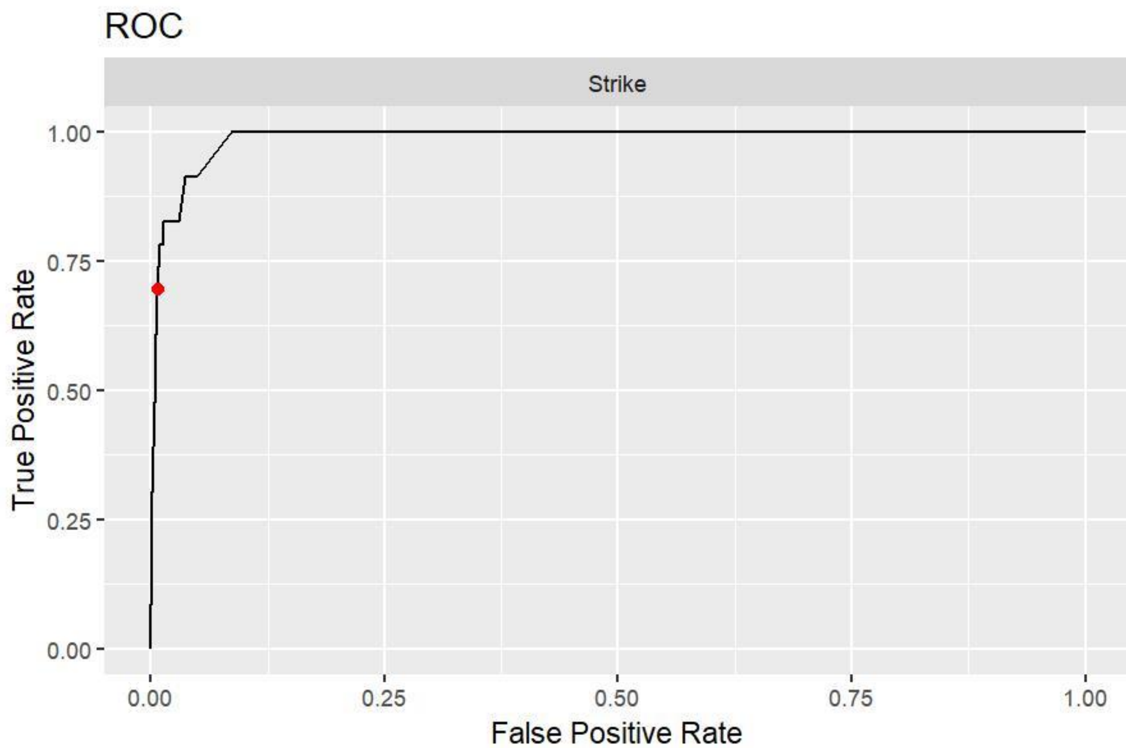


Figure 1:ROC curve for Strike classification model. The red dot represents the DNN confidence threshold selected for our analysis.

CMI Channel selection

Song meter sensors are equipped with two microphones (left and right) that record acoustic data in stereo. During our initial data ingestion process, we split those stereo files into their component channels (*See above*). We then chose only one channel from each recording to analyze for collision sounds. This decision was sometimes based on UMP's guidance (i.e. when UMP utilized two different microphone types for the purposes of a specific equipment test or if there was a clear problem with one microphone). When channel selection wasn't specified by UMP (which was the majority of recordings) we conducted our own assessment of recording quality; using long-form spectrograms and metrics of microphone sensitivity to select the channel with the best quality data.

CMI Auditing - manual review of events of interest

We applied our DNN classification model to all acoustic data received to predict clips containing potential strike sounds, or "events of interest". We then manually reviewed all events that are assigned confidence score above our threshold (0.006). All acoustic "events of interest" occurring in the sensor channel selected for analysis are then reviewed by a human analyst. We call this quality assurance/quality control (QA/QC) review process "auditing". A 16-panel browser screen in CMI's Auditor software enables the analyst to rapidly assess presence/absence of strike sounds in spectrograms of each event of interest – both visually and by listening to the sound (either the 2-second clip, or a longer section of recordings where context is needed). All potential strike sounds were labeled as either strikes or not-strikes by the analyst. As a final QA/QC step, all strike sounds tagged by the analyst were reviewed by a senior CMI staff member to confirm the classification. This two-step process removes all false positive detections predicted as possible events by the DNN. The end result is that all collision sounds positively identified through this process have been manually reviewed by two people to confirm that they meet the criteria of a strike sound - as identified and recorded by UMP field staff.

Data Exclusions

For this analysis, we removed acoustic data from experimental monitoring methods (e.g. SM4, Vibration sensors), and field experiments such as LASER nights, white Light nights, and diverters. We excluded acoustic data collected outside of the night period and for the first half hour after dark and the first half hour before dawn. Removal of the first and last half-hours is a conservative approach, as seabirds do fly with risk in these time windows and the strike patterns detected in these windows match that of seabirds and not other species. However, there is elevated risk that other species could also hit wires during this time period. To reduce the concerns of some reviewers we have removed these collisions. We also removed all acoustic data from areas where we have discerned through years of research that acoustic sensors were not functioning and predicted strikes within these areas using the model parameter estimates. Using BRS data, we determined that there is a 0% chance of detecting a strike sound in the areas KR, KT, WC on the east side, and in area HW on the west side. These areas had ambient noise levels that resulted in a detection rate of zero BRS strike sounds. These are areas we have highlighted in past years as having zero strikes but have dead seabirds under wires (see previous UMP Annual Reports). Removing these data specifically from the Kealia area, also address the issue of the fiber-optic cable. Fiber-opitic cable does not produce a strike sound and thus results in underestimating of strike acoustically. We have not made any adjustment for the fiber-optic cable in the lines running from Ele'ele to Kapaia power plant, which will result in an underestimate for these lines. Lastly, for the current model run, we have elected to be conservative and exclude Waimea Canyon acoustic data because we determined there was a discrepancy with this data when compared to the observational data. In this region, the acoustic data indicated a higher strike rate than did the observation results and to date we have no studies to determine why this would be the case. Since 2017, UMPKESRP has recommended multiple methods to examine the strike rate more closely for this region but due to funding decisions we could not undertake these studies.

Data Analyses Overview

We used a Bayesian hierarchical modeling framework to estimate the annual rate of bird–powerline collisions based on data from acoustic sensors. To accommodate the large volume of data collected from acoustic sensors deployed over many spans and sample periods, we used a tiered analytical approach consisting of 4 steps: 1) We use a sub-sample of data from representative spans for each region to estimate generalized patterns of temporal variation in strike rates. We account for two temporal scales of variation, seasonal (variation across weeks) and diel (variation across 15-minute time steps), and we allow for temporal autocorrelation at both scales; 2) We use a sub-set of data from well-sampled spans to estimate the effect of acoustic signal quality on the likelihood of strike detection; 3) We sequentially step through each sampled site (i.e. an acoustic sensor deployed at the intersection of two adjacent spans) and use all available data to estimate the mean annual number of strikes, accounting for the effects of temporal variation (using the generalized temporal effect estimate from step 1 as a prior for local temporal effects), lunar illumination and fluctuations in acoustic signal quality; and 4) Using the mean annual strike rate estimates for sampled spans as a dependent variable, we use MCMC methods to fit a generalized linear mixed effect model (GLMM) estimating annual strike rate as a function of environmental, geographic and structural covariates, while allowing for random effects (unexplained variation) among regions and spans. We then apply this model to predict annual strike rates for all spans on Kauai, as well as associated estimation uncertainty. We explain each of these analytical steps in the following sections.

Step 1: Generalized Patterns of Temporal Variation

The rate of powerline strikes by seabirds at any given span is not expected to be constant, but rather to vary temporally as a function of changes in the relative abundance and behavior of birds. For example, more birds are likely present at some points of the year and/or times of night, potentially resulting in more strikes, and the strike rate can also change depending on behavioral attributes such as relative flight height with respect to wire spans. Accounting for this temporal variability is necessary to allow for meaningful comparisons of strike rates among spans, or extrapolation of rates across an entire season, while controlling for confounding effects of seasonal and diel variation. We note that it would be less critical to account for temporal variability if all spans were sampled evenly across all days of the year and all times of night, but such uniform sampling is rarely possible.

For analytical tractability we identified two distinct time scales for evaluating temporal variation in strike rates. Specifically, we discretized time into intervals of one week (w = 1, 2… W) for evaluating seasonal effects, and intervals of 15 minutes (q = 1,2… Q) for evaluating diel effects. Exploratory analysis of pilot data suggested that these intervals were appropriate for capturing meaningful patterns of variation at the relevant scales, while still ensuring that time steps were functionally independent. In the case of diel effects, we recognized that biologically meaningful patterns of variation in bird behavior are best described with respect to solar time (sunset and sunrise) rather than a fixed 24-hour clock. In particular, for the first half of the night it is convenient to describe variation in bird activity (and thus strike frequency) with respect to the time elapsed since sunset, while for the second half of the night we can describe variation in bird activity with respect to the number of minutes before sunrise. Assuming that we are interested in describing behavior (and thus powerline strikes) from 30 minutes after sunset to 30 minutes before sunrise, then for nights around summer solstice there are Q = 38 timesteps (9.5 hours) of interest. We can describe q = 1–19 in terms of minutes after sunset (with q = 1 starting at 30 minutes after sunset) and q = 20–38 in terms of minutes before sunrise (with q = 38 ending at 30 minutes before sunrise). However, as one moves backward and forward in the season away from solstice the total night duration increases: we allow for this by having an extendable "middle-of-night" period, and classify all 15-minute intervals in the middle of the night as q = 19 (recognizing that this results in a disproportionally larger number of records for q = 19) This adjustment is reasonable because there tends to be less bird activity (and thus less variability) in the middle of the night. We keep track of the number of additional minutes of q=19 to account for each week and incorporate this adjustment into our calculations of total seasonal strike rates (see below).

In addition to discretization of time at multiple scales, there are several challenges inherent in measuring and describing temporal variation: these include autocorrelation of strike rates between time-steps, non-linear patterns of variation, and interactions between the seasonal and diel time scales (i.e. the functional form of diel effects can vary over the course of the season). Conditional Autoregressive (CAR) models have become a widely used approach for describing complex patterns of variation in a parameter of interest that is autocorrelated across time or space (Besag 1974, Banerjee et al. 2003, Gelfand and Vounatsou 2003). CAR models are an effective means of incorporating temporal correlations into an analysis, particularly in Bayesian models where they require estimation of only a few additional parameters (Lee 2011), and they can be adapted for univariate or multivariate non-linear effects. For our model we wished to describe patterns of variation and autocorrelation in relative strike rates across two temporal dimensions, corresponding to the seasonal and diel timescales. Our specific objective was to estimate a temporal effects matrix, **T**, having dimensions W (number of weeks) and Q (number of quarter-hour timesteps), whose cell values $\gamma_{w,q}$ describe the log ratio of the mean strike rate in week w and timestep q relative to the average rate over all weeks and timesteps. To accomplish this we utilized a CAR model designed to estimate correlated variation in a variable of interest over two dimensions, following the specific formulation described by Liu et al. (2017) based on a generalized multi-dimensional CAR model (Stern and Cressie 1999). We model variation in $\gamma_{w,\mathbf{v}}$, where **v** represents vector [q(1), q(2)… q(Q)], using the following autoregressive structures:

$$\gamma_{1,\mathbf{v}} = \phi_{1,\mathbf{v}} \tag{1}$$

$$\gamma_{w,\mathbf{v}} \mid \gamma_{w-1,\mathbf{v}}, \rho_w = \rho_w\left(\gamma_{w-1,\mathbf{v}}\right) + \phi_{w,\mathbf{v}}, \quad \textit{for } w = 2,3\ldots W \tag{2}$$

$$\phi_{w,\mathbf{v}} \sim \textit{multivariate normal}\left(0, \Sigma\right) \tag{3}$$

$$\mathbf{\Sigma} = \sigma_\gamma^2 \cdot \textit{inverse}\left(\mathbf{D} - \rho_q \mathbf{G}\right) \tag{4}$$

Equation (2) describes the temporal autocorrelation component for seasonal effects, and follows a standard "AR(1)" autoregressive model formulation (Brockwell and Davis 2016). The value of $\gamma_{w,\mathbf{v}}$ depends (in part) on the value of $\gamma_{w-1,\mathbf{v}}$, with the strength of the correlation determined by fitted parameter ρ_w.

Equation (3) describes the temporal autocorrelation component for diel effects, and follows a conditional autoregressive distribution (Besag 1974): $\phi_{w,\mathbf{v}}$ is a random vector ($\phi_{w,1}$, $\phi_{w,2}$ … $\phi_{w,Q}$), the joint distribution of which is multivariate normal with mean 0 and variance-covariance matrix $\mathbf{\Sigma}$. Equation (4) describes the computation of the variance-covariance matrix, $\mathbf{\Sigma}$: the magnitude (scale) of variation is determined by the fitted parameter σ_γ, while the degree of correlation across timesteps is determined by correlation coefficient ρ_q. The remaining variables in equation (4), **D** and **G**, represent square matrices with dimension Q: the elements of **G** ($g_{q,q'}$) are equal to 1 if timestep q occurs immediately before or after timestep q' (i.e. they are sequential) and 0 otherwise, while the elements of **D** ($d_{q,q'}$) are equal to 0 for all elements except the diagonal and the q^{th} diagonal element gives the number of sequential timesteps for q (1 for q = 1 and q = Q, 2 for all other time steps).

To estimate generalized patterns of temporal variation in strike rate (for use as a prior for temporal effects at individual spans), we selected a sub-set of representative sites for which there were abundant data collected across the entire season over multiple years. To ensure even geographic representation, we selected from each of 7 regions the two sites having the largest sample size of acoustic records from multiple years and for all weeks between Apr 1 - Nov 30 (an acoustic record is defined as a 15 minute time step in which the number of detected strikes has been recorded). For each unique combination of site (i = 1, 2… S), week (w) and timestep (q), we tallied the number of acoustic records available ($R_{i,w,q}$) and the total number strikes detected in those records ($H_{i,w,q}$). The mean expected number of strikes at site i in week w and timestep q is calculated as:

$$\lambda_{i,w,q} = \exp\left(\zeta + \psi_i + \gamma_{w,q}\right) \cdot R_{i,w,q} \tag{5}$$

Where ζ gives the overall mean log strike rate (for these 14 sites), ψ_i is the log proportional deviation from the overall mean associated with site i (estimated as a hierarchical random effect drawn from a normal distribution with mean of 0 and standard deviation σ_i) and $\gamma_{w,q}$ is the average temporal effect for week w and timestep q (estimated using CAR methods as described above). We note that other fixed effects are expected to affect strike rate (including lunar illumination and fluctuations in signal quality), but while these effects are included in site-specific models (see below) we exclude them from this generalized model because, for this data-rich sub-set of sites, the large number of samples over multiple years for each week-timestep combination means that those other effects are effectively “averaged out”.
We treat $H_{i,w,q}$, the number of detected strikes, as our observed variable, assumed to be described by a negative binomial distribution that is related probabilistically to the mean expected number of strikes:

$$H_{i,w,q} \sim negative\ binomial\left(mean = \lambda_{i,w,q}, \nu\right) \tag{6}$$

where the inverse scale parameter υ determines the degree of over-dispersion in the recorded number of strikes per sample.

The observed variable $H_{i,w,q}$ constrains the possible values of unknown parameters in equations (1) – (5), allowing us to estimate posterior distributions for these parameters using standard Markov Chain Monte Carlo (MCMC) methods. We used vague prior distributions for all parameters (i.e., weakly informed based on biological feasibility but having no information specific to the analysis): a Cauchy prior (scale = 2.5) for ζ, half-Cauchy priors (scale = 2.5) for 0-bounded parameters σ_γ, σ_i and υ, and flat beta priors for 0-1 bounded parameters ρ_w and ρ_q (Gelman 2006, Gelman et al. 2008). We used R (R.Core.Team 2014) and Stan software (Carpenter et al. 2017) to code and fit the model, saving 20,000 samples after a burn-in of 5,000 samples. We evaluated model convergence by graphical examination of trace plots from 20 independent chains and by ensuring that Gelman-Rubin convergence diagnostic (Rhat) was ≤1.1 for all fitted model parameters. We conducted posterior predictive checking (PPC) to evaluate model goodness of fit, both by graphical comparison of the frequency distributions of empirical data vs. out-of-sample ("new") estimates, and by using the χ^2 statistic (sum of squared Pearson residuals for observed counts vs expected values) to compare fit of observed data and out-of-sample estimates (Gelman et al. 2000). We examined scatter plots of the posterior distribution of χ^2 scores for new vs observed data (in the case of well-fitting models, points in such a plot should be distributed around a line with slope 1) and we computed the associated "Bayesian-P" value (the proportion of new observations more extreme than existing observations; Gelman 2005, Ghosh et al. 2007), which should fall within the range 0.2< Bayesian-P <0.8 for a well-fit model. We summarized results graphically and by reporting the mean and 95% CI of parameter posterior distributions.

Step 2: Effect of Acoustic Signal Quality on Strike Detection

Acoustic recordings, combined with machine learning algorithms for detecting a signal of interest (in this case the sound of a bird-sized object striking a powerline), have been shown to be an effective and scalable method for monitoring the abundance and/or behavior of seabirds (Buxton and Jones 2012, Borker et al. 2014). One challenge inherent with acoustic detection of signals is that the quality of the acoustic recording is sometimes impaired (often as a function of environmental conditions such as wind and rain), such that the probability of signal detection declines as signal quality decreases. This can potentially lead to a bias, with lower levels of detection during times when the signal quality is impaired. Fortunately, there are several metrics of acoustic signal quality that together can be used as an index of relative signal quality, and thereby provide the ability to correct biases associated with poor signal quality. Signal quality metrics show predictable patterns under certain conditions (e.g. microphone failure, rain or water-logged microphones) that are associated with reduced probability of signal detection. The challenge for a given data set is thus to determine the relationship between signal quality metrics and detection probability.

To estimate the effect of acoustic signal quality on the likelihood of powerline strike detection, we first sub-sampled data from those sites that were recorded during the peak period of strike activity ($3<w<19$ and $26<q<32$, as determined from the generalized temporal matrix **T** described in the previous section) and for which at least one strike was detected. We then developed a conditional logistic regression model to estimate the effects of signal quality variables on the probability of strike detection. Specifically, for each detected strike we randomly selected 4 "matching" non-strike records from the same site during the same peak period (and having the same lunar illumination and set of environmental conditions): for H detected strikes, this resulted in a data set of $N = 5H$ records, with a mean expected strike probability of 0.2. These data were analyzed as a series of Bernoulli trials, in which the outcome of each record (Y = 1 for a strike, Y = 0 for no strike) was estimated as:

$$y_n \sim bernoulli\left(\theta_n\right) \quad (7)$$

where θ_n is the probability of that a strike occurs and is detected in record *n*, calculated as:

$$logit(\theta_n) = \kappa + \sum \alpha_j \cdot X_{n,j} \tag{8}$$

where κ determines the baseline strike probability for the sample and α_j is a vector of parameters associated with predictor variables X_j that potentially affect the likelihood that a strike is detected.

We next added a second observed data set to the model: for a sub-set of acoustic records that overlapped with visual surveys it was possible to compare observed strikes with their corresponding acoustic records to evaluate a) the average probability that visually-confirmed strikes were detected by the acoustic algorithm and b) the effect of signal quality metrics on this probability. For each of *c* = 1, 2… *C* visually confirmed strikes, we define z_c as a binary variable with value of 1 if the strike was detected by the acoustic recording and a value of 0 otherwise. These data were analyzed as a series of Bernoulli trials, in which the outcome of each record was estimated as:

$$z_c \sim bernoulli(\varphi_c) \tag{9}$$

and φ_n is the probability that a visually confirmed strike is detected in acoustic record *c*, calculated as:

$$logit(\varphi_c) = \alpha_0 + \sum \alpha_j \cdot X_{c,j} \tag{10}$$

where α_0 is a parameter specifying the baseline strike detection probability, α_j is the same vector of parameters defined for equation (8) and X_j are predictor variables that potentially affect the likelihood that a strike is detected.

There were 6 signal attribute metrics that we expected *a priori* to potentially provide information on the likelihood of a strike being successfully detected by an acoustic record: flux, flux sensitive, level, level absolute, click and burst. Unfortunately, the raw metrics were colinear to a certain degree and thus not fully independent. Moreover, the relationship between metrics and detection probability was not necessarily linear and there were potential interactions between metrics. To address the problem of collinearity we used principal components analysis (PVA) to collapse variation and obtain a smaller number of orthogonal variables (factors) that were linear transformations of the original signal attribute metrics. We used function “prcomp” in the stats library of R (R.Core.Team 2014), which utilizes singular value decomposition of the centered and re-scaled data matrix to produce orthogonal factors that were rotated functions of the original variables, centered on zero and with unit variance. The first 4 factors explained 96% of the variation in the raw signal attribute metrics, so we used these as predictor variables for equation (8). We also evaluated quadratic terms for each of the PCA factors as well as first-order interactions.

We used standard MCMC techniques to fit equations (7) - (10) to the observed data, with model fitting and evaluation methods identical to those described for the temporal effects model (see step 1, above). We evaluated alternative combinations of predictor variables, retaining those terms where the 90% credible intervals of the posterior distributions did not overlap 0, and we used the “Leave-out-one Information Criterion” (LooIC) to compare models with different combinations of predictor variables and select the best-supported model (Vehtari et al. 2017). With the best-supported model we drew from posterior predictive distributions of model parameters and calculated the predicted signal detection probability (SDP) associated with each 15-minute acoustic record (*a*) in the full data set:

$$SDP_a = logit^{-1}\left(\alpha_0 + \sum \alpha_j \cdot X_{a,j}\right) \tag{11}$$

We summarize graphically the distribution of SDP values and report the mean, standard error, and upper and lower 95% quantiles.

Step 3: Estimating Site-specific Strike Rates

The generalized temporal matrix (**T**) and the SDP estimates generated from step 1 and step 2 models were used as inputs for a site-specific model to estimate annual strike rates. The structure of the site-specific model is similar to the generalized temporal model of step 1, with the mean expected number of detected strikes at site *i* in week *w* and timestep *q* ($\Lambda_{i,w,q}$) calculated as:

$$\Lambda_{i,w,q} = \exp\left(\zeta + \psi_i + \overline{\gamma}_{w,q} + \gamma^*_{w,q}\right) \cdot R_{i,w,t} \cdot \overline{SDC}_{i,w,q} \cdot \Omega_{i,w,q} \tag{12}$$

where ζ is the overall mean log strike rate (as estimated in model step 1) and ψ_i is the log proportional deviation from the overall mean associated with site *i* (estimated as a hierarchical random effect drawn from a normal distribution with mean of 0 and standard deviation σ_i). Unlike equation (5), the temporal effect in equation (12) is divided into two components: $\overline{\gamma}_{w,q}$, which represents the generalized temporal effect common to all sites (as estimated in model step 1), and $\gamma^*_{w,q}$, which represents deviations from the generalized temporal effect that are specific to site *i* and is estimated using the CAR methods described in equations (1) - (4). By using this split formulation, we effectively treat the generalized temporal effect matrix as a prior, providing a reasonable baseline for those sites having low sample sizes or missing data from portions of the season. For sites having larger sample sizes and complete seasonal coverage, the sum of $\overline{\gamma}_{w,q}$ and $\gamma^*_{w,q}$ produces a locally-specific temporal effects matrix. The last 3 terms in equation (12) represent sample-specific adjustment factors: $R_{i,w,q}$ is a multiplier that adjusts the per-capita strike rate for the number of observed records, $\overline{SDC}_{i,w,q}$ is the signal detection probability statistic (as estimated in model step 2) averaged over the sample of acoustic records for site *i* in week *w* and timestep *q*, and $\Omega_{i,w,q}$ adjusts for the effects of lunar illumination in week *w* and timestep *q*. This last term was included based on *a priori* knowledge that moon illumination can affect bird behavior and thus the frequency of wire strikes. To account for the effects of lunar illumination, the relative degree of moon illumination for each record was specified as the proportion of moon face illuminated (and forced to 0 when the moon was below the horizon). We then re-centered this variable such that the mean value across all timesteps within a single season was 0, and we define *MI* as the re-scaled moon illumination associated with a single acoustic record. We then computed the mean and standard deviation of *MI* for all records recorded at site *i* in week *w* and timestep *q* (designated as $\overline{MI}_{i,w,q}$ and $sMI_{i,w,q}$, respectively). Finally, we calculate the moon illumination adjustment factor as:

$$\Omega_{i,w,q} = \exp\left(\overline{MI}_{i,w,q} \cdot \omega + 0.5 \cdot (sMI_{i,w,q} \cdot \omega)^2\right) \tag{13}$$

Where ω is a fitted parameter that accounts for the effects of moon illumination on strike rate.

For each site, i, and for each unique value of week and timestep, we tallied the number of acoustic records available ($R_{i,w,q}$) and the total number strikes detected in those records ($H_{i,w,q}$). For some sites a modification of the wire array (e.g. removal of the top wire) occurred part way through the sampling period: in these cases we partitioned the data into before and after the modification event (treatment), and consider each of these data sets as separate "sites" for the purpose of estimating strike rates before vs. after the treatment. We treat $H_{i,w,q}$, the number of detected strikes, as our observed variable, and we assumed it was described by a negative binomial distribution related probabilistically to the mean expected number of strikes:

$$H_{i,w,q} \sim negative\ binomial\left(mean = \Lambda_{i,w,q}, \nu\right) \tag{14}$$

where the inverse scale parameter υ determines the degree of over-dispersion in the recorded number of strikes per sample. The observed variable $H_{i,w,q}$ constrains the possible values of unknown parameters in equations (12) - (13), allowing us to estimate posterior distributions for these parameters using standard Markov Chain Monte Carlo (MCMC) methods. Model fitting and evaluation methods were identical to those described for the generalized temporal effects model (see step 1, above).

The posterior predictive distributions of fitted parameters were then used to estimate annual strike rates for each site, Y_i. We first created an index vector t representing all combinations of w and q, iterated so as to create a complete and ordered temporal sequence for all days over all weeks of a season from Apr 1 - Nov 30 (and accounting for variation in night duration via the extendable "middle-of-night" period, as described in step 1). We used this index vector to estimate the expected sum of strikes over an entire season:

$$Y_i = \exp\left(\zeta + \psi_i\right) \cdot \sum_{t}^{T} \exp(\overline{\gamma}_t + \gamma_t^*) \tag{15}$$

In comparing equation (15) to equation (12), we note that the terms adjusting for signal quality and number of records have dropped out, as we are now interested in "true" number of strikes rather than detectable strikes, and we assume just one record per unique value of t. Similarly, the term for moon illumination effect is dropped from equation (15) because the re-centered moon illumination variable *MI* results in an average seasonal moon effect value of 0. The posterior distribution for Y_i therefore represents our expectations (and associated uncertainty) about the average annual number of strikes at a given site and wire-array configuration. We use this posterior distribution as the "observed data" input for the final model step.

Step 4: Predictors of Strike Rate and Island-wide Estimate

We can express the expected annual number of strikes at a given span as a generalized linear mixed-effects model (GLMM), whereby the log of the mean expected value is an additive linear function of several fixed effects (corresponding to geographic, environmental and/or structural covariates) as well as a random effects that account for unexplained variation among regions and spans-within-regions. Specifically, if we define $Yexp_s$ as the expected mean annual number of strikes at span i, then:

$$\log(Yexp_s) = \xi + \sum_k X_{k,s} \cdot \beta_k + \log(Lng_s) + \eta_{region|s} + \varepsilon_s \tag{16}$$

where the intercept parameter ξ represents the log mean value, X_k is a matrix whose columns consist of k predictor variables (normalized and re-centered to have mean of 0 and standard deviation of 1) and β_k is a vector of k fitted parameters that describe the effect of the predictor variables, Lng_s is the total length of span s (in units of 100m), η represents unexplained variance (random effects) associated with region (estimated as a hierarchical random effect drawn from a normal distribution with mean of 0 and standard deviation σ_r) and ε represents unexplained variance (random effects) associated with a given span (estimated as a hierarchical random effect drawn from a normal distribution with mean of 0 and standard deviation σ_s). We evaluated a variety of potential predictor variables, using an information theoretic approach to determine which fixed effects to include in the final model. Potential geographic predictor variables included distance from ocean (*dstoc*), distance to nearest known nesting colony (*dstcol*), mean angle or slope of the landscape between adjacent poles (*slp*), mean gradient of the landscape in the area surrounding the span (*grad*), and topographical position index (*tpi*, a neighborhood-based measure of local variability in elevation). Potential environmental variables included mean annual wind shear (*wshr*), mean annual windspeed (m/sec.) within 100m of the span (wnd^{100}) and mean annual windspeed within 30m of the span (wnd^{30}). Potential structural predictor variables included the number of wire layers (*wlyr*) mean height (m) above ground (*abgh*) for the top wire level within the array, mean exposure (*exmn*, where exposure is defined as the height difference between the top wire level in the array and the top of the tallest obstacle to flight), standard deviation in exposure (*exsd*), maximum exposure (*exmx*), the percent of the wire layer exposed (*pcex*), and the total height of the array (i.e. the height between the top and bottom wire layer) divided by the number of layers, which provides a measure of the space between wire layers (*sbwl*).

To estimate the parameters in equation (16) we summed the values of $Yexp_s$ for the two spans comprising each site to obtain a site-specific value ($Yexp_i$), which we could then compare to "observed" values represented by the posterior predictive estimates of annual strike rate by site (Y_i) based on acoustic monitoring data (model step 3). Because the posterior distributions of Y_i were well-fit by gamma distributions, we were able to use a limited vector of quantiles to capture the distribution of uncertainty in the estimated value of Y_i for a given span. Specifically, for each span we computed 11 evenly spaced quantiles between 0.05 and 0.95 from the posterior distribution of Y_i. We confirmed that the original posterior distribution could be well-approximated by fitting a gamma distribution to the vector of quantiles. The combined array of quantile values for all spans (designated as $y_{i(u)}$) was then treated as an observed data variable, assumed to be described by a gamma distribution that was related probabilistically to the expected strike rate

$$y_{i(u)} \sim gamma\left(shape_i = \left(Yexp_i \cdot \tau_i\right), \tau_i\right) \tag{17}$$

where the inverse scale parameter τ_i was estimated separately for each site to account for differing degrees of precision in estimates of Y_i. In this way, sites having greater sample sizes (and thus more precise estimates of Y_i) contributed more to the estimation of fixed effect parameters in equation (16).

We used standard MCMC techniques to fit equations (16) - (17) to the observed data, with model fitting and evaluation methods identical to those described for the temporal effects model (see step 1, above). We set vague priors for all parameters, including Cauchy priors for ξ and β parameters and half-Cauchy priors for σ parameters (scale parameter = 2.5 in both cases). The prior distribution for τ_i was a half-Cauchy distribution with scale parameter ι itself a fitted parameter with a vague normal prior. We evaluated all combinations of predictor variables, retaining those effects where the 90% credible intervals of the posterior distributions did not overlap 0, and we used the "Leave-out-one Information Criterion" (LooIC) to compare models with different combinations of predictor variables and select the best-supported model (Vehtari et al. 2017). We present goodness of fit statistics and credible intervals for parameters included in the final model.

Finally, drawing from the posterior predictive distributions of fixed effect parameters and random effects, we generated predictive distributions of $Yexp_s$ (mean expected annual strike rate) for all spans around the island. We noted that the site-specific estimates for sampled spans in Waimea Canyon appeared anonymously high relative to visual surveys. Accordingly, we relied on posterior predictive estimates of strike rates for all spans in the Waimea Canyon region, which resulted in lower, more conservative estimates for sampled spans.

Results

Acoustic data on powerline strikes were collected over 7 years, from 2013 – 2019, with sample sizes of 500 or more 15-minute recordings analyzed from each of 441 sites (882 spans) for a total of 902,520 data records. There were 7,339 bird strikes positively identified from these records, for an average strike rate across the entire power grid of 0.008 per 15-minute recording.

Step 1: Generalized Patterns of Temporal Variation

The model to estimate generalized patterns of temporal variation in strike rate converged well, with Rhat <1.1 for all parameters (Table 1). Posterior predictive distribution plots indicated excellent goodness of fit (Figure 3), with a Bayesian-P value of 0.42. While there was considerable variation in mean log strike rate among sites (see ψ random effect values, Table 1), seasonal and diel trends in the relative frequency of strikes exhibited clear patterns when averaged across sites (Figure 4). The average period where strike rates were generally highest was 30-90 minutes before sunrise between April 20 and September 20, although it should be noted that the highest strike rate period is very site specific and can vary dramatically across different portions of the power line grid.

Step 2: Effect of Acoustic Signal Quality on Strike Detection

Results from a principal component analysis (PCA) indicated that 4 orthogonal PCA factors captured 96% of the combined variation in 6 signal quality metrics (Figure 5a). Loadings plots indicated that level, level absolute and burst loaded heaviest on PC1, flux and flux sensitive loaded heaviest on PC2, click loaded heaviest on PC3, and burst loaded heaviest on PC4 (Figure 5b-d). These 4 PCA factors were included as predictor variables in a model estimating the probability of signal detection. This model converged well, with Rhat <1.1 for all parameters (Table 2). Posterior predictive distribution plots indicated excellent goodness of fit (Figure 6), with a Bayesian-P value of 0.48. The best-supported model included 6 predictor variables that had significant effects on signal detection (Figure 7): PC1 and PC2 were positively related to the likelihood of signal detection, PC3 and PC4 had negative effects on signal detection, and significant quadratic effects included $PC2^2$ and $PC3^2$ (which had negative and positive effects, respectively, on the probability of signal detection). Applying the fitted model to all data records produced an estimated average strike detection rate of ~60%, although the distribution of signal detection probabilities was highly skewed (Figure 8). The most common detection probability rate was in the range of 60-85%, but there was a long "left tail" of records having detection probabilities of 0-60%, reflecting poorer signal quality.

Step 3: Site-specific Strike Rates

We fit separate models estimating annual strike rates to data from 441 sites, representing 882 spans. Models converged well, with Rhat values <1.1 for all parameters estimated for all spans, and provided excellent goodness of fit: sample posterior predictive plots from representative spans (Figure 9) show a close match between observed and out-of-sample predictive distributions, with Bayesian-P values from posterior predictive checks close to 0.5 (Figure 10). The temporal matrices for individual sites were broadly similar, although there were some site-specific differences in the seasonal and diel timing of peaks in strike activity (Figure 11). Sites also varied in terms of the effect of moon illumination on strike rates (Figure 12), although most sites exhibited a negative relationship between moon illumination and strike rates. PL Trail was an exception, with more sites in this region exhibiting a positive relationship between moon illumination and strike rates (Figure 12).

The estimated annual strike rates differed considerably among sites, and the precision of estimates was generally greater for sites having more robust sample sizes (Figure 13). The overall distribution of estimated annual strike rates was skewed, with most sites having low estimated numbers (<10) but a few sites having relatively high numbers of strikes (100 or more; Figure 14). The estimated mean annual number of strikes per site (corresponding to current wire configurations) was 31.6, with a standard deviation of 76.5, a median value of 4.9 and a 95% CI of 1.96 – 247.5.

Step 4: Predictors of Strike Rate and Island-wide Estimate

The model analyzing predictors of annual strike rate converged well, with Rhat <1.1 for all parameters (Table 3). Posterior predictive distribution plots indicated excellent goodness of fit (Figure 15), with a Bayesian-P value of 0.496. The best-supported model included 6 fixed-effect predictor variables (Figure

16): strike rates tended to increase with distance to ocean (*dstoc*) and decrease with increasing gradient of the landscape (*grad*); there were more strikes for arrays having more wire layers (*wlyr*) although arrays having greater space between wire layers (*sbwl*) had fewer strikes; and strike rate was higher for arrays having a greater percent of the wire span exposed (*pcex*) and lower for spans having more variance in exposure height (*exsd*).

In addition to the above-described fixed effects, there was a substantial degree of variance in strike rate attributable to unexplained differences (random effects) among regions and among sites within regions, with site differences accounting for a larger component of variation (Figure 17). The region having the highest strike rates was the PL Trail. Applying a posterior predictive approach, we estimated annual strike rates for all spans: the cumulative mean annual number of strikes across all spans prior to wire modification was estimated as **18,956 (95% CI = 4,417– 56,903**)[2]. A map of the strike rate estimates shows that most areas have less than 20 strikes per year, with a few clear hot spots of strike activity occurring in PL TRAIL and CENTRAL regions (Figure 18).

Step 5- Estimating immediately grounded seabirds and species ratios

When seabirds collide with power lines the minimum immediate grounding rate has been calculated as 13.0%, while the upper bound is 22.8% (Travers et al. 2020). When these immediate grounding rates are applied to the 18,956 acoustic strikes the minimum and upper bound of immediately grounded birds is **2,464-4,321 per year**.

The seabird passage rate was used in the past to identify the species-specific ratio of collisions and mortalities. If we apply the 70/30 Newell's Shearwaters to Hawaiian Petrel passage rate ratio used in the past, the immediate grounding rate by species is **1,725-3,025 immediately grounded Newell's Shearwaters and 739-1,296 immediately grounded Hawaiian Petrels**. However, separate to the Bayesian model it should be noted that we are actively working on updating the species specific collision rate and will present those updated results when the updated analysis is complete.

Step 6- Minimizing seabird power line collisions

Given the very large numbers of seabird power line collisions illustrated by this model update, which is in line with previous KESRP take models (see previous Briefing Documents), mitigation alone is clearly not practicable for offsetting this level of take. This is true for the current minimum grounding estimate of 2,462 seabirds annually but was also true for all previous model estimates. The previous estimates

[2] Note this number was created using all data prior to any minimization. The number presented does not include reductions for Kahili Undergrounding and the static wire removal in the coffee fields. Furthermore, in the 2020 seabird breeding season, KIUC has started implementing larger scale minimization efforts than prior to 2020, by removing the static wire across multiple larger sections of wires.– see discussion below. With new measures in place, take estimates for 2020 will be lower.

(UMPKESRP 3 model amalgamation and the 3 versions of the FWS acoustic strike models from 2014, 2015, and 2016) considered fewer power line sections and had lower totals collisions, but each estimate also exceeded the available practicable mitigation options. As has been outlined in previous UMP Annual Reports and Briefing Documents, to mitigate for seabird power line collisions, power line minimization needs to be implemented in a manner that dramatically lowers the current level of collisions.

We have previously recommended several minimization actions that will help reduce seabird power line collisions to a level that can be mitigated. Before examining those options, we should first consider ideal minimization efficacy levels and the remaining mortalities for mitigation. If power line minimization targets of 80 or 90% reductions are achieved the required mitigation offset would be reduced to 492 or 246 seabirds annually, respectively. Certainly, the target goal of 90% minimization would reduce mitigation requirements (246 seabirds) to a level that is both practicable and financially feasible for KIUC. Minimization can be achieved through the following actions.

Static wire removal- We have previously reported estimates for several minimization actions. Static wire removal resulted in an estimated reduction of 36-72% depending on the terrain. Recent unreported observation work indicates that static wire removal could reduce strikes by as much as 78% on steel towers in flat terrain. Static wires are present in nearly all high strike locations and are geographically widespread and are therefore an ideal starting point for large scale geographic minimization[3].

LED Diverters- In discussion with researchers tackling powerline collisions in South Africa in early 2016, we were provided with unpublished information that LED diverters used in their work reduced avian collision rates at their study sites by more than 90%. If diverters were studied thoroughly on Kauai, diverters could also be implemented at a large geographic scale.

Power line reconfiguration- We have previously reported that wire modification plans put forward by KIUC in their first draft HCP produced in 2016, would lower collisions by 72-96% depending on the plan and the terrain. In the most challenging terrain, we have recommended that combining reconfiguration with the addition of static wire removal and or diverters would achieve significantly better reductions. Lastly, KIUC’s new seabird team has put forth a wire design called spacer cable. This construction uses insulated wires, which increases the diameter of the wires, and allows wires to be closer together and much lower on the poles. We have not yet been asked to estimate the benefit of this method, but our opinion is that any method that maximizes the lowering of wires will greatly reduce collisions. If the spacer cable is lowered to the level currently being discussed, we believe that spacer cable could also achieve greater the 90% collision reductions.

[3] In 2020 the new KIUC seabird team began large scale static wire removals at multiple high collision areas. At the time of writing, static wires have been removed in Kilauea, CP central region (previously in Ele’ele). Preparations are completed and static wire removal is about to begin in LC Central region. Once the third minimization action is complete KIUC will have partially minimization of 29.3 Kilometers of power lines in the beginning half of 2020. Prior to 2020, 8.4 Kilometers of power lines had been minimized. Lastly, the new KIUC team is developing plans for removing the static wire on the northern section of power line trail.

Maintenance of existing trees or promoting tree growth in a wire safe manner- In most areas trees that are taller than wires force bird to fly over wires, which would thus achieve 100% reduction when fully shielding wires.

Conclusion- As discussed above, achieving a 90% or greater seabird collision reduction should be achievable at power line sections on Kauai that are modified. High collision areas need to be modified immediately to minimize powerline collisions and bring the strike rate down to a level that can then be offset through mitigation actions such as predator control in colonies and the creation of fully protected areas surrounded by predator proof fences. Minimization needs to be implemented at a geographic scale that will reduce island-wide take to levels where mitigation will realistically offset take. While the modeled strike rates produced in this briefing document (and through previous models) are high, we believe that it is entirely possible and financially feasible to do this.

Tables

Table 1. Parameter estimates from model step 1. Hierarchical random effect values of ψ are shown for 14 representative sites (2 from each of 7 regions) selected for analysis of generalized temporal trends.

Parameter	*mean*	*sd*	*2.5%*	*50%*	*97.5%*	*Rhat*
ζ	0.193	0.606	-1.083	0.212	1.339	1.013
σ_γ	0.180	0.050	0.083	0.181	0.275	0.999
σ_i	2.162	0.565	1.336	2.072	3.516	1.002
υ	3.150	0.705	2.094	3.045	4.828	1.001
ρ_w	0.649	0.051	0.543	0.652	0.742	1.012
ρ_q	0.853	0.038	0.765	0.857	0.914	1.014
ψ*[1]*	1.972	0.593	0.854	1.951	3.233	1.012
ψ *[2]*	1.373	0.603	0.244	1.352	2.657	1.012
ψ *[3]*	1.323	0.600	0.185	1.296	2.594	1.012
ψ *[4]*	-0.018	0.653	-1.245	-0.034	1.345	1.010
ψ *[5]*	-1.950	1.005	-4.163	-1.881	-0.147	1.003
ψ *[6]*	-2.916	1.447	-6.268	-2.726	-0.673	1.003
ψ *[7]*	2.113	0.591	1.008	2.089	3.387	1.012
ψ *[8]*	2.449	0.591	1.334	2.426	3.716	1.013
ψ *[9]*	-2.546	0.983	-4.680	-2.488	-0.781	1.004
ψ *[10]*	-2.461	1.486	-5.946	-2.267	-0.145	1.001
ψ *[11]*	2.010	0.609	0.858	1.986	3.304	1.011
ψ *[12]*	0.520	0.637	-0.706	0.503	1.849	1.011
ψ *[13]*	-1.521	0.739	-3.001	-1.513	-0.063	1.008
ψ *[14]*	0.005	0.632	-1.194	-0.013	1.329	1.011

Table 2. Parameter estimates from model step 2. The fixed effect parameters affecting signal detection probability (α_j for J = 1:6) correspond to linear and quadratic effects of 4 PCA factors: PC1, PC2, PC3, PC4, $PC2^2$, $PC3^2$.

Parameter	***mean***	***sd***	***2.5%***	***50%***	***97.5%***	***Rhat***
κ	-1.969	0.087	-2.140	-1.970	-1.801	1.001
α_0	-0.632	0.190	-1.008	-0.632	-0.261	1.000
α_1	0.426	0.053	0.323	0.426	0.532	1.002
α_2	0.669	0.070	0.534	0.668	0.809	1.002
α_3	-0.392	0.126	-0.647	-0.389	-0.146	1.000
α_4	-0.722	0.107	-0.932	-0.722	-0.512	1.001
α_5	-0.042	0.027	-0.096	-0.041	0.009	1.001
α_6	0.057	0.024	0.009	0.058	0.101	1.000

Table 3. Parameter estimates from model step 4. The fixed effect parameters affecting signal detection probability (β_j for J = 1:6) correspond to predictor variables *dstoc*, *grad*, *wlyr*, *sbwl*, *pcex*, and *exsd*

Parameter	***mean***	***sd***	***2.5%***	***50%***	***97.5%***	***Rhat***
ξ	-0.341	0.476	-1.302	-0.337	0.524	1.005
σ_r	0.897	0.337	0.461	0.829	1.723	1.001
σ_s	1.169	0.044	1.087	1.169	1.256	1
ι	0.089	0.006	0.079	0.089	0.1	1
β_1	0.643	0.132	0.389	0.641	0.904	1.006
β_2	-0.096	0.094	-0.276	-0.094	0.09	1.009
β_3	0.179	0.06	0.06	0.179	0.296	1.01
β_4	-0.396	0.141	-0.675	-0.395	-0.12	1.009
β_5	1.205	0.342	0.533	1.207	1.878	1.013
β_6	-0.125	0.083	-0.288	-0.124	0.037	1.01

Figures

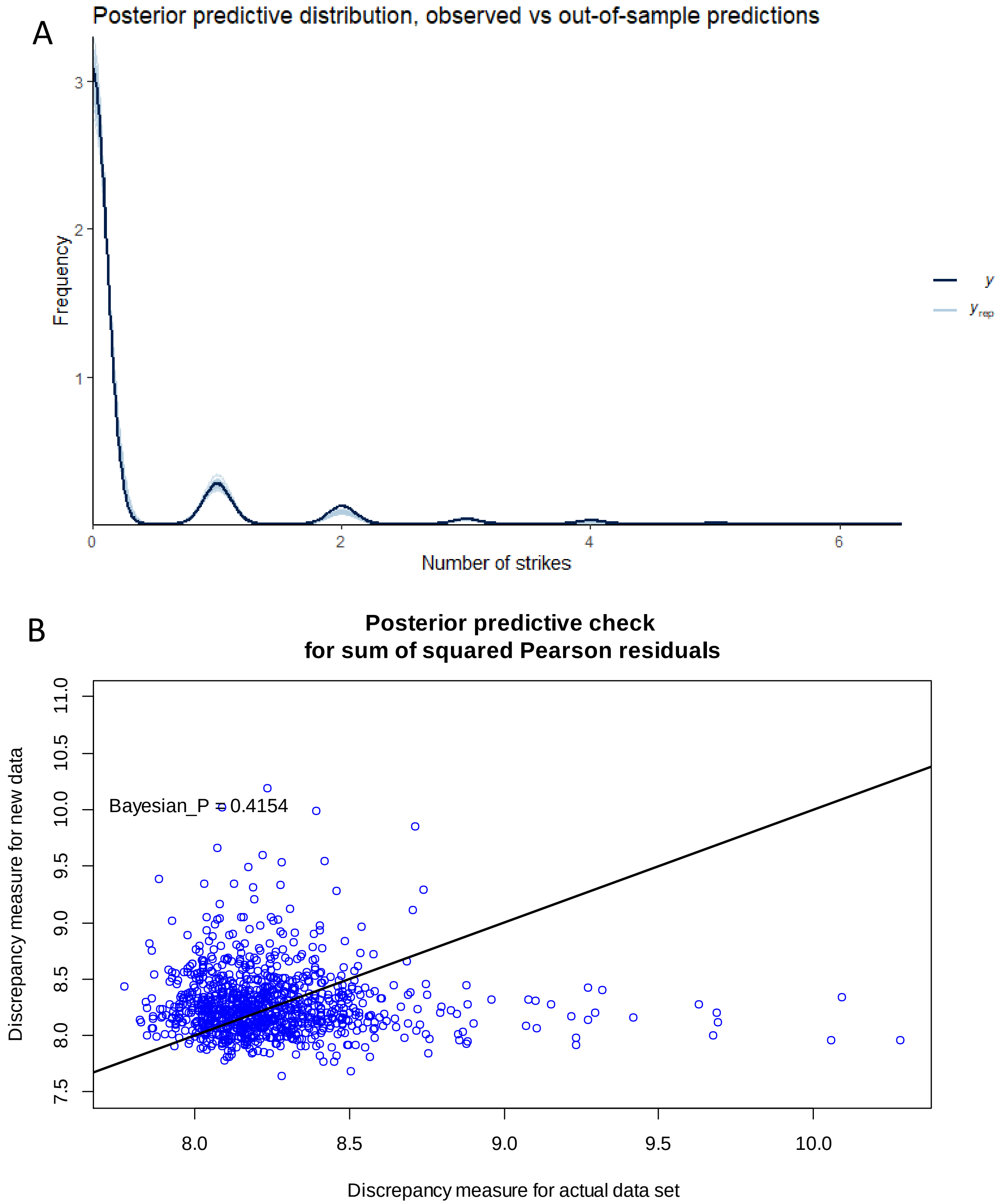


Figure 3. Posterior predictive plots for Bayesian model of temporal variation in strike rate. A) frequency distribution of observed number of strikes per sample (y = black line) and out-of-sample predictions (y_{rep} = grey lines), with the degree of concordance between distributions indicating goodness of fit ; and B) scatter plot of a discrepancy measure (squared Pearson residuals) for observed data vs “new data” (out-of-sample predictions) generated by model: clustering of values around a 1:1 relationship (solid black line) indicates a well-fit model, as quantified by a Bayesian-P value near 0.5.

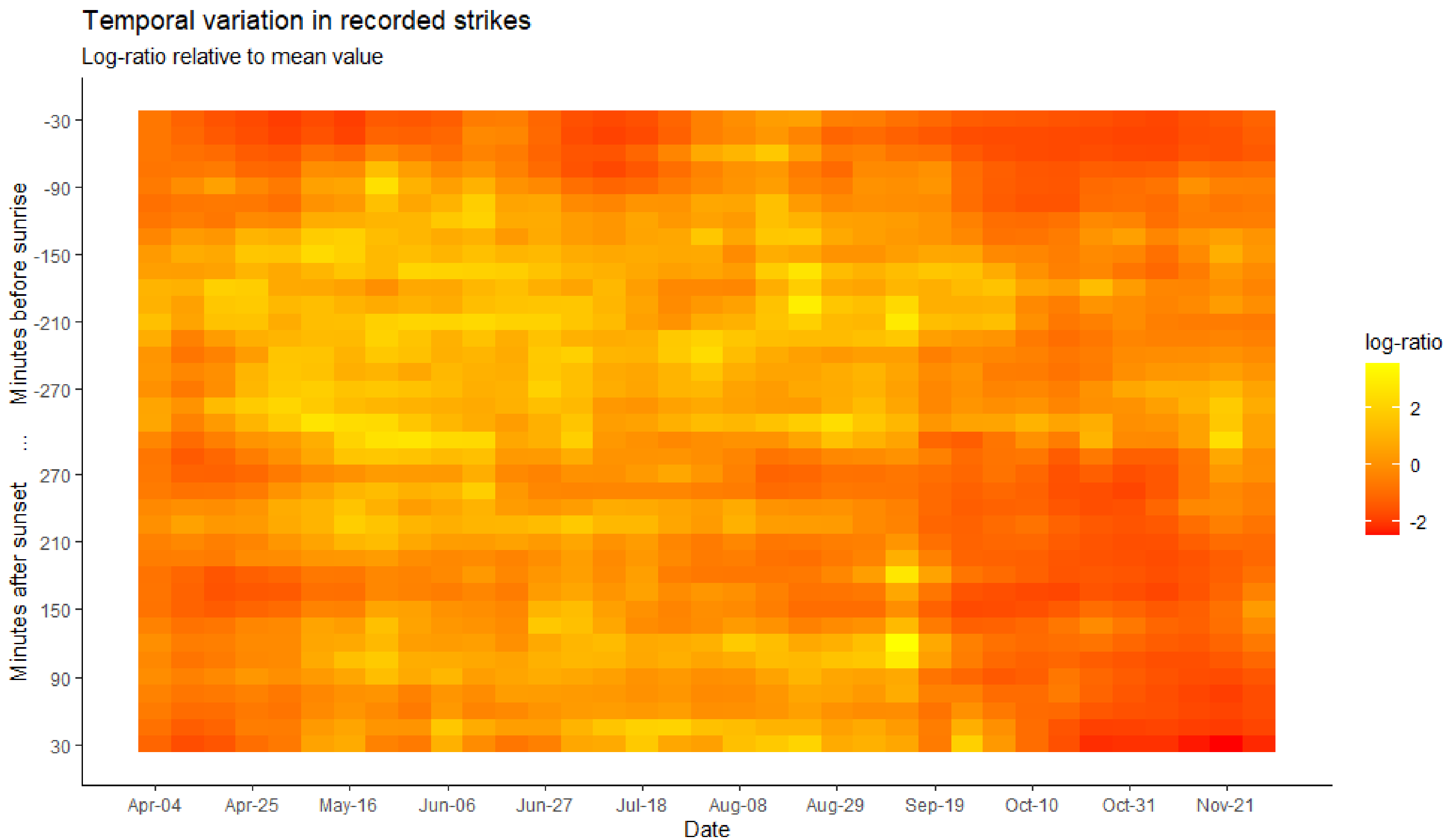


Figure 4. Heatmap plot of a temporal matrix (**T**) of the relative rate of bird strikes as a function of date of the season (x-axis) and time of night (y-axis). Colors show variaiton in the log-ratio relative to the overall mean, such that a value of 0 corresponds to the mean.

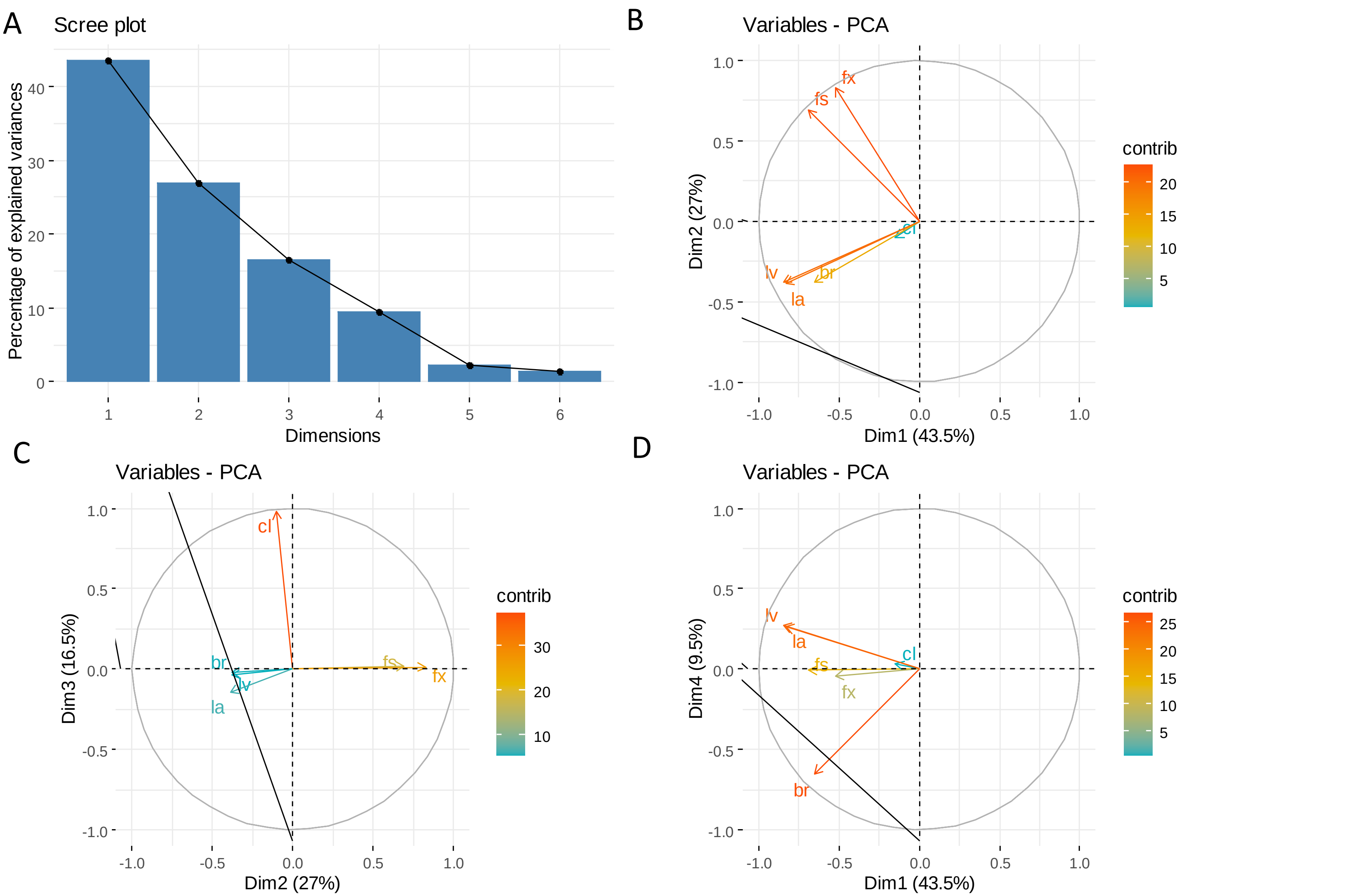
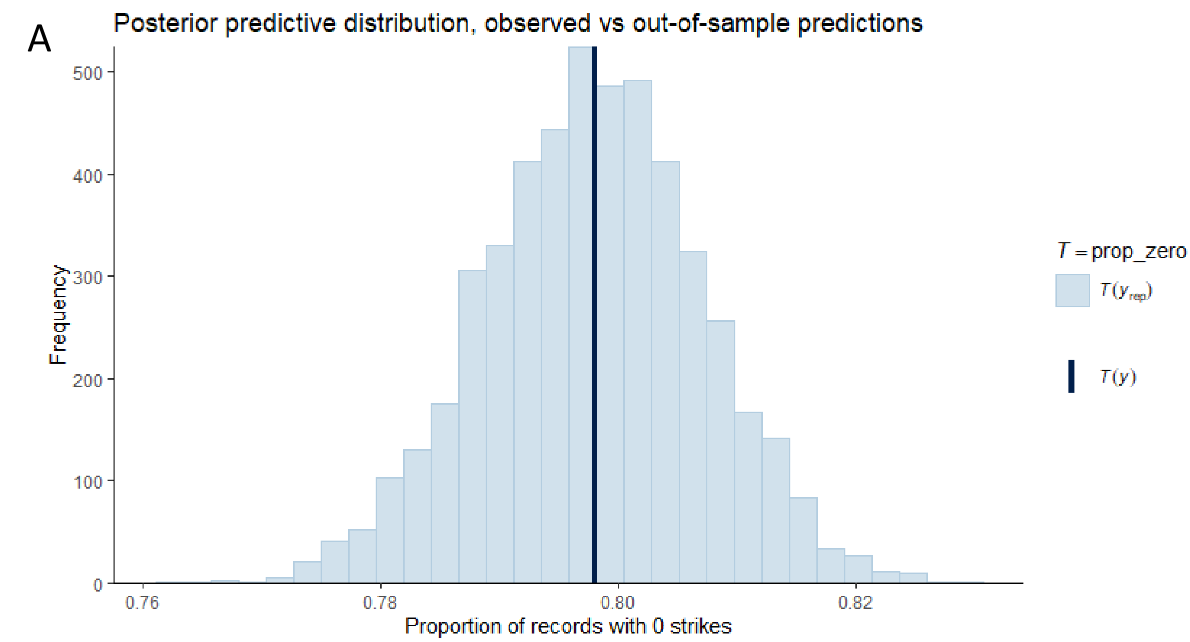


Figure 5. Graphical results from a principal components analysis (PCA) of 6 signal quality metrics: flux (fx), flux sensitive (fs), level (lv), level absolute (la), burst (br) and click (cl) . A) Scree plot showing the reletive amount of variation in the original 6 variables explained by each of the PCA factors (ordered). B) radial loadings plot showing the relationship betweeen the original variables (loadings vectors) and PCA factors 1 (x-axis) and 2 (y-axis); C) radial loadings plot showing the relationship betweeen the original variables and PCA factors 2 (x-axis) and 3 (y-axis); D) radial loadings plot showing the relationship betweeen the original variables and PCA factors 1 (x-axis) and 4 (y-axis). In plots B-D, the color of loadings vectors indicates their relative contribution to the PCA factors in the respective ordination.



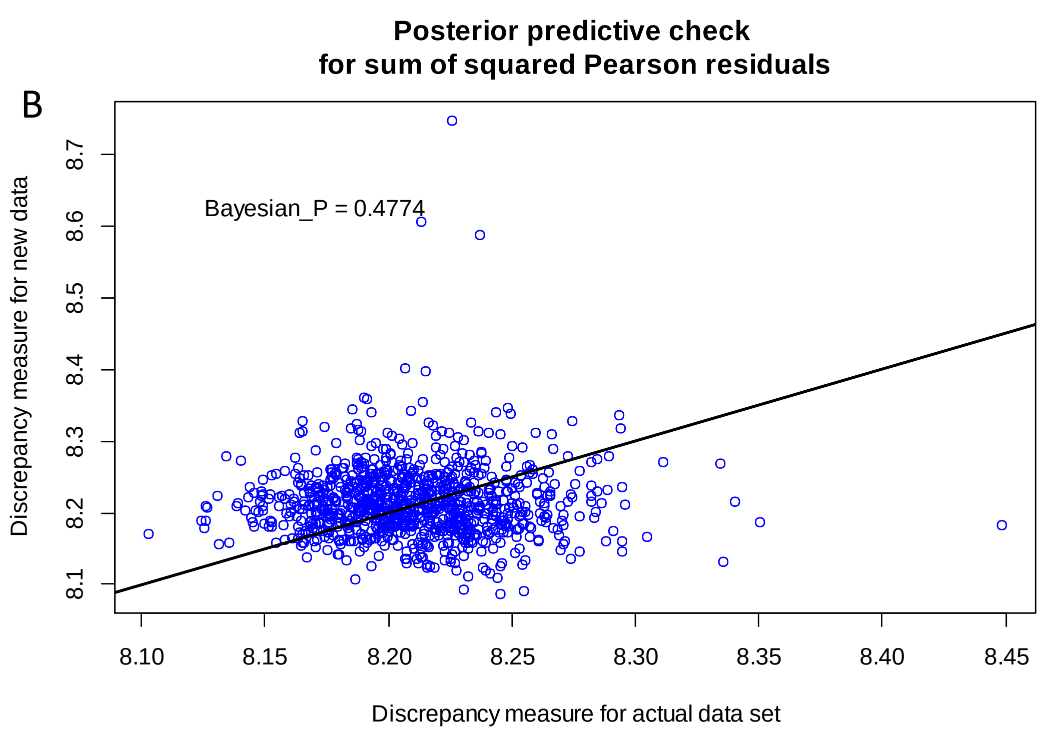


Figure 6. Posterior predictive plots for Bayesian model of signal quality effects on strike detection probability. A) frequency distribution of the proportion of out-of-sample model predictions where 0 strikes were detected (grey bars) as compared to the actual proportion of 0-detections in the observed data set (y = black line); and B) scatter plot of a discrepancy measure (squared Pearson residuals) for observed data vs "new data" (out-of-sample predictions) generated by the model: clustering of values around a 1:1 relationship (solid black line) indicates a well-fit model, as quantified by a Bayesian-P value near 0.5.

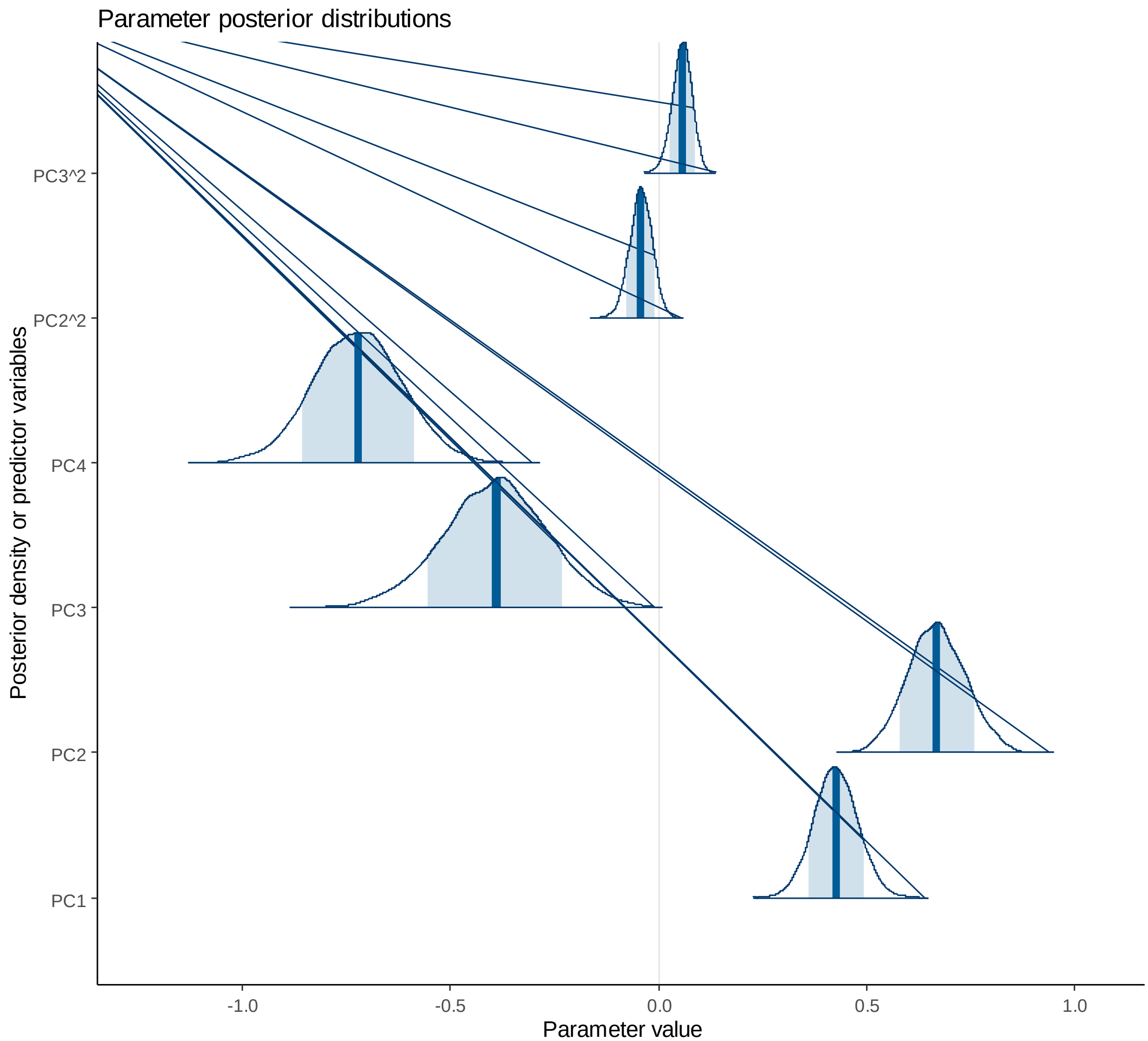


Figure 7. Posterior distribution plots for the parameters in a model predicting strike detection probability as a funciton of signal quality metrics. A PCA was used to collapse variaiton of raw signal quality metrics into 4 orthogonal PCA factors, and the parameters of the model correspond to linear and/or quadratic effects of these factors. Shaded area of each density distribution indicates the 90% CI, and the solid vertical line indicates the mean parameter estimate.

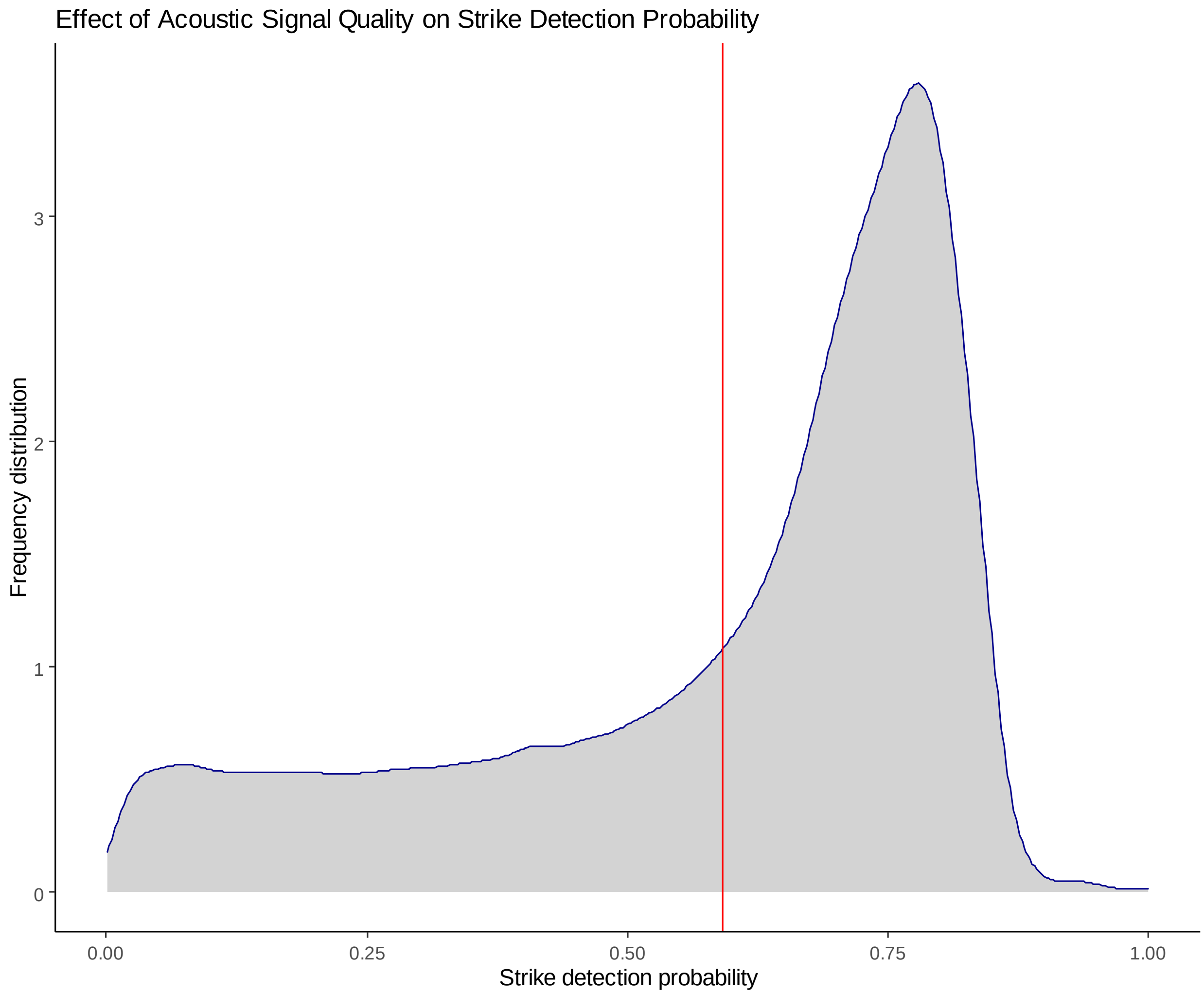


Figure 8. Density-distribution of the estimated strike detection probability for all acoustic records included in the analyses (N=902,520).

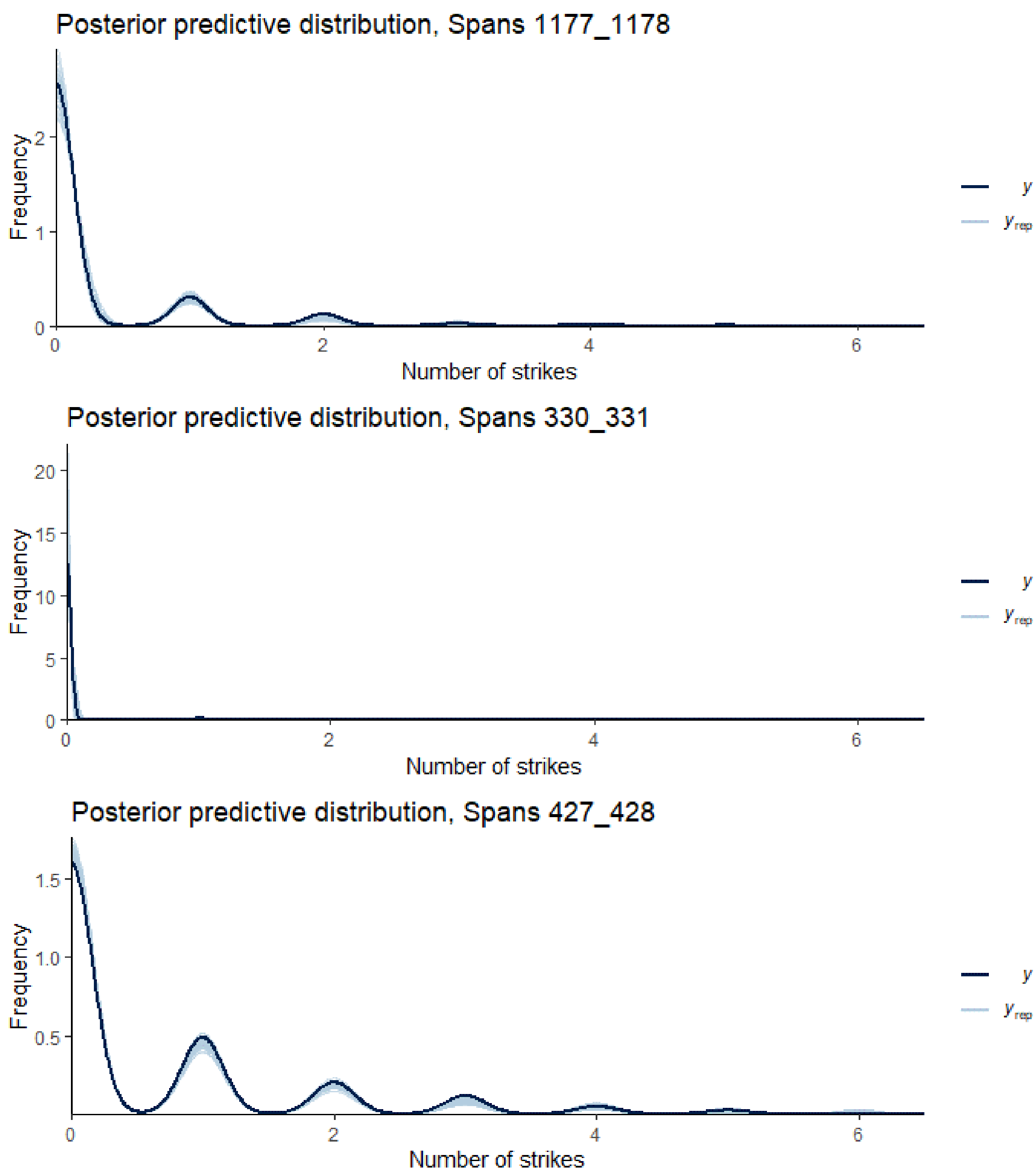


Figure 9. Posterior predictive plots for Bayesian model of site-specific annual strike rates, with each panel representing the results from an analysis of one site (2 spans) selected haphazardly. Plots show the frequency distribution of observed number of strikes per sample (y = black line) and out-of-sample predictions (y_{rep} = grey lines), with the degree of concordance between distributions indicating goodness of fit.

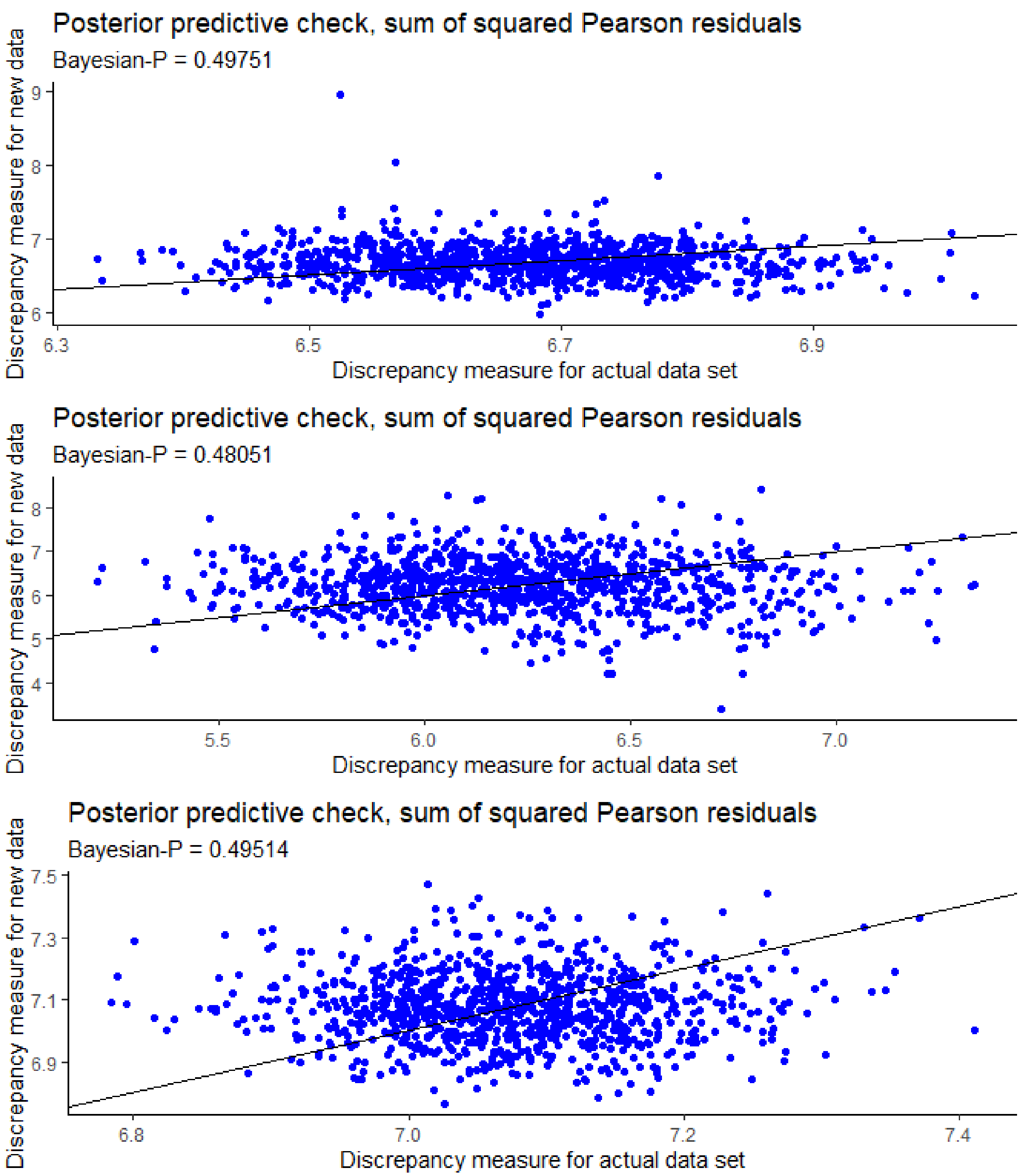


Figure 10. Posterior predictive plots for Bayesian model of site-specific annual strike rates, with each panel representing the results from an analysis of one site (2 spans) selected haphazardly. Scatter plots represent an ordination of a discrepancy measure (squared Pearson residuals) for observed data vs "new data" (out-of-sample predictions) generated by model: clustering of values around a 1:1 relationship (solid black line) indicates a well-fit model, as quantified by a Bayesian-P value near 0.5.

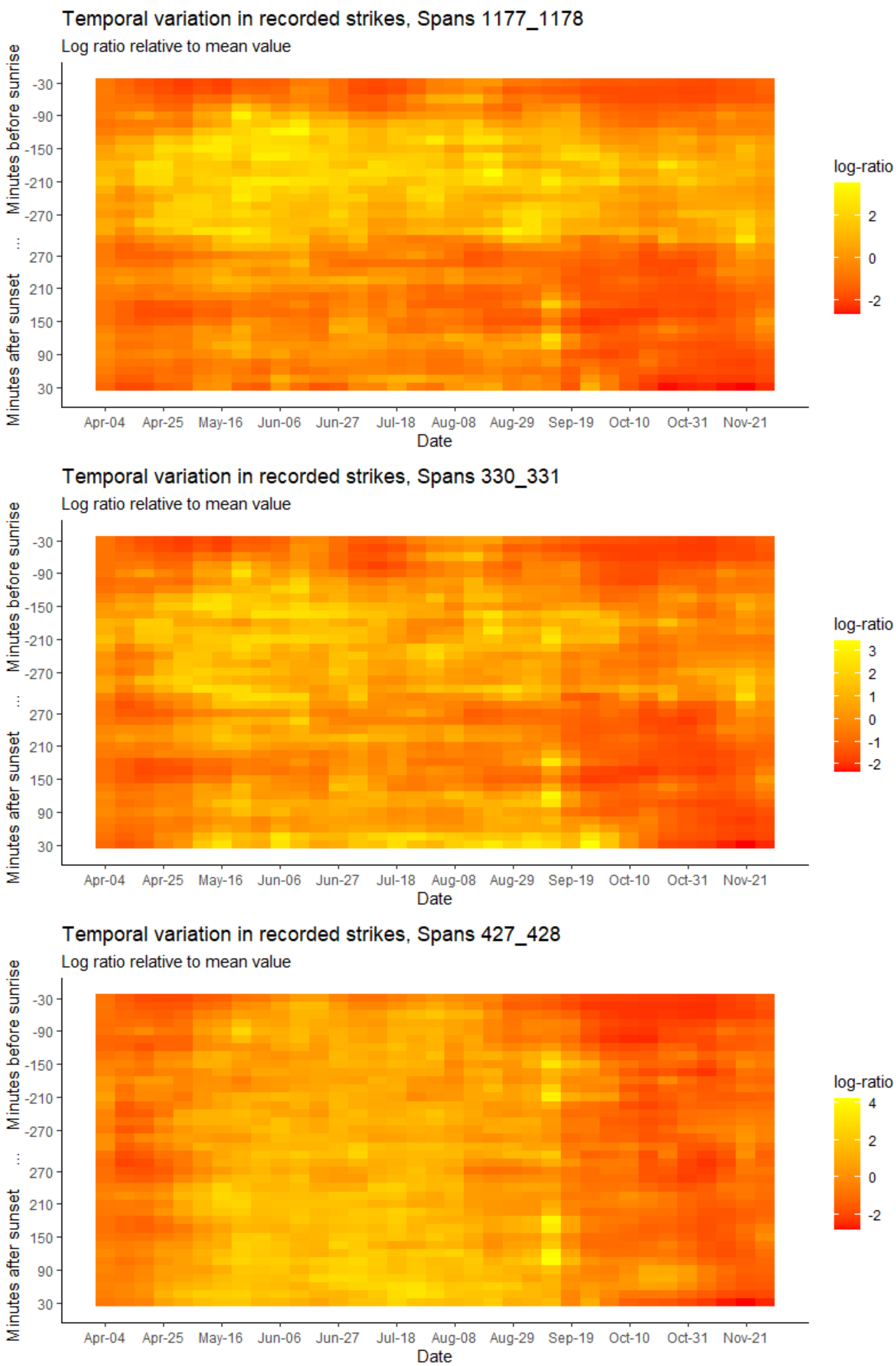


Figure 11. *Representative heatmap plots for 3 arbitrarily selected sites, showing variability among sites in the temporal matrix (***T***) of relative rate of bird strikes as a function of date of the season (x-axis) and time of night (y-axis). Colors show variaiton in the log-ratio relative to the overall mean, such that a value of 0 corresponds to the mean.*

Figure 12. Plot of the estimated values of parameter ω, the effect of moon illumination of strike rate, for each of the 441 sites analyzed, color-coded by region. Points represent the mean estimate of ω for each site (values <0 correspond to a negative relationship between moon illumination and strike rate) and dotted error bar lines show parameter uncertainty (± 1 standard deviation of posterior samples).

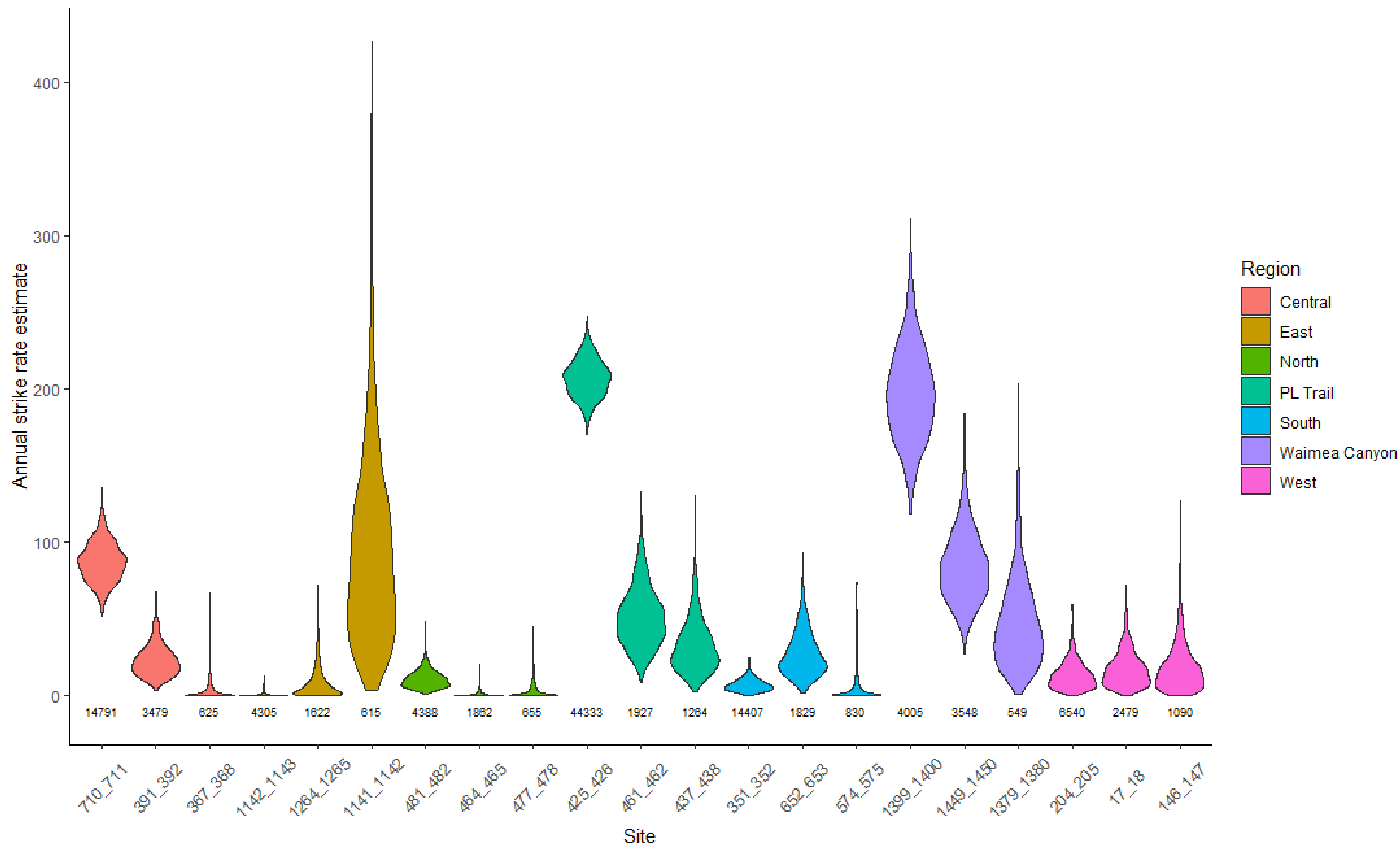


Figure 13. Violin plot of the posterior distributions of estimated annual strike rates for 21 randomly selected sites (3 from each of 7 regions). Site labels show the ID numbers of the two spans at each site, and the numbers below each violin are the sample sizes (number of 15-minute acoustic records) for each site.

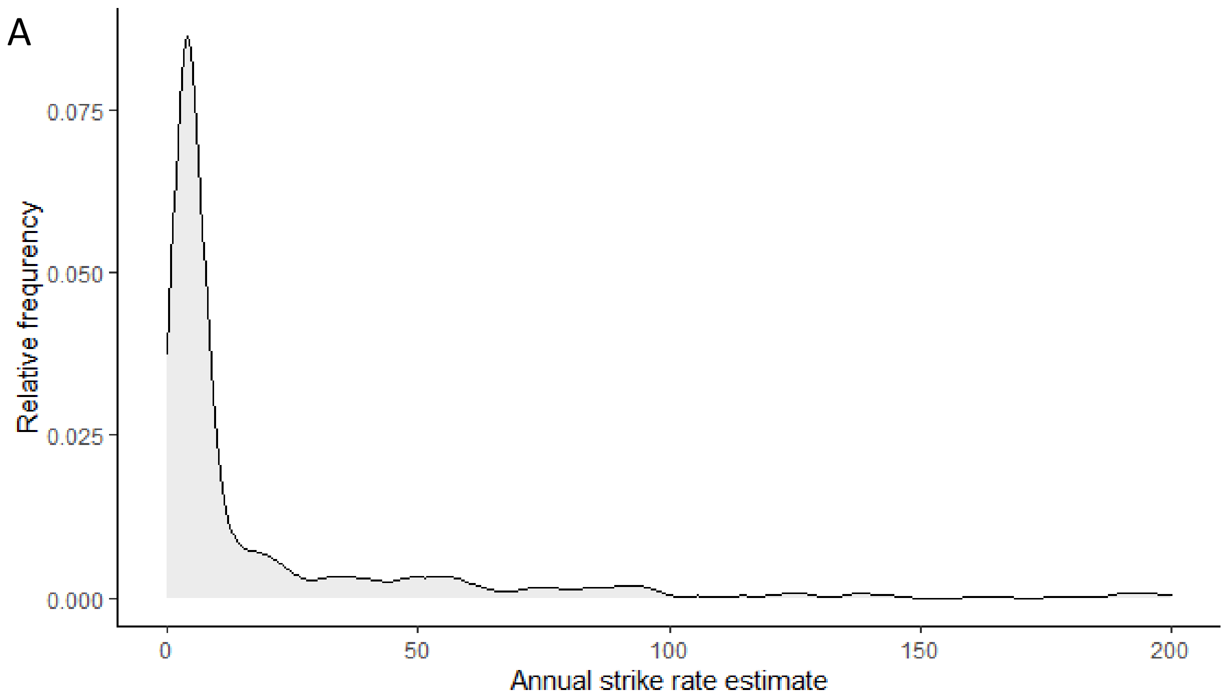


Figure 14. Results from site-specific analyses of annual strike rate. Density distribution of annual strike rate estimates across all 441 sampled sites.

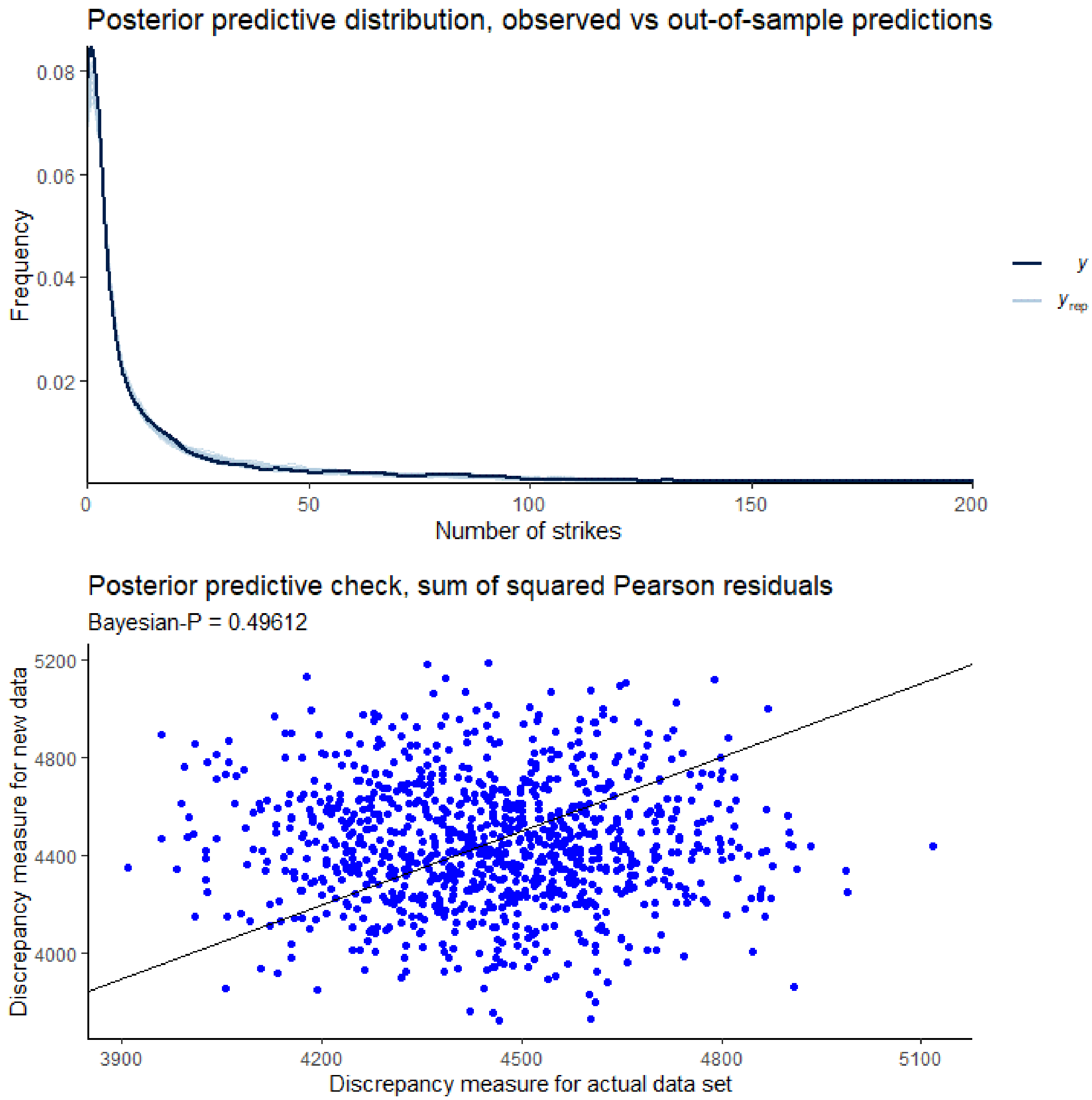


Figure 15. Posterior predictive plots for Bayesian model of the factors explaining variation in annual strike rate. A) frequency distribution of observed number of strikes per sample (y = black line) and out-of-sample predictions (y_{rep} = grey lines), with the degree of concordance between distributions indicating goodness of fit ; and B) scatter plot of a discrepancy measure (squared Pearson residuals) for observed data vs “new data” (out-of-sample predictions) generated by model: clustering of values around a 1:1 relationship (solid black line) indicates a well-fit model, as quantified by a Bayesian-P value near 0.5.

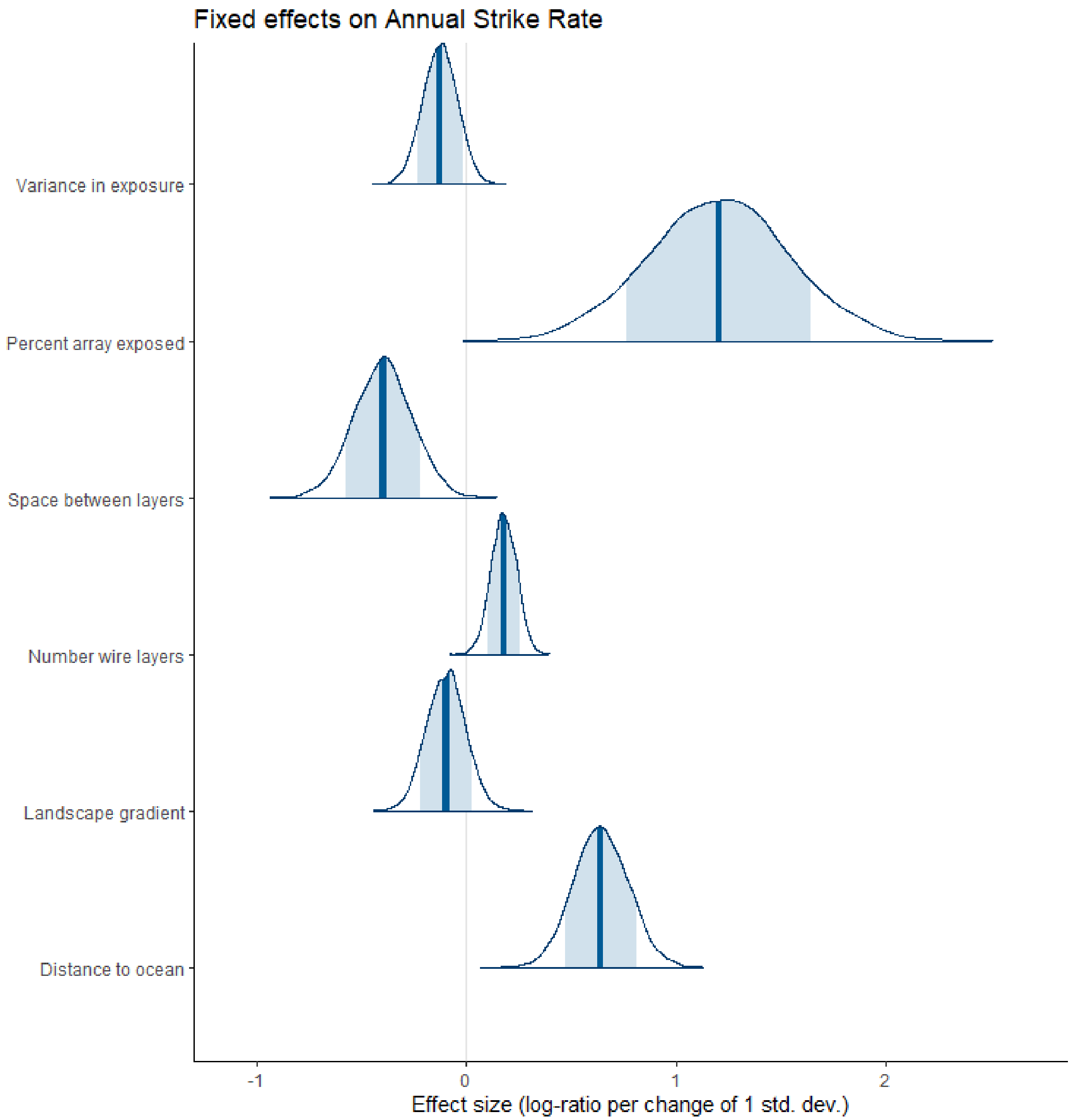


Figure 16. Posterior distributions for fixed-effect parameter estimates (β) from a Bayesian model examining the predictors of annual strike rate. The shaded area of each density distribution indicates the 90% CI, and the solid vertical line indicates the mean parameter estimate. An effect value of 0 indicates no effect of the predictor variable on annual strike rate, while values >0 indicate a positive relationship between the variable and strike rate.

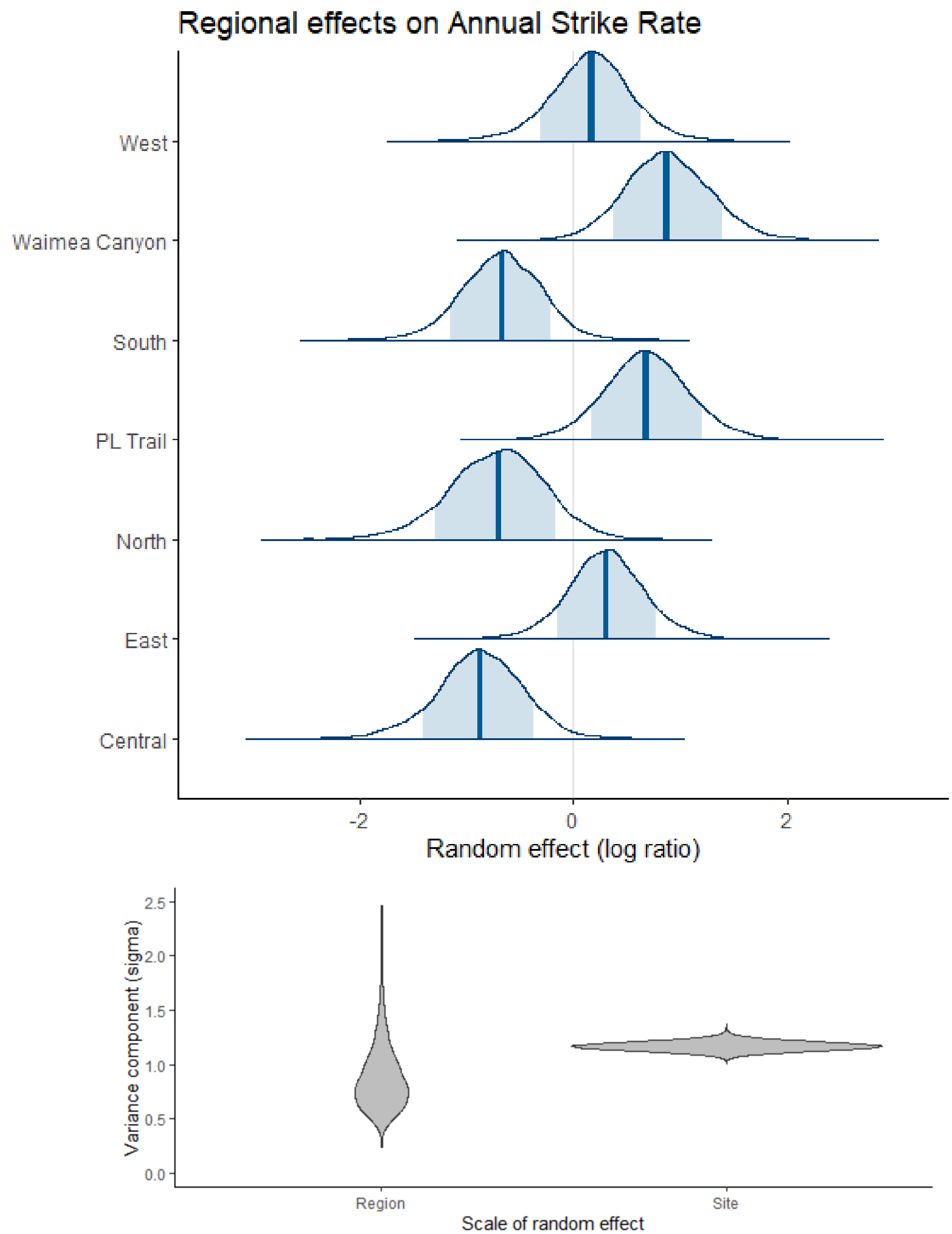


Figure 17. A) Posterior distributions of regional effects from a Bayesian model examining the predictors of annual strike rate. The shaded area of each density distribution indicates the 90% CI, and the solid vertical line indicates the mean parameter estimate. The vertical line (0) represents the average across all regions, while values >0 indicate a higher-than-average strike rate values for the indicated region. B) Violin plots showing the posterior distribution of estimated variance components (σ parameters) associated with unexplained differences among regions and unexplained differences among sites within regions.

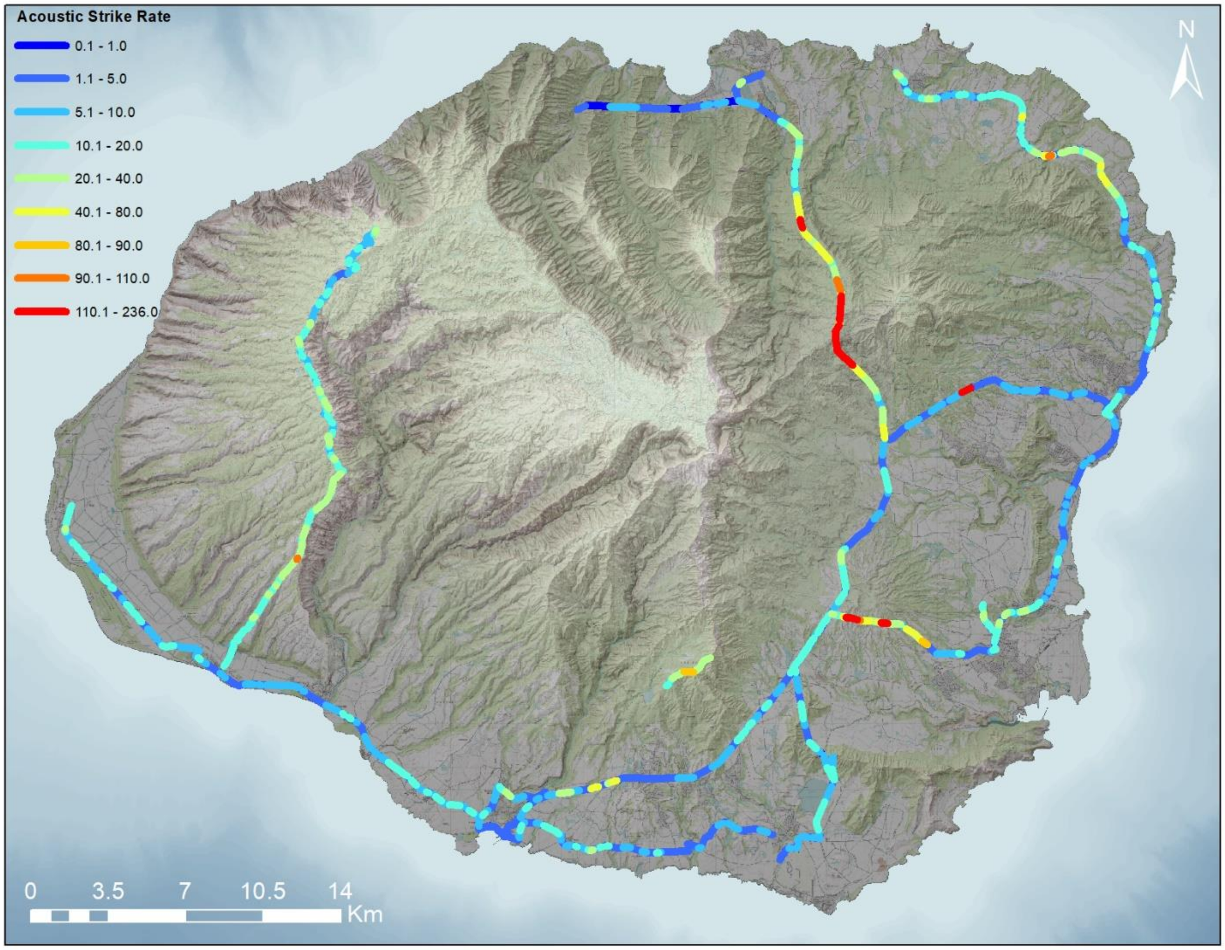


Figure 18. Map of Kauai showing the locations of all wire spans, color-coded to indicate the estimated annual number of bird strikes for each span.

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Appendix 5D

Population Dynamics Model for Newell’s Shearwater (‘a‘o) on Kaua‘i

The purpose of this appendix is to describe the population dynamics model developed by the Kauaʻi Island Utility Cooperative (KIUC) for Newell's shearwater (ʻaʻo). The population dynamics model for Hawaiian petrel (ʻuaʻu) is presented in Appendix 5E, *Population Dynamics Model for Hawaiian Petrel (ʻuaʻu) on Kauaʻi*.

A population dynamics model was not developed for band-rumped storm-petrel (ʻakēʻakē) because of the lack of data on this species, as described in Chapter 5, *Effects*.

The population dynamics model for Newell's shearwater (ʻaʻo) was developed for the following specific uses in the habitat conservation plan (HCP):

1. To convert the estimated rates of powerline collision and light attraction to a variable estimate of take authorization that accounts for estimated changes in island-wide population size (described in Chapter 5, *Effects*).
2. To evaluate the effects of the requested take authorization of the species from KIUC's covered activities (described in Chapter 5, *Effects*) in the absence of any mitigation.
3. To quantify the benefits of the conservation measures proposed in Chapter 4, *Conservation Strategy*, to the Kauaʻi metapopulation of the species.
4. To determine the net effects of the HCP covered activities and conservation measures on the Kauaʻi metapopulation of this species and to quantify the net benefit provided by the HCP.
5. To estimate population trends during HCP implementation, over the 50-year permit term.

This appendix is divided into four sections: (1) Overview of the model, including methods, initial conditions, technical specifications, and tables with model input values, (2) Model results, (3) A discussion of model limitations, uncertainties, and assumptions, and (4) References cited. The key findings of this appendix are discussed in Chapter 5, *Effects,* along with more detail on the implications of the model results for the regulatory requirements of the HCP.

The appendix and technical details of the population dynamics model were developed by John R. Brandon, PhD, Senior Biometrician at ICF, with extensive review by David Zippin, PhD, Senior Conservation Biologist, and Dawn Huff, HCP Project Manager for KIUC. Dr. Brandon developed the computing code for modeling. The spatial representation of Kauaʻi metapopulation structure and model inputs were developed in close collaboration with André F. Raine, PhD, Science Director for Archipelago Research and Conservation (ARC), and Marc Travers, MS, Senior Scientist at ARC, both of whom are experts on Kauaʻi seabird biology and lead scientists on multiple studies of endangered seabirds on Kauaʻi. Dr. Raine and Mr. Travers provided input and data for many of the model parameters as cited throughout the appendix. The U.S. Fish and Wildlife Service (USFWS) and Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) reviewed model assumptions and results and provided valuable input on earlier drafts of this model and appendix.

5D.1 Overview of the Population Dynamics Model

5D.1.1 Model Subpopulations

The model for Newell's shearwater (ʻaʻo) is composed of 17 distinct subpopulations.[1] Five subpopulations are modeled in areas outside of the 12 conservation sites proposed in the HCP. A conservation site in this context may refer to either: (1) sites with dedicated, intensive predator control measures like trapping but no predator-exclusion fence (some sites may also be protected by ungulate fencing), or (2) sites with predator-exclusion fencing (PF) where social attraction will be implemented. All four conservation sites with social attraction and with predator-exclusion fences are located within larger conservation sites with the same name: Honopū, Pōhākea, Upper Limahuli Preserve, and Upper Mānoa Valley. For example, the Pōhākea PF conservation site with social attraction and a predator-exclusion fence is located within the larger Pōhākea conservation site with dedicated, intensive predator control but no predator-exclusion fence. The same is true for Honopū, Upper Limahuli Preserve, and Upper Mānoa Valley (Table 5D-1).

Each conservation site is modeled as a distinct subpopulation (Table 5D-1). For example, two subpopulations are modeled at Upper Limahuli Preserve, one corresponding to the large conservation site with dedicated, intensive predator control but no predator-exclusion fence and the other corresponding to the social attraction site with a predator exclusion fence (Upper Limahuli Preserve PF). There are four conservation sites with dedicated, intensive predator control but no predator-exclusion fence and no social-attraction: Hanakāpiʻai, Hanakoa, Pihea, and North Bog.

The 17 subpopulations that comprise the modeled Kauaʻi metapopulation as a whole, and the corresponding HCP management measures affecting each subpopulation are listed in Table 5D-1, with general subpopulation breeding areas illustrated in Figure 5D-1 (see Chapter 4, *Conservation Strategy*, and Appendix 4A, *Conservation Site Selection*, for additional details about the conservation sites).

Outside of the 12 conservation sites, the rest of Kauaʻi was subdivided into five regions that correspond to the known metapopulation distribution of the species on Kauaʻi (see Figure 1 in Appendix 3A, *Species Accounts*). Each area in the model encompasses a geographic portion of the island which has similar conservation threats and management efforts for the species, as well as similar available data sources for estimating the abundance and trend of breeding pairs which nest there (Table 5D-2).

The modeling framework allows each subpopulation to have its own set of vital rate values and therefore different trends in abundance through time. This reflects the fact that pressures such as powerline collisions and predation vary depending on region and topography. For example, the remote areas in the northwestern region of the island do not have powerlines (see Figure 5D-1). Available tagging data is consistent with the flyways of breeding colonies in those areas resulting in little to no vulnerability to powerline collisions (e.g., Raine et al. 2017a). For breeding colonies in northwestern Kauaʻi (including the conservation sites), where powerline collision vulnerability is low and predator control efforts have been effective, acoustic monitoring data has demonstrated

[1] The term *subpopulation* is used here for the purposes of the HCP to distinguish between groups of individuals associated with breeding colonies located in different parts of the island and that are exposed to different types and levels of threats. There is no evidence that genetically distinct "populations" exist on Kauaʻi, so that term is avoided. Together, the modeled subpopulations make up the Kauaʻi metapopulation.

increases in abundance since 2014–2015 (Raine et al. 2022a). The opposite is true in other areas of the island where breeding colonies are particularly vulnerable to powerline collisions and light attraction, and predation levels are high. Examples include those sites that have flyways crossing the Powerline Trail in the middle of the island, where collisions historically have been the highest, prior to powerline collision minimization efforts (Travers et al. 2020; also see Chapter 5, Figures 5-1a and 5-1b estimated rates of bird strikes per wire span in 2019 and 2024, respectively).

Furthermore, available monitoring data also differs by each area. For example, radar survey data, which is the longest running systematic monitoring study for trends in relative abundance for this species, are only available from areas with road access (the radar system is mounted on a vehicle, and there are no roads in the northwest region of Kauaʻi, including the conservation sites).

The spatially explicit model described here serves to account for these differences and complexities in the overall Kauaʻi metapopulation dynamics. This approach allows for monitoring data (e.g., estimated trends in relative abundance) from different surveys, in different areas, to be incorporated in the model. The vital rates for each subpopulation are also modeled to change over time as future management efforts are implemented under the HCP, corresponding to the timeline of these measures described in Chapter 4, *Conservation Strategy*. For example, increases in estimated powerline strike reductions due to minimization are modeled through time to reduce powerline strike mortality rates. Similarly, the timing of installation of predator exclusion fencing around particular management sites are modeled to reduce predation mortality rates for the corresponding subpopulations at those sites in future years.

Island-based estimates of abundance for each subpopulation are used to initialize population trajectories, which are then projected forward in time through the 50-year permit term. For simplicity, the model does not assume any dispersal among the Kauaʻi subpopulations, except for immigration into the four social attraction sites (see Section 5D.2.3, *Social Attraction Site Dynamics and Dispersal*, for details), which is reasonable because shearwaters and petrels exhibit strong natal philopatry[2] (e.g., Harris 1966; Perrins et al. 1973; Warham 1980) and established breeding pairs typically return to the same nesting burrow year after year. The model also does not assume any dispersal between Kauaʻi and other islands in Hawaiʻi.

[2] *Natal philopatry* is the tendency of an animal to return to breed in the place of its birth.

Table 5D-1. Modeled Subpopulations, HCP Status, HCP Management Actions with Benefits Modeled and Other HCP Management Actions with Benefits not Modeled.

Modeled Subpopulation	HCP Status	HCP Management Actions with Modeled Benefit[a]	HCP Management Actions with Benefit not Modeled[a]
1. Pihea	Conservation site	Predator control[b],	Invasive plant species management and partial ungulate fence[c]
2. North Bog	Conservation site	Predator control[b]	Invasive plant species management and partial ungulate fence[c]
3. Pōhākea (site excludes Pōhākea PF)	Conservation site	Predator control[b]	Invasive plant species management and partial ungulate fence[c]
4. Pōhākea PF[d]	Conservation site with social attraction	Predator control, invasive plant species management, existing predator exclusion fence encircling this site; social attraction initiated in 2022	
5. Hanakāpiʻai	Conservation site	Predator control[b]	Invasive plant species management and partial ungulate fence[c]
6. Hanakoa	Conservation site	Predator control[b]	Invasive plant species management and partial ungulate fence[c]
7. Upper Limahuli Preserve	Conservation site	Predator control[b]	Invasive plant species management and pig exclusion fencing
8. Upper Limahuli Preserve PF	Conservation site with social attraction	Predator exclusion fence to be completed in 2025; predator eradication to be conducted in 2026; social attraction to be initiated in 2027: ongoing predator monitoring and breach response; invasive plant species management	
9. Upper Mānoa Valley	Conservation site	Predator control[b]	Invasive plant species management
10. Upper Mānoa Valley PF	Conservation site with social attraction	Predator exclusion fence to be completed in 2027; predator eradication to be conducted in 2028; social attraction to be initiated in 2029; ongoing predator monitoring and breach response; invasive plant species management	

Modeled Subpopulation	HCP Status	HCP Management Actions with Modeled Benefit[a]	HCP Management Actions with Benefit not Modeled[a]
11. Honopū (site excludes Honopū PF)	Conservation site	Predator control	Invasive plant species management and ungulate fencing
12. Honopū PF	Conservation site with social attraction	Existing predator exclusion fence encircling this site, social attraction initiated in 2022; ongoing predator monitoring and breach response; invasive plant species management.	
13. Hanalei to Kekaha	N/A	Powerline and streetlight minimization	Save our Shearwaters (SOS) Program
14. Wainiha and Lumahaʻi Valleys	N/A	Powerline and streetlight minimization	SOS Program
15. Kalalau east to Upper Mānoa (excluding conservation sites)	N/A	Powerline and streetlight minimization	SOS Program
16. Nā Pali Coast	N/A	Powerline and streetlight minimization	SOS Program
17. Waimea Canyon	N/A	Powerline and streetlight minimization	SOS Program

[a] See Chapter 4, *Conservation Strategy*, for details.
[b] Predator control involves species-specific trapping and removal efforts for ungulates, cats, rodents, bees, and barn owls.
[c] Sections of ungulate fence are installed along the borders of Hono O Nā Pali Natural Area Reserve and are combined with extremely steep terrain assumed to be impassable by ungulates. These sites are located within the Hono O Nā Pali Natural Area Reserve. These fences were installed and are managed by DOFAW.
[d] PF stands for predator-exclusion fence. Construction of the predator-exclusion fences at Honopū PF and Pōhākea PF was completed in 2021 by others. KIUC will maintain these fences for the term of HCP.

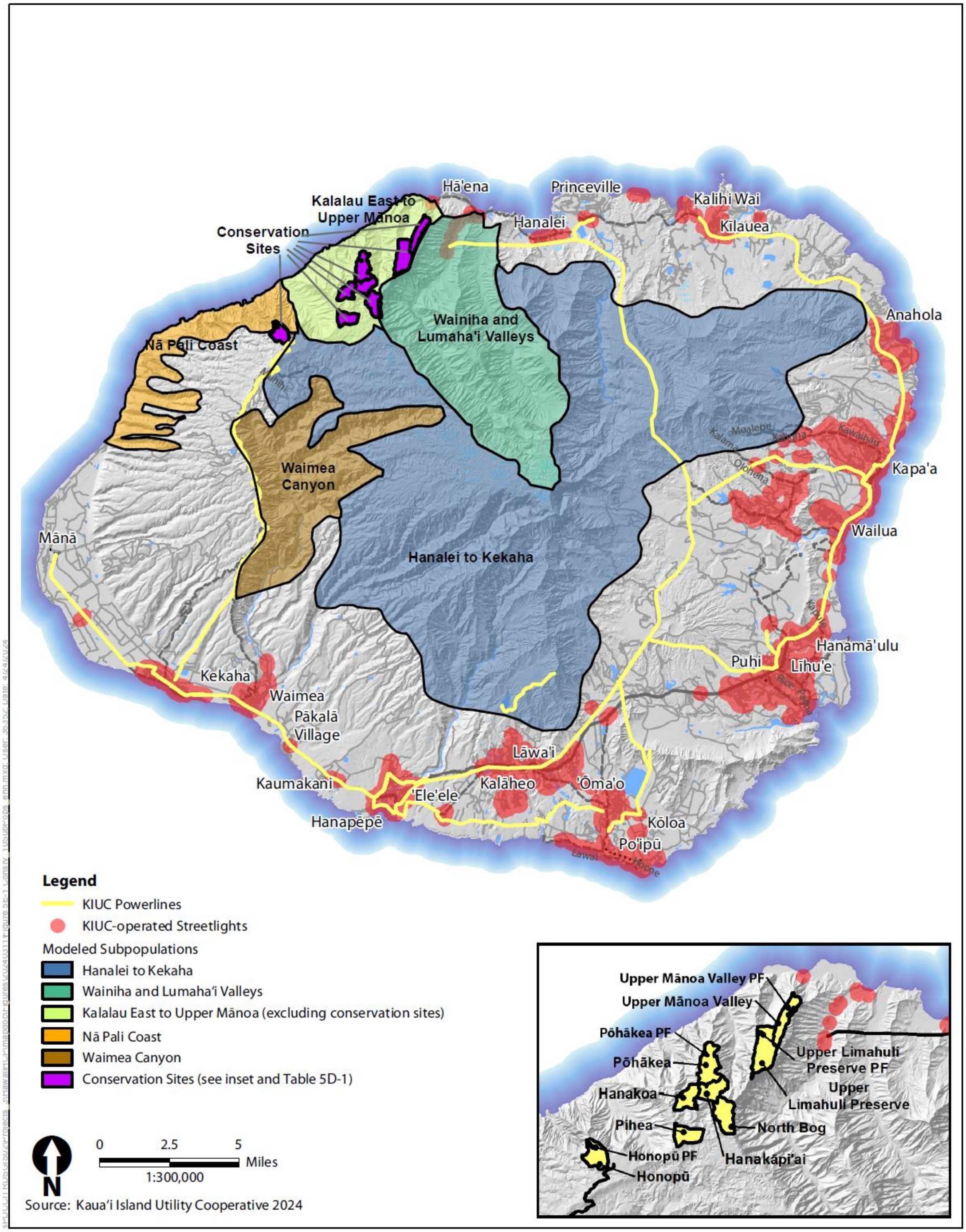

Figure 5D-1. Locations of Modeled Newell's Shearwater (ʻaʻo) Subpopulations and Locations of KIUC's Covered Facilities

5D.1.2 Two Model Scenarios

Two abundance trend scenarios were modeled for Newell’s shearwater (‘a‘o) on Kaua‘i. For the January 2023 public review draft of this HCP, KIUC developed the population dynamics model for Newell’s shearwater (‘a‘o) with the assumption that abundance is rapidly declining outside of the conservation sites (Kaua‘i Island Utility Cooperative 2023). This scenario modeled a steeply declining trend in the population of Newell’s shearwater (‘a‘o) in the most affected areas outside of the conservation sites. This approach was chosen to err on the side of the species by providing a highly conservative evaluation of the effects of the HCP on the species, including identifying a plausible upper bound on the impact of the taking. This scenario also captures the lower bound of the benefits of the HCP by assuming an extreme case for the status for the birds that could still be supported by some small preselected subset of available monitoring data on trends (i.e., can the conservation strategy provide a net benefit to the species, even if the preselected subset of trend monitoring data is extrapolated and assumed to represent a widespread rapid decline in abundance outside the conservation sites).

Although the assumption of a rapidly declining population is not consistent with radar and powerline collision data since 2010, which suggest a stable trend in abundance in areas with monitoring data outside the conservation sites (e.g., the Hanalei to Kekaha area; Figure 5D-1), there was a concern that due to the long-lived nature of the species another decline may occur at some point in the future. The supposition of an impending future decline, following the current stable trend period, is based on the conjecture that the demographic age-structure is currently highly skewed, such that all, or nearly all, of the surviving Newell’s shearwater (‘a‘o) on Kaua‘i are breeding adults. This postulates that the higher vulnerability of subadults to light fallout and the higher ratio of subadults in powerline collisions (80:20 subadult:adult age ratio; Cooper and Day 1998), results in few, if any, subadults currently surviving to breeding age. The rationale follows that once the remaining cohort of adults reach the end of their lifespan (c.f. 36 years; Griesemer and Holmes 2011), abundance of the Kaua‘i metapopulation will collapse as the current cohort of adults reaches senescence with few or no surviving subadults to replace them. This situation would represent a demographically induced “extinction vortex”.

However, Newell’s shearwater (‘a‘o) start reproducing at age 6. That combined with over 10 years of data indicating trends in abundance have been stable in the Hanalei to Kekaha area, it is expected that, if such a demographically induced decline were going to occur, it would have already started. If subadults are not recruiting to breeding age per the extinction vortex hypothesis, monitored abundance would start to decline rapidly after roughly 6 years, due to annual natural and anthropogenic mortalities of adults each year. If this were occurring, we would observe a downward trend in the radar and powerline monitoring data since 2010 (e.g., reduced passage rates and powerline collisions associated with reductions in underlying abundance). However, such declines in passage rates or powerline collisions have not been observed prior to substantial powerline minimization being implemented by KIUC starting in 2020. Therefore, the data do not support the “extinction vortex” hypothesis.

For the lag-time before such a hypothesized collapse to have lasted more than 10 years (i.e., for the data to still be consistent with the extinction vortex hypothesis), one must assume that adults have near 100 percent survival rates in the areas of Kaua‘i with the highest levels of anthropogenic threats (i.e., that there have been almost zero adult mortalities in areas like Hanalei to Kekaha since 2010, areas where there is no dedicated predator control and where powerline collisions are highest). Even after accounting for the implausibility of this scenario, in discussion with the agencies, KIUC took a conservation approach erring on the side of the species in modeling an abundance trend that was collapsing (and ultimately declines to zero) in large areas like Hanalei to Kekaha. This scenario was presented in the January 2023 draft HCP (aka the "worse-case" scenario, as described further below).

There are two complications with the January 2023 public draft HCP approach: First, as noted above, it conflicts with the most current radar and powerline collision data. Second, it likely *underestimates* future take from powerline collisions and light attraction under the HCP, because the amount of take from both of these sources of injury and mortality is assumed to be a function of abundance. In other words, as a population increases with a constant risk or powerline collision or light attraction, one would expect the amount of collision and fallout to increase. With the assumption of a rapidly declining trend in abundance (i.e., the worse-case scenario), take from powerline collisions and light attraction would also rapidly decline through time because there are fewer and fewer birds in the air exposed to those risks. Therefore, modeling in the January 2023 public draft HCP did not provide a plausible upper bound on abundance trends. By extension, the January 2023 public draft HCP also did not provide a plausible upper bound of future take from powerline collisions and light attraction assuming a stable or growing population.

The state Endangered Species Recovery Committee (ESRC) reviewed the January 2023 public draft and provided comments to this effect. In light of such issues, the ESRC recommended developing a more realistic modeling scenario for comparison purposes.

Multiple sources of data for the Hanalei to Kekaha area document a large decline in abundance during the 1990s (e.g., Raine et al. 2017b). In contrast, radar and powerline collision data since 2010 indicate the recent trend in abundance in the Hanalei to Kekaha area has changed. The trend is no longer rapidly declining, but rather has been stable at relatively low abundance levels compared to the 1990s. Using these more recent estimates of trends in abundance in the Hanalei to Kekaha area, KIUC developed a second modeling scenario to address the issues noted above and to respond to the comments received from the state ESRC. To distinguish the two model scenarios, they are briefly outlined below:

- ***Worse-case trend*** population dynamics model scenario (or worse-case trend scenario) assumes the population trend outside of the conservation sites is rapidly declining at model initiation, a far worse status for the birds than the second scenario. This scenario is described in detail in the next section below.
- ***Stable trend*** population dynamics model scenario (or stable trend scenario) assumes the initial population trend outside of the conservation sites is flat, meaning no increase or decline. This scenario has the same underlying modeling structure (e.g., spatially explicit areas) as the worse-case trend scenario. The different assumptions of the stable trend scenario are described in Attachment 5D-1, *Newell's Shearwater ('a'o) Population Dynamics Model Fit to the Stable 2010–2022 Radar Trend under KIUC's Proposed Habitat Conservation Plan* (the same information is also provided in Table 5-1 in Chapter 5, *Effects*).

These two model scenarios differ in three primary ways: starting abundance, maximum rate of population growth, and survival rates for adults and juveniles, each of which is summarized below.

- **Starting abundance.** The starting abundance of the conservation sites are the same for each model scenario and based on estimates from field monitoring at each site. The starting abundance of the worse-case trend scenario for subpopulations outside of the conservation sites, in those areas where long-term radar trends are not available, is based on professional judgement and more limited observational data. These initial abundance estimates were made independent of estimates of powerline collisions, and are identical between the modeled trend scenarios. In the areas of Kauaʻi most affected by anthropogenic mortality, abundance is estimated such that once the level of anthropogenic mortality (e.g., unminimized powerline collision levels) is applied in the model, the trend in modeled abundance matches the applied trend estimate from the radar survey data (either the subset of historical radar data with a rapid decline, or the larger data set across all radar sites since 2010 which shows a recent stable trend).

The rationale for this approach is that the abundance of Newell's shearwater (ʻaʻo) on Kauaʻi must be at a level that can sustain the number of estimated powerline collisions prior to minimization during 2013–2019 (Travers et al. 2020) while also sustaining the population trend consistent with radar data. For more explanation of this approach in terms of modeling the stable trend scenario, see Attachment 5D-1.

- **Survival rates for adults and juveniles**. The worse-case trend scenario assumes that the "natural" survival rate[3] of Newell's shearwater (ʻaʻo) is 92 percent per year for post-fledgling and adult age-classes (Ages 2 years and older). Because this survival rate has not been measured directly, it is based on values from a different species, Manx shearwater, in the North Atlantic. In the stable trend scenario, this natural survival rate is not fixed *a priori* at a point value based on a proxy species, but treated as an estimable model parameter (resulting estimated survival rate of 96 percent per year). The estimated survival rate is what is needed to match estimates of powerline collisions and a stable trend in the areas surveyed by radar.

  Fledgling natural survival (Age 1) also differs between the two scenarios. In the worse-case trend scenario, fledgling natural survival is assumed *a priori* to be 37 percent per year, compared to the estimated value of 53 percent in the stable trend scenario. The higher fledgling natural survival in the stable trend scenario is also necessary to ensure that modeled population dynamics are consistent with both the estimated level of unminimized powerline collisions (while also matching the 80:20 subadult:adult collision ratio) and a stable trend in the areas surveyed by radar. Both of these adjustments in vital rates produce a difference in the maximum population growth rate, as described below.

- **Maximum rate of growth**. In the worse-case trend scenario, the theoretical maximum rate of growth of Newell's shearwater (ʻaʻo) is 3.0 percent per year. This value represents the most that any subpopulation can grow without predation by invasive species, powerline collisions, or light attraction (i.e., without anthropogenic threats) in a given year. In the stable trend scenario, the theoretical maximum rate of growth of the species increases to 8.0 percent as a function of the higher estimated natural survival rates summarized above. This increase in the theoretical maximum growth rate is necessary to fit the model to an initial stable trend in the areas surveyed by radar, given available estimates of anthropogenic mortality levels in those areas.

[3] "Natural" refers to vital rates in the absence of anthropogenic mortality.

5D.2 Inputs for the Worse-Case Trend Scenario

This section describes the model inputs used in the worse-case trend population dynamics model scenario. Model inputs[4] for the stable trend population dynamics model scenario are mostly the same as for the worse-case trend scenario. Different model inputs for each scenario, and the rationale for those differences in the stable trend scenario are described in Attachment 5D-1, *Newell's Shearwater (ʻaʻo) Population Dynamics Model Fit to the Stable 2010–2022 Radar Trend under KIUC's Proposed Habitat Conservation Plan*. In addition to Attachment 5D-1, a comparison between the assumptions under each trend scenario can be found in Table 5-1 in Chapter 5, *Effects*.

5D.2.1 Initial Conditions

The initial conditions for the model were set in 2019, before projections forward in time from that year were carried out. Modeled reductions in powerline line mortality rates due to minimization efforts that are accounted for in the model start in 2020. Population trajectories for Newell's shearwater (ʻaʻo) were based on the following parameter categories, each of which is described below:

1. Estimates of **abundance** on Kauaʻi.
2. **Vital rates** by age class under optimal conditions (i.e., natural mortality and fertility rates in the absence of introduced predators, light fallout, and powerline collisions).
3. Estimates of **powerline injury and mortality**, prior to 2020 minimization efforts.
4. Estimates of **predation rates** with and without predator control measures.

5D.2.1.1 Estimates of Abundance on Kauaʻi

All population dynamics models must begin with an estimate of initial population size to forecast future abundance levels. The only published estimates of abundance of Newell's shearwater (ʻaʻo) come from transect surveys conducted on ships at sea. Because of the use of these estimates in previous studies, these at-sea population estimates and their limitations are summarized in the following subsection. This summary is followed by an explanation of the methods used for this HCP to develop a spatially explicit population estimate of Newell's shearwater (ʻaʻo) on Kauaʻi. The estimates used in the HCP are based on the best and most current data available and were derived from multiple monitoring surveys specifically for this purpose.

At-Sea Abundance Estimates

Seabird populations are often estimated using counts of birds observed at sea and calculations of what proportion of the total population may have been sampled. This technique is used because (1) a substantial fraction of seabirds remains at sea prior to reaching breeding age (e.g., counts are representative of total abundance across all age classes, rather than just breeding age individuals), and (2) at-sea surveys can enumerate populations which may have breeding colonies spread over different islands or geographic locations, and which can otherwise be difficult to locate and count on land during the breeding season. This is the case for Newell's shearwater (ʻaʻo), where nesting adults

[4] Model inputs are also called "parameters" if the values (e.g., survival rates) are statistically estimated from independent data that is integrated in the model.

are nocturnal, and nests are located underground in densely vegetated and rugged, remote montane environments.

Neither of the available at-sea estimates were adopted for the HCP population dynamics model because they include serious spatial deficiencies in geographical survey coverage, leading to uncorrected sources of statistical bias. Further, at-sea estimates alone, even if they could be corrected for these biases, provide only a single population estimate for the entire island of Kauaʻi. An important innovation of the HCP population dynamics model is that it considers important spatial differences in mortality risk in different areas of Kauaʻi, as discussed below. The at-sea abundance estimates are briefly described here for context, however, because they have been used in previous population modeling studies.

The modeling studies of Ainley et al. (2001) and Griesemer and Holmes (2011) incorporated the at-sea abundance estimate of Newell's shearwater (ʻaʻo) from Spear et al. (1995) to form the basis for estimating mortality rates from light fallout. These earlier modeling studies did not project trajectories of absolute abundance based on the at-sea survey estimates. Rather, the modeled trajectories were based on a hypothetical relative abundance level of 1,000 Newell's shearwater (ʻaʻo) in the first year of the population trajectories (e.g., Ainley et al. 2001:120; Griesemer and Holmes 2011:30).

Spear et al. (1995) estimated a total population size of 84,000 Newell's shearwater (ʻaʻo) based on shipboard observations between 1984 and 1993. Subsequently, Joyce (2016) analyzed shipboard observations from more recent surveys during 1998–2011 and calculated an at-sea total abundance estimate of 27,011. Vorsino (2016) adopted the Joyce (2016) at-sea estimate of abundance to forecast model trajectories of absolute abundance for Newell's shearwater (ʻaʻo) on Kauaʻi. In all three modeling studies that incorporated available at-sea abundance estimates (Ainley et al. 2001; Griesemer and Holmes 2011; Vorsino 2016), 90 percent of the total population of Newell's shearwaters (ʻaʻo) was assumed to be from Kauaʻi.

The authors of the at-sea estimates of abundance explicitly acknowledge that the resulting estimates of abundance are not comprehensive because available survey data does not encompass the entire at-sea range of either species (e.g., Joyce 2016:183). As Griesemer and Holmes (2011:16) note, "Repeating at-sea surveys or determining another method of population estimation is critical to recovery planning." Available estimates from at-sea surveys have limitations for several reasons.

- The at-sea range of Newell's shearwater (ʻaʻo) is incredibly large, and dedicated survey coverage of their at-sea range has not been undertaken in any systematic way. For example, the available at-sea data analyzed by Joyce (2016) comes from surveys with spatial coverage designed to estimate the abundance and distribution of cetaceans (whales and dolphins), and which did not survey areas north of the United States Exclusive Economic Zone around Hawaiʻi (an area from the shoreline to 200 nautical miles [370.4 kilometers] outside the islands), where chick provisioning (breeding adult) Newell's shearwater (ʻaʻo) have been observed through tagging (Joyce 2016:230). Likewise, more recent tagging data for this species are also consistent with the available at-sea survey effort covering only a fraction of the at-sea range of this species (Raine et al. 2020; Archipelago Research and Conservation unpublished tagging data). Therefore, the at-sea estimates of abundance represent a fraction of total abundance.
- In order to take into account the spatial complexities of different pressures and conservation benefits in different areas of Kauaʻi, the at-sea abundance estimates would need to be partioned such that a proportion of the at-sea estimates (which represent the total at-sea population)

could be assigned to each area of the island. In other words, what proportion of the at-sea estimates of abundance represents those birds associated with the conservation sites? Such assumptions would have a high degree of uncertainty, so it is preferable to use available survey data from the conservation sites themselves. Survey data at the conservation sites provide a more current and defensible estimate of covered seabird abundance than older at-sea estimates.

- At-sea estimates are compiled from survey data collected during different times of year, which further complicates interpretation because the at-sea range of Newell's shearwater (ʻaʻo) changes according to life stage and season (see Joyce 2016:230, which shows tag locations of chick provisioning adults generally north of Kauaʻi during the summer nesting season, and Raine et al. 2020:45, which shows at-sea locations of fledglings south of Kauaʻi, including south of the equator, during the late fall and early winter).

- There are no available correction factors to scale the at-sea abundance estimates to total abundance on Kauaʻi, which is necessary to incorporate estimates of powerline strike numbers, and the effects of powerline strike minimization on total abundance for the HCP population dynamics model. This is important because using an abundance estimate that only represents a fraction of total population size would lead to negatively biased results in terms of forecasting future abundance levels given estimated strike numbers or trends from radar data.

  For example, if the abundance estimate from Joyce (2016) is assumed to pertain to the year 2004 (the approximate mid-year of the corresponding 1998–2011 at-sea survey period), where the number of Newell's shearwater (ʻaʻo) on Kauaʻi represent 90 percent of the estimated at-sea abundance, and a negative 13 percent annual rate of population decline is assumed (e.g., from Raine et al. 2017b), the forecasted abundance would be 4,571 total Newell's shearwater (ʻaʻo) on Kauaʻi in the year 2016. Given the assumptions made here about the mortality level associated with estimated powerline collisions (e.g., the proportion of powerline collisions resulting in mortality is 28.8 percent; Travers et al. 2021), the annual average number of Newell's shearwater (ʻaʻo) mortalities resulting from powerline collisions during 2013 to 2019 was 3,196. Applying this level of mortality to the projected 2016 abundance level based on the uncorrected at-sea survey estimate would result in an approximate negative 70 percent annual decline, which is inconsistent with long-term monitoring data.

  If a negative 6.9 percent rate of decline were assumed instead, from an updated analysis of trends including more recent years of radar survey data (Raine and Rossiter 2020), the model forecasted total population size on Kauaʻi from this at-sea abundance estimate would be 7,744 Newell's shearwater (ʻaʻo) in the year 2020. In either case, recent population sizes this low are not consistent with concurrent observational data from multiple sources, including: (1) Estimates of breeding pairs in the conservation sites (Raine et al. 2022a); (2) Estimated collisions and resulting mortality levels (Travers et al. 2020, 2021); and (3) Trends in relative abundance from the radar surveys, which would be expected to exhibit much more drastic rates of decline if the at-sea abundance estimates were not biased low due to incomplete survey coverage of the species at-sea range, and instead represented an accurate measure of true abundance, rather than an estimate of minimum abundance.

For all of these reasons we chose not to utilize at-sea population estimates. Instead, the population estimates used to initialize the model are based on different Kauaʻi-specific data sets, as described below.

Breeding Pair Population Estimates on Kauaʻi

Given the limitations of the at-sea abundance estimates, which miss a significant (but as of yet unquantified) proportion of the island's breeding population—and breeding colonies in different areas of Kauaʻi are not uniformly vulnerable to threats such as introduced predators, light fallout, or powerline strike mortalities—staff at ARC developed spatially explicit estimates of Newell's shearwater (ʻaʻo) breeding pair abundance on Kauaʻi for this HCP.

These estimates were adopted as the basis for calculating the initial model population size in the HCP population dynamics model. They also allow for a modeling approach that can help to address the fundamental question of whether localized conservation efforts (e.g., predator control, predator-proof fencing, or social attraction sites) in targeted breeding areas on Kauaʻi can result in a sufficient net benefit to offset future minimized powerline strike mortalities for the island-wide population (metapopulation) on Kauaʻi.

Breeding pair abundance in 2021 was estimated for each of the modeled subpopulations (Table 5D-2, Figure 5D-1). The approach used to estimate the number of breeding pairs differed between areas, dictated in part by the extent to which various data sources are available (or lacking) for each area. In general, however, the breeding pair estimates developed by ARC are informed by acoustic call rate and nesting burrow monitoring studies, which have demonstrated a significant relationship between call rates and estimated densities of active nesting burrows (e.g., Raine et al. 2019). These acoustic call rates are used in combination with published habitat suitability models (Troy et al. 2014, 2017). To the extent possible, the most recently analyzed study data from 2021 have been used to inform the resulting breeding pair estimates.

For the two modeled areas of Kauaʻi that have the highest level of collisions (Hanalei to Kekaha and Waimea Canyon), preliminary model results indicated that ARC's estimates of breeding pairs for these areas were, in combination with the biological assumptions in the model, incompatible with the observed trends from the radar survey and the level of mortality from the average annual unminimized strike estimate during 2013–2019. In other words, preliminary model results for these two areas, when based on ARC's breeding pair estimates and the low modeled maximum population growth rate (i.e., resiliency) produced modeled subpopulation trends from unminimized powerline strike mortality rates that were much more negative (i.e., much greater recent declines) than any trends estimated from the radar survey since that systematic survey began collecting data in 1993.

Therefore, an alternative approach was used to calculate the breeding pair abundance necessary to sustain the rate of decline observed in the radar data (Raine et al. 2017b; Raine and Rossiter 2020), given the estimated average annual number of unminimized powerline collisions during 2013–2019 for these two areas (Travers et al. 2020). This approach to initialize the breeding pair abundance in the model for the Hanalei to Kekaha and Waimea Canyon areas is described in more detail under the area-specific descriptions of breeding pair abundance estimation process and background considerations for each modeled subpopulation below. Using estimated trends from radar data to initialize the model also integrates the effects of powerline collisions and light fallout prior to the HCP, to the extent available data allow, because the trend estimate is based on radar survey data starting in 1993.

Table 5D-2 provides a summary of the approach used for each modeled subpopulation as well as a relative comparison of mortality sources (the differences in mortality help explain why each subpopulation was modeled) and uncertainty in the estimate of abundance. Where certainty in abundance was moderate and habitat suitability modeling was used (i.e., Kalalau east to Upper

Mānoa), nesting densities were extrapolated from other areas with available data, and expert opinion was used to derive density correction factors to account for lower expected nest densities in areas with higher levels of mortality (i.e., due to unmanaged predation outside the conservation sites).

Table 5D-2. Summary of Approach to Initial Population Estimate, Relative Mortality Levels by Source, and Data Availability by Modeled Subpopulation of Newell's Shearwater ('a'o)

Modeled Subpopulation	Data Sources Used for Initial Population Estimate	Relative Population-Level Mortality by Source			Certainty in Abundance Estimate
		Powerlines	Light Attraction	Predation	
Conservation Sites (12)[a]	Habitat Suitability Model and auditory survey polygons (based on annual surveys)	Low	Low	Low	High
Nā Pali Coast	Song meters/regression analysis	Low	Low	Low	Moderate
Wainiha and Lumaha'i Valleys	Habitat suitability model and auditory survey polygons	Low	Low	Moderate	Moderate
Kalalau east to Upper Mānoa	Habitat suitability model and cover ratios[b] calculated from auditory survey polygons in Wainiha and Lumaha'i Valleys	Low	Low	Moderate	Moderate
Hanalei to Kekaha	Radar trend and strike estimate	**High**	Moderate	**High**	Low
Waimea Canyon	Radar trend and strike estimate	**High**	Moderate	Low	Low

[a] See Table 5D-1 for a list of all conservation sites.

[b] Cover ratios were used to extrapolate the fraction of suitable habitat used by nesting seabirds detected through acoustic surveys to areas without available acoustic survey data, before applying density correction factors to account for lower nesting densities in areas that have been more greatly affected by powerline strike, light attraction, and predation mortalities (Raine et al. 2019, 2022a).

Hanalei to Kekaha

This largest area of Kaua'i is most affected by powerline collisions, light attraction, and predation (e.g., Troy et al. 2014 and see Figure 5D-1). It is also the area of the island for which trends in relative abundance have been estimated through the long-term systematic radar survey since 1993 (e.g., Day and Cooper 1995; Raine et al. 2017b). Thirteen radar sites have been surveyed since 1993 in the Hanalei to Kekaha area. Two additional radar sites have also been surveyed in Wainiha and Lumaha'i Valleys starting in 2006, where trends have been stable (Raine and Rossiter 2020; see below for details).

The radar survey on Kaua'i represents the longest systematic monitoring study of trends in abundance for this species anywhere. Raine et al. (2017b) estimated the average rate of decline in Newell's shearwater ('a'o) abundance, between 1993 and 2013, across all radar sites in the Hanalei to Kekaha area at approximately -13 percent per year. Since that study, Raine and Rossiter (2020) present the most recent estimates for the long-term subpopulation trend for this area. When averaged across all radar sites in this area, the more recent estimate of the average annual rate of decline is -6.9 percent per year during 1993–2020. During those three decades, the most extreme rate of decline for any of the 13 individual radar sites in this area has been estimated at the Hanalei radar site. The trend in relative abundance from that radar site is -10.7 percent per year during 1993–2020.

As noted above, the total breeding pair estimates developed by ARC for Hanalei to Kekaha were found through preliminary modeling results to be incompatible with the estimated number of powerline collisions, associated mortalities, and the most negative trend estimated from radar survey data. Given the biological assumptions in the model, this combination of factors, as initially explored (i.e., relatively small abundance relative to the magnitude of powerline collision mortalities for a species with low maximum rates of modeled population growth) led to resulting modeled rates of decline that were much greater than any trends that have been observed through the radar surveys in this area, or elsewhere on Kauaʻi.

To correct this inconsistency, an alternative approach to initializing abundance for the Hanalei to Kekaha area was developed so that the model would match both the magnitude of powerline collisions estimated from acoustic monitoring and trends in abundance estimated from the long-term systematic radar surveys. This approach was also applied to the Waimea Canyon area, which ran into similar compatibility issues between estimates, given the relatively large number of unminimized collisions in that area.

The initialization approach for Hanalei to Kekaha and for Waimea Canyon involved solving for the combination of (1) abundance at age, and (2) the subadult and adult powerline mortality rates that result in the estimated number of collision mortalities, while matching the -10.7 percent rate of decline estimated from the radar survey at the Hanalei radar site (a worst-case recent trend). The solutions for abundance and powerline mortality rates at age were found using non-linear numerical optimization (a penalized maximum likelihood approach) as implemented in the Stan programming language using the *cmdstanr* package (Stan Development Team 2022; Gabry and Češnovar 2022). The specific penalties used to fit the model were as follows.

1. The Bayes acoustic estimate of powerline strikes was assumed to follow a log-normal distribution with a mean in log-space corresponding to the strike allocation for this area (described below), and a coefficient of variation assumed to be 0.001, which ensures the resulting modeled number of strikes matches the mean of the reported estimate.
2. The trend from the radar data was modeled as a normally distributed random variable with a coefficient of variation of 0.01, which again ensured the resulting modeled trend matched the point estimate for the rate of decline.
3. The proportion of powerline collision mortalities that were subadult was assumed to follow a *Beta*(11, 3) probability distribution, which corresponds to the sample of 14 downed Newellʻs shearwater (ʻaʻo) examined and categorized as 11 subadults and 3 adults by Cooper and Day (1998), i.e., the expected proportional age-class split for powerline collision mortalities was 79 percent subadult and 21 percent adult.

The estimate of powerline collisions is an annual average during 2013–2019. It was assumed that this estimate pertained to 2016, the midpoint year of the acoustic monitoring data analyzed by Travers et al. (2020). In an analogous example, this approach to estimating abundance is the same as solving a problem where one wants to calculate the amount of money in a stock market account 1 year earlier. If one knows the rate of decline in the market from one year to the next was -10 percent, and the account lost $10 last year, there must have been $100 in the account before the loss.

The resulting abundance at age from this approach was then projected forward from 2016, under the assumption of a stable age distribution at the -10.7 percent rate of decline, through 2019, after which time the initial unminimized powerline mortality rates at age were reduced each year according to the modeled minimization schedule under the HCP.

Estimates for the number of annual powerline collisions are not available prior to 2013. However, incorporating estimated trends from radar data to initialize the model integrates the effects of powerline collisions and other sources of mortality prior to 2013, to the extent available data allow, because the radar trend is based on observations starting in 1993.

Conservation Sites

Predator Exclusion Fenced Sites

Four social attraction sites are included in the population dynamics model: Pōhākea PF, Upper Mānoa Valley PF, Upper Limahuli Preserve PF, and Honopū PF. These sites are assumed to start from zero birds in the first year of operation and are mentioned here for completeness in terms of listing modeled subpopulations. The modeling assumptions for social attraction sites are described in detail under Section 5D.2.3, *Social Attraction Site Dynamics and Dispersal*.

Other Sites

The Upper Limahuli Preserve, Upper Mānoa Valley, Pihea, North Bog, Pōhākea, Honopū, Hanakāpiʻai, and Hanakoa conservation sites have the highest level of management (mainly predator control) and are in northwest Kauaʻi away from most powerlines and light sources (Figure 5D-1). The Upper Limahuli Preserve, Upper Mānoa Valley, and North Bog conservation sites are close to the towns of Hāʻena and Wainiha and thus closer to powerlines and light sources. There is one streetlight at Hāʻena Beach Park that is approximately 0.4 mile north of the Upper Limahuli Preserve; however, all lights and powerlines are located over 1 mile to the east. The remaining four conservation sites in the Hono O Nā Pali Natural Area Reserve are west of the Upper Limahuli Preserve, Upper Mānoa Valley, and North Bog conservation sites, over 3 miles from the nearest powerlines or light sources to the east.

The covered seabirds in this area are expected to be affected the least of any area by all stressors (Table 5D-2). This area also has the best available data (e.g., annual auditory surveys, extensive burrow searches) for abundance estimates based on annual surveys (e.g., Raine et al. 2019, 2022a). Breeding pair estimates have been conducted on an individual basis for the conservation sites and have been presented previously in annual seabird monitoring reports (e.g., Archipelago Research and Conservation 2021; Raine et al. 2022b).

In 2017, the first estimates of breeding pair abundance were produced at all monitored conservation sites using two independent methods: (1) a habitat suitability model, which utilized the peer-reviewed models presented in Troy et al. (2014, 2017) where suitable habitat ranked 7+ and an average nearest neighbor distance was used from known burrows at monitored colonies to model nesting density; and (2) a regression analysis of acoustic monitoring data, which provides an estimate of active burrows (i.e., breeding pairs) as a function of call detections, given previous studies comparing paired visual and acoustic data in the same nesting areas. Based on the outputs of the two models, it was decided that the habitat suitability model was the most appropriate way of providing population estimates and that the acoustic method would need to be further refined before it could be used for this metric (e.g., Raine et al. 2019). For these sites, habitat suitability modeling (Troy et al. 2014, 2017) is also employed for portions of the conservation sites outside the acoustic arrays, using the estimated nearest neighbor distances between active burrows (i.e., burrow densities) to predict breeding pair numbers outside the acoustic array footprint.

The habitat suitability model was updated in 2021 by including new polygons from auditory surveys undertaken in 2021 and total surface area to take into account vertical space such as drainages and cliff walls. Two population estimates were then created for each site: (i) a low population estimate using only polygons related to "hot spot heavy" or "ground calling activity," and (ii) a high population estimate using *all polygons* collected during auditory surveys. In areas where suitable nesting habitat overlapped between Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) (i.e., where the habitat is suitable for nesting for either species), the habitat was partitioned between species to prevent double counting of available nesting habitat.

The breeding pair abundance in 2021 in the population dynamics model is equal to the lower of the two estimated values for all areas except for Hanalei to Kekaha and Waimea Canyon, where the approach to estimating initial abundance is described in the respective area descriptions.

Kalalau East to Upper Mānoa

This area is in the northwest of Kauaʻi away from most powerlines and light attraction issues. However, this area is unmanaged and thus more heavily affected by predators than adjacent conservation sites. Like Hanalei to Kekaha, the Troy et al. (2014, 2017) habitat suitability model was used to estimate breeding pairs in this area, but only included suitable habitat ranked at 8+ (i.e., suitable habitat ranked lower than 8 was assumed to contain zero breeding pairs). The modeled suitable habitat was also further reduced by an elevation cut-off, such that suitable habitat below 1,922 feet (585.9 meters) above sea level for Newell's shearwater (ʻaʻo) was assumed to contain zero breeding pairs. As this area is largely unsurveyed, a cover ratio was applied. The cover ratio used was the same ratio calculated for Lumahaʻi (see *Wainiha and Lumahaʻi Valleys*). To calculate estimated densities of active nests, the average nearest neighbor distance from burrows in Upper Limahuli Preserve was multiplied by 1.5, to account for active nests being more dispersed in unmanaged areas.

Nā Pali Coast

This area is in northwest Kauaʻi far from powerlines and light attraction sources. The entire subpopulation is within steep, north-trending valleys. As a result, foraging breeding adults and fledglings are expected to exit and enter the region almost entirely towards the ocean. While this area is largely unmanaged, the seabirds breeding here nest on nearly vertical cliffs several thousand feet high and are thus assumed to be much less affected by predators than other unmanaged sites. The current breeding pair estimate for the Nā Pali Coast is based on call rate data collected from 15 song meters deployed in this area in 2020, and a regression fit between call rates and active nests, to predict the number of breeding pairs (Raine et al. 2019). There is a strong statistically significant relationship between call rate and the number of active burrows located around acoustic sensors (Raine et al. 2019).

Waimea Canyon

This area is in the center of Kauaʻi, but it is affected by powerline collisions and light attraction. While this area is largely unmanaged, like the Nā Pali Coast area the birds breeding here nest on near-vertical cliff walls and are thus assumed to be less affected by predators than other unmanaged sites. Initial modeled abundance for this area was calculated using the same approach described above for the Hanalei to Kekaha area, except that the modeled rate of decline was assumed equal to the average estimated across all radar sites in the Hanalei to Kekaha area (-6.9 percent per year).

Wainiha and Lumahaʻi Valleys

This area encompasses two of the largest valleys on Kauaʻi with breeding Newell's shearwater (ʻaʻo). While affected to some degree by powerlines and light attraction, radar data has shown no trend since monitoring began in 2006 (e.g., Raine and Rossiter 2020) and tracking data shows that birds transiting over this area are predominantly higher than powerlines (Raine et al. 2017a). There is no predator management in this area, but in order to match the stable radar trend since 2006, it was assumed that predation rates were equal to those modeled in the Waimea Canyon and Nā Pali Coast areas (i.e., that birds in these valleys have been confined to very steep and less accessible habitat and have reduced predation rates).

Auditory surveys were conducted in portions of Lumahaʻi Valley in 2020, and the corresponding call rate data was combined with survey data in both valleys in 2012–2014 and used after filtering out any call rates that did not meet the "heavy" and "ground calling" criteria (e.g., Raine et al. 2020). This approach excluded any breeding pairs associated with low-density nesting areas. Like other areas, habitat suitability modeling was also incorporated, and the breeding pair estimate for Wainiha and Lumahaʻi Valleys only included suitable habitat ranked at 8+ (i.e., suitable habitat ranked lower than 8 was assumed to contain zero breeding pairs). For areas within each valley that were not surveyed a cover ratio was applied. This was created by considering all areas within each site where auditory surveys were undertaken, drawing an 0.6-mile (1-kilometer) radius around each survey point, and creating a cover ratio within that survey radius of seabird activity polygons (heavy and ground calling) to suitable habitat. The cover ratio was then extrapolated to unsurveyed areas. The modeled suitable habitat was also further reduced by an elevation cut-off, such that suitable habitat below 1,922 feet (585.9 meters) above sea level for Newell's shearwater (ʻaʻo) was assumed to contain zero breeding pairs. The estimated densities of active nests were multiplied by 1.5, which reduced the breeding pair estimate, to account for active nests being more dispersed in unmanaged areas.

Table 5D-3. Abundance Estimates (males and females combined) of Newell's Shearwater (ʻaʻo) on Kauaʻi in 2021 by Subpopulation and Age Class. Abundance estimates for the Waimea and the Hanalei to Kekaha subpopulations are shown for the worse-case trend scenario. Abundance estimates for those subpopulations under the stable trend scenario are presented in Attachment 5D-1.

Subpopulation (see Figure 5D-1 for locations)	2021 Breeding Adults (ages 6+)[a]	2021 Subadults (ages 1–5)[b]	2021 Total Abundance (ages 1+)	Fraction of Total Powerline Strikes[c]	2016 Powerline Mortalities (all ages) per 100 breeding adults in 2020
Pihea	< 2	< 1	< 2	2×10^{-6}	0.5
North Bog	133	76	209	0.0013	2.5
Pōhākea[e]	579	330	909	0.0015	1.0
Hanakāpiʻai	152	87	239	0.0007	1.0
Hanakoa	89	51	140	0.0001	0.5
Upper Limahuli Preserve[e]	996	568	1,564	0.0077	2.5
Upper Mānoa Valley[e]	397	226	623	0.0024	2.5
Honopū[e]	180	103	283	0.0003	0.5
Wainiha and Lumahaʻi Valleys	4,698	2,677	7,375	0.0221	1.5
Hanalei to Kekaha	13,538	8,368	21,906	0.8604	20.3
Kalalau east to Upper Mānoa[f]	1,642	936	2,578	0.0077	1.5
Nā Pali Coast	818	466	1,284	0.0013	0.5
Waimea Canyon	1,971	1,426	3,343	0.0945	15.3
Total Kauaʻi abundance	**25,194**	**15,314**	**40,454**		

[a] Values for breeding adults correspond with the minimum theoretical estimate of abundance based on several alternative data sources, methods for estimation, including a partioning of suitable nesting habitat between Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu), and expert opinion (e.g. Raine et al. 2019, 2022a). Estimates for all conservation sites with established subpopulations (first 8 rows) were derived in 2021. Estimates of unmanaged subpopulations (last 4 rows) are derived from the habitat suitability analysis of Troy et al. (2014) restricted to 1,922 feet (585.6 meters) above sea level and above (the lowest elevation in managed colonies with a known burrow) correcting for the more dispersed nature of unmanaged colonies as compared to managed colonies.
[b] Except for the Hanalei to Kekaha and Waimea areas, the initial number of subadults was derived under the assumption that subadults comprise 36.3 percent of the age 1+ (non-chick) component of the population (Ainley et al. 2001). This assumption is quite close to the numerical solution for the proportion in a stable age distribution for the first two areas, which is a function of the high fledgling natural mortality rate assumed, as well as the high proportion of powerline mortalities that are assumed to be subadults in the model.
[c] Spatial patterns in the acoustic collision detection data from powerline collision monitoring and rationale for the modeled strike allocation is described in more detail below.
[d] The Pihea conservation site is aimed at protecting Hawaiian petrel (ʻuaʻu). The amount of suitable nesting habitat for Newell's shearwater (ʻaʻo) is more limited there than at other sites. Due to the limited amount of suitable nesting habitat, the estimated number of existing breeding pairs is between zero and one.
[e] The social attraction sites at Pōhākea, Upper Limahuli Preserve, Upper Mānoa Valley, and Honopū have initial starting populations of zero so are not listed (see Table 5D-7).
[f] The area from Kalalau east to Upper Mānoa Valley excluding conservation sites.

5D.2.1.2 Vital Rates under Optimal Conditions

A critical set of assumptions used in the KIUC HCP population dynamics model relate to the vital rates of the target species. *Vital rates* for any population dynamics model dictate population trajectories in the absence of any external factors, also referred to here as *optimal conditions*. Estimated reductions in vital rates relative to optimal conditions[5] allow the modeling of expected impacts on population dynamics from combined threats (e.g., mortalities due to introduced predators, powerline collisions, and light attraction). Likewise, the estimated effects of conservation measures on vital rates allow the modeling of expected benefits of mitigation and minimization measures. Vital rates for this model include the following.

- Survival from one age class to the next age class
- The age at first reproduction (also termed the "adult" age)
- The annual breeding probability for adults (expressed as a fraction of adult birds that breed each year)
- The reproductive success rate (i.e., the fraction of eggs laid by adults that survive to emerge from the nest as fledglings)

During the last decade, burrow monitoring and other studies have led to a substantial increase in available species-specific estimates of endangered seabird vital rates on Kaua'i (e.g., Raine et al. 2020, 2022a; Archipelago Research and Conservation 2021). Likewise, advances in powerline monitoring methods have resulted in estimates of powerline strike numbers, resulting mortalities, and locations (e.g., Travers et al. 2020, 2021). In addition to recent estimates of vital rates related to reproduction and recruitment from burrow monitoring studies, acoustic monitoring of call rates and satellite tagging studies also provide information on trends in abundance and relative vulnerability to powerline collisions for breeding colonies in conservation sites in northwestern Kaua'i. These newly available estimates serve to inform the biological assumptions of the KIUC HCP population dynamics model.

However, even with the improved estimates of vital rates and additional information on trends in abundance that recent monitoring efforts provide, there remains a high level of uncertainty for many of the biological assumptions that are input parameters for the population dynamics model. For example, the most recently reported estimate of the number of seabird powerline strikes from the Bayesian analysis of acoustic strike monitoring data collected between 2013 and 2019 has a 95 percent posterior predictive probability interval of 4,417–56,903 strikes per year (Travers et al. 2020). Moreover, in some instances, the parameter values adopted for this set of biological assumptions may be based wholly, or in part, upon expert opinion, and therefore confidence intervals cannot be calculated. Despite these limitations, the biological assumptions described in this appendix represent the best available scientific data, which is the regulatory standard for HCPs under the federal Endangered Species Act and Hawai'i Endangered Species Act.

The optimal rate of population growth is related to (but might be less than) the intrinsic rate of growth of the population, which is the maximum expected exponential growth rate that populations can achieve in the absence of density dependent competition for resources, and decreases in vital rates through anthropogenic effects and invasive predators (e.g., Caughley 1977). The optimal rate

[5] Also called vital rates under "natural conditions" in other parts of this appendix and in Chapter 5, *Effects*. The terms are equivalent for the purposes of the HCP.

of population growth is a key parameter in conservation risk assessments and management strategy evaluations (e.g., Niel and Leberton 2005). However, the optimal population growth rate is also a difficult parameter to estimate, especially for species without long-term surveys of abundance to monitor the rate of recovery from low population levels. At present, no empirical estimate exists for the optimal rate of population growth for Newell's shearwater ('a'o).

Given the biological assumptions for the vital rates of this model, the resulting optimal rate of modeled population growth (i.e., in the absence of introduced predators, powerline strike or light fallout mortality) is 2.36 percent per year. This is similar to the optimal rate of population growth modeled by Griesemer and Holmes (2011:30), which was 2.3 percent per year.

In practice, however, the optimal rate of population growth is never achieved in the KIUC model, because even for those sites with predator-proof fences, birds are still assumed to be vulnerable to powerline strike mortalities (at relatively low levels, given these sites are in northwestern Kaua'i) as well as aerial predation by introduced barn owls. The highest rate of modeled population growth in the KIUC model is achieved at the Honopū PF site. This site has a relatively low powerline strike mortality rate in the model (0.5 unminimized powerline mortalities per 100 breeding adults), due to its remote geographic location on the Nā Pali Coast, and predation rates other than barn owls are assumed to be zero. Ignoring immigration of existing birds from other areas due to social attraction at this site, the underlying modeled population growth rate is 2.03 percent per year at Honopū PF.

The optimal rate of population growth in a population dynamics model is a function of the optimal input values for the vital rates. All else being equal, higher optimal input values for survival or reproductive rates (or lower age at reproduction) result in higher values of optimal population growth rates and vice versa (e.g., Caswell 2001). The biological assumptions for the individual component life history values in the model are as follows.

Fledgling Survival Rates

Fledgling (age 1) survival rates and subsequent survival rates to breeding age were derived from the satellite tagging study reported by Raine et al. (2020). In that study, 12 Newell's shearwater ('a'o) fledglings were tracked at sea. From the tag signals it was possible to estimate if a fledgling died at sea (i.e., the tag stopped reporting movements in a manner that indicated it had not simply fallen off). Based on the observations of tagged fledglings, only 25 percent of tagged fledglings survived their first month at sea, suggesting that this percentage or lower would reach breeding age (Raine et al. 2020). Therefore, the fledgling survival rate assumed in the model was set such that, in combination with the assumed subadult survival rate, 25 percent of fledglings in the model (under near optimal conditions) would reach breeding age. Combined with the subadult survival rates at age described below, this assumption yields a fledgling survival rate of 0.371 (i.e., survival from age 1 to age 2). Accounting for fallout from light attraction further reduces the fledgling survival rate in the Hanalei to Kekaha area of the model (Section 5D.4.1.1, *Conservative Assumptions*). The estimated level of fallout includes correction factors for the proportion of grounded seabirds that go undetected, e.g., for KIUC streetlights, 89.6 percent of grounded Newell's shearwater ('a'o) are assumed to go undetected (Appendix 5B, *Light Attraction Modeling for Covered Seabirds*). Fallout, whether detected or not, is assumed to result in 100 percent mortality in the model.

Subadult and Adult Survival Rates

There are no available empirical estimates of adult survival rates for Newell's shearwater (ʻaʻo). Instead, adult survival rates were based on multiple studies undertaken on the similar Manx shearwater (Harris 1966; Perrins et al. 1973; Brooke 1977) and were set to 0.924. Subadult survival rates (ages 2–5 years) were set equal to the adult survival rate, which is consistent with a life history punctuated by very high first year at-sea mortality rates for fledglings, followed by relatively low natural mortality rates for subadults and adults. The exact values for subadult survival rates at age are uncertain, in part because subadults may spend several years at sea, making conventional approaches for estimating survival rates, like mark-recapture, impracticable. The values for subadult survival rates at age assumed in the model are consistent with the Raine et al. (2020) satellite tagging study on Kauaʻi described above in *Fledgling Survival Rates* and result in 25 percent of modeled fledglings reaching breeding age (age 6) under near optimal conditions.

Age at First Breeding

Like previous modeling studies, the age at first breeding was assumed to occur at 6 years (Ainley et al. 2001; Griesemer and Holmes 2011; Vorsino 2016).

Reproductive Success Rate

The reproductive success rate (RS) in the model measures the fraction of eggs that develop into a chick that survives to fledge. This is consistent with how reproductive success rates have been defined in the burrow monitoring study data. Reproductive success rates have been estimated from burrow monitoring studies at the conservation sites, both before (RS = 0.558) and after (RS = 0.872) dedicated predator mitigation measures. The RS rate at the conservation sites is taken from 3-year average value estimated across sites during 2019–2021 (e.g., Archipelago Research and Conservation 2021; Raine et al. 2022a). As a conservative assumption, this observed value was further reduced to account for observations of seabird bycatch in predator traps (n = 34 since 2016; Hallux unpublished data). Dividing the number caught in predator traps by estimated breeding age abundance at the conservation sites, the observed RS was reduced to 0.867. For areas in the model without predator mitigation, the reproductive success rate is assumed to be equal to that estimated at the conservation sites prior to dedicated mitigation measures. An adjustment was made for the Nā Pali Coast and Waimea areas, given that nests in these areas are confined to very steep and inaccessible cliff sides. Following the assumption that predation mortality rates in these two areas are 25 percent of those in unmanaged areas, due to the nests in these areas being confined to vertical high cliffsides largely inaccessible to mammalian predators (see also *Predation Rates*), it was also assumed that the reproductive success rate in these two areas is 25 percent greater than in unmanaged areas (RS = 0.698).

The RS rates in areas with predator-proof fences were based on the estimated RS rates at the conservation sites following dedicated predator mitigation, with an upward percentage adjustment corresponding to observed predation rates on nests without predator proof fences, which were 0.0023 for adults and 0.02 for chicks (Raine et al. 2022a; Raine unpublished data). This resulted in a modeled RS rate inside predator-proof fences of 0.891, or a 2.2 percent increase compared to the estimated RS rate from burrow monitoring studies at the conservation sites.

An additional area-specific adjustment was made to the RS values to account for powerline collisions that result in injury but not mortality and might cause breeding individuals to be unable to fledge a chick successfully (e.g., due to an inability to forage effectively that season). Following the observations of Travers et al. (2021), 24.5 percent of powerline collisions were assumed to result in non-lethal injury. These were individuals with post-collision elevation loss that were not assigned to immediate grounding mortality or short-term grounding mortality (within 3,609 feet [1,100 meters] of wires). The observed elevation loss of these birds not assigned as grounded/mortality, was used as a proxy for injury. The elevation loss indicates the collision was more severe or affected the bird more than those that flew off without elevation loss.

Future powerline collision levels, and their non-lethal effects, were derived from the powerline mortality rate calculations described below, under the assumption that mortalities were 28.8 percent of all collisions. The derived number of collisions was then multiplied by 24.5 percent to calculate the associated number of collisions resulting in non-lethal injuries. This number was multiplied by 21.4 percent to account for the proportion of collisions that are expected to be breeding adults (Cooper and Day 1998). And the resulting number of collisions resulting in non-lethal injuries of breeding age birds was divided by the number of breeding birds in an area each year, and used as a percentage reduction in reproductive success rate in that area that year.

Breeding Probability

Breeding probability is the percentage of adults (age 6 or older) that breed each year. This probability has been estimated through long-term studies of active breeders at the conservation sites and is 0.993 for Newell's shearwater ('a'o) (Raine et al. 2022b). The breeding probability value is assumed to be constant across all geographic areas and through time in the model.

5D.2.1.3 Powerline Mortality

The powerline mortality rate for each area *i* with no minimization was calculated for subadults and adults by dividing the proportion of unminimized powerline mortalities for each age class by the corresponding estimates of abundance for that area.

$$\psi_{a,i}^{sa} = \frac{p_i \Omega \rho \nu \pi_{sa}}{\sum_{a=3}^{5} \hat{N}_{a,i}^{sa}}$$

(Equation 1)

$$\psi_{6+,i} = \frac{p_i \Omega \rho \nu (1 - \pi_{sa})}{\hat{N}_{6+,i}}$$

Where:

- $\psi_{a,i}^{sa}$ and $\psi_{6+,i}$ are the annual powerline mortality rates for subadults, ages 3–5 years, and adults (ages 6 years and older; Figure 5D-2) in area *i* prior to any minimization (i.e., unminimized). In the context of powerline strikes, subadults refer to ages 3–5 years because ages 1 and 2 are assumed to be at sea and are not vulnerable to powerline strikes in the model (Equation 3). The powerline mortality rates are assumed to be equal for subadults of each vulnerable age.
- p_i is the modelled fraction of total powerline strikes for each species that are associated with birds from area *i* in 2016 (see Table 5D-2 for list of areas).
- Ω is the estimated number of seabird powerline strikes in 2016 (Hawaiian petrels ['ua'u] and Newell's shearwater ['a'o] combined).

- ρ is the proportion of total strikes that are Newell's shearwater (ʻaʻo) (Travers et al. 2021).
- ν is the total grounding rate (i.e., the proportion of strikes that result in mortality; Travers et al. 2021).
- π_{sa} is the proportion of powerline strikes that are subadults (Cooper and Day 1998).
- $\widehat{N}_{a,i}^{sa}$ is the number of subadults at age (ages 3–5 years) and $\widehat{N}_{6+,i}$ is the number of adults in 2016, which when projected forward through time in the model, equal the island-based estimates from 2021 (see Table 5D-3). The initial age structure in the model, for those areas outside Hanalei to Kekaha and Waimea, assumes that 63.7 percent of the population is composed of breeding adults (the remaining 36.3 percent are assumed to be ages 1–5 subadults), following Ainley et al. (2001).

Table 5D-4 shows the assumed values for most of the variables above. The text below the table explains the rationale for these variables.

Table 5D-4. Powerline Strike Assumptions for the Population Dynamics Model

Powerline Strike Variable	Model Variable	Assumed Value
2016 annual powerline strikes of Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) combined, before minimization (i.e., average annual unminimized strike estimate during 2013–2019)	Ω	15,853[a]
Total grounding rate	ν	0.288[b]
Proportion of strikes that are Newell's shearwater (ʻaʻo)	ρ	0.70[c]
2016 annual estimated mortalities of Newell's shearwater (ʻaʻo)	calculation	3,196[d]
Proportion of powerline strikes that are subadults	π_{sa}	0.79[e]

[a] Total number of estimated seabird powerline strikes of Newell's shearwater (ʻaʻo) and Hawaiian petrels (ʻuaʻu) combined. Estimate excludes waterbird strikes and strikes minimized during the Short-Term HCP. Based on 2013–2019 acoustic data and the Bayesian estimate model described in Travers et al. (2020).
[b] The total grounding rate includes 13 percent "immediately grounded," 10.2 percent "unknown outcome", and 5.6 percent of birds that strike powerlines having been observed with the most severe of post-flight behaviors and that are hence assumed to have eventually died (Travers et al. 2021).
[c] Travers et al. (2021)
[d] Mortalities are calculated as the proportion of unminimized seabird strikes for each species, multiplied by the total grounding rate.
[e] See text for additional explanation (Cooper and Day 1998).

Powerline Strike Allocation by Subpopulation

The powerline strike allocation by subpopulation is based on the percentage of acoustically detected strikes that have been analyzed to estimate strike totals across the island (Travers et al. 2020). The assumed empirical strike allocations are: 89.1 percent of strikes in the Hanalei to Kekaha area, 10.8 percent of strikes in the Waimea Canyon area, and 0.1 percent of strikes from the Wainiha and Lumahaʻi Valleys area (Travers et al. 2020; Travers unpublished data). Some variance from the empirical acoustic detections was incorporated in the modeled allocation so that 3.1 percent of strikes from the Hanalei to Kekaha area were assumed to result from collisions by individuals from breeding colonies in the remote northwestern areas. This allowed the model to incorporate a low level of powerline collision vulnerability for individuals associated with the conservation sites and surrounding areas, which is consistent with observations from tagging studies (Raine et al. 2017a).

In general, the spatial differences that have been observed through acoustic powerline collision monitoring data served as a key motivating factor for developing a spatially explicit population dynamics modeling framework.

Powerline Strike Allocation by Species

As described in Chapter 5, *Effects*, estimates of powerline strikes of the covered seabirds are derived from acoustic data on strikes for all seabirds combined. Acoustic data cannot be separated by species. Instead, we must make an assumption of the proportion of strikes allocated to either Newell's shearwater (ʻaʻo) or Hawaiian petrel (ʻuaʻu). Travers et al. (2021) has reported that powerline collisions directly observed in the field occur in a proportion of 70.5 percent Newell's shearwater (ʻaʻo) to 29.5 percent Hawaiian petrel (ʻuaʻu). The modeling assumption corresponds to these proportions, with 70 percent of all estimated strikes assumed to be Newell's shearwater (ʻaʻo) and 30 percent assumed to be Hawaiian petrel (ʻuaʻu) (Table 5D-4).

Powerline Strike Allocation by Age Class

Birds detected colliding with powerlines through acoustic monitoring, which is used to estimate strike numbers, cannot be identified to age class. However, the proportions of strikes that are subadults and adults are important for the population dynamics model. Limited evidence suggests that subadults are more susceptible to powerline strikes than adults. For the purposes of this model, powerline strikes of Newell's shearwater (ʻaʻo) are assumed to be composed of 79 percent subadults (ages 3–5 years) and 21 percent adults (ages 6 years and older) (Table 5D-4).

This assumption corresponds to the proportions estimated by Cooper and Day (1998), who analyzed brood patch vascularization and wear of rectrices for 14 downed Newell's shearwater (ʻaʻo) collected on powerline mortality searches during 1993–1994. Three of those downed Newell's shearwater (ʻaʻo) had highly vascularized brood patches and worn rectrices, which suggests those birds were incubating eggs in burrows, and hence they were classified as breeding adults (age 6+). The remaining 11 birds either had no brood patch (n=10) or a downy brood patch (n=1); all but the latter had unworn rectrices. Those 11 birds (78.6 percent) were classified as subadults, and the three others (21.4 percent) were classified as breeding adults.

Mortality from Future Powerlines

Mortality due to construction of future powerlines was assumed to apply only to the Hanalei to Kekaha area (Figure 5D-1). The vast majority (> 99 percent) of new powerlines are expected to be constructed in this area, which is where human population growth is forecast to occur on Kauaʻi (see Chapter 2, *Covered Activities*, for details). As described in Chapter 5, *Effects*, at the end of the 50-year permit term, powerline strikes would be increased by an estimated 4.7 percent. The species-specific increase in future strikes was calculated by applying the species split to this percentage, and then applying a linear increase in the strike mortality rate each year, such that by the end of the HCP term, the strike mortality rate was increased consistent with the estimated percent increase in strikes.

Mortality from Fallout from Existing and Future Streetlights and Covered Facility Lights

Appendix 5B, *Light Attraction Modeling for Covered Seabirds*, describes the process for quantifying take of the covered seabirds from attraction to lights owned and operated by KIUC. Mortality due to fallout from light attraction was assumed to affect fledglings (age 1 year) only in the Hanalei to Kekaha area. Fallout is assumed to result in 100 percent mortality in the model, so as a conservative approach the benefits of Save Our Shearwaters (SOS) rehabilitation efforts are not counted (given that there is little data on survival once the birds are released). Based on this assumption, and the light attraction modeling (Appendix 5B), the number of mortalities from fallout each year for Newell's shearwater (ʻaʻo) was set to 99.9 in the model. This estimate represents expected mortalities resulting from existing and future light sources anticipated by the end of the 50-year permit term. However, this value was applied at the start of the population trajectories as a conservative approach for modeling fallout mortality levels through time, so annual fallout mortalities from attraction to lights owned and operated by KIUC is likely overestimated at the start of the metapopulation projections.

5D.2.1.4 Predation Rates

Predation mortality rates have been estimated at the conservation sites, both with and without trapping and fencing (i.e., mitigation). Prior to dedicated predator control, predation mortality rates for all predators combined were estimated to be 0.18 for chicks in the nest, and 0.0272 for breeding adults[6] at the nest (Raine et al. 2022a; Raine unpublished data). For areas outside the conservation sites (with no active management), predation rates at the nest were assumed to be equal to the estimates for the conservation sites prior to dedicated predator control, with three exceptions. The exceptions were the Nā Pali Coast, Wainiha and Lumahaʻi Valleys, and Waimea Canyon areas, where predation mortality rates are assumed to be 25 percent of the unmitigated rates. These values were assumed for the Wainiha and Lumahaʻi Valleys in order to match the stable trend in abundance estimated from radar surveys in this area during 2006–2020 (Raine and Rossiter 2020). In the Nā Pali Coast and Waimea Canyon areas predation rates are expected to be substantially less than other areas due to the steep and inaccessible cliff locations to which breeding pairs are largely confined. As discussed in Chapter 4, *Conservation Strategy*, breeding colonies likely persist in these locations because of their inaccessibility to mammalian predators (as well as being far away from the majority of threats from powerline collision and light attraction).

With predator control measures at the conservation sites, predation mortality rates were estimated to decrease to 0.02 for chicks and 0.0023 for adults (Raine et al. 2022a; Raine unpublished data). The effect of these reductions in predation rates at the nests is also evident in the reproductive success rates estimated before (55.8 percent reproductive success rate) and after dedicated predator control measures (86.7 percent reproductive success rate) at the conservation sites (e.g., Raine et al. 2022a). Although predation mortality rates for chicks are not explicitly included as a variable in the model and are therefore not considered further, they are subsumed in the reproductive success rate estimates used in the model, as discussed above under *Reproductive Success Rate*.

Barn owl predation rates on the wing for adults were assumed to be equal to the adult predation rate at the nest (0.0023; Raine et al. 2022a; Raine unpublished data), and the same barn owl

[6] In other words, 18 percent of all chicks at all conservation sites are assumed to be lost to predators in the absence of dedicated predator control structures or actions. Similarly, 2.7 percent of all adults at the conservation sites are assumed to be lost to predators annually in the absence of any predator control structures or actions. Chicks are not tracked explicitly in the model, but chick survival (and mortality from predation) is measured in the estimated reproductive success rates of adults from burrow monitoring studies, and those reproductive success rate estimates (and hence chick mortality) from monitoring studies are explicitly included in the model.

predation rate on the wing was assumed for ages 3–6+ in the absence of additional information. The assumed barn owl predation rate on the wing was added to the terrestrial predation rates at the nest for all areas. For example, in the Kalalau east to Upper Mānoa area, the adult predation rates at the nest were assumed to be equal to those estimated at the conservation sites prior to dedicated predator control measures (0.0272) plus the assumed barn owl predation rate on the wing (0.0023), or a total adult predation rate of 0.0295 (Table 5D-5). For areas with predator-proof fences, the terrestrial predation rate was assumed to be zero, and the assumed predation rate was limited to that assumed for barn owls on the wing. In other words, the adult predation rate was modeled as the sum of the applied nest predation rate (which differed between areas in the model) and the assumed barn owl predation rate on the wing (which was constant between areas in the model). Predation rates at the nests were assumed to vary between different areas according to different management measures (Table 5D-5).

The predation rate for ages 3–5 was set to 0.0023, under the assumption that those ages are not vulnerable to terrestrial predators because they are not nesting, but they are vulnerable as prospectors to being killed by barn owls on the wing (Table 5D-5).

Table 5D-5. Assumptions for Annual Predation Rates, with and without Predator Control

	Without Predator Control[a]		With Predator Control[b]	
Site	**Adults**	**Subadults (3–5 yrs)**	**Adults**	**Subadults (3–5 yrs)**
Conservation Sites	--	--	0.0046	0.0023
Conservation Sites with Predator-Proof Fences	--	--	0.0023	0.0023
Kalalau east to Upper Mānoa	0.0295	0.0023	--	--
Hanalei to Kekaha	0.0295	0.0023	--	--
Wainiha and Lumahaʻi Valleys[c]	0.0074	0.0006	--	--
Nā Pali Coast[c]	0.0074	0.0006	--	--
Waimea Canyon[c]	0.0074	0.0006	--	--

[a] Without predator control is defined as no fencing, no predator trapping, and no predator removal efforts. With predator control includes trapping and ungulate fences for the conservation sites, or sites with predator-proof fences (second row).
[b] See Table 5D-6 for differences in predation mortality rates assumed for different age classes.
[c] Due to the inaccessibility of these sites (Nā Pali Coast and Waimea Canyon), predation rates for adults and subadults are set at 25 percent of the rates of other sites without predator control. The same assumption is made in terms of reduced predation rates for Wainiha and Lumahaʻi Valleys in order for the initial modeled trend to match the stable trend in radar survey data at the two monitoring sites for these valleys during 2006–2020 (Raine and Rossiter 2020).

5D.2.2 Population Dynamics Model and Projections of Abundance

This section describes the model structure, each of the model parameters, and the rationale for each model input.

The population dynamics model is described below in terms of the numbers of females-at-age for each species, under the assumption of a 50:50 sex-ratio:

$$N_{1,t,i} = 0.5\gamma_{t-1,i}\beta N_{6+,t-1,i}S^*_{6+,t-1,i} - F_{t,i} \quad \text{(Equation 2)}$$

$$N_{2,t,i} = N_{1,t-1,i}S^*_{1,t-1,i}$$
$$N_{3,t,i} = N_{2,t-1,i}S^*_{2,t-1,i}$$
$$N_{4,t,i} = N_{3,t-1,i}S^*_{3,t-1,i}$$
$$N_{5,t,i} = N_{4,t-1,i}S^*_{4,t-1,i}$$
$$N_{6+,t,i} = N_{5,t-1,i}S^*_{5,t-1,i} + N_{6+,t-1,i}S^*_{6+,t-1,i}$$

Where:

- $N_{a,t,i}$ is the number of female birds at age a during year t in area i. Birds aged 6 years and older (denoted as age 6+) are modeled as a plus-group, *aka* a self-loop group (Figure 5D-2). Fledglings are denoted as age 1 in the model.
- $\gamma_{t,i}$ is the reproductive success rate during year t in area i. Reproductive success rates in the model vary between conservation sites and unmanaged areas, and can change with time for areas with future predator control measures (e.g., predator-proof fences).
- β is the breeding probability for sexually mature birds (assumed constant across areas).
- "Fertility" is defined here as the product: $0.5\gamma_{t-1,i}\beta S^*_{6+,t-1,i}$
- Hence, fertility, or the number of female fledglings produced per breeding female per year, is a function of the adult survival rate. Chick mortality rates, which are subsumed in the reproductive success rate variable, are therefore directly related to parental mortality rates in the model vis-à-vis reductions in the numbers of fledglings produced.
- $F_{t,i}$ is the number of age 1 birds that die from fallout due to KIUC lights during year t in area i. This term is included with a time and area component for generality, but in practice, fallout is assumed to be limited to the Hanalei to Kekaha subpopulation with 46.3 age 1 female mortalities per year (i.e., 92.6 fallout mortalities per year for age 1 males and females combined).

- $S^*_{a,t,i}$ is the survival rate of birds at age a during year t in area i, which for ages 3 years and older is a function of the estimated predation and powerline mortality rates-at-age, as well as the powerline minimization level in year t:

$$
\begin{gathered}
S^*_{1,t,i} = S_1 \\
S^*_{2,t,i} = S_2 \\
S^*_{3,t,i} = S_3(1-\phi_{3,t,i})\left[1-\psi_{3,i}(1-\delta_t)\right] \\
S^*_{4,t,i} = S_4(1-\phi_{4,t,i})\left[1-\psi_{4,i}(1-\delta_t)\right] \\
S^*_{5,t,i} = S_5(1-\phi_{5,t,i})\left[1-\psi_{5,i}(1-\delta_t)\right] \\
S^*_{6+,t,i} = S_{6+}(1-\phi_{6+,t,i})\left[1-\psi_{6+,i}(1-\delta_t)\right]
\end{gathered}
\quad \text{(Equation 3)}
$$

Where:

- S_a is the natural survival rate at age a prior to any mortalities from predators or powerlines (Table 5D-5).
- $\phi_{a,t,i}$ is the predation mortality rate at age a during year t in area i (Tables 5D-5 and 5D-6). Predation rates vary through time in the model in the areas where future predator control measures will occur or where predator-proof fences are installed.
- $\psi_{a,i}$ is the unminimized powerline mortality rate at age a in area i. The unminimized powerline mortality rates vary by area due to unequal per-capita vulnerability to powerline strikes (Equation 1; Table 5D-3).
- δ_t is the minimization efficacy in terms of reducing powerline strikes during year t. The minimization rate varies between years according to the strike minimization schedule under the HCP (Table 5D-8).

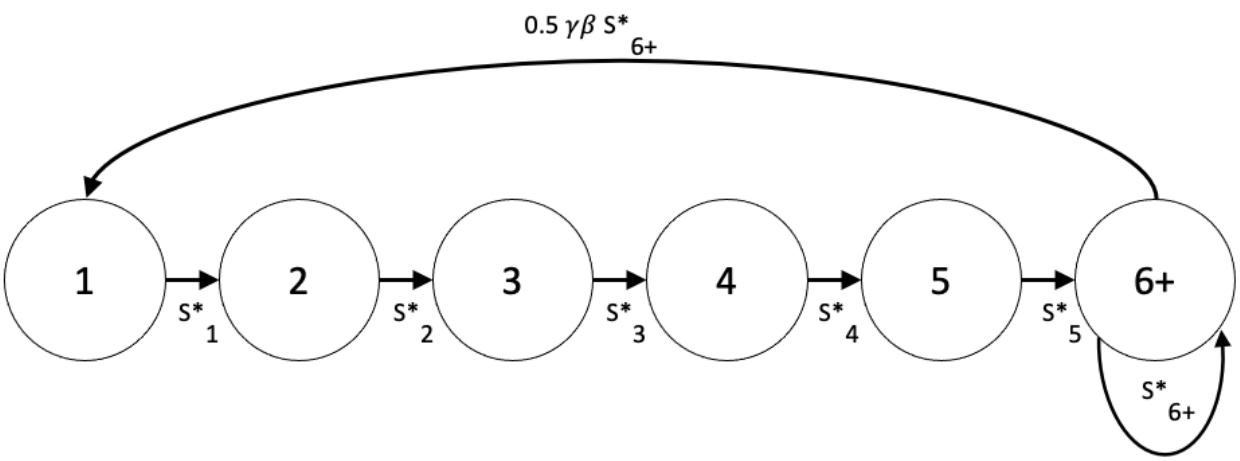

Figure 5D-2. Life Cycle Graph with Age-Structured Transition Parameters for the Population Dynamics Model

The life-cycle model shown in Figure 5D-2 is similar to the model developed by Griesemer and Holmes (2011). The circles, and numbers therein, correspond with a single age-class in the model. Birds aged 6 years and older were modeled as a self-loop group (i.e., senescence was not assumed to be a knife-edge where all birds die at a given age). The survival rates at age a, S_a^* are a function of predation and powerline mortality rates at age as well as the powerline strike minimization rates (Equation 3). For conciseness, the subscripts for year and area are dropped in the transition parameters shown in the figure.

Table 5D-6. Survival, Predation Mortality, and Fertility Rates by Age for Newell's Shearwater (ʻaʻo)

Age	Natural Survival Rate[a]	Predation Mortality Rate without Predator Control or Fencing[b]	Predation Mortality Rate with Predator Control and Ungulate Fencing[b]	Predation Mortality Rate with Predator-Proof Fencing[d]	Natural Fertility[a]	Fertility without Predator Control or Fencing[e]
1	0.371	0	0	0	0	0
2	0.924	0	0	0	0	0
3	0.924	0.0023[c]	0.0023[c]	0.0023[c]	0	0
4	0.924	0.0023[c]	0.0023[c]	0.0023[c]	0	0
5	0.924	0.0023[c]	0.0023[c]	0.0023[c]	0	0
6+	0.924	0.0295	0.0046	0.0023[c]	0.416	0.243

[a] Natural survival and natural fertility represent the modeled rates in the absence of predation and powerline mortalities. The value of 0.924 for natural survival is based on survival rates estimated from studies of Manx shearwater and Hawaiian petrel (ʻuaʻu) (Simmons 1984, 1985), with age 1 survival adjusted to result in ~25 percent of birds reaching breeding age, based on satellite tagging results for Newell's shearwater (ʻaʻo) on Kauaʻi (Raine et al. 2020).

[b] Estimated from burrow monitoring studies at conservation sites (e.g., Raine et al. 2022a), and assuming that ages 1 and 2 are not vulnerable to introduced predators on the island, because they are largely expected to be at sea.

[c] Taken from estimated barn owl predation rates for nesting birds and assumed in the model to be equal for age 3–5 birds (i.e., the barn owl predation rate is applied to this age under the assumption that ages 3–5 would be "prospectors" and predated by barn owls on the wing).

[d] All predation mortality rates are assumed to be reduced to zero by predator-proof fences, except for ages 3–6+ which are assigned the estimated barn owl predation rate on the wing.

[e] This fertility value corresponds to the Hanalei to Kekaha subpopulation with unminimized powerline strike mortality rates. The fertility values are a function of the adult powerline mortality rates and non-lethal injury calculations, and therefore change through time in the model as a function of the minimization schedule. Likewise, the fertility rates differ between areas in the model due to spatial differences in the adult powerline mortality rates between areas in the model. Because the Hanalei to Kekaha area has the highest powerline strike mortality rate, it also has the lowest modeled fertility rate, which reflects the expectation that if a nesting parent is killed, its egg/chick will not survive to fledge.

Table 5D-7. Reproductive Rates Assumed in the Population Dynamics Model

Vital Rate	Value
Sex ratio	0.5
Reproductive success rate without predator control and without fencing	0.558[a]
Reproductive success rate with predator control	0.867[a]
Reproductive success rate with predator-proof fencing	0.891[a]
Breeding probability	0.993[b]
Age at sexual maturity	6 yr

[a] Estimated from burrow monitoring studies at management sites prior to dedicated predator control ("Year 0") and after predator control measures (e.g., Raine et al. 2022a). The reproductive success rate with predator control measures is estimated from the 3-year, 2019–2021 average reproductive success rate and includes bycatch of seabirds in predator traps at conservation sites. The reproductive success rate at conservation sites with predator-proof fencing is assumed to be 2.23 percent greater than at conservation sites with trapping and ungulate fencing. This is comparable to reducing the estimated adult and chick predation rates (combined) from terrestrial predators at nests in those conservation sites to zero.
[b] Estimated from long-term studies of active breeders at the conservation sites (Raine et al. 2022b).

Table 5D-8. The Annual Powerline Minimization Schedule[a]

Year	Cumulative Island-Wide Powerline Mortality Minimization Rate[b]
2019	0.0004
2020	0.145
2021	0.352
2022	0.488
2023	0.653
2024	0.664
2025–2075	0.664

[a] See Conservation Measure 1, *Implement Powerline Collision Minimization Projects*, in Chapter 4, *Conservation Strategy*, for details on the specific powerline minimization projects and the locations.
[b] Minimization represents the efficacy to reduce the mortality rate due to powerline strikes. In other words, minimization = 0.0 corresponds to no change in powerline mortality rate (without any minimization measures implemented). A minimization = 1.0 represents a scenario where a powerline was removed or modified so that bird collisions no longer occurred, and powerline mortality rates are zero. A minimization efficacy of 0.5 represents a 50 percent reduction in strike mortalities.

5D.2.3 Social Attraction Site Dynamics and Dispersal

The population dynamics model assumes natal fidelity and internal recruitment for each subpopulation, such that birds that fledge in area *i* return to the same area to breed for the remainder of their lives. The exception to this is immigration into social attraction sites. The numbers of new breeding birds that immigrate into each social attraction site each year following the installation of the site are shown in Table 5D-9. The model assumes that the number of breeding birds that immigrate into a social attraction site each year from area *i* is proportional to the abundance of the subpopulation in area *i* relative to total abundance that year. For example, if a subpopulation in area *i* in year *t* represents 50 percent of total abundance, then 50 percent of the immigrants into social attraction sites that year will be from that subpopulation. Age 3 subadults are the only age class assumed to immigrate into social attraction sites. This age class represents subadult "prospectors" that are searching for suitable habitat to establish a nest. The number of subadult prospectors immigrating into social attraction sites was determined such that the expected number of established breeding pairs 3 years later was matched (Table 5D-9). Immigration into social attraction sites is assumed to be permanent and once breeding pairs are established their offspring are assumed to have natal fidelity (Procellariids exhibit strong natal philopatry) and return to breed at the same social attraction site in subsequent years.

5D.2.3.1 Carrying Capacity

Because the proposed social attraction sites are relatively small compared to their surrounding conservation sites, and because they are enclosed by a predator exclusion fence, we assume that each social attraction site has a finite carrying capacity. Suitable habitat within the proposed predator exclusion areas was used by ARC to estimate the carrying capacity of nesting Newellʻs shearwater (ʻaʻo) breeding pairs for each site: 136 Pōhākea PF; 468 at Honopū PF; 396 at Upper Mānoa Valley PF, and 453 at Upper Limahuli Preserve PF. Once the carrying capacity of breeding pairs is reached within each predator exclusion fence, the subpopulation is held constant. Any reproduction that occurs within the predator exclusion fence in excess of this carrying capacity, and any immigration due to continued social attraction is assumed to result in new breeding age birds nesting in the adjacent management area of the same site, as seen in Figure 5D-3 for the four sites with predator exclusion fences. These are estimates only based on theoretical limits of carrying capacity.

5D.2.3.2 Kauaʻi Seabird HCP Social Attraction Site

To accurately reflect the island-wide population of Newell's shearwater (ʻaʻo), a additional social attraction site was added to this population dynamics model to account for the Kauaʻi Seabird HCP[7] (KSHCP). The KSHCP, approved in 2020, began implementation in 2021. A primary conservation measure of the KSHCP is the establishment of a new social attraction at the Kahuamaʻa Seabird Preserve (abbreviated here to Kahuamaʻa). This site is approximately 5 acres (2 hectares) in size and is located on the Kalalau Rim in northwestern Kauaʻi at approximately 3,500 feet in elevation (see Figure 5-1 in the KSHCP for specific location). The site is surrounded by a predator-proof fence (completed in 2021) and site management will be very similar to that proposed for this HCP (i.e., cat and rodent control, barn owl control, and invasive plant management). Because it is similar in size to Pōhākea PF, the same carrying capacity for breeding pairs was assumed.

The one exception in the KIUC HCP population dynamics model to the assumption for the number of new breeding pairs immigrating into social attraction sites is at the Kahuamaʻa site. The dynamics for this site assume that the number of new breeding pairs that become established each year is one half the number shown in Table 5D-9. This results in 511 new fledglings produced over the first 30 years of the modeled projection, given the assumed predation rates for sites with predator proof fences (Table 5D-5) and powerline mortality rates set equal to the Kalalau to Upper Mānoa area. The assumption of a lower immigration rate to this social attraction site is meant to mimic the assumed benefit in the KSHCP for the number of fledglings that would be produced at the Kahuamaʻa site over 30 years (Table 7 of KSHCP Appendix C under predation scenario 2, and 90–95 percent site fidelity, provides a comparable prediction of 462–932 new fledglings produced over 30 years at this site).

[7] See https://fws.gov/pacificislands/documents/KSHCP/Kauai-Seabird-HCP.pdf

Table 5D-9. Number of Breeding Pairs Expected to Immigrate into Each Social Attraction Site from Other Areas Each Year Following the Introduction of Social Attraction Efforts

Immigration into social attraction sites is assumed in the model to be permanent. After 30 years, the rate of immigration due to social attraction is assumed to remain constant at the average immigration rate during years 20 to 30 modeled for each site. Once a social attraction site has reached the estimated carrying capacity of the predator-exclusion fencing, additional immigration and recruitment into the adjacent breeding colony is assumed to occur in the surrounding conservation site.

Social Attraction Site Year	New Breeding Pairs[a]	Total Breeding Pairs
1	0	0
2	0	0
3	0	0
4	0	0
5	3	3
6	2	5
7	2	7
8	5	12
9	1	13
10	1	14
11	16.77	30.77
12	14.60	45.37
13	14.68	60.05
14	14.34	74.39
15	14.21	88.60
16	13.94	102.54
17	14.14	116.68
18	12.73	129.41
19	13.33	142.74
20	13.03	155.77
21	13.43	169.20
22	12.96	182.16
23	13.09	195.25
24	13.58	208.83
25	13.54	222.37
26	11.85	234.22
27	13.10	247.32
28	13.30	260.62
29	13.23	273.85
30	13.13	286.98

Source: Raine 2020

[a] The expected number of breeding pairs immigrating into social attraction sites is based on data collected at multiple existing social attraction sites, including those for Huttons shearwater (New Zealand), Bermuda petrel (Bermuda) and Newell's shearwater (ʻaʻo) (Makamakaʻole). All show the same pattern of slow establishment (low immigration in the first few years), and then immigration increases more quickly after year 10.

5D.3 Model Results for Worse-Case Trend Scenario

All model results for Newell's shearwater (ʻaʻo) for the worse-case trend scenario are presented in Figures 5D-3 through 5D-7 at the end of this section. The population dynamics results in Figures 5D-3 and 5D-4 demonstrate that the conservation measures implemented will substantially benefit Newell's shearwater (ʻaʻo) relatively quickly at four of the conservation sites. Benefits to Newell's shearwater (ʻaʻo) are modest at three other conservation sites. The only conservation site with no benefit to Newell's shearwater (ʻaʻo) is Pihea, which is designed primarily to benefit Hawaiian petrel (ʻuaʻu). HCP benefits are greatest at the four conservation sites with predator exclusion fencing and social attraction, as expected (Figure 5D-3).

The population trajectory for Newell's shearwater (ʻaʻo) at all conservation sites combined is shown in Figure 5D-5 and shows a similar pattern. According to the model, the total population size of Newell's shearwater (ʻaʻo) at all of the conservation sites is expected to increase immediately with the rate gradually increasing through approximately 2035. After that, the population increases steadily and more substantially due to the contributions of the newest social attraction sites (Upper Limahuli Preserve PF[8], Upper Mānoa Valley PF, Pōhākea PF, and Honopū PF). By the end of the permit term the combined number of breeding pairs in all conservation sites is projected to be over 4,300.

Continued predator control by the HCP at the six conservation sites with ungulate fencing, combined with powerline collision minimization, will prevent substantial declines of existing subpopulations of Newell's shearwater (ʻaʻo) and likely prevent local extirpation (red lines in Figure 5D-4). Eight of these conservation sites with predator control (Upper Limahuli Preserve, Upper Limahuli Preserve PF, Pōhākea, Pōhākea PF, Upper Mānoa Valley, Upper Mānoa Valley PF, Honopū, and Honopū PF) collectively contribute substantial numbers of new breeding pairs to the Kauaʻi metapopulation of Newell's shearwater (ʻaʻo) with the HCP (blue lines in Figure 5D-4). Combined, these four conservation sites are projected to have a breeding pair abundance of over 2,500 by the end of the permit term.

Figure 5D-6 shows the subpopulation trajectories at each of the five areas outside the conservation sites (see Figure 5D-1 for area locations), with and without the KIUC HCP. Hanalei to Kekaha is the largest subpopulation area, by far. This area is projected to be locally extirpated without the HCP, and severely depleted with a continued downward trend with the HCP, under the initial modeled rate of decline based on the Hanalei radar site. Without the HCP, local extirpation is projected to occur by approximately 2050. With the HCP, extirpation would be delayed beyond 30 years in the model, but not avoided in the more distant future. The difference in subpopulation declines is due largely to powerline minimization. Because 86 percent of powerline collisions for Newell's shearwater (ʻaʻo) are assumed to be from individuals associated with breeding colonies within this area (see Figure 5D-1), powerline minimization provides a greater benefit in this area than in other areas. This result is not surprising, because for all areas other than Hanalei to Kekaha and Waimea Canyon there is a much lower risk of powerline collisions in the first place (Table 5D-3). By 2023 the rate of modeled decline has slowed from the initial 2016 applied radar trend in the Hanalei to Kekaha and Waimea Canyon areas due to powerline strike minimization (Table 5D-10). For Hanalei to Kekaha the rate of decline in abundance then increases again through time, due to the modeled effect of future powerline construction and fledgling fallout mortality.

[8] PF stands for predator exclusion fence

The subpopulation trajectory in the Wainiha and Lumahaʻi Valleys area is similar with and without the HCP (Figure 5D-6). This is due to the assumptions that (1) powerline strikes are minimal in this area, so powerline minimization with the HCP has a small benefit, and (2) there is no predator control in this area. The trajectory of abundance starts off stable, which is consistent with the lack of trend in either direction estimated at the Wainiha and Lumahaʻi Valleys radar sites (Raine and Rossiter 2020; Sahin 2023). Because of the model assumptions for social attraction sites (Figure 5D-3), the stable trend in the Wainiha and Lumahaʻi Valleys becomes slightly negative due to emigration from this area to social attraction sites (Figure 5D-6). This "pull" of social attraction sites becomes more pronounced later in the permit term as all of the planned social attraction sites become operational, and once they have all reached a critical mass of breeding pairs increasing the attraction from greater levels of naturally produced calls (Table 5D-9). This modeled dynamic is not unique to Newell's shearwater (ʻaʻo) from the Wainiha and Lumahaʻi Valleys, but because this area has a relatively high abundance with a stable trend it is predicted to act as a substantial source of new breeding pairs into the social attraction sites. It is also the area where it is easiest to visualize the effect of the modeled emigration graphically (Figure 5D-6), and likewise the effect of emigration is also evident in the tabled values for the rates of change in abundance through time for this area (Table 5D-11). This emigration would be beneficial to the metapopulation of the species because it would mean that birds were being drawn from unprotected areas in these two valleys into management areas with predator exclusion fences and predator control measures.

Two of the remaining three areas in Figure 5D-6, Kalalau east to Upper Mānoa and the Nā Pali Coast area, are assumed to have relatively low vulnerabilities to powerline strikes, given their geographic remoteness (especially the Nā Pali Coast area) and orientation away from any existing powerlines and light sources. The initial stable trend modeled for the Nā Pali Coast area (Table 5D-10) matches observed patterns in Newell's shearwater (ʻaʻo) acoustic call detection data from that area. The overall trend in call rates in the Nā Pali Coast area has been stable in recent years, with no pattern of increase or decrease in call rates (e.g., Raine et al. 2023). Like discussed above for the Wainiha and Lumahaʻi Valleys, the modeled trend in the Nā Pali Coast area eventually turns to a small rate of decline, which is largely independent of powerline mortality, but results instead because a proportion of subadult birds are modeled to emigrate into social attraction sites. Again, while this dynamic reduces the number of modeled breeding pairs in certain areas like the Nā Pali Coast (Table 5D-11), there is a benefit to the metapopulation as a whole from individuals relocating to areas with predator exclusion fences and predator control measures.

The Waimea Canyon area has the second highest modeled vulnerability to powerline collisions and mortalities (Table 5D-2; based on 10.8 percent of all detected powerline strikes during 2013–2019 having occurred in this area (Travers et al. 2020; Travers unpublished data). Unlike areas with lower powerline strike rates, the modeled trend in this area benefits from minimization efforts (Figure 5D-6). In other words, the trend becomes less negative due to the modeled reduction in powerline mortality rates in this area, moving from -6.9 percent without minimization to -3.3 percent per year under the HCP (Table 5D-10). Similar to the Hanalei to Kekaha area, the modeled slowdown in the rate of decline is not sufficient to prevent continued reductions in modeled abundance in these areas (Tables 5D-11 and 5D-12).

When all subpopulations are combined (Figure 5D-7), the Newell's shearwater (ʻaʻo) metapopulation on Kauaʻi is projected to continue to decline without the HCP (red line; unminimized take scenario). Without the HCP, abundance is projected to continue to decline from approximately 12,600 breeding pairs at the start of the permit term to less than 3,000 by the end of 2075, a decline of over 70 percent (Figure 5D-7; red line). With the HCP conservation measures the

Newell's shearwater (ʻaʻo) metapopulation on Kauaʻi is projected by the end of the permit term to reverse this decline and result in an increasing Kauaʻi metapopulation (Figure 5D-7, blue line). HCP conservation measures are projected to slow the metapopulation decline considerably between 2050 and 2060, stabilizing at approximately 6,400 breeding pairs during that time, before increasing (Table 5D-11).

The metapopulation is projected to increase gradually, as the continued increases in abundance of Newell's shearwater (ʻaʻo) colonies at the conservation sites overcomes the declines in abundance in the Kalalau east to Upper Mānoa, Hanalei to Kekaha, and Waimea Canyon areas (Figure 5D-7). The latter two areas have the highest initial modeled abundance, and in addition to the Kalalau to Upper Mānoa area, they also have a relatively high degree of uncertainty in terms of initial and therefore projected abundance (Table 5D-2). Therefore, the metapopulation projection, especially as it relates to the relative contribution of the abundance in the aforementioned areas to the overall island-wide trend, is also uncertain. However, the abundance and life history parameters of Newell's shearwater (ʻaʻo) within the conservation sites are relatively well understood given dedicated monitoring efforts at those sites, leading to higher confidence in the population projections in these areas. This means we have a relatively high confidence that the increase in subpopulations of the 12 conservation sites combined will meet management objectives of maintaining a Kauaʻi viable metapopulation abundance level and provide a substantial net benefit to Newell's shearwater (ʻaʻo) on Kauaʻi.

Without the HCP, and under worse-case assumptions, the Kauaʻi metapopulation of Newell's shearwater (ʻaʻo) would be approaching extirpation throughout much of its breeding range by 2075. Depending on the age structure and spatial distribution of the species at that time, it may become functionally extinct without conservation efforts under the HCP, due to the species' slow reproductive rate and other factors. However, with the continuation of conservation efforts associated with the HCP, by 2050 the assumed rate of metapopulation decline is projected to be overcome by growth at the conservation sites, and the resulting metapopulation increase is forecast to continue through the end of the permit term. The 12 conservation sites are large enough in size and have such extensive suitable habitat for Newell's shearwater (ʻaʻo) that subpopulations (and densities) are expected to increase during the permit term without experiencing any density-dependent constraints outside of the smaller social attraction sites with predator exclusion fencing, assuming management actions continue at the same level as outlined in this HCP.

The cumulative number of strikes for each area from these modeled projections are provided in Table 5D-13. The predictions of strikes should be considered conservative (i.e., strike predictions may be too low) because these results are based on modeling a rate of decline for Hanalei to Kekaha that represents a worst-case scenario based on the most drastic rate of decline estimated from the 1993–2020 radar survey data. This rate of decline, while based on data, is more negative than the average rate of decline estimated across all radar sites in the Hanalei to Kekaha area during the same period; further, it does not reflect the more recent stabilization of trend across radar sites in this area during 2010–2022 (Raine and Rossiter 2020; Sahin 2023). Additionally, the 2010–2022 decade-plus of radar data exhibiting a stable trend in relative abundance for the Hanalei to Kekaha area also overlaps in time with the estimate of unminimized seabird strikes from acoustic powerline monitoring data during 2013–2019 (Travers et al. 2020). Together, these two sources of monitoring data suggest that, at least during the last decade, the Hanalei to Kekaha subpopulation experienced a relatively high level of powerline mortality while also maintaining a stable abundance level. If this situation were to continue in the future (i.e., trends in both powerline strikes and abundance are stable), the modeled decline in abundance for Hanalei to Kekaha, and hence the modeled reduction in strikes associated with declining future abundance in this area, would underestimate future strikes.

Table 5D-10. Modeled Newell's Shearwater (ʻaʻo) Subpopulation Lambda Values for the Worse-Case Trend Scenario, Starting with the First Year of the HCP (2025), and then Shown at 5-Year Snap-Shot Intervals over the 50-year Permit Term (to 2075)

Lambda is the population multiplier, i.e., the rate of change in abundance from the prior year is equal to one minus Lambda. Values of Lambda less than 1.0 represent a decline in abundance; values greater than 1.0 represent an increase. For example, a Lambda value of 1.01 represents a positive rate of change of 1 percent per year. The maximum possible intrinsic value for Lambda in the model is 1.024 (2.4 percent growth), which is never achieved in practice because each subpopulation (even those behind predator-proof fences) is assumed to have some level of vulnerability to introduced predators (e.g., barn owl predation) and some level of vulnerability to powerline collisions. Values in the table greater than 1.024 include a combination of births and deaths plus the assumed level of future immigration associated with social attraction sites. "NA" represents pre-operational social attraction sites.

Area	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
HCP Conservation Sites											
Upper Limahuli Preserve	1.012	1.012	1.007	1.006	1.006	1.006	1.014	1.016	1.015	1.03	1.032
Upper Limahuli Preserve PF	NA	1.994	1.907	1.172	1.096	1.066	1.058	1.048	1.042	1.000	1.000
Upper Mānoa Valley	1.013	1.012	1.007	1.007	1.007	1.007	1.006	1.007	1.031	1.053	1.044
Upper Mānoa Valley PF	NA	1.994	1.906	1.172	1.097	1.066	1.058	1.048	1.024	1.000	1.000
Pōhākea	1.014	1.014	1.009	1.008	1.033	1.034	1.03	1.027	1.025	1.023	1.022
Pōhākea PF	NA	1.195	1.266	1.113	1.016	1.000	1.000	1.000	1.000	1.000	1.000
Pihea	1.009	1.014	1.007	1.006	1.005	1.007	1.006	1.006	1.006	1.005	1.005
North Bog	1.012	1.011	1.006	1.006	1.005	1.005	1.005	1.005	1.005	1.005	1.006
Hanakāpiʻai	1.014	1.013	1.008	1.008	1.007	1.007	1.007	1.007	1.007	1.007	1.008
Hanakoa	1.015	1.014	1.009	1.009	1.009	1.009	1.008	1.009	1.009	1.009	1.009
Honopū	1.012	1.014	1.009	1.009	1.009	1.009	1.008	1.008	1.029	1.097	1.070
Honopū PF	NA	1.195	1.267	1.114	1.081	1.062	1.052	1.045	1.034	1.002	1.000
Other Areas (outside KIUC conservation sites)											
Wainiha and Lumahaʻi Valleys	1.000	1.000	0.994	0.994	0.994	0.994	0.994	0.994	0.994	0.994	0.994
Hanalei to Kekaha	0.938	0.938	0.931	0.929	0.926	0.921	0.913	0.901	0.875	0.88	0.882
Kalalau east to Upper Mānoa	0.972	0.971	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.966
Nā Pali Coast	1.001	1.001	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995
Waimea Canyon	0.971	0.974	0.968	0.968	0.968	0.968	0.967	0.967	0.968	0.968	0.968
Kahuamaʻa (KSHCP)	NA	1.195	1.266	1.113	1.080	1.061	1.014	1.000	1.000	1.000	1.000
Kauaʻi Metapopulation	0.972	0.978	0.983	0.988	0.993	0.998	1.001	1.004	1.007	1.009	1.010

Table 5D-11. Modeled Newell's Shearwater (ʻaʻo) Breeding Pair Abundance (ages 6 years and older) for the Worse-Case Trend Scenario at 5-Year Intervals for each Subpopulation over the 50-Year Permit Term (2025–2075)

Area	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
HCP Conservation Sites											
Upper Limahuli Preserve	522	553	575	593	612	632	665	721	779	873	1,023
Upper Limahuli Preserve PF	0	5	27	83	136	193	258	328	404	454	454
Upper Mānoa Valley	209	222	232	240	248	257	265	274	297	389	485
Upper Mānoa Valley PF	0	5	27	83	136	194	260	331	396	396	396
Pōhākea	306	328	344	359	410	484	563	645	730	820	914
Pōhākea PF	0	11	64	115	136	136	136	136	136	136	136
Pihea	0	0	0	0	0	0	0	0	0	0	0
North Bog	69	73	76	78	80	82	84	87	89	91	94
Hanakāpiʻai	80	85	89	93	96	100	103	107	111	115	119
Hanakoa	47	51	54	56	59	61	64	67	69	73	76
Honopū	92	100	105	109	114	119	124	129	140	239	343
Honopū PF	0	11	64	115	173	235	308	386	468	468	468
Other Areas (outside KIUC conservation sites)											
Wainiha and Lumahaʻi Valleys	2,341	2,335	2,286	2,219	2,154	2,090	2,022	1,959	1,898	1,842	1,789
Hanalei to Kekaha	4,018	2,962	2,116	1,486	1,036	713	481	316	199	117	63
Kalalau east to Upper Mānoa	707	610	516	432	362	304	254	212	178	149	125
Nā Pali Coast	411	413	406	397	387	378	368	358	349	341	333
Waimea Canyon	734	648	556	472	401	341	288	244	207	176	150
Kahuamaʻa (KSHCP)	0	6	32	57	86	116	136	136	136	136	136
Total	**9,536**	**8,418**	**7,569**	**6,987**	**6,626**	**6,435**	**6,379**	**6,436**	**6,586**	**6,815**	**7,104**

Table 5D-12. Modeled Newell's Shearwater ('a'o) Total (non-chick) Abundance at 5-Year Intervals for the Worse-Case Trend Scenario for each Subpopulation over the 50-Year Permit Term (2025–2075)

Initial abundance is based on the estimates of breeding pairs from ARC, with two exceptions: (1) Hanalei to Kekaha and (2) Waimea Canyon. For these two areas, the pre-HCP abundance is estimated as a function of the allocated strikes for that area (86 percent and 10 percent of all strikes in each area) and trends in abundance from radar, which are assumed to be -10.7 percent and -6.9 percent per year in 2016, respectively, given the trend at the Hanalei radar site and the averaged trend across all radar sites on Kaua'i during 1993–2020 (Raine and Rossiter 2020).

Area	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
HCP Conservation Sites											
Upper Limahuli Preserve	1,968	2,087	2,182	2,253	2,325	2,398	2,507	2,708	2,927	3,235	3,781
Upper Limahuli Preserve PF	0	12	73	277	480	698	942	1,210	1,500	1,736	1,761
Upper Mānoa Valley	787	837	878	910	942	975	1,007	1,041	1,102	1,408	1,773
Upper Mānoa Valley PF	0	12	73	278	481	702	949	1,220	1,490	1,536	1,536
Pōhākea	1,155	1,236	1,306	1,361	1,513	1,788	2,089	2,398	2,722	3,061	3,418
Pōhākea PF	0	35	196	400	521	529	529	529	529	529	529
Pihea	1	1	1	1	1	1	1	1	1	1	1
North Bog	262	277	288	296	304	313	321	329	338	347	357
Hanakāpi'ai	302	322	339	351	365	379	392	406	421	436	453
Hanakoa	179	192	203	212	222	232	242	252	263	275	288
Honopū	349	375	397	415	433	452	471	491	522	830	1,224
Honopū PF	0	35	196	400	619	857	1,132	1,430	1,749	1,818	1,818
Other Areas (outside KIUC conservation sites)											
Wainiha and Lumaha'i Valleys	8,122	8,108	7,978	7,746	7,521	7,296	7,064	6,841	6,630	6,431	6,246
Hanalei to Kekaha	12,888	9,393	6,691	4,647	3,182	2,131	1,378	842	463	235	125
Kalalau east to Upper Mānoa	2,286	1,972	1,675	1,405	1,178	987	825	690	577	484	406
Nā Pali Coast	1,426	1,432	1,417	1,384	1,352	1,319	1,285	1,252	1,220	1,190	1,163
Waimea Canyon	2,568	2,250	1,941	1,650	1,402	1,190	1,008	854	725	615	523
Kahuama'a (KSHCP)	0	17	98	199	307	424	519	528	528	528	528
Total	**32,293**	**28,593**	**25,932**	**24,185**	**23,148**	**22,671**	**22,661**	**23,022**	**23,707**	**24,695**	**25,930**

Table 5D-13. Modeled Newell's Shearwater (ʻaʻo) Strikes for the Worse-Case Trend Scenario, Starting with the First Year of the HCP (2025), and then Shown as a Cumulative Total at 5-Year Intervals for each Subpopulation until the End of the Permit Term (2075)

Area	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
HCP Conservation Sites											
Upper Limahuli Preserve	55	150	251	356	464	576	692	814	946	1,089	1,250
Upper Limahuli Preserve PF	0	0	1	7	23	49	85	134	196	271	355
Upper Mānoa Valley	17	46	78	111	145	180	216	254	293	336	392
Upper Mānoa Valley PF	0	0	1	6	18	38	66	104	152	208	266
Pōhākea	11	31	51	73	96	123	154	190	231	277	330
Pōhākea PF	0	0	1	5	13	22	30	39	48	57	66
Pihea	0	0	0	0	0	0	0	0	0	0	0
North Bog	9	25	42	59	77	96	115	134	154	174	195
Hanakāpiʻai	5	14	24	34	44	55	66	78	90	103	116
Hanakoa	1	2	3	5	6	8	10	11	13	15	17
Honopū	2	6	9	13	17	22	26	31	36	42	51
Honopū PF	0	0	1	3	8	15	24	36	51	68	86
Other Areas (outside KIUC conservation sites)											
Wainiha and Lumahaʻi Valleys	135	361	585	805	1,018	1,225	1,426	1,620	1,808	1,991	2,168
Hanalei to Kekaha	4,453	10,013	14,058	16,915	18,871	20,177	21,011	21,506	21,757	21,836	21,858
Kalalau east to Upper Mānoa	39	96	145	187	221	251	275	296	313	327	339
Nā Pali Coast	8	21	35	48	61	73	86	98	109	121	132
Waimea Canyon	766	1,862	2,824	3,654	4,359	4,958	5,467	5,898	6,263	6,573	6,836
Kahuamaʻa (KSHCP)	0	0	1	5	11	21	35	50	66	81	97
Total	**5,501**	**12,627**	**18,110**	**22,286**	**25,452**	**27,889**	**29,784**	**31,293**	**32,526**	**33,569**	**34,554**

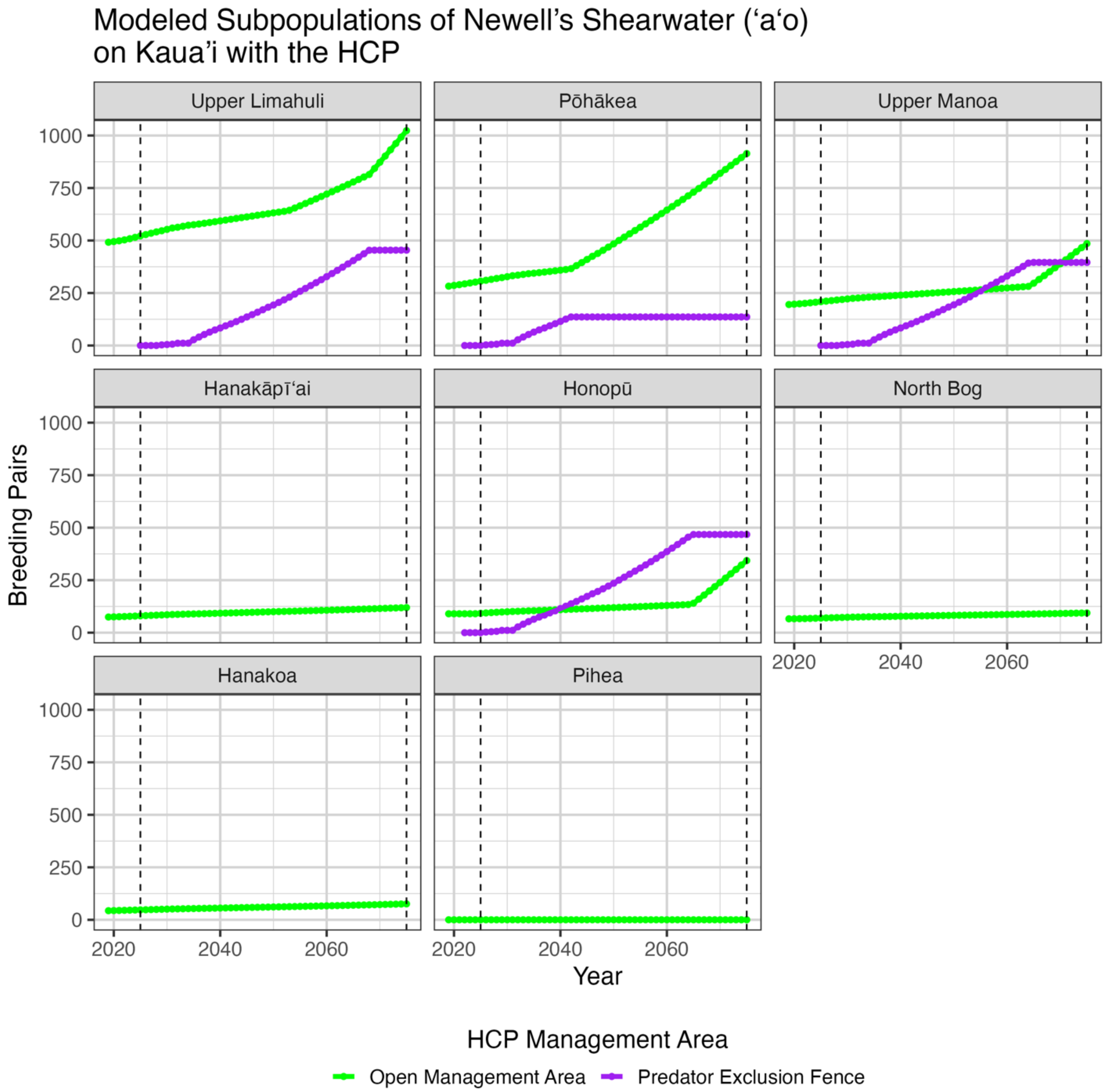

Figure 5D-3. Population Dynamics Model Results for Newell's Shearwater (ʻaʻo) for the Worse-Case Trend Scenario for each Subpopulation at the Conservation Sites showing the Relative Contribution of Different Conservation Sites to Breeding Pair Abundance

Purple lines show breeding pair abundance in the social attraction sites enclosed with predator exclusion fences (PF). These trajectories plateau at the nesting burrow carrying capacities estimated for each site inside the proposed PF area. It is assumed that social attraction will continue in the future and that once the PF carrying capacities are reached, new breeding pairs (either those hatched in the PF, or prospecting subadults attracted from other areas) will spill over to nest in the surrounding conservation site subject to dedicated, intensive predator control measures. Green lines show breeding pair abundance in the conservation sites with predator control but no predator-exclusion fence. The leftmost vertical dashed line denotes the first year of the proposed HCP (2025) and the rightmost vertical dashed line denotes the end of the 50-year permit term (2075). See Figure 5D-1 for site locations.

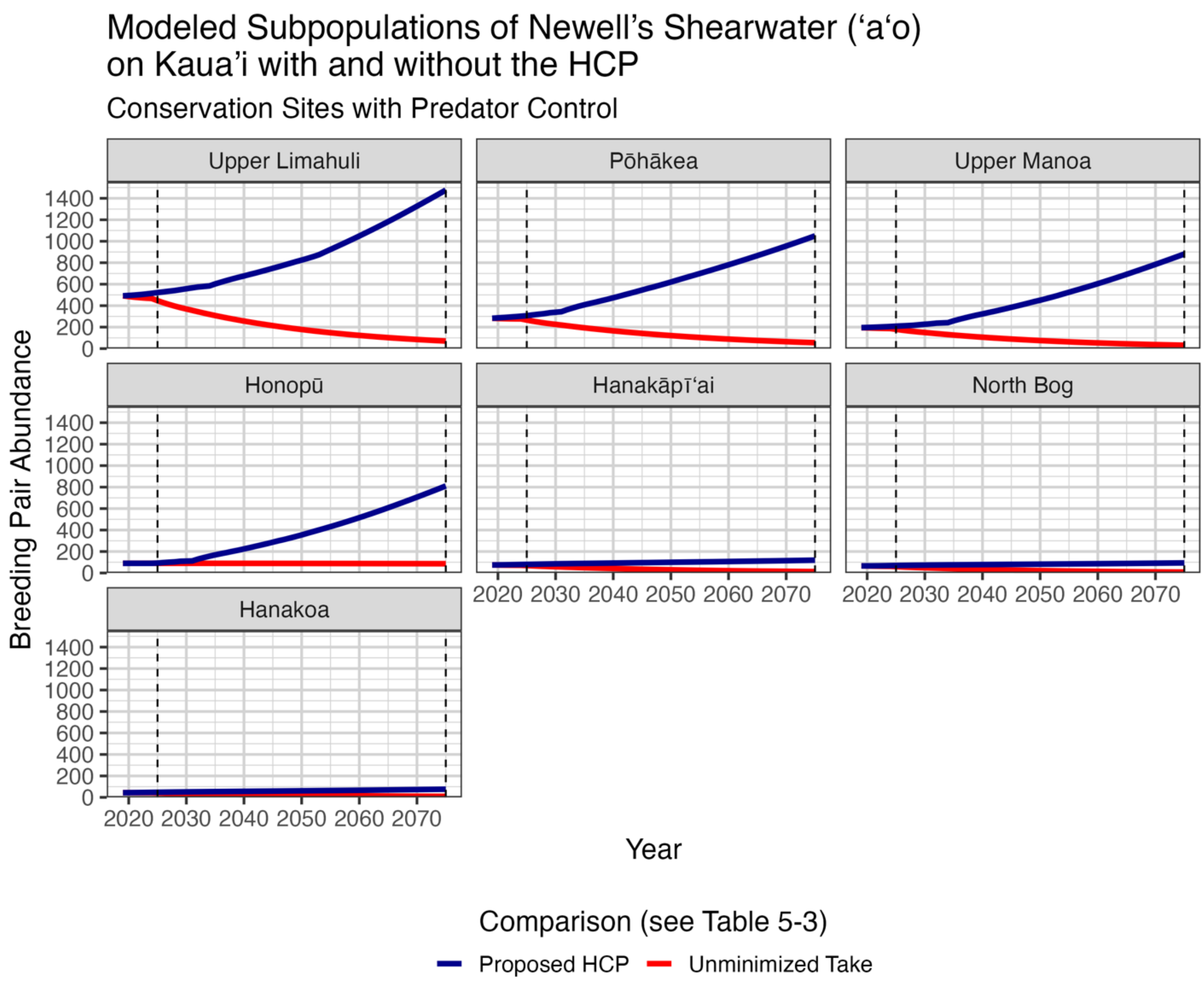

Figure 5D-4. Population Dynamics Model Results for Newell's Shearwater (ʻaʻo) for the Worse-Case Trend Scenario for each Subpopulation with Predator Control Measures and Ungulate Fencing

Red lines show the unminimized take model scenario without the HCP (take continues without powerline minimization, and without conservation measures; see Table 5-3 in Chapter 5, *Effects*). Blue lines are with the proposed HCP according to the schedule of conservation measures described in Chapter 4, *Conservation Strategy*. The vertical dashed lines denote the first and last year of the permit term. See Figure 5D-1 for site locations. Note: Pihea is not shown in this plot because no appreciable number of Newell's shearwater (ʻaʻo) are estimated to be associated with that area.

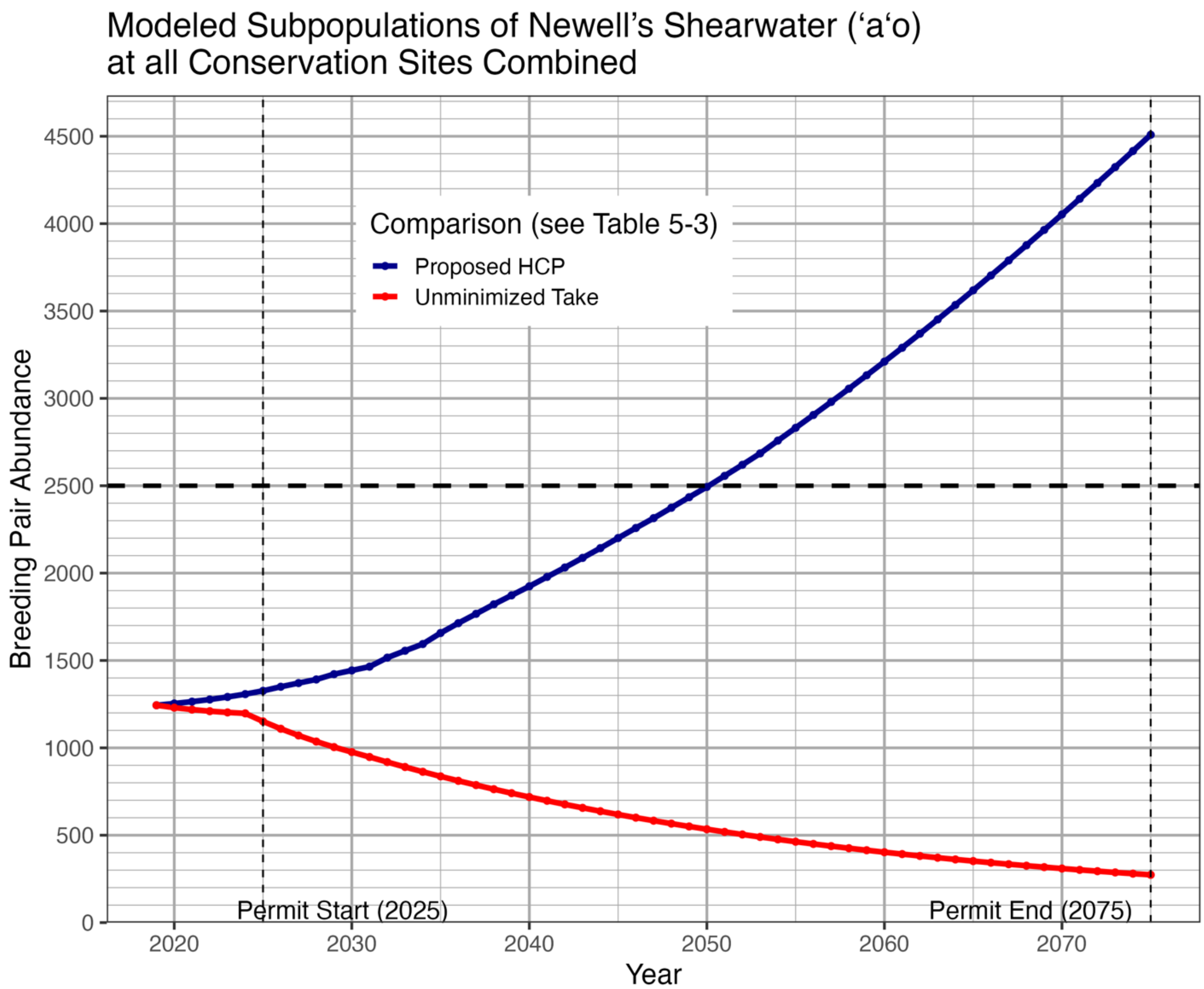

Figure 5D-5. Population Dynamics Model Results for Newell's Shearwater (ʻaʻo) for the Worse-Case Trend Scenario for all Conservation Sites Combined

Red line shows the unminimized take scenario without the HCP (take continues without powerline minimization, and without conservation measures; see Table 5-3 in Chapter 5, *Effects*). Blue line is with the HCP according to the schedule of conservation measures described in Chapter 4, *Conservation Strategy*. The benefits of the KSHCP Kahuamaʻa social attraction site (with predator-proof fencing) are included in both lines. The horizontal dashed line highlights 2,500 breeding pairs, which the U.S. Fish and Wildlife Service considers to be an abundance threshold level for a viable metapopulation on the island (see Chapter 5 for details).

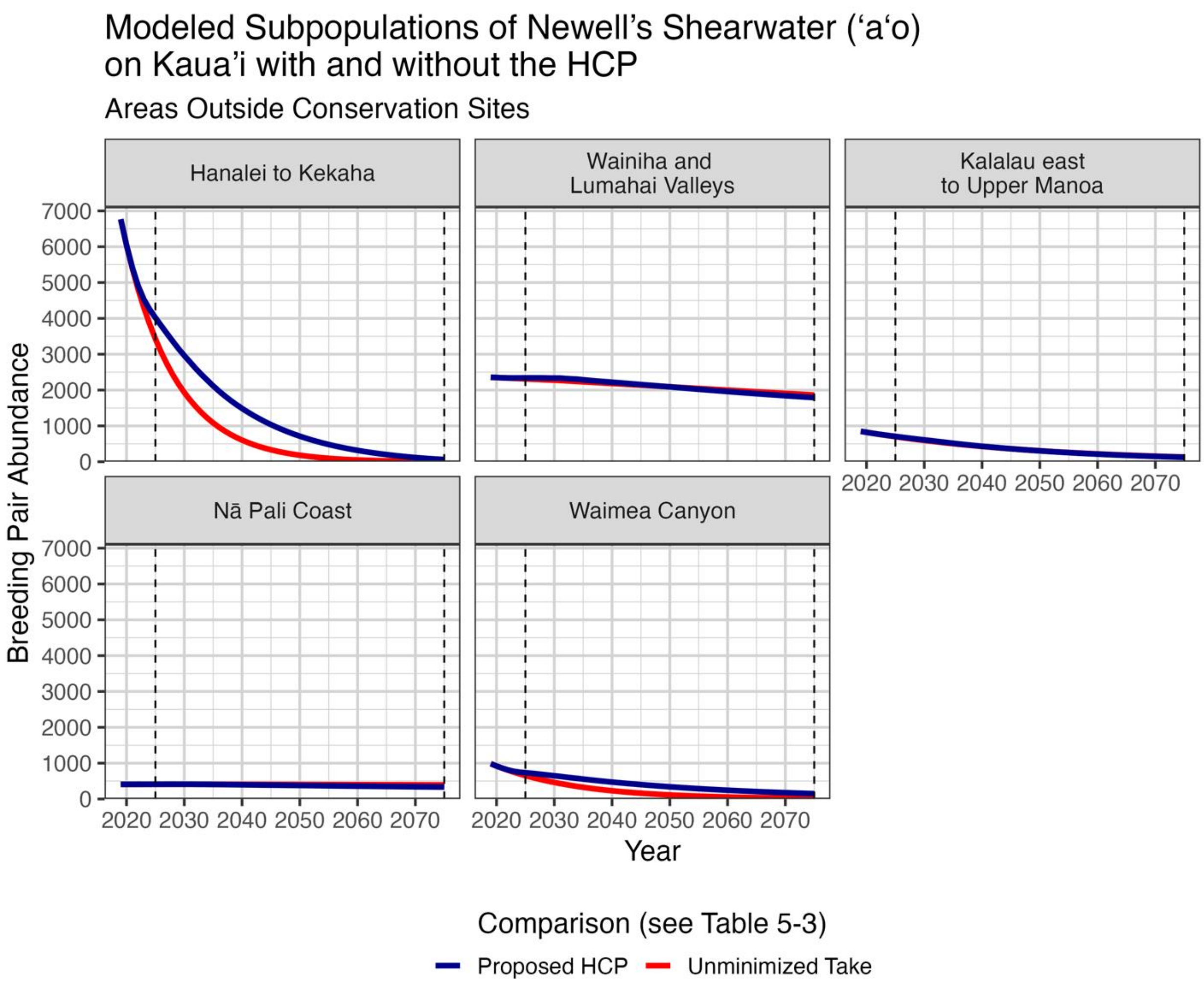

Figure 5D-6. Population Dynamics Model Results for Newell's Shearwater ('a'o) for the Worse-Case Trend Scenario for each Subpopulation outside the Conservation Sites

Red lines show the unminimized take model scenario without the HCP (take continues without powerline minimization, and without conservation measures; see Table 5-3 in Chapter 5, *Effects*). Blue lines are with the proposed HCP according to the schedule of conservation measures (i.e., powerline collision minimization) described in Chapter 4, *Conservation Strategy*. The vertical dashed lines denote the first and last year of the permit term. See Figure 5D-1 for site locations.

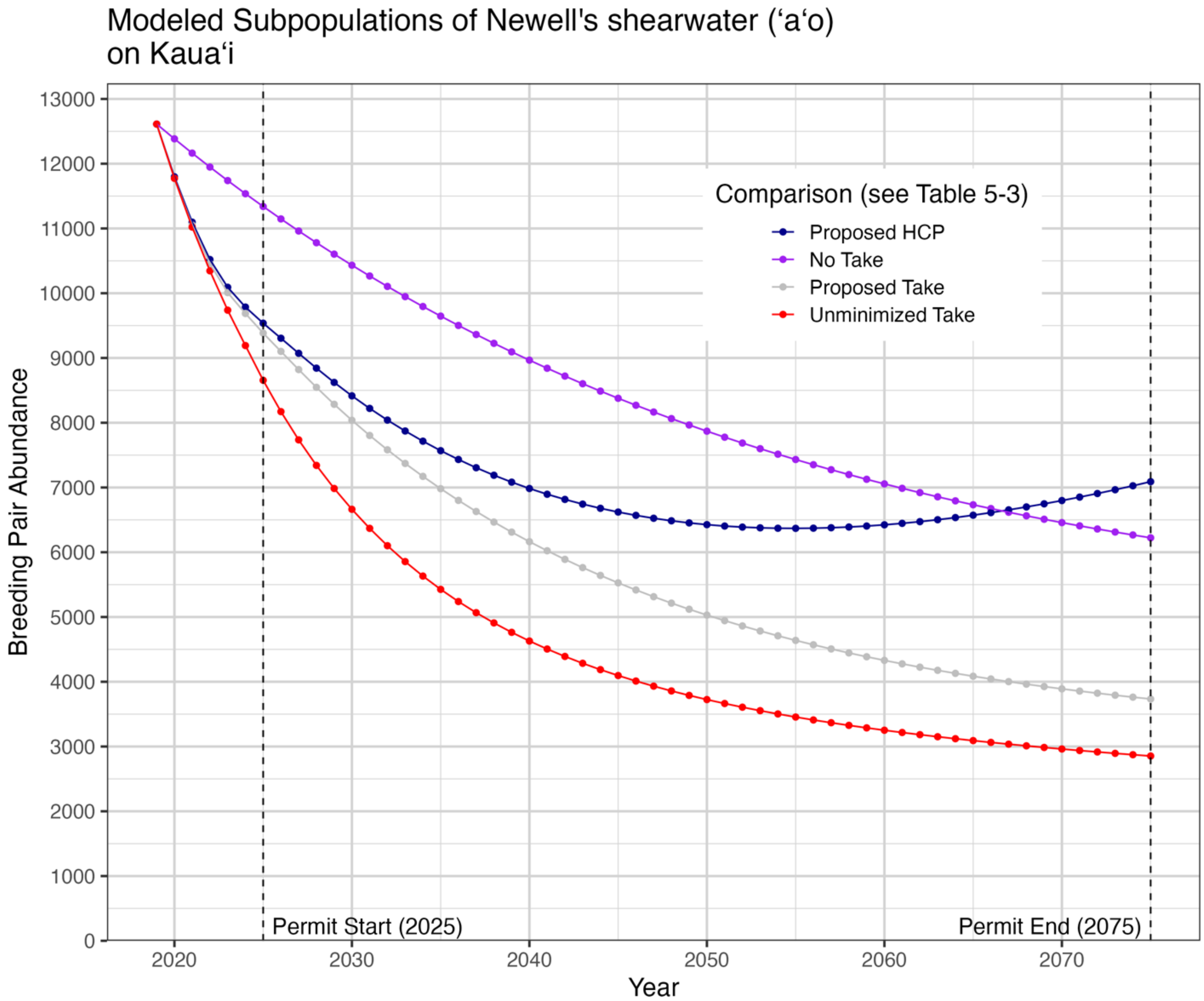

Figure 5D-7. Population Dynamics Model Results for Newell's Shearwater (ʻaʻo) for the Worse-Case Trend Scenario for all Subpopulations Combined (all of Kauaʻi)

Red line is the unminimized take model scenario without the HCP (take continues without powerline minimization, and without conservation measures). Blue line is with the proposed HCP according to the schedule of conservation measures (i.e., powerline collision minimization) described in Chapter 4, *Conservation Strategy*. The grey line is with the proposed minimized take; the purple line is with no take. See Table 5-3 in Chapter 5, *Effects*, for additional description of each model scenario. The vertical dashed lines denote the first and last year of the permit term.

5D.4 Model Limitations, Uncertainties, and Assumptions

The population dynamics model described in this appendix is a useful tool with which to compare outcomes to Newell's shearwater (ʻaʻo) on Kauaʻi both with and without the KIUC HCP under two different scenarios (worse-case trend and stable trend). The model is also an important tool to confirm that the quantitative biological objectives for Newell's shearwater (ʻaʻo), particularly at the conservation sites, can be achieved by the end of the permit term under either modeling scenario. However, as with all models there are uncertainties in model inputs and outputs that should be considered. Model limitations include, but are not limited to, the following.

- Lack of statistical confidence limits around the island-based estimates of abundance.
- Uncertainty in certain vital rates (e.g., barn owl predation rates on the wing are difficult to estimate, and predation rates in general are not available from data in areas without predator control and burrow monitoring, and must be extrapolated from other areas where these data have been collected).
- Uncertainty in the reduction of powerline strikes due to minimization efforts (although continued powerline monitoring will help narrow those uncertainties within a few years).
- Logistical difficulties in monitoring the population at the colony and burrow level outside of established conservation sites (e.g., lack of or difficulty in access due to land ownership, rugged and inaccessible terrain, or both).

Due to these limitations, the uncertainty in the model results has not been quantified for either modeling scenario. However, any population dynamics model of Newell's shearwater (ʻaʻo) relies on a suite of assumptions. The assumptions chosen for this model were in many cases selected to be as conservative as reasonably possible knowing that many model uncertainties have not been quantified. A list of the key assumptions is provided below for this model, with reasons these assumptions may be conservative or optimistic in terms of predicting effects of the HCP conservation measures on this species. These sections are intended to provide the reader with a qualitative understanding of the level and sources of uncertainty in model results for each model scenario. Model limitations and uncertainties are described below for the worse-case trend scenario. For a discussion of model limitations and uncertainties for the stable trend scenario, see Attachment 5D-1, *Newell's Shearwater (ʻaʻo) Population Dynamics Model Fit to the Stable 2010–2022 Radar Trend under KIUC's Proposed Habitat Conservation Plan*.

5D.4.1 Worse-Case Trend Scenario

The worse-case trend scenario of the population dynamics model includes assumptions that likely result in an overly conservative projection of outcome. In other words, the model results with conservative assumptions may overestimate the impacts of the covered activities on Newell's shearwater (ʻaʻo), underestimate the benefits of the conservation strategy for Newell's shearwater (ʻaʻo), or both. This section describes how model assumptions may be overly conservative or overly optimistic for the worse-case trend scenario.

5D.4.1.1 Conservative Assumptions

The population dynamics model under the worse-case trend scenario is likely overly conservative (i.e., overestimates adverse effects or underestimate beneficial effects for Newell's shearwater [ʻaʻo]) for the following reasons.

- **Total powerline strikes.** The reported point estimate that is used as a model input for the annual average of seabird strikes corresponds to the mean of the Bayesian posterior predictive probability distribution, corrected to account for strikes that were subsequently recategorized as waterbirds (Travers et al. 2020; Travers unpublished data). For a right skewed (longer right tail) probability distribution, like the Bayes posterior predictive probability distribution for seabird strikes, the mean is greater than the expectation of the estimate. Statistically, this results in using a conservative (i.e., higher) level of powerline collisions in the model than would be expected from the data.
- **Strike allocation.** Allocation of powerline strikes may be even lower at some or all of the conservation sites than estimated, given flight paths, and observed altitudes from satellite tagging. For example, the estimated breeding probability from burrow monitoring data at seven conservation sites for Newellʻs shearwater (ʻaʻo) during 2012–2019 is 0.993 (Raine et al. 2022b), which indicates that non-predation sources of mortality for breeding adults were quite low in these areas.
- **Population trend and optimal growth rate.** In the worse-case trend scenario, the modeled population trend for the Hanalei to Kekaha area assumes a continued steep rate of decline, based on the long-term trend from the Hanalei radar site. Given both recent and longer term radar trends from all radar sites, the current population trend for all breeding colonies in this area is unlikely to be in an ongoing steep decline. Again, recent data indicate the trend for those areas surveyed by radar has been stable since 2010, albeit at reduced abundance levels following the steep decline in the 1990s.

  Recent analyses of the radar trend data (Raine and Rossiter 2020; Sahin 2023) have shown that the average trend in radar estimates across all radar survey sites has leveled out since 2010, indicating that after a very large decline in abundance the population trend may now be relatively stable in the Hanalei to Kekaha area. For example, a regression of radar data including all 13 monitored sites was flat with no significant increase or decrease during the last decade (2010–2022; Sahin 2023). This seems to suggest that during the last decade mortality levels have decreased, perhaps due to mechanisms like remaining colonies being confined to habitat that is less accessible to introduced predators (Raine and Rossiter 2020).

  This pattern is also consistent with data on the amounts of rescues of Newell's shearwater (ʻaʻo) from the SOS Program, which are relatively stable over a similar period (Ainley et al. 2023). Also, it is consistent with the stable trend in passage rates (the number of seabirds transiting powerlines) since 2013 estimated from visual night-time observations during powerline monitoring surveys (Travers et al. 2023).

  Therefore, based on these three data sources (radar surveys, SOS rescues, and powerline monitoring surveys) the aggregate modeled population trend in the absence of minimization and mitigation is likely to be conservative, at least in terms of observed trends over the last decade. If the aggregate population trend is more positive (either a smaller negative number or a number close to zero for a stable population), then the effects of the HCP conservation strategy will result in a greater benefit to the island-wide metapopulation of Newell's shearwater (ʻaʻo) than what is estimated (cf. the stable trend scenario).

It is also worth noting that the optimal rate of modeled population growth assumed in the model is much lower than has been estimated for the family Procellariidae (all petrels, prions and shearwaters) in multiple published allometric and demographic modeling studies. The results of those studies are consistent with species in this seabird family having expected maximum rates of population growth closer to 6.8 percent per year (Dillingham et al. 2016) or 7.1 percent per year (Dillingham and Fletcher 2011), depending on the methods used. The worse-case trend scenario assumed a maximum rate of modeled population growth (i.e., in the absence of introduced predators, powerline strikes or light fallout mortality) of 3.0 percent per year. This factor is addressed by the stable trend scenario, described in more detail in Attachment 5D-1, *Newell's Shearwater (ʻaʻo) Population Dynamics Model Fit to the Stable 2010–2022 Radar Trend under KIUC's Proposed Habitat Conservation Plan*.

- **Social attraction.** Birds are assumed to be attracted to social attraction sites with an equal per capita probability from all other areas for which island-based abundance estimates are available.[9] This is a reasonable assumption without any data to suggest otherwise.[10] However, the assumption may be conservative. If birds attracted to social attraction sites come mostly from non-managed sites, then the benefits to the island-wide metapopulation of the social attraction sites would be even greater than what the model estimates.

  Additionally, the modeled dynamics of social attraction sites ignore any benefits that nearby nesting birds may have in terms of attracting prospecting birds. The modeled numbers at social attraction sites start at zero birds for the first 3 years, then slowly increase with an average of 1.6 new breeding pairs during the first 9 years, after which that number increases to an average of 13.7 new breeding pairs becoming established each year (Table 5D-9). In other words, there is a lag before social attraction sites reach a critical mass and start attracting more than 10 breeding pairs per year. Given that the planned social attraction sites exist in areas with existing breeding pairs nearby (e.g., at Upper Limahuli Preserve), there may be less of a time lag for the initial rate of attraction to social attraction sites than assumed in the model. If this is the case, the growth at a conservation site would be faster than predicted by the model, resulting in a larger conservation site subpopulation at the end of the permit term than predicted.

- **Total powerline strikes.** The reported point estimate that is used as a model input for the annual average of seabird strikes corresponds to the mean of the Bayesian posterior predictive probability distribution, corrected to account for strikes that were subsequently recategorized as waterbirds (Travers et al. 2020; Travers unpublished data). For a right skewed (longer right tail) probability distribution, like the Bayes posterior predictive probability distribution for seabird strikes, the mean is greater than the expectation of the estimate. Statistically, this results in using a conservative (i.e., higher) level of powerline collisions in the model than would be expected from the data.

[9] The exception to this is when a bird is born into a social attraction site after social attraction begins, that bird is assumed to return to that site or spillover and nest in the surrounding conservation site for the rest of its life and not emigrate to another social attraction site. In general, the model assumes natal fidelity and internal recruitment to each modeled area, with the exception being dispersal of breeding age birds into the social attraction sites from other areas.

[10] Social attraction assumptions were based, in part, on published literature for similar seabirds outside of the Hawaiian Islands.

- **Strike allocation.** Allocation of powerline strikes may be even lower at some or all of the conservation sites than estimated, given flight paths, and observed altitudes from satellite tagging. For example, the estimated breeding probability from burrow monitoring data at seven conservation sites for Newellʻs shearwater (ʻaʻo) during 2012–2019 is 0.993 (Raine et al. 2022b), which indicates that non-predation sources of mortality for breeding adults were quite low in these areas during those years (which preceed powerline minimization efforts).
- **Fallout from light attraction.** A constant number of 92.6 age-1 (fledglings) from the Hanalei to Kekaha subpopulation are assumed to die annually from fallout associated with KIUC facilities and streetlights. The estimated level of fallout includes correction factors for the proportion of grounded seabirds that go undetected, e.g., for KIUC streetlights, 89.6 percent of grounded Newellʻs shearwater (ʻaʻo) are assumed to go undetected (Appendix 5B, *Light Attraction Modeling for Covered Seabirds*). Fallout, whether detected or not, is assumed to result in 100 percent mortality in the model.

  This assumption is conservative for three reasons: (1) The estimate for fallout is based on the number of expected streetlights and facility lights at the end of the permit term, not at the beginning. Fallout from light attraction is therefore likely overestimated at the start of the projections; (2) This assumes zero individuals rehabilitated by the SOS Program survive; and, (3) Fallout mortality is modeled as a fixed number of fledglings lost, not a mortality rate. In other words, even when the Hanalei to Kekaha subpopulation is much smaller at the end of 50 years, 92.6 fledglings (or the number of modeled fledglings produced, whichever is smaller) are still removed in the model from this area each year. Furthermore, the level of mortality from fallout is estimated to be less than five percent of the level of mortality estimated from powerline collisions. So, while fallout mortality is a contributing factor to metapopulation dynamics, it does not have as large of an effect on metapopulation trends as powerline collisions.
- **Conservation actions performed by others.** The population dynamics of the Kauaʻi metapopulation of Newell's shearwater (ʻaʻo) are modeled only assuming the full implementation of this HCP's conservation strategy and that of the KSHCP (i.e., the Kahuamaʻa social attraction site). Numerous federal, state, and local agencies and conservation organizations are either implementing or planning to implement additional conservation actions separately from this HCP and the KSHCP, and which will benefit Newell's shearwater (ʻaʻo) (Table 5D-14). However, due to a lack of data available on these other conservation efforts, their benefits, current or expected, could not be included in the model. Similarly, due to a lack of available estimates for reductions in predation rates resulting from barn owl control at the conservation sites, no attempt has been made to include the benefit of that form of predator control effort at the conservation sites. Because this model does not consider these other current or planned conservation actions, the impacts of the taking of this HCP are conservative (i.e., overestimates effects).

Table 5D-14. Conservation Programs for the Covered Seabirds on Kauaʻi Excluded from the Population Dynamics Model.

Conservation Project	Entities	Covered Seabirds Benefitting	Duration	Conservation Actions
Hono O Nā Pali Natural Area Reserve Kalepa Communication Tower Mitigation	U.S. Coast Guard	Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu)	2013–2033	Seabird colony management
Kalaheo Communication Tower Mitigation	Federal Communication Commission	Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu)	2013–2033	Seabird colony management
Kōkeʻe Air Force Station	U.S. Air Force	Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu), band-rumped storm-petrel (ʻakēʻakē)	2017 to present and foreseeable future	Barn owl and other predator control in seabird colonies
Lehua Island Ecosystem Restoration Project	U.S. Coast Guard, DOFAW, USFWS, National Tropical Botanical Gardens, Island Conservation, Others	Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu)	2017 to present and foreseeable future	Rat eradication (2017–2021) and seabird colony management and monitoring (ongoing)
Nihoku Fence and Translocation Project at Kīlauea Point National Wildlife Refuge	U.S. Fish and Wildlife Service, Pacific Rim Conservation, American Bird Conservancy, and others	Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu)	2014 to present and foreseeable future	Construction of 2,130 foot predator exclusion fence (2014–2023); construction of 11,200-foot predator exclusion fence (2023)
Pacific Missile Range Facility	U.S. Navy	Newell's shearwater (ʻaʻo)	2018–2068	Seabird colony management
Save Our Shearwaters Program	KIUC, DOFAW	Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu), band-rumped storm-petrel (ʻakēʻakē)	1979–2074	Downed or injured bird rescue, assessment, rehabilitation, and release

Sources: U.S. Fish and Wildlife Service 2022; State of Hawaiʻi Division of Forestry and Wildlife 2011; Young et al. 2018.

5D.4.1.2 Potentially Optimistic Assumptions

The population dynamics model for Newell's shearwater (ʻaʻo) under the worse-case trend scenario may be too optimistic (i.e., underestimate adverse effects or overstate benefits) for the following reasons.

- **Total metapopulation size.** The estimate of the island-wide metapopulation may be too high, despite the integration of multiple independent data sources, and what are otherwise thought to be conservative assumptions by experts. If this is true, then impacts of the taking would be greater than predicted by the model. However, all else being equal, the *relative* effects of the HCP would be the same because the comparison is made with and without the HCP using the same initial abundance estimate and estimates of trends in relative abundance (i.e., positive trends in call rates from the conservation sites and negative trends in relative abundance from the radar survey). Also, if a smaller value for metapopulation abundance were used, the modeled trend would become inconsistent with long-term monitoring data (e.g., the modeled rate of decline in the Hanalei to Kekaha area would be even more negative compared to the lowest estimated rates of decline from the radar survey). Such a steep rate of decline, which would result from the estimated number of powerline collisions if abundance was indeed lower would not be supported by the best available science on long-term trends in abundance.
- **Social attraction.** As noted above, birds are assumed to be attracted to social attraction sites with an equal per capita probability from all other areas (e.g., if half the island-wide population is estimated to be from Hanalei to Kekaha area in a given year, then half the number of birds immigrating into social attraction sites would be from Hanalei to Kekaha that year). Shearwaters and petrels are known to have a high level of natal fidelity (e.g., Harris 1966; Perrins et al. 1973; Warham 1980), however, and therefore this assumption could be optimistic because it would result in more immigration from areas with high predation and powerline mortality rates into "safe havens" than under a stronger model of natal fidelity.
- **Cat predation events.** The model is deterministic, which means that mortality and reproductive rates are assumed to be constant between years (with the exceptions of powerline collision minimization and the effects of immigration into social attraction sites through time). As such, interannual variation (stochasticity) in predation rates is not modeled even though the number of predations by cats can be variable between years. In particular, there have been instances of individual cats predating multiple nests during certain years before they have been caught. As such, a conservation site may have low predation mortality rates for a period of years, with an incursion of a single cat one year leading to a spike in predation mortality rates that year. Breeding pairs and chicks inside predator exclusion fences may be subject to such events in rare instances (i.e., before the cat incursion is caught on camera and additional control efforts can be deployed). Such events may also occur outside of conservation sites despite aggressive predator control techniques.

  The predation mortality rates used in the model are based on burrow monitoring data from multiple conservation sites over multiple years. The resulting estimate represents an average annual predation mortality rate under predator control that includes punctuated predation mortality events due to single cats. If the estimated predation mortality rate from burrow monitoring surveys does not fully capture the extent or frequency of these predation events, the model results with respect to the benefits of predator control at the conservation sites would be optimistic. However, independent acoustic monitoring data indicate that at least since 2014/2015, the extent of punctuated cat predation events has not resulted in negative trends in recruitment into the breeding colonies at the conservation sites. Instead, call rates have continued to increase, and have doubled at most of the conservation sites under predator control efforts (Raine et al. 2022a). In other words, call rates have continued to increase, despite predation events having occured during the same time.

- **Carrying capacity.** Social attraction sites inside predator exclusion fenced sites are modeled using estimates of carrying capacity for the number of breeding pairs that could nest in these areas. These sites are relatively small and available nesting habitat is well defined by the fenced perimeter. Additionally, the rate of increase in breeding pairs in these areas is assumed to be relatively high after 10 years, given the expected number of new immigrants attracted to these areas once they reach a critical mass (Table 5D-9). Therefore, reaching carrying capacity of breeding pairs during the permit term seems likely.

  Conversely, there is no assumption in the model that population growth in the adjacent management areas will be limited by carrying capacity during the 50-year permit term. If, in the future, population growth in the adjacent mangement areas is limited by the carrying capacity of suitable nesting habitat, and there is emigration out of those conservation sites to areas without the benefit of predator control and where powerline collision vulnerability may be higher, the model results would overestimate the long-term benefit of the conservation sites to the metapopulation. However, not only are carrying capacities difficult to estimate reliably for the large, adjacent management areas, but estimates of predation rates prior to dedicated predator control in the conservation sites in combination with the assumed low rates of population recovery (e.g., 1 percent per year at Upper Limahuli; Table 5D-10) suggests that recovery from depletion to carrying capacity in the adjacent management areas would not be likely during the permit term.

- **Allee effects.** The model does not account for compensatory or depensatory density dependence on the population growth rate. The former would account for higher expected population growth rates at lower population sizes, for example due to decreasing competition for resources. The latter, also known as "Allee" effects, arises in situations where population growth rates might be expected to decrease at lower abundance levels, for example due to difficulties finding a mate at low densities. Given that Newell's shearwater (ʻaʻo) is a threatened species with a low intrinsic rate of increase, there does not seem to be support for considering compensatory density dependence during the permit term. However, if modeled subpopulations that are vulnerable to large declines (e.g., Waimea Canyon and Hanalei to Kekaha areas) experience Allee effects at lower densities in the future, the degree of the modeled declines there could be optimistic. There is no indication that Allee effects are occurring at recent abundance levels, at least at the broader scales monitored by the radar survey. Recent population trends from the radar data have generally flattened out (e.g., Raine and Rossiter 2020; Sahin 2023) instead of experiencing accelerating rates of decline that would be expected from Allee effects. Even if some smaller colonies are experiencing Allee effects, those losses would be balanced out by other colonies experiencing growth, or the recent trend from radar monitoring would still be decreasing.

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Attachment 5D-1
Newell's Shearwater (ʻaʻo) Population Dynamics Model Fit to the Stable 2010–2022 Radar Trend under KIUC's Proposed Habitat Conservation Plan

Context

The HCP seabird population dynamics model (PDM) for Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) in the area of Kauaʻi most affected by powerline collisions (Hanalei to Kekaha) was run in the January 2023 draft HCP to match the worse-case observed trend in abundance for any single radar monitoring site on Kauaʻi[11]: estimated as an 11 percent[12] decline (-11 percent) in abundance per year at the Hanalei radar site during 1993 through 2020 (Raine and Rossiter 2020).[13] In other words, the PDM scenario that is modeled in the January 2023 draft HCP assumes abundance is rapidly declining at present in the most affected areas outside the conservation sites. In the absence of survival rates derived from data on these species, the HCP model is also based on assumed survival rate values for the covered seabirds from adopting estimated survival rates from a related seabird species in the North Atlantic.[14] This assumption results in modeled population productivity that is at the low end of the range when compared to other long-lived endangered species, but it is consistent with previously assumed population growth rates in models for these seabird species on Kauaʻi. The maximum rate of increase in abundance for the Kauaʻi metapopulation of Newell's shearwater (ʻaʻo) is assumed to be 3 percent per year without any anthropogenic sources of mortality (i.e., no invasive predators, no fallout from light attraction, and no powerline collisions). This assumed maximum rate of increase is important, because it determines the nature of projected trends in abundance, and hence estimates of future incidental take.

In this case, a key uncertainty with estimating future incidental take under the HCP stems from inconsistencies between independent monitoring surveys. During the last decade, estimated trends in abundance and available estimates of anthropogenic mortality seem at odds, given estimates of minimum metapopulation abundance that are relatively low and what has been commonly assumed about low population productivity. After a large estimated decline in abundance for both seabird species during 1993 to 2013 (Raine et al. 2017), the trend in abundance appears to have changed. More recent analyses of trend from the radar survey data have concluded that since 2010 there has been no significant annual change in the index of abundance through time for either seabird species (e.g., Raine and Rossiter 2020; Sahin 2023). Nevertheless, during the same decade that indices of

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[11] Detailed PDM methods, assumptions, and results can be found in Chapter 5, *Effects*, Appendix 5D, *Population Dynamics Model for Newell's Shearwater (ʻaʻo) on Kauaʻi*, and Appendix 5E, *Population Dynamics Model for Hawaiian Petrel (ʻuaʻu) on Kauaʻi*, of the draft KIUC HCP.

[12] Estimated trends from radar are rounded to the nearest whole percentage in this text (i.e., -10.7 and -6.9 percent are rounded in the text to -11 and -7 percent). The estimates are not rounded when fitting the PDM to the trend data. Likewise, modeled rates of increase and vital rate values are also rounded to the nearest percentage point in this text.

[13] *c.f.* the average rate of decline across all 13 long-term radar sites during the same time period of -7 percent per year.

[14] Adopting survival rate values from estimates for related seabird species has been the default practice in previous population dynamics models for Kauaʻi seabirds as well, absent direct data from Kauaʻi.

abundance have been stable in the Hanalei to Kekaha area, there have also been relatively high and consistent annual estimated levels of unminimized powerline collisions. This, coupled with a lack of data from Kauaʻi on survival rates, presents a challenge in terms of initializing model projections of future trends in Kauaʻi metapopulation abundance; these projections are used to evaluate the proposed minimization and mitigation measures presented in the January 2023 draft KIUC HCP. This situation also introduces uncertainty in terms of providing estimates of future incidental take over the permit term because incidental take under the HCP is assumed to be a function of future projected trends in Kauaʻi metapopulation abundance.

Neither of the model scenarios (either the worse-case scenario with a steep population decline or the model fit to the stable abundance trend in Hanalei to Kekaha) should be considered realistic projections of abundance of the covered seabirds into the future. Instead, these two model scenarios can be viewed as plausible bounds of what may occur given different suites of assumptions. In reality, the outcome from the HCP is likely to be somewhere between the results of these two models. We do not know how long a stable trend in abundance may continue in the Hanalei to Kekaha area, nor do we know when and by how much that large portion of the island-wide population may experience a shift in trend, given uncertainties and data inconsistencies.

These uncertainties and data inconsistencies stem from previous abundance estimates being inconsistent with the estimated number of unminimized powerline collisions from 2013 to 2019, and a lack of burrow monitoring data in the Hanalei to Kekaha area to inform estimates of demographic rates (e.g., predation mortality, reproductive success rates). The predicted outcomes of both model scenarios provide important reference points for understanding the effects on the covered seabirds of the HCP covered activities (powerline collisions and light attraction from streetlights and facility lights) and of the island-wide benefits of the HCP conservation sites. Both of these scenarios demonstrate that, within these plausible bounds of population dynamics of the covered seabirds, the proposed HCP conservation strategy is able to fully offset the impacts of the taking of the covered seabird species and contribute a net benefit to their island-wide metapopulations.

How the January 2023 HCP PDM Scenario Benefits the HCP

The PDM in the January 2023 HCP is a critical tool to evaluate the combined adverse effects of the covered activities and the beneficial effects of the conservation measures. The results of PDM scenario in the January 2023 HCP demonstrates the ability of the proposed conservation sites to fully offset KIUC's impacts and provide a net benefit to the Kauaʻi metapopulation, even assuming a worse-case population decline within the plausible bounds of available data in the Hanalei to Kekaha area. In other words, the PDM scenario in the January 2023 HCP provides a plausible lower bound of the benefits of the HCP (i.e., with a worse-case Kauaʻi metapopulation decline). This helps to address the conflicts between datasets for the covered seabird species and, ultimately, the uncertainty in the biological assumptions for areas that do not have burrow monitoring studies.

Why the Worse Case PDM Scenario is Insufficient by Itself

Three independent datasets suggest that the island-wide population of both covered seabirds has been "stable"[15] over the last decade, not declining. First, radar data collected by the Kauaʻi Endangered Species Recovery Project (KESRP) from 2010 through 2022 from 15 coastal sites in the Hanalei to Kekaha area (Sahin 2023) found no significant population trend for both species during this time period.

Secondly, powerline strike data collected by KIUC over a similar time period (2013–2019) also show no significant trend in annual collisions prior to the majority of the minimization projects. Significant strike rate reductions have been estimated from the monitoring data since minimization (Travers et al. 2020, 2023, 2024). Like the radar index of abundance, the unminimized annual collision estimates, as well as observed annual passage rates during the last decade are inconsistent with abundance having experienced a continued steep decline during the last decade (Travers et al. 2023); if there was a continued steep population decline during the period of 2013 to 2019, when unminimized collisions were monitored, we would have expected to see a reduction in powerline collisions as fewer and fewer seabirds were still alive to collide with powerlines each year.

Finally, data from the Save Our Shearwaters (SOS) Program on collected and rescued seabirds from light attraction fallout provides an independent data source. SOS Program data tracks the earlier steep decline observed in the radar index of abundance (Raine et al. 2017) and has more recently shown a stable trend similar to the radar index (e.g., Sahin 2023).

The PDM scenario of a continued steep decline in the January 2023 HCP is, by itself, insufficient to estimate future levels of incidental take under the HCP. The resulting predictions of powerline collisions into the future are likely a significant *underestimate,* unless all three datasets described above are failing to detect the very steep decline assumed in the Hanalei to Kekaha area in that model scenario. As the model projected population declines substantially, the number of powerline collisions also declines substantially because the per-capita risk of collision risk is assumed constant in the future after minimization is fully implemented. This would result in a request for incidental take of the covered species by KIUC that is likely much too low and will therefore be exceeded well before the end of the permit term. Put another way, the estimated abundance and productivity of the covered species must be high enough to be consistent with the powerline strike rates that have been estimated from observations and acoustic monitoring.

Although the Worse Case PDM scenario was developed with assumptions that err on the side of the species (i.e., a worse-case effect on the species), it also results in estimates of powerline collisions that will become increasingly unrealistic over time, to the extent that the assumed modeled rate of steep population decline is greater than the true trend in abundance.

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[15] We use the word "stable" to refer to estimates indicative of abundance levels that have shown no signs of significantly increasing or decreasing over multiple years of data collection. Though estimates from availale data show no trend, one can hypothesize a demographic scenario in this case, where high subadult powerline mortality rates do not immediately impact current estimated "stable" trends, but high subadult mortality does result in an unstable underlying age structure. This could lead to a demographically induced lag before a negative trend in abundance takes over due to a collapse in recruitment to the breeding age component of the population. However, given the age at sexual maturity of 6 years, we have found through separate exploratory model runs that stable trends in abundance would not persist as hypothesized for 13 years (c.f. 2010–2022 "stable" radar index of abundance), unless one assumes much higher (near 100 percent) rates of adult survival during that time in the areas of Kauaʻi most affected by anthropogenic mortality.

Stable Trend Modeling Scenario

To address the issues summarized above, KIUC has conducted a second modeling scenario for the HCP, for three reasons:

- To incorporate more realistic assumptions of recent underlying population stability of the covered seabirds, consistent with the three long-term datasets summarized above.
- To address the unrealistically low take estimate for powerline collision and light attraction that results when the PDM is based on an -11 percent decline in abundance per year in the Hanalei to Kekaha area, given that three separate datasets (radar, powerline collisions, and SOS recoveries) indicate a relatively flat trend since 2010.
- Loyal Mehrhoff of the State's ESRC requested that a new scenario should be run based on the recent stable trend in the radar index for both covered seabirds for comparison with the worse-case radar trend scenario in the January 2023 draft HCP.

Data Reliability and Uncertainties

There are substantial data gaps in the Hanalei to Kekaha area compared to the conservation sites. Available data for this area include the radar trend data, the spatial risk and magnitude of powerline collisions since 2013, SOS returns, and some auditory survey efforts where observers listen for calling birds and collect data on the areas of calling activity, using night vision equipment for concurrent visual observations of activity states. However, auditory survey efforts are much more sparsely distributed in the Hanalei to Kekaha area and carried out infrequently compared to the conservation sites, where auditory surveys are undertaken annually. While the radar data do not measure seabird abundance directly, the data provide a consistent and useful index of relative abundance that has been calculated every year since 1993. Even if there are biases in this sampling program, we would expect those biases to remain relatively constant over the sampling period, producing a consistent and reliable index for both seabird species. Similarly, KIUC's powerline monitoring program has collected consistent observational and acoustic strike data at sites throughout the Hanalei to Kekaha area, including locations in the interior of the island that radar cannot reach. While not measuring abundance directly, the time series of unminimized annual powerline collisions are assumed to be related to underlying trends in abundance. Similar to the radar data, even if there were biases in the unminimized powerline collision data, we would expect those biases to remain relatively constant throughout the sampling period, producing a useful comparison with the radar index of population trends.[16] The radar index and powerline strike data are the best systematic sources of monitoring data currently available for the Hanalei to Kekaha area, and reflect on the Kauaʻi metapopulation trends of the covered seabirds.

SOS data are not as reliable as the radar index or powerline collision monitoring because of the opportunistic nature of birds being turned-in to SOS by volunteers for rehabilitation and release. However, during the last decade volunteer effort has remained largely constant, and despite some limitations, the SOS data have been used to corroborate earlier declines observed in the radar data (Raine et al. 2017) and since 2010 consistent SOS numbers recovered each year also corroborate the stable radar trend over the last decade for the covered seabirds.

[16] The powerline monitoring program goes to great lengths to minimize observer bias in the sampling program within sampling years and between years.

We do not know or have data from Kauaʻi to directly estimate the theoretical population growth rate for the covered seabird species without any anthropogenic sources of mortality. In other words, we do not know what the growth rate would be without any predation from invasive predators, without powerline collision, and without light attraction.[17] This growth rate is called the maximum theoretical rate of increase in abundance, or R_{MAX}. With intensive predator control at HCP conservation sites, it has been demonstrated through ongoing burrow monitoring studies that breeding adult predation mortality rates of less than 1 percent[18] can be achieved for the covered seabirds. Also, given very low powerline collision and light fallout risk in northwestern Kauaʻi where these conservation sites occur, the population growth rate at the conservation sites approaches this important theoretical growth rate in the PDM. However, given limitations of available trend monitoring data (e.g., trends in call rates at the conservation sites are not directly translatable to trends in absolute abundance), the maximum theoretical rate of increase in abundance (R_{MAX}) in the PDM must be derived from independent data, some of which is conflicting, or has been assumed based on proxy species such as Manx shearwater in the North Atlantic.

The current or starting Kaua'i metapopulation abundance for the covered seabird species with which to "initialize" the PDM is uncertain. Past estimates of covered seabird abundance on Kauaʻi have tried to extrapolate from strip-transect estimates of *minimum* abundance from ships at sea. However, there remain unresolved questions about what proportion of *total* abundance these at-sea estimates represent, because they occurred in only a portion of the vast and dynamic at-sea range of the species (e.g., Adams and Flora 2010; Raine et al. 2021, 2023).[19]

To estimate the current abundance of the covered seabirds on Kauaʻi, Archipelago Research and Conservation (ARC) developed ranges of abundance of each species in different areas of Kauaʻi based on all of the available long-term datasets on the island. The breeding pair estimates developed by ARC are informed by auditory survey, habitat suitability modeling, and nesting densities observed during burrow monitoring studies at the conservation sites. We have confidence in these abundance estimates from the relatively data-rich conservation sites. However, in the Hanalei to Kekaha area there are large gaps in the auditory survey data and burrow monitoring data are not available. Llike the at-sea abundance estimates, the abundance estimates derived from data collected on Kauaʻi are also not consistent with observed trends and estimated number of annual powerline collisions that have occured since 2013.

Stable Trend Model Scenario Assumptions

This modeling approach is based on the stable trend in the radar index of abundance during the last decade, and is also consistent with the average annual unminimized powerline strike data. To match the modeled trend to the stable radar index and the unminimized powerline strike data, certain assumptions used in Worse Case model scenario must be adjusted:

- **Starting abundance.** KIUC, U.S. Fish and Wildlife Service, and State of Hawaiʻi Division of Forestry and Wildlife (DOFAW) agree on the estimates of powerline collisions, both before powerline minimization (before 2019) and after powerline minimization (after 2023). Given

[17] This value retains "natural" sources of mortality such as predation at sea, disease, or failures in at-sea food sources.

[18] Terrestrial predation mortality rates estimated for all burrows monitored at the conservation sites represent 0.2 percent of breeding adults being predated on average per year under dedicated predator control.

[19] Additional discussion of issues with the at-sea estimates of minimum abundance in the PDM are provided in Appendices 5E and 5F of the January draft HCP.

this, there must be enough birds on Kaua‘i to account for the number of collisions estimated *and* maintain a stable population trend based on the radar index since 2010 in the Hanalei to Kekaha area. The starting abundance has been adjusted in Halanlei to Kehaha area to ensure that it is consistent for modeling purposes. In other words, modeled abundance is estimated such that the unminimized collisions derived from the model estimate of abundance equal the annual average number of powerline collisions estimated by Travers et al. (2020). This is a critical calibration to ensure the model provides as accurate an estimate of future incidental take under the HCP as possible.

- **Maximum rate of growth.** Estimated predation rates from burrow monitoring studies at the conservation sites suggest that uncontrolled predation in the Hanalei to Kekaha area would lead to declining abundance in that area if the maximum theoretical rate of increase in abundance (R_{MAX}) is 3 percent. To fit the model to a stable population trend in the areas surveyed by radar, the maximum theoretical rate of increase in abundance (R_{MAX}) must be greater than 3 percent.
- **Survival rates for adults and juveniles.** For the PDM to match the stable trend in the radar index of abundance, it is necessary to adjust the subadult and adult natural survival rates[20] from 92 to 96 percent and the fledgling natural survival rate from 37 to 53 percent per year. These higher survival rates produce a maximum theoretical rate of increase in abundance (R_{MAX}) of 8 percent. In combination with the model estimate of abundance, these survival rates result in the modeled trend under unminimized power line collisions matching the post-2010 stable radar trend.

How the New Modeling Scenario Benefits the HCP

This new modeling approach provides a more realistic estimate of incidental take from powerline collisions throughout the permit term, and one that is consistent with the trend observed in all three of the recent currently available datasets in the developed areas of Kaua‘i. Specifically, this new modeling approach provides a plausible upper bound for abundance trends in the Hanalei to Kekaha area. As a result, because this part of Kaua‘i is also where covered seabirds are exposed to the greatest risk of powerline collision and light attraction, the new modeling approach provides a more realistic estimate of future powerline collisions when modeled trends in abundance in the Hanalei to Kekaha area are consistent with multiple independent data sources.

The estimated Kaua‘i metapopulation growth under the HCP in this new scenario is driven largely by the benefits of powerline minimization in the Hanalei to Kekaha area. Like the worse-case scenario, the new scenario also mimics the positive trends observed at the conservation sites over the last decade, where monitoring data has demonstrated increasing abundance due to invasive predator densities being successfully controlled in these sites, and where seabirds are also subject to very low risk of powerline collision or light attraction. The modeled rapid growth in the Hanalei to Kekaha area under the stable trend scenario is largely due to the increased survival rates for juveniles and adults in the model, by 16 percent and 4 percent, respectively (Table 1). Under this new modeling approach the HCP would fully achieve its biological goals and objectives for the covered seabirds by year 25, halfway through the permit term.

[20] Also called the “survival rate under optimal conditions” in Chapter 5 and Appendix 5D. The terms are equivalent for the purposes of the HCP.

Why the New Modeling Scenario is Incomplete

We do not know the actual maximum rate of increase in abundance (R_{MAX}) for either seabird species. An 8 percent maximum growth rate for the covered seabirds on Kauaʻi may be higher than reality. However, the model cannot account for a stable trend in abundance in Hanalei to Kekaha from radar data, a stable trend based on powerline strike data (2013–2019), and available estimates of mortality rates from uncontrolled predation without assuming an 8 percent maximum growth rate and an abundance level that is higher than previously estimated. This issue highlights some of the discrepancies in the various datasets available for these seabirds.

Growth at the conservation sites would eventually lead to a high number and density of nesting seabirds under the stable trend scenario. Although these covered seabirds are capable of nesting at high densities, at some point, nesting density could not increase any further at the managed conservation sites due to space constraints in suitable habitat. This site saturation would occur first for Newell's shearwater (ʻaʻo) in the smallest conservation sites, which are the ones with predator exclusion fences and social attraction measures. Subadults returning to prospect for a mate and burrowing space that could no longer find suitable nesting space inside the predator exclusion fences are likely to prospect and establish burrows nearby, outside of the fences (i.e., in the adjacent and much larger conservation sites where predators are aggressively controlled through active trapping and intensive monitoring). As densities increase, so will call rates, and hence natural social attraction to the breeding colony. If any of the larger conservation sites with predator control reach saturation, birds nesting outside of the areas protected by predator control would be exposed to higher levels of predation than within the larger managed sites.

None of the conservation sites active today have densities approaching their physical or biological capacity. Therefore, we do not know with confidence what nesting burrow densities might be at carrying capacity. For purpose of the model we have assumed a reasonable abundance limit for the conservation sites with predator exclusion fencing. There is no limit of abundance in the model put on the remaining conservation sites without predator exclusion fencing. This may overestimate future potential abundance of the covered seabirds in the larger conservation sites.

If growth at or close to 8 percent were to occur at the conservation sites, potential site saturation issues would be addressed either through adaptive management or through a permit amendment. The goal of either change would be to ensure that continued growth at the conservation sites would continue to fully offset the impacts of the taking on the covered seabirds, and to ensure that the conservation strategy continued to provide a net benefit to the covered seabirds.

Implications for the HCP

The two model scenarios can be viewed as plausible bounds of what may occur given different suites of assumptions. In reality, the outcome from the HCP is likely to be somewhere between the results of these two models. We do not know how long a stable trend in abundance may continue in the Hanalei to Kekaha area, nor do we know when and by how much that large portion of the island-wide population may experience a shift in trend, given uncertainties in assumptions about current conditions. These key uncertainties stem from previous abundance estimates being inconsistent with the estimated number of unminimized powerline collisions having no apparent impact on trends in abundance, and a lack of burrow monitoring data in the most impacted areas to inform estimates of demographic rates (e.g., predation mortality, reproductive success rates). Both possible outcomes are important determinants of the effects on the covered seabirds of the HCP covered activities (powerline collisions and light attraction from streetlights and facility lights) and of the island-wide benefits of the HCP conservation sites.

Both of the model scenarios demonstrate that, even under this range of plausible bounds of population dynamics of the covered species, the proposed HCP conservation strategy is able to fully offset the impacts of the take of the covered seabird species and contribute a net benefit to the island-wide metapopulation. Under the worse-case scenario of steep population decline in Hanalei to Kekaha area, positive island-wide population growth will not be achieved until approximately 2055, and the net benefit under the HCP is not achieved until approximately 2067. Under the stable trend scenario, positive island-wide population growth occurs immediately after permit issuance[21].

Worse Case and Stable Trend Scenarios

In the worse-case scenario the PDM for Newellʻs shearwater (ʻaʻo) in the area of Kauaʻi most affected by powerline collisions and light attraction (Hanalei to Kekaha) was run to match the steepest rate of decline in abundance observed at any single radar monitoring site on Kauaʻi.[22] This was estimated as an -11 percent[23] decline in abundance per year at the Hanalei radar site during 1993 to 2020 (Raine and Rossiter 2020 *c.f.* the average rate of decline across all 13 radar sites during the same time period of -7 percent per year). In other words, the worse-case scenario assumes abundance is crashing at present in the most affected areas outside the HCP conservation sites.

The stable trend scenario addresses an ESRC request that a PDM scenario be run based on the recent stable trend in the radar index of abundance, and this scenario also addresses the issue of the take estimate. This additional scenario can be compared to the worse-case radar trend scenario to provide a more comprehensive evaluation over a range of HCP projections.

The maximum rate of increase in abundance, or maximum population growth rate, is the highest theoretical rate of increase in abundance a closed population[24] can achieve in the population model. Here, "R_{MAX}" is used to represent the maximum rate of increase, expressed as a percentage increase in abundance per year. This rate of increase is a function of the vital rate values in the model (survival, age at sexual maturity, and reproductive success rates in this case), with higher values for vital rates leading to higher modeled maximum rates of increase. R_{MAX} can be calculated in the population model when the parameters for anthropogenic mortality[25] are set to zero, and there is no

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[21] Under the stable trend scenario positive population growth is actually estimated by 2021, given pre-HCP minimization measures.

[22] Detailed model methods, assumptions, and results can be found in Chapter 5, *Effects*, and Appendices 5D and 5E.

[23] Estimated trends from radar are rounded to the nearest whole percentage in this text (i.e., -10.7 percent and -6.9 percent are rounded in the text to -11 percent and -7 percent). The estimates are not rounded when fitting the population model to the trend data. Likewise, modeled rates of increase and vital rate values are also rounded to the nearest percentage point in this summary.

[24] A closed population means no emigration or immigration. For example, the social attraction sites are modeled to have a higher maximum rate of increase in abundance than a closed population could achieve in the model because the increase in abundance at the social attraction sites is driven by immigration from other areas, whereas the rate of increase in a closed population is driven solely by internal recruitment and natal fidelity to breeding colonies in a modeled area.

[25] Anthropogenic mortality sources in the population model include invasive predators, fallout from light attraction, and powerline collisions.

density dependence[26] on the modeled population growth rate or dispersal from social attraction measures. The population model scenario in the January 2023 draft HCP is referred to below as the "3 percent R_{MAX} scenario".

The worse-case PDM scenario is based on estimated reproductive success rates from burrow monitoring data. However, unlike reproductive success rates, there are no available data on post-fledgling (subadult) and adult survival rates for Newell's shearwater (ʻaʻo). Post-fledgling and adult survival rates for the worse-case PDM scenario are based on assumed (i.e., Manx shearwater) survival rate values from a proxy species. This combination of estimated and assumed vital rate values results in an R_{MAX} for the Kauaʻi metapopulation of Newell's shearwater (ʻaʻo) of 3 percent per year. In other words, without any predation from non-native predators, powerline collisions, light attraction, or other anthropogenic threats, the fastest possible growth rate for Newell's shearwater (ʻaʻo) is assumed to be 3 percent per year under the worse-case PDM scenario.

One result of the assumptions in the worse-case scenario is that the assumed rapid decline modeled in the Hanalei to Kekaha area would continue under the HCP projection, because a 3 percent R_{MAX} represents a population with a very low level of resiliency to anthropogenic mortality.[27] For example, when we apply the rate of predation mortality estimated from burrow monitoring studies prior to dedicated control measures in the PDM with 3 percent R_{MAX}, the rate of change in abundance drops from positive 3 percent to negative -2 percent per year (see also the "No Take" scenario in Figure 5-4a). This is before powerline collisions or light fallout mortality are accounted for in the population model.

Once powerline collisions and light fallout are applied, the modeled rate of decline becomes even more negative. This means that maintaining a stable abundance level (i.e., a flat trend of 0 percent change in abundance per year) is not possible when available estimates of anthropogenic mortality levels are applied in modeled areas like Hanalei to Kekaha, unless R_{MAX} is higher than 3 percent.

While the assumptions of the worse case scenario error on the side of the species, the radar monitoring survey data collected during the last decade (2010–2022) are not consistent with a steep ongoing decline in abundance. Instead, recent analyses by the State of Hawaiʻi of this State-collected monitoring data indicate that the trend in abundance has been flat (i.e., no change in the mean index value) since at least 2010 (Raine and Rossiter 2020; Sahin 2023). This presents a fundamental uncertainty in terms of estimating future take of Newell's shearwater (ʻaʻo). During the same decade that the index of abundance from radar has remained unchanged, powerline collision levels during 2013 to 2019 are estimated to have been relatively high, with no appreciable trend (up or down) in the annual unminimized collision levels during those years[28] (Travers et al. 2020). This suggests a plausible future scenario where as the rate (and risk) of powerline collisions declines due

[26] Density dependence refers to modeled population growth rates that are a function of the abundance or density of individuals. Common models of density dependence result in population growth rates declining as abundance increases, which mimics the effects of resource limitation and declines in productivity and recruitment at higher population densities.

[27] For perspective, one of, if not the most K-selected (long-lived; low fecundity) endangered species in Hawaiʻi is the Main Hawaiian Islands Insular Stock of false killer whales (*Pseudorca crassidens*). This species becomes sexually mature at a later age than Newell's shearwater (ʻaʻo), produces one offspring about every 7 years, and is assumed by the National Marine Fisheries Service to have an R_{MAX} of 4 percent in calculations of anthropogenic mortality and serious injury limits under U.S. statutes: https://doi.org/10.25923/5ysf-gt95

[28] This period predates almost all of the powerline minimization projects that KIUC has installed since January 2020.

to powerline minimization projects under the HCP, and survival and reproductive success rates increase as a result, the flat trend in abundance would be expected to turn positive, all else being equal.

This is a very different scenario in terms of both potential future abundance and potential future levels of take as informed by the model because powerline collisions are assumed to be a function of abundance in the most affected areas in the population model. Table 1 provides a comparison of model assumptions between the the worse case and stable trend scenarios. Results are presented in Table 2 below in which the population model is initialized from the 2010 through 2022 stable radar index of abundance of 8 percent R_{MAX}, with comparison to the 3 percent R_{MAX} (Worse Case) scenario in the January 2023 draft HCP.

Table 1. Summary of Model Assumptions and Results for Newell's Shearwater (ʻaʻo).

Values are shown for the modeled Hanalei to Kekaha area, where 90 percent of powerline collisions are assumed to occur based on estimates from acoustic collision detection data. The radar trend and unminimized collision estimate from this area are used to estimate the survival rates and abundance that in combination result in a flat model trend.[29]

	Model Scenario		
Model Parameter for Newell's Shearwater	**Worse Case (-11% per year pre-HCP Trend)[30]**	**Stable Trend (0% per year Pre-HCP Trend)**	**Notes and HCP reference**
R_{MAX}	3% per year	8% per year	Maximum theoretical rate of increase in abundance in the absence of anthropogenic mortality (e.g., powerline collisions, light fallout, and invasive predators)
Post-fledgling and Adult "Natural[31]" Survival (Age 2+)	92% per year	96% per year	Worse Case: Survival based on Manx shearwater in North Atlantic Stable Trend: Survival estimated based on: Estimates for unminimized powerline collisions (2013–2019) and flat radar trend (2010–2022)

[29] The survival rate estimates shown for the stable trend scenario pertain to all areas modeled for the Kauaʻi metapopulation, before different levels of anthropogenic mortality are applied to each area in the population model. Assumptions for the worse case scenario are presented in Appendix 5D. The stable trend scenario integrates uncertainty in estimates of radar trend and unminimized powerline collisions through a Bayesian approach, and also differs from the worse case scenario in that survival rates are treated as an estimated parameter (instead of a fixed point value), which allows for the higher value of R_{MAX} in the population model.

[30] Appendix 5D.

[31] The word "natural" is used here to refer to modeled vital rates in the absence of anthropogenic mortality on Kauaʻi, i.e., natural survival and reproductive rates are those when anthropogenic mortality rates are set to zero in the population model and correspond to resulting population growth rates at R_{MAX}. Any athropogenic sources of mortality without available estimates (e.g., any fisheries bycatch) are subsumed in the "natural" survival rates. The natural reproductive success rate is based on estimates under dedicated predator control at the conservation sites.

Model Parameter for Newell's Shearwater	Model Scenario: Worse Case (-11% per year pre-HCP Trend)[30]	Model Scenario: Stable Trend (0% per year Pre-HCP Trend)	Notes and HCP reference
Fledgling "Natural" Survival (Age 1)	37% per year	53% per year	Worse Case: Age 1 survival set for an ~30% survivorship to breeding age Stable Trend: Survival estimated based on unminimized powerline collision mortalities (2013–2019) and flat radar trend estimate (2010–2022)
Reproductive Success Rate	56% per year	Same	Table 5D-7; *c.f.* 87% reproductive success rate at the conservation sites
Uncontrolled Adult Predation Mortality Rate (without predator control)	3% per year	Same	Table 5D-6
Sex ratio (M:F)	50:50	Same	Table 5D-7
Age at sexual maturity	6 years	Same	Table 5D-7
Breeding probability (Age 6+)	0.993	Same	Table 5D-7
Proportion of powerline collisions that are Newell's shearwater (ʻaʻo)	0.70	Same	Table 5D-4
Proportion of powerline collisions that result in mortality	0.29	Same	Table 5D-4
Proportion of powerline collisions that are subadults	0.79	Same	Table 5D-4 (Proportion of collisions that are adults = 0.21)
Annual island-wide powerline mortality minimization rate for HCP	0.664	Same	Table 5D-8
Starting total abundance Hanalei to Kekaha (total individuals all ages) in 2025	12,888	96,056	Worse Case: Table 5D-12
Ending total abundance Hanalei to Kekaha in 2075	125	276,659	Worse Case: Table 5D-12

Table 2. Comparison of Model Results between the Two Scenarios for the Kauaʻi Metapopulation.

Model Result	Model Scenario: Worse Case	Model Scenario: Stable Trend	Notes
Metapopulation growth rate at end of permit term (2075)	1%	4%	Projected population growth rates are always less than R_{MAX} due to modeled sources of anthropogenic mortality (i.e., invasive predators, minimized powerline collisions, and fallout)
Starting island-wide metapopulation size (total individuals, all ages) in 2025 (A)	32,293	119,887	Worse Case: Table 5D-12 Worse Case and Stable Trend: Initial abundance is estimated based on assumed trend, unminimized collision estimate, and R_{MAX} model
Ending island-wide metapopulation size in 2075 (B)	25,930	492,566	Worse Case: Table 5D-12
Starting abundance at all HCP conservation sites in 2021 (C)	3,967	Same	Table 5D-3 (estimated from burrow monitoring, auditory surveys and habitat suitability modeling)
Ending total abundance at all HCP conservation sites in 2075 (D)	16,939	234,991[32]	Worse Case: Table 5D-12 Stable Trend results do not impose carrying capacity constraints on abundance other than the predator exclusion fenced areas
Net gain at all HCP conservation sites (E = D – C)	12,972	231,024	
Year when island-wide metapopulation growth becomes positive	2055	2021	Stable Trend: Abundance is projected to start increasing after the first year of powerline collision minimization.
Total number of predicted powerline collisions over the 50-year permit term	34,554	293,034	Worse Case: Table 5D-13 Stable Trend: Table 5-7a
Total injury and mortality resulting from powerline collisions over the 50-year permit term	22,537	187,426	Same assumptions used for both scenarios. Includes loss of chicks and eggs. Stable Trend: Table 5-7a

[32] This is not a reasonable abundance level to expect for the conservation sites. It results because these provisional population model runs do not impose values for carrying capacities outside the predator exclusion fence areas.

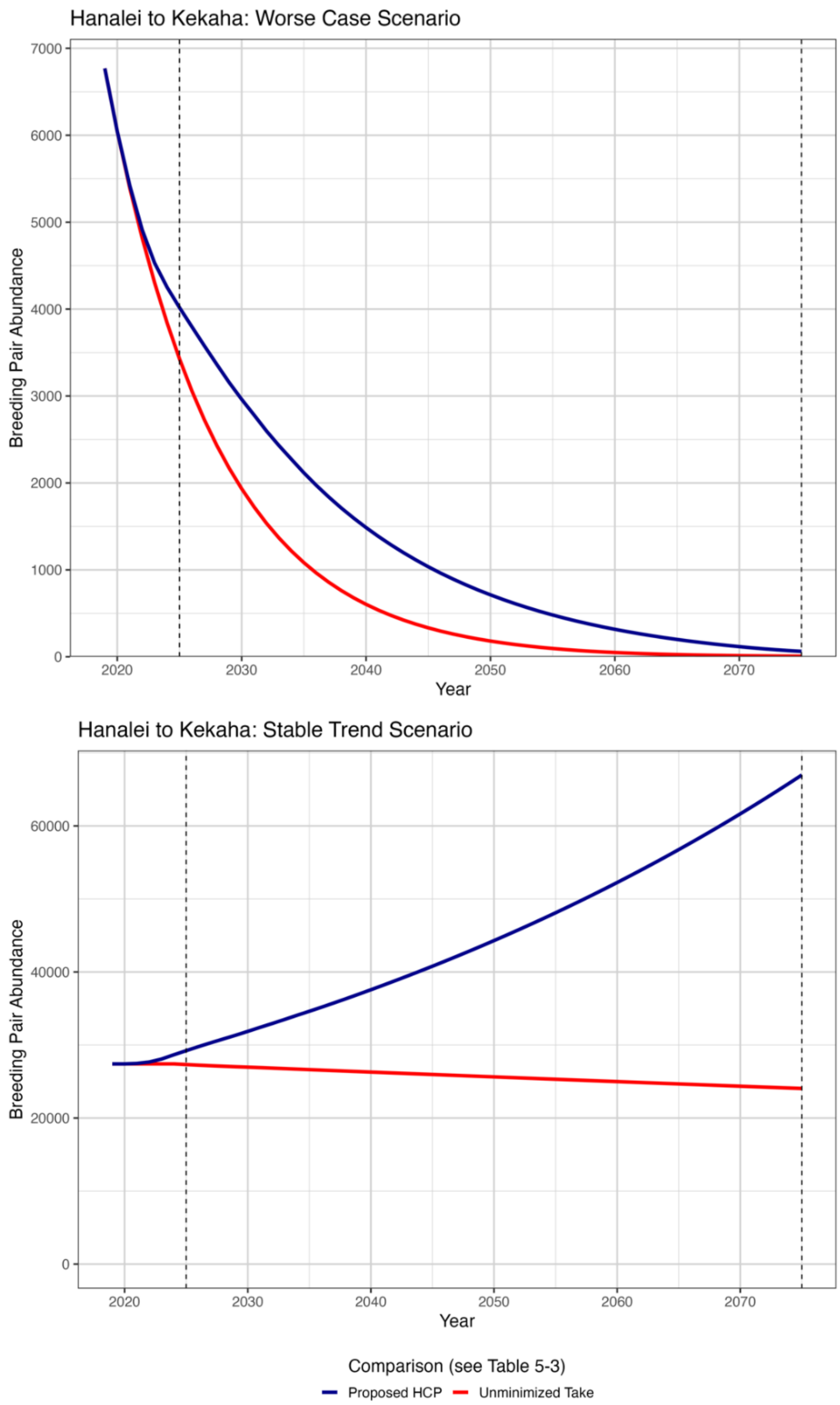

Figure 1. Projections of breeding pair abundance in the Hanalei to Kekaha area under the worse-case scenario from the draft HCP (top plot) and the stable-trend scenario (bottom plot).

The stable-trend scenario is initialized from the recent KESRP estimate of trend through the 2010 through 2022 data (Sahin 2023). The dashed verticle lines in each plot denote the first and last year of the permit term.

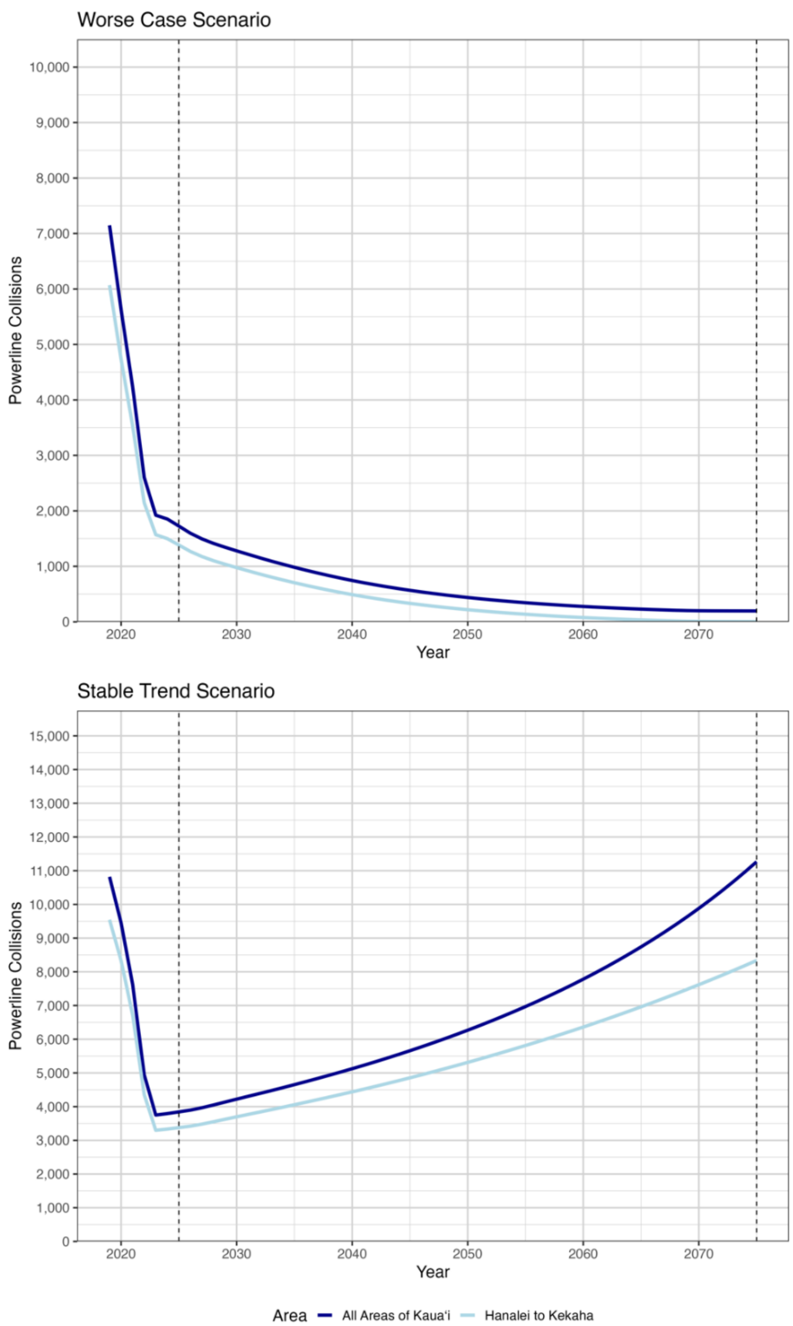

Figure 2. Projected future powerline collisions under the worse case scenario (top plot) and stable trend scenario (bottom plot).

Each plot shows the subset of collisions in the Hanalei to Kekaha area (light blue line) compared to total projected collisions across all areas combined (dark blue line). Note that pre-implementation minimization ramps up between 2020 and 2023, resulting in the rapid initial drop in collision rates for both scenarios. Starting in 2023, full minimization is implemented in the model and thereafter the trend in projected collisions tracks trends in abundance. Both scenarios are initialized assuming the estimate of annual unminimized collisions pertains to 2016 (the mid-year of the 2013–2019 data analyzed by Travers et al. 2020). Because the modeled trend in abundance differs between scenarios (e.g., see Figure 1), the trend in projected collisions through time also differs between scenarios.

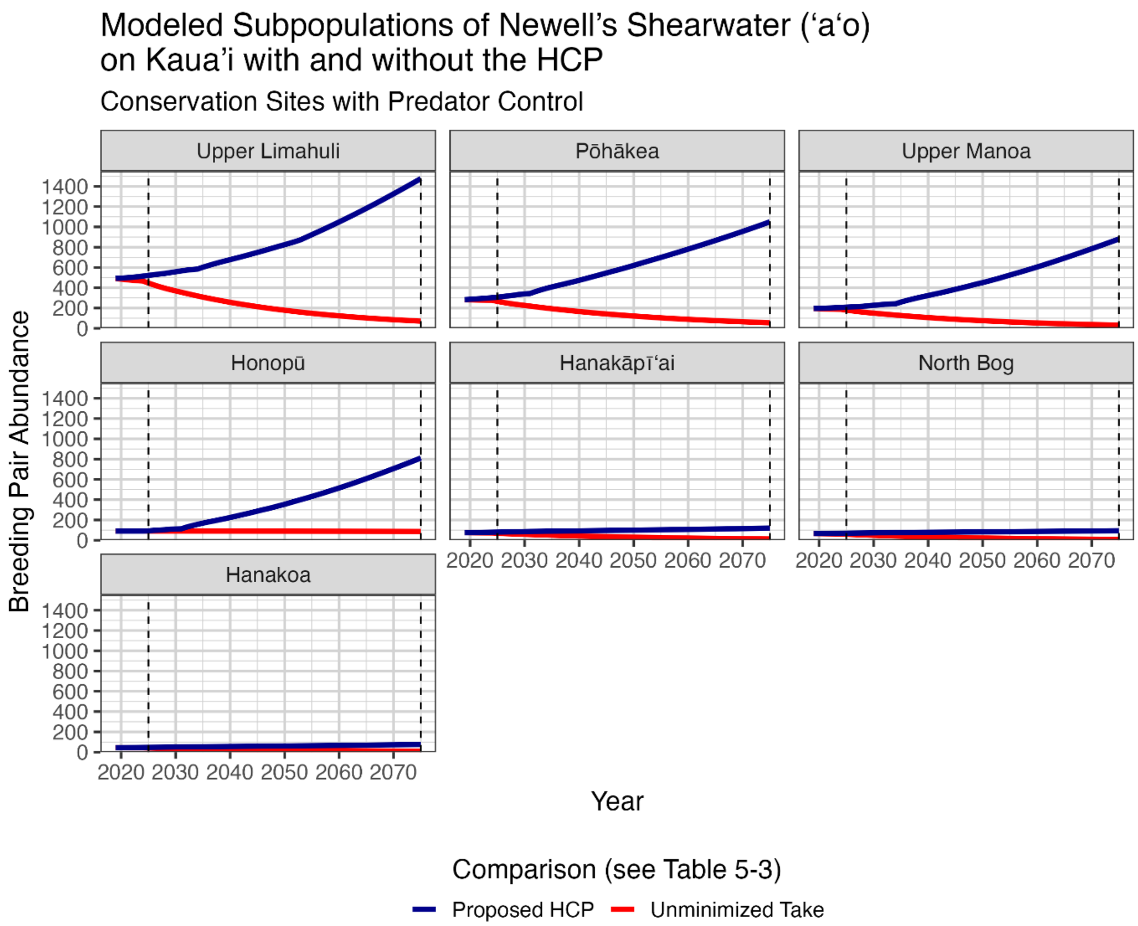

Figure 3a. Projections of breeding pair abundance at the conservation sites under the worse case scenario from the draft HCP.

Each of the conservation site projections are initialized from the minimum estimate of 2021 breeding pair abundance at each conservation site (Raine et al. 2022). The results assume there is no density dependence (carrying capacity) outside the predator exclusion fences. Note the scales differ between the plot's y-axes on Figure 3a and 3b.

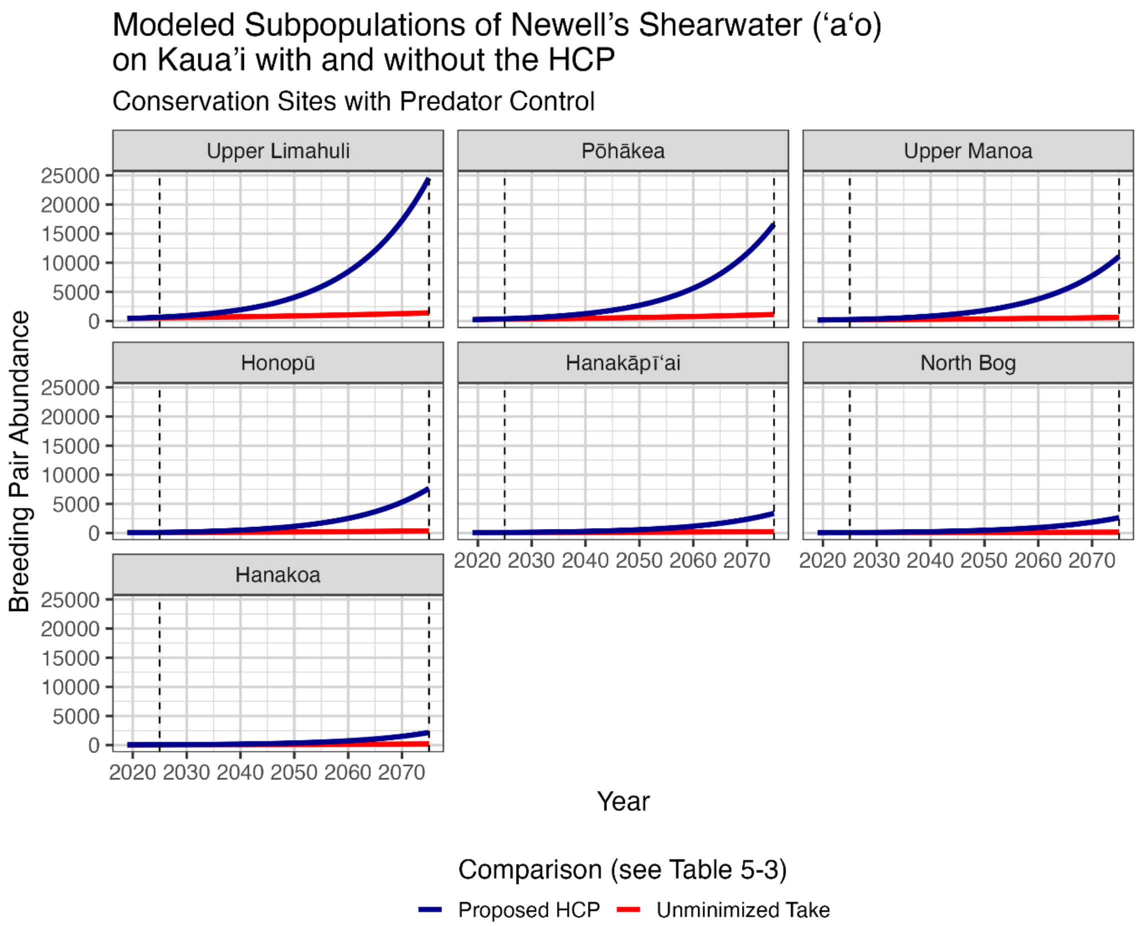

Figure 3b. Projections of breeding pair abundance at the conservation sites under the stable trend scenario.

Each of the conservation site projections are initialized from the same minimum estimate of 2021 breeding pair abundance at each conservation site (Raine et al. 2022). The results assume there is no density dependence (carrying capacity) outside the predator exclusion fences. The scales differ between the plot's y-axes on Figures 3a and 3b.

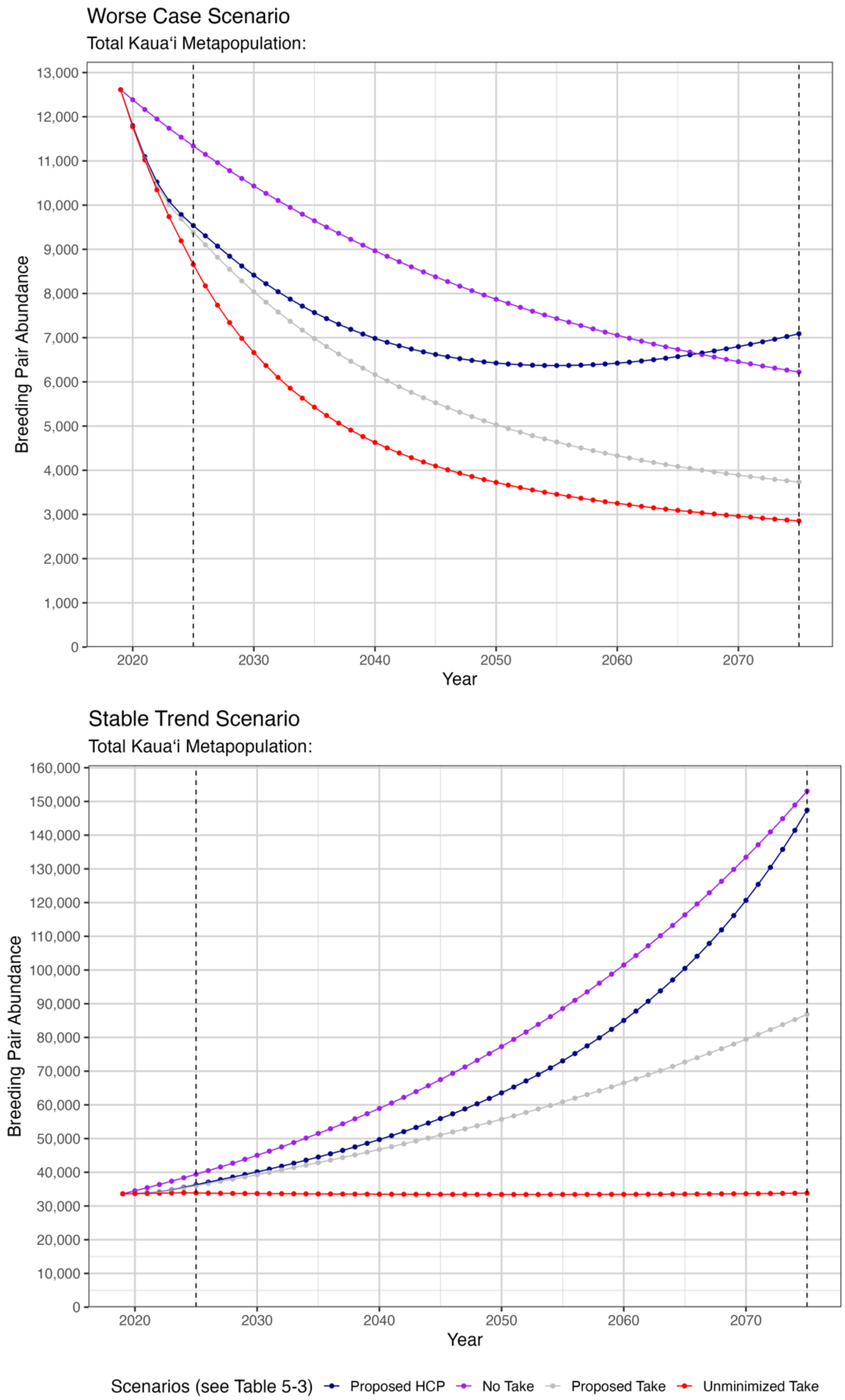

Figure 4. Kaua'i metapopulation comparison projections are shown for the worse case (top plot) and stable trend scenarios (bottom plot). Scales on the y-axes differ between worse case and stable trend scenario plots.

Model Limitations, Uncertainties, and Assumptions

Similar to the worse-case scenario, the stable trend scenario of the PDM includes assumptions that may result in overly conservative or overly optimistic outcomes. In practical terms, this means that the model may overestimate or underestimate the impacts of the covered activities on Newell's shearwater (ʻaʻo), or underestimate or overestimate the benefits of the conservation strategy for Newell's shearwater (ʻaʻo), or possibly both. This section describes cases in which model assumptions may be overly conservative or overly optimistic for the stable trend scenario. Many of these reasons are shared with the worse-case scenario (see Section 5D.4, *Model Limitations, Uncertainties, and Assumptions*, for a summary of factors related to the worse-case scenario).

Conservative Assumptions

The PDM with the stable trend scenario may be overly conservative for the following reasons.

- **Total powerline strikes.** Total powerline strikes are statistically higher (i.e., more conservative) level of powerline collisions in the model than would be expected from the data. This factor applies to both PDM scenarios because the assumptions of powerline collision risk across the island are the same in both scenarios. See the worse-case scenario explanation in Section 5D.4.1.1, *Conservative Assumptions*, for more details.
- **Strike allocation.** Allocation of powerline strikes may be even lower at some or all of the conservation sites than estimated, given flight paths, and observed altitudes from satellite tagging. This factor applies to both PDM scenarios because assumptions of powerline collision risk in each of the 17 subpopulations are the same in each scenario. See the worse-case scenario explanation in Section 5D.4.1.1 for more details.
- **Social attraction.** Assumptions of the benefits of social attraction may be conservative and may underestimate the benefits to the species. This factor applies to both PDM scenarios because assumptions of rates of social attraction are the same in each scenario. See the worse-case scenario explanation in Section 5D.4.1.1 for more details.
- **Conservation actions by others.** In both scenarios, the population dynamics of the Kauaʻi metapopulation of Newell's shearwater (ʻaʻo) are modeled only assuming the full implementation of this HCP's conservation strategy and that of the KSHCP (i.e., the Kahuamaʻa social attraction site). No other conservation actions performed by others are assumed to benefit Newell's shearwater (ʻaʻo). See the worse-case scenario explanation in Section 5D.4.1.1, including Table 5D-14, for more details.

Potentially Optimistic Assumptions

The PDM for Newell's shearwater (ʻaʻo) using the stable trend scenario may be too optimistic (i.e., underestimate adverse effects or overstate benefits) for the following reasons.

- **Total metapopulation size.** The estimate of the island-wide metapopulation may be too high, despite the integration of multiple independent data sources, and what are otherwise thought to be conservative assumptions by experts (e.g., using the estimates of minimum abundance for the conservation sites and other areas not surveyed by radar). If this is true, then impacts of the taking would be greater than predicted by the model. However, all else being equal, the *relative* effects of the HCP would be the same because model comparisons are made with and without the HCP using the same initial abundance estimate and estimates of trends in relative abundance (e.g., Figure 5-3b). This factor applies to both PDM scenarios. See the worse-case scenario explanation in Section 5D.4.1.1, *Conservative Assumptions*, for more details.

- **Social attraction.** As noted above, birds are assumed to be attracted to social attraction sites with an equal per capita probability from all other areas. Because shearwaters and petrels are known to have a high level of natal fidelity (e.g., Harris 1966; Perrins et al. 1973; Warham 1980), this assumption could be optimistic because it would result in more modeled immigration from areas with high predation and powerline mortality rates into "safe havens" than under a stronger model of natal fidelity. This factor applies to both PDM scenarios. See the worse-case scenario explanation in Section 5D.4.1.1 for more details.
- **Cat predation events.** The predation mortality rates used in the model under both scenarios are based on burrow monitoring data from multiple conservation sites over multiple years. The resulting estimate represents an average annual predation mortality rate under predator control that includes punctuated predation mortality events due to single cats. If the estimated predation mortality rate from burrow monitoring surveys does not fully capture the extent or frequency of these rare predation events from single cats, the model results with respect to the benefits of predator control at the conservation sites would be optimistic. However, independent acoustic monitoring data indicate that at least since 2014/2015, the extent of punctuated cat predation events has not resulted in negative trends in recruitment into the breeding colonies at the conservation sites. This factor applies to both PDM scenarios because assumptions of predation rates are the same in each scenario. See the worse-case scenario explanation in Section 5D.4.1.1 for more details.
- **Carrying capacity.** Social attraction sites inside predator exclusion fenced sites are modeled using estimates of carrying capacity for the number of breeding pairs that could nest in these areas. These sites are relatively small and available nesting habitat is well defined by the fenced perimeter. Additionally, the rate of increase in breeding pairs in these areas is assumed to be relatively high after 10 years, given the expected number of new immigrants attracted to these areas once they reach a critical mass (Table 5D-9). Therefore, it is likely that one or more of these social attraction site will reach carrying capacity of breeding pairs during the permit term. The model assumes that any additional breeding pairs (i.e., through continued immigration or internal recruitment) will "spillover" from the social attraction site into the larger surrounding conservation site. Carrying capacities are not assumed for the larger conservation sites.

This factor applies to both PDM scenarios. However, this is a larger issue for the stable trend scenario because of the higher rate of population growth modeled in the conservation sites with the stable trend assumptions. The issue of carrying capacity for the stable trend scenario is discussed earlier in this Attachment.

Acknowledgements

Dilek Sahin and Afsheen Siddiqi have provided the radar index values through data sharing requests submitted to DOFAW.

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Appendix 5E
Population Dynamics Model for Hawaiian Petrel (‘ua‘u) on Kaua‘i

The purpose of this appendix is to describe the population dynamics models developed by the Kauaʻi Island Utility Cooperative (KIUC) for Hawaiian petrel (ʻuaʻu). The population dynamics model for Newell's shearwater (ʻaʻo) is presented in Appendix 5D, *Population Dynamics Model for Newell's Shearwater (ʻaʻo) on Kauaʻi*.

A population dynamics model was not developed for band-rumped storm-petrel (ʻakēʻakē) because of the lack of data on this species, as described in Chapter 5, *Effects*.

The population dynamics model for Hawaiian petrel (ʻuaʻu) was developed for the following specific uses in the habitat conservation plan (HCP).

1. To convert the estimated rates of powerline collision and light attraction to a variable estimate of take authorization that accounts for estimated changes in island-wide population size (described in Chapter 5, *Effects*).
2. To evaluate the effects of the requested take authorization of the species from KIUC's covered activities (described in Chapter 5, *Effects*) in the absence of any mitigation.
3. To quantify the benefits of the conservation measures proposed in Chapter 4, *Conservation Strategy*, to the Kauaʻi metapopulation of the species.
4. To determine the net effects of the HCP covered activities and conservation measures on the Kauaʻi metapopulation of this species and to quantify the net benefit provided by the HCP.
5. To estimate population trends during HCP implementation over the 50-year permit term.

This appendix is divided into four sections: (1) Overview of the model, including methods, initial conditions, technical specifications, and tables with model input values, (2) Model results, (3) A discussion of model limitations, uncertainties, and assumptions, and (4) References cited. The key findings of this appendix are discussed in Chapter 5, *Effects,* along with more detail on the implications of the model results for the regulatory requirements of the HCP.

The appendix and technical details of the population dynamics model were developed by John R. Brandon, PhD, Senior Biometrician at ICF, with extensive review by David Zippin, PhD, Senior Conservation Biologist, and Dawn Huff, HCP Project Manager for KIUC. Dr. Brandon developed the computing code for modeling. The spatial representation of Kauaʻi metapopulation structure and model inputs were developed in close collaboration with André F. Raine, PhD, Science Director for Archipelago Research and Conservation (ARC), and Marc Travers, MS, Senior Scientist at ARC, both of whom are experts on Kauaʻi seabird biology and lead scientists on multiple studies of endangered seabirds on Kauaʻi. Dr. Raine and Mr. Travers provided input and data for many of the model parameters as cited throughout the appendix. The U.S. Fish and Wildlife Service (USFWS) and Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) reviewed model assumptions and results and provided valuable input on earlier drafts of this model and appendix.

5E.1 Overview of the Population Dynamics Model

5E.1.1 Model Subpopulations

The model for Hawaiian petrel (ʻuaʻu) is composed of nine distinct subpopulations. Six of the subpopulations correspond to conservation sites proposed in the HCP where Hawaiian petrel (ʻuaʻu) breeding pairs are estimated to occur. Breeding pairs of Hawaiian petrel (ʻuaʻu) have not been observed and are not predicted based on habitat suitability models (Troy et al. 2017) to nest at Upper Mānoa Valley. Hence, a subpopulation of Hawaiian petrel (ʻuaʻu) was not modeled for this conservation site. Likewise, it was assumed that the planned social attraction site at Upper Mānoa Valley PF would not benefit Hawaiian petrel (ʻuaʻu). In general, the social attraction site efforts are not aimed at attracting Hawaiian petrel (ʻuaʻu). For example, species-specific playback calls are only planned for Newell's shearwater (ʻaʻo). Therefore, it is assumed that no Hawaiian petrel (ʻuaʻu) will immigrate into the four social attraction sites. The modeled subpopulations for Hawaiian petrel (ʻuaʻu) are listed in Table 5E-1 with their locations illustrated in Figure 5E-1 (see Chapter 4, *Conservation Strategy*, and Appendix 4A, *Conservation Site Selection*, for details of the conservation sites).

Outside of the six conservation sites with Hawaiian petrels (ʻuaʻu), the rest of Kauaʻi was subdivided into three subregions[1] that correspond to the known metapopulation distribution of this species on Kauaʻi (see Figure 2 in Appendix 3A, *Species Accounts*). Hawaiian petrel (ʻuaʻu) are known to occur in the Hanalei to Kekaha area, the Wainiha and Lumahaʻi Valleys area, and the Kalalau east to Upper Mānoa area, so these areas were included in the model for this species. Waimea Canyon was excluded from the model because Hawaiian petrel (ʻuaʻu) are not known or expected to occur in that area. Each area in the model encompasses a geographic portion of the island that has similar conservation threats and management efforts for the species, as well as similar available data sources for estimating the abundance and trends of breeding pairs that nest there (Table 5E-2).

The modeling framework allows each subpopulation to have its own set of vital rate values and therefore different trends in abundance through time. This reflects the fact that pressures such as powerline collisions and predation vary depending on region and topography. For example, the remote areas in the northwestern region of the island do not have powerlines (see Figure 5E-1). Available tagging data is consistent with the flyways of breeding colonies in those areas, resulting in little to no vulnerability to powerline collisions (e.g., Raine et al. 2017a). For breeding colonies in northwestern Kauaʻi (including the conservation sites), where powerline collision vulnerability is low and predator control efforts have been effective, acoustic monitoring data has demonstrated increases in abundance since 2014–2015 (Raine et al. 2022). The opposite is true in other areas of the island where breeding colonies are particularly vulnerable to powerline collisions and light attraction, and predation levels are high. Examples include those sites that have flyways crossing the Powerline Trail in the middle of the island, where collisions historically have been the highest, prior to powerline collision minimization efforts (Travers et al. 2020; also see Chapter 5, Figures 5-1a and 5-1b estimated rates of bird strikes per wire span in 2019 and 2024, respectively).

[1] Unlike Newell's shearwater (ʻaʻo; Appendix 5D), there were zero Hawaiian petrel (ʻuaʻu) breeding pairs estimated in one of the four subregions of Kauaʻi outside the conservation sites. The breeding pair estimates for Hawaiian petrel (ʻuaʻu) are described in Section 5E.2.1, *Initial Conditions*. Subpopulation dynamics of Hawaiian petrel (ʻuaʻu) were not modeled for those subregions with zero estimated breeding pairs.

Furthermore, available monitoring data also differs by each area. For example, radar survey data, which is the longest running systematic monitoring study to estimate trends in relative abundance for this species on Kauaʻi, are only available from areas with road access (the radar system is mounted on a vehicle).

The spatially explicit model described here accounts for these differences and complexities in the overall metapopulation dynamics and allows monitoring data (e.g., trends) from different areas to be incorporated in the model. The vital rates for each subpopulation are also modeled to change over time as future management efforts are implemented under the HCP, corresponding to the timeline of these measures described in Chapter 4, *Conservation Strategy*. For example, increases in estimated powerline strike reductions due to minimization are modeled through time to reduce powerline strike mortality rates. Similarly, the timing of installation of predator exclusion fencing around particular management sites are modeled to reduce predation mortality rates for the corresponding subpopulations at those sites in future years.

Island-based estimates of abundance for each subpopulation are used to initialize population trajectories, which are then projected forward in time through the 50-year permit term. For simplicity, the model does not assume any dispersal among the Kauaʻi subpopulations, which is reasonable because shearwaters and petrels exhibit strong natal philopatry[2] (e.g., Harris 1966; Perrins et al. 1973; Warham 1980) and established breeding pairs typically return to the same nesting burrow year after year. The model also does not assume any dispersal between Kauaʻi and other islands in Hawaiʻi.

Table 5E-1. Modeled Subpopulations, HCP Status, and Associated HCP Management Actions

Modeled Subpopulation	HCP Status	HCP Management Actions with Modeled Benefit[a]	HCP Management Actions with Benefit not Modeled[a]
1. Pihea	Conservation site	Predator control[b]	Invasive plant species management and partial ungulate fence[c]
2. North Bog	Conservation site	Predator control[b]	Invasive plant species management and partial ungulate fence[c]
3. Pōhākea (site excludes Pōhākea PF)	Conservation site	Predator control[b]	Invasive plant species management and partial ungulate fence[c]
4. Hanakāpiʻai	Conservation site	Predator control[b]	Invasive plant species management and partial ungulate fence[c]
5. Hanakoa	Conservation site	Predator control[b]	Invasive plant species management and partial ungulate fence[c]
6. Upper Limahuli Preserve	Conservation site	Predator control[b]	Invasive plant species management and pig exclusion fencing
7. Hanalei to Kekaha	N/A	Powerline and streetlight minimization	Save our Shearwaters (SOS) Program

[2] *Natal philopatry* is the tendency of an animal to return to breed in the place of its birth.

Modeled Subpopulation	HCP Status	HCP Management Actions with Modeled Benefit[a]	HCP Management Actions with Benefit not Modeled[a]
8. Wainiha and Lumahaʻi Valleys	N/A	Powerline and streetlight minimization	SOS Program
9. Kalalau east to Upper Mānoa (excluding conservation sites)	N/A	Powerline and streetlight minimization	SOS Program

[a] See Chapter 4, *Conservation Strategy*, for details.
[b] Predator control involves species specific efforts for ungulates, cats, rodents, and barn owls.
[c] Sections of ungulate fence are installed along the borders of Hono O Nā Pali Natural Area Reserve and are combined with extremely steep terrain assumed to be impassable by ungulates. These sites are located within the Hono O Nā Pali Natural Area Reserve managed by DOFAW.

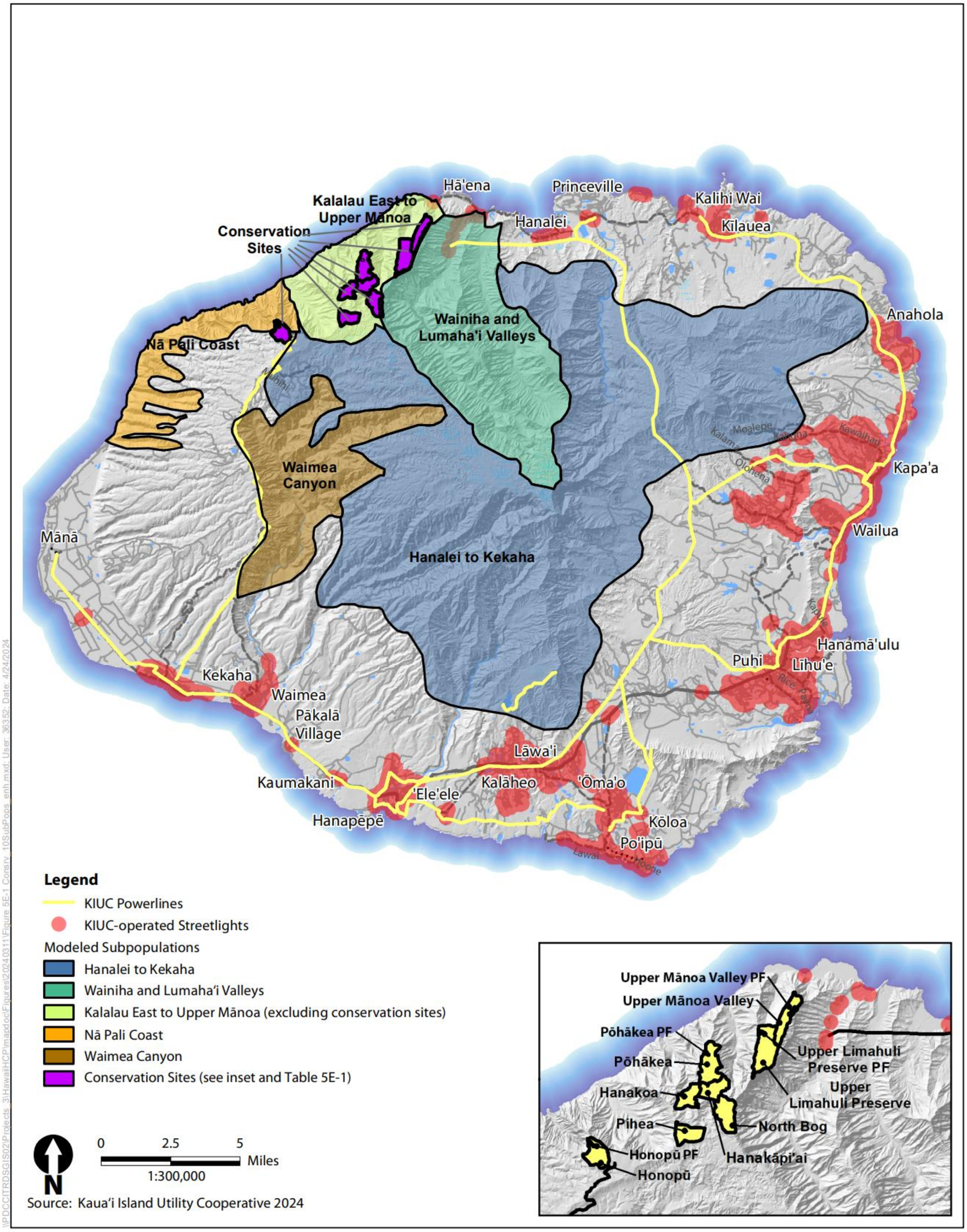

Figure 5E-1. Locations of Modeled Hawaiian Petrel ('ua'u) Subpopulations and Locations of KIUC's Covered Facilities

5E.1.2 Two Model Scenarios

Two abundance trend scenarios were modeled for Hawaiian petrel (ʻuaʻu) on Kauaʻi. For the January 2023 public review draft of this HCP, KIUC developed the population dynamics model for Hawaiian petrel (ʻuaʻu) with the assumption that abundance is rapidly declining outside of the conservation sites (Kauaʻi Island Utility Cooperative 2023). This scenario modeled a steeply declining trend in the population of Hawaiian petrel (ʻuaʻu) in the most affected areas outside of the conservation sites. This approach was chosen to err on the side of the species by providing a highly conservative evaluation of the effects of the HCP on the species, including identifying a plausible upper bound on the impact of the taking. This scenario also captures the lower bound of the benefits of the HCP by assuming an extreme case for the status for the birds that could still be supported by some small preselected subset of available monitoring data on trends (i.e., can the conservation strategy provide a net benefit to the species, even if the preselected subset of trend monitoring data is extrapolated and assumed to represent a widespread rapid decline in abundance outside the conservation sites).

Although the assumption of a rapidly declining population is not consistent with radar and powerline collision data since 2010, which suggest a stable trend in abundance in areas with monitoring data outside the conservation sites (e.g., the Hanalei to Kekaha area; Figure 5E-1), there was a concern that due to the long-lived nature of the species another decline may occur at some point in the future. The supposition of an impending future decline, following the current stable trend period, is based on the conjecture that the demographic age-structure is currently highly skewed, such that all, or nearly all, of the surviving Hawaiian petrel (ʻuaʻu) on Kauaʻi are breeding adults. This postulates that the higher vulnerability of subadults to light fallout and the higher ratio of subadults in powerline collisions (assumed 80:20 subadult:adult age ratio; Cooper and Day 1998), results in few, if any, subadults currently surviving to breeding age. The rationale follows that once the remaining cohort of adults reach the end of their lifespan, abundance of the Kauaʻi metapopulation will collapse as the current cohort of adults reaches senescence with few or no surviving subadults to replace them. This situation would represent a demographically induced "extinction vortex".

However, Hawaiian petrel (ʻuaʻu) start reproducing at age 6. That combined with over 10 years of data indicating trends in abundance have been stable in the Hanalei to Kekaha area, it is expected that, if such a demographically induced decline were going to occur, it would have already started. If subadults are not recruiting to breeding age per the extinction vortex hypothesis, monitored abundance would start to decline rapidly after roughly 6 years, due to annual natural and anthropogenic mortalities of adults each year. If this were occurring, we would observe a downward trend in the radar and powerline monitoring data since 2010 (e.g., reduced passage rates and powerline collisions associated with reductions in underlying abundance). However, such declines in passage rates or powerline collisions have not been observed prior to substantial powerline minimization being implemented by KIUC starting in 2020. Therefore, the data do not support the "extinction vortex" hypothesis.

For the lag time before such a hypothesized collapse to have lasted more than 10 years (i.e., for the data to still be consistent with the extinction vortex hypothesis), one must assume that adults have near 100 percent survival rates in the areas of Kauaʻi with the highest levels of anthropogenic threats (i.e., that there have been almost zero adult mortalities in areas like Hanalei to Kekaha since 2010, areas where there is no dedicated predator control and where powerline collisions are highest). Even after accounting for the implausibility of this scenario, in discussion with the agencies, KIUC took a conservation approach erring on the side of the species in modeling an abundance trend that was collapsing (and ultimately declines to zero) in large areas like Hanalei to Kekaha. This scenario was presented in the January 2023 draft HCP (aka the "worse-case" scenario, as described further below).

There are two complications with the January 2023 public draft HCP approach: First, as noted above, it conflicts with the most current radar and powerline collision data. Second, it likely *underestimates* future take from powerline collisions and light attraction under the HCP, because the amount of take from both of these sources of injury and mortality is assumed to be a function of abundance. In other words, as a population increases with a constant risk or powerline collision or light attraction, one would expect the amount of collision and fallout to increase. With the assumption of a rapidly declining trend in abundance (i.e., the worse-case scenario), take from powerline collisions and light attraction would also rapidly decline through time because there are fewer and fewer birds in the air exposed to those risks. Therefore, modeling in the January 2023 public draft HCP did not provide a plausible upper bound on abundance trends. By extension, the January 2023 public draft HCP also did not provide a plausible upper bound of future take from powerline collisions and light attraction assuming a stable or growing population.

The state Endangered Species Recovery Committee reviewed the January 2023 public draft and provided comments to this effect. In light of such issues, the Endangered Species Recovery Committee recommended developing a more realistic modeling scenario for comparison purposes.

Multiple sources of data for the Hanalei to Kekaha area document a large decline in abundance during the 1990s (e.g., Raine et al. 2017b). In contrast, radar and powerline collision data since 2010 indicate the recent trend in abundance in the Hanalei to Kekaha area has changed. The trend is no longer rapidly declining, but rather has been stable at relatively low abundance levels compared to the 1990s. Using these more recent estimates of trends in abundance in the Hanalei to Kekaha area, KIUC developed a second modeling scenario to address the issues noted above and to respond to the comments received from the state Endangered Species Recovery Committee. To distinguish the two model scenarios, they are briefly outlined below:

- ***Worse-case trend*** population dynamics model scenario (or worse-case trend scenario) assumes the population trend outside of the conservation sites is rapidly declining at model initiation, a far worse status for the birds than the second scenario. This scenario is described in detail in the next section below.
- ***Stable trend*** population dynamics model scenario (or stable trend scenario) assumes the initial population trend outside of the conservation sites is flat, meaning no increase or decline. This scenario has the same underlying modeling structure (e.g., spatially explicit areas) as the worse-case trend scenario. The different assumptions of the stable trend scenario are described in Attachment 5E-1, *Hawaiian Petrel ('ua'u) Population Dynamics Model Fit to the Stable 2010–2022 Radar Trend under KIUC's Proposed Habitat Conservation Plan* (the same information is also provided in Table 5-2 in Chapter 5, *Effects*).

These two model scenarios differ in three primary ways: starting abundance, maximum rate of population growth, and survival rates for adults and juveniles, each of which is summarized below.

- **Starting abundance.** The starting abundance of the conservation sites are the same for each model scenario and based on estimates from field monitoring at each site. The starting abundance of the worse-case trend scenario for subpopulations outside of the conservation sites, in those areas where long-term radar trends are not available, is based on professional judgement and more limited observational data. These initial abundance estimates were made independent of estimates of powerline collisions, and are identical between the modeled trend scenarios. In the areas of Kauaʻi most affected by anthropogenic mortality, abundance is estimated such that once the level of anthropogenic mortality (e.g., unminimized powerline collision levels) is applied in the model, the trend in modeled abundance matches the applied trend estimate from the radar survey data (either the subset of historical radar data with a rapid decline, or the larger data set across all radar sites since 2010 which shows a recent stable trend).

The rationale for this approach is that the abundance of Hawaiian petrel (ʻuaʻu) on Kauaʻi must be at a level that can sustain the number of estimated powerline collisions prior to minimization during 2013–2019 (Travers et al. 2020) while also sustaining the population trend consistent with radar data. For more explanation of this approach in terms of modeling the stable trend scenario, see Attachment 5E-1.

- **Survival rates for adults and juveniles**. The worse-case trend scenario assumes that the "natural" survival rate[3] of Hawaiian petrel (ʻuaʻu) is 92 percent per year for post-fledgling and adult age-classes (Ages 2 years and older). Because this survival rate has not been measured directly, it is based on values from a different species, Manx shearwater, in the North Atlantic. In the stable trend scenario, this natural survival rate is not fixed *a priori* at a point value based on a proxy species, but treated as an estimable model parameter (resulting estimated survival rate of 96 percent per year). The estimated survival rate is what is needed to match estimates of powerline collisions and a stable trend in the areas surveyed by radar.

  Fledgling natural survival (Age 1) also differs between the two scenarios. In the worse-case trend scenario, fledgling natural survival is assumed *a priori* to be 37 percent per year, compared to the estimated value of 53 percent in the stable trend scenario. The higher fledgling natural survival in the stable trend scenario is also necessary to ensure that modeled population dynamics are consistent with both the estimated level of unminimized powerline collisions (while also matching the 80:20 subadult:adult collision ratio) and a stable trend in the areas surveyed by radar. Both of these adjustments in vital rates produce a difference in the maximum population growth rate, as described below.

- **Maximum rate of growth**. In the worse-case trend scenario, the theoretical maximum rate of growth of Hawaiian petrel (ʻuaʻu) is 3.0 percent per year. This value represents the most that any subpopulation can grow without predation by invasive species, powerline collisions, or light attraction (i.e., without anthropogenic threats) in a given year. In the stable trend scenario, the theoretical maximum rate of growth of the species increases to 8.0 percent as a function of the higher estimated natural survival rates summarized above. This increase in the theoretical maximum growth rate is necessary to fit the model to an initial stable trend in the areas surveyed by radar, given available estimates of anthropogenic mortality levels in those areas.

5E.2 Inputs for the Worse-Case Trend Scenario

This section describes the model inputs used in the worse-case trend population dynamics model scenario. Model inputs[4] for the stable trend population dynamics model scenario are mostly the

[3] "Natural" refers to vital rates in the absence of anthropogenic mortality.

[4] Model inputs are also called "parameters" if the values (e.g., survival rates) are statistically estimated from independent data that is integrated in the model.

same as for the worse-case trend scenario. Different model inputs for each scenario, and the rationale for those differences in the stable trend scenario are described in Attachment 5E-1, *Hawaiian Petrel (ʻuaʻu) Population Dynamics Model Fit to the Stable 2010–2022 Radar Trend under KIUC's Proposed Habitat Conservation Plan*. In addition to Attachment 5E-1, a comparison between the assumptions under each trend scenario can be found in Table 5-1 in Chapter 5, *Effects*.

5E.2.1 Initial Conditions

The initial conditions for the model were set in 2019, before projections forward in time from that year were carried out. Modeled reductions in powerline line mortality rates due to minimization efforts that are accounted for in the model start in 2020. Population trajectories for Hawaiian petrel (ʻuaʻu) were based on the following parameter categories, each of which is described below:

1. Estimates of **abundance** on Kauaʻi.
2. **Vital rates** by age class under optimal conditions (i.e., natural mortality rates in the absence of introduced predators, light fallout, and powerline collisions).
3. Estimates of **powerline injury and mortality**, prior to 2020 minimization efforts.
4. Estimates of **predation rates** with and without predator control measures.
5. For the Hanalei to Kekaha area and the Waimea Canyon area, the modeled abundance was initialized based on **trends from the long-term radar survey**, in combination with estimates of powerline injury and mortality, prior to 2020 minimization efforts.

5E.2.1.1 Estimates of Abundance on Kauaʻi

All population dynamics models must begin with an estimate of initial population size to forecast future abundance levels. Published estimates of abundance for Hawaiian petrel (ʻuaʻu) are available from transect surveys conducted on ships at sea (Spear et al. 1995; Joyce 2016). Because of the use of these estimates in previous studies for listed seabirds on Kauaʻi, the at-sea population estimates and their limitations are summarized below. This summary is followed by an explanation of the methods used for this HCP to develop a spatially explicit metapopulation abundance estimate of Hawaiian petrel (ʻuaʻu) on Kauaʻi. The estimates used in the HCP are based on the best and most current data available and were derived from multiple monitoring surveys specifically for this purpose.

At-Sea Abundance Estimates

Seabird populations are often estimated using counts of birds observed at sea and calculations of what proportion of the total population may have been sampled. This technique is used because (1) a substantial fraction of seabirds remain at sea prior to reaching breeding age (e.g., counts are representative of total abundance across all age classes, rather than just breeding age individuals), and (2) at-sea surveys can enumerate populations which may have breeding colonies spread over different islands or geographic locations, and which can otherwise be difficult to locate and count on land during the breeding season. This is the case for Hawaiian petrel (ʻuaʻu)—nesting adults are nocturnal, and nests are located underground in densely vegetated and rugged, remote montane environments.

At-sea estimates were not adopted for the HCP seabird population dynamics model because they include serious spatial deficiencies in geographical survey coverage. For example, during the breeding season adult Hawaiian petrel (ʻuaʻu) are known to forage in the North Pacific (e.g., Adams and Flora 2010), outside the survey areas included in the at-sea abundance estimates, leading to uncorrected sources of statistical bias. Further, at-sea estimates alone, even if they could be corrected for these biases, provide only a single population estimate. That single estimate would need to be split into the proportion of the at-sea population of Hawaiian petrel (ʻuaʻu) that are associated with breeding colonies on Kauaʻi, and then further subdivided for different areas (e.g., the conservation sites) on Kauaʻi, given the spatial complexities that are relevant to conservation and management. In other words, what proportion of the at-sea estimates of abundance represents those birds associated with the conservation sites? Such assumptions would have a high degree of uncertainty, so it is preferable to use available survey data from the conservation sites themselves. Survey data at the conservation sites provide a more current and defensible estimate of covered seabird abundance than older at-sea estimates.

For all of these reasons we chose not to utilize at-sea population estimates. Instead, the population estimates used to initialize the model are based on different Kauaʻi-specific data sets, as described below.

Breeding Pair Population Estimates on Kauaʻi

Given the limitations of the at-sea abundance estimates, which miss a significant (but as of yet unquantified) proportion of the island's breeding population—as well as the fact that breeding colonies in different areas of Kauaʻi are not uniformly vulnerable to threats such as introduced predators, light fallout, or powerline strike mortalities —staff at ARC developed spatially explicit estimates of Hawaiian petrel (ʻuaʻu) breeding pair abundance on Kauaʻi for this HCP.

These estimates were adopted as the basis for calculating the initial model population size in the HCP population dynamics model. They also allow for a modeling approach that can help to address the fundamental question of whether localized conservation efforts (e.g., predator control, predator-proof fencing, or social attraction sites) in targeted breeding areas on Kauaʻi can result in a sufficient net benefit to offset future minimized powerline strike mortalities for the island-wide population (i.e., metapopulation) on Kauaʻi. An important innovation of the HCP population dynamics model is that it considers important spatial differences in mortality risk in different areas of Kauaʻi, as discussed below.

Breeding pair abundance in 2021 was estimated for each of the modeled subpopulations (Table 5E-2, Figure 5E-1). The approach used to estimate the number of breeding pairs differed between areas, dictated in part by the extent to which various data sources are available (or lacking) for each area. In general, however, the breeding pair estimates developed by ARC are informed by acoustic call rate and nesting burrow monitoring studies, which have demonstrated a significant relationship between call rates and estimated densities of active nesting burrows (e.g., Raine et al. 2019). These acoustic call rates are used in combination with published habitat suitability models (Troy et al. 2014, 2017). To the extent possible, the most recently analyzed study data from 2021 have been used to inform the resulting breeding pair estimates.

For the single modeled area of Kauaʻi that has the highest level of powerline collisions (Hanalei to Kekaha; Travers et al. 2020), preliminary model results indicated that ARC's estimates of breeding pairs for this area was, in combination with the biological assumptions in the model, incompatible with the observed trends from the radar survey and the level of mortality from the average annual unminimized strike estimate during 2013–2019. In other words, preliminary model results for the Hanalei to Kekaha area, when based on ARC's breeding pair estimates and the low modeled maximum population growth rate (i.e., resiliency), produced modeled subpopulation trends from unminimized powerline strike mortality rates that were much more negative (i.e., much greater recent declines) than any trends estimated from the radar survey since that systematic survey began collecting data in 1993.

Therefore, an alternative approach was used to calculate the breeding pair abundance necessary to sustain the rate of decline observed in the radar data (Raine et al. 2017b; Raine and Rossiter 2020), given the estimated average annual number of unminimized powerline collisions during 2013–2019 for these two areas (Travers et al. 2020). This approach to initialize the breeding pair abundance in the model for the Hanalei to Kekaha area is described in more detail under the area-specific descriptions of breeding pair abundance estimation process and background considerations for each modeled subpopulation below. Using estimated trends from radar data to initialize the model also integrates the effects of powerline collisions and light fallout prior to the HCP, to the extent available data allow, because the trend estimate is based on radar survey data starting in 1993.

Table 5E-2 provides a summary of the approach used for each modeled subpopulation as well as a relative comparison of mortality sources (the differences in mortality help explain why individual subpopulations were modeled) and uncertainty in the estimate of abundance. Where certainty in abundance was "moderate" and habitat suitability modeled was used (i.e., Kalalau east to Upper Mānoa), nesting densities were extrapolated from other areas with available data and expert opinion was used to derive density correction factors to account for lower expected nest densities in areas with higher levels of mortality (i.e., due to unmanaged predation outside the conservation sites).

Table 5E-2. Summary of Approach to Initial Population Estimate, Relative Mortality Levels by Source, and Data Availability by Modeled Subpopulation for Hawaiian Petrel (ʻuaʻu)

Modeled Subpopulation	Data Sources Used for Initial Population Estimate	Relative Population-Level Mortality by Source			Certainty in Abundance Estimate
		Powerlines	Light Attraction	Predation	
Existing Conservation Sites (6)[a]	Habitat suitability model and auditory survey polygons (based on annual surveys)	Low	Low	Low	High
Wainiha and Lumahaʻi Valleys	Habitat suitability model and auditory survey polygons	Low	Low	Moderate	Moderate
Kalalau east to Upper Mānoa	Habitat suitability model and cover ratios[b] calculated from auditory survey polygons in Wainiha & Lumahaʻi	Low	Low	Moderate	Moderate
Hanalei to Kekaha	Radar trend and powerline strike estimate	**High**	Moderate	**High**	Low

[a] See Table 5E-1 for a list of all conservation sites.
[b] Cover ratios were used to extrapolate the fraction of suitable habitat used by nesting seabirds detected through acoustic surveys to areas without available acoustic survey data, before applying density correction factors to

account for lower nesting densities in areas that have been more greatly impacted by powerline strike, light attraction, and predation mortalities (Raine et al. 2019).

Hanalei to Kekaha

This largest area of Kauaʻi is the most affected by powerline collisions, light attraction, and predation (e.g., Troy et al. 2017; Figure 5E-1). It is also the area of the island for which trends in relative abundance have been estimated through the long-term systematic radar survey since 1993 (e.g., Day and Cooper 1995; Raine et al. 2017b). Thirteen radar sites have been surveyed since 1993 in the Hanalei to Kekaha area. Two additional radar sites have also been surveyed in Wainiha and Lumahaʻi Valleys starting in 2006, where trends have been stable (Raine and Rossiter 2020; see below for details).

The radar survey on Kauaʻi represents the longest systematic monitoring study of trends in abundance for this species. Raine et al. (2017a) estimated the average rate of decline in Newell's shearwater (ʻaʻo) abundance, between 1993 and 2013, across all radar sites in the Hanalei to Kekaha area at approximately -6 percent per year. Since that study, Raine and Rossiter (2020) present the most recent estimates for the long-term subpopulation trend for this area. When averaged across all radar sites in this area, the more recent estimate of the average annual rate of decline is -4.7 percent per year during 1993–2020. During those three decades, the most extreme rate of decline for any of the 13 individual radar sites in this area has been estimated at the Waiakalua Stream site. The trend in relative abundance from that radar site is -8.1 percent per year during 1993–2020.

As noted above, the total breeding pair estimates developed by ARC for Hanalei to Kekaha were found through preliminary modeling results to be incompatible with the estimated number of powerline collisions, associated mortalities, and the most negative trend estimated from radar survey data. Given the biological assumptions in the model, this combination of factors, as initially explored (i.e., relatively small abundance relative to the magnitude of powerline collision mortalities for a species with low maximum rates of modeled population growth) led to modeled rates of decline that were much greater than any trends that have been observed through the radar surveys in this area, or elsewhere.

To correct this inconsistency, an alternative approach to initializing abundance for the Hanalei to Kekaha area was developed so the model would match both the magnitude of powerline collisions estimated from acoustic monitoring and trends in abundance estimated from the long-term systematic radar surveys.

The initialization approach for Hanalei to Kekaha involved solving for the combination of (1) abundance at age, and (2) the subadult and adult powerline mortality rates that result in the estimated number of collision mortalities, while matching the -8.1 percent rate of decline estimated from the radar survey at the Waiakalua Stream radar site (a worst-case recent trend) and the assumed proportions of powerline collisions that are subadults and adults. The solutions for abundance and powerline mortality rates at age were found using non-linear numerical optimization (a penalized maximum likelihood approach) as implemented in the Stan programming language using the *cmdstanr* package (Stan Development Team 2022; Gabry and Češnovar 2022). The specific penalties used to fit the model were as follows.

1. The Bayes acoustic estimate of powerline strikes was assumed to follow a log-normal distribution with a mean in log-space corresponding to the strike allocation for this area (described below), and a coefficient of variation assumed to be 0.01, which ensures the resulting modeled number of strikes matches the mean of the reported estimate.

2. The trend from the radar data was modeled as a normally distributed random variable with a standard error of 0.01, which again ensured the resulting modeled trend matched the point estimate for the rate of decline.
3. The proportion of powerline collisions that were subadult was assumed to follow a Beta (11, 3) probability distribution, which corresponds to the sample of 14 downed Newell's shearwaters (ʻaʻo) examined by Cooper and Day (1998), with 11 of those birds categorized as subadults and 3 as adults, i.e., the expected proportional age-class split for Hawaiian petrel (ʻuaʻu) was assumed to be the same as estimated for Newell's shearwater (ʻaʻo) and was 79 percent subadult and 21 percent adult.

The estimate of powerline collisions is an annual average during 1993–2019. It was assumed that this estimate pertained to 2016, the midpoint year of the acoustic monitoring data analyzed by Travers et al. (2020). In an analogous example, this approach is to the same as solving a problem where one wants to calculate the amount of money in a stock market account one year earlier. If one knows the rate of decline in the market from one year to the next was -10 percent, and the account lost $10 last year, there must have been $100 in the account before the loss.

The resulting abundance at age from this approach was then projected forward from 2016, under the assumption of a stable age distribution at the -8.1 percent rate of decline, through 2019, after which time the initial unminimized powerline mortality rates at age were reduced each year according to the modeled minimization schedule under the HCP.

Estimates for the number of annual powerline collisions are not available prior to 2013. However, incorporating estimated trends from radar data to initialize the model integrates the effects of powerline collisions and other sources of mortality prior to 2013, to the extent available data allow, because the radar trend is based on observations starting in 1993.

Upper Limahuli Preserve, Pihea, North Bog, Pōhākea, Hanakāpiʻai, and Hanakoa

These conservation sites have the highest level of management (mainly predator control) and are in northwest Kauaʻi away from most powerlines and light sources (Figure 5E-1). The Upper Limahuli Preserve and North Bog conservation sites are close to the towns of Hāʻena and Wainiha and thus closer to powerlines and light sources. There is one streetlight at Hāʻena Beach Park that is approximately 0.4 mile (mi) (0.64 kilometer [km]) north of the Upper Limahuli Preserve; however, all lights and powerlines are over 1 mi (1.6 km) to the east. The remaining four conservation sites, which are in the Hono O Nā Pali Natural Area Reserve, are west of the Upper Limahuli Preserve and North Bog conservation sites, and thus are over 3 mi (4.8 km) from the nearest powerlines or light sources to the east.

The covered seabirds in this area are expected to be affected the least of any area by all stressors (Table 5E-2). This area also has the best available data (e.g., annual auditory surveys, extensive burrow searches) for abundance estimates based on annual monitoring surveys (e.g., Raine et al. 2022). Breeding pair estimates have been conducted on an individual basis for the conservation sites and have been presented previously in annual ARC monitoring reports (e.g., Archipelago Research and Conservation 2021; Raine et al. 2022).

In 2017, the first population estimates were produced for all monitored conservation sites using two independent methods: a habitat suitability model, which utilized the peer-reviewed models presented in Troy et al. (2014, 2017) where suitable habitat ranked 7+ and an average nearest-neighbor distance was used from known burrows at monitored colonies to model density, and a regression analysis of acoustic monitoring data, which provides an estimate of active burrows (i.e., breeding pairs) as a function of call detections, given previous studies comparing paired visual and acoustic data in the same nesting areas. Based on the outputs of the two models, it was decided that the habitat suitability model was the most appropriate way of providing population estimates and that the acoustic method would need to be further refined before it could be used for this metric (see Raine et al. 2019). For these sites, habitat suitability modeling (Troy et al. 2014, 2017) is also employed for portions of the conservation sites outside the acoustic arrays, using the estimated nearest neighbor distances between active burrows (i.e., burrow densities) to predict breeding pair numbers outside the acoustic array footprint.

The habitat suitability model was updated in 2021 by including (i) new polygons from auditory surveys undertaken in 2021 and (ii) total surface area to take into account vertical space such as drainages and cliff walls. Two population estimates were then created for each site: (i) a low population estimate using only polygons related to "hot spot heavy" or "ground calling activity" and (ii) a high population estimate using *all polygons* collected during auditory surveys. In areas where suitable nesting habitat overlapped between Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu), i.e., where the habitat is suitable for nesting for either species, the habitat was partitioned between species to prevent double counting of available nesting habitat.

The breeding pair abundance in 2021 in the population dynamics model is equal to the lower of the two estimated values for all areas except for Hanalei to Kekaha, where the approach to estimating initial modeled abundance is described in the respective area description.

Kalalau East to Upper Mānoa

This area is in the northwest of Kauaʻi away from most powerlines and light attraction issues. However, this area is unmanaged and thus more heavily affected by predators than adjacent conservation sites. Like Hanalei to Kekaha, the Troy et al. (2014, 2017) habitat suitability model was used to estimate breeding pairs in this area, but only included suitable habitat with the highest probability of nesting occurrence (i.e., suitable habitat with less than the highest ranking was assumed to contain zero breeding pairs). The modeled suitable habitat was also further reduced by an elevation cutoff, such that suitable habitat below 1,922 feet (585.9 meters) above sea level for Hawaiian petrel (ʻuaʻu) was assumed to contain zero breeding pairs. This altitude represents the lowest height above sea level that an active nest has been detected during burrow monitoring studies in the conservation sites. The Kalalau east to Upper Mānoa area is largely unsurveyed, and therefore the estimated densities of active nests from Lumahaʻi Valley were used with the nearest neighbor distance from the conservation sites multiplied by 1.5, to account for active nests being more dispersed in this unmanaged area due to a lack of predator control measures.

Wainiha and Lumahaʻi Valleys

This area encompasses two of the largest valleys on Kauaʻi with Hawaiian petrel (ʻuaʻu). While affected to some degree by powerlines and light attraction, radar data has shown no trend since monitoring began in 2006 (e.g., Raine and Rossiter 2020) and tracking data shows that birds transiting over this area are predominantly higher than powerlines (Raine et al. 2017a). There is no predator management in this area, but in order to match the stable radar trend since 2006, it was assumed that predation rates were 25 percent of those in other unmanaged areas (i.e., that birds in these valleys have been confined to very steep and less accessible habitat and have reduced predation rates).

Auditory surveys were conducted in portions of Lumahaʻi Valley in 2020, and the corresponding call rate data was combined with survey data in both valleys in 2012–2014 and used after filtering out any call rates that did not meet the “heavy” and “ground calling” criteria (e.g., Raine et al. 2020), which excluded any breeding pairs associated with low-density nesting areas. Like other areas, habitat suitability modeling was also incorporated, and the breeding pair estimate for Wainiha and Lumahaʻi Valleys only included suitable habitat ranked at 8+ (i.e., suitable habitat ranked lower than 8 was assumed to contain zero breeding pairs). For areas within each valley that were not surveyed a cover ratio was applied. This was created by considering all areas within each site where auditory surveys were undertaken, drawing a. 0.6-mi (1-km) radius around each survey point, and creating a cover ratio within that survey radius of seabird activity polygons (heavy and ground calling) to suitable habitat. The cover ratio was then extrapolated to unsurveyed areas. The modeled suitable habitat was also further reduced by an elevation cutoff, such that suitable habitat below 1,922 feet (585.9 meters) above sea level for Hawaiian petrel (ʻuaʻu) was assumed to contain zero breeding pairs. This altitude represents the lowest height above sea level that an active nest has been detected during burrow monitoring studies in the conservation sites. The estimated densities of active nests were multiplied by 1.5, which reduced the breeding pair estimate, to account for active nests being more dispersed in unmanaged areas.

Table 5E-3. Abundance Estimates of Hawaiian Petrel (ʻuaʻu) on Kauaʻi in 2020 by Subpopulation and Age Class (males and females combined). Abundance estimates for the Waimea and the Hanalei to Kekaha subpopulations are shown for the worse-case trend scenario. Abundance estimates for those subpopulations under the stable trend scenario are presented in Attachment 5E-1.

Subpopulation (see Figure 5E-1 for locations)	2021 Breeding Adults (ages 6+)[a]	2021 Subadults (ages 1–5)[b]	2021 Total Abundance (ages 1+)	Fraction of Total Powerline Strikes[c]	2016 Powerline Mortalities (all ages) per 100 breeding adults
Pihea	1,291	736	2,027	0.005	0.5
North Bog	1,759	1,002	2,761	0.020	1.5
Pōhākea	321	183	504	0.002	1.0
Hanakāpiʻai	578	330	908	0.004	1.0
Hanakoa	342	195	536	0.001	0.5
Upper Limahuli Preserve	224	127	351	0.003	2.5
Wainiha and Lumahaʻi Valleys	2,383	1,358	3,741	0.027	1.5
Hanalei to Kekaha	9,215	5,635	14,850	0.925	13.7
Kalalau east to Upper Mānoa (excluding conservation sites)	1,361	775	2,136	0.015	1.5
Total Kauaʻi abundance	**17,474**	**10,341**	**27,814**		

[a] Values for breeding adults correspond with the minimum theoretical estimate of abundance based on several alternative data sources, methods for estimation, and expert opinion (e.g., Raine et al. 2019, 2022). Estimates for all conservation sites with established subpopulations (first 3 rows) were derived from 2021 burrow monitoring data. Estimates of unmanaged subpopulations (last 3 rows) are derived from the habitat suitability analysis of Troy et al. (2017) restricted to 1,922 feet (585.6 meters) above sea level and above (the lowest elevation in managed colonies with a known burrow) correcting for the more dispersed nature of unmanaged colonies as compared to managed colonies.

[b] Except for the Hanalei to Kekaha area, the initial number of subadults was derived under the assumption that subadults comprise 36.3 percent of the age 1+ (non-chick) component of the population (Ainley et al. 2001).
[c] The powerline strike allocation is based on the percentage of acoustically detected strikes that have been analyzed to estimate strike numbers (Travers et al. 2020). The empirical strike percentages are: 89.1 percent of strikes in the Hanalei to Kekaha area, 10.8 percent of strikes in the Waimea area, and 0.1 percent of strikes from the Wainiha and Lumahaʻi Valleys area (Travers et al. 2020; Travers, unpublished data). The modeled allocation differs slightly from these values to account for a percentage of strikes that are seabirds associated with different breeding colonies transiting across powerlines in other areas (e.g., to account for breeding adults at the conservation sites having some vulnerability to colliding with powerlines).

5E.2.1.2 Vital Rates under Optimal Conditions

A critical set of assumptions used in the KIUC HCP population dynamics model relate to the vital rates of the target species. *Vital rates* for any population dynamics model dictate population trajectories in the absence of any external factors, also referred to here as *optimal conditions*. Estimated reductions in vital rates relative to optimal conditions[5] allow for the modeling of expected impacts on population dynamics from combined threats (e.g., mortalities due to introduced predators, powerline collisions, and light attraction). Likewise, the estimated effects of conservation measures on vital rates allow for the modeling of expected benefits of mitigation and minimization measures. Vital rates for this model include the following.

- Survival from one age class to the next age class
- Age at first reproduction (also termed the “adult” age)
- Annual breeding probability for adults (expressed as a fraction of adult birds that breed each year)
- Reproductive success rate (i.e., the fraction of eggs laid by adults that survive to emerge from the nest as fledglings)

During the last decade, burrow monitoring and other studies have led to a substantial increase in available species-specific estimates of endangered seabird vital rates on Kauaʻi (e.g., Archipelago Research and Conservation 2021; Raine et al. 2022). Likewise, advances in powerline monitoring methods have resulted in estimates of powerline strike numbers, resulting mortalities, and locations (e.g., Travers et al. 2020, 2021). In addition to recent estimates of vital rates related to reproduction and recruitment from burrow monitoring studies, acoustic monitoring of call rates and satellite tagging studies also provide information on trends in abundance and relative vulnerability to powerline collisions for breeding colonies in conservation sites in northwestern Kauaʻi. These newly available estimates serve to inform the biological assumptions of the KIUC HCP population dynamics model.

However, even with the improved estimates of vital rates and additional information on trends in abundance that recent monitoring efforts provide, there remains a high level of uncertainty for many of the biological assumptions that are input parameters for the population dynamics model. For example, the most recently reported estimate of the number of seabird powerline strikes from the Bayesian analysis of acoustic strike monitoring data collected between 2013 and 2019 has a 95 percent posterior predictive probability interval of 4,417–56,903 strikes per year (Travers et al. 2020). Moreover, in some instances, the parameter values adopted for this set of biological assumptions may be based wholly, or in part, upon expert opinion, and therefore confidence

[5] Also called vital rates under “natural conditions” in other parts of this appendix and in Chapter 5, *Effects*. The terms are equivalent for the purposes of the HCP.

intervals cannot be calculated. Despite these limitations, the biological assumptions described here represent the best available scientific data, which is the regulatory standard for HCPs under the federal Endangered Species Act and Hawai'i Endangered Species Act.

The optimal rate of population growth is related to (but might be less than) the intrinsic rate of growth of the population, which is the maximum expected exponential growth rate that populations can achieve in the absence of density dependent competition for resources and decreases in vital rates through anthropogenic effects and nonnative predators (e.g., Caughley 1977). The optimal rate of population growth is a key parameter in conservation risk assessments and management strategy evaluations (e.g., Niel and Leberton 2005). However, the optimal population growth rate is also a difficult parameter to estimate, especially for species without long-term surveys of abundance to monitor the rate of recovery from low population levels. At present, no empirical estimate exists for the optimal rate of population growth for Hawaiian petrel ('ua'u).

Given the biological assumptions for the vital rates of this model, the resulting optimal rate of modeled population growth (i.e., in the absence of introduced predators, powerline strike or light fallout mortality) is 2.0 percent per year. This is similar to the optimal rate of population growth modeled by Griesemer and Holmes (2011:30) for Newell's shearwater ('a'o), which was 2.3 percent per year.

In practice, however, the optimal rate of population growth is never achieved in the KIUC model, because even for those sites with predator-proof fences, birds are still assumed to be vulnerable to powerline strike mortalities (albeit at relatively low levels) and aerial predation by introduced barn owls. The highest rate of population growth achieved in the model is at the Pihea and Hanakoa conservation sites. These sites have a relatively low powerline strike mortality rate in the model (0.5 unminimized powerline mortalities per 100 breeding adults), due to their remote geographic location. The underlying modeled population growth rate reaches 1.1 percent per year at Pihea and Hanakoa.

The optimal rate of population growth in a population dynamics model is a function of the optimal input values for the vital rates. All else being equal, higher optimal input values for survival or reproductive rates (or lower age at reproduction) result in higher values of optimal population growth rates and vice versa (e.g., Caswell 2001). The biological assumptions for the individual component life history values in the model are as follows.

Fledgling Survival Rates

Fledgling (age 1) survival rates and subsequent survival rates to breeding age are not available from empirical data. Instead, the modeled Hawaiian petrel ('ua'u) survival rates were assumed to be equal to those employed for Newell's shearwater ('a'o; Appendix 5D, *Population Dynamics Model for Newell's Shearwater ('a'o) on Kaua'i*). These rates were derived from the satellite tagging study reported by Raine et al. (2020). In that study, 12 Newell's shearwater ('a'o) fledglings were tracked at sea. From the tag signals it was possible to estimate if a fledgling had died at sea (i.e., the tag stopped reporting movements in a manner that indicated it had not simply fallen off). Based on the observations of tagged fledglings, only 25 percent of tagged fledglings survived their first month at sea, suggesting that this percentage (or lower) would reach breeding age (Raine et al. 2020). This low level of fledgling survival was also assumed for Hawaiian petrel ('ua'u); the fledgling survival rate assumed in the model was set such that, in combination with the assumed subadult survival rate, 25 percent of fledglings in the model (under near-optimal conditions) would reach breeding age. Combined with the subadult survival rates at age described below, this assumption yields a fledgling survival rate of 0.371 (i.e., survival from age 1 to age 2). Accounting for fallout from light attraction further reduces the fledgling survival rate in the Hanalei to Kekaha area of the model (see Section 5E.4.1.1, *Conservative Assumptions*). The estimated level of fallout includes correction factors for the proportion of grounded seabirds that go undetected, e.g., for KIUC streetlights, 89.6 percent of grounded Hawaiian petrel (ʻuaʻu) are assumed to go undetected (Appendix 5B, *Light Attraction Modeling for Covered Seabirds*). Fallout, whether detected or not, is assumed to result in 100 percent mortality in the model.

Subadult and Adult Survival Rates

There are no available empirical estimates of adult survival rates for Hawaiian petrel (ʻuaʻu). Instead, adult survival rates were based on multiple studies undertaken on the similar Manx shearwater (Harris 1966; Perrins et al. 1973; Brooke 1977) and were set to 0.924. Subadult survival rates (ages 2–5 years) were set equal to the adult survival rate, which is consistent with a life history punctuated by very high first year at-sea mortality rates for fledglings, followed by relatively low natural mortality rates for subadults and adults. The exact values for subadult survival rates at age are uncertain, in part because subadults may spend several years at sea, making conventional approaches for estimating survival rates, like mark-recapture, impracticable. The values for subadult survival rates at age assumed in the model are consistent with the Raine et al. (2020) satellite tagging study on Kauaʻi for Newell's shearwater (ʻaʻo), described above in *Fledgling Survival Rates* and result in 25 percent of modeled fledglings reaching breeding age (age 6) under near-optimal conditions.

Age at First Breeding

The age at first breeding was assumed to occur at 6 years, following the common assumption for Newell's shearwater (ʻaʻo) and the similarity between demographic traits for these two seabird species.

Reproductive Success Rate

The reproductive success rate (RS) in the model measures the fraction of eggs that develop into a chick that survives to fledge. This is consistent with how RS rates have been defined in the burrow monitoring study data. RS rates have been estimated from burrow monitoring studies at the conservation sites, both before (RS = 0.413) and after (RS = 0.787) dedicated predator mitigation measures. The RS rate at the conservation sites is taken from a 3-year average value estimated across sites during 2019–2021 (e.g., Archipelago Research and Conservation 2021; Raine et al. 2022). For areas in the model without predator mitigation, the RS rate is assumed to be equal to that estimated at the conservation sites prior to dedicated mitigation measures. An adjustment was made for the Wainiha and Lumahaʻi Valleys area, given that the radar trend for this area has been stable (neither increasing or decreasing) since monitoring began in 2006, which in combination with the assumed low population growth rate and relatively low vulnerability to powerline strikes, suggests that predation mortality rates in this area are 25 percent of those in estimated at the conservation sites prior to dedicated predator control measures (see also *Predation Rates*). It was also assumed that the RS rate in the Wainiha and Lumahaʻi Valleys area is 25 percent greater than in other unmanaged areas (RS = 0.516).

The RS rates in areas with predator-proof fences were based on the estimated RS rates at the conservation sites following dedicated predator mitigation, with an upward percentage adjustment corresponding to observed predation rates on nests without predator-proof fences, which were 0.0023 for adults and 0.02 for chicks (Raine et al. 2022; Raine unpublished data). This resulted in a modeled RS rate inside predator-proof fences of 0.872 * (1 + 0.0023 + 0.02) = 0.805, or a 2.23 percent increase compared to the estimated RS rate from burrow monitoring studies at the conservation sites.

An additional area-specific adjustment was made to the RS values to account for powerline collisions that result in injury but not mortality and might cause breeding individuals to be unable to fledge a chick successfully (e.g., due to an inability to forage effectively that season). Following the observations of Travers et al. (2021), 24.5 percent of powerline collisions were assumed to result in nonlethal injury. These were individuals with post-collision elevation loss that were not assigned to immediate grounding mortality or short-term grounding mortality (within 3,609 feet [1,100 meters] of wires). The observed elevation loss of these birds not assigned as grounded/mortality, was used as a proxy for injury. That is, the elevation loss indicates the collision was more severe or affected the bird more than those that flew off without elevation loss.

Future powerline collision levels, and their non-lethal effects, were derived from the powerline mortality rate calculations described below, under the assumption that mortalities were 28.8 percent of all collisions. The derived number of collisions was then multiplied by 24.5 percent to calculate the associated number of collisions resulting in non-lethal injuries. This number was multiplied by 21.4 percent to account for the proportion of collisions that are expected to be breeding adults (Cooper and Day 1998). And the resulting number of collisions resulting in non-lethal injuries of breeding age birds was divided by the number of breeding birds in an area each year, and used as a percentage reduction in reproductive success rate in that area that year.

Breeding Probability

Breeding probability is the percentage of adults (age 6 or older) that breed each year. This probability has been estimated through long-term studies of active breeders at the conservation sites and is 0.982 for Hawaiian petrel ('ua'u) (Raine et al. 2022). The breeding probability value is assumed to be constant across all geographic areas and through time in the model.

5E.2.1.3 Powerline Mortality

The powerline mortality rate for each area *I* with no minimization was calculated for subadults and adults by dividing the proportion of unminimized powerline mortalities for each age class by the corresponding estimate of abundance for that area:

$$\psi_{a,i}^{sa} = \frac{p_i \Omega \rho \nu \pi_{sa}}{\sum_{a=3}^{5} \hat{N}_{a,i}^{sa}}$$

(Equation 1)

$$\psi_{6+,i} = \frac{p_i \Omega \rho \nu (1 - \pi_{sa})}{\hat{N}_{6+,i}}$$

Where:

- $\psi^{sa}_{a,i}$ and $\psi_{6+,i}$ are the annual powerline mortality rates for subadults, ages 3–5 years, and adults (ages 6 years and older, denoted as age "6+"; Figure 5E-2) in area *i* prior to any minimization (i.e., unminimized). In the context of powerline strikes, subadults refer to ages 3–5 years because ages 1 and 2 are assumed to be at sea and are not vulnerable to powerline strikes in the model (Equation 3). The powerline mortality rates are assumed to be equal for subadults of each vulnerable age.
- p_i is the modeled fraction of total powerline strikes for each species that are associated with birds from area *i* in 2016 (see Table 5E-2 for list of areas).
- Ω is the estimated number of seabird powerline strikes in 2016 (Hawaiian petrels [ʻuaʻu] and Newell's shearwater [ʻaʻo] combined).
- ρ is the proportion of total strikes that are Hawaiian petrel (ʻuaʻu; Travers et al. 2021).
- ν is the total grounding rate (i.e., the proportion of strikes that result in mortality; Travers et al. 2021).
- π_{sa} is the proportion of powerline strikes that are subadults.
- $\widehat{N}^{sa}_{a,i}$ is the number of subadults at age (ages 3–5 years) and $\widehat{N}_{6+,i}$ is the number of adults in 2019, which when projected forward in the model 1 year, equal the island-based estimates from 2021 (see Table 5E-3). The initial age structure in the model, for those areas outside Hanalei to Kekaha, assumes that 63.7 percent of the population is composed of breeding adults (the remaining 36.3 percent are assumed to be ages 1–5), following Ainley et al. (2001).

Table 5E-4 shows the assumed values for most of the variables above. The text below the table explains the rationale for these variables.

Table 5E-4. Powerline Strike Assumptions for the Population Dynamics Model

Powerline Strike Variable	Model Variable	Assumed Value
2016 Annual powerline strikes of Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) combined, before minimization (i.e., average annual unminimized strike estimate during 2013–2019)	Ω	15,853[a]
Total grounding rate	ν	0.288[b]
Proportion of strikes that are Hawaiian petrel (ʻuaʻu)	ρ	0.30[c]
2016 annual estimated mortalities of Hawaiian petrel (ʻuaʻu)	calculation	1,370[d]
Proportion of powerline strikes that are subadults	π_{sa}	0.79[e]

[a] Total number of estimated seabird powerline strikes of Newell's shearwater (ʻaʻo) and Hawaiian petrels (ʻuaʻu) combined. Estimate excludes waterbird strikes and strikes minimized during the Short-Term HCP. Based on 2013–2019 acoustic data and the Bayesian estimate model described in Travers et al. (2020).
[b] The total grounding rate includes 13 percent immediately grounded, 10.2 percent unknown outcome, and 5.6 percent of birds that strike powerlines having been observed with the most severe of post-flight behaviors and that are hence assumed to have eventually died (Travers et al. 2021).
[c] Travers et al. 2021
[d] Mortalities are calculated as the proportion of unminimized seabird strikes for each species, multiplied by the total grounding rate.
[e] See text for additional explanation. Assumes Hawaiian petrel (ʻuaʻu) vulnerability at age to powerline strikes is the same as that of Newell's shearwater (ʻaʻo), i.e., follows the sampling distribution of 11 out of 14 downed birds categorized as subadults by Cooper and Day (1998).

Powerline Strike Allocation by Subpopulation

The powerline strike allocation by subpopulation is based on the percentage of acoustically detected strikes that have been analyzed to estimate strike totals across the island (Travers et al. 2020). The empirical distribution of seabird strikes during 2013–2019 was: 89.1 percent of strikes in the Hanalei to Kekaha area, 10.8 percent of strikes in the Waimea Canyon area, and 0.1 percent of strikes from the Wainiha and Lumaha'i Valleys area (Travers et al. 2020; Travers unpublished data). Some variance from the empirical acoustic detections was incorporated in the modeled allocation because, for example, Hawaiian petrel ('ua'u) are not assumed to occur in the modeled Waimea area, and likewise approximately 5 percent of strikes were assumed to result from collisions by individuals from breeding colonies in the remote northwestern areas. This allowed the model to incorporate a low level of powerline collision vulnerability for individuals associated with the conservation sites and surrounding areas, which is consistent with observations from tagging studies (Raine et al. 2017a). In general, the spatial differences that have been observed through acoustic powerline collision monitoring data served as a key motivating factor for developing a spatially explicit population dynamics modeling framework.

Powerline Strike Allocation by Species

As described in Chapter 5, *Effects*, estimates of powerline strikes of the covered seabirds are derived from acoustic data on strikes for all seabirds combined. Acoustic data cannot be separated by species. Instead, we must assume of the proportion of strikes allocated to either Newell's shearwater ('a'o) or Hawaiian petrel ('ua'u). Travers et al. (2021) has reported that powerline collisions directly observed in the field occur in a proportion of 70.5 percent Newell's shearwater ('a'o) to 29.5 percent Hawaiian petrel ('ua'u). The modeling assumption corresponds to these proportions, with 70 percent of all estimated strikes assumed to be Newell's shearwater ('a'o) and 30 percent assumed to be Hawaiian petrel ('ua'u) (Table 5E-3).

Powerline Strike Allocation by Age Class

Birds detected colliding with powerlines through acoustic monitoring, which is used to estimate strike numbers, cannot be identified to age class. However, the proportions of strikes that are subadults and adults are important for the population dynamics model. Although there are no available estimates for Hawaiian petrel ('ua'u), limited evidence suggests that Newell's shearwater ('a'o) subadults are more susceptible to powerline strikes than adults. For the purposes of this model, powerline strikes of Hawaiian petrel ('ua'u) are assumed to be composed of 79 percent subadults (ages 3–5 years) and 21 percent adults (ages 6 years and older) (Table 5E-3).

This assumption corresponds to the proportions estimated by Cooper and Day (1998), who analyzed brood patch vascularization and wear of rectrices[6] for 14 downed Newell's shearwater ('a'o) collected on powerline mortality searches during 1993–1994. Three of those downed Newell's shearwaters ('a'o) had highly vascularized brood patches and worn rectrices, which suggests those birds were incubating eggs in burrows, and hence they were classified as breeding adults (age 6+). The remaining 11 birds either had no brood patch (n=10) or a downy brood patch (n=1); all but the latter had unworn rectrices. Those 11 birds (78.6 percent) were classified as subadults, and the three others (21.4 percent) were classified as breeding adults.

[6] A brood patch is a featherless patch of skin near the belly, which allows heat transfer from nesting parents to their eggs during incubation. Rectrices are the larger tail feathers, which may show signs of wear associated with nesting.

Mortality from Future Powerlines

Mortality due to construction of future powerlines was assumed to apply only to the Hanalei to Kekaha area (Figure 5E-1). The vast majority (more than 99 percent) of new powerlines are expected to be constructed in this area, which is where human population growth is forecast to occur on Kaua'i (see Chapter 2, *Covered Activities*, for details). As described in Chapter 5, *Effects*, at the end of the 50-year permit term, powerline strikes would be increased by an estimated 4.7 percent. The species-specific increase in future strikes was calculated by applying the species split to this percentage, and then applying a linear increase in the strike mortality rate each year, such that by the end of the permit term, the strike mortality rate was increased consistent with the estimated percent increase in strikes.

Mortality from Fallout from Existing and Future Streetlights and Covered Facility Lights

Appendix 5B, *Light Attraction Modeling for Covered Seabirds*, describes the process for quantifying take of the covered seabirds from attraction to lights owned and operated by KIUC. Mortality due to fallout from light attraction was assumed to affect fledglings (age 1 year) only in the Hanalei to Kekaha area. Fallout is assumed to result in 100 percent mortality in the model, so as a conservative approach the benefits of Save Our Shearwaters (SOS) rehabilitation efforts are not counted (given that there is little data on survival once the birds are released). Based on this assumption, and the light attraction modeling (Appendix 5B), the number of mortalities from fallout each year for Hawaiian petrel ('ua'u) was set to 5.5 in the model. This estimate represents expected mortalities resulting from existing and future light sources anticipated by the end of the 50-year permit term. However, this value was applied at the start of the population trajectories as a conservative approach for modeling fallout mortality levels through time, i.e., annual fallout mortalities from attraction to lights owned and operated by KIUC is likely overestimated at the start of the metapopulation projections.

5E.2.1.4 Predation Rates

Predation mortality rates have been estimated at the conservation sites, both with and without trapping and fencing (i.e., mitigation). Prior to dedicated predator control, predation mortality rates for all predators combined were estimated to be 0.18 for chicks in the nest, and 0.0272 for breeding adults[7] at the nest (Raine et al. 2022; Raine unpublished data). For areas outside the conservation sites (with no active management), predation rates at the nest were assumed to be equal to the estimates for the conservation sites prior to dedicated predator control, with one exception. The exception was the Wainiha and Lumaha'i Valleys area, where predation mortality rates are assumed to be 25 percent of the unmitigated rates. This reduction in assumed predation rates allowed the model to match the stable trend in abundance that has been observed through the radar survey data (Raine and Rossiter 2020). This observed stable trend in the Wainiha and Lumaha'i Valleys area, where powerline strikes are relatively uncommon, would be consistent with lower predation rates,

[7] In other words, 18 percent of all chicks at all conservation sites are assumed to be lost to predators in the absence of any dedicated predator control structures or actions. Similarly, 2.7 percent of all adults at the conservation sites are assumed to be lost to predators annually in the absence of any predator control structures or actions. Chicks are not tracked explicitly in the model, but chick survival (and mortality from predation) is measured in the estimated RS rates of adults from burrow monitoring studies, and those RS rate estimates (and hence chick mortality) from monitoring studies are explicitly included in the model.

perhaps due to the remaining breeding colonies being confined to areas that are less accessible to mammalian predators.

With predator control measures at the conservation sites, predation mortality rates were estimated to decrease to 0.02 for chicks and 0.0023 for adults (Raine et al. 2022; Raine unpublished data). The effect of these reductions in predation rates at the nests is also evident in the RS rates estimated before (41.3 percent RS rate) and after dedicated predator control measures (78.7 percent RS rate) at the conservation sites. Although predation mortality rates for chicks are not explicitly included as a variable in the model and are therefore not considered further, they are subsumed in the RS rate estimates used in the model, as discussed above under RS rates.

Barn owl predation rates on the wing for adults were assumed to be equal to the adult predation rate at the nest (0.0023; Raine et al. 2022; Raine unpublished data), and the same barn owl predation rate on the wing was assumed for ages 3–6+ in the absence of additional information. The assumed barn owl predation rate on the wing was added to the terrestrial predation rates at the nest for all areas. For example, in the Kalalau east to Upper Mānoa area, the adult predation rates at the nest were assumed to be equal to those estimated at the conservation sites prior to dedicated predator control measures (0.0272) plus the assumed barn owl predation rate on the wing (0.0023), or a total adult predation rate of 0.0295 (Table 5E-5). Predation rates at the nests were assumed to vary between different areas according to different management measures (Table 5E-5).

The predation rate for ages 3–5 was set to 0.0023, under the assumption that those ages are not vulnerable to terrestrial predators because they are not nesting, but they are vulnerable as prospectors to being killed by barn owls on the wing (Table 5E-5).

Table 5E-5. Assumptions for Annual Predation Rates, with and without Predator Control

	Without Predator Control[a]		With Predator Control[b]	
Site	**Adults**	**Subadults (3–5 yrs)**	**Adults**	**Subadults (3–5 yrs)**
Conservation Sites	--	--	0.0046	0.0023
Kalalau east to Upper Mānoa[c]	0.0295	0.0023	--	--
Hanalei to Kekaha	0.0295	0.0023	--	--
Wainiha and Lumaha'i Valleys[c]	0.0074	0.0006	--	--

[a] Without predator control is defined as no fencing, no predator trapping, and no predator removal efforts. With predator control includes trapping and ungulate fences for the conservation sites, or sites with predator-proof fences (second row).
[b] See Table 5E-6 for differences in predation mortality rates assumed for different age classes.
[c] Reduced predation rates were assumed for the Wainiha and Lumaha'i Valleys area in order for the initial modeled trend to match the stable trend in radar survey data at the two monitoring sites for these valleys during 2006–2020 (Raine and Rossiter 2020).

5E.2.2 Population Dynamics Model and Projections of Abundance

This section describes the model structure, each of the model parameters, and the rationale for each model input.

The population dynamics model is described below in terms of the numbers of females-at-age for each species, under the assumption of a 50:50 sex-ratio:

$$N_{1,t,i} = 0.5\gamma_{t-1,i}\beta N_{6+,t-1,i}S^*_{6+,t-1,i} - F_{t,i} \quad \text{(Equation 2)}$$

$$N_{2,t,i} = N_{1,t-1,i}S^*_{1,t-1,i}$$
$$N_{3,t,i} = N_{2,t-1,i}S^*_{2,t-1,i}$$
$$N_{4,t,i} = N_{3,t-1,i}S^*_{3,t-1,i}$$
$$N_{5,t,i} = N_{4,t-1,i}S^*_{4,t-1,i}$$
$$N_{6+,t,i} = N_{5,t-1,i}S^*_{5,t-1,i} + N_{6+,t-1,i}S^*_{6+,t-1,i}$$

Where:

- $N_{a,t,i}$ is the number of female birds at age a during year t in area i. Birds aged 6 years and older (age 6+) are modeled as a plus-group, *aka* a self-loop group (Figure 5E-2). Fledglings are denoted as age 1 in the model.
- $\gamma_{t,i}$ is the RS rate during year t in area i. RS rates in the model vary between conservation sites and unmanaged areas, and can change with time for areas with future predator control measures (e.g., predator-proof fences).
- β is the breeding probability for sexually mature birds (assumed constant across areas).
- "Fertility" is defined here as the product: $0.5\gamma_{t-1,i}\beta S^*_{6+,t-1,i}$

  Hence, fertility, or the number of female fledglings produced per breeding female per year, is a function of the adult survival rate. Chick mortality rates, which are subsumed in the reproductive success rate variable, are therefore directly related to parental mortality rates in the model vis-à-vis reductions in the numbers of fledglings produced.
- $F_{t,i}$ is the number of age 1 birds that die from fallout due to KIUC lights during year t in area i. This term is included with a time and area component for generality, but in practice, fallout is assumed to be limited to the Hanalei to Kekaha subpopulation with 2.65 age 1 female mortalities per year (i.e., 5.3 fallout mortalities per year for age 1 males and females combined).
- $S^*_{a,t,i}$ is the survival rate of birds at age a during year t in area i, which for ages 3 years and older is a function of the estimated predation and powerline mortality rates-at-age, as well as the powerline minimization level in year t:

$$S^*_{1,t,i} = S_1 \quad \text{(Equation 3)}$$
$$S^*_{2,t,i} = S_2$$
$$S^*_{3,t,i} = S_3(1-\phi_{3,t,i})\left[1-\psi_{3,i}(1-\delta_t)\right]$$
$$S^*_{4,t,i} = S_4(1-\phi_{4,t,i})\left[1-\psi_{4,i}(1-\delta_t)\right]$$
$$S^*_{5,t,i} = S_5(1-\phi_{5,t,i})\left[1-\psi_{5,i}(1-\delta_t)\right]$$
$$S^*_{6+,t,i} = S_{6+}(1-\phi_{6+,t,i})\left[1-\psi_{6+,i}(1-\delta_t)\right]$$

Where:

- S_a is the natural survival rate at age a prior to any mortalities from predators or powerlines (Table 5E-5).
- $\phi_{a,t,i}$ is the predation mortality rate at age a during year t in area i (Tables 5E-5 and 5E-6). Predation rates vary through time in the model in the areas where future predator control measures will occur or where predator-proof fences are installed.

- $\psi_{a,i}$ is the unminimized powerline mortality rate at age a in area i. The unminimized powerline mortality rates vary by area due to unequal per-capita vulnerability to powerline strikes (Equation 1; Table 5E-3).
- δ_t is the minimization efficacy in terms of reducing powerline strikes during year t. The minimization rate varies between years according to the strike minimization schedule under the HCP (Table 5E-8).

Table 5E-6. Survival, Predation Mortality, and Fertility Rates by Age for Hawaiian Petrel (ʻuaʻu)

Age	Natural Survival Rate[a]	Predation Mortality Rate without Predator Control or Fencing[b]	Predation Mortality Rate with Predator Control and Ungulate Fencing[c]	Predation Mortality Rate with Predator-Proof Fencing[d]	Natural Fertility[a]	Fertility without Predator Control or Fencing[e]
1	0.371	0	0	0	0	0
2	0.924	0	0	0	0	0
3	0.924	0.0023[c]	0.0023[c]	0.0023[c]	0	0
4	0.924	0.0023[c]	0.0023[c]	0.0023[c]	0	0
5	0.924	0.0023[c]	0.0023[c]	0.0023[c]	0	0
6+	0.924	0.0295	0.0046	0.0023[c]	0.416	0.182

[a] Natural survival and natural fertility represent the modeled rates in the absence of predation and powerline mortalities. The value of 0.924 for natural survival is based on survival rates estimated from studies of Manx shearwater and Hawaiian petrel (ʻuaʻu) (Simmons 1984, 1985), with age 1 survival adjusted to result in ~25 percent of birds reaching breeding age, based on satellite tagging results for Newell's shearwater (ʻaʻo) on Kauaʻi (Raine et al. 2020).
[b] Estimated from burrow monitoring studies at conservation sites (Raine et al. 2022; Raine unpublished data), and assuming that ages 1 and 2 are not vulnerable to introduced predators on the island because they are largely expected to be at sea. Predation mortality rates for the Wainiha and Lumahaʻi Valleys area are reduced to 25 percent of the values at other unmanaged sites to match the stable trend in abundance from the radar survey data in that area during 2006–2020 (Raine and Rossiter 2020).
[c] Taken from estimated barn owl predation rates for nesting birds and assumed in the model to be equal for age 3–5 birds (i.e., the barn owl predation rate is applied to this age under the assumption that ages 3–5 would be "prospectors" and predated by barn owls on the wing).
[d] All predation mortality rates are assumed to be reduced to zero by predator proof fences, except for ages 3–6+ which are assigned the estimated barn owl predation rate on the wing.
[e] This fertility value corresponds to the Hanalei to Kekaha subpopulation with unminimized powerline strike mortality rates. The fertility values are a function of the adult powerline mortality rates, and therefore change through time in the model as a function of the minimization schedule. Likewise, the fertility rates differ between areas in the model due to spatial differences in the adult powerline mortality rates between areas in the model. Because the Hanalei to Kekaha area has the highest powerline strike mortality rate, it also has the lowest modeled fertility rate, which reflects the expectation that if a nesting parent is killed, it's egg/chick will not survive to fledge.

Table 5E-7. Reproductive Rates Assumed in the Population Dynamics Model

Vital Rate	Value
Sex ratio	0.5
Reproductive success rate without predator control and without fencing	0.413[a]
Reproductive success rate with predator control	0.787[a]
Breeding probability	0.982[b]
Age at sexual maturity	6 yr

[a] Estimated from burrow monitoring studies at management sites before (in parentheses) and after predator control measures (e.g., Raine et al. 2022; Raine unpublished data).
[b] Estimated from long-term studies of active breeders at the conservation sites (Raine et al. 2022).

Table 5E-8. Annual Powerline Minimization Schedule[a]

Year	Cumulative Island-Wide Powerline Mortality Minimization Rate[b]
2019	0
2020	0.127
2021	0.303
2022	0.550
2023	
2024	
2025–2075	0.664

[a] See Conservation Measure 1, *Implement Powerline Collision Minimization Projects*, in Chapter 4, *Conservation Strategy*, for details on the specific powerline minimization projects and the locations.
[b] Minimization represents the efficacy to reduce the mortality rate due to powerline strikes. In other words, minimization = 0.0 corresponds to no change in powerline mortality rate (without any minimization measures implemented). A minimization = 1.0 represents a scenario where a powerline was removed or modified so that bird collisions no longer occurred, and powerline mortality rates are zero. A minimization efficacy of 0.5 represents a 50 percent reduction in strike mortalities.

The life-cycle model shown in Figure 5E-2 is similar to the model developed by Griesemer and Holmes (2011). The circles, and numbers therein, correspond with a single age class in the model. Birds aged 6 years and older were modeled as a self-loop group (i.e., senescence was not assumed to be a knife-edge where all birds die at a given age). The survival rates at age a, S_a^* are a function of predation and powerline mortality rates at age as well as the powerline strike minimization rates (Equation 3). For conciseness, the subscripts for year and area are dropped in the transition parameters shown in the figure.

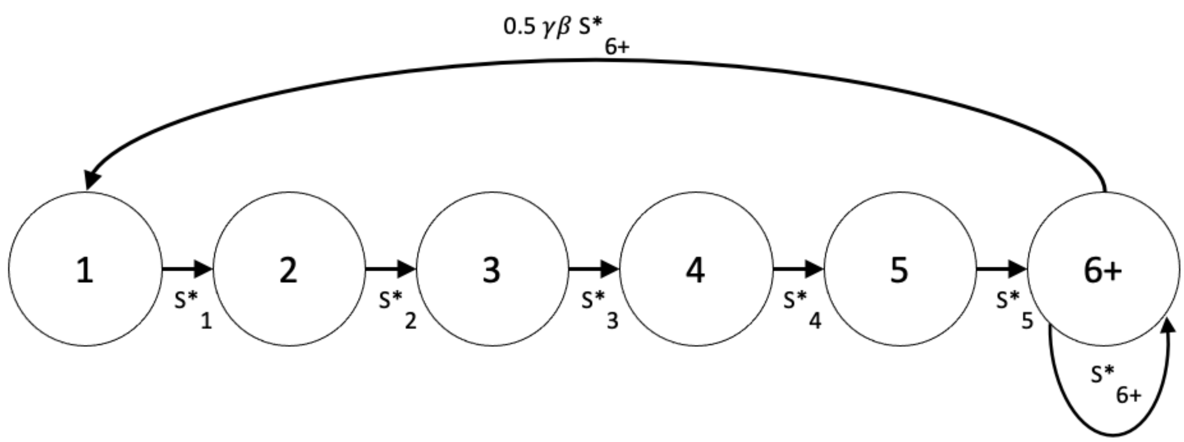

Figure 5E-2. Life Cycle Graph with Age-Structured Transition Parameters for the Population Dynamics Model

5E.3 Model Results for Worse-Case Trend Scenario

All model results for Hawaiian petrel (ʻuaʻu) for the worse-case trend scenario are presented in Figures 5E-3 through 5E-6. The population dynamics results in Figures 5E-3 and 5E-4 demonstrate that the conservation measures implemented will substantially benefit Hawaiian petrel (ʻuaʻu) relatively quickly at all conservation sites where Hawaiian petrel (ʻuaʻu) are modeled and expected to occur.

The population trajectory for Hawaiian petrel (ʻuaʻu) at all conservation sites combined is shown in Figure 5E-4 and shows a similar pattern. According to the model, the total population size of Hawaiian petrel (ʻuaʻu) at all of the conservation sites is expected to increase immediately, consistent with observed increases in call rates at the conservation sites that have been ongoing with predator control since 2014–2015 (Raine et al. 2022). Of the conservation sites, North Bog and Pihea contribute the greatest number of new birds because of their much larger starting populations (Figure 5E-3).

Continued predator control by the HCP at the conservation sites, combined with powerline collision minimization, will prevent substantial declines of existing subpopulations of Hawaiian petrel (ʻuaʻu) and likely prevent local extirpation (red lines in Figure 5E-3). Three of these conservation sites with predator control (North Bog, Pihea, and Hanakāpiʻai) collectively contribute substantial numbers of new breeding pairs to the Kauaʻi metapopulation of Hawaiian petrel (ʻuaʻu) with the HCP (blue lines in Figure 5E-3). Combined, the six conservation sites are projected to have more than 3,100 Hawaiian petrel (ʻuaʻu) breeding pairs by the end of the permit term.

Figure 5E-5 shows the subpopulation trajectories at each of the three areas outside the conservation sites (see Figure 5E-1 for area locations), with and without the KIUC HCP. Hanalei to Kekaha is the largest subpopulation in the area, by far. This area is projected to be approaching extirpation without the HCP by approximately 2060. With the HCP, the negative rate of modeled decline is slowed, but not reversed by the end of the permit term (2075). The difference in declines between these scenarios is due largely to powerline minimization. Because 92 percent of all powerline collisions involving Hawaiian petrel (ʻuaʻu) are within the Hanalei to Kekaha area (see Figure 5E-1), powerline minimization provides a greater benefit in this area compared to other areas. This result is not surprising, because for all areas other than Hanalei to Kekaha the risk of powerline collisions is much lower in the first place (Table 5E-3). By 2023 the rate of modeled decline has slowed from the initial 2016 radar trend in the Hanalei to Kekaha area due to powerline strike minimization (Table 5E-9). For Hanalei to Kekaha the rate of decline in abundance then increases again through time, due to the modeled effect of future powerline construction and fledgling fallout mortality.

The subpopulation trajectory in the Wainiha and Lumahaʻi Valleys area benefits with the HCP (Figure 5E-5). This is due to the area having vital rates modeled to match a stable trend (based on radar data) prior to minimization, and as minimization decreases mortality rates in the future, abundance is projected to have a positive trend. The remaining area in Figure 5E-5, Kalalau east to Upper Mānoa, is assumed to have relatively low vulnerabilities to powerline strikes, given its geographic remoteness. Therefore, powerline strike minimization is not predicted to have much of an effect on the modeled trend in abundance for this area, i.e., the blue (with HCP) and the red (without HCP) trajectories of abundance overlap. Nevertheless, Hawaiian petrel (ʻuaʻu) are modeled to decline in this area throughout the permit term. This decline is therefore almost completely due to the assumed effect of unmitigated mortality from introduced predators in this area. In other words, given the assumption of a low rate of maximum population growth, when the predation mortality rates are applied from the conservation sites prior to dedicated control measures, the trend in modeled abundance for the Kalaua to Upper Mānoa area is approximately -3 percent per year.

When all subpopulations are combined (Figure 5E-6), the Hawaiian petrel (ʻuaʻu) metapopulation on Kauaʻi is projected to continue to decline without the HCP (red line). Without the HCP, abundance is projected to continue to decline from approximately 8,000 breeding pairs at the start of the permit term to just under 1,500 by the end of the permit term (2075), a decline of over 80 percent. With the HCP conservation measures the Hawaiian petrel (ʻuaʻu) metapopulation on Kauaʻi is projected by the end of the permit term to stabilize and begin to experience a small net increase in the Kauaʻi metapopulation (Figure 5E-6, blue line). HCP conservation measures are projected to slow the metapopulation decline considerably between 2050 and 2060, stabilizing at approximately 5,000 breeding pairs, before increasing (Table 5E-10).

If conservation efforts are maintained for 50 years, the metapopulation is projected to increase gradually, governed in part by the assumed low intrinsic maximum rate of population growth, as the continued increases in abundance of Hawaiian petrel (ʻuaʻu) colonies at the conservation sites overcomes the declines in abundance in the Hanalei to Kekaha area (Figure 5E-7; Tables 5E-10 and 5E-11). The Hanalei to Kekaha area has the highest initial modeled abundance, and in addition to the Kalalau to Upper Mānoa area, it also has a relatively high degree of uncertainty in terms of initial and therefore projected abundance (Table 5E-2). Therefore, the metapopulation projection, especially as it relates to the relative contribution of the abundance in the aforementioned areas to the overall island-wide trend, is also uncertain. However, the abundance and life history parameters of Hawaiian petrel (ʻuaʻu) within the conservation sites are relatively well understood, leading to higher confidence in the population projections in these areas. This means that we have a relatively high confidence that the increase in subpopulations of the conservation sites combined will meet management objectives of maintaining a Kauaʻi viable metapopulation abundance level and provide a substantial net benefit to Hawaiian petrel (ʻuaʻu) on Kauaʻi, because the modeled rate of decline for the Hanalei to Kekaha area errs on the side of the species.

Without the HCP, and under worse-case assumptions, the Kauaʻi metapopulation of Hawaiian petrel (ʻuaʻu) is projected to fall below the USFWS 2,500 breeding pair threshold for viability (Figure 5E-6). With no KIUC take, the Kauaʻi metapopulation of Hawaiian petrel (ʻuaʻu) is projected to be near the USFWS 2,500 breeding pair threshold, due to the negative impacts of non-native predators alone. However, with the continuation of conservation efforts associated with the HCP, by 2032 the assumed rate of metapopulation decline is projected to be overcome by growth at the conservation sites, and the resulting net benefit to the metapopulation is forecast to continue through the end of the permit term. The conservation sites are large enough in size and have such extensive suitable habitat for Hawaiian petrel (ʻuaʻu) that subpopulations (and densities) are expected to continue to increase without experiencing any density-dependent constraints, assuming management actions continue at the same level as outlined in this HCP.

The cumulative number of strikes for each area from these modeled projections are provided in Table 5E-12. The predictions of strikes should be considered conservative (i.e., strike predictions may be too low) because these results are based on modeling a rate of decline for Hanalei to Kekaha that represents a worst-case scenario based on the most drastic rate of decline estimated from the 1993–2020 radar survey data. This rate of decline, while based on data, does not represent the less drastic average rate of decline estimated across all radar sites in the Hanalei to Kekaha area during the same period; further, it does not reflect the more recent stabilization of trend across radar sites in this area during 2010–2022 (Raine and Rossiter 2020; Sahin 2023). Additionally, the 2010–2022 decade-plus of radar data exhibiting a stable trend in relative abundance for the Hanalei to Kekaha area also overlaps in time with the estimate of unminimized seabird strikes from acoustic powerline monitoring data during 2013–2019 (Travers et al. 2020). Together, these two sources of monitoring data suggest that, at least during the last decade, the Hanalei to Kekaha subpopulation experienced a relatively high level of powerline mortality while also maintaining a stable abundance level. If this situation were to continue in the future, i.e., trends in both powerline strikes and abundance area remain stable, the modeled decline in abundance for Hanalei to Kekaha (and hence the modeled reduction in strikes associated with declining future abundance in this area) would underestimate future strikes.

Table 5E-9. Modeled Hawaiian Petrel (ʻuaʻu) Subpopulation Lambda Values for the Worse-Case Trend Scenario, Starting with the First Year of the HCP (2025), and then Shown at 5-Year Snap-Shot Intervals Over the 50-Year Permit Term (to 2075).

Lambda is the population multiplier, i.e., the rate of change in abundance from the prior year is equal to one minus Lambda. Values of Lambda less than 1.0 represent a decline in abundance, and values greater than 1.0 represent an increase. The maximum possible value for Lambda in the model is 1.02 (2.0 percent population growth), which is never achieved in practice because each subpopulation is assumed to have some level of vulnerability to introduced predators (e.g., barn owl predation on the wing) and some level of vulnerability to powerline collisions.

Area	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
HCP Conservation Sites											
Upper Limahuli Preserve	1.005	1.006	1.006	1.006	1.006	1.006	1.006	1.006	1.006	1.006	1.006
Pōhākea	1.006	1.006	1.006	1.006	1.006	1.006	1.006	1.006	1.006	1.006	1.006
Pihea	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007
North Bog	1.005	1.006	1.006	1.006	1.006	1.006	1.006	1.006	1.006	1.006	1.006
Hanakāpiʻai	1.006	1.006	1.006	1.006	1.006	1.006	1.006	1.006	1.006	1.006	1.006
Hanakoa	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007
Other Areas											
Wainiha and Lumahaʻi Valleys	1.004	1.004	1.004	1.004	1.004	1.004	1.004	1.004	1.004	1.004	1.004
Hanalei to Kekaha	0.943	0.943	0.943	0.943	0.942	0.942	0.942	0.941	0.941	0.940	0.940
Kalalau east to Upper Mānoa	0.955	0.955	0.955	0.955	0.955	0.955	0.955	0.955	0.955	0.955	0.955
Kauaʻi Metapopulation	0.970	0.975	0.980	0.984	0.988	0.992	0.995	0.997	0.999	1.001	1.002

Table 5E-10. Modeled Hawaiian Petrel (ʻuaʻu) Breeding Pair Abundance (ages 6 years and older) for the Worse-Case Trend Scenario at 5-Year Intervals for each Subpopulation over the 50-Year Permit Term (2025–2075)

Area	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
HCP Conservation Sites											
Upper Limahuli Preserve	114	117	120	123	127	130	134	138	142	146	150
Pōhākea	164	170	175	181	187	193	199	205	212	219	226
Pihea	666	691	716	743	770	798	827	858	889	921	955
North Bog	893	919	944	971	998	1,026	1,054	1,084	1,114	1,145	1,177
Hanakāpiʻai	296	306	316	326	336	347	358	370	382	394	407
Hanakoa	176	183	190	196	204	211	219	227	235	244	253
Subtotal: All Conservation Sites	2,309	2,386	2,461	2,540	2,622	2,705	2,791	2,882	2,974	3,069	3,168
Other Areas											
Wainiha and Lumahaʻi Valleys	1,200	1,223	1,247	1,270	1,294	1,319	1,344	1,369	1,395	1,422	1,449
Hanalei to Kekaha	4,905	3,669	2,734	2,037	1,515	1,126	836	620	459	339	250
Kalalau east to Upper Mānoa	536	427	340	270	215	171	136	108	86	69	55
Total	**8,950**	**7,705**	**6,782**	**6,117**	**5,646**	**5,321**	**5,107**	**4,979**	**4,914**	**4,899**	**4,922**

Table 5E-11. Modeled Hawaiian Petrel (‘ua‘u) Total (non-chick) Abundance at 5-Year Intervals for the Worse-Case Trend Scenario for each Subpopulation over the 50-Year Permit Term (2025–2075)

Initial abundance is based on the estimates of breeding pairs from ARC, with the exception of the Hanalei to Kekaha area, where the pre-HCP abundance is estimated as a function of the allocated strikes (92 percent) for that subpopulation and trends in abundance from radar, which is assumed to be -8.1 percent per year in 2016 and corresponds to the trend for Hawaiian petrel (‘ua‘u) at the Waiakalua Stream radar site, the most negative rate of decline observed at any single radar site for this species during 1993–2020 (Raine and Rossiter 2020).

Area	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
HCP Conservation Sites											
Upper Limahuli Preserve	409	420	432	444	457	469	482	496	510	524	538
Pōhākea	593	612	631	652	673	694	717	740	764	788	814
Pihea	2,402	2,490	2,581	2,676	2,774	2,875	2,981	3,090	3,203	3,320	3,442
North Bog	3,218	3,308	3,400	3,495	3,592	3,692	3,795	3,901	4,010	4,121	4,236
Hanakāpi‘ai	1,067	1,101	1,137	1,173	1,211	1,250	1,290	1,332	1,375	1,419	1,465
Hanakoa	636	659	683	708	734	761	789	818	848	879	911
Subtotal: All Conservation Sites	8,325	8,590	8,864	9,148	9,441	9,741	10,054	10,377	10,710	11,051	11,406
Other Areas											
Wainiha and Lumaha‘i Valleys	4,238	4,318	4,400	4,483	4,568	4,655	4,743	4,833	4,924	5,018	5,113
Hanalei to Kekaha	14,412	10,750	8,009	5,962	4,434	3,293	2,442	1,808	1,335	983	722
Kalalau east to Upper Mānoa	1,573	1,251	996	793	631	502	400	318	253	201	160
Total	**28,548**	**24,909**	**22,269**	**20,386**	**19,074**	**18,191**	**17,639**	**17,336**	**17,222**	**17,253**	**17,401**

Table 5E-12. Modeled Hawaiian Petrel (ʻuaʻu) Powerline Strikes for the Worse-Case Trend Scenario, Starting with the First Year of the HCP (2025), and then Shown as a Cumulative Total at 5-Year Intervals for each Subpopulation until the End of the Permit Term (2075)

Area	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
HCP Conservation Sites											
Upper Limahuli Preserve	5	28	53	78	103	130	157	185	214	243	274
Pōhākea	5	28	51	76	101	127	155	182	211	241	272
Pihea	9	56	105	156	208	263	319	377	438	501	566
North Bog	37	223	415	611	814	1,022	1,236	1,455	1,681	1,913	2,152
Hanakāpiʻai	8	50	93	137	182	230	278	328	380	434	489
Hanakoa	2	15	28	41	55	69	84	100	116	133	150
Other Areas											
Wainiha and Lumahaʻi Valleys	47	287	531	780	1,034	1,292	1,555	1,823	2,097	2,375	2,659
Hanalei to Kekaha	721	3,722	5,977	7,667	8,934	9,881	10,588	11,115	11,506	11,796	12,010
Kalalau east to Upper Mānoa	14	76	126	165	196	221	241	257	269	279	287
Total	**848**	**4,485**	**7,379**	**9,711**	**11,627**	**13,235**	**14,613**	**15,822**	**16,912**	**17,915**	**18,859**

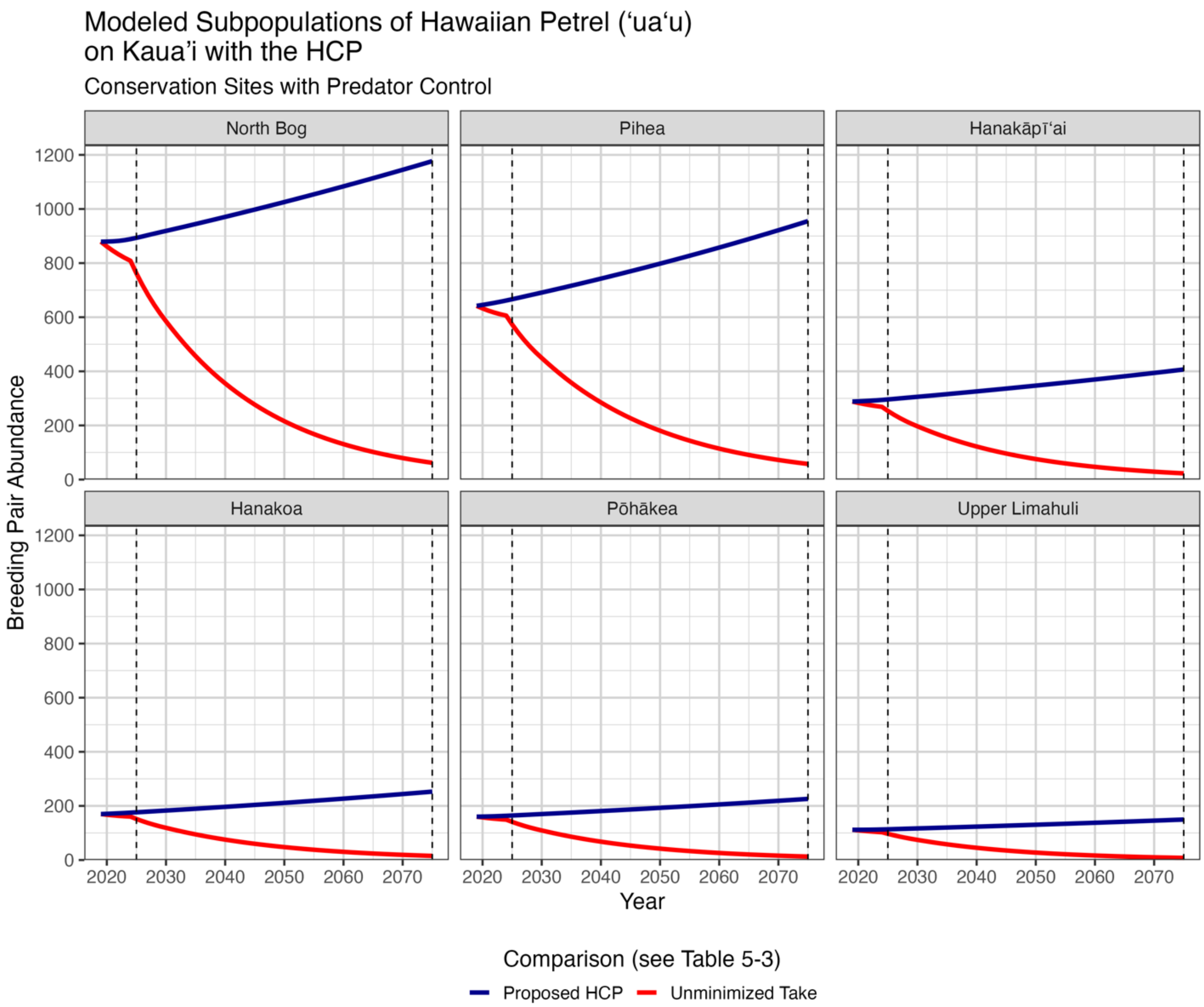

Figure 5E-3. Population Dynamics Model Results for Hawaiian Petrel ('ua'u) for the Worse-Case Trend Scenario for each Subpopulation with Predator Control Measures and Ungulate Fencing

Red lines show the unminimized take model scenario without the HCP (take continues without powerline minimization, and without conservation measures; see Table 5-1 in Chapter 5, *Effects*). Blue lines are with the proposed HCP according to the schedule of conservation measures described in Chapter 4, *Conservation Strategy*. The vertical dashed lines denote the first and last year of the permit term. See Figure 5E-1 for site locations.

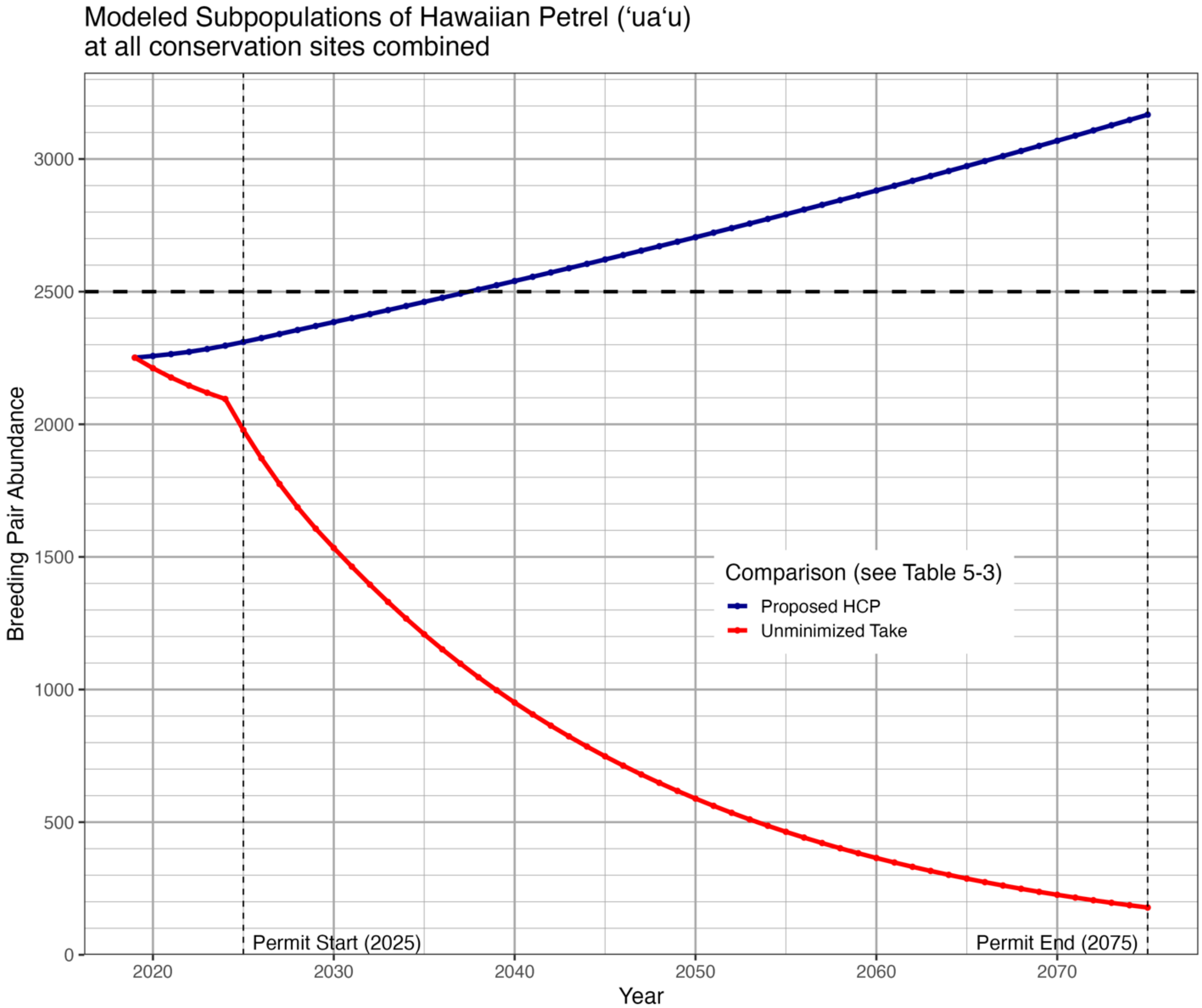

Figure 5E-4. Population Dynamics Model Results for Hawaiian Petrel (ʻuaʻu) for the Worse-Case Trend Scenario for all Conservation Sites Combined

Red line shows the unminimized take scenario without the HCP (take continues without powerline minimization, and without conservation measures; see Table 5-3 in Chapter 5, *Effects*). Blue line is with the HCP according to the schedule of conservation measures described in Chapter 4, *Conservation Strategy*. The horizontal dashed line highlights 2,500 breeding pairs, which USFWS considers to be an abundance threshold level for a Kauaʻi viable metapopulation (see Chapter 5 for details).

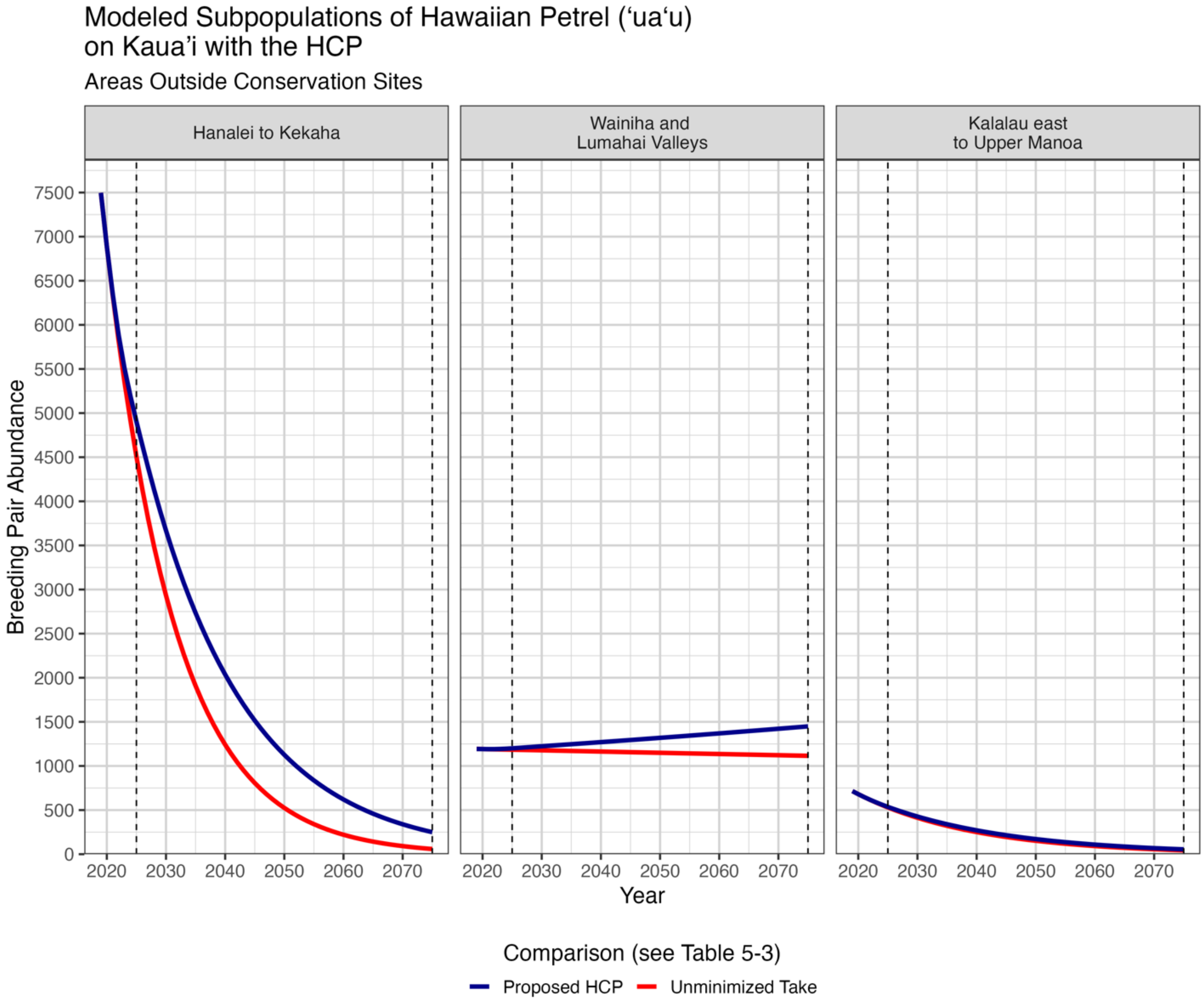

Figure 5E-5. Population Dynamics Model Results for Hawaiian Petrel (ʻuaʻu) for the Worse-Case Trend Scenario for each Subpopulation outside the Conservation Sites

Red lines show the unminimized take model scenario (take continues without powerline minimization, and without conservation measures; see Table 5-3 in Chapter 5, *Effects*). Blue lines are with the proposed HCP according to the schedule of conservation measures (i.e., powerline collision minimization) described in Chapter 4, *Conservation Strategy*. The vertical dashed lines denote the first and last year of the permit term. See Figure 5E-1 for site locations.

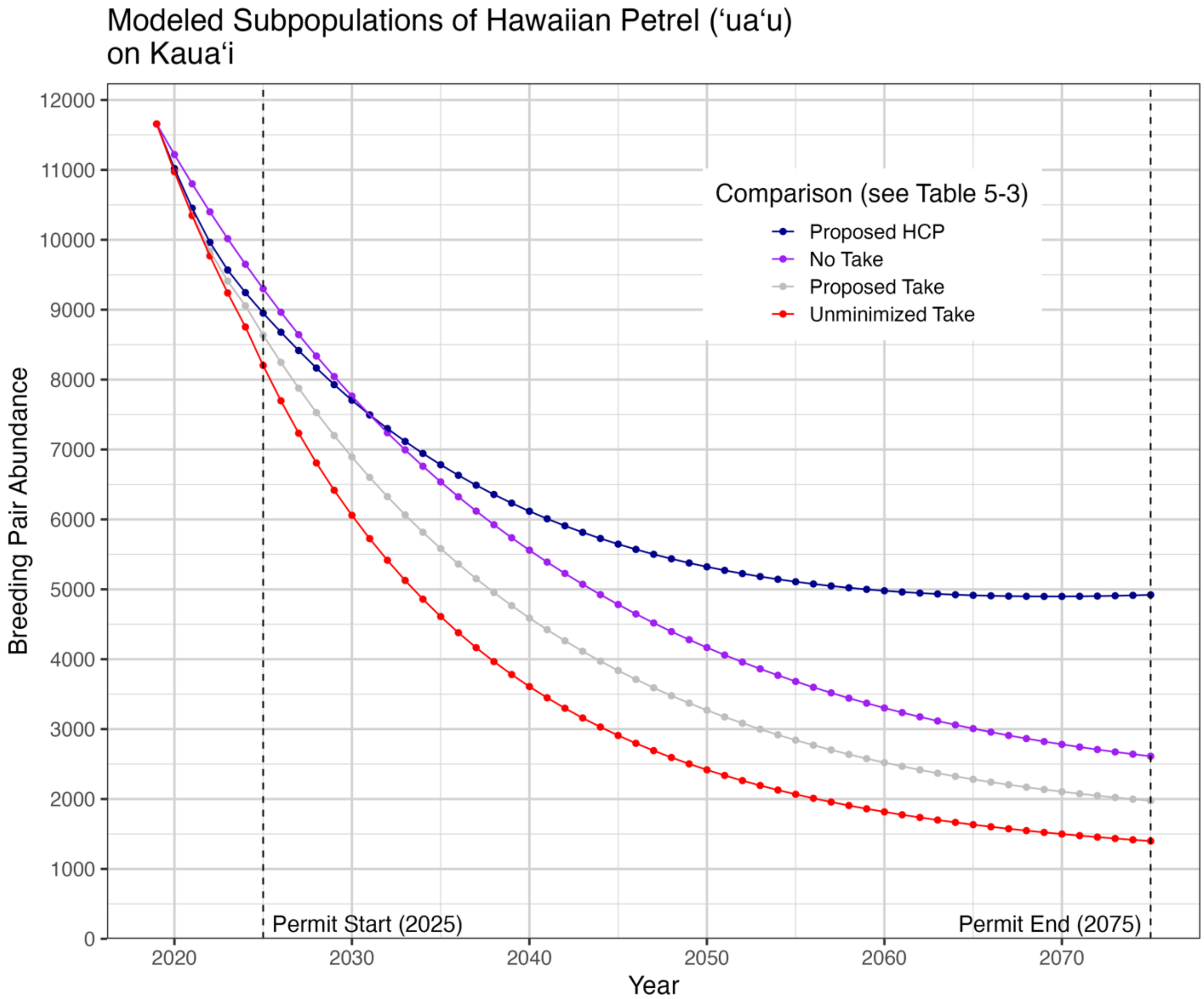

Figure 5E-6. Population Dynamics Model Results for Hawaiian Petrel (‘ua‘u) for the Worse-Case Trend Scenario for all Subpopulations Combined (all of Kaua‘i)

Red line is the unminimized take model scenario without the HCP (take continues without powerline minimization, and without conservation measures). Blue line is with the proposed HCP according to the schedule of conservation measures (i.e., powerline collision minimization) described in Chapter 4, *Conservation Strategy*. The grey line is with the proposed minimized take; the purple line is with no take. See Table 5-3 in Chapter 5, *Effects*, for additional description of each model scenario. The vertical dashed lines denote the first and last year of the permit term.

5E.4 Model Limitations, Uncertainties, and Assumptions

The population dynamics model described in this appendix is a useful tool with which to compare outcomes to Hawaiian petrel (ʻuaʻu) on Kauaʻi both with and without the KIUC HCP under two different scenarios (worse-case trend and stable trend). The model is also an important tool to confirm that the quantitative biological objectives for Hawaiian petrel (ʻuaʻu), particularly at the conservation sites, can be achieved by the end of the permit term under either modeling scenario. However, as with all models there are uncertainties in model inputs and outputs that should be considered. Model limitations include, but are not limited to, the following.

- Lack of statistical confidence limits around the island-based estimates of abundance.
- Uncertainty in certain vital rates (e.g., barn owl predation rates on the wing are difficult to estimate, and predation rates in general are not available from data in areas without predator control, and must be extrapolated from other areas where these data have been collected).
- Uncertainty in the reduction of powerline strikes due to minimization efforts (although continued powerline monitoring will help narrow those uncertainties within a few years).
- Logistical difficulties in monitoring the population at the colony and burrow level outside of established conservation sites (e.g., lack of or difficulty in access due to land ownership, rugged and inaccessible terrain, or both).

Due to these limitations, the uncertainty in the model results has not been quantified for either modeling scenario. However, any population dynamics model of Hawaiian petrel (ʻuaʻu) relies on a suite of assumptions. The assumptions chosen for this model were in many cases selected to be as conservative as reasonably possible knowing that many model uncertainties have not been quantified. A list of the key assumptions is provided below for this model, with reasons these assumptions may be conservative or optimistic in terms of predicting effects of the HCP conservation measures on this species. These sections are intended to provide the reader with a qualitative understanding of the level and sources of uncertainty in model results for each model scenario. Model limitations and uncertainties are described below for the worse-case trend scenario. For a discussion of model limitations and uncertainties for the stable trend scenario, see Attachment 5E-1, *Hawaiian Petrel (ʻuaʻu) Population Dynamics Model Fit to the Stable 2010–2022 Radar Trend under KIUC's Proposed Habitat Conservation Plan*.

5E.4.1 Worse-Case Trend Scenario

The worse-case trend scenario of the population dynamics model includes assumptions that likely result in an overly conservative projection of outcome. In other words, the model results with conservative assumptions may overestimate the impacts of the covered activities on Hawaiian petrel (ʻuaʻu), underestimate the benefits of the conservation strategy for Hawaiian petrel (ʻuaʻu), or both. This section describes how model assumptions may be overly conservative or overly optimistic for the worse-case trend scenario.

5E.4.1.1 Conservative Assumptions

The population dynamics model under the worse-case trend scenario is likely overly conservative (i.e., overestimates adverse effects or underestimates beneficial effects for Hawaiian petrel ['ua'u]) for the following reasons.

- **Total powerline strikes.** The reported point estimate that is used as a model input for the annual average of seabird strikes corresponds to the mean of the Bayesian posterior predictive probability distribution, corrected to account for strikes that were subsequently recategorized as waterbirds (Travers et al. 2020; Travers unpublished data). For a right skewed (longer right tail) probability distribution, like the Bayes posterior predictive probability distribution for seabird strikes, the mean is greater than the expectation of the estimate. Statistically, this results in using a conservative (i.e., higher) level of powerline collisions in the model.
- **Strike allocation.** Allocation of powerline strikes may be even lower at some or all of the conservation sites than estimated, given flight paths, and observed altitudes from satellite tagging. For example, the estimated breeding probability from burrow monitoring data at seven conservation sites for Hawaiian petrel ('ua'u) is 0.982 (Raine et al. 2022), which indicates that non-predation sources of mortality for breeding adults were quite low in these areas.
- **Population trend and optimal growth rate.** In the worse-case trend scenario, the modeled population trend for the Hanalei to Kekaha area assumes a continued steep rate of decline, based on the long-term trend from the Waiakalua Stream radar site. Based on recent (and longer-term) radar trends from the other radar sites, the current population trend for all breeding colonies in this area is unlikely to be in an ongoing steep decline. Again, recent data indicate the trend for those areas surveyed by radar has been stable since 2010, albeit at reduced abundance levels following the steep decline in the 1990s.

  Recent analyses of the radar trend data (Raine and Rossiter 2020; Sahin 2023) have shown that the average trend in radar estimates across all radar survey sites have leveled out since 2010, indicating that after a very large population decline the population trend may now be relatively stable on an island-wide basis. For example, a regression of radar data including all 13 monitored sites was flat with no significant change during the last decade (2010–2022; Sahin 2023).

  This pattern is consistent with data on the amounts of rescues of Hawaiian petrel ('ua'u) from the SOS Program, which are relatively stable over a similar period (Ainley et al. 2023). Also, it is consistent with the stable trend in passage rates (the number of seabirds transiting powerlines) since 2013 estimated from visual night-time observations during powerline monitoring surveys (Travers et al. 2023).

  Therefore, based on these three data sources (radar surveys, SOS rescues, and powerline monitoring surveys) the aggregate modeled population trend in the absence of minimization and mitigation is likely to be conservative, at least in terms of observed trends over the last decade. If the aggregate population trend is more positive (either a smaller negative number or a number close to zero for a stable population), then the effects of the HCP conservation strategy will result in a greater benefit to the island-wide metapopulation of Hawaiian petrel ('ua'u) than what is estimated (cf. the stable trend scenario).

  Also, the optimal rate of modeled population growth assumed in the model is much lower than has been estimated for the family Procellariidae (all petrels, prions and shearwaters) in multiple published allometric and demographic modeling studies. The results of those studies are consistent with species in this seabird family having expected optimal rates of population growth closer to 6.8 percent per year (Dillingham et al. 2016) or 7.1 percent per year (Dillingham and Fletcher 2011), depending on the methods used. The worse-case trend scenario assumed an optimal rate of modeled population growth (i.e., in the absence of introduced predators, powerline strikes or light fallout mortality) of approximately 2.0 percent per year. This factor is addressed by the stable trend scenario, described in more detail in Attachment 5E-1, *Hawaiian Petrel (ʻuaʻu) Population Dynamics Model Fit to the Stable 2010–2022 Radar Trend under KIUC's Proposed Habitat Conservation Plan*.

- **Total powerline strikes.** The reported point estimate that is used as a model input for the annual average of seabird strikes corresponds to the mean of the Bayesian posterior predictive probability distribution, corrected to account for strikes that were subsequently recategorized as waterbirds (Travers et al. 2020; Travers unpublished data). For a right skewed (longer right tail) probability distribution, like the Bayes posterior predictive probability distribution for seabird strikes, the mean is greater than the expectation of the estimate. Statistically, this results in using a conservative (i.e., higher) level of powerline collisions in the model than would be expected from the data.
- **Strike allocation.** Allocation of powerline strikes may be even lower at some or all of the conservation sites than estimated, given flight paths, and observed altitudes from satellite tagging. For example, the estimated breeding probability from burrow monitoring data at seven conservation sites for Hawaiian petrel (ʻuaʻu) during 2012–2019 is 0.982 (Raine et al. 2022), which indicates that non-predation sources of mortality for breeding adults were quite low in these areas during those years (which preceed powerline minimization efforts).
- **Fallout from light attraction.** Currently a constant amount of 5.3 age-1 (fledglings) from the Hanalei to Kekaha subpopulation are assumed to die annually from fallout associated with KIUC streetlights. The estimated level of fallout includes correction factors for the proportion of grounded seabirds that go undetected, e.g., for KIUC streetlights, 89.6 percent of grounded Hawaiian petrel (ʻuaʻu) are assumed to go undetected (Appendix 5B, *Light Attraction Modeling for Covered Seabirds*). Fallout, whether detected or not, is assumed to result in 100 percent mortality in the model. This assumption is conservative for three reasons: (1) The estimate for fallout is based on the number of expected streetlights and facility lights at the end of the permit term, not at the beginning. Fallout from light attraction is therefore likely overestimated at the start of the projections; (2) This assumes zero individuals rehabilitated by the SOS program survive; and, (3) Fallout mortality is modeled as a fixed number of fledglings lost, not a mortality rate. In other words, even when the Hanalei to Kekaha subpopulation is much smaller towards the end of 50 years, 5.3 fledglings (or the number of modeled fledglings, whichever is smaller) are still removed in the model from this area each year. Furthermore, the level of mortality from fallout is estimated to be less than five percent of the level of mortality estimated from powerline collisions. So, while fallout mortality is a contributing factor to metapopulation dynamics, it does not have as large of an effect on metapopulation trends as powerline collisions.
- **Conservation actions performed by others.** The population dynamics of the Kauaʻi metapopulation of Hawaiian petrel (ʻuaʻu) are modeled only assuming the full implementation of this HCP's conservation. Numerous federal, state, and local agencies and conservation organizations are either implementing or planning to implement additional conservation actions separately from this HCP, which will benefit Hawaiian petrel (ʻuaʻu). However, due to a lack of

data available on these other conservation efforts, their benefits, current or expected, could not be included in the model (see Table 5D-14 in Appendix 5D for a list of these projects and which benefit Hawaiian petrel ['ua'u]). Similarly, due to a lack of available estimates for reductions in predation rates resulting from barn owl control at the conservation sites, no attempt has been made to include the benefit of that form of predator control effort at the conservation sites. Because this model does not consider these other current or planned conservation action, the impacts of the taking of this HCP are conservative (i.e., overestimate effects).

5E.4.1.2 Potentially Optimistic Assumptions

The population dynamics model for Hawaiian petrel ('ua'u) under the worse-case trend scenario may be too optimistic (i.e., underestimate adverse effects or overstate benefits) for the following reasons.

- **Total metapopulation size.** The estimate of the island-wide metapopulation may be too high, despite the integration of multiple indpendent data sources, and what are otherwise thought to be conservative assumptions by experts. If this is true, then impacts of the taking would be greater than predicted by the model. However, all else being equal, the *relative* effects of the HCP would be the same because the comparison is made with and without the HCP using the same initial abundance estimate and estimates of trends in relative abundance (i.e., positive trends in call rates from the conservation sites and negative trends in relative abundance from the radar survey). Also, if a smaller value for metapopulation abundance were used, the modeled trend would become inconsistent with long-term monitoring data, e.g., the modeled rate of decline in the Hanalei to Kekaha area would be even more negative compared to the lowest estimated rates of decline from the radar survey. Such a steep rate of decline, which would result from the estimated number of powerline collisions if abundance was indeed lower, would not be supported by the best available science on long-term trends in abundance.
- **Cat predation events.** The model is deterministic, which means that mortality and reproductive rates are assumed to be constant between years (with the exceptions of powerline collision minimization and the effects of immigration into social attraction sites through time). As such, interannual variation (stochasticity) in predation rates is not modeled even though the number of predations by cats can be variable between years. In particular, there have been instances of individual cats predating multiple nests during certain years before they have been caught. As such, a conservation site may have low predation mortality rates for a period of years, with an incursion of a single cat one year leading to a spike in predation mortality rates that year. Breeding pairs and chicks inside predator exclusion fences may be subject to such events in rare instances (i.e., before the cat incursion is caught on camera and additional control efforts can be deployed). Such events may also occur outside of conservation sites despite aggressive predator control techniques.

  The predation mortality rates used in the model are based on burrow monitoring data from multiple conservation sites over multiple years. The resulting estimate represents an average annual predation mortality rate under predator control that includes punctuated predation mortality events due to single cats. If the estimated predation mortality rate does not fully capture the extent or frequency of these predation events, for example because they are not observed during the burrow monitoring surveys (i.e., predations are occurring at burrows that are yet undiscovered and are not currently monitored), the model results with respect to the benefits of predator control at the conservation sites would be optimistic. However, independent acoustic monitoring data indicate that at least since 2014–2015, the extent of punctuated cat predation events has not resulted in negative trends in recruitment into the breeding colonies at the conservation sites—call rates have continued to increase and have doubled at many conservation sites under predator control efforts (Raine et al. 2022), despite such predation events having occured during the same time.

- **Carrying capacity.** There is no assumption in the model that Hawaiian petrel (ʻuaʻu) population growth in the conservation sites will be limited by carrying capacity during the 50-year permit term. If, in the future, population growth is limited by the carrying capacity of suitable nesting habitat, the model results would overestimate the long-term benefit of the conservation sites to the metapopulation. However, not only are carrying capacities difficult to estimate reliably for these large management areas, but estimates of predation rates prior to dedicated predator control in the conservation sites in combination with the assumed low rates of population recovery suggest that reaching carrying capacity in the adjacent management areas is not likely during the permit term.
- **Allee effects.** The model does not account for either compensatory, or depensatory, density dependence on the population growth rate. The former would account for higher expected population growth rates at lower population sizes, for example due to decreasing competition for resources. The latter, also known as “Allee” effects, arises in situations where population growth rates might be expected to decrease at lower abundance levels, for example due to difficulties finding a mate at low densities. Given that Hawaiian petrel (ʻuaʻu) is an endangered species with a low intrinsic rate of increase, there does not seem to be support for considering compensatory density dependence within the permit term. However, if modeled subpopulations that are vulnerable to large declines (e.g., breeding colonies in the Hanalei to Kekaha area) experience Allee effects at lower densities in the future, the degree of the modeled declines there could be optimistic. There is no indication that Allee effects are occurring at recent abundance levels, at least at the broader scales monitored by the radar survey. Recent population trends from the radar data have generally flattened out (e.g., Raine and Rossiter 2020; Sahin 2023) instead of experiencing accelerating rates of decline that would be expected from Allee effects. Even if some smaller colonies are experiencing Allee effects, those losses would be balanced out by other colonies experiencing growth, or the recent trend from radar monitoring would still be decreasing.

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Attachment 5E-1

Hawaiian Petrel (ʻuaʻu) Population Dynamics Model Fit to the Stable 2010–2022 Radar Trend under KIUC's Proposed Habitat Conservation Plan

The results below for Hawaiian petrel (ʻuaʻu) supplement the context and rationale for a second trend scenario which is presented in detail in Appendix 5D (Attachment 5D-1) for Newell's shearwater (ʻaʻo). The background, modeling approach, and rationale for this additional scenario are the same for both species. Corresponding tables and figures are presented here with results for Hawaiian petrel (ʻuaʻu). A discussion of model limitations, uncertainties, and assumptions for Hawaiian petrel (ʻuaʻu) is also presented here. Please see the write-up focused on Newell's shearwater (ʻaʻo) for more detailed information and discussion around this new modeling scenario.

Table 1. Summary of Model Assumptions and Results for Hawaiian Petrel (ʻuaʻu).

Values are shown for the modeled Hanalei to Kekaha area, where 90% of powerline collisions occur based on acoustic collision detection data. The radar trend and unminimized collision estimate from this area are used to estimate the survival rates and abundance that in combination result in a flat model trend.[8]

Model Parameter for Hawaiian Petrel	Model Scenario		Notes and HCP reference
	Worse Case (-8.1% per year pre-HCP Trend)[9]	Stable Trend (0% per year Pre-HCP Trend)	
R_{MAX}	3% per year	8% per year	Maximum theoretical rate of increase in abundance in the absence of anthropogenic mortality (e.g., powerline collisions, ligth fallout, and nonnative predators)
Post-fledgling and Adult "Natural[10]" Survival (Age 2+)	92% per year	96% per year	Worse Case: Survival based on Manx shearwater in North Atlantic Stable Trend: Survival estimated based on: Estimates for unminimized powerline collisions (2013–2019) and flat radar trend (2010–2022)
Fledgling "Natural" Survival (Age 1)	37% per year	53% per year	Worse Case: Age 1 survival set for an ~30% survivorship to breeding age Stable Trend: Survival estimated based on unminimized powerline collision mortalities (2013–2019) and flat radar trend estimate (2010–2022)
Reproductive Success Rate	41% per year	Same	Table 5E-7; *c.f.* 78% reproductive success rate at the conservation sites

[8] The survival rate estimates shown for the stable trend scenario pertain to all areas modeled for the Kauaʻi metapopulation, before different levels of anthropogenic mortality are applied to each area in the population model. Assumptions for the worse case scenario are presented in Appendix 5E. The stable trend scenario integrates uncertainty in estimates of radar trend and unminimized powerline collisions through a Bayesian approach, and also differs from the worse case scenario in that survival rates are treated as an estimated parameter (instead of a fixed point value), which allows for the higher value of R_{MAX} in the population model. This is necessary for the model to integrate both the level of unminimized take as well as the 0% per year rate of change in the radar index of abundance since 2010.

[9] Appendix 5E. For each species, the individual radar site with the most drastic rate of estimated decline is used for the initial trend in this scenario. For Hawaiian petrel (ʻuaʻu) this rate of decline is based on the trend estimated at the Waiakalua Stream radar survey site, which has an estimated -8.1 percent rate of decline per year during 1993–2020 (cf. the rate of decline of -11 percent per year assumed for the Newell's shearwater [ʻaʻo] in its worse-case scenario, which is based on data for that species from the single radar site at Hanalei instead). The recent stable trend estimated by KESRP for each species (0 percent per year during 2010–2022) averages the radar index data across all 13 long-term monitoring sites between Wainiha and Kekaha.

[10] The word "natural" is used here to refer to modeled vital rates in the absence of anthropogenic mortality on Kauaʻi, i.e., natural survival and reproductive rates are those when anthropogenic mortality rates are set to zero in the population model and correspond to resulting population growth rates at R_{MAX}. Any athropogenic sources of mortality without available estimates (e.g., any fisheries bycatch) are subsumed in the "natural" survival rates. The "natural" reproductive success rate is based on estimates under dedicated predator control at the conservation sites.

Model Parameter for Hawaiian Petrel	Model Scenario		Notes and HCP reference
	Worse Case (-8.1% per year pre-HCP Trend)[9]	Stable Trend (0% per year Pre-HCP Trend)	
Uncontrolled Adult Predation Mortality Rate (without predator control)	3% per year	Same	Table 5E-6
Sex ratio (M:F)	50:50	Same	Table 5E-7
Age at sexual maturity	6 years	Same	Table 5E-7
Breeding probability (Age 6+)	0.982	Same	Table 5E-7
Proportion of powerline collisions that are Hawaiian petrel (ʻuaʻu)	0.30	Same	Table 5E-4
Proportion of powerline collisions that result in mortality	0.288	Same	Table 5E-4
Proportion of powerline collisions that are subadults	0.79	Same	Table 5E-4 (Proportion of collisions that are adults = 0.21)
Annual island-wide powerline mortality minimization rate for HCP	0.664	Same	Table 5E-8
Starting total abundance Hanalei to Kekaha (total individuals all ages) in 2025	14,412	60,911	Worse Case: Table 5E-11
Ending total abundance Hanalei to Kekaha in 2075	722	103,840	Worse Case: Table 5E-11

Table 2. Comparison of Model Results between the Two Scenarios for the Kauaʻi Metapopulation.

Model Result	Model Scenario: Worse Case	Model Scenario: Stable Trend	Notes
Metapopulation growth rate at end of permit term (2075)	1%	6%	Projected population growth rates are always less than R_{MAX} due to modeled sources of anthropogenic mortality (i.e., invasive predators, minimized powerline collisions, and fallout)
Starting island-wide metapopulation size (total individuals, all ages) in 2025 (A)	28,548	77,806	Worse Case: Table 5E-11 Worse Case and Stable Trend: Initial abundance is estimated based on assumed trend, unminimized collision estimate, and R_{MAX} model
Ending island-wide metapopulation size in 2075 (B)	17,401	543,672	Worse Case: Table 5E-11
Starting abundance at all HCP conservation sites in 2021 (C)	7,087	Same	Table 5E-3 (estimated from burrow monitoring, auditory surveys and habitat suitability modeling)
Ending total abundance at all HCP conservation sites in 2075 (D)	11,406	129,106[11]	Worse Case: Table 5E-11 Stable Trend results do not impose carrying capacity constraints on abundance other than the predator exclusion fenced areas
Net gain at all HCP conservation sites (E = D – C)	4,319	122,019	
Year when island-wide metapopulation growth becomes positive	2070	2021	Stable Trend: Abundance is projected to start increasing after the first year of powerline collision minimization.
Total number of predicted powerline collisions over the 50-year permit term	18,859	111,084	Worse Case: Table 5E-12 Stable Trend: Table 5-10a.
Total injury and mortality resulting from powerline collisions over the 50-year permit term	13,936	71,050	Same assumptions used for both scenarios. Includes loss of chicks and eggs. Stable Trend: Table 5-10a.

[11] This is not a reasonable abundance level to expect for the conservation sites. It results because these provisional population model runs do not impose values for carrying capacities outside the predator exclusion fence areas.

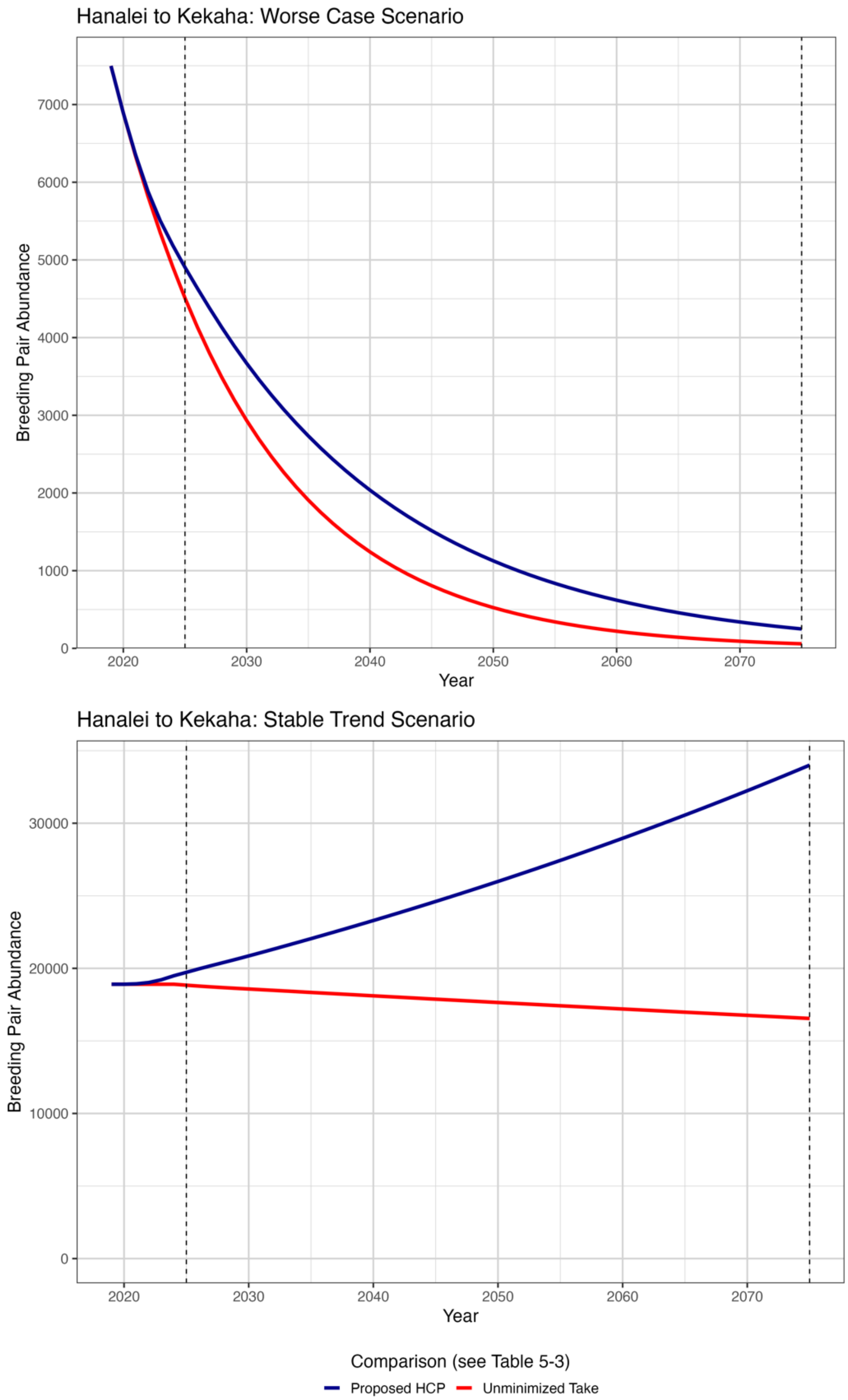


Figure 1. Projections of breeding pair abundance in the Hanalei to Kekaha area under the worse-case scenario from the draft HCP (top plot) and the stable-trend scenario (bottom plot).

The stable-trend scenario is initialized from the recent KESRP estimate of trend through the 2010 through 2022 radar survey data (Sahin 2023). The dashed vertical lines in each plot denote the first and last year of the permit term.

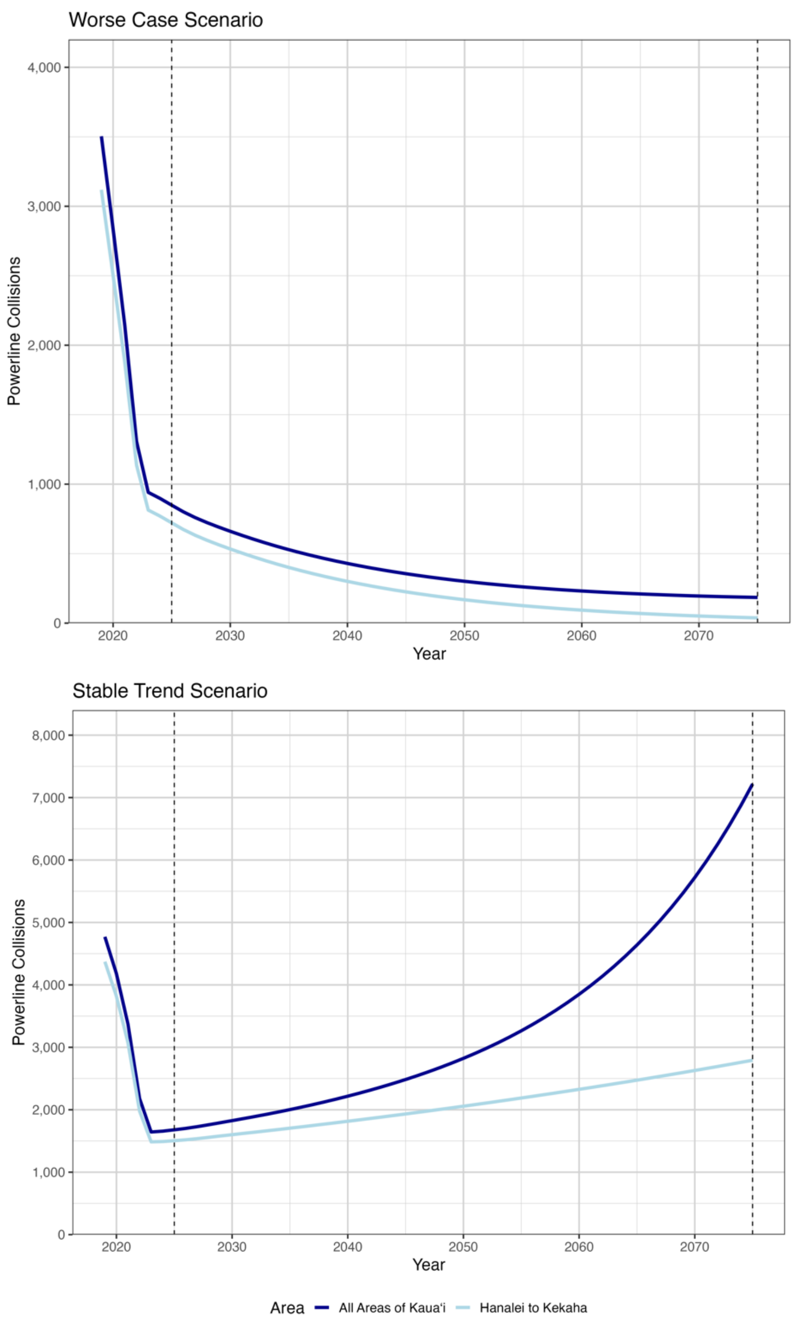


Figure 2. Projected future powerline collisions under the worse case scenario (top plot) and stable trend scenario (bottom plot).

Each plot shows the subset of collisions in the Hanalei to Kekaha area (light blue line) compared to total projected collisions across all areas combined (dark blue line). Note that pre-implementation minimization ramps up between 2020 and 2023, resulting in the rapid initial drop in collision rates for both scenarios. Starting in 2023, full minimization is implemented in the model and thereafter the trend in projected collisions tracks trends in abundance. Both scenarios are initialized assuming the estimate of annual unminimized collisions pertains to 2016 (the mid-year of the 2013–2019 data analyzed by Travers et al. 2020). Because the modeled trend in abundance differs between scenarios (e.g., see Figure 1), the trend in projected collisions through time also differs between scenarios.

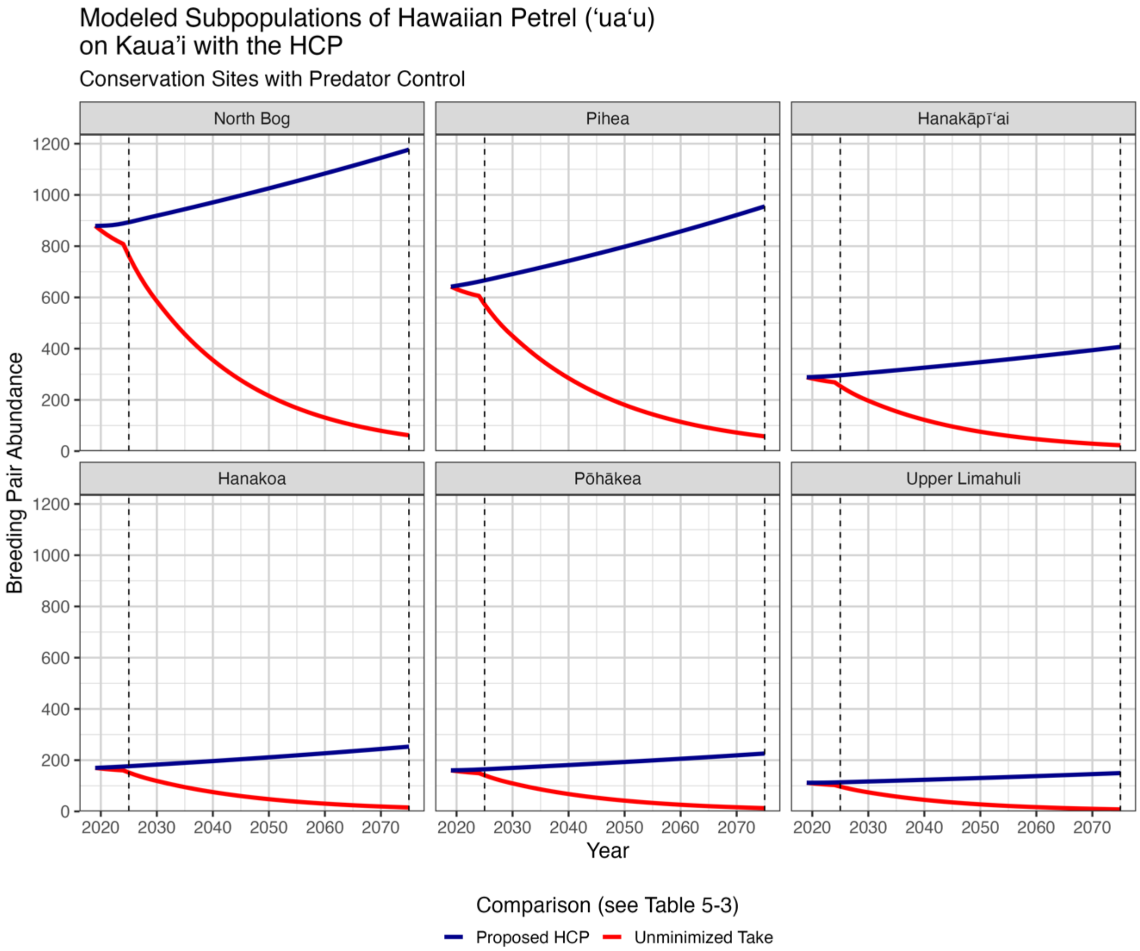


Figure 3a. Projections of breeding pair abundance at the conservation sites under the worse case scenario.

Each of the conservation site projections are initialized from the minimum estimate of 2021 breeding pair abundance at each conservation site (Raine et al. 2022). The results assume there is no density dependence (carrying capacity) outside the predator exclusion fences. The scales differ between the top and plot's y-axes in Figures 3a and 3b.

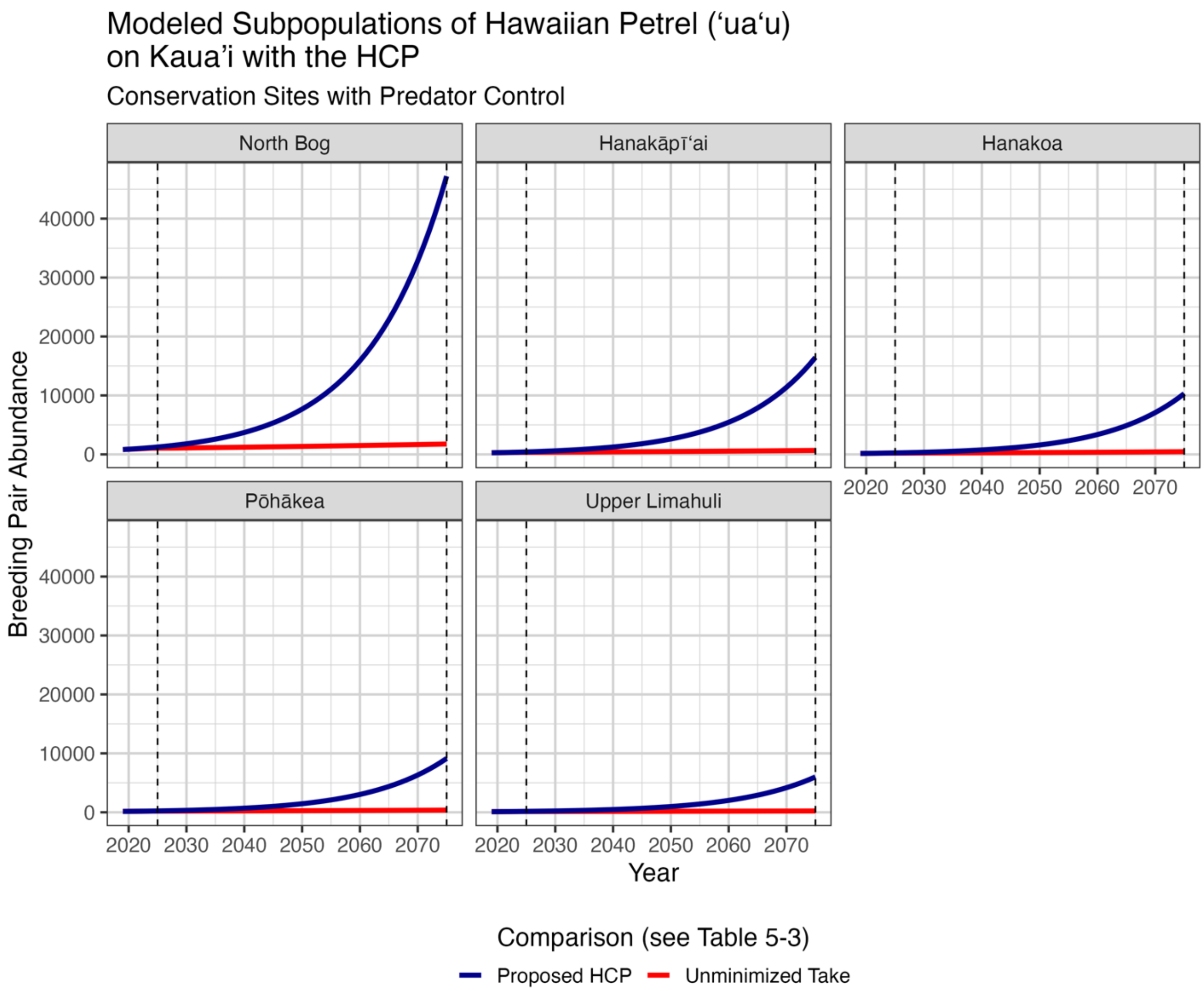
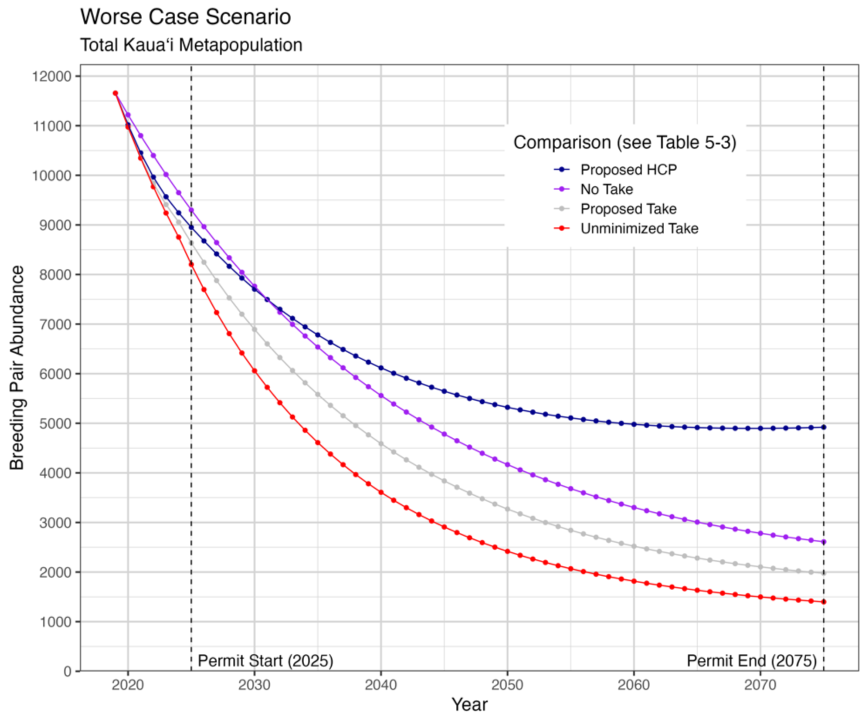


Figure 3b. Projections of breeding pair abundance at the conservation sites under the stable trend scenario.

Each of the conservation site projections are initialized from the minimum estimate of 2021 breeding pair abundance at each conservation site (Raine et al. 2022). The results assume there is no density dependence (carrying capacity) outside the predator exclusion fences. The scales differ between the top and plot's y-axes in Figures 3a and 3b.



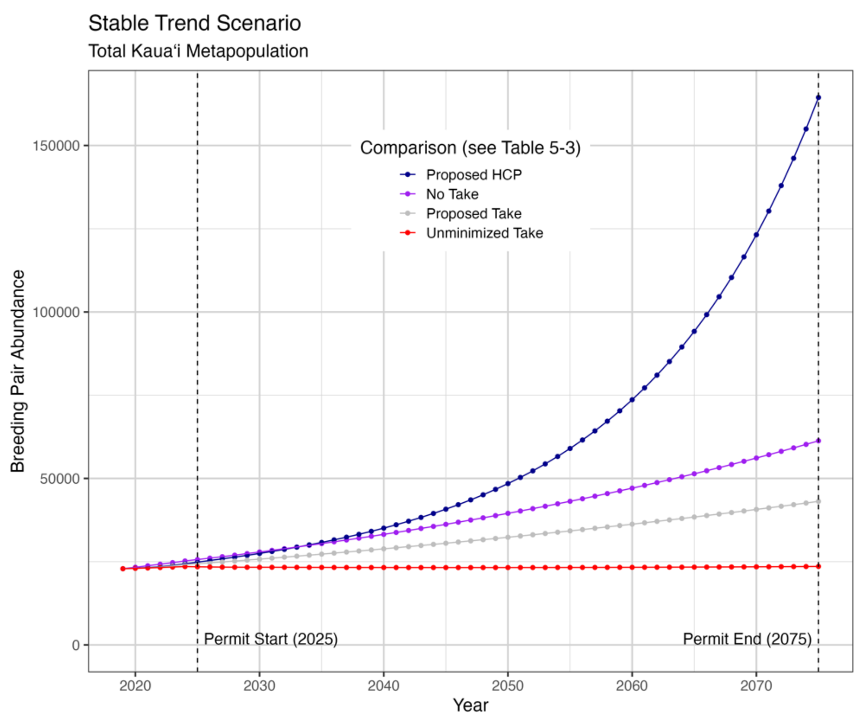


Figure 4. Kauaʻi metapopulation comparison projections are shown for the worse case (top plot) and stable trend scenarios (bottom plot).

Scales on the y-axes differ between worse case and stable trend scenario plots.

Model Limitations, Uncertainties, and Assumptions

Similar to the worse-case scenario, the stable trend scenario of the population dynamics model includes assumptions that may result in overly conservative or overly optimistic outcomes. In practical terms, this means that the model may overestimate or underestimate the impacts of the covered activities on Hawaiian petrel (ʻuaʻu), or underestimate or overestimate the benefits of the conservation strategy for Newell's shearwater (ʻuaʻu), or possibly both. This section describes cases in which model assumptions may be overly conservative or overly optimistic for the stable trend scenario. Many of these reasons are shared with the worse-case scenario (see Section 5E.4, *Model Limitations, Uncertainties, and Assumptions*, for a summary of factors related to the worse-case scenario).

Conservative Assumptions

The population dynamics model with the stable trend scenario may be overly conservative for the following reasons.

- **Total powerline strikes.** Total powerline strikes are statistically higher (i.e., more conservative) level of powerline collisions in the model than would be expected from the data. This factor applies to both population dynamics model scenarios because the assumptions of powerline collision risk across the island are the same in both scenarios. See the worse-case scenario explanation in Section 5E.4.1.1, *Conservative Assumptions*, for more details.
- **Strike allocation.** Allocation of powerline strikes may be even lower at some or all of the conservation sites than estimated, given flight paths, and observed altitudes from satellite tagging. This factor applies to both population dynamics model scenarios because assumptions of powerline collision risk in each of the 17 subpopulations are the same in each scenario. See the worse-case scenario explanation in Section 5E.4.1.1 for more details.
- **Social attraction.** Assumptions of the benefits of social attraction may be conservative and may underestimate the benefits to the species. This factor applies to both population dynamics model scenarios because assumptions of rates of social attraction are the same in each scenario. See the worse-case scenario explanation in Section 5E.4.1.1 for more details.
- **Conservation actions by others.** In both scenarios, the population dynamics of the Kauaʻi metapopulation of Hawaiian petrel (ʻuaʻu) are modeled only assuming the full implementation of this HCP's conservation strategy. No other conservation actions performed by others are assumed to benefit Hawaiian petrel (ʻuaʻu). See the worse-case scenario explanation in Section 5E.4.1.1, as well as Table 5E-14, for more details.

Potentially Optimistic Assumptions

The population dynamics model for Hawaiian petrel (ʻuaʻu) using the stable trend scenario may be too optimistic (i.e., underestimate adverse effects or overstate benefits) for the following reasons.

- **Total metapopulation size.** The estimate of the island-wide metapopulation may be too high, despite the integration of multiple independent data sources, and what are otherwise thought to be conservative assumptions by experts (e.g., using the estimates of minimum abundance for the conservation sites and other areas not surveyed by radar). If this is true, then impacts of the taking would be greater than predicted by the model. However, all else being equal, the *relative* effects of the HCP would be the same because model comparisons are made with and without the HCP using the same initial abundance estimate and estimates of trends in relative abundance (e.g., Figure 5-3b). This factor applies to both population dynamics model scenarios. See the worse-case scenario explanation in Section 5E.4.1.1 for more details.

- **Cat predation events.** The predation mortality rates used in the model under both scenarios are based on burrow monitoring data from multiple conservation sites over multiple years. The resulting estimate represents an average annual predation mortality rate under predator control that includes punctuated predation mortality events due to single cats. If the estimated predation mortality rate from burrow monitoring surveys does not fully capture the extent or frequency of these rare predation events from single cats, the model results with respect to the benefits of predator control at the conservation sites would be optimistic. However, independent acoustic monitoring data indicate that at least since 2014/2015, the extent of punctuated cat predation events has not resulted in negative trends in recruitment into the breeding colonies at the conservation sites. This factor applies to both population dynamics model scenarios because assumptions of predation rates are the same in each scenario. See the worse-case scenario explanation in Section 5E.4.1.1 for more details.
- **Carrying capacity.** Social attraction sites inside predator exclusion fenced sites are modeled using estimates of carrying capacity for the number of breeding pairs that could nest in these areas. These sites are relatively small and available nesting habitat is well defined by the fenced perimeter. Additionally, the rate of increase in breeding pairs in these areas is assumed to be relatively high after 10 years, given the expected number of new immigrants attracted to these areas once they reach a critical mass (Table 5E-9). Therefore, it is likely that one or more of these social attraction site will reach carrying capacity of breeding pairs during the permit term. The model assumes that any additional breeding pairs (i.e., through continued immigration or internal recruitment) will "spillover" from the social attraction site into the larger surrounding conservation site. Carrying capacities are not assumed for the larger conservation sites.

This factor applies to both population dynamics model scenarios. However, this is a larger issue for the stable trend scenario because of the higher rate of population growth modeled in the conservation sites with the stable trend assumptions. The issue of carrying capacity for the stable trend scenario is discussed earlier in this Attachment.

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Dilek Sahin and Afsheen Siddiqi have provided the radar index values through data sharing requests submitted to DOFAW.

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Appendix 6A
Adaptive Management Comparison Tables

The tables in this appendix represent projected 5-year rolling averages of powerline collisions (Tables 6A-1 and 6A-2) and breeding pair abundance at the conservation sites (Tables 6A-3 and 6A-4). Data in these tables are intended to be used in the adaptive management process. The starting year for all tables is 2029 because data from the first 5 years of the permit term (2025–2029) will comprise the first 5-year rolling averages.

Table 6A-1. Newell's Shearwater ('a'o) Powerline Collisions: Projected 5-year Rolling Averages Based on Stable Trend Scenario

year	5-yr ave.	year	5-yr ave.	year	5-yr ave.	year	5-yr ave.	year	5-yr ave.
2029	3,979	2039	4,838	2049	5,896	2059	7,283	2069	9,179
2030	4,054	2040	4,932	2050	6,017	2060	7,446	2070	9,408
2031	4,136	2041	5,029	2051	6,143	2061	7,614	2071	9,645
2032	4,221	2042	5,128	2052	6,271	2062	7,788	2072	9,891
2033	4,306	2043	5,229	2053	6,404	2063	7,967	2073	10,147
2034	4,391	2044	5,333	2054	6,540	2064	8,152	2074	10,413
2035	4,478	2045	5,440	2055	6,680	2065	8,343	2075	10,689
2036	4,565	2046	5,549	2056	6,824	2066	8,541		
2037	4,654	2047	5,662	2057	6,973	2067	8,747		
2038	4,745	2048	5,777	2058	7,126	2068	8,959		

Table 6A-2. Hawaiian Petrel ('ua'u) Powerline Collisions: Projected 5-year Rolling Averages Based on Stable Trend Scenario

year	5-yr ave.	year	5-yr ave.	year	5-yr ave.	year	5-yr ave.	year	5-yr ave.
2029	1,733	2039	2,085	2049	2,613	2059	3,485	2069	5,043
2030	1,762	2040	2,128	2050	2,681	2060	3,602	2070	5,260
2031	1,794	2041	2,173	2051	2,752	2061	3,726	2071	5,490
2032	1,826	2042	2,220	2052	2,828	2062	3,857	2072	5,736
2033	1,860	2043	2,268	2053	2,907	2063	3,997	2073	5,999
2034	1,894	2044	2,319	2054	2,990	2064	4,146	2074	6,279
2035	1,929	2045	2,373	2055	3,079	2065	4,304	2075	6,579
2036	1,966	2046	2,429	2056	3,172	2066	4,472		
2037	2,004	2047	2,487	2057	3,270	2067	4,650		
2038	2,044	2048	2,549	2058	3,374	2068	4,841		

Table 6A-3. Newell's Shearwater (ʻaʻo) Breeding Pairs at All Conservation Sites Combined: Projected 5-year Rolling Averages[1] Based on Worse-Case Scenario

year	5-yr ave.	Year	5-yr ave.	year	5-yr ave.	year	5-yr ave.	year	5-yr ave.
2029	1,372	2039	1,766	2049	2,316	2059	2,981	2069	3,790
2030	1,395	2040	1,820	2050	2,375	2060	3,056	2070	3,877
2031	1,418	2041	1,873	2051	2,435	2061	3,133	2071	3,965
2032	1,447	2042	1,926	2052	2,496	2062	3,211	2072	4,053
2033	1,480	2043	1,979	2053	2,558	2063	3,291	2073	4,143
2034	1,515	2044	2,033	2054	2,623	2064	3,371	2074	4,233
2035	1,558	2045	2,088	2055	2,690	2065	3,453	2075	4,324
2036	1,607	2046	2,144	2056	2,760	2066	3,536		
2037	1,658	2047	2,201	2057	2,832	2067	3,619		
2038	1,711	2048	2,258	2058	2,906	2068	3,704		

Table 6A-4. Hawaiian Petrel (ʻuaʻu) Breeding Pairs at All Conservation Sites Combined: Projected 5-year Rolling Averages[1] Based on Worse-Case Scenario

year	5-yr ave.	year	5-yr ave.	year	5-yr ave.	year	5-yr ave.	year	5-yr ave.
2029	2,340	2039	2,493	2049	2,655	2059	2,827	2069	3,011
2030	2,355	2040	2,508	2050	2,671	2060	2,845	2070	3,030
2031	2,370	2041	2,524	2051	2,688	2061	2,863	2071	3,050
2032	2,385	2042	2,540	2052	2,705	2062	2,881	2072	3,069
2033	2,400	2043	2,556	2053	2,722	2063	2,899	2073	3,088
2034	2,415	2044	2,572	2054	2,740	2064	2,918	2074	3,108
2035	2,431	2045	2,589	2055	2,757	2065	2,936	2075	3,128
2036	2,446	2046	2,605	2056	2,774	2066	2,955		
2037	2,461	2047	2,621	2057	2,792	2067	2,974		
2038	2,477	2048	2,638	2058	2,809	2068	2,992		

[1] These tables are not equivalent to Tables 5D-11 and 5E-10, which have snapshots of breeding pair abundances instead of 5-year rolling averages.

Appendix 6B

KIUC Site Monitoring Protocols and Procedures for Protected Seabirds

KIUC

Site Monitoring Protocols & Procedures for Protected Seabirds



Table of Contents

Section 1
Introduction & Site Monitoring (Electronic Inspection Log)

INTRODUCTION

KIUC has developed a variety of support materials to assist its employees in executing the requirements of site monitoring, recovery, and reporting of protected seabirds that are found downed, injured, or dead at KIUC facilities. This manual includes information and guidance about the following:

1. Site monitoring protocol for all KIUC personnel
2. Threatened and endangered seabird species
3. Recovery and reporting process when dealing with a downed, injured, or dead seabird
4. KIUC Oppenheimer Seabird Recovery Kit
5. Location of SOS Aid Stations

SITE MONITORING

ALL PERSONNEL will report any downed seabirds they encounter during their daily work routine immediately to the Operations Shift Supervisor/Designee or Warehouse Supervisor/Designee for recovery and reporting.

DESIGNEE FOR EACH RESPECTIVE FACILITY shall watch for downed seabirds as they conduct their routine plant inspections throughout the year.

During the seabird fallout season (September 15 - December 15), searches targeted specifically at finding downed seabirds will be conducted as per the table in Figure 1, 7 days a week. The results of daily inspections conducted during the seabird season shall be recorded on the Electronic Seabird Weekly Inspection Log (see next page). Any downed seabirds shall be recovered and reported following the established protocols detailed in the KIUC Seabird Recovery Reporting Form under Section 3 of this manual. **In the event that a scheduled search cannot be conducted due to an operational emergency, the Operations Shift Supervisor or Designee will conduct the survey as soon as possible. A notation should be made on the inspection log accordingly.**

Figure 1:

	FREQUENCY		
FACILITY	**3 to 4 hours after sunset**	**1 hour before sunrise**	**weekends & holidays**
PAGS	X	X	x*
Kapaia GS	X	X	

** note : On Saturdays, Sundays and company holidays, PAGS will conduct an additional search for downed seabirds between 7:00 AM and 8:00 AM.*

ELECTRONIC SEABIRD INSPECTION LOG

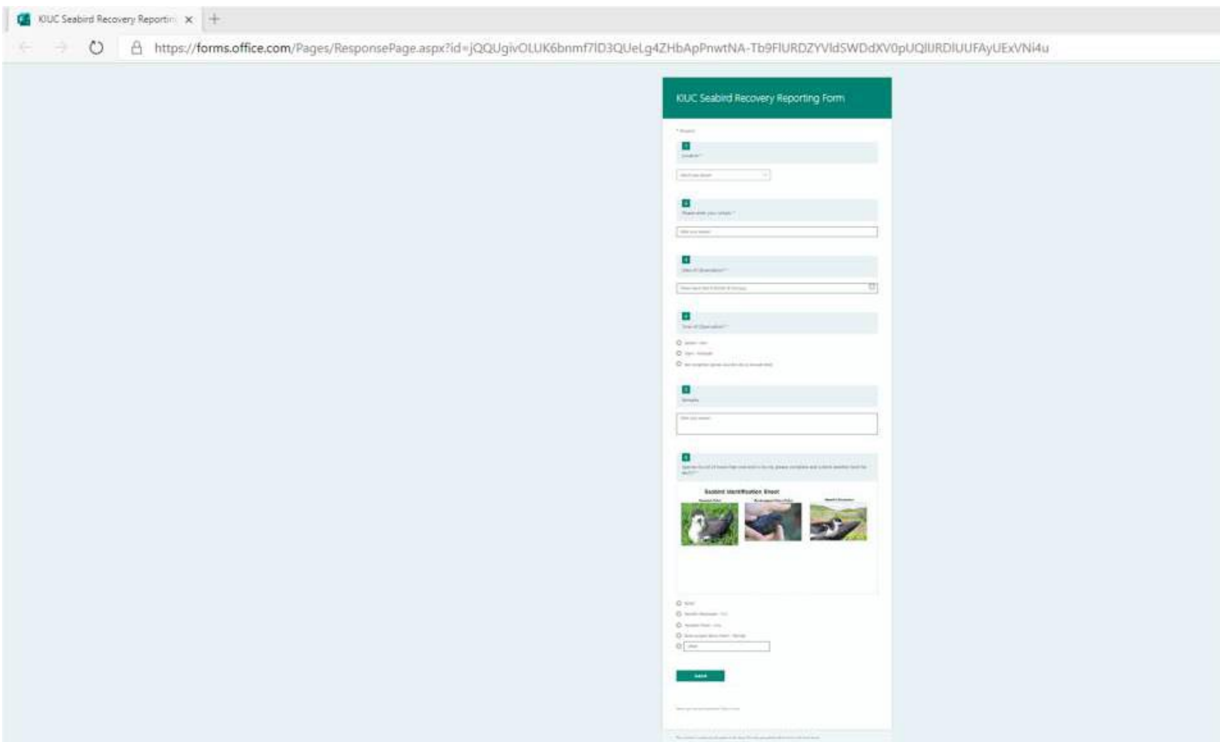
KIUC has developed an electronic inspection log to make the process more efficient. Using Microsoft Forms and the below link, anyone can get to and submit an inspection using a desktop computer, smart phone, or tablet.

Link to the electronic seabird inspection log can be found here:

[KIUC Seabird Recovery Reporting Form]

or by copy/paste the below into your browser:

https://forms.office.com/Pages/ResponsePage.aspx?id=jQQUgivOLUK6bnmf7lD3QUeLg4ZHbApPnwtNA-Tb9FlURDZYVldSWDdXV0pUQllJRDlUUFAyUExVNi4u



Please coordinate with your team to ensure your inspection frequencies are met for your respective facility. If ever in doubt if an inspection occurred or not, it's best to submit oneagain anyway (better to double up rather than missing an inspection).

A weekly report will be run and distributed to the teams so all submissions to date can be reviewed, corrected, and/or actioned. Please contact Chris Yuh for any issues or questionsabout the form (cyuh@kiuc.coop; 808-246-8281; 808-679-2388).

As a last resort backup, the paper documents from previous seasons can be found in Section 6.

Section 2

Protected Seabird Species

PROTECTED SEABIRD SPECIES

Why is KIUC taking special precautions with respect to protected seabirds?

KIUC's electrical transmission and distribution system is largely above ground and consists of poles and wires that extend from 25 to more than 100 feet above ground. The overhead wires andpoles occupy airspace through which birds fly, and collisions between birds and these facilities have been reported. Covered facilities, which include the Port Allen and Kapaia Generating Stations, are of less concern, but there is potential for take.

In addition to collisions, urban lights, including KIUC's covered facility lights and streetlights KIUC owns and operates on behalf ofthe County of Kaua'i, State of Hawai'i, and private entities, can attract and/or disorient fledglingsof these species making their first flights to sea. Birds that become disoriented by these lights canexhaust themselves by flying around the lighted areas before eventually landing, and can also collide with obstacles such as power lines, utility poles, buildings, and other tall structures. The protected seabirds have very limited ability to resume flight from flat surfaces, therefore once on the ground they are highly subject to predation by dogs, cats, and other mammals, and to injury and death by vehicles, other human activity, or due to dehydration or starvation.

Studies indicate that KIUC's existing facilities have affected three species of seabirds that are protected by the Federal Endangered Species Act (ESA), the Hawai'i Endangered Species Act, and other federal and state laws and regulations. All three species are also listed by the State of Hawai'i as threatened or endangered species. The species are:

- the Federally listed endangered **Hawaiian Petrel** (*Pterodroma sandwichensis*);
- the Federally listed threatened **Newell's Shearwater** (*Puffinus newelli*); and
- the Federally listed endangered **Band-rumped Storm-Petrel** (*Oceanodroma castro*).

These species nest and breed in certain inland locations on the island but spend most of their livesat sea. They generally travel between land and sea during hours of darkness or near-darkness.

What are the legal implications?

There are significant legal implications if any of these birds are harmed, or the protected seabird protocols are not followed. Violations of the Federal ESA may include civil fines of up to $25,000per incident, and criminal fines of up to $50,000, and up to one year imprisonment per incident. Violations of the state law include fines of up to $10,000 per species, up to one year imprisonment,or both.

Why do the seabirds fallout/What happens to them if they do?

- Nocturnally flying seabirds can be attracted to lights. This is particularly true of fledglingbirds on their way to sea for the first time.
- The lights appear to confuse seabirds, leading them to collide with structures or simplycircle until they land on the ground too tired to continue flying.
- Once on the ground they cannot take off again and will die from starvation, dehydration orbe killed by predators if not rescued.

When is the seabird fallout season?

Adult seabirds arrive on the island as early as late March to find their mates and establish their nesting sites. These seabirds typically fly inland to their nests from sunset to about 3 hours after sunset and fly out to sea to forage for food during the 3 hours before sunrise. The potential for downings occurs during these flights. If downed, the seabirds will then attempt to seek places to hide at first light to escape from predators. Typical hiding places include under vegetation, in stairwells, under building materials, and under equipment including parked vehicles.

The vast majority of seabird fallout is by fledglings and occurs between September 15 and December 15 each year. However, adults and juveniles are typically present on Kaua‘i from mid-April onward.

Newell's Shearwater - ‘a‘o.

- Listed as a threatened species by both the U.S. and State of Hawai‘i
- Ninety percent (90%) of the population nests on Kaua‘i. Also breeds on Maui, Hawai‘i, and possibly Moloka‘i
- The Newell's Shearwater has an almost black head, upper wings and tail, and is white below. It has a thin narrow bill. Legs and feet are grey/black. Newell's are 12-14 incheslong, and have a wingspan of 30 inches.

Hawaiian Petrel - ‘u‘au.

- Listed as an endangered species by both the U.S. and State of Hawai‘i
- Breeding populations exist on Kaua‘i, Maui, Lana‘i, and Hawai‘i
- The Hawaiian Petrel has a dark gray head, wings, and tail, and a white forehead and belly.It has a stout grayish-black bill that is hooked at the tip. Its legs are pinkish with black andpink feet. This bird measures 16-17 inches in length and has a wing span of 35-37 inches.

Band-rumped Storm Petrel - ‘ake‘ake.

- Listed as an endangered species by both the U.S. and State of Hawai‘i
- Breeding populations exist on Kaua‘i, Lehua Island, Hawai‘i and possibly on Maui.
- The Band-rumped Storm-Petrel is an overall blackish-brown bird with an evenly-cut white rump band and slightly forked tail. It has a dark bill with a tube on top. This bird measures 8-9 inches in length and has a wing span of 17-18 inches.

Section 3

Seabird Recovery ReportingForm

ELECTRONIC SEABIRD RECOVERY REPORTING FORM

As part of this year's process improvements, the seabird recovery form can also be logged using our electronic form. Using Microsoft Forms and the below link, anyone can get to andsubmit a recovery form using a desktop computer, smart phone, or tablet.

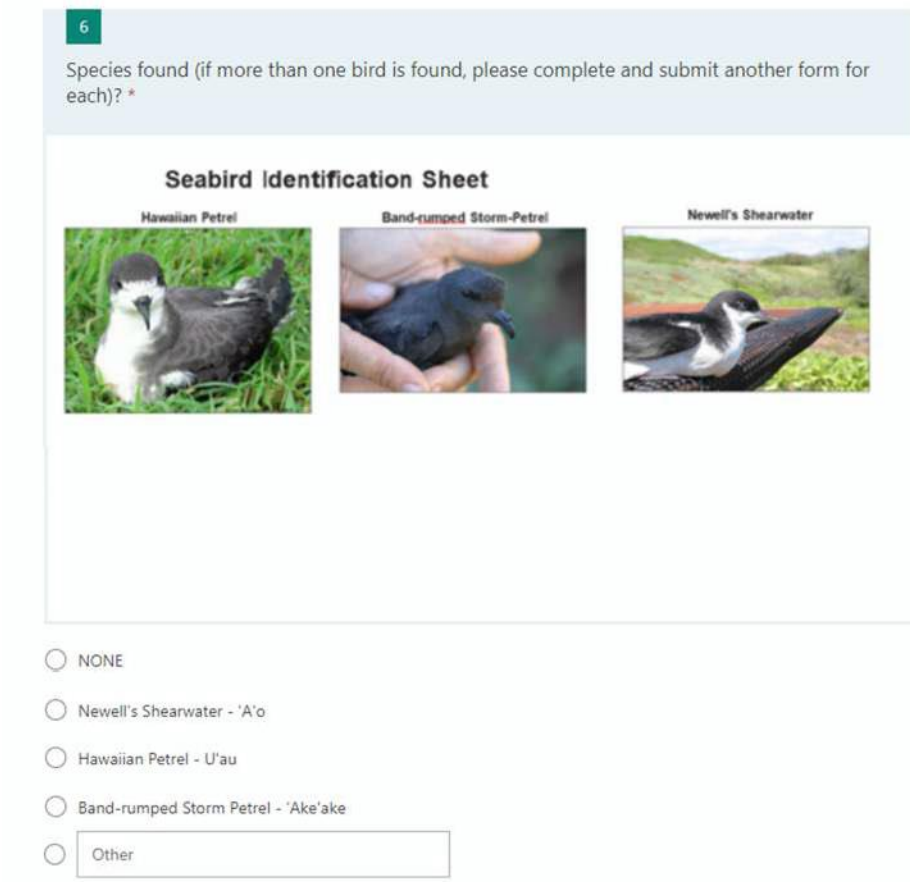
Link to the electronic seabird recovery form can be found using the SAME link to the seabird inspection log and found here:

KIUC Seabird Recovery Reporting Form

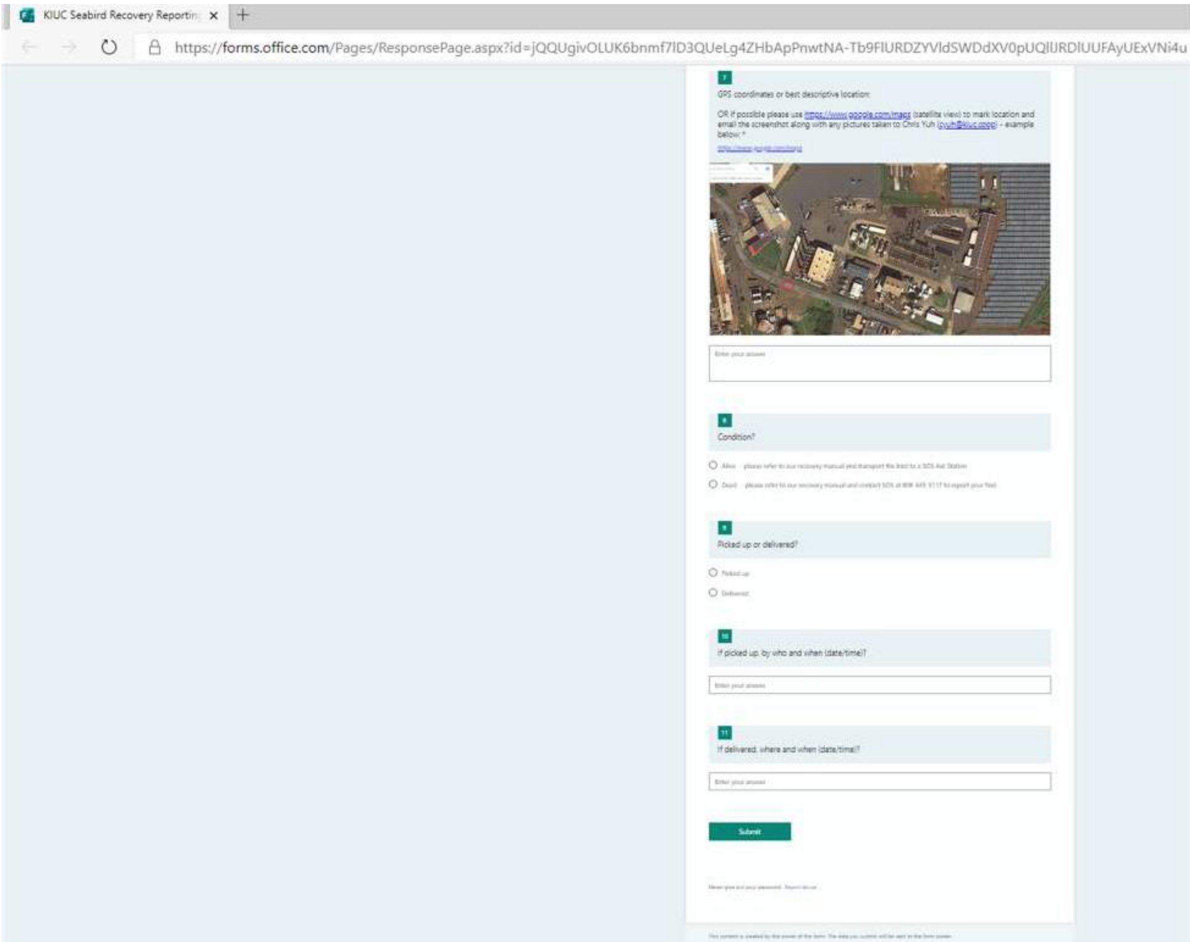
or by copy/paste the below into your browser:

https://forms.office.com/Pages/ResponsePage.aspx?id=jQQUgivOLUK6bnmf7lD3QUeLg4ZHbApPnwtNA-Tb9FlURDZYVldSWDdXV0pUQllJRDlUUFAyUExVNi4u

If your answer to question 6 is anything other than "NONE," then you will be prompted to fillout the electronic seabird recovery reporting form.



You will then be required to answer an additional set of questions regarding the endangeredspecies you found.



As a last resort backup, the paper documents from previous seasons can be found in Section 6.

If you encounter a living seabird:

1. Before touching the downed seabird take at least one photograph of the scene showing thebird as it was found.
2. If possible please use https://www.google.com/maps (satellite view) to mark location the mapand save the screenshot OR on the back side of the paper recovery reporting form, mark an "X" on the facility map to indicate where the seabird was found.
3. Deploy the KIUC Oppenheimer Seabird Recovery Kit.
4. Put on protective gloves.
5. Carefully wrap the bird in the clean towel from your kit and gently place it in the recovery box.
6. Transport the bird to the nearest SOS Aid Station.
7. Place the bird in the SOS Aid Station.
8. Call SOS at 635-5117 and report that seabird has been dropped off.
9. If seabird is dropped off after hours, leave a message with SOS providing all details andfollow-up with a telephone call during business hours.
10. Fill in the Shearwater Aid Station log and provide Chris Yuh's contact information.
11. Contact Chris Yuh (cyuh@kiuc.coop, 808-246-8281 or 808-679-2388).
12. Completely fill out the *Electronic KIUC Seabird Recovery Reporting Form* OR manually fill outthe paper version.
13. Submit all pictures, screenshots, and/or the paper reporting form to Chris Yuh.

If you encounter a dead seabird:

1. Take at least one photograph of the scene showing the carcass as it was found.
2. If possible please use https://www.google.com/maps (satellite view) to mark location the mapand save the screenshot OR on the back side of the paper recovery reporting form, mark an "X" on the facility map to indicate where the seabird was found.
3. Put on protective gloves.
4. Carefully place the carcass in two (2) Ziploc bags.
5. Place in refrigerator.
6. Contact SOS at 635-5117 and wait for further instructions (if after hours, leave a messagewith details and follow-up during business hours).
7. 7. Contact Chris Yuh (cyuh@kiuc.coop, 808-246-8281 or 808-679-2388).
8. Completely fill out the *Electronic KIUC Seabird Recovery Reporting Form* OR manually fill outthe paper version.
9. Submit all pictures, screenshots, and/or the paper reporting form to Chris Yuh.

Section 4

Contents of Oppenheimer Seabird Recovery Kit

CONTENTS OF OPPENHEIMER SEABIRD RECOVERY KIT

To assist KIUC employees in fulfilling the conditions of its permits, it is equipping all KIUC vehicles and designated facilities with a package of materials which will help them deal with casesof downed, injured or dead protected species. Known as an *Oppenheimer Seabird Recovery Kit*, this kit is kept in their service vehicles and at selected KIUC facilities for use by employees as needed. As part of the Seabird Protection Training Program, all KIUC employees have been trained in how to use the contents of the kit to help them follow policies and procedures regardingthe handling and reporting of downed, injured, or dead protected species they may encounter in the course of their duties.

Each *Oppenheimer Seabird Recovery Kit* includes the following five items:

- ***Folded Cardboard Carrier*.** This carrier is a collapsible cardboard box, approximately 18 inches long, 10 inches wide, and 12 inches deep. This is large enough to accommodate any of the Covered Species. It can be folded to allow for carrying in service vehicles and can be quickly deployed whenever necessary.
- ***Nitrile Gloves*.** A pair of Nitrile gloves, which are to be worn whenever a KIUC employee needs to handle a seabird. These gloves prevent contamination of the bird and protect the employee.
- ***Cloth Towel*.** A clean towel, such as a generic automotive cleanup towel, approximately 12 inches square. Once the employee has donned the Nitrile gloves, he/she may use this towel to gently wrap the bird and place it in the cardboard carrier described above. This helps prevent any further harm to the bird as it is transported to a recovery location.
- ***Seabird Recovery Reporting Form*.** This document is to be filled out by the KIUC employee(s) in the process of recovering a seabird. It contains fields for relevant information, such as the date,time, and location of the recovery, as well as GPS coordinates, species, status at time of recovery(i.e. living or dead), and the person/organization to which the bird was delivered. The form also summarizes the procedure which the employee is to follow at the time of recovery and reporting.
- ***Seabird Identification Photographs*.** Correctly identifying seabirds can be challenging, and KIUC employees are not expected to be able to do so with total accuracy. To assist them in the sometimes difficult process of accurately reporting species information, photographs of the three threatened or endangered covered species (i.e., Newell's Shearwater, Hawaiian Petrel, and Band-rumped Storm-Petrel) have been included on the back side of the *Seabird Recovery Reporting Form*. Detailed information is also located in this manual under the "Protected Seabird Species" section.

  It is suggested that the items listed above are inserted into the collapsed carrier and then kept in a plastic trash bag for ease of storage in service vehicles and to keep them clean and free of any possible contaminants.
- ***Ziploc Bags*.** Two 2-gallon-sized Ziploc bags are to be used in the event a dead seabird is found at the facility. Thedouble-bagged carcass should then be placed into a refrigerator until further instructions are received from SOS.

Section 5
SOS Aid Stations

SOS AID STATIONS

After initiating the proper recovery procedures, the downed seabird can be transported to one of the SOS Aid Stations located below:

North Hanalei Fire Station Hanalei Liquor Store North Shore Pharmacy Parking Lot *(formerly N.Shore Medical Center)*	**Central-East** Kaiʻakea Fire Station Kapaʻa Fire Station Kauaʻi Humane Society Līhuʻe Fire Station
West Hanapēpē Fire Station Kalāheo Fire Station Port Allen Chevron Waimea Fire Station	**South** Koloa Fire Station

Contact Number for SOS: 635-5117

Photograph of SOS Aid Station

Section 6
Backup Paper Docs

2020 Seabird Fallout Season

KIUC Facility Site Monitoring - Weekly Inspection Log

Facility: **Week Starting:** ________________________ **Week Ending:** _______________________

		DATE	INSPECTION DONE BY	START TIME	BIRDS FOUND (Y/N)*	ALIVE / DEAD	IF YES, LOCATION
Monday	1 hour before sunrise						
	3-4 hours after sunset						
Tuesday	1 hour before sunrise						
	3-4 hours after sunset						
Wednesday	1 hour before sunrise						
	3-4 hours after sunset						
Thursday	1 hour before sunrise						
	3-4 hours after sunset						
Friday	1 hour before sunrise						
	3-4 hours after sunset						
Saturday	1 hour before sunrise						
	3-4 hours after sunset						
Sunday	1 hour before sunrise						
	3-4 hours after sunset						

* If a seabird is found, immediately follow established protocol specified on the ***KIUC Seabird Recovery Reporting Form***.

IF A SCHEDULED SEARCH CANNOT BE CONDUCTED DUE TO AN OPERATIONAL EMERGENCY, PLEASE NOTE ON LOG.

KIUC SEABIRD RECOVERY REPORTING FORM

DATE:		**TIME:**		**RESPONDER:**	
LOCATION:					
GPS LOCATION:					
SPECIES:					**ALIVE / DEAD**
PHOTO REFERENCE #S:					
AGENCY PICKUP – WHO:					
PICK UP OR DELIVERY:					
IF DELIVERY WHERE:					
REMARKS:					

If you encounter a living seabird:

1. Before touching the downed seabird take at least one photograph of the sceneshowing the bird as it was found.
2. If possible please use https://www.google.com/maps (satellite view) to mark locationthe map and save the screenshot OR on the back side of the paper recovery reporting form, mark an “X” on the facility map to indicate where the seabird was found.
3. Deploy the KIUC Oppenheimer Seabird Recovery Kit.
4. Put on protective gloves.
5. Carefully wrap the bird in the clean towel from your kit and gently place it in therecovery box.
6. Transport the bird to the nearest SOS Aid Station.
7. Place the bird in the SOS Aid Station.
8. Call SOS at 635-5117 and report that seabird has been dropped off.
9. If seabird is dropped off after hours, leave a message with SOS providing all detailsand follow-up with a telephone call during business hours.
10. Fill in the Shearwater Aid Station log and provide Chris Yuh’s contact information.
11. Contact Chris Yuh (cyuh@kiuc.coop, 808-246-8281 or 808-679-2388).
12. Completely fill out the *Electronic KIUC Seabird Recovery Reporting Form* ORmanually fill out the paper version.
13. Submit all pictures, screenshots, and/or the paper reporting form to Chris Yuh.

If you encounter a dead seabird:

1. Take at least one photograph of the scene showing the carcass as it was found.
2. If possible please use https://www.google.com/maps (satellite view) to mark locationthe map and save the screenshot OR on the back side of the paper recovery reporting form, mark an “X” on the facility map to indicate where the seabird was found.
3. Put on protective gloves.
4. Carefully place the carcass in two (2) Ziploc bags.

5. Place in refrigerator (continued next page).
6. Contact SOS at 635-5117 and wait for further instructions (if after hours, leave amessage with details and follow-up during business hours).
7. Contact Chris Yuh (cyuh@kiuc.coop, 808-246-8281 or 808-679-2388).
8. Completely fill out the *Electronic KIUC Seabird Recovery Reporting Form* ORmanually fill out the paper version.
9. Submit all pictures, screenshots, and/or the paper reporting form to Chris Yuh.

SEABIRD IDENTIFICATION SHEET

Hawaiian Petrel

Band-rumped Storm-Petrel

Newell’s Shearwater

SOS Aid Station Locations

North
Hanalei Fire Station
Hanalei Liquor Store
North Shore Pharmacy
Parking Lot *(formerly N.Shore Medical Center)*

Central-East
Kaiʻakea Fire Station
Kapaʻa Fire Station
Kauaʻi Humane Society
Līhuʻe Fire Station

West
Hanapēpē Fire Station
Kalāheo Fire Station
Port Allen Chevron
Waimea Fire Station

South
Koloa Fire Station

Revised 11/2022

Kauaʻi Island Utility Cooperative

Appendix 7A

Cost Model

Kaua'i Island Utility Cooperative Habitat Conservation Plan
Cost Model

Prepared by ICF

Introduction

This model estimates the cost of implementing the Kaua'i Island Utility Cooperative (KIUC) Habitat Conservation Plan (HCP) in fulfillment of its terms and conditions. The goal of the cost model is to demonstrate that costs to KIUC over the 50-year HCP permit term have been reasonably and conservatively estimated in a manner that is transparent and reproducable. The table of contents, below, describes and links to each interconnected component of the model.

To briefly summarize the model design and function: The annual costs of the HCP are estimated within a series of distinct cost categories across the 50-year HCP permit term. Sources, assumptions, and calculations for estimating costs within each category are provided on the group of sheets listed under "HCP Implementation Cost Estimates," below. The model also recognizes costs incurred by KIUC for early implementation of certain conservation actions from 2020 through 2023, prior to issuance of the HCP permit, on the group of sheets listed under "Early Implementation Costs," below. Wherever possible, cost estimates are based on actual costs or detailed cost estimates for the same or similar activities that would be implemented for the HCP. Where this information was not available, cost were estimated based on reasonable assumptions and best professional judgement of the HCP preparation team. The sheets listed under "Assumptions and Parameters," below, identify global parameters and assumptions applied to the model. Certain fundamental assumptions and parameters can be updated dynamically throughout the model. Lastly, the sheets listed under "Summary Tables and Charts," below, draw from each individual cost category calculation sheet to present the aggregated costs of the HCP in tabular and graphic formats.

Chapter 7 of the HCP, "Plan Implementation," provides additional description of plan implementation and summary of HCP costs.

Table of Contents

Cost Summary Table

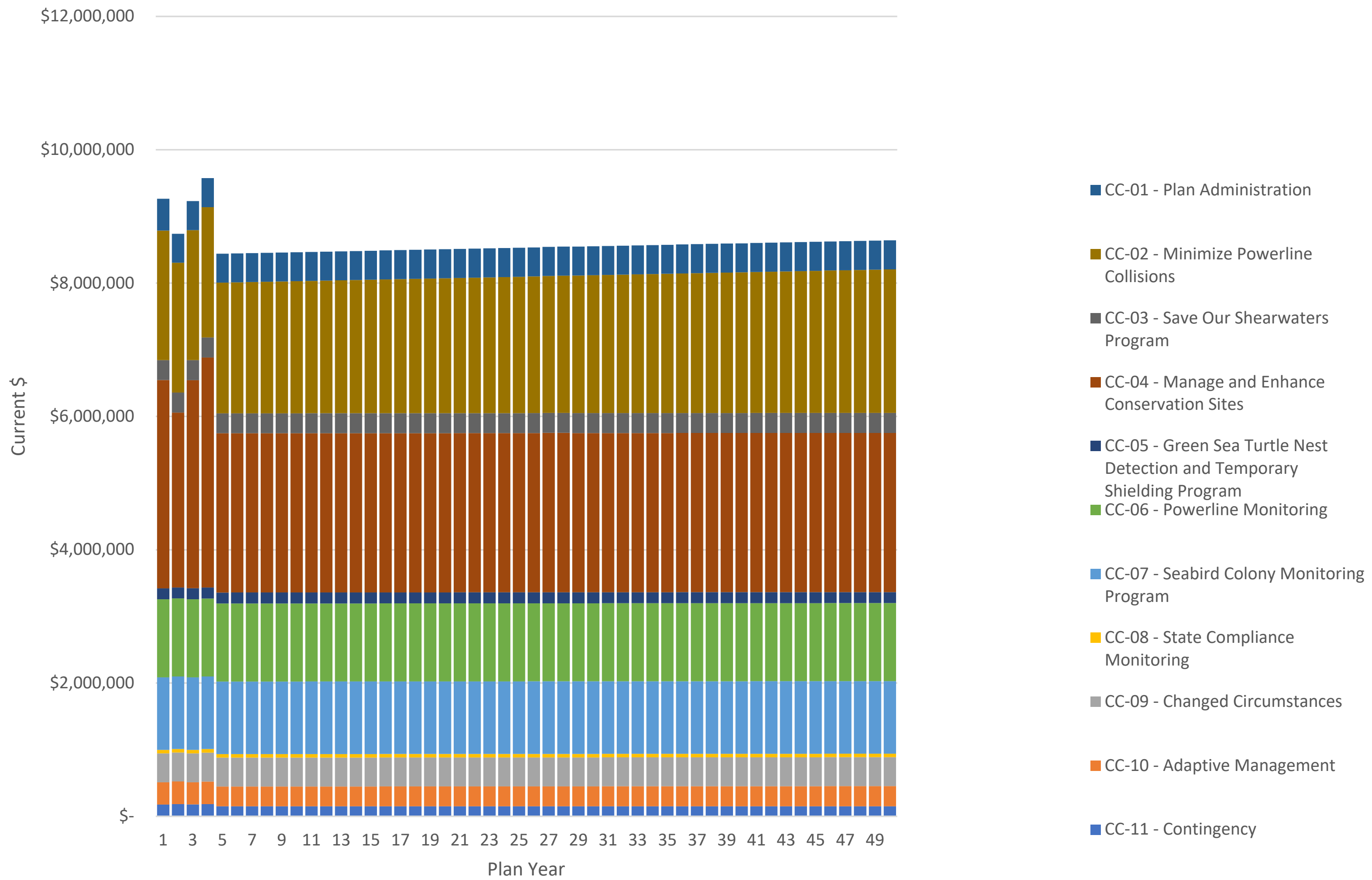
Table showing KIUC HCP implementation cost estimates by category and plan year

			Permit period (calendar years)															
Cost categories	**Avg. annual cost during permit period**	**Early implementation period: 2021–2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030–2034**	**2035–2039**	**2040–2044**	**2045–2049**	**2050–2054**	**2055–2059**	**2060–2064**	**2065–2069**	**2070–2074**	**50-year total**	**% of total cost by category**
Plan Administration	$435,685	N/A	$477,008	$434,842	$434,842	$434,842	$434,842	$2,174,210	$2,174,210	$2,174,210	$2,174,210	$2,174,210	$2,174,210	$2,174,210	$2,174,210	$2,174,210	$21,784,266	5.1%
Minimize Powerline Collisions	$2,048,769	$27,832,555	$1,943,136	$1,947,447	$1,951,759	$1,956,071	$1,960,382	$9,866,584	$9,974,373	$10,082,163	$10,189,952	$10,297,742	$10,405,531	$10,513,320	$10,621,110	$10,728,899	$102,438,469	23.8%
Save Our Shearwaters Program	$300,000	$1,639,598	$300,000	$300,000	$300,000	$300,000	$300,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$15,000,000	3.5%
Manage and Enhance Conservation Sites	$2,442,480	$6,829,735	$3,121,771	$2,622,619	$3,119,867	$3,448,682	$2,387,059	$11,935,295	$11,935,295	$11,935,295	$11,935,295	$11,941,620	$11,935,295	$11,935,295	$11,935,295	$11,935,295	$122,123,979	28.3%
Green Sea Turtle Nest Detection and Temporary Shielding Program	$166,913	N/A	$166,913	$166,913	$166,913	$166,913	$166,913	$834,565	$834,565	$834,565	$834,565	$834,565	$834,565	$834,565	$834,565	$834,565	$8,345,650	1.9%
Powerline Monitoring	$1,169,795	$4,240,540	$1,169,795	$1,169,795	$1,169,795	$1,169,795	$1,169,795	$5,848,977	$5,848,977	$5,848,977	$5,848,977	$5,848,977	$5,848,977	$5,848,977	$5,848,977	$5,848,977	$58,489,770	13.6%
Seabird Colony Monitoring Program	$1,088,034	$3,783,729	$1,088,034	$1,088,034	$1,088,034	$1,088,034	$1,088,034	$5,440,169	$5,440,169	$5,440,169	$5,440,169	$5,440,169	$5,440,169	$5,440,169	$5,440,169	$5,440,169	$54,401,693	12.6%
State Compliance Monitoring	$52,708	N/A	$52,708	$52,708	$52,708	$52,708	$52,708	$263,540	$263,540	$263,540	$263,540	$263,540	$263,540	$263,540	$263,540	$263,540	$2,635,405	0.6%
Changed Circumstances	$433,510	N/A	$433,510	$433,510	$433,510	$433,510	$433,510	$2,167,548	$2,167,548	$2,167,548	$2,167,548	$2,167,548	$2,167,548	$2,167,548	$2,167,548	$2,167,548	$21,675,483	5.0%
Adaptive Management	$318,974	N/A	$352,650	$325,400	$350,370	$366,919	$313,945	$1,571,343	$1,574,038	$1,576,733	$1,579,427	$1,582,438	$1,584,817	$1,587,512	$1,590,206	$1,592,901	$15,948,699	3.7%
Contingency	$163,795	N/A	$189,910	$169,987	$189,920	$203,116	$160,694	$804,117	$805,195	$806,273	$807,351	$808,681	$809,506	$810,584	$811,662	$812,740	$8,189,736	1.9%
Total	**$8,620,663**	**$44,326,157**	**$9,295,435**	**$8,711,256**	**$9,257,719**	**$9,620,589**	**$8,467,882**	**$42,406,349**	**$42,517,911**	**$42,629,473**	**$42,741,035**	**$42,859,491**	**$42,964,159**	**$43,075,721**	**$43,187,283**	**$43,298,845**	**$431,033,150**	**100.0%**
																	$269,692,364.15	
																	$5,393,847.28	

Sources and notes: All costs are reported in current $ (year 2024). See individual cost category tabs for explanation of estimates.

Cost Summary Chart

Chart showing KIUC HCP implementation cost estimates by category and plan year



Sources and notes: All costs are reported in current $ (year 2024). See individual cost category tabs for explanation of estimates.

General Assumptions

Assumptions for plan start year, permit term, cost base year, and future inflation

Source $: Cost expressed in dollar value from year it was paid
Current $: Cost expressed in dollars adjusted for purchasing power based on annual Consumer Price Index data
It is assumed that all cost components will increase over time due to inflation. To simplify the presentation, all costs are expressed in current $ (year 2024), allowing comparisons between costs today and costs later in the permit term. KIUC will pay all costs associated with HCP implementation, including inflation, even if those costs are above the costs estimated here.

Plan start year	2025
Plan end year	2074
Permit term (years)	50
Current $ Year	2024
Inflation	

Plan year	Calendar year
	2024
1	2025
2	2026
3	2027
4	2028
5	2029
6	2030
7	2031
8	2032
9	2033
10	2034
11	2035
12	2036
13	2037
14	2038
15	2039
16	2040
17	2041
18	2042
19	2043
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29	2053
30	2054
31	2055
32	2056
33	2057
34	2058
35	2059
36	2060
37	2061
38	2062
39	2063
40	2064
41	2065
42	2066
43	2067
44	2068
45	2069
46	2070
47	2071
48	2072
49	2073
50	2074

Consumer Price Index Conversions

Historical consumer price index data used to convert costs to current dollars

CPI for All Urban Consumers (CPI-U)
Original Data Value

Series Id: CUURS49FSA0,CUUSS49FSA0
Not Seasonally Adjusted
Series Title: All items in Urban Hawaii, all urban consumers, not seasonally adjusted
Area: Urban Hawaii
Item: All items
Base Period: 1982-84=100
Years: 2010 to 2024
Link: BLS Table

Historical consumer price index (CPI) data used to convert costs from previous years (source $) to current $.

Source: U.S. Bureau of Labor Statistics. 2023. Accessed May 7, 2025.

■ = calculated by ICF
■ = add or replace with actual values when available

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	HALF1	HALF2	Annual Inflation Rate	Covert to current year cost
2010													234.869	233.822	235.916		144.845%
2011													243.622	241.902	245.342	3.727%	139.641%
2012													249.474	248.646	250.303	2.402%	136.366%
2013													253.924	253.202	254.646	1.784%	133.976%
2014													257.589	255.989	259.190	1.443%	132.070%
2015													260.165	257.848	262.482	1.000%	130.762%
2016													265.283	264.038	266.528	1.967%	128.239%
2017											274.346		272.014	270.738	273.290	2.537%	125.066%
2018	273.909		275.408		276.359		277.389		279.113		279.700		277.078	275.196	278.960	1.862%	122.780%
2019	279.005		280.263		282.271		281.928		282.106		282.248		281.585	280.666	282.503	1.627%	120.815%
2020	283.683		285.321		285.834		285.725		287.529		286.872		286.008	285.086	286.931	1.571%	118.947%
2021	287.634		290.361		296.559		298.820		301.891		302.332		296.818	292.475	301.161	3.780%	114.615%
2022	304.988		312.158		317.207		319.197		321.799		319.971		316.076	312.137	320.016	6.488%	107.631%
2023	320.790		322.608		323.708		325.836		328.905		331.428		322.718	322.718	329.190	2.101%	105.416%
2024	333.172		338.060		340.521		340.439		342.676		343.189		340.197	338.045	342.350	5.416%	100.000%
2025	346.772		346.816										340.197	338.045	342.350	0.000%	100.000%

References

List of references and specific assumptions supporting the cost model

Sheet Name	Subject	Cost Year(s)	Reference	Notes
EIC_Summary	Minimize powerline collisions	2020-2023	See notes.	See 'EIC_Summary' sheet.
EIC_Summary	Save our Shearwaters Program	2020	Save Our Shearwaters Program. 2023. Email correspondence between Dawn Huff (Joule Group, LLC) and Christopher Yuh (KIUC) between February 16, 2023 and February 22, 2023. File name: "SOS-Payments_2000-2023.pdf".	Values from table in February 16, 2023 email from Chris Yuh; however, $300,000 was used for 2023 per subsequent correspondence.
EIC_Summary	Manage and enhance conservation sites - Upper Lumahuli Preserve	2020	National Tropical Botanical Garden. 2020. 2020 Scope of Work: Predator/Weed Control in Upper Lumahuli Preserve. File name: "2020_KIUC_NTBG_SOW_FINAL.pdf".	2020 cost estimate of $529,805 for Upper Lumahuli Preserve is sum of 'Base Contract Total' in Table 1 ($441,459) and 'GRAND TOTAL' in Table 2 ($88,346). KIUC Contigency Fund amount ($17,500) not included.
EIC_Summary	Manage and enhance conservation sites - Hono O Nā Pali Natural Area Reserve	2020	Hallux Ecosystem Restoration LLC. 2020. 2020 Predator Control in Hono o Nā Pali Natural Area Reserve, Scope of Work. File name: "HER HONP NAR Predator 2020 SOW Final 02 13 2020.docx".	2020 cost estimate of $608,919 for three Hono O Nā Pali Natural Area Reserve sites (Pihea, Pōhākea, North Bog) is sum of 'HER Total' row of 'TOTAL' column on page 6 ($607,047) and 'KIUC Subtotal' row of 'TOTAL' column on page 7 ($1,872). KIUC Contigency Fund amount ($60,705) not included.
EIC_Summary	Manage and enhance conservation sites - Upper Lumahuli Preserve	2021	National Tropical Botanical Garden. 2021. 2021 Scope of Work: Predator/Weed Control in Upper Limahuli Preserve. File name: "2021_KIUC_NTBG_ULV_Budget.docx".	2021 cost estimate of $465,235 for Upper Lumahuli Preserve is sum of 'Base Contract Total' of $440,989 in Table 1 and 'GRAND TOTAL' of $24,246 in Table 2. KIUC Contigency Fund amount ($17,500) not included.
EIC_Summary	Manage and enhance conservation sites - Hono O Nā Pali Natural Area Reserve	2021	Archipelago Research and Conservation. 2021a. File name: "2021 HONP Predator Control budget draft.xlsx".	2021 cost estimate of $712,851 for predator control at three Hono O Nā Pali Natural Area Reserve sites (Pihea, Pōhākea, and North Bog) is sum of 'AA Batteries' rows ($1,612+$260) and 'HER Total' row ($710,979) of 'TOTAL' column on 'PK NB PH Only' sheet. 2021 cost estimate of $232,055 for predator control at two remaining sites (Hanakoa and Hanakāpīʻai) is sum of 'AA Batteries' rows ($1,040+$130) and 'HER Total' row ($230,885) of 'TOTAL' column on 'HPHO Breakout' sheet.
EIC_Summary	Manage and enhance conservation sites - Upper Lumahuli Preserve	2022	Hallux Ecosystem Restoration LLC. 2022. File name: "2022 KIUC Hallux All Projects Budget Draft 091421.xlsx".	2022 cost estimate of $492,555 for Upper Lumahuli Preserve predator and weed control is '2022 Base contract and one-time expenses Total' row on in Table 1 on PDF page 13.
EIC_Summary	Manage and enhance conservation sites - Hono O Nā Pali Natural Area Reserve	2022	Hallux Ecosystem Restoration LLC. 2022. File name: "2022 KIUC Hallux All Projects Budget Draft 091421.xlsx".	2022 cost estimate of $1,151,099 for predator control at five Hono O Nā Pali Natural Area Reserve sites (Pihea, Pōhākea, North Bog, Hanakoa, and Hanakāpīʻai) is 'Grand Total' row on sheet 'HONP'.
EIC_Summary	Manage and enhance conservation sites - Pōhākea PF	2022	Hallux Ecosystem Restoration LLC. 2022. File name: "2022 KIUC Hallux All Projects Budget Draft 091421.xlsx".	2022 cost estimate of $26,558 for predator control at Pōhākea PF is 'Grand Total' row on sheet 'Pohakea Fence Monitor-Response'.
EIC_Summary	Manage and enhance conservation sites - Pōhākea PF	2022	Archipelago Research and Conservation. 2022a. File name: "ARC Pohakea SAS site budget_2022.xlsx".	2022 cost estimate of $10,456 for social attraction at Pōhākea PF is 'Grand Total' row on sheet 'Sheet1'.
EIC_Summary	Manage and enhance conservation sites - Hono O Nā Pali Natural Area Reserve	2023	Hallux Ecosystem Restoration LLC. 2023. File name: "2023 KIUC Hallux All Projects Budget Draft 120822(1).xlsx".	2023 cost estimate of $1,199,533 for predator control at five Hono O Nā Pali Natural Area Reserve sites (Pihea, Pōhākea, North Bog, Hanakoa, and Hanakāpīʻai) is 'Grand Total' row on sheet 'HONP'.
EIC_Summary	Manage and enhance conservation sites - Upper Lumahuli Preserve	2023	National Tropical Botanical Garden. 2023. NTBG Scope of Work and Work Plan 2023 Budget. File name: "NTBG 2023 SOW and Workplan Budget.pdf".	2023 cost estimate of $612,431 for Upper Lumahuli Preserve is 'Base Contract Total' in Table 1. Contigency Fund amount ($20,000) not included.

References

List of references and specific assumptions supporting the cost model

Sheet Name	Subject	Cost Year(s)	Reference	Notes
EIC_Summary	Manage and enhance conservation sites - Honopū	2023	Hallux Ecosystem Restoration LLC. 2023. File name: "2023 KIUC Hallux All Projects Budget Draft 120822(1).xlsx".	2023 cost estimate of $1,199,533 for predator control at five Hono O Nā Pali Natural Area Reserve sites (Pihea, Pōhākea, North Bog, Hanakoa, and Hanakāpīʻai) is 'Grand Total' row on sheet 'HONP'.
EIC_Summary	IMMP	2020	Kauaʻi Endangered Seabird Recovery Project. 2020a. Underline Monitoring Project Scope of Work During CY 2020. File name: "Updated UMP SOW 03 23 2020 final.pdf".	2020 cost estimate of $132,810.12 is sum of 'GRAND TOTAL' row of 'Cost for 2020' column on PDF page 8 ($464,560) minus 'Contingency 10%' row (34,690), plus 'Grand Total' on PDF page 10 ($165,275).
EIC_Summary	IMMP	2021	Archipelago Research and Conservation. 2021b. File name: "ARC Budget_Seabird & UMP_2021_200825.xlsx".	2021 cost estimate of $1,052,500.63 from 'TOTAL' row of 'TOTAL' column on sheet 'Upper Honopu (Sep-Dec)'.
EIC_Summary	IMMP	2022	Archipelago Research and Conservation. 2022a. File name: "MASTER ARC Budget_Seabird & IMMP_2022.xlsx".	2022 cost estimate of $1,075,985 from 'GRAND TOTAL' row of 'Total Cost' column on sheet "Underline Monitoring Project'.
EIC_Summary	IMMP	2023	Archipelago Research and Conservation. 2023a. File name: "MASTER ARC Budget_2023_all combined to Dawn 220708.xlsx".	2023 cost estimate of $1,108,195.03 from 'GRAND TOTAL' row of 'Total Cost' column on sheet "IMMP'.
EIC_Summary	Seabird Colony Monitoring Program	2020	Kauaʻi Endangered Seabird Recovery Project. 2020b. Scope of Work for Monitoring Newell's Shearwater and Hawaiian Petrel in the Upper Mānoa Valley (UMV) During CY 2020. File name: "KESRP UMV Seabird SOW 2020 final.pdf".	2020 cost estimate of $60,364 for seabird colony monitoring at Upper Manoa Valley is 'GRAND TOTAL' row of 'Total' column ($65,493) minus 'Contingency (10%)' row ($5,129) on PDF page 8.
EIC_Summary	Seabird Colony Monitoring Program	2020	Kauaʻi Endangered Seabird Recovery Project. 2020c. Scope of Work for Monitoring Newell's Shearwater and Hawaiian Petrel in the Upper Limahuli (ULP) During CY 2020. File name: "KESRP ULP Seabird SOW 2020 final.pdf".	2020 cost estimate of $104,516 for seabird colony monitoring at Upper Lumahuli Preserve is 'GRAND TOTAL' row of 'Total' column ($111,647) minus 'Contingency 10%' row ($7,131) on PDF page 7.
EIC_Summary	Seabird Colony Monitoring Program	2020	Kauaʻi Endangered Seabird Recovery Project. 2020d. Scope of Work for Monitoring Newell's Shearwater and Hawaiian Petrel in the Hono o Nā Pali Natural Area Reserve (HNP) During CY 2020. File name: "KESRP HNP Seabird SOW 2020 final 03 02 2020.pdf".	2020 cost estimate of $186,209 for seabird colony monitoring at Hono O Nā Pali Natural Area Reserve is 'GRAND TOTAL' row of 'Total Cost' column ($198,250) minus 'Contingency (10%) row ($12,041) on PDF page 7.
EIC_Summary	Seabird Colony Monitoring Program	2021	Archipelago Research and Conservation. 2021b. File name: "ARC Budget_Seabird & UMP_2021_200825.xlsx".	2021 cost estimate of $976,918 for seabird colony monitoring at 7 conservation sites is 'GRAND TOTAL' row of 'Total Cost to KIUC' column on 'Seabird Monitoring - 7 sites' sheet.
EIC_Summary	Seabird Colony Monitoring Program	2022	Archipelago Research and Conservation. 2022a. File name: "MASTER ARC Budget_Seabird & IMMP_2022.xlsx".	2022 cost estimate of $971,275 for seabird colony monitoring at 7 conservation sites is 'GRAND TOTAL' row of 'Total Cost to KIUC' column on 'Seabird Monitoring - 7 sites' sheet.
EIC_Summary	Seabird Colony Monitoring Program	2022	Archipelago Research and Conservation. 2022b. File name: "ARC_Seabird Monitoring_Na Pali_2022.xlsx".	2022 cost estimate of $34,471.39 for seabird colony monitoring at Nā Pali Coast sites is 'Total' row of 'Total' column on 'Sheet 1'.
EIC_Summary	Seabird Colony Monitoring Program	2023	Archipelago Research and Conservation. 2023a. File name: "MASTER ARC Budget_2023_all combined to Dawn 220708.xlsx".	2023 cost estimate of $1,104,129 is sum of (1) 'GRAND TOTAL' row of 'Total Cost' column on sheet 'Seabird Monitoring - 8 sites' and (2) 'Total' row of 'Total' column on sheet 'Na Pali 20 rovers'.
EIC_Powerline Collisions	Number of Spans with Powerline Collision Minimization Projects Completed or Planned	2020-2023	ICF. 2023. File name: "KIUC-HCP_Minimization_07 06 2023.xlsx".	Minimization projects by span based on percent of strikes reduced as calculated by ICF in coordination with the Joule Group, which included inventory of KIUC's completed and planned minimization projects as of December 31, 2022.
EIC_Powerline Collisions	Average Cost per Span for Powerline Collision Minimization Activities	2020-2023	Yuh, Christopher. 2021a. Email from Christopher Yuh (Kauaʻi Island Utility Cooperative) to Torrey Edell (ICF) on February 18, 2021. File name: "Book 5.xlsx".	Estimated 30-year costs per span based on 'Assumptions' sheet for all minimization types except "Reconfiguration, Static wire removal," which is from 'Cost Assumptions' sheet. And "57kV removal, Static wire removal" is from separate source listed below.

References

List of references and specific assumptions supporting the cost model

Sheet Name	Subject	Cost Year(s)	Reference	Notes
EIC_Powerline Collisions	Average Cost per Span for Powerline Collision Minimization Activities	2020-2023	Yuh, Christopher. 2021b. File name: "Span by Span Minimization HCP Draft_4.19.2021.xlsx".	Estimated 30-year costs per span for "57kV removal, Static wire removal" from column L of 'CAMERON PLAY' sheet.
IC_Plan Administration	Plan Administration Costs	50-year permit term	See notes.	All plan administration cost assumptions developed through coordination between ICF and the Joule Group.
IC_Powerline Collisions	Average Cost per Span for Powerline Collision Minimization Activities	2020-2023	Yuh, Christopher. 2021a. Email from Christopher Yuh (Kaua'i Island Utillity Cooperative) to Torrey Edell (ICF) on February 18, 2021. File name: "Book 5.xlsx".	Estimated 30-year costs per span based on 'Assumptions' sheet for all minimization types except "Reconfiguration, Static wire removal," which is from 'Cost Assumptions' sheet. And "57kV removal, Static wire removal" is from separate source listed below.
IC_Powerline Collisions	Average Cost per Span for Powerline Collision Minimization Activities	2020-2023	Yuh, Christopher. 2021b. File name: "Span by Span Minimization HCP Draft_4.19.2021.xlsx".	Estimated 30-year costs per span for "57kV removal, Static wire removal" from column L of 'CAMERON PLAY' sheet.
IC_Powerline Collisions	New Diverter Installations per Plan Year	50-year permit term	Edell, Torrey. 2021. Email from Torrey Edell (ICF) to Dan Nally (ICF) on September 7, 2021. File name: "T-Edell_Pers-Comm_2021_0907.pdf".	Assumes 7 new spans per year beginning in 2023 would need reflective diverter installation. Applied separately referenced assumptions for cost per span (see "EIC_Powerline Collisions" sheet references).
IC_SOS Program	Funds contributed by KIUC annually	50-year permit term	Kaua'i Island Utility Cooperative. 2020. Email from Torrey Edell (ICF) to Dan Nally (ICF) on November 19, 2021. File name: "T-Edell_Pers-Comm_2020_1119.pdf".	KIUC committed to fund the SOS program at at $300,000 per year. The $300,000 annual contribution will be held constant until issuance of the 50-year permit, at which time the annual contribution will increase with an inflation index.
IC_Conservation Sites	Predator Control Costs - Upper Manoa Valley	50-year permit term	Hallux Ecosystem Restoration LLC. 2024. File name: "2024_KIUC_Hallux_Budget_Draft_070323.xlsx".	Annual predator control costs for UMV estimated based on 2024 budget. Annual cost assumed to be $15,000 lower after plan year 1 to account for initial setup costs for predator control at Upper Manoa Valley.
IC_Conservation Sites	Predator Control Costs - Upper Limahuli Preserve	50-year permit term	National Tropical Botanical Garden. 2023. NTBG Scope of Work and Work Plan 2023 Budget. File name: "NTBG 2023 SOW and Workplan Budget.pdf".	Estimated annual costs for predator control at Upper Limahuli Preserve using 2023 draft budget. Excluded contingency funds ($20,000), but assumed $15,000 annually for one-time expenses. Per communication with Dawn Huff (Joule Group), omitted costs primarily associated with weed control, including weed control coordinator, one field technician, $2,000 from GIS specialist budget, and half of training and safety budget.
IC_Conservation Sites	Predator Control Costs - Hono O Nā Pali Natural Area Reserve	50-year permit term	Hallux Ecosystem Restoration LLC. 2023. File name: "2023 KIUC Hallux All Projects Budget Draft 120822(1).xlsx".	Estimated annual costs for predator control at Hono O Nā Pali Natural Area Reserve using 2023 draft budget on sheet 'HONP'. Excluded 2023 one-time purchases and added line item for annual purchase/repair/replancement costs (assumed $15,000).
IC_Conservation Sites	Predator Control Costs - Honopū	50-year permit term	Hallux Ecosystem Restoration LLC. 2023. File name: "2023 KIUC Hallux All Projects Budget Draft 120822(1).xlsx".	Estimated annual cost for predator control at Honopū based on draft 2023 budget for on sheet 'Upper Honopu (Sep-Dec)'. Excluded 2023 one-time purchases and added line item for annual purchase/repair/replancement costs (assumed $2,000).
IC_Conservation Sites	Weed Control - All Sites Except Upper Manoa Valley	50-year permit term	Koke'e Resource Conservation Program. 2024. File name: "KRCP 2024 SOW_Pohakea_Honopu_07 07 2023.pdf".	Office & Overhead and Field Labor costs for Honopu and Pohakea used as basis for weed control estimate for all sites except Upper Manoa Valley.

References

List of references and specific assumptions supporting the cost model

Sheet Name	Subject	Cost Year(s)	Reference	Notes
IC_Conservation Sites	Predator Fence Installation Costs - Upper Manoa Valley and Upper Limahuli Preserve	2024-2027	Pono Pacific, LLC. 2023a. January 16, 2023. File name: "Pono Pacific Work Order #6 ULP PPF Construction 01 16 23- signed.pdf".	Estimated one-time costs (in 2023 $) for labor, equipment, subcontractors, and miscellaneous from PROJECT COST table on page 4 of PDF. For Upper Limahuli Preserve, 50% of these costs were assumed to occur in plan year 1. Remaining 50% were assumed to occur in plan year 2. Per discussion with Dawn Huff (Houle Group) on 1/3/23, Upper Limahuli Preserve costs are assumed to be a reasonable estimate for costs for fence installation at Upper Manoa Valley. UMV installation costs were divided in half between plan year 3 and plan year 4.
IC_Conservation Sites	Predator Fence Eradication Costs - Upper Manoa Valley and Upper Limahuli Preserve	2025, 2027	Young, L., and E. VanderWerf. 2016. Proposed Mammal Eradication Plan for Upper Limahuli and Upper Mānoa Valleys on Kaua`i, Hawai`i. August 2016. File name: "Young and VanderWerf ULP and UMV proposed eradication plans 16 Aug 2016.pdf".	Estimated one-time costs for predator eradication at Upper Limahuli Preserve based on 'High estimate' scenarios in Table 3 and Table 4. Values were adjusted from original source based on discussion with Dawn Huff (Joule Group) and 2024 cost estimates from contractors who would perform the work. Cost roughly scaled based on lenth of fencing. Predator eradication costs assumed to occur in plan year 2 for Upper Limahuli Preserve and plan year 4 for Upper Manoa Valley.
IC_Conservation Sites	Social Attraction Site Setup and Maintenance	50-year permit term	Archipelago Research and Conservation. 2024. File name: "MASTER ARC Budget 2024_all combined to Dawn 07 07 2023.xlsx".	Estimated one-time costs for social attraction site setup and soundsystem replacement at Upper Manoa Valley and Upper Limahuli Preserve using 2024 draft budget for Upper Limahuli Preserve. Social attraction setup would begin in plan year 2 for Upper Limahuli Preserve and plan year 3 for Upper Manoa Valley.
IC_Turtle Shielding	Nest Detection and Shielding Program Cost	50-year permit term	Archipelago Research and Conservation. 2023b. File name: "Turtle Survey Budget_KIUC HCP 2023 v2.xlsx".	Estimated annual costs for turtle work based on draft HCP.
IC_IMMP	IMMP	50-year permit term	Archipelago Research and Conservation. 2023a. File name: "MASTER ARC Budget_2023_all combined to Dawn 220708.xlsx".	Estimated annual costs based on sheet 'IMMP.' Assumed approximately $1,500 for other misc. annual equipment purchases.
IC_Colony Monitoring	Seabird Colony Monitoring Program Costs	50-year permit term	Archipelago Research and Conservation. 2023a. File name: "MASTER ARC Budget_2023_all combined to Dawn 220708.xlsx".	Estimated annual costs for 8 conservation sites based on sheet 'Seabird Monitoring - 8 sites.' Assumed $3,000 for other misc. annual equipment purchases. Assumes helicopter costs are covered under management and enhancement of conservation sites.
IC_Colony Monitoring	Seabird Colony Monitoring Program Costs	50-year permit term	Archipelago Research and Conservation. 2023a. File name: "MASTER ARC Budget_2023_all combined to Dawn 220708.xlsx".	Estimated annual costs for Nā Pali Coast sites based on sheet 'Na Pali 20 rovers.' Assumed $2,000 for other misc. annual equipment purchases.
IC_State Compliance	Endangered Species Monitoring Costs	50-year permit term	ICF. 2023. KIUC HCP. Chapter 7. Working draft as of August 2023.	KIUC has included a total of $50,000 annually to fund state monitoring to comply with HSR Chapter 195D, Section G.3. This amount is assumed to be sufficient for State compliance monitoring of KIUC's implementation of the HCP considering that accessibility to most of KIUC's electrical infrastructure is easy and quick (e.g., along roadways, at facilities) and the 10 conservation sites is very difficult to access (which means that this likely will not occur on an annual basis).

Early Implementation Costs: Summary

Costs for early implementation of conservation measures and other actions from 2020 to 2023

Early Implementation Cost Summary (source $)

Category	2020	2021	2022	2023	TOTAL
Minimize Powerline Collisions	**$6,649,966**	**$6,654,252**	**$7,796,489**	**$3,703,817**	**$24,804,524**
Save Our Shearwaters Program	**$304,760**	**$441,669**	**$400,142**	**$322,721**	**$1,469,292**
Manage and Enhance Conservation Sites	**$1,138,724**	**$1,410,140**	**$1,680,668**	**$1,944,774**	**$6,174,307**
Upper Manoa Valley	-	-	-	-	-
Upper Limahuli Preserve	*$529,805*	*$465,235*	*$492,555*	*$612,431*	*$2,100,026*
Pihea, Pōhākea, North Bog	*$608,919*	*$712,851*	-	-	*$1,321,770*
Hanakoa, Hanakāpīʻai	-	*$232,055*	-	-	*$232,055*
Pihea, Pōhākea, North Bog, Hanakoa, Hanakāpīʻai	-	-	*$1,151,099*	*$1,199,533*	*$2,350,632*
Pōhākea PF	-	-	*$37,014*	-	*$37,014*
Honopū	-	-	-	*$132,810*	*$132,810*
Honopū PF	-	-	-	-	-
Powerline Monitoring	**$595,145**	**$1,052,501**	**$1,075,985**	**$1,108,195**	**$3,831,825**
Seabird Colony Monitoring Program	**$351,089**	**$976,918**	**$1,005,746**	**$1,104,129**	**$3,437,882**
TOTAL	**$9,039,684**	**$10,535,480**	**$11,959,030**	**$8,183,636**	**$39,717,830**

Early Implementation Cost Summary (current $)

Category	2020	2021	2022	2023	TOTAL
Minimize Powerline Collisions	**$7,909,913**	**$7,626,750**	**$8,391,470**	**$3,904,423**	**$27,832,555**
Save Our Shearwaters Program	**$362,502**	**$506,217**	**$430,678**	**$340,200**	**$1,639,598**
Manage and Enhance Conservation Sites	**$1,354,474**	**$1,616,228**	**$1,808,927**	**$2,050,106**	**$6,829,735**
Upper Manoa Valley	-	-	-	-	-
Upper Limahuli Preserve	*$630,185*	*$533,228*	*$530,144*	*$645,601*	*$2,339,158*
Pihea, Pōhākea, North Bog	*$724,289*	*$817,032*	-	-	*$1,541,320*
Hanakoa, Hanakāpīʻai	-	*$265,969*	-	-	*$265,969*
Pihea, Pōhākea, North Bog, Hanakoa, Hanakāpīʻai	-	-	*$1,238,944*	*$1,264,502*	*$2,503,446*
Pōhākea PF	-	-	*$39,839*	-	*$39,839*
Honopū	-	-	-	*$140,003*	*$140,003*
Honopū PF	-	-	-	-	-
Powerline Monitoring	**$707,905**	**$1,206,320**	**$1,158,097**	**$1,168,217**	**$4,240,540**
Seabird Colony Monitoring Program	**$417,609**	**$1,119,691**	**$1,082,499**	**$1,163,930**	**$3,783,729**
TOTAL	**$10,752,404**	**$12,075,206**	**$12,871,671**	**$8,626,876**	**$44,326,157**

Sources and notes

Minimize Powerline Collisions: See following page for cost estimation methods.

Save our Shearwaters: Save Our Shearwaters Program 2023.

Manage and Enhance Conservation Sites: Hallux Ecosystem Restoration LLC 2020, 2022, 2023; National Tropical Botanical Garden 2020, 2021, 2023; Archipelago Research and Cons
Pono Pacific, LLC 2023a.

Infrastructure Monitoring and Minimization Project: Kauaʻi Endangered Seabird Recovery Project 2020a; Archipelago Research and Conservation 2021b, 2022a, 2023.

Seabird Colony Monitoring Program: Kauaʻi Endangered Seabird Recovery Project 2020b, 2020c, 2020d; Archipelago Research and Conservation 2021b, 2022a, 2022b, 2023.

See the References tab for more detailed information about the cited sources.

Early Implementation Costs: Implement Powerline Collisions Minimization Projects

Costs for early implementation of powerline collisions minimization measures

Number of Spans with Powerline Collision Minimization Projects Completed or Planned (2020–2023)

Minimization type(s)	Number of spans minimized, 2020	Number of spans minimized, 2021	Number of spans minimized, 2022	Number of spans minimized, 2023
57kV removal, Static wire removal	-	-	-	-
57kV removal, Diverter installation (Reflective)	-	-	-	29
Diverter installation (LED)	24	50	17	32
Diverter installation (LED), Static wire removal	-	4	-	16
Diverter installation (Reflective)	-	267	744	122
Diverter installation (Reflective), Static wire removal	109	134	3	2
Reconfiguration, Static wire removal	45	-	-	8
Static wire removal	43	249	5	310
Underground	-	-	-	-
Total	**221**	**704**	**769**	**519**

Estimated Costs of Early Implementation Powerline Collision Minimization Projects (2020-2023)

Minimization type(s)	Estimated cost per span (current $)	Estimated total cost, 2020 (source $)	Estimated total cost, 2021 (source $)	Estimated total cost, 2022 (source $)	Estimated total cost, 2023 (source $)	Estimated total cost, 2020-2023 (Source $)
57kV removal, Static wire removal	$4,868	-	-	-	-	
57kV removal, Diverter installation (Reflective)	$12,929	-	-	-	$445,980	
Diverter installation (LED)	$30,210	$862,411	$1,731,255	$610,874	$1,149,881	
Diverter installation (LED), Static wire removal	$32,644	-	$149,659	-	$621,263	
Diverter installation (Reflective)	$8,061	-	$2,466,837	$7,133,689	$1,169,772	
Diverter installation (Reflective), Static wire removal	$10,495	$1,360,696	$1,611,861	$37,450	$24,967	
Reconfiguration, Static wire removal	$80,379	$4,302,367	-	-	$764,865	
Static wire removal	$2,434	$124,492	$694,641	$14,476	$897,500	
Underground	$339,093	-	-	-	-	
Total		**$6,649,966**	**$6,654,252**	**$7,796,489**	**$5,074,228**	**$ 26,174,935.50**

Sources and notes

Number of spans with powerline collisions minimization projects completed or planned: ICF 2023

Average cost per span for powerline collision minimization activities: Yuh 2021a, 2021b

See the References tab for more detailed information about the cited sources.

Implementation Costs: Plan Administration

Staffing, legal support, database administration, and annual reporting

Plan Adminsitration Costs

Type	Average annual cost (source $)	Source $ year	Average annual cost (current $)
Program Management HCP Program Manager (1 FTE) Data Analyst/GIS Specialist (1 FTE) Accountant/Budget Analyst (1 FTE)	$385,000	2023	$405,852
Legal Support	$25,000	2023	$26,354
Database Administration and Software License Fees	$2,500	2023	$2,635
Additional Cost to Prepare 1st KIUC Annual Report	$40,000	2023	$42,166
Annual Total (Plan Year 1)			**$477,008**
Annual Total (Plan Years 2-50)			**$434,842**

Sources and notes

All plan administration cost assumptions developed through coordination between ICF and the Joule Group. Program management costs are based on current support provided by the Joule Group and additional tasks anticipated to implement the long-term HCP. Plan administration costs include costs for compliance monitoring oversight; compliance monitoring may be conducted by the HCP Program Manager or a separate individual. Program Management costs are to support the three HCP positions described in Section 7.4.2 of the HCP.

Implementation Costs: Implement Powerline Minimization Monitoring (Conservation Measure 1)

Collision reduction through static wire removal, diverter installation, and reconfiguration

Estimated Costs of Reflective Diverter Installations on New Powerlines (Plan Years 1-50)

Year	Number of spans minimized per plan year	Estimated cost per span (source $)	Estimated cost per plan year (source $)	Source $ year	Estimated cost per plan year (current $)
Plan Years 1-50 (2025-2074)	7	$8,061	$56,427	2021	$64,674

Estimated Costs of Reflective Diverter Replacement (Plan Years 1-50)

Year	Number of spans replaced per plan year	Estimated cost per span (source $)	Estimated cost per plan year (source $)	Source $ year	Estimated cost per plan year (current $)
Plan Year 1 (2025)	95.7	$8,061	$771,169	2021	$883,873
Plan Years 2-50 (2026-2074) added incremental cost	0.47	$8,061	$3,762	2021	$4,312

Estimated Costs of LED Diverter Replacement (Plan Years 1-50)

Year	Number of spans replaced per plan year	Estimated cost per span (source $)	Estimated cost per plan year (source $)	Source $ year	Estimated cost per plan year (current $)
Plan Years 1-50 (2025-2074)	28.6	$30,210	$864,006	2021	$990,278

Sources and notes

Average cost per span for powerline collision minimization activities: Yuh 2021a, 2021b

New diverter installations per plan year: Assumes 7 new spans installed each year would be equipped with reflective diverters.

Reflective diverter replacements per plan year: There will be an estimated 1,435 spans with reflective diverters installed by Plan Year 1. Per previous note, an estimated 7 new spans would be equipped with reflective diverters each successive plan year. Cost estimate assumes all reflective diverters would be replaced once every 15 years. This equates to replacing reflective diverters on approximately 6.6% of all spans in the system each year when averaged over the 50-year permit term.

LED diverter replacements per plan year: There will be an estimated 143 spans with LED diverters installed by Plan Year 1. Cost estimate assumes all LED diverters would be replaced once every 5 years. This equates to replacing LED diverters on approximately 20% of all spans in the system each year when averaged over the 50-year permit term.

See the References tab for more detailed information about the cited sources.

Implementation Costs: Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites (Conservation Measure 4)

Perform various combinations of predator and weed controls at conservation sites

Summary of Estimated Annual Costs by Activity at All Conservation Sites							
Management Activity	**Annual Cost Plan Year 1 (current $)**	**Annual Cost Plan Year 2 (current $)**	**Annual Cost Plan Year 3 (current $)**	**Annual Cost Plan Year 4 (current $)**	**Annual Cost Plan Years 5-26 (current $)**	**Annual Cost Plan Years 27-28 (current $)**	**Annual Cost Plan Years 29-73 (current $)**
Predator Control	$2,018,714	$2,003,714	$2,003,714	$2,003,714	$2,003,714	$2,003,714	$2,003,714
Weed Control	$211,465	$211,465	$211,465	$211,465	$211,465	$211,465	$211,465
Predator Fence Installation and Predator Eradication	$744,818	$267,072	$744,818	$1,100,627	-	-	-
Predator Fence Maintenance and Replacement	$94,875	$94,875	$114,377	$114,377	$153,381	$153,381	$266,326
Social Attraction Site Setup and Maintenance	-	$26,994	$26,994	-	-	$3,162	-
Admin. and Monitoring Fee to Easement Holder (UMV only)	$51,900	$18,500	$18,500	$18,500	$18,500	$18,500	$18,500
Total	**$3,121,771**	**$2,622,619**	**$3,119,867**	**$3,448,682**	**$2,387,059**	**$2,390,221**	**$4,774,118**

Sources and notes: See details below for each cost category

Predator Control

All Sites					
Item	**Units**	**Estimated unit cost (source $)**	**Source $ year**	**Estimated unit cost (current $)**	**Total cost (current $)**
Personnel Salaries and Fringe (Up to 14 staff full time (FTEs): 2 Sr. Assoc. Biologist, 4 Assoc. Biologist, 8 Predator Control Specialists)	1	$993,320	2023	$1,047,120	$1,047,120
Materials and Supplies (traps, trapping supplies, wildlife cameras [incl. replacement], batteries, safety equipment, weatherport consumables, camping gear replacement)	1	$299,247	2023	$315,455	$315,455
Training (first aid, firearms, HCP)	1	$16,600	2023	$17,499	$17,499
Direct Procurement, Communications, Services (Helicopter flights, vehicle mileage, shipping, camera repair, satellite phone charges, other)	1	$214,850	2023	$226,487	$226,487
Direct Contractor Cost					**$1,606,560**
Contractor Overhead Cost (20%)					**$321,312**
General Excise Tax (4.7120%)					**$90,841**
Annual Total (Plan Year 1)					**$2,018,714**
Annual Total (Plan Years 2-50)					**$2,003,714**

Sources and notes

Hallux Ecosystem Restoration LLC 2024, National Tropical Botanical Garden 2023, Hallux Ecosystem Restoration LLC 2023. Annual cost assumed to be $15,000 greater in Plan Year 1 due to higher initial setup costs for predator control at Upper Manoa Valley.

See the References tab for more detailed information about the cited sources.

Weed Control

All Sites Except Upper Manoa Valley

Item	Units	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Total cost (current $)
Office and Overhead ($50/hr)	800	$50	2023	$53	$42,166
Field Labor ($110/hr)	800	$110	2023	$116	$92,766
Helicotor Transport ($1,100/hr)	66	$1,100	2023	$1,160	$76,532
Annual Total (Plan Years 1-50)					**$211,465**

Sources and notes

KRCP 2024.

Scaled based on estimated costs for weed control at all sites.

See the References tab for more detailed information about the cited sources.

Predator Fence Installation and Predator Eradication

Upper Manoa Valley

Item	Unit	Estimated cost per unit (source $)	Source $ year	Estimated cost per unit (current $)	Total cost (current $)
Fence Installation					
Materials (fence hoods, posts, mesh, brackets, etc.)	1	$453,200	2023	$477,746	$477,746
Labor (Crew of 4-5 people for 20-22 weeks)	1	$209,400	2023	$220,741	$220,741
Equipment (tools, camp gear, etc.)	1	$11,800	2023	$12,439	$12,439
Subcontractors (helicopter time, 110 hrs assumed)	1	$204,400	2023	$215,471	$215,471
Miscellaneous (travel, fuel, etc.)	1	$81,100	2023	$85,493	$85,493
Predator Eradication	1				
Labor (3 staff part time for 9 months + fringe)	1	$418,600	2016	$536,810	$536,810
Equipment (tracking tunnels, ink cards, bait stations, bait, traps)	1	$70,200	2016	$90,024	$90,024
Helicopter time	1	$66,235	2016	$84,939	$84,939
Miscellaneous (travel, fuel, overhead, other)	1	$94,965	2016	$121,782	$121,782

Annual Total (Plan Year 3 (2027)) - All Materials cost + 50% of all other costs except Predator Eradication	**$744,818**
Annual Total (Plan Year 4 (2028)) - All Predator Eradication Costs + 50% of all other costs except Materials	**$1,100,627**

Sources and notes
Fence material and installation costs: Pono Pacific, LLC 2023a.
Predator eradication costs: Young and VanderWerf 2016, scaled to size of predator-proof fencing. Predator eradication is expected to take up to 6 months at ULP.
See the References tab for more detailed information about the cited sources.

Upper Limahuli Preserve

Item	Unit	Estimated cost per unit (source $)	Source $ year	Estimated cost per unit (current $)	Total cost (current $)
Fence Installation					
Materials (fence hoods, posts, mesh, brackets, etc.)	1	$453,200	2023	$477,746	$477,746
Labor (Crew of 4-5 people for 20-22 weeks)	1	$209,400	2023	$220,741	$220,741
Equipment (tools, camp gear, etc.)	1	$11,800	2023	$12,439	$12,439
Subcontractors (110 hrs helicopter time)	1	$204,400	2023	$215,471	$215,471
Miscellaneous (travel, fuel, etc.)	1	$81,100	2023	$85,493	$85,493
Predator Eradication					
Labor (3 staff part time for 6 months + fringe)	1	$225,400	2016	$289,051	$289,051
Equipment (tracking tunnels, ink cards, bait stations, bait, traps)	1	$37,800	2016	$48,474	$48,474
Helicopter time (1-2 trips monthly for 6 months)	1	$35,665	2016	$45,737	$45,737
Miscellaneous (travel, fuel, overhead, other)	1	$51,135	2016	$65,575	$65,575

Annual Total (Plan Year 1 (2025)) - All Materials cost + 50% of all other costs except Predator Eradication	**$744,818**
Annual Total (Plan Year 2 (2026)) - All Predator Eradication Costs + 50% of all other costs except Materials	**$267,072**

Sources and notes
Fence material and installation costs: Pono Pacific, LLC 2023a.
Predator eradication costs: Young and VanderWerf 2016, scaled to size of predator-proof fencing. Predator eradication is expected to take 9 months at UMV.
See the References tab for more detailed information about the cited sources.

Predator Fence Maintenance and Replacement

All Fenced Sites

Item	Unit	Estimated cost per unit (source $)	Source $ year	Estimated cost per unit (current $)	Total cost (current $)
Fence Maintainance					
Fence Maintenance (Pōhākea and Honopū) (Plan Years 1-50 (2025-2074))	1	$65,000	2023	$68,521	$68,521
Fence Rapid Response (All 4 sites) (Plan Years 1-50 (2025-2074))	1	$25,000	2023	$26,354	$26,354
Fence Maintenance (Upper Limahuli Preserve) (Plan Years 3-50 (2027-2074))	1	$18,500	2023	$19,502	$19,502
Fence Maintenance (Upper Manoa Valley) (Plan Years 5-50 (2029-2074))	1	$37,000	2023	$39,004	$39,004
Fence Replacement					
Full fence replacement during 50-year permit term	6	$1,000,000	2023	$1,054,162	$6,324,971
Annual Total - Maintenance (Plan Years 1-2 (2025-2026))					**$94,875**
Annual Total - Maintenance (Plan Years 3-4 (2027-2028))					**$114,377**
Annual Total - Maintenance (Plan Years 5-50 (2029-2074))					**$153,381**
Full Fence Replacement (Plan Years 5-50 (2029-2074))					**$6,324,971**
Annual Total of Full Fence Replacement (Plan Years 5-50 (2029-2074))					**$112,946**

Sources and notes

Developed through coordination between ICF and the Joule Group. Maintenance of ungulate fencing is covered in annual predator control costs.

Fence replacement cost is a rough average based on actual fence construction costs to date at 4 conservation sites. Assumes 4 sites replaced fully twice during permit term (total of 8 full replacements), minus the cost of two fence replacements that are already assumed as a changed circumstance in response to severe storms or landslides at same average cost. Because fence replacement due to deteriorating material and conditions will occur much later in the permit term, the estimate is a rough average knowing that actual costs will vary.

Social Attraction Site Setup and Maintenance

Upper Manoa Valley and Upper Limahuli Preserve

Item	Units	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Total cost (current $)
Social Attraction Equipment Subtotal					**$10,268**
Artificial nest boxes (NESH)	30	$150	2023	$158	$4,744
Tubing (for burrow tunnels)	1	$100	2023	$105	$105
Cattle tags for burrows	1	$32	2023	$34	$34
Quickrete 45lb Coral Sand	22	$11	2023	$12	$255
Zinc-Plated Hook and Eye	30	$3	2023	$3	$95
Sand Bags	30	$1	2023	$1	$32
Hygrochron iButtons (to assess humidity in burrows)	5	$129	2023	$136	$680
Thermochron iButtons (to assess temp. in burrows)	15	$32	2023	$34	$506
Tropicool Tan Paint - heat reflective 4.75gal	1	$371	2023	$391	$391
Miscellaneous supplies for boxes	1	$250	2023	$264	$264
Social Attraction System	1	$3,000	2023	$3,162	$3,162
Social Attraction Monitoring Subtotal					**$8,066**
Reconyx cameras (HP2X)	15	$460	2023	$485	$7,274
Reconyx cameras thunderbolt mounting block	15	$19	2023	$20	$300
Reconyx cameras (HP2X) shipping	1	$347	2023	$366	$366
2 Reconyx SD cards per camera 32 GB	30	$4	2023	$4	$126
Transportation Subtotal					**$5,102**
Helicopter (sling loads of boxes and sand)	2	$1,100	2023	$1,160	$2,319
Helcopter (transport digging crew)	2.4	$1,100	2023	$1,160	$2,783
Direct Contractor Costs					**$23,436**
Contractor Overhead Costs (10%)					**$2,344**
General Excise Tax (4.7120%)					**$1,215**
Total Setup Cost for Upper Limahuli Preserve in Plan Year 2 (2026)					**$26,994**
Total Setup Cost for Upper Manoa Valley in Plan Year 3 (2027)					**$26,994**
Total Soundsystem Replacement Cost for Upper Limahuli Preserve in Plan Year 27 (2051) and Upper Manoa Valley in Plan Year 28 (2052)					**$3,162**

Sources and notes

Archipelago Research and Conservation 2024.

All costs associated with staff time for social attraction are assumed to be covered in other existing budgets.

See the References tab for more detailed information about the cited source.

Administration and Monitoring Fees to Easement Holder

Upper Manoa Valley

Item	Unit	Estimated cost per unit (source $)	Source $ year	Estimated cost per unit (current $)	Total cost (current $)
Endowment startup cost	1	$3,400	2024	$3,400	$3,400
Year 1-3 Admin fee reserve (paid in Year 1)	1	$45,000	2024	$45,000	$45,000
Annual admin fee during permit term (Years 2-50)	1	$15,000	2024	$15,000	$15,000
Initial endowment contribution (Year 1)	1	$3,500	2024	$3,500	$3,500
Annual endowment contribution (Years 2-50)	1	$3,500	2024	$3,500	$3,500
Annual Total (Plan Year 1)					**$51,900**
Annual Total (Plan Years 2-50)					**$18,500**

Sources and notes

Endowment assumes a 3.5% net interest rate during the permit term and a net 3.5% rate of return after the permit term (net of financial management fees and inflation)

Implementation Costs: Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program (Conservation Measure 5)

Implement a nest detection and shielding program for green sea turtle

Nest Detection and Shielding Program Costs by Plan Year

Item	Quantity	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Total cost (current $)
Personnel Subtotal					**$127,095**
Personnel Salaries and Fringe (2 weeks Science Director, 1 week GIS Analyst, 12 months Senior Biologist, 6 months Junior Biologist)	*1*	*$120,565*	*2023*	*$127,095*	*$127,095*
Materials and Supplies Subtotal					**$3,900**
Light Meter	*1*	*$200*	*2023*	*$211*	*$211*
Light-Proof Fencing Materials for Turtle Nests	*1*	*$500*	*2023*	*$527*	*$527*
Field Equipment (staff field gear and first-aid training)	*2*	*$1,500*	*2023*	*$1,581*	*$3,162*
Travel Subtotal					**$13,915**
Vehicle charge (use, fuel, repairs, etc.)	*12*	*$1,100*	*2023*	*$1,160*	*$13,915*
Direct Contractor Costs					$144,911
Contractor Overhead Cost					*$14,491*
General Excise Tax (4.7120%)					*$7,511*
GRAND TOTAL					**$166,913**

Sources and notes

Implementation Costs: Implement Powerline Monitoring and Minimization

Monitor seabird and water bird collision rates at KIUC powerlines

Current $ year = 2024

Powerline and Minimization Monitoring Costs by Plan Year

Item	Quantity	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Annual cost (current $)
Personnel Subtotal					**$645,974**
Personnel Salaries and Fringe	1	$612,784	2023	$645,974	$645,974
Science Director (2 months, 0.2 FTE)					
Project Manager (5 mo., 0.4 FTE)					
Field Crew Leader (5 mo., 0.4 FTE)					
Biologists (12 mo, 2 FTEs)					
Junior Biologist (9 mo., 0.75 FTE)					
GIS & Data Analyst (5 mo., 0.4 FTE)					
Equipment and Supplies Subtotal					**$303,758**
Estimated Annual Misc. Expenses	*1*	*$1,500*	*2023*	*$1,581*	*$1,581*
SONG METERS					
Song meters - SM4 (replacements every 5 years)	*18.2*	*$825*	*2023*	*$870*	*$15,828*
*Song Meter - D batteries (91 units*4*3)*	*1,092*	*$1*	*2023*	*$1*	*$1,059*
Microphone for SM4 (replacements)	*36.4*	*$50*	*2023*	*$53*	*$1,919*
32GB SD cards for SM2/4 (replacements)	*72.8*	*$13*	*2023*	*$13*	*$962*
Song meters - shipping	*19*	*$42*	*2023*	*$44*	*$831*
Song meter repairs ($147 per unit, including postage - $22 out, $25 return post, repair cost $100)	*18.2*	*$147*	*2023*	*$155*	*$2,820*
Analysis of song meter data by Conservation Metrics - all UMP work	*1*	*$231,522*	*2023*	*$244,062*	*$244,062*
CAMERAS					
Reconyx HP2X - replacements	*1*	*$460*	*2023*	*$485*	*$485*
Reconyx Repair (avg cost per camera to repair, including shipping)	*1.2*	*$60*	*2023*	*$63*	*$76*
Lithium AA batteries (3 sets per camera)	*18*	*$15*	*2023*	*$15*	*$278*
T post camera mount - replacements	*1.2*	*$20*	*2023*	*$21*	*$25*
SanDisk 32GB SDHC Memory Card (replacements)	*4*	*$13*	*2023*	*$13*	*$53*
FIELD EQUIPMENT					
iPad (replacements)	*2*	*$300*	*2023*	*$316*	*$632*
Ipad Cases (replacements)	*3*	*$45*	*2023*	*$47*	*$142*
Handheld Camera (replacements)	*1*	*$210*	*2023*	*$221*	*$221*
Helicopter Helmet (replacemets)	*2.2*	*$1,660*	*2023*	*$1,750*	*$3,850*
CWU-27/P Flight Suit (replacements)	*2.2*	*$238*	*2023*	*$251*	*$552*
USNV PVS-7 GEN III Auto-Gated Nightvision Goggles (replacements)	*1*	*$3,695*	*2023*	*$3,895*	*$3,895*
MSR Hubba NX 1 Tent & footprint (replacements)	*2*	*$410*	*2023*	*$432*	*$864*
Field Equipment (new gear for each new staff member, includes first aid training NOLS)	*2*	*$3,300*	*2023*	*$3,479*	*$6,957*
Field Equipment (replacement gear for existing staff members)	*4*	*$825*	*2023*	*$870*	*$3,479*
Field Equipment (annual group gear purchases)	*1*	*$1,500*	*2023*	*$1,581*	*$1,581*
PROGRAM-SPECIFIC MONITORING EQUIPMENT					
Near Infrared Lights (replacements)	*1.2*	*$3,200*	*2023*	*$3,373*	*$4,048*
Near Infrared Lights (annual small repairs)	*1*	*$500*	*2023*	*$527*	*$527*
Honda Generator (replacements)	*1.2*	*$1,000*	*2023*	*$1,054*	*$1,265*
Light shields, mallets , cables, locks (annual)	*1*		*2023*	*-*	*-*
NV portable Cameras (replacements)	*1.5*	*$1,200*	*2023*	*$1,265*	*$1,897*
Weather station (replacements)	*0.3*	*$2,000*	*2023*	*$2,108*	*$703*
Heli sling gear (Replacements)	*0.25*	*$2,000*	*2023*	*$2,108*	*$527*
Miscelanious supplies- pegs, ropes, tapes, wood, rain guards, etc	*1*	*$2,500*	*2023*	*$2,635*	*$2,635*
Transportation Subtotal					**$65,864**
Helicopter	*22*	*$1,040*	*2023*	*$1,096*	*$24,119*
Equipment (3 vehicles) Charge	*36*	*$1,100*	*2023*	*$1,160*	*$41,745*
Subtotal					*$1,015,595*
Contractor Overhead (10%)					*$101,560*
General Excise Tax (4.712%)					*$52,640*
GRAND TOTAL					**$1,169,795**

Implementation Costs: Implement Seabird Colony Monitoring Program
Monitor seabird breeding colonies at ten sites

Current $ year = 2024

Seabird Colony Monitoring Program Costs by Plan Year (Detail)

All Conservation Sites

Item	Quantity	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Annual cost (current $)
Personnel Subtotal					**$631,408**
Personnel Salaries and Fringe	*1*	*$598,967*	*2023*	*$631,408*	*$631,408*
Science Director (6 months, 0.5 FTE)					
Field Crew Leader (12 mos., 1 FTE)					
GIS & Data Analyst (5 mos., 0.4 FTE)					
Biologists (9-12 mos., 3.7 FTEs)					
Includes Na Pali Coast monitoring					
Equipment and Supplies Subtotal					**$250,195**
Estimated Annual Misc. Expenses	*1*	*$3,000*	*2023*	*$3,162*	*$3,162*
SONG METERS					
Song meters - SM4 - replacements every 5 years, 82 units	*16.4*	*$805*	*2023*	*$849*	*$13,917*
Microphone for SM4 (replacements every 5 years, 2 mics per unit, 82 units)	*32.8*	*$50*	*2023*	*$53*	*$1,729*
32GB SD cards for SM2/4 (replacements every 3 years, 4 SD cards per unit, 82 units)	*109.3*	*$13*	*2023*	*$13*	*$1,445*
Wildlife Acoustics - shipping	*1*	*$400*	*2023*	*$422*	*$422*
*Song Meter - D batteries (6 sites - 10 units*4*3)*	*720*	*$1*	*2023*	*$1*	*$701*
*Song Meter - D batteries (ULP - 14 units*4*3)*	*168*	*$1*	*2023*	*$1*	*$163*
*Song Meter - D batteries (UMV - 8 units*4*3)*	*96*	*$1*	*2023*	*$1*	*$110*
Song meter repairs ($147 per unit, including postage - $22 out, $25 return post, repair cost $100)	*16.4*	*$147*	*2023*	*$155*	*$2,541*
Data analysis of 32 song meters by Conservation Metrics for 3 covered seabirds	*1*	*$143,757*	*2023*	*$151,543*	*$151,543*
RECONYX CAMERAS					
Reconyx HP2X - replace each unit (n=240) every 5 years	*48*	*$414*	*2023*	*$436*	*$20,948*
T post camera mount (replacements)	*48*	*$20*	*2023*	*$21*	*$1,011*
Reconyx - shipping	*1*	*$720*	*2023*	*$759*	*$759*
Lithium AA batteries (3 sets per camera)	*720*	*$15*	*2023*	*$15*	*$11,123*
SanDisk 32GB SDHC Memory Card (replacements)	*160*	*$13*	*2023*	*$13*	*$2,115*
Reconyx Repair (avg cost per camera to repair, including shipping)	*82*	*$60*	*2023*	*$63*	*$5,186*
MISC. FIELD GEAR					
Hygrochrons for Honopu SAS site	*20*	*$169*	*2023*	*$178*	*$3,563*
Shipping for hygrochrons	*1*	*$100*	*2023*	*$105*	*$105*
Garmin Inreach Explorer + (replacements)	*1*	*$450*	*2023*	*$474*	*$474*
Garmin GPS Unit (replacements)	*4*	*$550*	*2023*	*$580*	*$2,319*
iPad (replacements)	*2.7*	*$300*	*2023*	*$316*	*$843*
Handheld Camera (replacements)	*4*	*$210*	*2023*	*$221*	*$885*
Helicopter Helmet (replacemets)	*1.2*	*$1,660*	*2023*	*$1,750*	*$2,100*
CWU-27/P Flight Suit (replacements)	*1.6*	*$238*	*2023*	*$251*	*$401*
USNV PVS-7 GEN III Auto-Gated Nightvision Goggles (replacements)	*1.3*	*$3,695*	*2023*	*$3,895*	*$5,194*
Tent & footprint (replacements)	*2.7*	*$410*	*2023*	*$432*	*$1,153*
Field Equipment (new field gear for each new staff member, includes first aid training NOLS)	*3*	*$3,300*	*2023*	*$3,479*	*$10,436*
Field Equipment (replacement gear for existing staff members)	*4*	*$825*	*2023*	*$870*	*$3,479*
Field Equipment (annual group gear purchases)	*1*	*$1,500*	*2023*	*$1,581*	*$1,581*
WEATHERPORT MAINTENANCE					
Buckets	*4*	*$7*	*2023*	*$7*	*$30*
Wood Shavings	*4*	*$20*	*2023*	*$21*	*$84*
Water filter Repair	*4*	*$40*	*2023*	*$42*	*$169*
Water Filter Replacement	*1.5*	*$317*	*2023*	*$334*	*$501*
Transportation Subtotal					**$27,830**
Equipment (2 vehicles) Charge	*24*	*$1,100*	*2023*	*$1,160*	*$27,830*
Subtotal					*$909,434*
Contractor Overhead (10%)					*$90,943*
General Excise Tax (4.712%)					*$47,138*
GRAND TOTAL (12 conservation sites)					**$1,047,515**

Nā Pali Coast Sites

Item	Quantity	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Annual cost (current $)
Personnel Subtotal					**-**
Covered under conservation site monitoring budget, above.	*0*	*-*	*2023*	*-*	*-*
Equipment and Supplies Subtotal					**$35,178**
Estimated Annual Misc. Expenses	*1*	*$2,000*	*2023*	*$2,108*	*$2,108*
Song meters - SM4 - replacements every 5 years, 20 units	*4*	*$805*	*2023*	*$849*	*$3,394*
32GB SD cards for SM2/4 (replacements, 1 per unit)	*20*	*$21*	*2023*	*$22*	*$436*
*Song Meter - D batteries (20 units*4)*	*80*	*$1*	*2023*	*$1*	*$78*
Analysis of song meter data by Conservation Metrics - 20 units, 3 species (NESH, BANP, BAOW), 3 months per unit	*1*	*$21,513*	*2023*	*$22,678*	*$22,678*
Helicopter - (3 hrs to deploy song meters, 3 hrs to receover song meters)	*6*	*$1,025*	*2023*	*$1,081*	*$6,483*
Subtotal					*$35,178*
Contractor Overhead (10%)					*$3,518*
General Excise Tax (4.712%)					*$1,823*
GRAND TOTAL					**$40,519**

Sources and notes

Implementation Costs: Fund State Compliance Monitoring

Funds for monitoring of endangered species by the State of Hawaii

State Compliance Monitoring Costs by Plan Year			
Type	Average annual cost (source $)	Source $ year	Average annual cost (current $)
Program Management	$50,000	2023	$52,708

Sources and notes

ICF 2022. KIUC has included a total of $50,000 annually to fund endangered species monitoring by the State of Hawaii.

See the References tab for more detailed information about the cited sources.

Implementation Costs: Changed Circumstances, Adaptive Management, and Contingency

Funds to address changed circumstances, adaptive management, and contingencies with plan implementation

Estimated Costs to Account for Changed Circumstances

Funding for changed circumstances is calculated as a percentage of the annual cost to manage and enhance conservation sites, using parameters below. These funds will accrue throughout the permit term. See Table 7-2 for details.

Changed circumstance	Explanation	2025	2026	2027	2028	2029	2030–2034	2035–2039	2040–2044	2045–2049	2050–2054	2055–2059	2060–2064	2065–2069	2070–2074
Severe Weather: Bird Flight Diverters	Total cost of $15,275,229, divided equally across the 50-year permit term, of replacing all reflective ($8,061 × 1,435 spans) and LED ($30,210 × 143 spans) diverters once due to severe weather.	$317,751	$317,751	$317,751	$317,751	$317,751	$1,588,757	$1,588,757	$1,588,757	$1,588,757	$1,588,757	$1,588,757	$1,588,757	$1,588,757	$1,588,757
Severe Weather: Fencing	Total cost of $2,000,000 (approximately twice the estimated total cost for installation of ULP predator fence) to replace two predator fences during permit term, divided equally across the 50-year permit term. Routine maintenance and fence repairs and replacements are included in operations costs.	$40,000	$40,000	$40,000	$40,000	$40,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000
Severe Weather: Loss of Accessibility To Conservation Sites or Increased Accessibility of Predators	Annual cost of $30,000 (approximately 0.01% of Plan Year 1 cost to manage conservation sites) to compensate for temporary loss of accessibility to or temporary or permanent destruction of conservation sites, as well as increased accessibility of sites by predators (e.g., vegetation damage).	$30,000	$30,000	$30,000	$30,000	$30,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000
Invasive Species - Equipment	Annual cost of $3,500 to purchase additional predator control equipment.	$3,500	$3,500	$3,500	$3,500	$3,500	$17,500	$17,500	$17,500	$17,500	$17,500	$17,500	$17,500	$17,500	$17,500
Invasive Species - Labor	Annual cost of $38,300 in additional labor costs, which is 2% of the estimated annual predator control cost for all conservation sites.	$38,300	$38,300	$38,300	$38,300	$38,300	$191,500	$191,500	$191,500	$191,500	$191,500	$191,500	$191,500	$191,500	$191,500
Vandalism	Annual cost to repair vandalism to predator fencing ($100 in 2012, inflated to $129.36 in 2023 $) plus vandalism to turtle nesting light mitigation structures ($2,240).	$2,369	$2,369	$2,369	$2,369	$2,369	$11,847	$11,847	$11,847	$11,847	$11,847	$11,847	$11,847	$11,847	$11,847
Destruction of Green Sea Turtle Nests	Annual cost of $1,589 (approximately 1% of Plan Year 1 cost to detect and shield nests) to compensate for destruction of green sea turtle nests.	$1,589	$1,589	$1,589	$1,589	$1,589	$7,945	$7,945	$7,945	$7,945	$7,945	$7,945	$7,945	$7,945	$7,945
Changed Circumstances Total		**$433,510**	**$433,510**	**$433,510**	**$433,510**	**$433,510**	**$2,167,548**	**$2,167,548**	**$2,167,548**	**$2,167,548**	**$2,167,548**	**$2,167,548**	**$2,167,548**	**$2,167,548**	**$2,167,548**

Estimated Adaptive Management Costs

Funding for adaptive management is calculated as a percentage of the annual costs for each cost category, as listed below. Percentages vary based on the degree of uncertainty within each cost category.

Cost categories	Percentage of annual and 5 year total costs allocated to adaptive management	Explanation	Cost by Category During Permit period (calendar years)												
			2025	2026	2027	2028	2029	2030–2034	2035–2039	2040–2044	2045–2049	2050–2054	2055–2059	2060–2064	2065–2069	2070–2074
Plan Administration	**0.0%**	Not applicable	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Minimize Powerline Collisions	**2.5%**	New technology may be available in future to improve collision avoidance	$48,578	$48,686	$48,794	$48,902	$49,010	$246,665	$249,359	$252,054	$254,749	$257,444	$260,138	$262,833	$265,528	$268,222
Save Our Shearwaters Program	**5.0%**	New techniques and technology may be available in future to improve rescue rates and rehabilitation	$15,000	$15,000	$15,000	$15,000	$15,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000
Manage and Enhance Conservation Sites	**5.0%**	New or different management approaches may improve reproductive success or predator control	$156,089	$131,131	$155,993	$172,434	$119,353	$596,765	$596,765	$596,765	$596,765	$597,081	$596,765	$596,765	$596,765	$596,765
Green Sea Turtle Nest Detection and Temporary Shielding Program	**10.0%**	As a new program, adaptive management changes are expected throughout	$16,691	$16,691	$16,691	$16,691	$16,691	$83,457	$83,457	$83,457	$83,457	$83,457	$83,457	$83,457	$83,457	$83,457
Powerline Monitoring	**5.0%**	New technology or techniques may improve monitoring effectiveness or efficiency	$58,490	$58,490	$58,490	$58,490	$58,490	$292,449	$292,449	$292,449	$292,449	$292,449	$292,449	$292,449	$292,449	$292,449
Seabird Colony Monitoring Program	**5.0%**	Same as above	$54,402	$54,402	$54,402	$54,402	$54,402	$272,008	$272,008	$272,008	$272,008	$272,008	$272,008	$272,008	$272,008	$272,008
State Compliance Monitoring	**0.0%**	Not applicable (fixed cost)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Changed Circumstances	**0.0%**	See below for separate contingency assumptions	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Letter of Credit account management fees		$3,400 establishment fee + $1,000 annual administration fee	$3,400	$1,000	$1,000	$1,000	$1,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000
Adaptive Management Total			**$352,650**	**$325,400**	**$350,370**	**$366,919**	**$313,945**	**$1,571,343**	**$1,574,038**	**$1,576,733**	**$1,579,427**	**$1,582,438**	**$1,584,817**	**$1,587,512**	**$1,590,206**	**$1,592,901**

Implementation Costs: Endowment Costs for Upper Manoa Valley Conservation Easement Compliance Monitoring

Assumptions

$	3,500	Initial KIUC payment (Year 1)
$	3,500	Annual KIUC payment Years 2-50
	3.50%	Net annual interest (minus fees and inflation) during permit term

Results

$	175,000	Total payment over permit term (current dollars)
$	299,540	Total interest over permit term (current dollars)
$	474,540	Total Endowment by Year 50
$	16,609	Annual net interest generated thereafter
$	16,500	Annual easement monitoring cost + 10% withdrawal fee

Plan Year	Calendar Year	KIUC Payment	Endowment Principal	Net Interest	Endowment Total
1	2025	$ 3,500	$ 3,500	$ 123	$ 3,623
2	2026	$ 3,500	$ 7,123	$ 249	$ 7,372
3	2027	$ 3,500	$ 10,872	$ 381	$ 11,252
4	2028	$ 3,500	$ 14,752	$ 516	$ 15,269
5	2029	$ 3,500	$ 18,769	$ 657	$ 19,426
6	2030	$ 3,500	$ 22,926	$ 802	$ 23,728
7	2031	$ 3,500	$ 27,228	$ 953	$ 28,181
8	2032	$ 3,500	$ 31,681	$ 1,109	$ 32,790
9	2033	$ 3,500	$ 36,290	$ 1,270	$ 37,560
10	2034	$ 3,500	$ 41,060	$ 1,437	$ 42,497
11	2035	$ 3,500	$ 45,997	$ 1,610	$ 47,607
12	2036	$ 3,500	$ 51,107	$ 1,789	$ 52,896
13	2037	$ 3,500	$ 56,396	$ 1,974	$ 58,369
14	2038	$ 3,500	$ 61,869	$ 2,165	$ 64,035
15	2039	$ 3,500	$ 67,535	$ 2,364	$ 69,899
16	2040	$ 3,500	$ 73,399	$ 2,569	$ 75,968
17	2041	$ 3,500	$ 79,468	$ 2,781	$ 82,249
18	2042	$ 3,500	$ 85,749	$ 3,001	$ 88,750
19	2043	$ 3,500	$ 92,250	$ 3,229	$ 95,479
20	2044	$ 3,500	$ 98,979	$ 3,464	$ 102,443
21	2045	$ 3,500	$ 105,943	$ 3,708	$ 109,651
22	2046	$ 3,500	$ 113,151	$ 3,960	$ 117,111
23	2047	$ 3,500	$ 120,611	$ 4,221	$ 124,833
24	2048	$ 3,500	$ 128,333	$ 4,492	$ 132,824
25	2049	$ 3,500	$ 136,324	$ 4,771	$ 141,096
26	2050	$ 3,500	$ 144,596	$ 5,061	$ 149,657
27	2051	$ 3,500	$ 153,157	$ 5,360	$ 158,517
28	2052	$ 3,500	$ 162,017	$ 5,671	$ 167,688
29	2053	$ 3,500	$ 171,188	$ 5,992	$ 177,179
30	2054	$ 3,500	$ 180,679	$ 6,324	$ 187,003
31	2055	$ 3,500	$ 190,503	$ 6,668	$ 197,171
32	2056	$ 3,500	$ 200,671	$ 7,023	$ 207,694
33	2057	$ 3,500	$ 211,194	$ 7,392	$ 218,586
34	2058	$ 3,500	$ 222,086	$ 7,773	$ 229,859
35	2059	$ 3,500	$ 233,359	$ 8,168	$ 241,527
36	2060	$ 3,500	$ 245,027	$ 8,576	$ 253,603
37	2061	$ 3,500	$ 257,103	$ 8,999	$ 266,101
38	2062	$ 3,500	$ 269,601	$ 9,436	$ 279,037
39	2063	$ 3,500	$ 282,537	$ 9,889	$ 292,426
40	2064	$ 3,500	$ 295,926	$ 10,357	$ 306,283
41	2065	$ 3,500	$ 309,783	$ 10,842	$ 320,626
42	2066	$ 3,500	$ 324,126	$ 11,344	$ 335,470
43	2067	$ 3,500	$ 338,970	$ 11,864	$ 350,834
44	2068	$ 3,500	$ 354,334	$ 12,402	$ 366,736
45	2069	$ 3,500	$ 370,236	$ 12,958	$ 383,194
46	2070	$ 3,500	$ 386,694	$ 13,534	$ 400,228
47	2071	$ 3,500	$ 403,728	$ 14,130	$ 417,859
48	2072	$ 3,500	$ 421,359	$ 14,748	$ 436,106
49	2073	$ 3,500	$ 439,606	$ 15,386	$ 454,993
50	2074	$ 3,500	$ 458,493	$ 16,047	$ 474,540
Total		**$ 175,000**		**$ 299,540**	

Appendix 7B
KIUC Funding Assurances: Supporting Information

7B.1 Introduction

The purpose of this appendix is to provide additional documentation to support the funding assurances for the Kauaʻi Island Utility Cooperative, Inc. (KIUC) Habitat Conservation Plan (HCP). Funding assurances are summarized in Section 7.5, *Funding Assurances*, of the HCP. This appendix provides additional detail on the following topics relevant to funding assurances:

- The financial health of KIUC.
- KIUC's ability to access debt financing and cost recovery to pay for HCP capital costs or unexpected costs.
- The approval process by the Hawaiʻi Public Utilities Commission (PUC) for rate increase requests by KIUC, the primary means KIUC will pay for HCP costs.
- Background on KIUC's previous rate approval through Hawaiʻi PUC.
- KIUC's ability to access to disaster recovery funding in the event of severe natural disasters.

7B.2 KIUC Financial Health

KIUC is a financially strong electric cooperative with excellent balance sheet liquidity and access to multiple sources of new, long-term debt financing to fund HCP implementation. As a regulated utility in Hawaiʻi, KIUC is able to recover all prudently incurred operating costs associated with the ongoing capital and operational expenses in its cost of service for ratemaking purposes.

The financial profile and cost recoverability of HCP capital and operational investments and expenses demonstrate that the commitments made by KIUC will be funded for decades in the future. Finally, in the event of a natural disaster, KIUC maintains access to disaster relief funding for restoration and rebuilding in order to immediately repair or replace HCP-related investments. Details on all of these components are provided in the following subsections.

7B.2.1 Balance Sheet Strength

Since becoming an operating electric generation, transmission and distribution electric cooperative in 2002, KIUC has managed its finances to maintain a highly creditworthy financial profile with debt service coverage (DSC) ratios well in excess of minimum levels. In addition, KIUC maintains patronage equity to total capitalization ratio which has built a substantial equity capital cushion over time.

Stipulations through lender agreements require that KIUC maintain a minimum amount of equity to be held in reserve in the event that additional borrowing is needed against that equity.

Prudent and conservative financial management has been adopted by the KIUC Board of Directors through Strategic Plans, which target financial ratios to maintain the conservative credit posture. The KIUC Board of Directors adopted their last Strategic Plan Update on January 17, 2023, for 2023–2030 (Kauaʻi Island Utility Cooperative 2023). The KIUC Board of Directors also adopts an Equity Management Plan that includes specific policies based on current and future financial projections. These projections are designed to assure KIUC and its Member-Owners of access to new debt capital at attractive rates reflective of a highly creditworthy borrower, even in times of financial stress in credit markets.

KIUC operates with an Indenture of Mortgage, Security Agreement and Financing Statement (Indenture) as its primary financing instrument. The Indenture is administered by U.S. Bank, NA as Trustee and secures the existing and future debt of all three of the electric cooperative direct lenders with which KIUC and cooperatives nationwide secure their funding.

KIUC has since its founding had a close borrowing relationship with the U.S. Department of Agriculture, Rural Utilities Service (RUS) which has funded loans to KIUC through the Federal Financing Bank. KIUC also maintains a foundational relationship with National Rural Utilities Cooperative Finance Corporation (CFC). The CFC is a nonprofit specialized financial institution lending solely to its electric cooperative members and borrowers. The CFC maintains reserves in excess of $30 billion. KIUC's relationship with the CFC dates back to KIUC's founding in 2002. CoBank, ASB, a leading financial institution that is part of the U.S. Farm Credit System, has also been a lender to KIUC over the last decade.

KIUC also maintains the ability to privately place bonds with insurance companies and pension funds due to its relatively unique status of having an Indenture in place.[1] In summary, KIUC has a particularly strong balance sheet that gives it access to capital from its direct lending relations with all three of the major cooperative lender sources and the ability through the Indenture to privately place long-term secured bonds.

7B.2.2 Balance Sheet Liquidity

As of December 31, 2022, KIUC had consolidated patronage capital equity of $157 million on a total asset base of $460 million (Moss Adams 2023). Long-term debt outstanding to RUS/FFB, CFC and CoBank totaled $248 million. Pursuant to the Indenture Equity Ratio calculation, KIUC ended 2022 at a 36 percent level, which is consistent with the objectives of the Equity Management Plan.

All of KIUC's current and future funding sources would be available to finance capital projects under the HCP.

Pursuant to the Indenture provisions for securing new long-term debt without lender approvals, KIUC must maintain an Equity Ratio of at least 20 percent and a DSC Ratio of at least 1.25. KIUC has consistently maintained DSC Ratios in excess of 1.60 over the last decade, again consistent with the objectives of the Equity Management Plan.

As of December 31, 2022, KIUC had $44.6 million of unrestricted cash and short-term investments on its balance sheet (Moss Adams 2023). KIUC maintains multiple revolving lines of credit for short-term liquidity and to fund capital projects to completion before obtaining term debt financing. CFC provides two perpetual lines of credit totaling $25 million. KIUC also has an unsecured $15 million line of credit with CoBank. There were no amounts outstanding on these lines of credit through April 2025. These lines of credit would be available to KIUC to use for the HCP if short-term operating costs exceeded annual budgets (Table 7B-1). Documentation from each financial institution of

[1] It is not typical for electric distribution cooperatives to have an Indenture in place, but it is the standard for generation and transmission cooperatives that finance more of their utility plant through private debt placements in the competitive capital markets.

KIUC's ability to access these lines of credit will be provided to the U.S. Fish and Wildlife Service and the State of Hawai'i Division of Forestry and Wildlife prior to permit issuance.

Table 7B-1. KIUC Lines of Credit

Financial Institution	Total Loans by Institution	KIUC Line of Credit	Notes
National Rural Utilities Cooperative Finance Corporation (CFC)	$32.4 billion (as of March 31, 2023)	$25 million	Two perpetual lines of credit
CoBank, ASB	$143 billion (as of March 31, 2023)	$15 million	
CFC	$32.4 billion (as of March 31, 2023)	$60 million	Disaster recovery line of credit (see Section 4A.2.3)
Total		**$100 million**	

Once an additional HCP expense beyond the expected annual budget and scope was identified, KIUC staff would submit the expense to the KIUC Board for approval of a budget variance for that calendar year. Because the HCP itself would be an approved program by the KIUC Board, the Board would be making the approval as a budget variance for that year. The KIUC Board meets monthly, so a budget variance can be approved relatively quickly to ensure no interruption in HCP implementation. If necessary, a special Board meeting can be called if a budget variance approval is urgently needed to ensure that HCP implementation continues uninterrupted.

7B.2.3 Disaster Recovery Line of Credit

KIUC also has a perpetual $60 million disaster recovery line of credit with CFC (Table 7B-1). This line of credit would ensure immediate liquidity to repair or replace electric facilities damaged in a federally declared natural disaster such as a hurricane. These funds could be available to support HCP remedial measures for changed circumstances associated with a federally declared natural disaster. These funds are available for use almost immediately following such disasters. Once restoration of the facilities was accomplished, including any repair of facilities dedicated to the HCP, permanent financing would be placed to repay the disaster relief line of credit and reset its availability back to $60 million. The disaster recovery line of credit would also be available to support the repair or replacement of any HCP assets (e.g., conservation site fencing, heliports) in the event of a federally declared natural disaster. The significant natural disasters on Kaua'i that have occurred since KIUC took over the electric power distribution and generation system on the island in 2002 did not substantially affect KIUC facilities or HCP implementation. Therefore, KIUC has not needed to access this line of credit to date.

7B.2.4 Ability to Recover HCP Costs and Expenses through Rate Cases

KIUC is a regulated public utility under Chapter 269 of the Hawai'i Revised Statutes, in the same way that investor-owned utilities are regulated. Jurisdiction over rates and financing matters of regulated public utilities are vested with Hawai'i PUC. Under Chapter 269, KIUC is allowed to recover all prudently incurred costs and expenses in its cost of service for ratemaking purposes. All

HCP costs are considered prudently incurred costs and expenses because they are directly related to KIUC's day-to-day operations. In other words, compliance with the HCP is critical to KIUC's mission and to its day-to-day operations.

KIUC has filed only two rate case proceedings since its formation in 2002. KIUC filed in 2009 to adjust rates in Docket No. 2009-0050, which was approved, settled, and closed in 2010. This first rate case included $1.9 million in HCP-related costs associated with the Short-Term HCP (2011–2016).

On October 17, 2022, KIUC filed Docket No. 2022-0208[2] to increase rates due to deterioration in its DSC Ratio due to inflationary pressures, increased expenses related to current HCP expenditures,[3] and the need to recover regulatory assets related to the COVID-19 pandemic. The HCP expenditures for which KIUC requested rate recovery include:

- Consultant costs associated with preparing the KIUC HCP and HCP Environmental Impact Statement.
- Ongoing costs of powerline collision monitoring.
- Ongoing costs to support the Save Our Shearwaters bird recovery and rehabilitation program.
- Early implementation of conservation sites for the covered seabirds, including predator fence construction, predator control, and site monitoring.

In Hawai'i, rate cases are requested for a forward looking "test year." KIUC's 2022 rate increase request is for the 2023 test year. For the HCP, this means costs KIUC expected to incur for the HCP in 2023.

The current pending rate case seeks complete recovery for $4.91 million in test-year operating costs related to HCP activities and depreciation and related debt service on $14.15 million in HCP-related capital projects completed to date.[4] KIUC believes that these and future HCP expenses will be deemed by Hawai'i PUC to be prudently incurred and fully reimbursed in cost of service. Once this rate increase is approved by Hawai'i PUC for the 2023 test year, the rate increase becomes permanent and applies to all future years until KIUC requests another rate change.

On November 27, 2023, the Hawai'i PUC issued an Interim Decision and Order that granted KIUC the ability to raise rates by 7.95 percent. The rate increase provides for complete recovery of $4.91 million in test-year operating costs related to HCP activities and depreciation and related debt service on $14.15 million in HCP-related capital projects completed to date. The interim rate increase remains in effect until the Hawai'i PUC makes a final decision. Upon final approval by Hawai'i PUC, the rate increase becomes permanent and applies to all future years until KIUC requests another rate change.

HCP average annual operating costs are estimated to be $8.6 million over the life of the HCP (Table 7-4). Of these, approximately $5.5 million are operating costs annually (Table 7B-2).The rate

[2] See https://dms.puc.hawaii.gov/dms/dockets?action=details&docketNumber=2022-0208 for all documents related to this filing.

[3] At the time, "current expenditures" were defined as $4.5 million for the HCP and $384,000 for one-time capital costs and operational costs associated with the Save Our Shearwaters Program.

[4] For details, see testimony of Mr. Chris Yuh of KIUC, Exhibit 10-T-700, and Attachment CY-701, both of Hawai'i PUC Docket 2022-0208.

increase approved by Hawai'i PUC covers $4.9 million (93 percent) of these HCP operating costs. The remaining amount ($352,100 annually) would be paid by KIUC's current rates as part of normal operating expenses.

It is unknown how often KIUC would need to reapply to Hawai'i PUC for rate increases to offset HCP costs due to inflation and other factors. KIUC estimates that the timing of such requests could be as short as every 3 to 5 years, or as long as every 10 or more years (the 2022 request was 12 years after the previous request in 2010). Rate case requests typically take 9 to 12 months from the initial filing to approval. During the pending request, KIUC would continue to fully fund HCP implementation.

7B.2.5 KIUC Spending Authority Once Rate Increase Authorized by Hawai'i PUC

KIUC has wide authority to spend its revenues to meet the HCP requirements. Once a rate increase is approved by Hawai'i PUC, KIUC can spend what it needs for all HCP operating costs (approximately 78 percent of average annual HCP costs are operating costs, see Table 7B-2), without any oversight from Hawai'i PUC. The same is true for any capital expenditures under $2.5 million.

The Hawai'i Revised Statutes requires all regulated public utilities to file a notification with Hawai'i PUC for any capital expenditure over $2.5 million. If there is no action taken by Hawai'i PUC the capital expenditure request is approved in 60 days. In some cases, Hawai'i PUC may open a docket for the capital expenditure filing and hold an administrative hearing to request more information. In any administrative hearing, an action is open for intervention from any person with standing.

Total average annual capital expenditures by the HCP are estimated at approximately $1.1 million from 2025 through 2074 (Table 7B-2). Therefore, almost all HCP capital expenditures will be well below the $2.5 million threshold for Hawai'i PUC notification (see Appendix 7A, *Cost Model*), and thus not subject to any additional Hawai'i PUC notification or review.

In rare instances, HCP capital expenditures may exceed the $2.5 million threshold and therefore be subject to this additional Hawai'i PUC notification and possible review through an administrative hearing. For example, in the event of a catastrophic landslide or hurricane, fencing at one or more conservation sites may need major repairs or complete replacement. To accomplish these repairs immediately, KIUC would likely utilize their disaster recovery line of credit (Table 7B-1), with Hawai'i PUC rate recovery request coming much later. KIUC would only later notify Hawai'i PUC of the capital expenditure to repay the line of credit. In the extremely unlikely event that Hawai'i PUC denies such a request, KIUC has the ability to appeal the decision or reapply.

The ability to recover these HCP expenses in the rates charged for the essential provision of electricity provides a high level of assurance as to KIUC's ability to meet its future obligations under an HCP.

Table 7B-2. KIUC HCP Costs and Funding Sources

Cost Category	Avg. Annual HCP Cost (2025–2074)[1]	Type of Cost (Operating or Capital)	KIUC Funding Sources
Plan Administration	$435,685	Operating	Annual operating budget (recovered through proposed 2022 rate increase)
Powerline Collisions Minimization	$2,048,769	Capital	Capital funding through debt financing or lines of credit with banks (see Table 7B-1)
Save Our Shearwaters Program	$300,000	Operating	Annual operating budget (recovered through proposed 2022 rate increase)
Manage and Enhance Conservation Sites	$2,442,480	Operating (68%) and Capital (32%)[2]	Annual operating budget (recovered through proposed 2022 rate increase); capital funding through debt financing or lines of credit with banks (see Table 7B-1)
Green Sea Turtle Nest Detection and Shielding Program	$166,913	Operating	Annual operating budget (recovered through proposed 2022 rate increase)
Powerline Minimization and Monitoring	$1,169,795	Operating	Annual operating budget (recovered through proposed 2022 rate increase)
Seabird Colony Monitoring Program	$1,088,034	Operating	Annual operating budget (recovered through proposed 2022 rate increase)
State Compliance Monitoring	$52,708	Operating	Annual operating budget (recovered through proposed 2022 rate increase)
Changed Circumstances	$433,510	Operating (50%) and Capital (50%)	Annual operating budget (for smaller costs) and disaster recovery line of credit (see Table 7B-1) for larger costs
Adaptive Management	$318,974	Operating (80%) and Capital (20%)	Annual operating budget (recovered through proposed 2022 rate increase)
Contingency	$163,795	Operating	Annual operating budget (for smaller costs) or line of credit through banks (see Table 7B-1) for larger unexpected costs
Total	**$8,620,663**		

[1] Source: Table 7-4

[2] Approximately 32% of costs in this category are for predator-proof fence construction, maintenance, and repair, which are considered capital costs. All other costs in this category are considered operational costs.

7B.3 References

7B.3.1 Published Sources

Kauaʻi Island Utility Cooperative. 2023. *Strategic Plan Update 2023–2030*. January. Available: https://www.kiuc.coop/sites/default/files/documents/2023_2033_KIUCStrategicContext%201.17.23%20FINAL.pdf.

Moss Adams, LLP. 2023. Report of Independent Auditors and Consolidated Financial Statements with Supplementary Information. Prepared by Moss Adams, LLP for Kauaʻi Island Utility Cooperative and Subsidiaries as of December 31, 2022 and 2021, Līhuʻe, HI. 42 pp. https://www.kiuc.coop/sites/default/files/documents/audited_financials/2022-AuditedFinancialStatements.pdf

Appendix 7C
Summary of Supplementary Climate Projections

7C.1 High-Level Takeaways

7C.1.1 Hurricanes

- The likelihood of both hurricane landfalls and near-landfalls on the Island of Kauaʻi is projected to increase slightly during the 21st century. The likelihood of the *most intense* Category 3+ hurricanes, however, is projected to increase at a faster rate than the frequency of overall hurricane frequency due to projected increases in maximum sustained wind speeds.

7C.1.2 Inland Flooding and Extreme Precipitation

- Risk for increased flood extent is projected to increase for exposed bays, inlets, and low-lying wetlands across the island, and heavy precipitation totals are projected to increase in intensity and frequency across Kauaʻi during the 50-year permit term.
- Combining the heavy precipitation projections with present-day Federal Emergency Management Agency (FEMA) floodplains, flood risk will likely increase for areas exposed to riverine and coastal flooding, particularly along the eastern portion of the island.

7C.1.3 Sea Level Rise

- Along the Kauaʻi coast, sea levels are projected to rise substantially faster than historically observed as warming accelerates, particularly under a higher-emissions scenario. Low-lying coastal areas, such as Mānā, will be particularly sensitive and vulnerable to sea level rise over the next 50 years.
- While sea level rise poses a significant risk, the cumulative impact of sea level rise on Kauaʻi relative to other regions in the United States is projected to be lower, owing to the coastal bathymetry and topography of Kauaʻi. Sea level rise, however, will likely pose a significant threat to Kauaʻi's coastline over the next 50 years.

7C.1.4 Wildfire

- Droughts are projected to intensify on Kauaʻi over the next 50 years, which could lead to greater wildfire risk. Models projecting future wind speeds are more uncertain, although maximum wind speeds are projected to increase, potentially exacerbating the likelihood and intensity of wildfires.

7C.2 Introduction

7C.2.1 Background

This supplementary section provides climate projections and associated methodologies for key hazards relevant to implementation of the Kauaʻi Island Utility Cooperative (KIUC) Habitat Conservation Plan (HCP). Climate projections serve two primary purposes within this context: they offer insights into the potential local effects of climate change on conservation sites, and they play an important role in distinguishing changed versus unforeseen circumstances.

The climate hazards selected for projection include hurricanes, inland flooding and extreme precipitation, sea level rise, and wildfire. These hazards may pose risks to the conservation sites and covered species under certain conditions.

- **Hurricanes:** Intense storm systems can damage conservation sites, potentially affecting seabird nesting areas on cliffs due to storm surges, heavy precipitation, and strong winds. An increase in hurricane frequency or intensity could further reduce available nesting sites. Sea turtles, which nest on sandy beaches, face threats from erosion and inundation.
- **Inland flooding and extreme precipitation:** Intense rainfall and flooding can alter the environments in conservation sites where seabirds nest, potentially causing landfalls or mudslides.
- **Sea level rise:** Rising sea levels threaten nesting beaches for sea turtles and may influence the base of cliff habitats.
- **Wildfire:** Changes in terrestrial habitats due to wildfires can affect seabirds and waterbird habitat suitability by altering the composition of vegetation.

Climate hazards can manifest as chronic or acute (extreme) events, including heat waves, drought, wildfire, extreme precipitation, and flooding. In the 21st century, the severity and frequency of each of these hazards is expected to increase relative to historical conditions. To supplement the *Thresholds for Changed Circumstances for Severe Weather and Natural Hazards* provided in Chapter 7, *Plan Implementation*, of the KIUC HCP, this appendix describes projected trends in frequency and intensity using a suite of qualitative and quantitative sources, including quantitative climate model projections, historical datasets, and scientific literature, to characterize the direction and magnitude of the relevant climate change hazards listed above.

7C.2.2 Methods

To support projected changes in inland flooding and wildfire hazards, the Study Team[1] used publicly available geospatial 25-kilometer (km) x 25-km (15.5-mile x 15.5-mile) National Aeronautics and Space Administration (NASA) Global Daily Downscaled Projections Sixth Phase of the Coupled Model Intercomparison Project (CMIP6) projections to compute tailored extreme temperature and precipitation variables (Thrasher et al. 2022). Climate projections of daily temperature and precipitation are drawn from an ensemble of statistically downscaled Global Climate Model[2] (GCM) datasets developed by NASA. These datasets align with the latest climate science developed for the United Nations Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report published in 2021, which is internationally considered the authoritative source of science on global climate change and impacts. The GCMs illustrate a range of possible climate futures, depending on both future global trends in greenhouse gas (GHG) emissions, the sensitivity of the climate system to those emissions, and other factors. Trends in GHG emissions are defined by Shared Socioeconomic

[1] The authors from ICF's Climate Resiliency group: Daniel Bishop, PhD; Carson Young; Noah Carpenter; Matia Whiting; and Fiona Price.

[2] GCMs are models that integrate climate system components to generate future projected climate conditions. GCMs are critical to understanding how different actions will affect future climate, particularly how different GHG emissions pathways affect future climate. These models inform our understanding of how the climate has changed in the past and may change in the future.

Pathways (SSPs), developed for CMIP6.[3] SSPs represent potential socioeconomic trajectories related to energy and land use, resource use, and governance, all of which affect GHG emissions. To avoid sensitivity to one model or to one SSP, climate scientists often use an ensemble approach, combining results from multiple GCMs. To plan for and anticipate multiple climate futures, this study focuses on two SSPs, including a lower and upper bound representation of future climate change.

- **SSP2-4.5 scenario (lower bound):** Reflecting aggressive global GHG emissions reductions by mid-century and middle-of-the-road assumptions on climate system sensitivity.
- **SSP5-8.5 scenario (upper bound):** Reflecting a high-end, lower-likelihood outcome from the failure of global GHG emissions reduction efforts and high-end climate sensitivity. This represents a high risk aversion level in planning for future climate change.

In order to account for interannual and interdecadal variability in the daily temperature and precipitation datasets, the Study Team analyzed climate projections of precipitation and temperature across prioritized 30-year time horizons centered on present-day, mid-century centered on 2050 (2036–2065), and late-century centered on 2070 (2056–2085) to evaluate climate change over the next 50 years—the HCP permit term—when available.

To support projected changes in sea level rise, the Study Team mapped sea level rise developed by the National Oceanic and Atmospheric Administration (NOAA). To support projected changes in hurricanes, inland flooding, and wildfire, the Study Team provided a supplementary analysis using projections derived from the scientific literature, historical mapped datasets, and Hawaiʻi-specific datasets and tools. The specific approach for each natural hazard is outlined in subsequent sections along with limitations.

7C.2.2.1 Hurricanes

Methods

While the science evaluating climate change and extreme events has improved in recent years, greater uncertainty remains for the most intense extreme weather events because of (1) the rarity of the event relative to the length of the historical record, (2) the small spatial and timescales at which the events occur, and (3) the limited ability of current global-scale climate models to resolve events at these scales. Consequently, this study assesses hurricane likelihood through a combination of historical data[4] and projections from a review of the scientific literature (Knutson et al. 2015). Specifically, the Study Team estimated the changes in the likelihood of hurricanes affecting Kauaʻi using historical annual frequency estimates of hurricanes provided in Chapter 7 of the KIUC HCP and basin-wide projections of hurricane frequency derived in the literature to extrapolate mid-century hurricane frequencies.

Hurricanes represent the most extreme example of windstorms affecting Kauaʻi. The Study Team also provides a literature review of projected trends in tropical cyclones in the eastern Pacific basin,

[3] CMIP is a collaborative project among international organizations to advance and establish the state of climate science through a set of standardized climate model simulations. CMIP is the primary modeling framework featured in the United Nations' IPCC assessment reports, which assess global scientific, technical, and socioeconomic information regarding climate change.

[4] Provided in Chapter 7 of the KIUC HCP and derived from the Atlantic Hurricane Database version 2 (HURDAT2) (Landsea et al. 2013).

including an explanation of the expected northward shift in hurricane tracks, increase in major (Category 3–5) hurricanes, and changes in overall frequency.

Limitations

- Projections do not provide geospatial estimates of landfall frequency or likelihood of experiencing specific windspeeds (e.g., different likelihoods of hurricane categories).
- The scientific consensus suggests that the most intense hurricanes may increase in frequency and that hurricanes in the Northern Hemisphere may experience a northward shift as global temperatures warm during the 21st century. These changes are not accounted for in the quantitative projections provided in this Study but are reviewed in the literature in Section 7C.3, *Summary of Future Climate Projections*.

7C.2.2.2 Inland Flooding

Methods

Flooding was first evaluated using present-day FEMA flood zones. Forward-looking climate projections of inland flooding are not readily available. Present-day FEMA flood maps are commonly used to estimate areas potentially exposed to future flooding. Although these flood maps represent present-day risks, the flood zones indicate which areas are most likely to flood first, or more frequently, as the climate changes.[5] FEMA provides flood hazard and risk data to help guide mitigation actions in the form of National Flood Insurance Program floodplain mapping. FEMA floodplains provide representations of present-day risk in terms of 100-year and 500-year floodplains (1 percent and 0.2 percent annual probability, respectively). Present-day FEMA floodplains represent a strong indicator of areas that may be at heightened riverine flood risk under climate change, as precipitation increases maximum flood stages, as well as FEMA-assessed risk of coastal flooding. In general, increases in heavy precipitation under climate change could increase flood flows and the severity of flooding within these floodplains.

The frequency, magnitude, and duration of flooding are expected to increase as a result of climate change, which is evaluated using projections of return period precipitation intensities and annual likelihoods of high-intensity precipitation events. Return period precipitation intensities are an imperfect but reasonable proxy for future flood exposure to the heaviest 1-day precipitation totals that occur during a set period of time (e.g., 5, 10, 20 years) given projected precipitation totals in the future. Precipitation projections are provided for:

- 10-, 25-, 50-, and 100-year 24-hour precipitation return period totals.[6]
- Return periods (annual likelihoods) for 4 and 5 inches of 24-hour precipitation totals.[7]

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[5] The Federal Flood Risk Management Standard identifies using the current 500-year floodplain as a proxy for the future 100-year floodplain as one of three possible ways to understand future flood risks.

[6] 24-hour precipitation totals represent a continuous 24-hour period, which could represent 9 p.m. to 9 p.m. or 3 a.m. to 3 a.m., for example. A 1-day period of precipitation represents a 12 a.m. to 12 a.m. timeframe only. As such, the 24-hour precipitation totals capture heavier periods of rain in one 24-hour window than does the 1-day window and provide a better means to evaluate the potential impacts from heavy precipitation.

[7] 1-day precipitation totals of 4 and 5 inches are selected to represent heavier precipitation totals (averaged within a 25 km x 25 km grid cell) on Kauaʻi.

Observed 24-hour heavy rainfall totals are sourced from the NOAA Atlas-14 dataset across Kaua'i.[8] These historical values are based on Intensity-Duration-Frequency curves of 24-hour precipitation totals at weather stations across the island. These curves use relationships derived from historical data that allow us to scale extreme daily precipitation to continuous 24-hour precipitation events and are used to derive return period event intensities during future time horizons using geospatial climate projections. The Study Team scaled future projections to observed NOAA Atlas-14 values, by applying the proportional change in projected return period precipitation totals to the observed NOAA Atlas-14 values.

Combined, the present-day floodplains and precipitation likelihoods and intensities will help identify the most vulnerable areas for inland flooding in the future. Short-duration and high-intensity rainfall events can lead to significant localized inland flooding. If extreme precipitation events were to increase in the future, the likelihood of inland flood events similar to present-day 100- and 500-year FEMA floodplains would increase.

Limitations

- Floodplain data represents present-day floodplain risk, but also indicates which areas are most likely to flood first, or more frequently, as the climate changes. They represent a reasonable proxy for future flood exposure.
- Precipitation projections provide a forward-looking estimate of future inland flood risk. As extreme precipitation increases in both intensity and frequency, the likelihood of inland flooding increases.
- The daily timescale of the precipitation projections does not directly account for deluge precipitation, heavy precipitation events that occur at an hourly timescale. Daily precipitation projections are scaled to observed 24-hour precipitation totals under the assumption that the proportional change in *daily* precipitation totals is consistent with the proportional change in *24-hour* precipitation totals.

7C.2.2.3 Sea Level Rise

Methods

Sea level rise projections used the Intermediate-High and Intermediate-Low scenarios developed by NOAA to bracket future coastal change (Sweet et al. 2022). NOAA sea level rise projections are frequently used in city, state, and federal reports, scientific assessments, and guidance documents across the country. The Intermediate-High scenario aligns approximately with the very high-end range of SSP5-8.5 and represents a low risk tolerance scenario,[9] whereas the Intermediate-Low scenario aligns approximately with the middle range of SSP2-4.5 and represents a higher risk tolerance scenario. The high and low risk tolerance scenarios provide a reasonable range of future climate outcomes for sea level rise. Sea level rise projections were centered on 2030, 2040, 2050,

[8] A point-and-click map interface with historical heavy rainfall amounts based on Intensity-Duration-Frequency estimates and 90 percent confidence intervals can be found at the following source: PF Map: Hawaiian Islands (noaa.gov)

[9] A low risk tolerance scenario represents a planning scenario that considers the potential for higher impact, worse-case climate change outcomes. Higher-impact scenarios, such as SSP5-8.5, help establish a low risk tolerance for planning and, in turn, increase resiliency to climate change.

2060, and 2070 and considered at Kaua'i's Nāwiliwili Bay tide gauge. Coastal floodplains corresponding to the sea level rise projections are evaluated spatially in terms of floodplain extent and depth using datasets available through the NOAA Sea Level Rise Viewer (https://coast.noaa.gov/slr/#).

Limitations

- Sea level rise projections provide geospatial floodplain and inundation levels under a range of climate change scenarios, but do not include the potential impacts from future storm surge.
- Sea level rise inundation maps are available under 1-foot (0.3-meter) increments. The Study Team provides inundation maps for 1, 2, and 3 feet (0.3, 0.6, and 0.9 meter) of sea level rise, corresponding with the range of projected sea level rise scenarios for Kaua'i.

7C.2.2.4 Wildfire

Methods

Wildfires are large, unplanned or unwanted fires that burn vegetation, often in arid, or dry, landscapes. Large wildfires require a substantial, relatively unfragmented supply of fuel, or flammable vegetation such as brush, grass, or forests across a landscape. Wildfires may occur naturally from lightning, but human activity is often cited as the predominant cause of wildfires. Fuel moisture refers to the amount of water within organic material; it is controlled by seasonal, daily, and sub-daily weather changes. Fuel moisture content can limit fire propagation. When fuel moisture content is high, fires are difficult to ignite and burn poorly, if at all. When fuel moisture is low during a drought, fires start easily, and wind and other driving forces may cause rapid and intense fire spread (U.S. Forest Service 1970).

GCMs are limited in their ability to simulate wildfire frequency and intensity absent effects of urbanization, land fragmentation and land use change, and spatiotemporal ignition frequency. GCMs, however, can simulate fire weather conditions, which include measures of drought or dry spells. The Study Team provided quantitative geospatial projections of annual maximum number of consecutive dry days to represent changes in dry spell length across Kaua'i during the next 50 years.

To build a qualitative summary of projected trends in wildfire weather and risk across Kaua'i, the Study Team also compiled maps of present-day Hawai'i GIS Program Fire Risk areas and ignition density (Hawai'i Statewide GIS Program 2017), U.S. Geological Survey National Land Cover Database maps for Kaua'i highlighting land reserved for development, grass, shrubs, and forest; and literature review of projected changes in wind speeds, hurricanes, drought, and wildfire in Hawai'i.

Limitations

- Geospatial projections of wildfire frequency and intensity are not readily available for Hawai'i.
- Projections investigate proxies of wildfire frequency and intensity, including land use, drought, wind, and present-day risk metrics. While the datasets used do not provide a quantifiable likelihood of large wildfires, they do provide an understanding of directional change in the likelihood of wildfires.

7C.3 Summary of Future Climate Projections

7C.3.1 Hurricanes

7C.3.1.1 Quantitative Projections

Results indicate that the likelihood of both a hurricane landfall and near landfall on Kauaʻi will increase slightly during the 21st century. For example, a landfalling hurricane increases from a 1-in-35-year event to a 1-in-30-year event by the end of the 21st century. Table 7C-1 summarizes the historical and future projected trends for hurricane frequency for Kauaʻi. These increases in overall hurricane frequency, however, are relatively small and do not indicate a significant increase in the likelihood of landfalls or near landfalls on Kauaʻi.

Table 7C-1. Historical and Future Annual Average Frequencies using Landfall, Close Approach, and Distant Approach methods. Historical Frequencies were Previously Calculated as Part of the KIUC HCP.

Hurricane Classification	Historical Annual Average	Mid-Century[a] (2050s)	Late Century[a] (2070s)	End of Century[a] (2090s)
Hurricane (Landfall)	0.028 1-in-35 years	0.031 (+9.7%) 1-in-32 years	0.032 (+14.5%) 1-in-31 years	0.033 (+19.3%) 1-in-30 years
Hurricane (Close approach[b])	0.028 1-in-35 years	0.031 (+9.7%) 1-in-32 years	0.032 (+14.5%) 1-in-31 years	0.033 (+19.3%) 1-in-30 years
Hurricane (Distant approach[b])	0.056 1-in-18 years	0.061 (+9.7%) 1-in-16 years	0.064 (+14.5%) 1-in-16 years	0.067 (+19.3%) 1-in-15 years

[a] Future projections derived from end-of-century projected trends in hurricane frequencies for the Northeast Pacific basin using a downscaled Global Climate Model ensemble under the RCP 4.5 scenario. Mid- and late-century projections are linearly interpolated between the historical and end-of-century projections.

[b] Close approach is defined as 0–50 miles (0–80.5 kilometers) offshore, distant approach is defined as 50–150 miles (82–241.4 kilometers) offshore. Hurricanes have been divided into these categories due to the differences in the potential damage, in terms of extent and magnitude, that may be expected at conservation sites associated with the HCP. Specifically, damage resulting from hurricanes making landfall or closely approaching the island is presumed to be more severe relative to hurricanes whose center remains at a distance from the island. "Distant" is synonymous with "less severe damage expected", and these distances were based on the extent of damage that resulted from various hurricanes passing at various distances from Kauaʻi.

7C.3.1.2 Scientific Literature Review

The likelihood of the most intense hurricanes may increase at a faster rate than the frequency of overall hurricane frequency due to projected increases in maximum sustained winds speeds. Knutson et al. (2015) note that, while overall hurricane frequency is projected to increase by 19 percent in the Northeast Pacific basin by late 21st century, the number of major hurricanes (Category 3–5, >111 miles per hour [mph; 179 kilometers per hour {kph}] maximum sustained wind speeds) are projected to increase at a faster rate, nearly an 84 percent increase by late century. Dynamically downscaled global climate model projections show warming atmospheric and ocean surface temperatures will likely invigorate hurricanes in the Northeast Pacific to become more intense (~5 percent increase with 3.6 degrees Fahrenheit [°F] [2 degrees Celsius {˚C}] warming of global temperatures) and have higher rainfall amounts (~20 percent increase) relative to historical hurricanes, leading to this greater likelihood for the strongest storm intensities

(Knutson et al. 2020; Intergovernmental Panel on Climate Change 2021). Increasing storm intensities indicate stronger hurricane winds and, in turn, coastal storm surge. Projections and historical data also both show a persistent northward migration of the location of hurricane maximum intensity (Studholme et al. 2022), which could draw hurricanes that historically missed the island to the south farther north and closer to the island in the future. The projected increase in frequency of the most intense hurricanes suggests that, while the overall frequency of all hurricanes is not projected to change significantly in the Northeast Pacific basin, the intensity of the hurricanes affecting Hawaiʻi will likely increase during the next 50 years. This could lead to more severe damage from hurricanes at conservation sites despite the relatively small increase in total hurricane frequency demonstrated in Table 7C-1.

7C.3.2 Flooding

Risk for increased flood extent is projected to increase for exposed bays, inlets, and low-lying wetlands across the island, including areas surrounding Kekaha and Mānā, Nāwiliwili Bay and Huleʻia Stream, and Hanapēpē Bay. Areas that would be flooded during a 100- and 500-year flood would be at highest risk for future exposure to more frequent flood events, coastal or inland, in the future. The majority of Kauaʻi's coastline is vulnerable to flooding from the 100-year flood event (Figure 7C-1). While the 100-year floodplain accounts for most of the exposed area along the coastline of Kauaʻi, the 500-year floodplain exposes more land to flooding across much of the island**.**

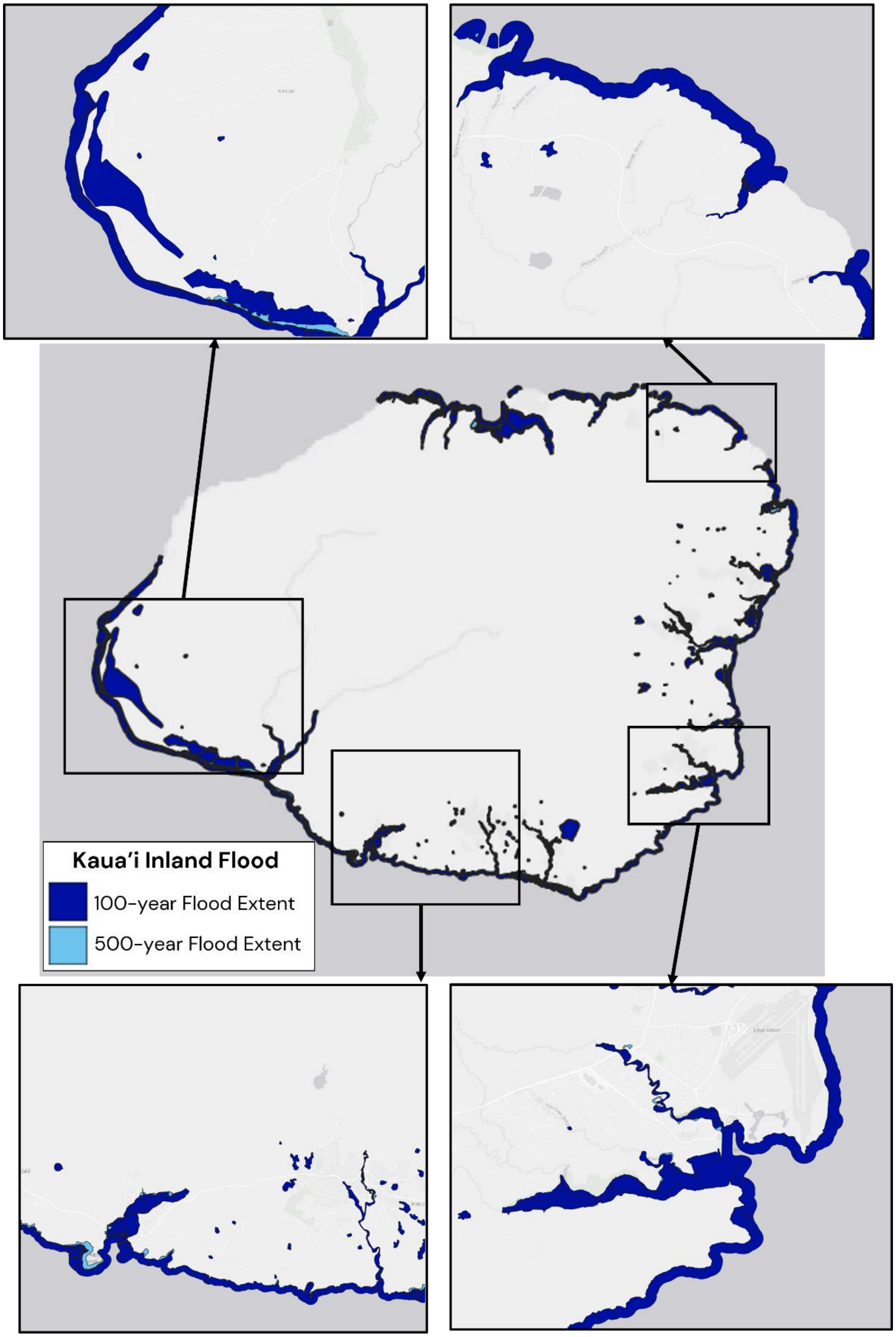


Figure 7C-1. 100- and 500-year FEMA Floodplain Maps for Kauaʻi. Inset Maps Highlight Four Areas with Green Sea Turtle Nesting Sites, including Mānā in the Upper Left Inset.

The scientific consensus is that the highest-intensity precipitation events may be increasing faster than lower-intensity events, indicating that urban areas may face increased exposure to these events. The IPCC Sixth Assessment Report states with high confidence that heavy precipitation events are very likely to increase in intensity and frequency globally with warming temperatures, with roughly a 7 percent increase in global precipitation intensity for each 1.8°F (1°C) increase in global temperature (Intergovernmental Panel on Climate Change 2021). To evaluate increases in the highest-intensity events, the Study Team used projections of high return period (high-intensity and less-frequent) precipitation totals across Kauaʻi.

Extreme precipitation totals are projected to increase across Kauaʻi. The heaviest precipitation totals are projected to increase in intensity and the frequency of these events are projected to become more common during the 50-year permit term. This will likely lead to increased flood risk across the island, particularly in the present-day 100- and 500-year FEMA floodplains. Historically, the eastern areas of the island are most susceptible to extreme precipitation, experiencing 10-year (10 percent annual likelihood) and 100-year (1 percent annual likelihood) precipitation totals of 10.1 and 17 inches (25.7 and 43.2 centimeters), respectively. In contrast, the western areas of the island experience 10- and 100-year precipitation totals of 7 and 10 inches (17.8 and 25.4 centimeters), respectively. Table 7C-2 through 7C-5 demonstrate how extreme precipitation intensities are projected to change through 2070. 10-, 25-, 50- and 100-year precipitation events are projected to increase by 0.2 to 0.8 inch (0.5 to 2 centimeters) by 2070, with relatively larger increases for less-frequent (e.g., 100-year or 1 percent annual likelihood) precipitation totals, particularly under the high-end SSP5-8.5 scenario.[10]

Table 7C-2. Observed Baseline and Future Projected Values for Number of Inches of Rainfall in a 10-Year Return Period for Mid (SSP2-4.5) and High (SSP5-8.5) Emissions Scenarios. Averages are Provided for the Eastern, Western, and Entire island.

10-Year (10% Annual Likelihood) 24-Hour Precipitation Totals			
SSP2-4.5	**Observed Baseline**	**Mid-Century (2050s)**	**Late Century (2070s)**
Eastern Island Average [a]	10.1	10.3	10.4
Western Island Average [a]	7	7.2	7.2
Island Average	9.3	9.5	9.6
SSP5-8.5	**Observed Baseline**	**Mid-Century (2050s)**	**Late Century (2070s)**
Eastern Island Average [a]	10.1	10.3	10.3
Western Island Average [a]	7	7.2	7.3
Island Average	9.3	9.5	9.5

[a] The eastern (western) island average values come from the mean of the two eastern- (western-) most grid cells on Kauaʻi.

[10] Gridded daily (1-day) return period precipitation projections are lower than observed baseline, station-based 1-day observations in Tables 7C-2 through 7C-5 because gridded reanalysis data may not fully resolve higher-intensity deluge precipitation events due to the coarse 10-km x 10-km spatial resolution of the dataset. Global climate projections tend to smooth peaks in precipitation intensity between weather stations, lowering rainfall intensity estimates during extreme precipitation events. Because of this limitation in the gridded data, the Study Team scaled future projections to observed NOAA Atlas-14 values. Specifically, the proportional change in projected return period precipitation totals is applied to the observed NOAA Atlas-14 values.

Table 7C-3. Observed Baseline and Future Projected Values for Number of Inches of Rainfall in a 25-Year Return Period for Mid (SSP2-4.5) and High (SSP5-8.5) Emissions Scenarios. Averages are Provided for the Eastern, Western, and Entire Island.

25-Year (4% Annual Likelihood) 24-Hour Precipitation Totals			
SSP2-4.5	**Observed Baseline**	**Mid-Century (2050s)**	**Late Century (2070s)**
Eastern Island Average [a]	12.6	12.9	13.0
Western Island Average [a]	8.3	8.6	8.7
Island Average	11.4	11.7	11.8
SSP5-8.5	**Observed Baseline**	**Mid-Century (2050s)**	**Late Century (2070s)**
Eastern Island Average [a]	12.6	13.0	13.0
Western Island Average [a]	8.3	8.6	8.8
Island Average	11.4	11.7	11.8

[a] The eastern (western) island average values come from the mean of the two eastern- (western-) most grid cells on Kauaʻi.

Table 7C-4. Observed Baseline and Future Projected Values for Number of Inches of Rainfall in a 50-Year Return Period for Mid (SSP2-4.5) and High (SSP5-8.5) Emissions Scenarios. Averages are Provided for the Eastern, Western, and Entire Island.

50-Year (2% Annual Likelihood) 24-Hour Precipitation Totals			
SSP2-4.5	**Observed Baseline**	**Mid-Century (2050s)**	**Late Century (2070s)**
Eastern Island Average [a]	14.8	15.2	15.3
Western Island Average [a]	9.4	9.8	9.8
Island Average	13.1	13.5	13.6
SSP5-8.5	**Observed Baseline**	**Mid-Century (2050s)**	**Late Century (2070s)**
Eastern Island Average [a]	14.8	15.3	15.4
Western Island Average [a]	9.4	9.9	10.0
Island Average	13.1	13.6	13.7

[a] The eastern (western) island average values come from the mean of the two eastern- (western-) most grid cells on Kauaʻi.

Table 7C-5. Observed Baseline and Future Projected Values for Number of Inches of Rainfall in a 100-Year Return Period for Mid (SSP2-4.5) and High (SSP5-8.5) Emissions Scenarios. Averages are Provided for the Eastern, Western, and Entire Island.

100-Year (1% Annual Likelihood) 24-Hour Precipitation Totals			
SSP2-4.5	**Observed Baseline**	**Mid-Century (2050s)**	**Late Century (2070s)**
Eastern Island Average [a]	17.0	17.5	17.7
Western Island Average [a]	10.3	10.7	10.8
Island Average	14.8	15.3	15.5
SSP5-8.5	**Observed Baseline**	**Mid-Century (2050s)**	**Late Century (2070s)**
Eastern Island Average [a]	17.0	17.6	17.8
Western Island Average [a]	10.3	10.9	11.1
Island Average	14.8	15.4	15.6

[a] The eastern (western) island average values come from the mean of the two eastern- (western-) most grid cells on Kauaʻi.

While increases in return period precipitation totals are modest, increasing less than 1 inch (2.5 centimeters) for all return periods through 2070, this represents a meaningful increase in flood risk across the island. Figure 7C-2 demonstrates how 50-year (2 percent annual likelihood) precipitation totals are projected to change across Kauaʻi. Historically, 50-year precipitation totals range from 8.4 to 18.7 inches (21.3 to 47.5 centimeters), with the highest totals over the northern areas of the island. 50-year precipitation totals increase to 8.9–19.2 inches (22.6–48.8 centimeters) in 2070 under the high-end SSP5-8.5 scenario.

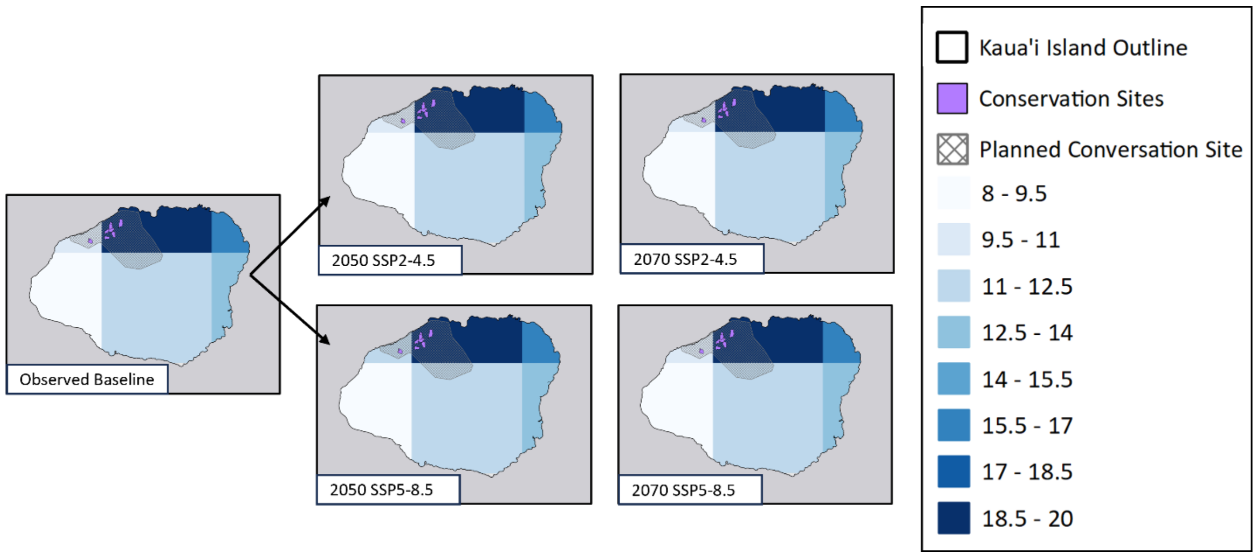


Figure 7C-2. Projected Precipitation Totals (in inches) for a 1-in-50-Year Rainfall Event in the Observed Baseline, 2050, and 2070 for Mid (SSP2-4.5) and High Emissions (SSP5-8.5) Scenarios on Kauaʻi. Current and Planned Conservation Sites Highlighted in Each Panel.

In addition to intensity increases, the likelihoods (or return periods) of extreme precipitation totals are projected to increase over the next 50 years. Table 7C-6 and 7C-7 show how extreme precipitation likelihoods are projected to change (in percent change) through 2070.[11] Climate models project larger increases for less-frequent, higher-intensity precipitation totals, particularly under the SSP5-8.5 scenario. For example, the models indicate that a 4-inch (10.2-centimeter) precipitation total (averaged over 10-km x 10-km [6.2-mile x 6.2-mile] grid cell) would occur once every 15–21 years. By 2070, climate models indicate that frequency could increase to once every 9–12 years (+39–58 percent). **Combining the heavy precipitation projections with present-day FEMA floodplains, flood risk will likely increase for areas exposed to riverine and coastal flooding, particularly along the eastern portion of the island.**

[11] Gridded daily (1-day) return period precipitation projections are lower than observed baseline, station-based 24-hour observations in Tables 7C-2 through 7C-5 because gridded reanalysis data may not fully resolve higher-intensity deluge precipitation events due to the coarse 10-km x 10-km (6.2-mile x 6.2-mile) spatial resolution of the dataset. Global climate projections tend to smooth peaks in precipitation intensity between weather stations, lowering rainfall intensity estimates during extreme precipitation events. **Because of this limitation in the gridded data, the Study Team evaluates proportional changes in the annual likelihood of precipitation totals relative to baseline to understand changes in heavy precipitation events with climate change, with less weight given to the magnitude of the baseline observed values.**

Table 7C-6. Historical Baseline and Future Projected Values and Percent Changes for Annual Likelihood for a 4-Inch 1-Day Maximum Rainfall Event for Mid (SSP2-4.5) and High (SSP5-8.5) Emissions Scenarios. Averages are Provided for the Eastern, Western, and Entire Island.

Change in Annual Likelihood of 4-Inch 1-Day Precipitation Total (% from baseline)			
SSP2-4.5	**Historical Baseline**	**Mid-Century (2050s)**	**Late Century (2070s)**
Eastern Island Average [a]	-	+39%	+54%
Western Island Average [a]	-	+78%	+111%
Island Average	-	+58%	+81%
SSP5-8.5	**Historical Baseline**	**Mid-Century (2050s)**	**Late Century (2070s)**
Eastern Island Average [a]	-	+45%	+57%
Western Island Average [a]	-	+74%	+91%
Island Average	-	+61%	+75%

[a] The eastern (western) island average values come from the mean of the two eastern- (western-) most grid cells on Kauaʻi.

Table 7C-7. Historical Baseline and Future Projected Values and Percent Changes for a Return Period for a 5-Inch 1-Day Maximum Rainfall Event for Mid (SSP2-4.5) and High (SSP5-8.5) Emissions Scenarios. Averages are Provided for the Eastern, Western, and Entire Island.

Change in Annual Likelihood of 5-Inch 1-Day Precipitation Total (% from baseline)			
SSP2-4.5	**Historical Baseline**	**Mid-Century (2050s)**	**Late Century (2070s)**
Eastern Island Average [a]	-	+154%	+201%
Western Island Average [a]	-	+512%	+705%
Island Average	-	+308%	+416%
SSP5-8.5	**Historical Baseline**	**Mid-Century (2050s)**	**Late Century (2070s)**
Eastern Island Average [a]	-	+207%	+291%
Western Island Average [a]	-	+415%	+537%
Island Average	-	+312%	+400%

[a] The eastern (western) island average values come from the mean of the two eastern- (western-) most grid cells on Kauaʻi.

7C.3.3 Sea Level Rise

Along the Kauaʻi coast, sea levels are projected to rise substantially faster than historically observed as warming accelerates, particularly under a higher-emissions scenario (i.e., Intermediate-High scenario). The majority of sea level rise occurs from melting ice sheets and glaciers, as well as thermal expansion of the ocean, both of which are triggered by warming air temperatures. In addition, Hawaiʻi has experienced land subsidence, or sinking, over recent years, which accelerates the rate of sea level rise as well as coastal erosion. Sea level rise projections use the NASA and NOAA Interagency Sea Level Rise Intermediate-Low and Intermediate-High scenarios at the Nāwiliwili Bay tide gauge on Kauaʻi. The scenarios are discussed in the Sea Level Rise Methods section above.

Table 7C-8 provides an overview of the sea level rise scenarios used at each time horizon to best represent coastal inundation extents resulting from sea level rise. Sea level rise could exceed 1 foot (0.3 meter) by 2070 under an Intermediate-Low scenario and exceed 2.5 feet (0.8 meter) under an Intermediate-High scenario. Sea level rise accelerates as we progress into the future, particularly after 2050 during the second half of the permit term under the more risk-averse Intermediate-High scenario.

Table 7C-8. NASA and NOAA Interagency Sea Level Rise Scenarios for Nāwiliwili Bay Tide Gauge under Intermediate-Low and Intermediate-High Scenarios for 2030–2070. Sea Level Rise is Relative to a Baseline Year of 2000.

Year	Intermediate-Low Scenario (feet)	Intermediate-High Scenario (feet)
2030	0.41	0.50
2040	0.58	0.77
2050	0.76	1.21
2060	0.96	1.82
2070	1.16	2.65

Increasing sea levels lead to greater floodplain extent and peak inundation along many coastal areas of Kauaʻi. In Figure 7C-3, the deepest inundation levels on Kauaʻi could reach up to 1.7 feet (0.5 meter) by 2070 along Mānā northwest of Kekaha in an Intermediate-High scenario (corresponding to up to 3 feet [0.9 meter] of sea level rise on Kauaʻi). This would affect the Kawaiʻele Waterbird Sanctuary and Mānā Plains Forest Reserve. This area consists of low-lying wetlands, all less than 10 feet (3 meters) above sea level. **Low-lying coastal areas similar to Mānā will be particularly sensitive and vulnerable to any increase in sea level in the next 50 years.**

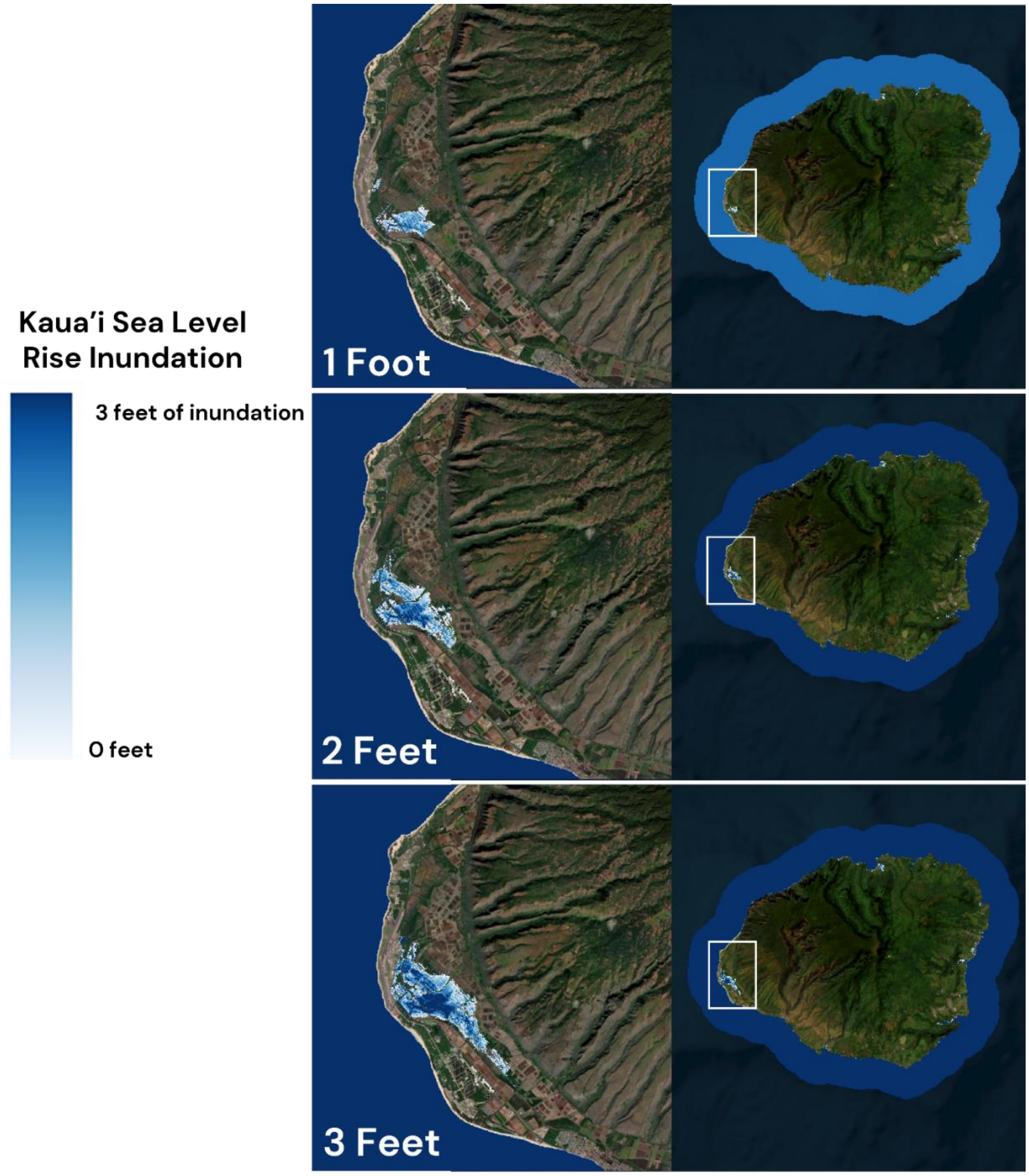


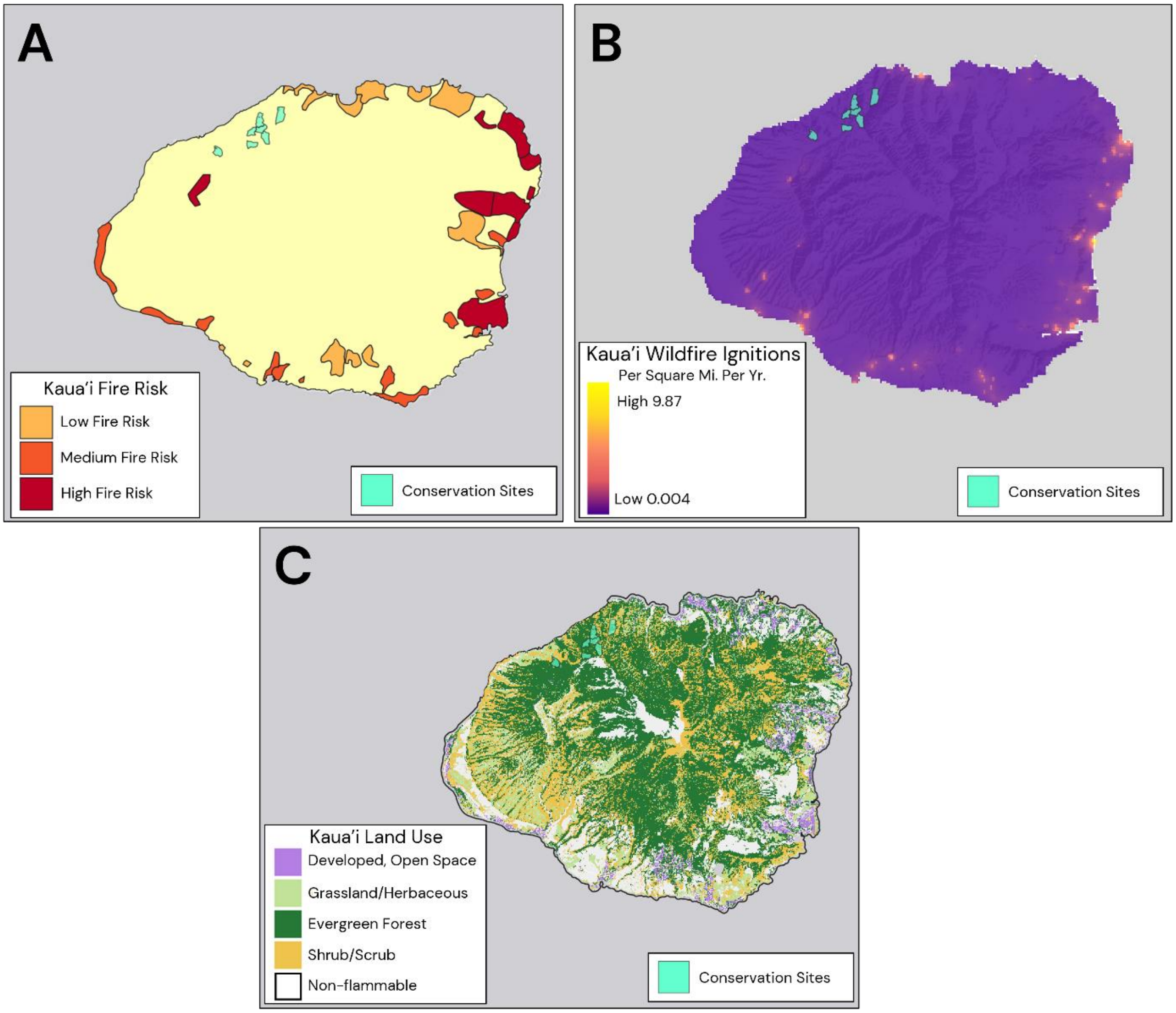
Figure 7C-3. NOAA Sea Level Rise Viewer Inundation Maps for 1, 2, and 3 Feet of Sea Level Rise across Kauaʻi.

Over the next 50 years, sea level rise could primarily affect areas of Mānā, Princeville, Kīlauea Stream, Keālia Beach, Wailua, and ʻEleʻele. While sea level rise poses a significant risk to nesting sea turtles, the cumulative impact of sea level rise on Kauaʻi relative to other regions in the United States (i.e., the Gulf Coast and Atlantic Coast) is projected to be lower, owing to the coastal bathymetry and topography of Kauaʻi. **However, sea level rise will pose a significant threat to Kauaʻi's coastline over the next 50 years, particularly under a higher-end scenario.**

7C.3.4 Wildfire

Wildfires can be caused by both natural occurrences (e.g., lightning strikes) and human activities. Weather conditions can influence the likelihood and severity of wildfires. Factors contributing to wildfire-prone conditions—conditions that ignite and/or lead to the spreading of fire—include drought and intense winds. Drought increases the risk of ignition and potential burned area, while wind enhances the speed and severity of the fire. **Droughts are projected to worsen due to climate change on Kauaʻi over the next 50 years, which could lead to greater wildfire risk. Models projecting future wind speeds are more uncertain, although maximum wind speeds are projected to increase, potentially exacerbating the likelihood and intensity of wildfires.**
Each year, Hawaiʻi averages over 1,000 fires and over 20,000 acres burned (Trauernicht et al. 2015). This has primarily affected forested, shrub, and grassland areas near developed communities, which are most vulnerable to wildfire during periods of drought or prolonged dry conditions. Land cover data highlights developed land, grass, shrubs, and forest. Developed land poses increased ignition risk and forest, shrub, and grassland represents fuel for wildfire development under drought conditions. Current conservation sites highlighted in each panel, which are not located in medium or high fire risk areas.

Figure 7C-4 highlights the areas across Kauaʻi that are historically most susceptible to wildfire risk. Regions designated as high-fire-risk areas include a large area north of Nāwiliwili Bay, surrounding areas of Kapaʻa and the shoreline east of Wailua, and the coastal area north of Anahola. Notably, there is also a designated high-risk area inland over the northwestern portion of the island toward the headwaters of Waimea Canyon. These are all located along the more drought-prone east and northeast coast of Kauaʻi. Medium-fire-risk areas are primarily along the south and southwest coast, and low-risk areas are primarily along the north coast. Current and potential conservation sites are in the northwestern portion of Kauaʻi and do not intersect with any low-, medium-, or high-fire-risk areas assigned by the Hawaiʻi GIS Fire Risk Program. Historical fire ignition densities coincide with many of the fire risk areas, particularly near more developed population centers. Wildfire ignition is primarily driven by human ignitions (both arson and accidental), with more isolated ignitions from lightning.



Land cover data highlights developed land, grass, shrubs, and forest. Developed land poses increased ignition risk and forest, shrub, and grassland represents fuel for wildfire development under drought conditions. Current conservation sites highlighted in each panel, which are not located in medium or high fire risk areas.

Figure 7C-4. Present-Day Hawaiʻi GIS Program (a) Fire Risk Areas and (b) Ignition Density, as well as (c) U.S. Geological Survey National Land Cover Database Maps for Kauaʻi.

7C.3.4.1 Dryness and Wildfires

As the climate warms, more frequent and longer-duration droughts may increase the likelihood of fire weather and drier fuel (or flammable vegetation) conditions, potentially increasing the magnitude, timing, and frequency of wildfires (Jones et al. 2020; Jia et al. 2019). In effect, wildfire risk is particularly sensitive to drought intensity and frequency. The August 2023 wildfires that affected Maui, for example, were preceded by a prolonged summer drought and a dry spell lasting up to 3 weeks depending on the location,[12] leading to elevated fire risk due to drier-than-usual vegetation across a relatively unmanaged landscape.

[12] Based on review of both NOAA Kahului Airport and Waiehu Camp 484 weather station records on Maui.

As a proxy for drought and dry spells, the Study Team used climate model-projected annual maximum consecutive dry days across Kaua‘i. Historically, the northern and eastern areas of the island are most susceptible to drought, with maximum consecutive dry days approaching 23 days, although maximum consecutive dry days ranges from 22.75 to 23.5 days (averaged over 30 years) across the island (Figure 7C-5). By 2070, annual maximum consecutive dry days could increase to upwards of 25 consecutive days in the high-end SSP5-8.5 scenario over northwestern Kaua‘i. Over the next 50 years, drought and dry spell length is projected to increase across Kaua‘i, although the increase is relatively small in magnitude: increases on the order of 0.2–0.4 day (1–2 percent increase) in the mid-range SSP2-4.5 and 0.7–0.9 day (3–4 percent) in the high-end SSP5-8.5 scenario (Table 7C-9).

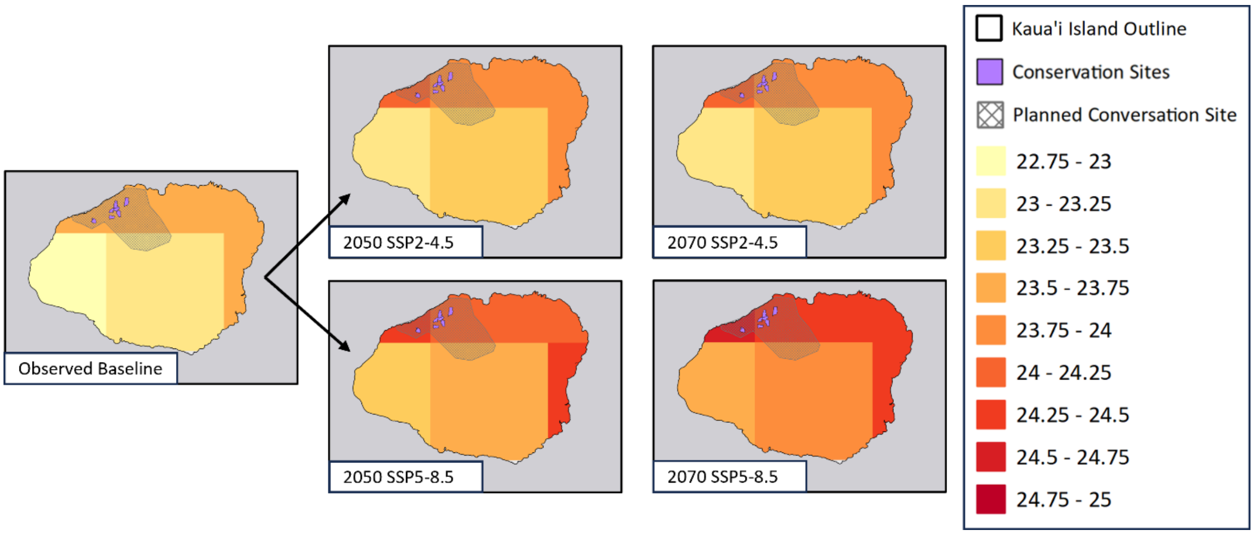


Figure 7C-5. Projected Number of Annual Maximum Consecutive Dry Days in the Observed Baseline, 2050, and 2070 for Mid (SSP2-4.5) and High (SSP5-8.5) Emissions Scenarios on Kaua‘i. Current and Planned Conservation Sites Highlighted in Each Panel.

Table 7C-9. Observed Baseline and Future Projected Values for Number of Annual Consecutive Dry Days for Mid (SSP2-4.5) and High (SSP5-8.5) Emissions Scenarios. Averages are Provided for the Eastern, Western, and Entire Island.

SSP2-4.5	Observed Baseline	Mid-Century (2050s)	Late Century (2070s)
Eastern Island Average [a]	23.7	23.9	23.9
Western Island Average [a]	23.3	23.6	23.7
Island Average	23.5	23.7	23.7
SSP5-8.5	**Observed Baseline**	**Mid-Century (2050s)**	**Late Century (2070s)**
Eastern Island Average [a]	23.7	24.2	24.4
Western Island Average [a]	23.3	23.9	24.1
Island Average	23.5	24.0	24.2

[a] The eastern (western) island average values come from the mean of the two eastern- (western-) most grid cells on Kaua‘i.

Based on the climate projections and historical wildfire risk maps, the risk of wildfire is currently relatively high in drier areas with a larger proportion of wildland-urban interface, or developed areas directly adjacent to burnable forests, grassland, and shrubs. Developed areas lead to an increased risk of ignition provided areas with dense, flammable vegetation are in close proximity. These areas are primarily located along the eastern and southwestern coastal areas of the island. **Over the next 50 years, warming temperatures will likely contribute to increased drought and dry spell intensity, although the peak dry spell intensities may not be significantly greater than present day. This would lead to an enhanced risk for wildfire, as increased drought dries out surface vegetation across the island more frequently.**

7C.3.4.2 Winds and Wildfires

In addition to the prolonged dry spell, the August 2023 Maui wildfires were likely exacerbated by anomalously extreme wind speeds that helped spread existing wildfires over a larger area. While the cause of wildfire ignition is still being investigated, these high wind speeds may have been partially enhanced by Hurricane Dora, a major Category 4 hurricane, passing to the south, although the North Pacific high-pressure system to the north likely played a greater role in enabling a favorable synoptic pattern for stronger-than-average straight-line winds (Reuters 2023). This led to strengthened warm, dry winds sweeping down the west-facing leeward side of the Maui Mountains, commonly referred to as Moaʻe or Aʻelo, towards Lahaina.

While Hurricane Dora's impact on starting the wildfires was likely minor relative to the North Pacific High, it helped facilitate dry and windy conditions that could exacerbate fire over the island. Although projections are less certain for hurricane occurrences than temperature and precipitation, there has been a downward trend in tropical cyclones since the early 1970s. As indicated in the Section 7C.3.1, *Hurricanes*, most simulations indicate there will be an increase in maximum wind speeds with future warming, but a decrease in overall tropical cyclone frequency. Difficulties modeling hurricanes stem from the challenges surrounding modeling the environmental conditions needed to produce them, as well as the short timescales of hurricanes compared to timescales used in global climate model simulations (Marra et al. 2017). The likelihood of the **most intense** hurricanes (Category 3 and higher), however, may increase over the next 50 years, which could lead to an increased likelihood of major hurricanes in close proximity to Hawaiʻi setting up a similar synoptic pattern over the tropical Pacific that facilitated wildfires on Maui.

While extreme winds during hurricanes may increase in the future, average wind speeds are not projected to change significantly. Uncertainty surrounds the direction and magnitude of future projections of average wind speeds. One study projects increased average wind speeds across Hawaiʻi, including Kauaʻi, through the end of the century (Zhang et al. 2016). The increases are projected to be minimal, on the order of 1–2 mph (1.6–3.2 kph) increases over most of Hawaiʻi. Another study, however, projects average wind speeds could decrease on Kauaʻi by the end of the century (Storlazzi et al. 2015). This study projects slight increases in monthly average wind speeds by mid-century for the majority of months under a high-emissions RCP 8.5 scenario (similar to SSP5-8.5) and some months for the mid-range RCP 4.5 scenario (similar to SSP2-4.5), with subsequent decreases by late century for both scenarios. In Honolulu, observed trends since 1948 indicate a 10 percent reduction in daily average wind speed (Marra et al. 2017). Historically, average wind speeds across Hawaiʻi are low; wind speeds are typically under 22 mph (35.4 kph) in Honolulu (Shope et al. 2016). For extreme wind speeds, however, there is more variability among the top 5 percent of wind speeds, which is projected to decrease in intensity by the end of the 21st century (Shope et al. 2016). Overall, mean wind speed in the tropics is not likely to be greatly affected by climate change, suggesting that, on average, increased wind speeds are not expected to influence wildfire propagation significantly during the permit term. Climate model projections of wind speeds, however, come with a high degree of uncertainty, and the level of wildfire risk associated with winds could change as scientific advances in high-resolution modeling occur in the coming decades. KIUC should monitor the state of the science and adjust planning, as necessary.

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