Appendix A:
Kahuamaʻa
Management Plan

KAHUAMAʻA SEABIRD PRESERVE

MANAGEMENT PLAN

PART OF THE KAUAʻI SEABIRD HABITAT CONSERVATION PLAN

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1. SUMMARY MANAGEMENT PLAN

The objective of the Kahuamaʻa Seabird Preserve Management Plan is to create and maintain a terrestrial predator proof sanctuary for ʻaʻo. Birds will be attracted to the site through a Social Attraction component.

Implementation of the plan will, in part, fulfill one of the biological goals of the Kauaʻi Seabird Habitat Conservation Plan (KSHCP): to mitigate authorized take impacts on the Covered Seabirds in the HCP (ʻaʻo or Newell's Shearwater –*Puffinus auricularis newelli*, ʻuaʻu or Hawaiian Petrel **-** *Pterodroma sandwichensis* and Hawaiʻi distinct population segment (DPS) of the ʻakēʻakē or band-rumped storm-petrel - *Oceanodroma castro*, hereafter ʻakēʻakē) due to light attraction by the participants of the plan, and provide a net benefit to the populations of the Covered Seabirds.

Management of the Kahuamaʻa Seabird Preserve (also referred to as 'the site') will be carried out by a Prime Contractor, on behalf of the participants in the KSHCP. The site is located in Kōkeʻe State Park and Nā Pali Coast State Park.

The creation of the site will commence with the construction of a predator proof fence around 2ha of suitable seabird habitat. Only terrestrial predators can be completely excluded, but barn owls will also be controlled to protect the birds within the site and in neighboring source colonies throughout the Kalalau Valley. Feral cats will also be removed at ingress points to the fenceline area and into neighboring source colonies in the Kalalau Valley.

The project will proceed with the removal of black rat (*Rattus rattus*), Norway rat (*Rattus norvegicus*), Polynesian rat (*Rattus exulans*), feral pigs (*Sus scrofa*)*,* black-tailed deer (*Odocoileus hemionus columbianus*), feral goats (*Capra hirca*) and feral cats (*Felis catus*) inside the fence. house mouse (*Mus musculus*) is expected to be eradicated by rat control but is not a target species. Eradication will be complete within the first year. The fence will be monitored constantly to ensure that predators cannot breach it and there will be monitoring within the fenced area in case of reinvasion.

After predator eradication within the fence is complete, the social attraction component of the project will be initiated to bring ʻaʻo to the project site to breed. This will consist of installing artificial burrows and a speaker system to broadcast calls, simulating a large colony.
A variety of monitoring methods will be undertaken to assess the effectiveness of management actions. For seabirds, these will include auditory and visual surveys, camera monitoring, acoustic bird monitoring and bird banding.

Invasive species (seabird habitat modifiers) will be removed from the site to optimize seabird nesting habitat. Monitoring will include a plant survey every five years.

Reporting obligations for the Prime Contractor will include an annual report.

2. INTRODUCTION

Kahuamaʻa Seabird Preserve is a 2 hectare (ha) Social Attraction Site (SAS) for ʻaʻo or Newell's Shearwater (*Puffinus auricularis newelli)* that will be surrounded by a terrestrial predator proof fence. It is located along the Western rim of the Kalalau Valley, part of the Nā Pali coast on the Island of Kauaʻi, Hawai'i at approximately 22°08'57.1"N 159°38'12.2"W.

The site is being developed as mitigation for "unavoidable incidental take impacts"[1] of ʻaʻo, a listed seabird, as part of the Kauaʻi Seabird Habitat Conservation Program (KSHCP). In addition, barn owl (*Tyto alba*) control around the site and the Kalalau Valley will provide mitigation for the take of ʻuaʻu or Hawaiian petrel (*Pterodroma sandwichensis*) and ʻakēʻakē or band-rumped storm-petrel *(Oceanodroma castro*). Collectively, all three species are referred as the "Covered Seabirds".

The KSHCP is an island-wide program to permit and mitigate for impacts to KauaʻI's endangered seabirds caused by light attraction. The KSHCP aims to offset take and provide conservation benefit to these species by increasing productivity at breeding colonies. The KSHCP has set 'Biological Goals' and 'Biological Objectives'. The purpose of this Kahuamaʻa Seabird Preserve Management Plan is to explain how the objectives toward achieving the goal of "*mitigating authorized take impacts of the Covered Seabirds by enhancing, protecting and managing suitable seabird breeding habitat on Kauaʻi to facilitate successful production of fledglings at a level that over the 30-year term of the Plan offsets or exceeds the impacts of take caused by Covered Activities on the production of fledglings in the wild*" will be delivered and monitored. As such, this Management Plan fulfils certain legal parameters of the KSHCP process as well as describing the management on site. The full suite of KSHCP requirements is described in the KSHCP document to which this Management Plan is an appendix.

'Social Attraction' is a well-established conservation strategy to encourage seabirds to breed in a predator-free location by the simulation of colony activity, principally through the playback of breeding calls, combined with the provision of artificial burrows area (Kildaw 2005, Sawyer and Fogle 2010, Major 2011, Jones and Kress 2012, Raine 2015b). The technique results in high productivity within a small and easily managed.

There are several benefits to establishing a breeding colony within a protected site free of terrestrial predators. The site offers protection from predation which is known to severely impact the breeding of both species on Kauaʻi (Raine et al. 2017f, d, g, e, Raine et al. 2017h). Breeding in a predator-free area can result in a positive growth rate, vitally important for these endangered seabirds (Veitch 2011, Young et al. 2012, Kappes 2014, Buxton 2015). In addition, because of the potential for a high breeding density, a relatively large amount of birds can be

[1] Section 9 of the Endangered Species Act prohibits taking, possession, sale, and transport of listed species. Taking is defined as to "harass, harm, pursue, hunt, shoot, wound, kill, capture, or collect." If an activity is conducted that would "take" a listed species, an 'incidental take permit' is required to avoid being in violation of Section 9 of the Endangered Species Act, a federal offense.

produced in a small area requiring less long term management and funding (Burger 1988, Buxton 2014) – fieldwork for management and monitoring is very labor intensive in this terrain, so having burrows close together for easy monitoring dramatically reduces staff time and thus costs. Finally, creating a “new” colony serves to expand the distribution of the species, recognized as important to the species persistence and survival in the wild (Jones and Kress 2012, Buxton 2015, USFWS 2017b, a). The site also has the potential to provide a sanctuary for other rare and endangered flora and fauna, several species of which are already present at the site. These include candidate or listed forest bird species (nests will be protected from rat predation), ʻōpeʻapeʻa or Hawaiian hoary bat (*Lasiurus cinereus semotus*) and the suite of plant species shown in Table 7.1.

Social Attraction relies on broadcasting breeding calls to attract seabirds to breed; distance to the source population has been identified as one of the most important drivers of seabird recolonization (Buxton et al. 2014). Research by the Kauaʻi Endangered Seabird Recovery Project (KESRP) indicates that Kahuamaʻa is located close to several ‘hot spots’ (concentrated locations of seabird activity) on the Nā Pali coast, with the nearest “hot spot” polygon just 210m away, two more within 60m, and 26 within 3km. In fact, the majority of known breeding colonies of ʻaʻo and ʻuaʻu on Kauaʻi are located within 25km of the mitigation site. In addition, ʻaʻo and ʻuaʻu calls were recorded at the site in 2016 using an acoustic song meter (Raine et al. 2016). Kahuamaʻa Seabird Preserve has therefore been identified as an excellent location for a SAS, within known seabird flyways along the Nā Pali Coast and nearby existing breeding colonies such as Hono O Nā Pali Natural Area Reserve and in Kalalau State Park.

In addition to the predator proof fenced area, Kahuamaʻa Seabird Preserve will include feral cat removal at ingress points to nearby source colonies in the Kalalau Valley, as well as to the fenceline. The project is expected to benefit this native vegetation as well as other native wildlife such as the ōpeʻapeʻa, pueo or Hawaiian short-eared owl (*Asio flammeus sandwichensis*) and various candidate or listed forest birds.

The site is on land owned and managed by the State of Hawaiʻi - Department of Land and Natural Resources (DLNR) Division of State Parks and straddles two parks: Kōkeʻe State Park and Nā Pali Coast State Park. The area is a designated hunting unit, restricted to archery use only (no firearms). Discussions with State Parks have indicated strong support for the project, which is in line with State Park goals of protecting and restoring native ecosystems.

Under the KSHCP, the Participants will oversee the implementation of the conservation and other plan-related actions and activities with the assistance of the National Fish and Wildlife Foundation and a Prime Contractor. NFWF will hold the funds received from the Participants for the term of the HCP and will make payments to implement the conservation and other plan-related activities. A Prime Contractor selected by the Participants’ Committee will implement the conservation and other plan-related activities to meet mitigation obligations under the ITP/ITL. The Prime Contractor may choose to sub-contract specific work to another entity as appropriate. This arrangement is ‘Participant-initiated’ mitigation and Participants remain ultimately responsible for implementing mitigation (including actions that may be necessary in response to Adaptive Management provisions as defined in the KSHCP.

3. VISION STATEMENT

The Kahuamaʻa Seabird Preserve will become a terrestrial predator free sanctuary for a thriving colony of breeding ʻaʻo. ʻUaʻu may also be present. The site will continue to attract new birds as well as seeing the return of previous breeders (both chicks and adults). Ongoing management will ensure that the interior of the fenced area remains completely terrestrial predator free and that feral cats are controlled at ingress points to the site and to neighboring source colonies. Mitigation for the take of ʻuaʻu and ʻakēʻakē will be provided through barn owl control. Neighboring colonies will also benefit from this work. The site will provide optimal breeding habitat through artificial burrows and the ongoing removal of invasive species. The site will also serve as a sanctuary for rare and listed plants.

Kahuamaʻa will act as a positive example of a Social Attraction Site benefitting a rapidly declining population of seabird. Key to the vision is that the site will meet its targets for successfully providing mitigation to offset take of a listed species as outlined in the KSHCP document.

4. INFORMATION

4.1. Location and Statutory Information

The Kahuamaʻa Seabird Preserve is located near the terminal end of Highway 550, within Kōkeʻe State Park and Nā Pali Coast State Park, between the Kalalau and Puʻu O Kila visitor lookouts, identified on the map as part of Kahuamaʻa Flat (Figure 4.1)

Figure 4.1: Satellite image of Kahuamaʻa Flats with Kalalau Lookout. Red pin indicates SAS. Google Maps.

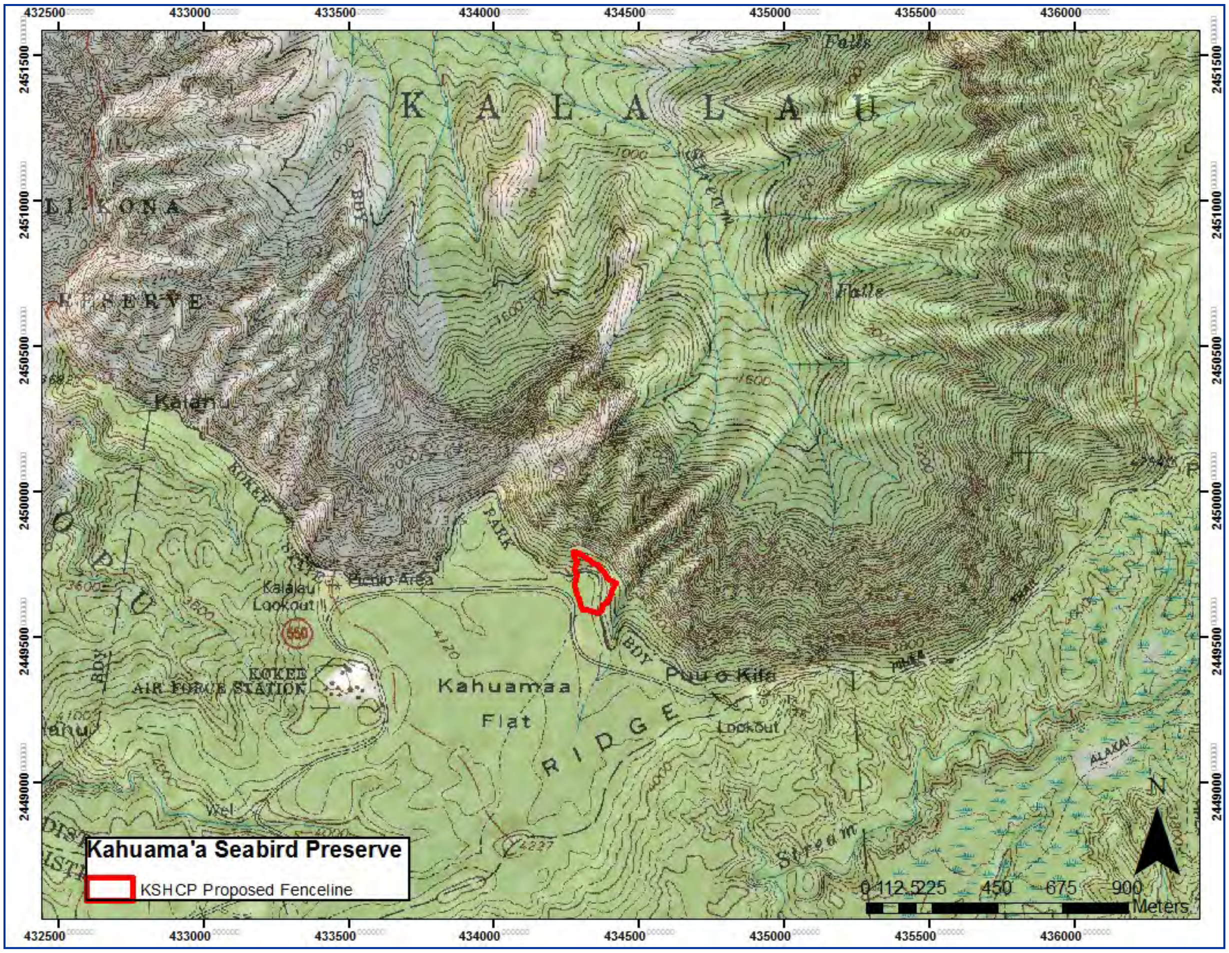


Figure 4.2. Map of SAS location in relation to Kalalau Valley.

Figure 4.3. Photographs of the SAS along the rim of the Kalalau Valley. Y Reiss.

4.2 Legal Status (legislation for site creation, ownership, official managers), MOA

The site is situated on lands managed by DLNR Division of State Parks as Kōkeʻe State Park and Nā Pali Coast State Park. Prior to the commencement of management by the Prime Contractor of the KSHCP, an Agreement between State Parks and the Participants' Committee will be in place as an Appendix to the KSHCP which will include all relevant permits for the activities specified in the Management Plan (for example use of rodenticide, erection of fence etc.). Discussions with State Parks have indicated strong support for this project, which is in line with State Park goals of protecting and restoring native ecosystems.

4.3 Access

The site lies immediately north of and adjacent to Highway 550. A small amount of parking (sufficient for construction and field staff) is available on the west side of the road adjacent to the site. Prior to fence construction, ideally this will be graveled as it is currently muddy (discussions will be held with State Parks or Highways upon commencement of the Management Plan). No public parking or vehicular access is currently planned as the focus of the project is the creation and maintenance of the seabird site for mitigation purposes.

There are no well-defined trails to the site. As management commences at the site, a foot trail to the site will be created to avoid rare plants (see section 17.7.4). Access for fence building and maintenance will use this new foot trail, with heavier equipment and supplies being dropped via helicopter at specified construction staging location immediately adjacent to the site, which will be large enough to provide storage space (see section 10.3). No permanent or vehicular access is planned.

The site is a designated hunting unit, restricted to archery use only. The site comprises only a tiny fraction of the archery hunting zone, therefore the exclusion of hunters from inside this small enclosure is not anticipated to negatively affect overall access to archery hunting.

4.4 Existing Infrastructure

There are currently no utilities or infrastructure at the site as it is a 'wildland portion of Kōkeʻe State Park' (DLNR, 1997) and Nā Pali Coast State Park.

5. ENVIRONMENTAL INFORMATION

5.1 Environmental Setting

Kahuamaʻa Seabird Preserve is located on the northwestern side of Kauaʻi, along the western rim of the Kalalau Valley and is part of the Nā Pali coast, which is characterized by steep cliffs and deeply eroded canyons and valleys. **Figure 5.1**

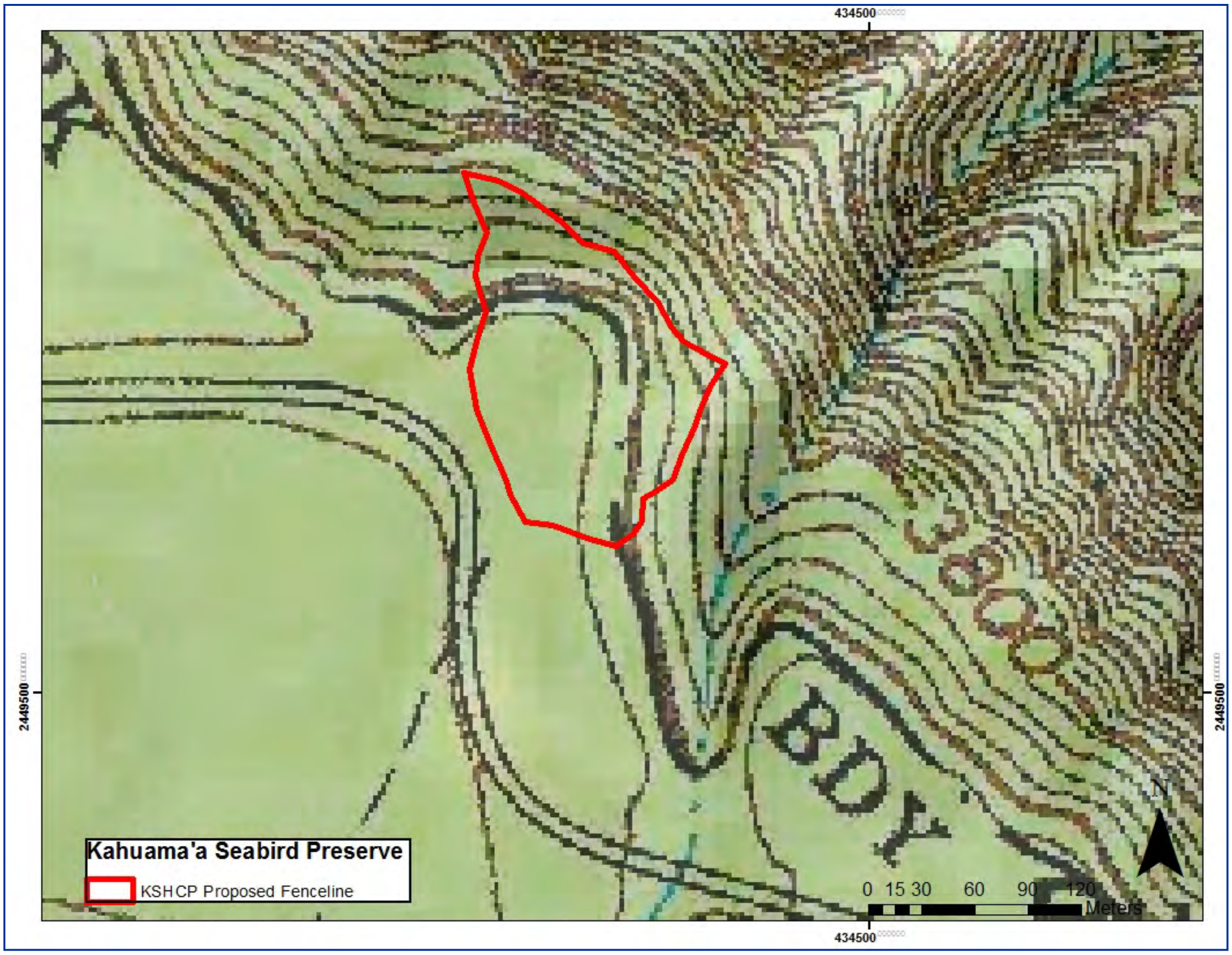


Figure 5.1. Image of site showing topography.

5.2 Climate

The Kahuamaʻa Seabird Preserve is located at an altitude of approx. 1250m. The site receives an estimated annual rainfall of around 150-200cm annually with fog (DLNR 1997). The average air temperature in Kōkeʻe ranges from 10°C in winter to 20°C in summer.

In the past 50 years, strong winds, heavy rains and storm surges caused by periodic hurricanes have resulted in devastating effects. Hurricanes Iwa (1982) and ʻIniki (1992) caused extensive damage to native plant communities.

5.3 Topography/Geology

The site consists of approximate 2ha of mostly sloping ground, interspersed with small hillocks. Carpenter and Yent (1994) describe the soils and topography as; "Kōkeʻe silty clay loam on the upper flat (well-drained soils weathered from igneous rock, probably mixed with volcanic ash). There is rough, mountainous land on the valley wall (very steep land broken by numerous drainages, very thin soil mantle if any, much of surface is rock, rock outcrop, and eroded spots)".

5.4 Hydrology/Streams, Rivers, Drainages

The site lies within Hanalei aquifer sector / Nāpali System (DLNR 2014) characterized as
- High-level - fresh water not in contact with sea water.
- Unconfined - the water surface is in the upper surface of a saturated aquifer.
- Dike-contained - aquifers are confined in basaltic dike compartments.

There are no streams within the site itself, although in times of heavy rain there is at least one gulch which is likely to channel water.

5.5 Existing Land Use

The primary use of the site and surrounding area is as a State Park which is intended to provide opportunities for outdoor recreation as well as protecting Hawaiʻi's natural and cultural history and aesthetic values.

The Kahuamaʻa Seabird Preserve falls within a designated hunting unit, restricted to archery use only. Firearm hunting is prohibited because of safety concerns for other users in the park and its proximity to the public highway and visitor viewpoints.

6. SOCIAL INFORMATION

6.1 Stakeholders

Success of the Kahuamaʻa Seabird Preserve depends in part upon cooperation amongst the stakeholders in the project. These include the KSHCP Participants, the Prime Contractor, the regulatory agencies, conservation groups and landowners. Table 6.1 outlines these groups in more detail and provides a framework for the Prime Contractor to identify the future point of contact.

Table 6.1. Stakeholders in Kahuamaʻa Seabird Preserve

Stakeholder	Role
KSHCP Participants	
Alexander and Baldwin (A&B)	KSHCP Participant
County of Kauaʻi	KSHCP Participant
Hawaiʻi Department of Transportation (HDOT)	KSHCP Participant
Kauaʻi Coffee	KSHCP Participant
Kauaʻi Marriott Resort, Līhuʻe	KSHCP Participant
Norwegian Cruise Line (Bahamas) Ltd. (NCL)	KSHCP Participant
Princeville Resort Kauaʻi	KSHCP Participant
Kauaʻi Blue, Inc. dba. Sheraton Kauaʻi	KSHCP Participant
Prime Contractor	
Project Manager	Prime Contractor Staff
Staff/Technician	Prime Contractor Staff
Agencies	
USFWS	Regulatory / Advisory
State Parks	Land Owner
DOFAW Plant Extinction Prevention Program (PEPP)	Regulatory / Advisory
DOFAW Admin (Oʻahu)	Regulatory / Advisory
DOFAW Kauaʻi Branch	Advisory
Conservation Groups	
KESRP	Advisory
Kōkeʻe Resource Conservation Program (KRCP)	Advisory
SOS (Kauaʻi Humane Society) or other qualified vet / rehab center shearwaters	Resource
NTBG	Advisory
Land Users	
Hunters (archers only)	Land User
Kōkeʻe Discovery Center	Land User

6.2 Archaeological, Cultural and Historical interest

In 1994, prior to the construction of the Kalalau Rim Endangered Plant Exclosure (which is within 1km of the Kahuamaʻa Seabird Preserve), State Park archaeologists conducted a reconnaissance survey in the area of the Kahuamaʻa Flat. No archaeological sites or features were encountered during this survey (Carpenter and Yent 1994). However, due to dense vegetation and steep slopes, a complete evaluation was not possible. Therefore, while the archaeologists deemed it unlikely that any important archaeological sites exist in this area (there are few such sites in the uplands of Kōkeʻe and the area is thought to have been a resource-gathering zone rather than a permanent habitation), they made several recommendations to ensure that any possible sites were not adversely affected. These are included in the Best Management Practices - Section 17.1.6 and 17.2.9).

6.3 Visitors

The principal focus of the Kahuamaʻa Seabird Preserve is to provide mitigation for unavoidable incidental take impacts to ʻaʻo. As a result, no funding is currently budgeted for outreach. However, the fence will be visible from the road and is between two popular lookouts, the Kalalau Lookout and the Puʻu O Kila Lookout. Therefore, as part of the Management Plan, the Prime Contractor will investigate ways to work with partner organizations that might allow for the erection of an interpretation panel at each lookout to explain the purpose of the Kahuamaʻa Seabird Preserve as well as providing some information on the special importance of ʻaʻo to Kauaʻi. If further funding can be found, the site has potential for education, awareness raising, demonstration and advocacy.

7. BIOLOGICAL INFORMATION

7.1 Habitats and vegetation communities

The Kahuamaʻa Seabird Preserve is within in a wider area known as the Kalalau rim, an extremely high cliff area which falls over a thousand meters into the Kalalau Valley. Due to the steepness and inaccessibility of the cliff, there are many rare, endemic plants which have survived undisturbed by humans, giving the Kalalau rim unique characteristics. The vegetation at the site is a subtype of ʻŌhiʻa Lowland Mesic Forest, with ʻuluhe fern (*Dicranopteris linearis*) comprising much of the ground cover (Williams, 2016 unpublished report). DLNR (1997) notes that this habitat is significant for endangered, threatened, candidate and other plants of concern; a number of rare and endangered plant species have in fact been recorded within and around the site.

There is degradation from the encroachment of invasive and non-native plants, particularly in the understory. They include Australian tree fern *(Sphaeropteris cooperi*), banana poka *(Passiflora tarminiana*), blackberry *(Rubus argutus*) bush beard grass *(Schizachyrium condensatum, Andropogon spp.*[2]), Karaka nut (*Corynocarpus laevigatus*), parasitic maidenfern (*Cyclosorus parasiticus*), air plant (*Kalanchoe pinnata*), fire tree (*Morella faya*) and daisy fleabane (*Erigeron karvinskianus*). Koster's curse *(Clidemia hirta*), Himalayan (kahili) ginger (*Hedychium gardnerianum*) and strawberry guava (*Psidium cattleianum*) are also present towards the road. Many of these plant species are significant threats for seabirds (particularly

[2] There is some taxonomic confusion about these species in Hawai'i and they are frequently mis-identified and can co-occur. Ecologically they are, however, similar with regard to their invasion biology. (A Williams, 2017, pers.comm.)

Australian tree fern, Himalayan (kahili) ginger and strawberry guava), as they modify the habitat in which they breed.

In addition, feral pigs, black-tailed deer and feral goats inhabit the area and are having a negative impact upon the vegetation community. Surveys carried out before fence construction (included as part of the Management Plan) will improve understanding of the vegetation communities and their condition.

The fenceline was decided upon based on characteristics suitable for seabirds, including vegetation, slope and aspect. However, PEPP experts and botanists from DOFAW and USFWS also identified the area as providing dual benefit for birds and listed plants, with the protection of rare and PEPP plants being a major consideration.

7.2 Flora

During a preliminary site visit by DOFAW Botanist Adam Williams and PEPP Botanist Steve Perlman, several listed plants were observed within the boundaries of the site. These include two federally Endangered Species, two species that are part of the Plant Extinction Prevention Program (PEPP), which indicates that there are less than 50 individuals left in the wild, and four State Species of Concern. These are highlighted in Table 7.1. This represents a very high concentration of rare and endangered plants. It is anticipated that the fence will be of direct conservation benefit to these plants (Williams 2016, unpublished report).

Surveys carried out before fence construction (included as part of the Management Plan) will detail the exact location and abundance of listed plants, as well as confirming the below species list in Table 7.1.

Table 7.1. Preliminary plant list from KSHCP Social Attraction Site visit on May 12, 2016 with DOFAW and PEP botanists. Highlighted plants are federally or state endangered, threatened or PEPP.

Family	Taxon Name	Common Name	Status	FedStat
Asteliaceae	*Astelia argyrocoma* A.Heller ex Skottsb.	Paʻiniu	Endemic	
Cyperaceae	*Carex wahuensis* sp.	ʻUki	Endemic	
Amaranthaceae	*Charpentiera elliptica* (Hillebr.) A.Heller	Pāpala	Endemic	
Asparagaceae	*Chrysodracon aurea* (H.Mann) P.-L. Lu & Morden	Halapepe	Endemic	
Araliaceae	*Cheirodendron fauriei* Hochr.	ʻŌlapa	Endemic	
Araliaceae	*Cheirodendron trigynum* subsp. *helleri* (Sherff) Lowry	ʻŌlapa	Endemic	
Dicksoniaceae	*Cibotium glaucum* (Sm.) Hook. & Arn.	Hāpuʻu	Endemic	
Dicksoniaceae	*Cibotium nealiae* O.Deg.	Hāpuʻu	Endemic	
Pteridaceae	*Coniogramme pilosa* (Brack.) Hieron.	Loulu	Endemic	
Rubiaceae	*Coprosma kauensis* (A.Gray) A.Heller	Kōī	Endemic	
Rubiaceae	*Coprosma waimeae* Wawra	ʻŌlena	Endemic	
Corynocarpaceae	*Corynocarpus laevigatus* J.R.Forst. & G.Forst.	Karaka nut	Naturalized	
Lauraceae	*Cryptocarya mannii* Hillebr.	Hōlio	Endemic	SOC
Thelypteridaceae	*Cyclosorus parasiticus* (L.) Farw.	Parasitic maidenfern	Naturalized	
Liliaceae	*Dianella sandwicensis* Hook. & Arn.	ʻUkiʻuki	Indigenous	
Gleicheniaceae	*Dicranopteris linearis*	ʻUluhe	Indigenous	
Athyriaceae	*Diplazium sandwichianum* (C.Presl) Diels	Hōʻiʻo	Endemic	
Gleicheniaceae	*Diplopterygium pinnatum* (Kunze) Nakai	ʻUluhe lau nui	Endemic	
Sapindaceae	*Dodonaea viscosa* Jacq.	ʻAʻaliʻi	Indigenous	
Blechnaceae	*Doodia kunthiana* Gaudich.	ʻŌkupukupu, Pāmoho	Endemic	
Asteraceae	*Dubautia kalalauensis*	Naʻenaʻe	Endemic	E, PEP
Dryopteridaceae	*Dryopteris fusco-atra* var. *fusco-atra*	ʻIʻi	Endemic	

Elaeocarpaceae	*Elaeocarpus bifidus* Hook. & Arn.	Kalia	Endemic	
Elaphoglossaceae	*Elaphoglossum paleaceum* (Hook. & Grev.) Sledge	Mākuʻe	Indigenous	
Asteraceae	*Erigeron karvinskianus* DC.	Daisy Fleabane	Naturalized	
Euphorbiaceae	*Euphorbia remyi* var. *remyi*	ʻAkoko	Endemic	E
Santalaceae	*Exocarpos luteolus* C.N.Forbes	Heau	Endemic	E
Pandanaceae	*Freycinetia arborea* Gaudich.	ʻIeʻie	Indigenous	
Zingiberaceae	*Hedychium gardnerianum* Sheppard ex Ker Gawl.	Himalayan (kahili) ginger	Naturalized	
Aquifoliaceae	*Ilex anomala* Hook. & Arn.	ʻAiea	Indigenous	
Rubiaceae	*Kadua affinis* DC.	Manono	Endemic	
Rubiaceae	*Kadua foggiana* (Fosberg) W.L.Wagner & Lorence	Manono	Endemic	
Crassulaceae	*Kalanchoe pinnata* (Lam.) Pers.	Air plant	Naturalized	
Epacridaceae	*Leptecophylla tameiameiae* (Cham. & Schltdl.) C.M.Weiller	Pūkiawe	Indigenous	
Campanulaceae	*Lobelia yuccoides* Hillebr.	Pānaunau	Endemic	SOC
Primulaceae	*Lysimachia kalalauensis* Skottsb.	No common name	Endemic	
Rutaceae	*Melicope clusiifolia* (A.Gray) T.G.Hartley & B.C.Stone	Kūkaemoa	Endemic	
Rutaceae	*Melicope feddei* (H.Lév.) T.G.Hartley & B.C.Stone	Alani	Endemic	
Myrtaceae	*Metrosideros polymorpha* var. *dieteri* J.W.Dawson & Stemmerm.	ʻŌhiʻa lehua	Endemic	
Myrtaceae	*Metrosideros polymorpha* var. *glaberrima* (H.Lév.) H.St.John	ʻŌhiʻa lehua	Endemic	
Dennstaedtiaceae	*Microlepia strigosa* var. *strigosa*	Palapalai	Indigenous	
Myricaceae	*Morella faya* (Aiton) Wilbur	Fire tree	Naturalized	
Myrsinaceae	*Myrsine alyxifolia* Hosaka	Kōlea	Endemic	
Myrsinaceae	*Myrsine knudsenii* (Rock) Hosaka	Kōlea	Endemic	E, PEP
Lomariopsidaceae	*Nephrolepis exaltata* (L.) Schott	Kupukupu, sword fern	Indigenous	
Oleaceae	*Nestegis sandwicensis* (A.Gray) O.Deg., I.Deg. & L.A.S.Johnson	Olopua	Endemic	
Solanaceae	*Nothocestrum longifolium* A.Gray	ʻAiea	Endemic	
Passifloraceae	*Passiflora tarminiana* Coppens & Barney	Banana poka	Naturalized	

Celastraceae	*Perrottetia sandwicensis* A.Gray	Olomea	Endemic	
Sapotaceae	*Planchonella sandwicensis* (A.Gray) Pierre	ʻĀlaʻa	Endemic	
Araliaceae	*Polyscias flynnii* (Lowry & K.R.Wood) Lowry & G.M.Plunkett	ʻOheʻohe	Endemic	E, PEP
Araliaceae	*Polyscias waialealae* (Rock) Lowry & G.M.Plunkett	ʻOheʻohe	Endemic	
Arecaceae	*Pritchardia minor* Becc.	Loulu	Endemic	SOC
Myrtaceae	*Psidium cattleianum* Sabine	Strawberry guava	Naturalized	
Dennstaedtiaceae	*Pteridium aquilinum* subsp. *decompositum* (Gaudich.) Lamoureux ex J.A.Thomson	Kīlau pueo	Endemic	
Rubiaceae	*Psychotria greenwelliae* Fosberg	Kōpiko	Endemic	
Rubiaceae	*Psychotria hexandra*	Kōpiko	Endemic	
Rosaceae	*Rubus argutus* Link	Sawtooth blackberry	Naturalized	
Blechnaceae	*Sadleria cyatheoides* Kaulf.	ʻAmaʻu	Endemic	
Blechnaceae	*Sadleria souleyetiana* (Gaudich.) T.Moore	ʻAmaʻu	Endemic	
Goodeniaceae	*Scaevola procera* Hillebr.	Naupaka kuahiwi	Endemic	
Poaceae	*Schizachyrium condensatum* , *Andropogon spp.* (Kunth) Nees	Bush beard grass	Naturalized	
Selaginellaceae	*Selaginella arbuscula* (Kaulf.) Spring	Lepelepe a moa	Endemic	
Cyatheaceae	*Sphaeropteris cooperi* (Hook. ex F.Muell.) R.M.Tryon	Australian tree fern	Naturalized	
Gleicheniaceae	*Sticherus owhyhensis* (Hook.) Ching	ʻUluhe	Endemic	
Myrtaceae	*Syzygium sandwicense* (A.Gray) Müll.Berol.	ʻŌhiʻa hā	Endemic	
Ericaceae	*Vaccinium calycinum* Sm.	ʻŌhelo	Endemic	
Ericaceae	*Vaccinium dentatum* Sm.	ʻŌhelo	Endemic	
Flacourtiaceae	*Xylosma Hawaiiense* Seem.	Maua	Endemic	
Rutaceae	*Zanthoxylum dipetalum* var. *dipetalum*	Kāwaʻu	Endemic	SOC

Key: SOC – Species of Concern (Fed); E – Endangered (Fed); PEP – Plant Extinction Prevention Program (State)

7.3 Fauna (mammals, amphibians, reptiles, invertebrates)

There have been no recent surveys of the site for mammals, amphibians, reptiles and invertebrates. However, a DLNR survey (DLNR 1997) carried out prior to construction of the nearby Kalalau Rim Endangered Plant Exclosure, encountered feral pigs, black-tailed deer, feral goats, feral cats, black rat, Norway rat, Polynesian rat and the house mouse.

The surveyors also noted that the ʻōpeʻapeʻa is known to occur 1km to the southwest of the site at the Hawaiʻi Air National Guard Radar Station and likely also resides in the forest surroundings. They further hypothesized at the time that the introduced Metallic skink (*Leiolopisma metallicum*) inhabits the area and the introduced wrinkled frog (*Rana rugose*) may inhabit the small drainages.

7.4 ʻAʻo – Newell's Shearwater

The ʻaʻo, or Newell's Shearwater, is endemic to Hawaiʻi, with Kauaʻi supporting the largest breeding population, estimated at 75 to 90% of the total world population (Ainley et al. 1995, USFWS 2011).
The species is listed as:

- Threatened under Federal and State of Hawaiʻi Endangered Species laws
- Endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (Birdlife International 2010).

Figure 7.1. The ʻaʻo. N Banfield.

Birds are nocturnal and ground nesting, breeding in burrows in steep, high elevation terrain. Their preferred habitat is open native forest dominated by ʻōhiʻa lehua (*Metrosideros polymorpha)* with a dense understory of ʻuluhe fern (*Dicranopteris linearis*).

Breeding begins in early April, when birds return to search for nest sites (Ainley et al. 1997, Zaun 2007, Deringer and Holmes 2009, Raine et al. 2017f, d, g, e). In June, the female lays one egg, which hatches in approximately 60 days. After hatching, both parents take turns to make foraging trips to the ocean to provision chicks. Fledging occurs late September to mid-November, peaking in October (Raine et al. 2017f). Fledglings will remain at sea for the next several years, returning to their natal areas to prospect for nesting sites in years two to five, and breeding by years five or six (Ainley et al. 1997). The ʻaʻo exhibits high site and mate fidelity.

The population of ʻaʻo is estimated to have declined by 94% (at an average rate of ~13% per year) from 1993-2013 (Raine et al. 2017b) and is predicted to continue to decline (Griesemer and Holmes 2011) . The restriction of the species' breeding range on the island is predicted to continue (Day et al. 2003, Holmes et al. 2009, Raine et al. 2017b).

Factors contributing to this decline are principally the effects of collisions with utility structures, fallout from the effect of light attraction and predation at breeding colonies by non-native predators (Raine et al. 2017a, Raine et al. 2017b, Raine et al. 2017f, d, g, e, Raine et al. 2017h). Other threats include climate change which can affect ocean conditions and food availability (Oro 2014).

7.5 Other Avifauna

DLNR surveyors in 1997 noted the koloa or Pacific golden plover (*Pluvialis dominica*), pueo and the nēnē or Hawaiian goose (*Branta sandvicensis*) in the vicinity of the site.

During a site visit and forest bird point counts in 2016 and 2017, KSHCP and KESRP staff observed ʻiʻiwi (*Drepanis coccinea*) (federally listed as threatened under the ESA), ʻapanane (*Himatione sanguinea*), Kauaʻi ʻelepaio (*Chasiempis sandwichensis)*, Kauaʻi amakihi (*Hemignathus Kauaiensis*) and ʻanianiau (*Magumma parva*). ʻAnianiau and Kauaʻi ʻamakihi were observed singing which may be an indication of breeding in the area.

The forest bird breeding season is from Jan – Jun, with most nests being high in the tops of trees. The pueo breeding season and population status is not fully understood but nests have been found throughout the year. Nests consist of simple scrapes in the ground (often under dense vegetative cover) lined with grasses and feather down (DLNR 2015).

Further surveys will be carried out in spring 2018 to complete a baseline of presence and nesting.

7.6 Listed Species

The following listed species are known to be present at the KSHCP mitigation site (.
Table 7.2).

Table 7.2. Listed species and Federal Species of Concern known to be present at the site.

Species Common Name	Scientific Name	Confir-med Present	State Status	Federal Status	IUCN Status
Plants					
ʻOheʻohe	*Polyscias flynnii*	√	Endangered, PEP	Endangered	Critically Endangered
Kōlea, (Rock) Hosaka	*Myrsine knudsenii*	√	Endangered, PEP	Endangered	Endangered
Heau	*Exocarpos luteolus*	√	Endangered	Endangered	Critically Endangered
ʻAkoko	*Euphorbia remyi var.*	√	Endangered	Endangered	Critically Endangered
N - CONFIDENTIAL	*D – CONFIDENTIAL*	(outside fence)	Endangered, PEP	Endangered	Critically Endangered
Pānaunau	*Lobelia yuccoides*	√	Species of Concern	Not Listed	Not Assessed
Loulu	*Pritchardia minor*	√	Species of Concern	Not Listed	Endangered
Kāwaʻu	*Zanthoxylum dipetalum var. dipetalum*	√	Species of Concern	Not Listed	Near Threatened
Hōlio	*Cryptocarya mannii Hillebr.*	√	Species of Concern	Not Listed	Near Threatened
Birds					
ʻIʻiwi	*Drepanis coccinea*	√	Threatened	Threatened	Vulnerable
Bats					
Hawaiian hoary bat - ʻōpeʻapeʻat	*Lasiurus cinereus semotus*	possible	Endangered	Endangered	Least Concern

SEABIRD STUDIES ON SITE – KAHUAMAʻA SEABIRD PRESERVE

8.1 Kauaʻi and the Kahuamaʻa Seabird Preserve – Background to Site Selection and Role in ʻAʻo Conservation

The island of Kauaʻi is critically important for meeting recovery and conservation goals for the ʻaʻo as it supports up to 90% of the world population (Spear et al. 1995, Ainley et al. 1997).

The Kauaʻi Endangered Seabird Recovery Project (KESRP) conducted auditory surveys and identified the ridges and slopes along the northwest coast of Kauaʻi as displaying the highest levels of ʻaʻo and ʻuaʻu breeding activity. These areas are known as ʻpolygonsʼ or ʻcalling hotspotsʼ (Figure 7.2) (Banfield et al. 2013, Raine et al. 2017f, d, g, e). This work helped to focus a search for a suitable SAS on the Kalalau Valley area which has high levels of activity, is relatively easy to access and is on land belonging to the state.

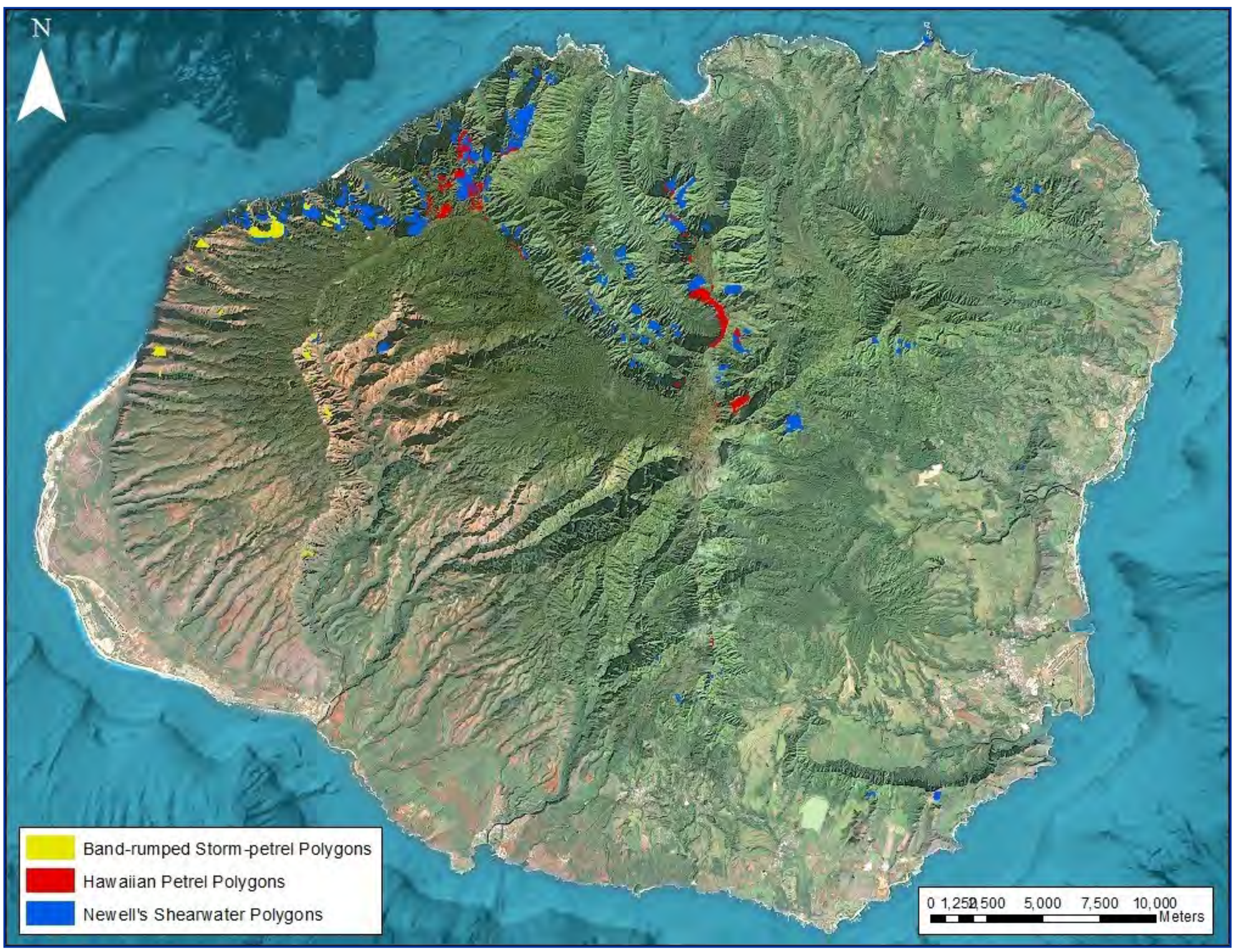


Figure 7.2. Map of ʻCalling Hotspotsʼ on Kauaʻi (KESRP).

KESRP conducted a series of surveys within and along the rim of the Kalalau Valley from 2006 to 2016 (Raine and Holmes, unpub. data), the results of which contributed heavily to the final selection of the site for the Seabird Preserve. Survey results identified 26 seabird polygons within 3km of the social attraction site, with the nearest polygon only 210 m away (Figure 7.3).

In addition, a song meter recording unit was installed on June 1, 2016 by KESRP staff to record ʻaʻo and ʻuaʻu activity (AUD 1: UTM 0434363 E, 2449690 N). The device was recovered on July 7th, 2016. Data was analyzed by KESRP and Conservation Metrics. ʻAʻo calls were detected almost nightly throughout the survey duration, with a site call rate of 0.3 calls/minute. This call rate is almost an order of magnitude lower than rates detected within a large monitored ʻaʻo colony in Upper Limahuli Preserve but is roughly comparable to lower-activity sites in Pohakea.

Although call rates were low at the survey site, compared to large monitored colonies of this species on Kauaʻi (such as Upper Limahuli Preserve), the fact that they were recorded on almost all nights suggests that potentially, a small number of pairs are breeding within or near to the site itself. The results also indicate that individual birds are flying around the area vocalizing on most nights, which could be drawn in by social attraction. Based on years of surveys by KESRP, it is clear that the wider area (Kalalau Valley and Nā Pali coast) has large breeding populations of both species (as seen in Section 6.2 and 6.3). Thus there are potential source colonies nearby that could be attracted into the site itself through social attraction (Raine et al. 2016).

Only 6 ʻuaʻu calls were recorded by the song meter. No barn owl calls or ʻakēʻakē calls were recorded.

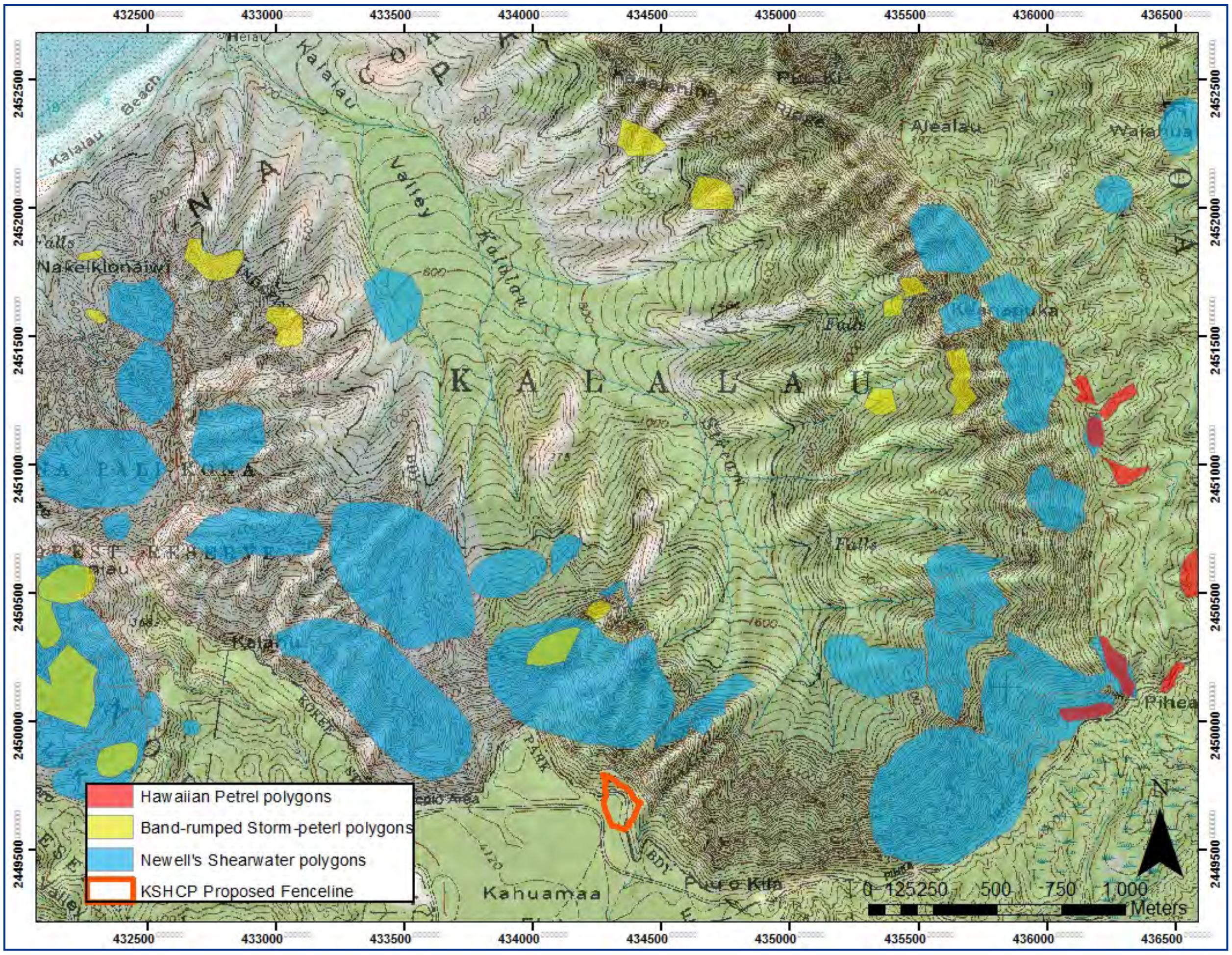


Figure 7.3. Map of location for the Kahuamaʻa Seabird Preserve showing ʻhotspotʼ polygons for the Covered Seabirds in surrounding area.

As a mitigation project for incidental take of ʻaʻo by KSHCP participants, the Kahuamaʻa Seabird Preserve will play an important part in protecting the species over the 30-year lifespan of the project. The habitat in the area is already of high quality for the species and management action at Kahuamaʻa will optimize this habitat. The site will become a stronghold for Newell's by providing a predator proof sanctuary, enhancing reproductive success.
Moreover, the remote northwest region of the island offers an opportunity to conduct conservation away from the threats of light attraction and utility line collisions. Kahuamaʻa is known to be relatively free of artificial light both at the site and also on the flyway to and from the ocean.

It should be noted that in 2015, a light attraction event resulted in a large number of downed seabirds at the Kōkeʻe Airforce base (Raine 2015a, Raine et al. 2015). The Air Force has since signed an agreement with USFWS to minimize lights at this base during the seabird season, and to monitor for any fallout that may occur.

8.2 KSHCP Studies

On the basis of KESRP findings in the broader Kalalau valley area, further work was undertaken at the Kahuamaʻa Seabird Preserve by the KSHCP team. In 2016 and 2017, preliminary auditory surveys were conducted to assess flyover patterns and confirm any seabird activity in and around the site, including any ground calling activity. The objective of auditory surveys is not to obtain an exact estimate of the number of seabirds breeding or present within the survey, but to generate average call rates to allow for a quantitative estimate of the species in comparison with other survey areas.

2016

Fourteen surveys in four locations were carried out for ʻaʻo from May 31 to June 3, 2016 by KSHCP staff. Data recorded included presence of birds calling on the ground with distance to the observer, presence of birds transiting over the site with elevation and distance and number of calls over time. The surveys followed a standardized protocol developed in 2006 by KESRP (see Appendix 1), such that the KSHCP data will serve as a baseline, compatible with KESRP data across years and sites.

For ʻaʻo, the surveys found that no evidence of ground activity at the site itself (birds being present on the ground may be indicative of burrows nearby) but did record ground calling at a distance of approximately 200m. Birds were detected transitting over the site, which indicates a high potential for them to be attracted to playback. No burrows were found in the site but the survey did not include a specific search for burrows. Continuous calling by ʻaʻo was recorded at a distance of >500m within the Kalalau Valley, corroborating some of the KESRP polygons in the area (Figure 7.3), and confirming presence of ʻaʻo in densities that could serve as source colonies for the site. The maximum number of ʻaʻo calls detected in one survey was comparable to KESRP observations at Wainiha which is noted as a 'Medium-activity site' with "ground calling or other signs of potential nesting behavior detected" (Raine and Banfield 2015).

2017

Six surveys in two locations were carried out from August 28-30. Since the proposed fence location has changed since 2016, only one survey site was repeated and the other survey location covered a location within the new fenceline. The majority of the calls recorded came from outside the project site, confirming presence of NESH in densities that could serve as source colonies for the proposed social attraction project. When data for calls within the site itself (0-200m range) was analyzed separately, the 'calls per hour average' was, as expected, low. Nonetheless, almost 200 calls were recorded in one session within this distance bracket, indicating a good number of birds circling or transiting over the site. This is encouraging, suggesting that the site is in an excellent location to attract prospecting birds once social attraction commences. In addition, several calls were heard that might have indicated ground calling, although these calls were not persistent enough to confirm the presence of breeders on site.

The presence of barn owls during three separate sessions indicates that barn owl control is likely to be of great importance at the site once social attraction starts as these introduced birds are known to be aerial predators of Newell's Shearwaters.

The results of the surveys, combined with the KESRP acoustic monitoring survey indicate that the installing a social attraction site at Kahuamaʻa has a high likelihood of success due to the presence of transiting birds, the presence of ground calling birds in the near vicinity and the fact that nearby source colonies have a suitable density of ʻaʻo which will supply new birds to the site.

Note that the social attraction component of the management plan will not be targeting ʻuaʻu directly because the applicants for the light attraction HCP have very low numbers of incidental take for ʻuaʻu which are being mitigated for by barn owl control in the Kalalau Valley. However, if ʻuaʻu choose to breed in the site, it will be an added conservation benefit.

8. OBJECTIVES

The objectives of the Kahuamaʻa Seabird Preserve mirror those of the KSHCP in Table 9.1.

Table 9.1: KSHCP Objectives

Goal 2: Mitigate authorized take of the Covered Species and provide a net gain in recovery for each of the Covered Species.	2.A. Construct a predator-proof fence and install social attraction equipment (nest boxes, speakers) within the fenced area at the mitigation site in Year 1 of KSHCP implementation.
	2.B. Remove predators from within the fenced enclosure with monitoring confirmation of their absence, and activation of the social attraction equipment by Year 2; predator eradication within fenced enclosure maintained for the life of the project.
	2.C. Ground activity by Covered Seabirds documented at the mitigation site by Year 4 of KSHCP program implementation.
	2.D. Breeding activity by Covered Seabirds documented at the mitigation site by Years 5-7 of KSHCP program implementation.
	2.E. Cumulative upward trend in Covered Seabird breeding documented at the mitigation site by Years 10-12 of KSHCP program implementation.
	2.F. Continued cumulative upward trend in Covered Seabird breeding documented at the mitigation site by Year 20 of KSHCP program implementation.
	2.G. Maintain high quality seabird habitat at the mitigation site by removal of habitat modifying invasive plants in Year 1 and annually throughout the 30-year duration of the KSHCP.
	2.H Protect nesting birds inside mitigation fence and in nearby source colonies by implementing predator control of 1) barn owls within the area surrounding the fenced enclosure and the Kalalau Valley, and 2) feral cats at ingress points to source colonies in the Kalalau Valley, beginning in year 1 and annually throughout the 30-year duration of the KSHCP.

9. ACTIVITIES

10.1 Activities Overview

Achieving the objectives of the Kahuamaʻa Seabird Preserve will require a series of actions over the duration of the project (30 years). For each specific activity within the Management Plan, the activity and methodology is described in the following sections. The approximate chronology of actions is as follows:

- Obtain permits
- Final confirmation of fence alignment
- Pre-construction surveys
- Fence Construction
- Predator Eradication
- Commence social attraction at site
- Vegetation management (invasive species removal)

Monitoring at the site will be ongoing and is a critical part of project success. All data will be collected digitally in the field to facilitate swift analysis into a database at the office. The Project Manager and Technician will work together to analyze data, produce appropriate monitoring documents and carry out all project management activities.
Section 17 outlines the Best Management Practices (BMPs) that will ensure that listed and / or rare species are not compromised by any of the activities.

10.2 Obtain Permits

Permits from the relevant authorities should be obtained in advance and will be outlined before the project begins. Permits may be required as follows:

Action	Permit / Permission
Fence construction and habitat enhancement	Develop MOA and secure any related approvals from DLNR
Invasive plant removal and pest control	Secure permits as required from DOA, USDA, USFWS and DLNR
Research and monitoring	Secure permits as required from DLNR and USFWS
All	NHPA Section 106 and ESA Section 7 consultation

10.3 Fence Alignment and Pre-Construction Surveys

OBJECTIVE 2A – Construct a predator-proof fence and install social attraction equipment (nest boxes, speakers) within the fenced area at the mitigation site in Year 1 of KSHCP implementation.

10.3.1 Initiate Bids Process. Select and Hire Contractor

The relationship with the fence contractor is extremely important to ensure that Best Management Practices are followed during construction and that the outcome of a terrestrial predator-free enclosure is successfully achieved. As soon as the Prime Contractor takes over management of the Kahuamaʻa Seabird Preserve, a fence contractor with a proven track record, capable of working in the terrain, will be engaged through a bids process.

10.3.2 Establish Sling Load Drop Zones, Final Fence Alignment

The chosen contractor will meet on site to establish the final fence alignment and sling load drop zones with Prime Contractor staff, the regulatory agencies and any other stakeholders considered necessary.

Following the onsite meeting, a document will be drawn up with a map showing the exact location of the fence and sling-load drop zones. The contractor will be asked to commit in writing to this document.

9.1.1. Pre-construction Surveys

Prior to work commencing on site, a series of surveys will be carried out and the results used to guide construction work and to ensure that all damage to listed species is completely avoided. These surveys are detailed in the following sections.

- Burrow surveys – Section 12.3.1
- Auditory survey – Section 12.3.4
- Bat survey – Section 17.1.3
- Candidate and listed forest bird & pueo survey – Section 7.5 & 17.1.4
- Archaeological survey – Section 17.1.6
- Plant Survey – Section 12.2

10.4 Fence Construction

OBJECTIVE 2A – Construct a predator-proof fence and install social attraction equipment (nest boxes, speakers) within the fenced area at the mitigation site in Year 1 of KSHCP implementation.

In order to establish a safe breeding sanctuary for the Covered Seabirds, a predator-proof fence will be constructed on site as follows.

10.4.1 Fence Design

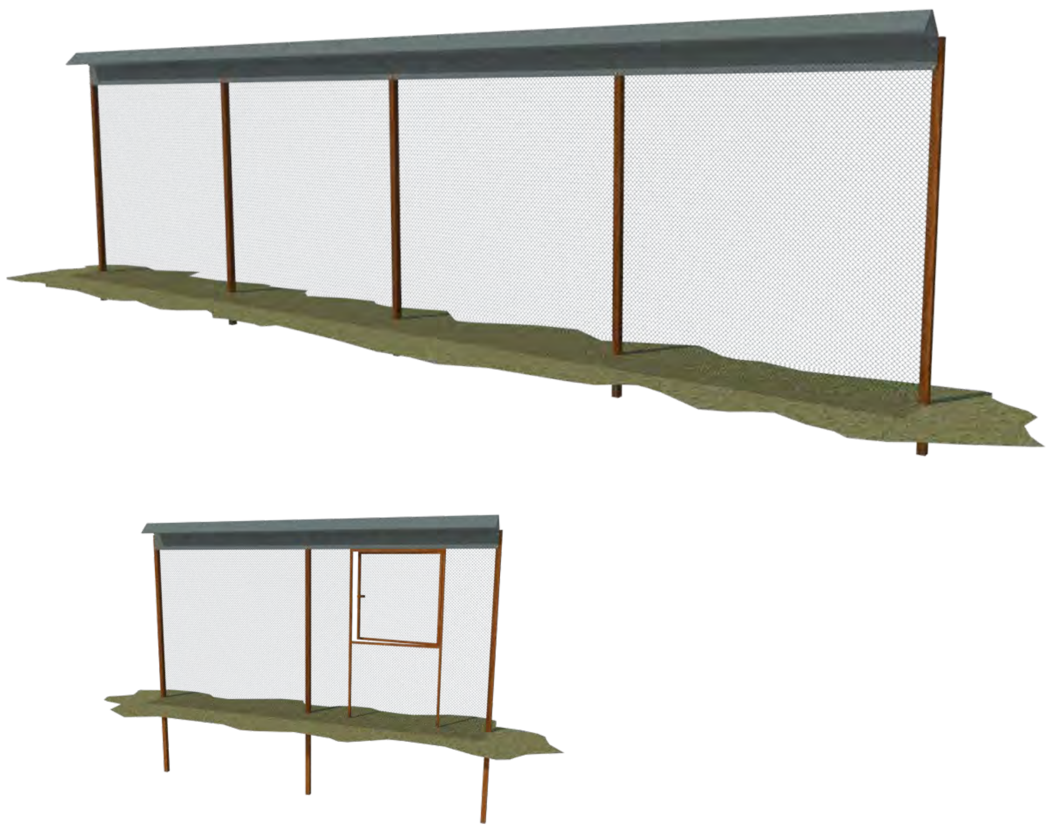


Figure 10.1. Technical Drawings of the Fence and Pedestrian Gate (PRC 2017)

The fence (Figure 10.1) will enclose approximately 2ha and will incorporate the following characteristics or similar (Young and VanderWerf 2014):

- Height of 2m
- All fence materials made of the same material (stainless steel)
- The fence base or frame should be constructed using 2.7m long posts spaced at approximately 2m intervals along the fence length. Spacing in areas of high winds along ridge lines should be closer
- Stays (diagonal braces placed behind the posts at a 45° angle) should be used on average every 4 posts and every 2 posts in high wind areas and on steep slopes. Stays must be placed only on the inside (pest-free) side of the fence.
- Stainless steel single strand wires should be tensioned to 150kg horizontally between the posts or poles and be fixed to each pole or post using stainless steel fastenings.
- Fine-aperture mesh will be applied that will exclude any terrestrial animal larger than a 2-day-old mouse. The face of the fence and the horizontal skirt extending out from the base of the fence should be marine grade “316” stainless steel mesh with an aperture no larger than 7mm by 25mm. The mesh should be fixed to the posts and post framework using stainless steel fittings.

- A mesh skirt will be added extending out and down approximately 0.5m to prevent digging, secured to the ground with pins or cement and not loose in any location, with its leading edge covered with topsoil or filled to a depth of approximately 45cm, and not scoured out or eroded under in any way
- Rolled hood will be added to allow animals to escape the enclosure, but not to jump inside. The hood should be of the same material as the rest of the fence and should be braced with brackets at each post and fixed to the fence frame using stainless steel fittings.
- The area immediately outside of the fence (i.e., the pest side) should be completely free of any objects or structures within two meters of the fence at all heights that an animal could use as a base for jumping over the fence
- The main body of the fence should be constructed in such a way that there are no gaps wider than 7 mm to exclude juvenile mice
- No fence corner should turn more sharply than 45 degrees off the line of the previous fence section (Figure 10.2).

Figure 10.2. Fence corner diagram

- Single, half-door design lockable pedestrian access gate will be located along the fence edge nearest to the road, not at ground level, requiring stepping over to reduce the chance of predators entering if the gate is accidentally left open (Figure 10.3). Gate sealed to the main body of the fence in a pest proof manner with no gaps greater than 7mm along more than one dimension, with a mesh skirt or solid concrete footing beneath the gate entrance that extends out from the gate by no less than 350mm
- An extra 5% of materials has been included in the budget to serve as "overage" in case there is variance from the estimated fence length or damage to some materials during transport. The extra materials also can be used for repairs after construction is complete.
- This design minimizes the risk of reinvasion as long as monitoring and maintenance procedures are in place (Day and MacGibbon 2007).

Figure 10.3. Example of pedestrian gate design that does not extend to ground level (Young and VanderWerf 2014)

Figure 10.4. Similar predator-proof fence at Hutton's shearwater colony, Kaikoura, New Zealand. A Raine.

10.4.2 Earthworks (Young and VanderWerf 2014)

- The fence platform should be formed as a gentle mound (when viewed in cross-section) so that drainage water cannot pass through the line of the fence.
- The earthworks and substrate in and around the fence should not have any channels or gaps continuously greater than 7mm across more than one dimension that extends from the ground surface on the outside (pest side) of the fence to the ground surface on the inside of the fence.

- The fence platform and ground conditions in the vicinity of the fence should be such that there is no immediate risk of slumping or erosion that may cause damage to the fence or compromise any of the standards outlined above.

10.4.3 Fence Construction Methods

Fence construction will ensure that the risks of predator incursion are minimal. Constructions will consist of:

- Fencing material will be flown in and landed on the agreed upon sling load drop zones (see section 10.3.2). Fence contractor will agree to a timetable for completion and all BMPs in writing.
- Clearing of fence-line (removing vegetation from a 4m wide swath, with machinery if possible or else by hand with chainsaws / hand tools) following the BMPs outlined in section 17.1 and 17.2
- Removal and maintenance of all woody vegetation from the outside the fence line to a distance of 3.7m to prevent incursion from predators. This may be less where there is an upwards slope away from the fence. Rats have a horizontal jumping capacity of 3.66m and a vertical jumping capacity of 1.8m (L. Young, 2017, pers. comm.). Grass may remain.
- Fence platform formation (earthworks, drainage works and culverts) with use of heavy equipment, such as a bobcat, if possible.
- Base fence erection (installation of posts, anchor poles, braces, 5 base wires);
- Attachment of mesh (including ground pinning/cementing);
- Attachment of cat-proof hood sections;
- Installation of waterway and access components.
- Removal of all waste upon completion.
- Due to the presence of tall canopy forest surrounding the fence, a solar powered tree fall response system (a metal wire that sits above the hood and is triggered if a branch falls on it) will be included in the fence construction process.

10.4.4 Delays in Fence Construction

Fence construction delays could result in additional costs. Some delays are avoidable; for example, in the case of permits, the KSHCP team will work with the agencies in advance, on the basis of the management plan, to ensure that the agencies issue permits before work commences and that any problems are flagged by the agencies early enough to be solved.

Fence construction must start during the period December to April, i.e. outside the breeding season. Fence construction may only commence during this period if it is reasonable to expect that the work that would affect seabirds will be completed on the sloping sections of the fenceline before the seabird breeding season commences, namely vegetation clearance, installation of initial posts and other ground disturbing work.

However, work may continue into the breeding season to complete the fence provided it is either on the flat areas of the site or does not include work noted above that would damage potential burrows or birds in burrows.

Since this means that missing the appropriate window could result in a delay of a year, the fence contractor will be asked to commit to deadlines such as ensuring that materials are in place in advance (see section 10.4). The contract will stipulate per-day monetary penalties beyond the specified deadline for contractor delays, regardless of weather. Intensive efforts will be made by the Prime Contractor to avoid delays.

10.4.5 Confirm Fence Construction Complete

The target for completion of fence construction is end of Year One to fulfil KSHCP requirements. Prime Contractor staff will confirm that this target has been met with a final fence inspection including photographs.

If it becomes clear during the course of construction that this target will be missed, Prime Contractor staff will consult regulatory agencies and initiate adaptive management (outlined in section 16) if required.

10.4.6 Long term Fence Monitoring and Maintenance

Even a well-built predator exclusion fence using proven materials will require a regular monitoring and maintenance program to be effective in the long term. Accidents, vandalism, and acts of nature are likely to damage the fence at some point, potentially resulting in pest reinvasions. A good maintenance and monitoring program will detect the damage quickly, will have people and resources in place to make emergency repairs, and will reduce the likelihood of animals entering when a breach occurs (Young and VanderWerf 2014).

Maintenance will be carried out as follows:

- The contractor will be required to provide a complete parts list, including item description, material, manufacturer and part number in a spreadsheet.
- They should also provide a written maintenance manual, repair kit parts list and one day of on the ground training for managers and staff.
- Based on discussions with other predator fence project managers, annual maintenance cost for materials is estimated to be 1% of the initial cost of the fence, plus labor.
- The fence will be monitored bi-monthly (this can be combined with other monitoring activities, such as predator control) following completion to avoid fresh incursions by predators. Personnel will check for holes, breaches, vandalism, and other damage throughout the life of the project. Ad hoc monitoring will occur after storm events or high winds to ensure no damage was sustained. Gates will be tested for functionality.
- When inspecting, there are four components to look at: hood, posts and stays, skirt and mesh. The hood should be examined for excess lichen growth which can facilitate cats climbing over, corrosion at seams, attachment points, bends and for scratches indicative

of cats attempting to jump over. If scratches are noticed, the area should be examined to determine if there are jump points. Posts and stays should be examined for corrosion and loose attachments. Mesh should be examined for breaks in welds or links, corrosion or abrasion and separation at the seams or attachment points. The skirt should be examined to ensure that there aren't any punctures, it is secured to the ground, not eroded underneath and that the lip is not curling up and allowing pests to dig under.

- Where scratches are seen, feral cat trapping outside the fence will be intensified (see section 11.1.2)
- A risk analysis will be carried out after construction, to identify possible areas of weakness. This analysis should identify possible reinvasion sites, such as at natural barriers like adjacent overhanging trees, steep slopes, areas prone to high winds or rock falls, or areas where public might try to access.
- To assist in having breaches reported in a timely manner, signs could be placed at high-risk areas and access points that provide contact information for whom to call in the event that a breach is noticed. Fence posts will be tagged with a unique number so that anyone reporting a breach can identify the location easily (e.g. fence panel #180). These can either be engraved into the fence posts, or added as separate metal tags.
- All project staff will carry a small tool box of patch materials and tools at all times during site visits.

10.5 Intruder Detection

Predator intrusions will be identified through the regular deployment of tracking tunnels inside of the fence line. See rodent removal section 11.1.1.

10.6 Predator Defense Zone Around Fenceline

To reduce the likelihood of pests entering through a fence breach, a zone of low, non-woody vegetation will be created and maintained around the perimeter of the fence. Predator eradication will also occur in this zone (and up to 50m beyond) because several species, particularly feral cats, have been noted using a fenceline as a transit trail within their territory (A. Raine, 2017, pers. comm.) and regularly patrol it, increasing their chances of finding a breach before it is repaired. See rodent and feral cat removal section 11.1.1 and 11.1.2.

10.7 Fence Crisis Response to Reduce or Eliminate the Risk of Predator Incursion

A tree fall response system will be installed along the fence which will issue an alert to a mobile phone if the fence is damaged by falling vegetation.

Following such an alert or a storm event and / or hurricane, staff will check the fence as soon as practically possible (ideally within 2 hours, if safe to do so). If a major breach is discovered, e.g. a tree falling on the fence and / or the fence being blown down or partially destroyed by a hurricane, staff will initiate a 'fence crisis procedure' as follows:

- Upon discovery of a major breach or serious damage, Prime Contractor staff will alert the regulatory authorities (DOFAW, DLNR, USFWS) and the KSHCP participants
- Where possible and safe to do so, staff will make an effort to repair the breach themselves for damage limitation
- Where the breach is too large, staff will retain the services of a fence contractor as soon as practically possible to repair the breach.
- If the breach occurred outside the breeding season for covered seabirds, staff will deploy ink card tracking tunnels, visual surveys and cameras to assess the likelihood of predators having entered the Kahuamaʻa Seabird Enclosure. If predators are found to be present, Prime Contractor staff will initiate the predator removal procedures outlined in this management plan in section 10.
- If the breach occurred during the breeding season, Prime Contractor staff will initiate the predator removal procedures immediately to avoid injury or death to the covered seabirds.
- IE staff will also check and repair any damaged artificial burrows following a storm event, as well as the social attraction equipment, cameras, Goodnature (or similar brand) traps and any other hardware relevant to the site.
- The KSHCP includes a contingency fund to pay for incidents of this nature. Prime Contractor staff will draw upon the fund as required to repair the breach.

10. OPERATION OF PROJECT SITE

11.1 Predator Eradication at Project Site

OBJECTIVE 2.B. Remove predators from within the fenced enclosure with monitoring confirmation of their absence, and activation of the social attraction equipment by Year 2; predator eradication within fenced enclosure maintained for the life of the project.

There are many precedents for successful predator removal in fenced seabird enclosures. In Hawaiʻi, these include the Nihoku Ecosystem Restoration Project at Kīlauea Point National Wildlife Refuge in Kauaʻi in 2015, Makamakaʻole Seabird Preserve in Maui in 2013 and Kaʻena Point Natural Area Reserve on Oʻahu in 2011.

Kahuamaʻa Seabird Preserve, predator eradication will target rodents, namely black rat, Norway rat and Polynesian rat. House mouse is likely to be eradicated as part of the process. It will also target feral cats, ungulates, pigs (although these are expected to leave of their own accord due to the levels of disturbance during construction) and barn owls.

11.1.1 Rodent Eradication Methods

Predator removal will be achieved through a grid of mechanical trapping (rodent snap traps, self-resetting rodent Goodnature traps or similar brand) and stationary rodenticide (diphacinone) bait stations. Monitoring will include the counting and collection of carcasses, monthly deployment of ink card tracking tunnels which show predator footprints, camera monitoring and bait-take monitoring (this is dealt with in section 12.1). Eradication within the fence is expected to take 3 months (Young et al. 2013) but may be longer.

There will also be a secondary line of rodent removal defense just outside the project fence in a 50m predator defense zone consisting of Goodnature (or similar) and snap traps which will remain there permanently. This will help to prevent the ingress of rats and mice into the site by removing them before they reach the fence; research suggests that reinvasion by rodents occurs within 24 hours of a breach (Connolly et al. 2009).

Project staff will be trained by predator eradication experts based on Kauaʻi. To remove rodents inside the fence enclosure, trained and certified technicians will set up the following grids using a GPS:

11.1.1.1 Self-resetting rat traps (Goodnature A24 traps or similar)

These traps house a firing system in a narrow opening, positioned vertically to the ground. When rats take the bait, a bolt fires, killing the predator instantly.

- 25 will be spaced every 50m - the average home range size for Black Rats ((Young et al. 2012) - on a grid inside the fence, mounted on trees or roots. If no other support is available, a pole can be used. Traps will be at least 12cm off the ground. They will remain for the duration of the project.
- A further 40 will be mounted every 50m in the 50m predator defense zone outside the fenceline and will remain there for the duration of the project
- Traps will be checked monthly, strike counter noted, CO_2 canister tested and changed if required and trap re-baited if necessary by removing the shroud cap, taking out the longlife lure bottle, tapping out tired lure as a pre-feed to attract pests, wiping and replacing lure. Check frequency may be reduced over time if the automatic lure pump proves effective.
- For further set up and management details see http://www.goodnature.co.nz/support. Similar brands may also be used.

11.1.1.2 Enclosed rat "snap" traps (Victor, DOC 200 or similar)

- Inside the fence, a grid of up to 75 "snap traps" or similar (placed inside a bird-safe housing to prevent non-target capture) will be set up (numbers may vary depending on predator level) with 50 spaced approximately every 25m inside the fence and 40 in the 50m predator defense zone outside the fence.
- These will be used throughout the initial eradication (expected to last three months) and then may be removed except in case of a reinvasion by predators and stored by project. However, if rat presence inside the fence continues to be a problem, the "snap" traps will remain. The snap traps will remain outside the fence for the duration of the project.

- Options include the Victor Rat Traps and the DOC200.
- There are a variety of possible baits. The Makamakaʻole project (S Engler, 2017, pers. comm.) have advised that the most effective bait to date is eggs (with a small hole poked in them) for the DOC200's and a homemade formula of peanut powder, coconut oil, wax and preservatives in a mold for snap traps. This wax bait has proven to last up to 2 weeks in the field without molding (whereas peanut butter alone lasts only 3 days). In Kauaʻi, GoodNature bait has proved effective for snap traps (K Pias, 2017, pers. comm.) but other brands can be used.
- Traps will be placed in a bird excluding box designed to exclude non-target species, guide target species, and maintain the integrity of the trap from weather (Mosher et al. 2010). Plans can be found at (http://www.doc.govt.nz/Documents/conservation/threats-and-impacts/animal-pests/doc250-predator-trap.pdf) (Peters 2017). See Figure 11.1. Alternatively, Tupperware boxes can be used with holes cut in the side of them to exclude birds from the traps, based on a design by Kyle Pias.
- While in use during initial eradication, traps will be checked every two days, carcasses removed and disposed of off-site and bait replaced if required.

Figure 11.1. Bird Excluding Box for DOC 200 Snap Traps from Makamakaʻole Project, Maui

11.1.1.3 Rat bait stations.

Rodent bait stations will be placed inside the fence. Stations are designed to prevent access by birds or non-target species.

Interior rat bait stations

- A grid of approximately 50 tamper-resistant Protecta ® plastic bait stations or similar will be placed every 25m inside the fence.
- Stations will be secured to the ground with metal rebar stakes and plotted by GPS.
- Stations will be baited with 11 1oz Ramik mini-bars ® containing 0.005% diphacinone or similar product approved for conservation of endangered species (Young et al. 2013). Bait will be placed on a rod and box will have lid screws to eliminate risk of removal and caching of bait by rodents. 16 bars are allowed per station according to the label, but 11 is the maximum that will fit in the station on the rod so that bait is not shaken free (Young et al. 2013)

- For the initial bait application, stations will be re-baited twice a week for one month. In month two, stations will be baited once per week; in month three to six, stations will be baited every two weeks; thereafter, stations will be baited once a month until sign disappears (by zero bait take or teethmarks and zero presence on ink cards).
- Bait take 'hot spots' will be mapped, where additional trapping / baiting would be of benefit.
- Once ink card tracking tunnels and bait stations show zero signs of take, predator eradication work and monitoring will continue for a further three months (the average reproductive cycle of a female rat) to ensure that a new litter did not survive. Detailed records of the level of bait take for each station will be kept.
- Any bait blocks that are wet or excessively moldy will be removed and replaced with fresh bait. Spoiled bait blocks will be placed in a plastic bag and disposed of in an off-site location and any bait blocks that have been dragged out of the station will be returned to the station (if in reusable state) or removed if unusable
- Bait stations may be re-utilized at any time during the project based on a suspected breach or rodent evidence found via tracking tunnels, cameras, or other detection methods following the above protocol until rodent signs disappears. They will therefore remain in place. However, their use will be kept to the minimum possible, if used at all.
- KSHCP personnel or contractor will be certified as applicators of restricted-use rodenticide. These certifications will need to be renewed every 4 years, or as dictated by the HDOA.
- Signs indicating diphacinone bait is being used will be placed on the pedestrian entrance to the fenced area.

Even when rodent eradication inside the predator-proof fence is complete, permanent rodent control (snap traps in bird excluding boxes and Goodnature traps or similar) immediately outside the fence will be maintained (traps left out and maintained) to keep animal densities low and prevent immigration into the fenced area.

To facilitate rapid response to a breach, unarmed snap traps and unbaited bait stations will remain in situ inside the fence so that they can be easily redeployed in an emergency.

11.1.2 Feral Cat Eradication, Biosecurity Methods Inside Kahuamaʻa Seabird Preserve Fence

2.B. Predators removed from within fenced enclosure with monitoring confirmation of their absence, and activation of the social attraction equipment by Year 2; predator eradication within fenced enclosure maintained for the life of the project.

It is anticipated that feral cats (*Felis catus*) will leave the interior area prior to completion of the fence, due to the disturbance caused by construction activities. This will be confirmed by the deployment of 2 live traps and 10 Reconyx camera traps inside the enclosure for three months or until social attraction commences (these cameras will later be used for burrow monitoring).

11.1.2.1 Potential Feral Cat Eradication Methods (inside the fence)

- Conibears

Conibears (Body Gripper Traps - Duke #220 or similar) for feral cats will be used following fence completion in case cats have not left the site by their own volition.

Conibears have the potential to kill birds and therefore will only be deployed within bird excluding boxes; these can be homemade out of a Tupperware box (K. Pias, pers. comm.) Two traps will be place in a location to be decided by technicians based on camera data and other evidence of cat presence / knowledge of cat behaviour.

Conibears may also be used in the event of an incursion, as outlined in section 11.1.2.

- Live Traps

If there is any evidence of cats inside the fence after construction (scat, camera, visual sightings etc.), the 8 live traps (tomahawks) from outside the fence will temporarily be deployed inside the fence until all cats are captured.

- Goodnature Traps

The current design of Goodnature cat traps has not proved effective in Kauaʻi, however new models are being considered and might be added to the project in the future.

- Shooting

If the above methods are not successful, feral cats can also be dispatched by shooting. This would be done at night, using visual, scent or aural lures, with a rifle with a night scope, operated by a trained technician.

11.1.2.2 Feral Cat Reinvasion

If cats are detected inside the predator proof enclosure after completion, through any means (for example visually, on a camera or through the appearance of a bird carcass that is likely to have been killed by a feral cat, scat, footprints or other signs), they must be urgently removed, following strict BMPs (see Section 17).

All 8 live feral cat traps will be deployed inside the fence. 2 conibears in bird excluding boxes will be set and baited inside the fenced area at an appropriate location as determined by cameras and other evidence, until the feral cat is eradicated. The feral cat may also be humanely dispatched by shooting as outlined above.

11.1.2.3 Feral Cat Control Methods (outside fence)

Feral cats are observed on the road to Pihea by NARS staff on a near-weekly basis, and NARS camera data reflects significantly higher numbers of cats moving along trails and fence lines than along densely vegetated areas (K Pias, 2017, pers. comm.). It is worth noting that a predated ʻaʻo was documented in 2014 in very close proximity to the Kalalau Lookout (A. Raine, 2016, pers. comm.).

At the Makamakaʻole Seabird Preserve, cats were noted prowling the exterior of the fenceline, apparently attracted by seabird calls played on the speaker (S. Engler, 2017, pers. comm.). This presents a risk of reinvasion by cats in the event of a breach and also an opportunity to remove cats which might prey on neighbouring source colonies. Therefore, feral cat control along the fenceline will be carried out as follows:

Live feral cat traps

- 8 live feral cat traps (30" and 36" Tomahawks or similar) will be deployed, 2 on each side of the fence. These will be a mixture of baited traps and un-baited trail set traps (double door tomahawks).
- Traps to be run, in the course of technicians' other duties. When open, they will be checked every 24 hours to adhere to IACUC standards.
- Bait will be a combination of dry cat food and synthetic shellfish oil replaced every 2-3 days or as needed. Baits will be adaptively implemented based on best available information and the findings of related projects.
- Traps will be locked open in place with added bait between trapping efforts to encourage regular visitation by cats. This technique has been observed to greatly increase capture rates (G. Reid, 2016, pers. comm.).
- Feral cat carcasses will be necropsied and stomach contents will be examined for evidence of seabird predation.
- Non-target pest species (e.g. rats) that are caught in the live traps will also be dispatched.

Cameras

- Two cameras will be used outside the fence to monitor for cat presence (see section 11.1.1 for methods)

Trapped Animal Dispatch

- Technicians will receive firearm training. Trapped feral cats will be dispatched humanely.
- The MOA with State Parks will include an agreement regarding use of firearms on designated State Parks land.

11.1.3 Mongoose

The establishment of Indian mongoose (Herpestes javanicus) is uncertain on the island of Kauaʻi (Phillips and Lucey 2016). Two mongoose have been caught on Kauaʻi in recent years and Kauaʻi Invasive Species Committee (KISC) receives multiple "credible" sightings annually. If a mongoose is detected or suspected at the site at any time, the project team will advise the regulatory agencies and seek advice from KISC within 12 hours of the animal being detected and will commence the procedures outlined by Phillips and Lucey (2016). Should this occur, the KSHCP activities will be modified if USFWS and DLNR reasonably determine, in consultation with Participants, that such a response is necessary.

11.1.4 Ungulates and Pigs

Site visits during the project development stage have indicated a high degree of goat disturbance, as well as some pig sign. Black-tailed deer may also be present. However, due to the relatively small size of the enclosure, a need for feral pig, feral goat and deer trapping is not anticipated as large ungulates typically avoid the kind of loud human disturbance that will occur during construction.

Scheduled fence monitoring and maintenance (Section 10.4.6) will ensure any ungulate or pig fence damage is noted and repaired.

Scheduled camera checks for cats and rats (Section 11.1) will ensure that any ungulate or pig presence inside the fence is noted. In the highly unlikely event that an ungulate or pig is found inside the enclosure, a firearm-certified technician will be remove them as soon as practically possible. Snares / legholds may be deployed if necessary.

11.2 Barn Owl Control

Objective 2.H. Protect nesting birds inside mitigation fence and in nearby source colonies by implementing predator control of 1) barn owls within the area surrounding the fenced enclosure and the Kalalau Valley, and 2) feral cats at ingress points to source colonies in the Kalalau Valley, beginning in year 1 and annually throughout the 30-year duration of the KSHCP.

Barn owls are a non-native species and known predators of seabirds (Thomsen and Kroeger 2015, Raine et al. 2017c). They cannot be completely excluded from the reserve as they are aerial predators and their home ranges can vary considerably in size from 1.5km² to 31km² depending on habitat and prey availability (Martin et al. 2014). Therefore, barn owl reduction methods will be deployed in and around the site to ensure that seabirds are not predated at the preserve. This predator control will begin in Year 1 and is expected to continue for the 30-

year duration of the Program. The barn owl control will enhance adult survivorship and the reproductive success of ʻaʻo, ʻuaʻu and 'akē'akē breeding in the affected area (USFWS 2017b).

This is particularly the case for those populations nesting along the Nā Pali Coast such as Honopū Valley (where large numbers of ʻaʻo are known to nest) and along the Pihea side of the Kalalau rim (where large numbers of both ʻaʻo and ʻuaʻu are known to nest (Raine et al. 2016)).

ʻAkēʻakē have also been documented vocalizing from cliff bands within the Kalalau Valley and are present in large numbers in the slot canyons of the Nā Pali coast, including nearby Honopū (KESRP, unpublished data). While they are not expected to breed in the social attraction site, they will benefit from barn owl control as, based on evidence from Lehua Island monitoring by KESRP and the propensity of barn owls to be attracted to ʻakēʻakē calls in Kauaʻi, they are likely to be heavily impacted by this predator. An ʻakēʻakē predated by a barn owl was found in nearby Nuʻalolo ʻĀina in 2014 (A Raine 2017 pers. comm.).

Once an individual or a mating pair of barn owls are removed, new individuals will move into the territory over time. Observers in nearby locations on Kauaʻi have noted a lapse of about 3-12 months between removal of original individuals from a territory and detections of new individuals (G. Reid, 2016, pers. comm.). This underscores the need for ongoing control.

11.2.1 Barn Owl Reduction Methods – Trapping

- 6 Bal-chatri prey traps or Swedish Goshawk-style trap will be employed approximately 4 nights per month or as needed at various points along the Kalalau Rim. These points will be moved as required.
- The owls will be electronically lured into the area using owl or prey calls. Traps will be baited using decoys (a moving toy and playback to mimic the presence of a mouse/rat, or with a live rat/mouse). When the owl pounces on the Bal-chatri trap to get at the decoy, their talons will become entangled in the snares set on top of the trap and the trapped owl dispatched humanely.
- Live bait will consist of captured, humanely-held rats (*Rattus rattus*) or mice (*Mus musculus)*. Food, shelter, water and insulating cover will be provided to bait rodents in the trap.
- Traps will be set at night and closed each morning to ensure humane treatment of both bait and potential target species, and to ensure that non-target species (such as pueo) can be safely released if caught.
- Barn owl traps will be set outside of the enclosure to prevent reintroduction of rodents to the facility.
- Mist netting, pole traps and any other relevant technologies that become available over the timespan of the project will also be employed.
- Trapping will continue for the 30-year duration of the project.

11.2.2 Barn Owl Reduction Methods - Shooting

- Shooting will occur 4 nights per month or as-needed (as determined by auditory surveys and field observations) for the duration of the 30-year Program. Fire-arm technician will choose a location based on auditory data and visual sightings. These points can be altered as more information is gained about individual territories, roosts, etc. to cover the Kalalau Valley.
- Timing will be at and just after sunset, and at or just prior to sunrise. This will be subject to change based upon observed activity patterns of owls, moonlight hours, and weather patterns (barn owls head back to dry roosts during heavy rains). Total hunt times should average 5 hours per night but may vary depending on barn owl activity.
- Barn owls will be lured to the area using playback (such as the noise of a squeaking mouse or an ʻakēʻakē call). Predator control staff will be trained by KESRP staff to distinguish between non-native barn owl and the native pueo. They will also be well-versed in seabird identification. Shooting will only occur when a 100% positive ID has been achieved. If seabirds or pueo are in the immediate environs, no shooting will occur.
- Barn owls will first be spotlit. One person will operate a spotlight, while the other will operate a shotgun with an effective radius of ~37m. Staff will listen and visually scan the area using single-tube night-vision goggles. When spotted, one person will illuminate the individual with a spotlight while the other person confirms the identification and then dispatches the barn owl.
- An attempt will be made to retrieve the remains for autopsy to assess stomach contents but this is frequently not possible (G. Reid, 2016, pers. comm.).
- Traps and shooting locations will be a minimum distance of 50m from all public facilities (parking lots, trails, roadways, and facilities), operating only during dark hours (sunset to sunrise). All shotgun shells will be retrieved after shooting and non-lead ammo will be used. Areas will be checked for human presence prior to shooting. If members of the public are present, shooting operations will be stopped immediately.
- If a barn owl is detected outside of planned trapping periods, a rapid response contingency plan will be in place, and the individual(s) will be hunted on the same night if possible or as soon as practically possible.
-

11.3 Feral Cat Removal at Ingress Points to Source Colonies in the Kalalau Valley

Objective 2.H Protect nesting birds inside mitigation fence and in nearby source colonies by implementing predator control of 1) barn owls within the area surrounding the fenced enclosure and the Kalalau Valley, and 2) feral cats at ingress points to source colonies in the Kalalau Valley, ongoing throughout the 30-year duration of the KSHCP.

Feral cats are using the roads and trails in the vicinity of the Kahuamaʻa Seabird Preserve as ingress points to prey upon nearby established colonies in the Kalalau Valley and Rim, Pihea (part of the Hono O Nā Pali NARS) and Honopū, expected source populations for the Kahuamaʻa Seabird Preserve. Feral cats are having a very serious negative effect on fledging success in these areas - KESRP have recorded numerous incidents of cats eating fledglings and a cat kill of an ʻaʻo was recorded at a parking area near the Honopū colony, which is close to the Kahuamaʻa Seabird Preserve (A. Raine, 2017, pers. comm.). Data from cameras and predation records at various colonies in Kauaʻi show that a cat that is targeting seabirds can predate a series of burrows in a single night, killing multiple adult and juvenile seabirds (A. Raine, 2017, pers. comm.).

The Kahuamaʻa Seabird Preserve Management Plan therefore includes feral cat removal at ingress points to source colonies in the Kalalau Valley. This will include at least 2km of linear trapping lines off roadways between the Kalalau and Puʻu O Kila lookouts, as well as trapping lines along likely cat trails into neighboring colonies and ad hoc trap placement as appropriate based on camera data.

This predator control effort will reduce the impact of feral cat predation on source colonies for the Kahuamaʻa Seabird Preserve by removing individual cats that are migrating towards the colonies, and reducing feline breeding in the area. It will also serve as a line of defense, removing cats which might attempt to enter the Kahuamaʻa Seabird Preserve.

This action will begin in Year 1 and is expected to continue for the 30-year duration of the Program.

11.1.1 Feral Cat Removal Methods

Feral cats will be targeted as follows:

Live feral cat traps

- 30 live feral cat traps (30” and 36” Tomahawks or similar) will be deployed at least 10 nights a month. These will be a mixture of baited traps and un-baited trail set traps (double door tomahawks). 20 will be spaced approximately every 100m along at least 2km of trap lines from Kalalau Lookout to Puʻu O Kila Lookout and along likely cat trails into neighboring colonies. Using camera data as a guide, a further 10 live cat traps will be used in a roving capacity for maximum efficacy.
- Each trap will be placed on level ground, and camouflaged using proximal vegetation. Visual lures and stepping sticks will be installed in all traps to pique feline curiosity and increase trap effectiveness. They will be checked once every 24 hours to meet humane standards and ensure that no seabirds are harmed.

- Traps will be baited using food derived lures such as sardines, cat biscuits and synthetic shellfish oil, replaced every 2-3 days or as needed. Baits will be adaptively implemented based on best available information and the findings of related projects.
- Live traps will be locked open in place with added bait between trapping efforts to encourage regular visitation by cats. This technique has been observed to greatly increase capture rates (Reid 2016 pers. comm.). Traps in public locations will be removed or hidden between trapping efforts to avoid vandalism. However, their locations can still be baited with cat lure between trapping efforts to encourage habitual visitation by cats and increase trapping success when they are reopened.

Conibear feral cats traps:

- 24 conibear traps (with appropriate seabird excluding box) will be deployed, with 14 placed approx. 150m apart along trapping lines, with an additional 10 being used in a roving capacity. Harm to seabirds will be prevented by mounting the traps in boxes and setting them approximately 20-25cm off the ground. Boxes will be cut in half so the bait is visually attractive to predators. This type of trap can be set and left active for longer periods of time, allowing active trapping to take place regardless of staff presence within the preserve. Conibear trap baits will alternate between food-based, glandular, and olfactory lures. Traps will be checked and rebaited twice a month.

Leg Holds:

- 20 Leg holds will be deployed as required. Traps will be “blind” sets, i.e. not baited and set in a manner that requires little behavioral modification on the part of the target animal. Traps will only be set on trails / locations where a feral cat has been observed during the previous week and when technicians consider there is imminent danger to seabirds from a feral cat. They will be deployed well away from any established tourist areas or trails. When set, traps will be checked at least every 24 hours.

Camera Traps

- Camera traps will be used to monitor trails for predator activity. Camera monitoring provides managers with data on the number and distribution of cats present, allowing them to make informed management decisions on the placement and types of traps to use at particular times. 20 cameras will be set at various locations on the 2km of feral cat removal trails, as well as other ingress points to provide observations on feral cats, including the exact time an animal is seen and the direction it is headed. The data from each trail camera will be collected and photos will be checked approximately every two weeks. All data will be reviewed in the field, and notable photos stored.
- DOFAW and NARS are working on a system which will equip traps with cameras and radio transmitters, advising technicians by text when the traps are triggered and showing the predator caught. The KSHCP may be able to deploy this technology once it becomes available, saving a great deal of staff time and reducing human presence and scent along trails. If this occurs, the budget for monitoring cameras for feral cats will be partially transferred to this technology.

Additional Protocols

- Other traps may be used as appropriate, particularly if new technology becomes available.
- In public use areas, care will be taken to place all traps out of the way, hidden within vegetation.
- Feral cat carcasses will be necropsied and stomach contents will be examined for evidence of seabird predation.
- If a feral cat is detected outside of planned trapping periods, the next trapping period will be brought forward to start as soon as practically possible.
- Non-target pest species (e.g. rats) that are caught in the live traps will also be dispatched.
- Technicians will receive firearm training to dispatch trapped animals humanely.
- All predator control activities performed by Prime Contractor staff will include the necessary training and permitting.

11.3 Creation of Social Attraction Site

2.A. Permanent, predator-proof fence constructed and social attraction equipment (nest boxes, speakers) installed at the mitigation site in Year 1 of KSHCP program implementation.
2.B. Predators removed from within fenced enclosure with monitoring confirmation of their absence, and activation of the social attraction equipment by Year 2; predator eradication within fenced enclosure maintained for the life of the project.
2.C. Ground activity by Covered Seabirds documented at the mitigation site by Year 4 of KSHCP program implementation.
2.D. Breeding activity by Covered Seabirds documented at the mitigation site by Years 5-7 of KSHCP program implementation.

Establishing a seabird breeding colony in a terrestrial predator free fence enclosure through the broadcasting of breeding calls is an effective and proven conservation tool (Gummer 2003, Sawyer and Fogle 2010, McIver et al. 2016). Seabirds, especially prospectors, transiting to and from their natal colonies, are drawn to the apparent activity at the site and, when they choose to breed there, are protected by the predator proof fence, increasing their breeding and fledging success considerably (Young et al. 2012).

An integral part of best management in a social attraction site is the provision of artificial burrows to optimize seabird habitat (Bourgeois et al. 2015) and expedite the process of establishing breeding at a new site - burrow excavation by a newly established breeding pair can take a year or more (Bancroft et al. 2004). Artificial burrows are used in almost all the successful social attraction sites documented in the literature. Not only does this increase the likelihood of earlier success at the social attraction site and increase the density of nesting pairs in an area (Podolsky and Kress 1992), it also makes the monitoring of nests much easier and less likely to cause disturbance to burrows and birds. Since monitoring of nests and nesting success is an important part of mitigation for the KSHCP, artificial burrows are key in this project. Since the vegetation understory at the site is already damaged and disturbed in the areas where burrows will be installed, the installation of artificial burrows will not affect a pristine habitat, based on observations by botanists at the site, who noted high levels of invasive species in the understory and little ground cover. It should be noted that other areas at the site provide excellent habitat for natural burrows). Artificial burrows will be located in two main areas (Figure 11.2).

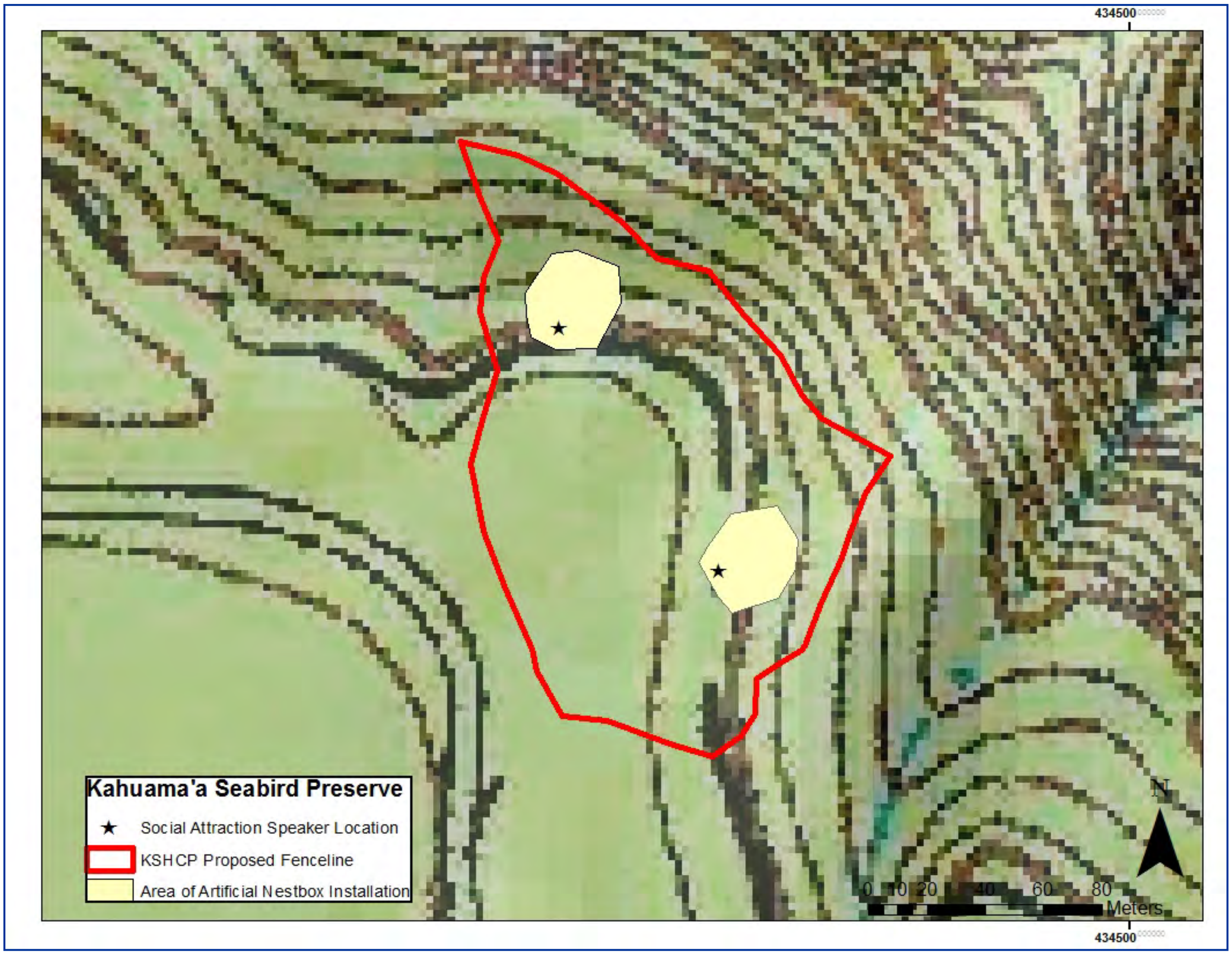


Figure 11.2. Map of Speaker System and Artificial Burrow Locations

11.3.1 Social Attraction – Call Broadcast Methods

The social attraction element of the Kahuama'a Seabird Preserve will be implemented as follows:

- Two speaker systems will be installed and maintained (the location is shown in Figure 11.2), consisting of 2 or 4 (as required) weatherproof, omni-directional outdoor speakers, mounted on the fence and / or poles inside the fence line and powered by 12v sealed solar powered batteries (see an example from New Zealand, Figure 11.3).

- Digital recordings will be obtained of ʻaʻo colonies taken within 2km of the site. Recordings will be of multiple birds (simulating a large colony) and using a complete set of typical colony sounds to attract the most birds (Podolsky et al. 1998).
- The speakers will turn on at sunset and continue to play species-specific calls until sunrise, drawing prospecting birds to the site to establish nesting within the predator-free area. Broadcasting will be timed to begin with the first arrival and courtship dates (01 Apr) until the 15th Sep (by which time the majority of non-breeders have left the colonies (A. Raine, 2017, pers. comm.).
- Because the Covered Seabirds are nocturnal, decoys are not anticipated to be needed (Jones and Kress 2012); However, if additional conservation actions are needed to enhance productivity at the site (e.g. if there is no ground activity by year 3), custom fabricated decoys will be placed on the ground as was done at the Makamakaʻole Seabird Preserve social attraction site on West Maui (Wind 2014, USFWS 2016).

Figure 11.3. Social attraction speaker system and nest boxes at Hutton's shearwater colony, Kaikoura, New Zealand. A. Raine

11.3.2 Social Attraction – Artificial Burrow Installation Methods

- The area for artificial burrows inside the Kahuamaʻa Seabird Preserve will be thoroughly searched for natural burrows (active or inactive) to prevent damage or destruction during artificial burrow installation (no surveys for burrows have been carried out to date).
- IE staff will be trained on burrow installation and operation.
- 100 artificial nest boxes will be purchased and installed. A proposed design is shown in Figure 11.4 but other alternatives will also be reviewed before purchase. Artificial burrows will likely consist of a box with a locking lid for convenient inspection and segments of drain pipe as the entry point.
- Two optimal locations (Figure 11.2) have been selected within the site based:
    - Slope - Shearwaters use wind and updrafts in addition to vigorous flapping to provide lift during takeoff (Elkins 1983, Yoda et al. 2017). A moderate to steeply

sloped site greater than or equal to 29° facing into the prevailing winds (A. Raine, 2016, pers. comm.) is preferred to facilitate flight and landing. A sloping site far enough away from the lower fenceline (>50m) also helps prevent the risk of collisions with the fence during landing and take-off.
    - Low vegetation, such as grasses, which will facilitate installation of next boxes.
- Invasive vegetation will be removed (see Section 11.3 Vegetation Restoration and Monitoring).
- Each artificially installed burrow will be assigned a nest ID, be clearly marked, labeled and mapped using GPS.
- Wherever possible, artificial burrows should be shaded by vegetation (Carlile et al. 2012).

Figure 11.4. Possible design (by David Wingate) of artificial seabird burrow to be used

Figure 11.5. V**egetation and slope in the "bowl" section of the site, where part of the artificial burrows will be installed.**

11.3.3 Social Attraction Site – Confirm Installation Complete

The target for the installation of social attraction equipment (playback speakers and nest boxes) is end of Year One to fulfil KSHCP requirements. Prime Contractor staff will confirm that this target has been met with a final inspection and a report including photographs (presented in the annual report).
If it becomes clear during the course of construction that this target will be missed, Prime Contractor staff will consult regulatory agencies and initiate adaptive management outlined in the KSHCP if required.

11.3.4 Social Attraction Site – Maintenance

Before the beginning of each breeding season, the social attraction site will be maintained as follows:

- Visually inspection of each burrow in Jan or Feb. Repair damaged burrows (old nesting material should be left in situ as a scent marker), ensure access.
- Test loudspeakers. After Year 4, test song meter / loud speaker alternation system.

11.4 Vegetation Management

OBJECTIVE 2G: Maintain high quality seabird habitat at the mitigation site by removal of habitat modifying invasive plants in Year 1 and annually throughout the 30-year duration of the KSHCP.

11.4.1 Background

The Kahuamaʻa Seabird Preserve predator proof fence is expected to benefit native vegetation and rare plants as they are currently being adversely affected by rats, pigs, goats and deer. The habitat at the site is dominated by native vegetation, but certain invasive plants are proliferating, especially within the understory. There is very little forest regeneration due to ungulate trampling and grazing, which is also encouraging swathes of thick, non-native invasive plants and grasses. Rat damage, consisting of chewing of stems, leaves, and fruit/seed predation has been observed at the site. Exclusion of these feral animals will have an immediate beneficial effect, especially when combined with the removal non-native invasive plants, some of which out-compete native plants in the understory and modify microhabitat suitable for seabirds.

Seabird habitat suitability mapping exercises consistently identify native vegetation as a critical component for successful nesting (Troy et al. 2014). Conversely, habitat modification by invasive plant species has been correlated with a reduction in seabird breeding. When compared to active breeding colonies, inactive breeding colonies were found to contain a higher proportion of non-native, invasive vegetation cover (Holmes and Troy 2008, Holmes et al. 2009). A suite of invasive plant species that have been identified as significant seabird habitat modifiers (Table11.1) are present at the Kahuamaʻa Seabird Preserve.

Table 11.1. Seabird Habitat Modifiers

Common Name	Scientific Name	Priority
Strawberry guava	*Psidium cattleianum*	*1*
Himalayan (kahili) ginger	*Hedychium gardnerianum*	*1*
Australian tree fern	*Sphaeropteris cooperi*	*1*
Blackberry	*Rubus argutus*	*2*
Banana poka	*Passiflora tarminiana*	*2*
Bush beard grass	*Schizachyrium condensatum, Andropogon spp.*	*2*
Koster's curse	*Clidemia hirta*	*2*
Daisy fleabane	*Erigeron karvinskianus*	*3*
Air plant	*Kalanchoe pinnata*	*3*

This list will be expanded during the project if new and important invasive seabird habitat modifiers are discovered in the area.

Vegetation work on site will focus on three key areas:

- Eradication or effective suppression of seabird habitat modifiers, focusing particularly on priority 1 & 2 species.
- Vegetation management during construction and operation of the fence (along fenceline and around artificial burrows and speaker system)
- Monitoring of vegetation to ensure that habitat quality targets are being met across the site.

It is important to note that the primary purpose of the Kahuamaʻa Seabird Preserve is to fulfil the obligations of the KSHCP by providing mitigation for take of the Covered Seabirds. The key requirement towards this process is the removal of seabird habitat modifiers and monitoring to ensure that the habitat remains suitable for seabird breeding.

To ensure that listed plants are not harmed during management on site, detailed BMPs have been prepared (see section 17).

Outplanting of rare species within the preserve is not in the remit of this management plan. Nonetheless, the Preserve presents an opportunity for other entities to outplant rare species on the flatter areas that will be protected within the predator proof fence and the regulatory authorities (USFWS and DLNR) have expressed strong support for this. In addition, this will be the first predator proof fence constructed on Kauaʻi in an area that is primarily native habitat. This provides an opportunity to study forest and ecosystem response to removal of rats and ungulates, and to the influx of seabird derived marine nutrients. The Prime Contractor will seek partnerships with universities and other interested research organizations who may desire to capitalize such opportunities.

11.4.2 Eradication / suppression of seabird habitat modifiers

Vegetation work at the Kahuamaʻa Seabird Preserve will focus primarily on removing invasive plants that negatively affect the ability of seabirds to nest (see Table 11.1 - Seabird Habitat Modifiers). Non-native vegetation can impede breeding activities such as take-off and landing, prospecting, courtship and burrow excavation. For example, fast growing strawberry guava (*Psidium cattleianum*) thickets reduce the burrowing habitat available (Penniman 2010, VanZandt et al. 2014) and their fruit have a synergistic interaction with non-native mammals (Nogueira-Filho et al. 2009). Plants such as Himalayan (kahili) ginger (*Hedychium gardnerianum)* and blackberry (*Rubus argutus*) can also form a dense thicket of roots and stands that prevents burrow excavation; Australian tree fern (*Sphaeropteris cooperi*) outcompetes native plants that shade burrows and provide shelter from predators, and can rapidly take over entire hillsides; and banana poka (*Passiflora tarminiana*), bush beard grass (*Schizachyrium condensatum, Andropogon spp.*[3]), Koster's curse (*Clidemia hirta*), daisy fleabane (*Erigeron karvinskianus*) and air plant (*Kalanchoe pinnata*) form mats that might impede take-off and landing or have spikes which deter birds from the area.

Conversely, native vegetation is likely to offer suitable appropriate vegetative structure to facilitate breeding (Asner G.P et al. 2008, Duffy 2010), while the structural root components of native trees provide burrow stability (Gilham 1961, Ainley et al. 1997, Underwood and Bunce 2004). Native trees also provide a launch pad for take-off (Ainley et al. 1997, Sullivan and Wilson 2001).

For the 30-year duration of the Program, Prime Contractor staff will remove habitat modifying plants (Table 11.1) from within the fence enclosure, with the goal of removal of habitat modifying invasive plants in Year 1 and annually throughout the 30-year duration of the KSHCP (ingress of these species will be ongoing due to the seedbank / seeds blowing in from outside the fence).

11.4.2.1 Methods

- The presence, location and abundance of the above seabird habitat modifiers will be mapped prior to removal using GPS and GIS. The priority one species (strawberry guava, Himalayan (kahili) ginger and Australian tree fern) are the most important to remove as they are likely to be the most damaging for seabirds.
- An initial removal effort will occur in a one-time targeted event during fence construction, carried out by a suitably qualified contractor. All three priority species will be targeted in this first pass, but subsequent maintenance will focus on priority 1 & 2 species first.

[3] There is some taxonomic confusion about these species in Hawai'i; they are frequently misidentified and can co-occur. Ecologically they are, however, similar with regard to their invasion biology. (A Williams, 2017, pers. comm.)

- For all plants, both for removal method as well as maintenance (except for blackberry), hand pulling for small/young individuals will often be the first method, with chemical used on larger plants that can't be hand pulled. As the project goes on, the use of chemicals will decline, with hand pulling increasing, as long as regular maintenance is occurring and new weeds are being found when still in seedling stage. Table 11.2 gives more detail on different methods for each modifier.
- During the initial removal of seabird habitat modifiers, groundcovers and low grasses will be left to reduce erosion.
- If appropriate, biodegradable erosion control cloths and / or weed control cloths will be laid down during the phase where large areas of non-natives are removed. The Kōkeʻe Resource Conservation Program has found this to be more cost effective than weeding afterwards (K. Cassel, 2017, pers. comm.)
- The entire site will be monitored annually for seabird habitat modifiers in Table 11.1. See Section 11.3.
- Additional removal and ongoing control of seabird habitat modifiers will then occur annually, outside the breeding season according to Table 11.2, with additional spot treatments carried out based on ad hoc sightings of concern. Technicians will also look for new species of concern. If found, a suitable eradication plan will be drawn up and carried out.

Table 11.2. Seabird Habitat Modifiers, Removal Methods, Maintenance and Harm Avoidance

Seabird habitat modifier	Scientific Name	Removal Method	Maintenance	Harm Minimization
Strawberry Guava	*Psidium cattleianum*	Trees "frilled" (notched girdling technique). Fill cuts with Garlon application using lab squirt applicator bottle / brush or use tool to pry strawberry guava < 2.5cm in diameter out of ground.	Drizzle spray Garlon on reemerging plants (TNC, 2015) (Trees currently not in large groves)	1) Careful application with squirt bottle or brush in dry weather only 2) no herbicide use with 10m of rare / listed plants or burrows 3) To be carried out by trained staff not volunteers 4) staff to be aware that *Myrsine knudsenii* might be mistaken for Strawberry Guava 5) No trees above 4.6m will be cut during bat pupping season June 1 – Sept 15.
Himalayan (Kahili) Ginger	*Hedychium gardnerianum*	Manually cut and spot-treat with Escort using a cut stump technique with a lab squirt applicator bottle	Pull out small shoots. Cut larger shoots and treat with Escort using lab squirt bottle (ginger mainly at edges of site and not currently in large clumps)	1) Careful application with squirt bottle or brush in dry weather only 2) no herbicide use with 10m of rare / listed plants or burrows 4) 4) to be carried out by trained staff not volunteers
Australian Tree Fern	*Sphaeropteris cooperi*	Manually remove by chopping with a machete and crushing the apical meristem	Should not resprout but follow up removal will be required due to presence of spores and new individuals	
Banana Poka	*Passiflora tarminiana*	Manually remove by pulling up with roots	Entire vine will die from uprooting but seeds are long-lived so ongoing uprooting required.	

Blackberry	*Rubus argutus*	Manually cut and treated with Garlon cut stump treatment. Foliar applications Garlon or Imazpyr	Follow up will be required as blackberry will come back if not maintained. Manually cut and treat with cut stump treatment. Foliar applications Garlon or Imazpyr	1) Careful application with squirt bottle or brush in dry weather only 2) no herbicide use with 10m of rare / listed plants or burrows 4) when plant is killed, dead stalks will be left in situ to inhibit growth of other invasive species and reduce removal effort 5) erosion / weed control cloths may be required. 4) to be carried out by trained staff not volunteers
Bush Beard Grass	*Schizachyrium condensatum* , Andropogon spp.	Spray application of Roundup Pro	Spray application of Roundup Pro	1) Careful application in dry weather only 2) large areas could be removed a little at a time and / or erosion / weed control cloths may be required 4) no herbicide use with 10m of rare / listed plants or burrows 5) to be carried out by trained staff and not volunteers
Koster's Curse	*Clidemia hirta*	Manually cut and treat with Garlon cut stump treatment. Attempt not to spread seeds during cutting	Manually cut and treated with Garlon cut stump treatment. 100% of seedling need to be killed to eradicate population so maintenance will be indefinite (DeWalt 2006)	1) Careful application with squirt bottle or brush in dry weather only 2) every effort to control spread of seeds such as seed collection during cutting, black bagging immediately rather than carrying in open off site 3) erosion / weed control cloths may be required 4) no herbicide use with 10m of rare / listed plants or burrows. 5) to be carried out by trained staff and not volunteers
Daisy Fleabane	*Erigeron karvinskianus*	Manual Removal. Foliar applications Garlon	Manual Removal. Foliar applications Garlon	1) Careful application with squirt bottle or brush in dry weather only 2) every effort to control spread of seeds such as seed collection during cutting, black bagging immediately rather than carrying in open off site 3) erosion / weed control cloths may be required 4) no herbicide use with 10m of rare / listed plants or burrows. 5) to be carried out by trained staff and not volunteers
Air Plant	*Kalanchoe Pinnata*	Foliar application of Roundup. Manual removal and bagging	Foliar application of Roundup. Manual removal and bagging	1) every effort to control spread of seeds such as seed collection during cutting, black bagging immediately rather than carrying in open off site Leaves will need to be bagged too, each leaf can produce several individuals 2) erosion / weed control cloths may be required

11.4.3 Vegetation Management during Construction and Operation of the Fence

There are three main actions in this project that will require the removal and / or ongoing control of vegetation:

- Fence construction
- Maintenance of a 4m zone outside the fence that is free of woody vegetation (this is within, but not the same as, the predator defense zone).
- Installation of artificial burrows and speaker system

11.4.3.1 Methods

- Following fence construction, restoration within the fence terrestrial predator defense zone will be carried out by means of replanting appropriate native grass and / or Aalii (*Dodonea viscoa*) to prevent the regrowth of seabird habitat modifiers. Alternatively, DOFAW has been looking into a 'low growing and low maintenance slurry' (W. Kishida, 2017, pers. comm.) made up of native ferns and grasses for use along road ways where a high incidence of nēnē 'take' happens. The slurry is still in development, but might be an option along the fence by construction. All planting will be vulnerable to grazing and trampling by pigs, goats or deer (A Williams, 2017, pers. comm.) but these options offer the best possibility of establishing some cover.
- No woody vegetation higher than 0.5m will be allowed to grow within the 4m zone along the fence line, to prevent reinvasion by predators. The height of vegetation will be kept low by means of trimming, scything, mowing or any other appropriate methods. Loose logs and vegetation will be moved off the mesh skirt area to prevent rodents using logs etc. as a solid edge to dig against (Day and MacGibbon 2007).
- Control of seabird habitat modifiers will be important in the cleared area outside the fence to ensure that this area does not become an ingress point for invasive plants. This will be carried out using the methods outlined in Table 11.2. Staff will conduct a monthly walk through of the zone (in conjunction with efforts to keep vegetation below 0.5m above) and conduct simplified veg plots (5 plots of 3x3m where the % of seabird habitat modifiers only is assessed) to confirm that the percentage of modifiers is not increasing.
- In the case of the artificial burrows, after installation it is expected that native vegetation will regenerate naturally. If this does not occur, or if seabird habitat modifiers invade the area, weeding (see Table 11.2) and / or outplanting will be considered. Vegetation will be managed to shade burrows to prevent heat stress to the seabirds. This may include some planting.

11.4.4 Targets for Removal of Habitat Modifiers

Objective 2G (Maintain high quality seabird habitat at the mitigation site by removal of habitat modifying invasive plants in Year 1 and annually throughout the 30-year duration of the KSHCP.) requires targets in order to measure success. These are shown in Tables 11.3 and 11.4.

Table 11.3: Targets for Removal of Seabird Habitat Modifiers

Action	Target Year 1	Target Year 5	Target Year 10	Target Year 15	Target Year 20	Target Year 30
% of Tier 1 & 2 seabird habitat modifiers removed across site (vs baseline)	≤50% cover	≤20% removed	≤5% cover of these species	≤5% cover of these species	≤5% cover of these species	≤5% cover of these species
% of Tier 1 & 2 invasive plants per veg plot	Target to be set once baseline established	Target to be set once baseline established	Target to be set once baseline established	Target to be set once baseline established	Target to be set once baseline established	Target to be set once baseline established

Note – Tier 3 Habitat Modifiers will be removed time permitting or if they are found to be affecting the burrowing ability of seabirds.

11.3.1 Consideration of PEPP and Endangered Plants

There are several PEPP and Endangered Plants at the site as shown in Table 7.1. However, extensive discussion and site visits with USFWS and DOFAW botanists has confirmed that the only plant that might be considered at risk from construction and operation is *E. remyi* var. *remyi*. Section 17, Best Management Practices, describes how damage will be completely avoided for this plant in particular as well as other PEPP and Endangered Plant species.

11. MONITOR EFFECTIVENESS OF KAHUAMAʻA SEABIRD PRESERVE & FERAL CAT / BARN OWL CONTROL AS MITIGATION FOR TAKE OF ʻAʻO

Effectiveness monitoring at the Kahuamaʻa Seabird Preserve will be carried out by the Prime contractor. Monitoring is intended to ensure that the objectives of the Kahuamaʻa Seabird Preserve and thus the KSHCP are met. Effectiveness monitoring will cover three main areas:

- Monitoring that predators have been removed and do not reinvade the site
- Monitoring barn owl Control
- Monitoring that Seabird Habitat Modifiers have been removed / suppressed
- Monitoring the Response of Covered Seabirds to management actions (Predator Removal, Vegetation Management and Social Attraction Components).

Monitoring to ensure that objectives 2, C, D, E and F have been met are further defined in Table 12.1.

Table 12.1: Definitions of KSHCP Objectives.

	Objective	Definition
2C	2.C. Ground activity by Covered Seabirds documented at the mitigation site by Year 4 of KSHCP program implementation.	Ground activity is defined as presence of one or more ʻaʻo individuals on the ground within the project enclosure as documented by an observer or a Reconyx camera trap. "Presence" includes guano, feathers, ground calling bird heard by observer / captured on camera and confirmed as being within the fence, as well as physical sightings.
2D	2.D. Breeding activity by Covered Seabirds documented at the mitigation site by Years 5-7 of KSHCP program implementation.	• Egg, chick, or incubating adult noted within the site • Breeding attempts in natural or artificial burrows are observed (such as copulation, digging a burrow, entering the burrow with nesting material, sitting in the burrow). • Signs of digging/trampling, feathers, guano, or an egg shell • Evidence of predation or nest failure
2E	2.E. Cumulative upward trend in Covered Seabird breeding documented at the mitigation site by Year 10-12 of KSHCP program implementation.	Increased number of active burrows (artificial or natural) compared to years 5-7
2F	2.F. Continued cumulative upward trend in Covered Seabird breeding documented at the mitigation site by Year 20 of KSHCP program implementation.	Increased number of active burrows (artificial or natural) compared to years 10-12

12.1 Monitoring of Predator Removal

12.1.1 Monitoring of Rodent Removal

Rodent removal will be monitored as follows:

- **Camera Traps**: predators will be monitored using 10 remote camera traps (Reconyx or similar) placed strategically at known ingress routes, along trails, along interior fencelines and at other appropriate locations. Camera will be checked monthly during initial eradication (more frequent checks make camera failure more likely). After rat eradication is completed in year one, cameras will be moved to focus on seabird ground and burrow activity, but will still be able to pick up any predator activity. They will be checked monthly at this point.

- **Ink-card tracking tunnels:** 25 tracking tunnels will be set out on a 50m transect (Gillies 2013). They will be placed on flat ground with the ends unobstructed, baited with a peanut butter lure (see snap traps) and monitored for three nights. This will be repeated bi-monthly until technicians feel confident that rodent eradication has been achieved (no rodent sign for one month). Thereafter, they will be deployed once a month for one night during breeding season (Apr to Dec). If reinvasion is suspected, the tunnels can be redeployed at any time.
- If, after the initial rodent eradication, **rat signs are noted again** on the ink card tracking tunnels, snap traps and stationary bait boxes (if necessary) will re-deployed, until all signs of rodents inside the fence cease. If rodenticide is considered necessary, it will be used for the minimum time possible.
- **Formal routine fence checks** will be carried out to discover potential biosecurity breaches monthly but technicians will also check fence while rebaiting traps outside the fence and in the course of other duties. In the case of a reinvasion, a more thorough fence check will be carried out to determine the ingress point of the predators and necessary maintenance action taken to prevent further breaches. Detailed records will be kept of breaches and reinvasion records. Technicians will also look for collision events (feathers, carcass).
- Goodnature traps have a counter (purchased as an add-on) which indicates the number of 'firings'. They will be checked weekly during initial eradication to ensure they are working and monthly thereafter with results noted on iPad. However, it should be noted that traps can fire on their own (e.g. through tree fall, wind etc.) so do not necessarily indicate the presence of predators. Where firings are noted, additional ink card tracking tunnels will be deployed and rat eradication action taken inside the fence. Similar brands can be used.
- Snap traps in a bird excluding housing will be checked daily during initial eradication to ensure they are working and remove any carcasses with results noted on iPad. They will remain in situ even when zero signs of rodents has been recorded for four weeks in case of reinvasion.
- Technicians will record and remove any carcasses from Goodnature (or similar) and snap traps daily during the initial eradication and weekly thereafter with results noted on iPad.
- Technicians will record number and species of predators present, location of predators and possible ingress pathways utilized, number of predators killed and caught by a monitored trap, fence integrity. Results noted on iPad.
- Monitoring frequency is summarized in Table 12.2.

Table 12.2: Summary of Predator Monitoring Frequency

Biological Objectives	Monitoring Frequency During Normal Operation
2.B. Remove predators from within the fenced enclosure with monitoring confirmation of their absence, and activation of the social attraction equipment by Year 2; predator eradication within fenced enclosure maintained for the life of the project.	- Camera traps checked monthly. - Monthly Goodnature check - Monthly ink-card tracking - Twice weekly snap trap checks 50m predator defense zone

12.1.2 Cat Removal Monitoring at Fenceline

Camera Traps

- Monitoring of cats will be ongoing using 4 camera traps along the fenceline, located on the outside of the fenceline, (in addition to the 20 burrow monitoring cameras around the project site. They can be moved as appropriate depending on trapping results, visual sightings and predation events. They will be checked monthly.

12.1.3 Barn Owl Control Monitoring

The objective of barn owl Control is to protect birds nesting inside the fence as well as in nearby source colonies. Complete eradication is not possible due to the propensity of new owls to fill an empty territory, however suppression of the population will have a beneficial effect. This objective will be monitored as follows:

- The technician will provide an annual report detailing how many barn owls were seen versus how many were shot during barn owl control operations (detailed in section 11.2). In addition, the technician will keep note of all ad hoc sightings of barn owls and barn owl calls during the course of other duties.
- Predation events (presence of carcasses, camera sightings or visual sightings) by barn owls inside or adjacent to the fence will be documented (barn owls may carry carcasses outside the fence). If a predation occurs, additional barn owl control will be undertaken (more shooting and trapping nights) and new techniques will be investigated

12.1.3 Feral Cat Control Monitoring

The objective of feral cat control is to protect birds nesting at nearby source colonies in the Kalalau Valley and to present the risk of reinvasion of cats into the predator proof fence. Complete eradication is not possible due to the propensity of new cats to enter the territory, however suppression of the population will have a beneficial effect. This objective will be monitored as follows:

- The technician will provide an annual report detailing how many feral cats were removed during control operations and where this occurred. In addition, the technician will keep note of all ad hoc sightings of cats (visually or on camera) during the course of other duties and will use both sets of information future feral cat removal work.
- Predation events by feral cats in the vicinity of the fence will be documented by project staff. In addition, managers of source colonies of the Kalalau Valley / Pihea / Honopū / Hono O Nā Pali) will be asked to supply data on predations in their area. If a predation occurs, additional feral cat control will be undertaken (more shooting and trapping nights) and new techniques will be investigated.
- Technicians will keep up to date on latest feral cat removal technology and employ new techniques as appropriate to increase efficiency.

12.1.4 Seabird Carcass Discovery

- Once seabird breeding is established, any bird carcasses found will be assessed for cause of death. Depending on the predator, the following action will be taken:
    - All: Camera traps will be checked to look for predators
    - Rodent: interior snap traps redeployed. Interior bait stations will be rebaited with diphacinone until all signs of predators (further deaths, ink-card tracking tunnels, camera sightings) end.
    - Feral cat: 8 live feral cat traps will be opened inside the fence. Firearm-certified technician will attempt to humanely remove feral cat with firearm. Fence will be checked for breaches.
    - Barn owl: additional shooting nights will be arranged as soon as practically possible after the discovery. New techniques will be investigated for barn owl removal.
    - Pig: firearm-certified technician will remove the pig

12.2 Monitoring of Vegetation Management

To ensure that the quality of native habitat remains optimal for seabirds (i.e. that basic structure of native vegetation is stable or improving and that the ingress of seabird habitat modifiers is not occurring), a vegetation monitoring project will be initiated.

12.2.1 Methods

- Prime Contractor staff will be trained in plant identification.
- A baseline plant inventory will be carried out by a suitably qualified consultant (with the assistance of Prime Contractor staff for training purposes) within the fence line and 50m zone outside the fence to determine a plant inventory as a baseline (including status and abundance of each species) and species composition. The survey will also map the

location of listed or rare plants to ensure their protection. This will take place before construction commences and will also cover the fenceline itself.

- Federally listed, endangered and threatened plants will be noted, flagged and mapped. This will be carried out by an appropriate consultant.
- To monitor vegetation composition and change over time, a plant survey will be conducted every five years to document improvements in desired habitat conditions to maximize seabird production. This will be achieved by "broad brush" monitoring of five randomly selected vegetation plots (50m x 50m) inside the fenced enclosure (if a plot is selected in an area with a PEP or listed plant, or an area which is unsuitable for surveying due to steepness or safety concerns, another plot will be generated). Compass bearings will be used to ensure that the lines are straight.
- The following data will be collected: Coordinates, dominant aspect, estimated slope, habitat classification (VI: Highest Quality Native Ecosystems; V2: Predominantly Native; V3: Considerably Disturbed; V4: Badly Degraded), Average Canopy Height Class. For the canopy and Understory, % Cover, % Native Species Cover, Max Height of Cover will be recorded. Bare ground will be recorded by %.
- Within each 50m plot, two smaller random $2m^2$ plots will be used to measure other vegetation (using a square of PVC pipes to form the size of the plot) in which the following will be monitored:
  - native woody vegetation cover, tree density, and species richness
  - seedling number, %, age class, stem diameter and cover
  - presence, %, cover and composition of seabird habitat modifiers
  - presence, % cover and composition of any other non-native species
- DOFAW and PEPP already monitor listed and rare species on the site. This will remain in their remit. (It should be noted that some of the rare and listed plants on site are already in decline due to factors outside the control of the project such as insects, wood boring beetles, etc.)
- Targets in Table 12.3 will be set at the beginning of the project, once a baseline has been established.

Table 12.3: Targets for Vegetation Monitoring

Action	Target Year 1	Target Year 5	Target Year 10	Target Year 15	Target Year 20	Target Year 30
% and composition of native plants per veg plot	Target to be set once baseline established	Target to be set once baseline established	Target to be set once baseline established	Target to be set once baseline established	Target to be set once baseline established	Target to be set once baseline established
% and composition of seabird habitat modifiers per veg plot	Target to be set once baseline established	Target to be set once baseline established	Target to be set once baseline established	Target to be set once baseline established	Target to be set once baseline established	Target to be set once baseline established
Listed plants - damage from project	0	0	0	0	0	0

12.3 Monitoring of Seabird Response to Management

Monitoring seabird response is a critical part of the social attraction site, not only to ensure that biological goals are met in terms of attracting the Covered Seabirds to breed and providing the right conditions to ensure breeding success, but also to fulfill the requirements of the KSHCP to provide mitigation for the take of these seabirds by KSHCP participants who are financing the project.

Effectiveness Monitoring will be carried out through the following means (listed in order of importance):

- Burrow Monitoring
- Camera monitoring
- Chick banding
- Auditory surveys with night vision
- Acoustic bird call monitoring (song meters)

The KSHCP supports the use of the best available, most cost-effective scientific tools and techniques for monitoring. Methods used may change based on new technological developments, site conditions and effectiveness in the field. For example, automated bird detection and monitoring technologies may be used to increase monitoring efficiency and accuracy. Any proposed changes will be discussed with the regulatory agencies in advance and with the KSHCP participants (and other stakeholders, if appropriate).

12.3.1 Burrow searching and monitoring

Burrow searching and monitoring of natural and artificial burrows is a critical part of seabird response monitoring. Technicians will search for burrows using established techniques outlined below. Once burrows are found, burrow checks will be undertaken to assess the status of any breeding attempts (e.g. is there an egg, chick or adult present). This data will be compared to data from the cameras to collect information which can be used to extrapolate results to unmonitored burrows on site.

Burrow monitoring fulfills, in part, Objective 2D – Breeding activity by Covered Seabirds documented at the mitigation site by Years 5-7 of KSHCP program implementation and Objective 2E &F – Cumulative upward trend in Covered Seabird breeding documented at the mitigation site by year 10-12 and 20.

12.3.1.1 Methods for locating and monitoring natural burrows

- Auditory surveys with night vision will occur twice a night for 4 nights per month (Jun – Aug) split over two observers (i.e. 2 nights a month each) to help guide burrow searching by indicating ground-calling hotspots.
- This will be supplemented with diurnal “cold searching” where staff actively search vegetation for burrow cavities with signs of seabirds (e.g., scent, feathers, guano, etc.). Burrow searching will happen a minimum of once a month for one day from Jun-Sep. (before incubation, burrow searching is too difficult due to a lack of clear signs of use, and requires unnecessary disturbance to vegetation). More searching could result in damage to vegetation.
- Active breeding can be distinguished from ground activity (Objective 2.C) if breeding attempts in natural or artificial burrows are observed (such as copulation, digging a burrow, entering the burrow with nesting material, sitting in the burrow), or an egg is laid.
- Natural burrows will have “stick fences” placed at their entrances after each inspection (these are toothpicks or short sticks placed in a ‘fence’ configuration i.e. in a row). Any activity by birds will knock down the sticks, alerting technicians to the possibility that the burrow is in use and triggering further monitoring through Reconyx camera traps and / or inserting push button cameras (such as Olympus Stylus Tough TG4) into burrow to capture image of end of burrow and / or use of endoscope.
- During burrow searching, any predator presence will also be assessed (such as scat, owl pellets or carcasses).
- Any burrows found will be marked with an identification tag and burrow locations will be recorded with a handheld global position system (GPS).
- Once burrow sites are located, they will be monitored, along with artificial burrows, once a month to determine occupancy, status changes over the course of the breeding season (abandonment, death of chick etc..), signs of predation and timing of breeding attempt.

12.3.1.2 Methods for monitoring artificial burrows.

- Each artificial burrow will be checked to make sure it is in working order and repaired if necessary before the breeding season commences and the entrance and tunnel will be cleared of obstructing vegetation.
- Each artificial burrow will be checked a minimum of once a month during the breeding season between April and October to monitor for signs of seabird activity around the entrance and inside the burrow chamber. Temperature and humidity will be monitored.
- Variables measured include number of active burrows, species present, signs of predator presence, evidence of predation, and nest success.
- A subset of 20 artificial burrows will be equipped with Reconyx camera traps to document visits by prospectors and / or breeders.
- Burrows occupied by breeding pairs will be monitored by Reconyx camera traps and checked monthly by Prime Contractor staff through the breeding season to estimate breeding success (egg laying, chick rearing and fledging) and any predator incursions.

12.3.1.3 Methods applicable to both artificial and natural burrows

- Document internal burrow contents with visual observations or a handheld digital camera,
- Burrows will be identified to species (if possible) and classified as follows:
    - Inactive
    - Prospecting birds (birds observed to be visiting a nest with no further evidence of breeding. Examples include fresh excavations in a previously inactive burrow, a single visit to a previously inactive burrow, bird(s) found in a burrow where both adults were confirmed killed in the previous year, or a seabird present at a preliminary burrow excavation
- Burrows are assessed for breeding activity by monitoring for signs of activity in and around the burrow, including:
    - Presence of an egg, chick, or adult in or near the burrow
    - Signs of digging/trampling, feathers, guano, or an egg shell
    - Evidence of predation or nest failure
    - Scent
    - Ability to see back of burrow
- Nesting outcomes for active nests are recorded as “success”, “failure”, or “outcome unknown” as follows:

    - Success is indicated by a successfully fledged chick. In the absence of a Reconyx burrow-monitoring camera, this is determined by a chick confirmed in the burrow until the typical fledging time (late September to early December, peaking in October), down outside the burrow entrance

indicating that the chick was exercising, and no signs of predation or predator presence.
- An active nest is recorded as a failure if it did not fledge a chick. Evidence of failure is recorded when observed.
- "Outcome unknown" is assigned to an active nest where breeding was confirmed but no follow-up visits were made, final visit was too early in the season, or signs were inconclusive. Very few, if any, burrows should fall into this category.

- All data collected in the field is digitized at the end of each trip with individual burrow locations, evidence of predation, and/or predator presence mapped using a GIS.

(Methods developed by KESRP)

12.3.2 Camera Monitoring

A camera trap is a remotely activated camera that is equipped with an infrared sensor. Camera trapping allows researchers to photograph birds or predators at a burrow and has been used in ecological research for decades.

At the site, camera traps will allow for ground activity to be observed on a continuous basis. Cameras will be initially placed near the speaker system where birds are most likely to land when responding to social attraction playback. They will also be used on burrows to record ingress of prospectors, breeding attempts and success of the egg, chick and fledging stage and predator interactions.

The cameras will provide data pertinent to Objective 2C – Ground activity by Covered Seabirds documented at the mitigation site by Year 4 of KSHCP implementation and Objective 2D – Breeding activity by Covered Seabirds documented at the mitigation site by Years 5-7 of KSHCP implementation, and will be ongoing throughout the lifetime of the project as the data will also be used to measure Objective 2E & F – Cumulative Upward Trend in Covered Seabird breeding documented at the mitigation site by Year 10 & 20.

The proposed models are a Reconyx Hyperfire PC900 camera trap (Figure 12.1) and a Reconyx Ultrafire XR6 (capable of also taking high definition video but using more memory and therefore requiring more frequent checks). However, if improved technology or another brand is found to be more effective or cost efficient, they will be selected instead.

Figure 12.1. Reconyx Camera Trap

12.3.2.1 Methods for Camera Monitoring

- IE staff will monitor artificial and / or natural burrows of ‘a‘o (and ‘ua‘u if they also arrive at the site) at mitigation sites using Reconyx Hyperfire PC900 or similar cameras.
- After the first year (cameras will initially be used to monitor predators only), 20 of the 100 artificial burrows will be monitored by cameras. Burrows closer to the speaker system are likely to be occupied first and so cameras will be placed there initially; they will also be able to pick up ground activity in that area.
- Artificial burrows or natural burrows (these will be mapped as they are found, either through burrow searching or auditory surveys) will be surveyed monthly during the breeding season and toothpicks placed in the entrance. Any that show signs of use (toothpicks falling, scent, guano etc.) will have a camera placed on them (moved from an inactive site).
- Cameras may be strategically placed in other areas within the fence enclosure to document ground activity not associated with specific burrows.
- Camera Monitoring will occur throughout the pre-breeding season, starting when the sub-adult prospectors and adults arrive (01 Apr). (Note that while most birds return in early Apr, cameras should be operational from mid-Mar to ensure that early birds are not missed)
- Variables measured include number of visitations (ground activity), number of burrows with breeding activity, number of active burrows with a chick that fledges, predator visitation rates and predation events.
- Cameras will be mounted on stakes 1-3m from the burrow entrance to record species, seabird activity and nesting outcome. Cameras will be triggered by movement and are set on a rapid-fire setting.
- All secure digital (SD) memory cards will be changed monthly, batteries changed as needed and all camera locations will be recorded using a handheld GPS unit. SD cards are to be viewed in the field to briefly assess activity levels and presence/absence of seabird predators at burrows. They will be reviewed fully in the office.

- Cameras will be checked monthly.
- All data collected in the field (i.e. on the number of images on the camera, date of SD card and battery switch out etc.) is digitized at the time on the iPad. Data will be downloaded to the server in the office. Camera viewing will take place in the office at the end of each trip and will be digitized.

12.3.3 Bird Banding

Banding is an important part of the SAS project and an established best practice monitoring technique for seabird colonies, providing data on sub-adult and adult survival rates, nest site fidelity, age at first breeding, ratio of birds recruited via social attraction versus natal philopatry and breeding probability. Morphometric measurements allow for inter-annual comparisons and could be used to indicate the general health of seabirds breeding at the mitigation site from one year to the next. This data will also contribute to the body of knowledge on ʻaʻo (and ʻuaʻu if found at the site) throughout the Island and the State.

This social attraction site was chosen because of the lack of artificial light in vicinity. It is thought that birds from this colony will not be subject to light attraction when fledging due to the orientation of the site, the dark conditions on the obvious flyway out to the ocean and a lack of visible artificial lights from the site. However, banding birds on site means that any birds that are downed by artificial lights can be identified back to the project site and mitigation measures taken to reduce any light attraction.

12.3.3.1 Methods for Banding Chicks and Adults

- Biologists conducting banding of seabirds will be required to be covered under Bird Banding Lab banding permits and be authorized by the DLNR to band or otherwise handle seabirds on Kauaʻi.
- Chicks will not receive bands until approximately 4 to 2 weeks from fledging, which occurs late September to early December, peaking in October.
- Banding will take place during burrow checks and opportunistically, if birds are found on site.
- IE staff will carry banding kits at all times during colony site visits in the breeding season and will ensure all caught birds are banded (both adults and chicks).
- A list of bird banding equipment needed to safely band and measure ʻaʻo and ʻuaʻu includes:
    - Appropriate shearwater-sized banding pliers;
    - Spreader pliers;
    - Pesola 1000 g scale;
    - 15 clean bird weighing bags;
    - Wing chord ruler;
    - Banding leg gauge;

- USGS issued bird bands size #4 (50) for ʻaʻo and 3A (50) for ʻuaʻu;
- 15 clean bird handling towels;
- Pens and pencils
- Banding logbook or notebook and iPad with custom built banding app (KESRP).
- Umbrella or tarpaulin in case of rain during banding
- Antibacterial handwash

Variables measured include individual identification number (USGS band number), species, weight, tarsus length, culmen length, wing length.

12.3.4 Auditory and Visual Surveys

Auditory surveys are an important part of the strategy for biological monitoring. ʻAʻo are nocturnal and tend to vocalize within their colonies (and occasionally in transit); therefore, activity and location of these species may be effectively monitored at a distance of up to 1km using an auditory point count survey technique to establish and document ground activity and / or flyovers at the site. ʻAkēʻakē and ʻuaʻu are also nocturnal - they may be breeding or transiting within the 1km radius and therefore will be included in the monitoring although they are not expected to breed at the site.

These surveys will measure criteria for Objective 2C. Ground activity by Covered Seabirds documented at the mitigation site by Year 4 of KSHCP program implementation, Objective 2D – Breeding activity by Covered Seabirds documented at the mitigation site by Years 5-7 of KSHCP program implementation. After Year 7, however, Acoustic Song Meters will be a more efficient and accurate way to measure Objective 2 E & F – Cumulative upward trend in Covered Seabird breeding documented at the mitigation site by Year 10 & 20 of KSHCP implementation, so Auditory Surveys will be reviewed at year 7 and phased out if the success of the project merits it.

12.3.4.1 Methods for Auditory & Visual Surveys

- Auditory surveys will be carried out by trained observers using night vision goggles. The observer auditory range is an estimated radius of 1 km. There will be 4 permanent survey locations.
- A standardized survey protocol and data sheet or iPad page (Appendix 1) will be used to allow for inter-site and inter-annual comparison and to make data compatible with KESRP surveys.
- Auditory surveys will take place twice a night (PM and AM) for 4 nights a month (1 night at each location). 2 surveyors will cover 2 locations a night for 2 nights.
- Ideally, there will be two observers for the surveys so surveys will take place AM and PM for location 1 and 2 for two nights and then likewise for 3+4 for two nights.

- Surveys will take place during the peak of the breeding season (Jun- Aug; vocalizations dramatically reduce after mid Sep).
- Surveys during full moon (and one week before and after) will be avoided as birds vocalize less during full moon periods.
- Observers will survey during the peak evening and pre-dawn activity period to account for the key calling periods of the Covered Seabirds. Although ʻaʻo are the primary focus, ʻuaʻu and ʻakēʻakē will also be recorded.) ʻAʻo are more vocal in the morning; ʻuaʻu and ʻakēʻakē are mainly vocal in the evening, while.
    - Evening surveys start at sunset and last for 2 hours: 4 x 30 min sessions, with 25 minutes to record seabird calls, and any visual seabird observations (using either naked-eye, binocular or night vision goggles) and 5 minutes allotted for weather data collection
    - Morning surveys start 2 hours prior to sunrise and last 1.5 hours: 3 x 30 min sessions, otherwise methodologically the same.
- Variables measured include number of calls and sightings for each species, breeding activity seen (flight paths, circling, ground calling etc.) distance and direction of each observation from the survey point, weather conditions during survey and habitat characteristics of the survey site. Particular attention will be paid to ground activity, with individual ground calling locations noted on a map.
- Auditory surveys will be used in tandem with static song meters (after year 4) as a method of ground- truthing the song meter data with the intent of locating and mapping calling hotspots, ground activity, and flight corridors for ʻaʻo (and ʻuaʻu and ʻakēʻakē if heard) unless song meters are found to be incompatible with the social attraction element.
- Survey locations are recorded in UTMs.
- At the end of the season the data from the field maps is entered into GIS digitized mapping to create individual breeding activity polygons for ʻaʻo and ʻuaʻu.

A standardized field datasheet can be found in Appendix 1 – a digital version will incorporate the same information.

12.3.5 Acoustic Bird Call Monitoring (Song Meters)

An acoustic recording device is a sound recording unit that is weather-proof, self-contained and can be used to remotely collect data in the field (Figure 12.2). The proposed models are SM4 Song Meters, made by Wildlife Acoustics.

Acoustic bird call monitoring uses song meters to create a database of calls over time, without observer bias, that can be useful in developing breeding density estimates. This technique is a powerful monitoring tool and is widely used by managers at monitored seabird colonies on Kauaʻi. It will be used to provide a baseline of activity at the colony which can be accurately measured to show population changes over the thirty years of the project (Oppel 2014).

Calls/hr are relatable to the number of burrows in an area, so if call rates increase over time, one can confidently assume that seabird activity at the site is increasing.

Figure 12.2: SM4 Song Meter

Auditory and visual surveys by human observers as well as onsite burrow searching and monitoring will remain important complementary parts of the monitoring strategy to confirm birds on the ground and indications of breeding until year 7. However, not all burrows will be found by observers – song meter data gives a monitoring output for the site as a whole to offset this problem.

The song meters can record seabird vocalizations at a distance of well over 250m. Outputs from the analysis will include call rate per minute, total number of calls and activity by time.

Song meters will provide data pertinent to Objective 2C - Ground activity by Covered Seabirds documented at the mitigation site by Year 4 of KSHCP implementation and Objective 2D – Breeding activity by Covered Seabirds documented at the mitigation site by Years 5-7 of KSHCP program implementation. They will be critical in terms of measuring Objective 2E & F – Cumulative Upward Trend in Covered Seabird breeding documented at the mitigation site by Year 10 & 20.

Song Meter use will only commence in year 4 as they are incompatible with full time social attraction playback, which is most critical in the first few years of the SAS.

In 2016, as part of an assessment of a potential social attraction site on the edge of the Kalalau Valley, KESRP deployed a song meter at a central location within the site to assess whether there was any seabird activity within the site. Both ʻaʻo and ʻuaʻu were recorded at the Social Attraction Site (Raine et al 2016). ʻAʻo were recorded almost nightly (suggesting regular activity of this species in the area), while ʻuaʻu were recorded on 6 occasions. The results will be used as a baseline at the site.

For the ʻaʻo, call rates were low at the survey site compared to large monitored colonies of this species on Kauaʻi (such as Upper Limahuli Preserve). However, the fact that they were recorded almost nightly during the survey suggests the possibility that a very small number of pairs may be breeding within or near the site itself. Further surveys will be carried out in 2017 and 2018 to look for burrows. Furthermore, individual birds are flying around the area vocalizing on most nights, and could therefore be drawn in by social attraction. Based on years of surveys by KESRP, the wider area (Kalalau Valley and Nā Pali coast) has large breeding populations of both species which will act as source colonies (Raine et al. 2016).

The results of this survey will represent a useful baseline for the site. The same surveys will be repeated annually until the Seabird Preserve is constructed.

12.3.5.1 Methods for Song Meter Deployment

- A Song Meter IV sensor (http://www.wildlifeacoustics.com) or similar model will be deployed within the social attraction site in the same location used by KESRP in preceding years.
- Deployment will commence in Year 4.
- The song meter will be powered by 4 D-cell alkaline batteries and store recordings on a 32GB SD memory card. Sensors will record on two channels at a sampling rate of 22 kHz. The sensor will be mounted 0.3m off the ground on a length of PVC pipe with the omni-directional microphones oriented horizontally. The location will be selected such that the sensor microphones are sheltered from prevailing winds, well away from moving branches and leaves. Microphones will be weather-proofed with scotch guard and sheltered from above with a length of PVC pipe cut in half. Other compatible technology may be used to compare previously gathered data as appropriate
- 2016 & subsequent years prior to the fence construction will provide a baseline of seabird acoustic activity at or around the site and will be supported by observer data from the auditory and visual surveys to pinpoint the location of the calls.
- To allow for comparison with KESRP data, sensors will be programmed to record 1 minute every 5 minutes for 3 hours after sunset, and 1 minute every 10 minutes for three hours before sunrise. Programming will be undertaken using the SMCONFIG software package.
- Year 1-3: Song meter recording requires social attraction vocalization speakers to be turned off. Therefore, no song meter data will be collected in Years 1-3 of the Program, because the key objective during those years is to attract seabirds through social attraction to fulfil objective 2C in response to mitigation requirements for the KSHCP.
- Year 4 onwards: Song meter will be deployed annually for 2 months (June-July) to monitor long term changes of the seabird populations within or around the site.
- To record calling activity in the absence of social attraction playback, during the above recording schedule, loudspeakers will be temporarily disabled every third night to allow for song meter recording. Electronic timers will be used to achieve this and two nights of testing will be carried out to ensure this works, along with periodic checks by project staff.
- All song meter audio data will be sent off to an appropriate organization for automated analysis (currently Conservation Metrics Inc., Santa Cruz, California).
- Song meter will be checked (cards and battery changed) once a month.
- Seabird response monitoring frequency is shown in Table 12.5.

12.3.6 Summary of Seabird Response Monitoring

Table 12.5 outlines the monitoring frequency required to establish seabird response to management.

Table 12.5: Seabird Response – Monitoring Frequency

Biological Objectives	Monitoring Frequency
2.C. Ground activity by Covered Seabirds documented at the mitigation site by Year 4 of KSHCP program implementation. 2.D. Breeding activity by Covered Seabirds documented at the mitigation site by Years 5-7 of KSHCP program implementation. 2.E&F. Cumulative upward trend in Covered Seabird breeding documented at the mitigation site by Year 10 and 20 of KSHCP program implementation.	- Cameras installed by end Mar and checked monthly 01 Apr to 15 Dec - Auditory surveys with night vision: 2 surveys 4 nights monthly (Jun to Aug) (to year 7) - Burrow monitoring monthly 15 Apr -15 Dec - Chicks banded 2-4 weeks before fledging; adults banded whenever encountered. - Song meters from year 4 (May to Jul / Aug)

12.4 Annual Reports

An annual report will be delivered to the agencies by 15th April. It will include a detailed section on the project monitoring and results. This will enable USFWS and DLNR to evaluate:

1) compliance with terms and conditions of ITP/ITLs issued under the Program;
2) effectiveness of KSHCP conservation measures;
3) that continuing to authorize the permitted Covered Activities will not appreciably reduce the likelihood of survival or recovery of the Covered Species in the wild;
4) that the implementation of the Program results in a net benefit to the Covered Species as required under State of Hawaiʻi law.

Reports will specifically outline project progress and / or achievement of the Biological Objectives 2A-H.

12. TIMELINES FOR ALL ACTIONS AT KAHUAMAʻA SEABIRD PRESERVE

Table 13.1 below provides an outline of the pre-construction, construction and initial set up maintenance actions required in the management plan for year one of conservation work at the Kahuamaʻa Seabird Preserve. The estimated time noted in the table is based on extensive discussions with local experts about their fieldwork. For example, in the case of setting Goodnature traps (or similar), the time taken per trap is multiplied by the total number of traps plus some time allotted for walking between traps. (This table does not include standard fieldwork operations, which are shown in Table 13.2).

Table 13.1: Fieldwork Actions and Estimated Staff Resources Pre & During Construction

Obj	Actions (Pre & During Construction) (additional actions to standard fieldwork during operation)	Frequency in 3 month constructio n period
	Pre-Construction	
All	Staff training	1
2A	12 return trips to the site (overnight stays at DOFAW cabin or camping	12
2A	Site meeting contractor	4+
2A	Search entire fenceline & surroundings for seabird burrows	2
2A	Forest bird & pueo survey - baseline & pre-construction & office write up	2
2A	Assist with pre-construction baseline veg monitoring	1
2G	Flag rare plants	1
2A	Assist contractor in removing vegetation along fenceline. Botanist and archaeologist present	1
2A	1 staff present during equipment fly in and entire fence construction to oversee all BMPs	1
2A	Training from contractor on fence maintenance	1
2A	Risk analysis for fence post construction	1
2A	Order and put up public signage on what to do if public sees a breach	1
2A	Report to confirm fence complete / report to confirm SAS work complete	1
2A, C,D	Install speaker system, test	1
2C-F	Install artificial burrows	1
All	Project management - 17 hours per week	12
	Rodent Trapping Post Construction Actions	
2B	Rodent trapping - Set up **snap trap grid**; 50 inside fence and 40 in 50m zone outside fence.	1
2B	Rodent trapping - Check snap traps (75) removal of carcass, bait and reset - inside & outside fence. Every 2 days for 3 months	45
2B	Rodent trapping - Set up **bait stations grid** (50) - inside fence	1

2B	Rodent trapping - Check and rebait bait stations: 50 inside fence twice a week for one month. Frequency can reduce to weekly after one month if appropriate, then twice a month for three months, then once a month thereafter if stations are still required	12
2B	Rodent trapping - Set up **Goodnature grid** (25) - inside fence, and 20 outside the fence in 50m predator defense zone.	1
2B	Rodent trapping - Check **Goodnature grid** (25) - inside fence, and 16 outside the fence in 50m predator defense zone. Check and zero counter, check CO_2, rebait monthly	3
2B	Rodent trapping - Set up **camera traps** (20) inside fence and outside fenceline (4)	1
2B	Rodent trapping - Check **camera traps** (24) check - 2 x month	6
2B	Set up live **feral cat traps** (8 outside fence - only outside ones will remain after initial eradication). 2 conibears will also be placed inside the enclosure for the initial eradication.	1
2B	Set up and monitor **ink card tracking tunnel** (25) 2 x a month	6
2C-F	Move 20 camera traps from rodent detection to burrow detection	1
All	Project management - 20 hours per week	weekly

Table 13.2: Ongoing conservation actions during operation and effectiveness monitoring.

Bio Obj	Action	No. per month	Season
	Fieldwork		
2A	Fence checks (additional checks will happen as part of rodent control outside fence)	1	all
2A	Fence maintenance, crisis response	1	all
All	Return drive to site	4	all
2B	Rodent trapping - Goodnature Check: 25 inside fence, 16 outside fence in 50m zone, rebaiting, counter check, CO_2 check	1	all
2B	Ink card tracking tunnel (25)	1	all
2B	Rodent trapping - Snap trap check (25) removal of carcass, bait and reset - 50m zone outside fence	2	all
2H	Feral cat trapping – fenceline (8) - opening & closing traps	2	all
2H	Feral cat trapping – fenceline (8) - checking & rebaiting	8	all
2H	Feral cat trapping – fenceline - camera trap (4) check (change cards and batteries) - occur at same time as cat trap checks	1	all

2H	Barn owl reduction - trapping (6)	4	all
2H	Barn owl reduction - shooting	4	all
2H	Feral cat control Kalalau valley - opening & closing traps, 30 live feral traps, 24 conibears, 20 legholds	2	all
2H	Feral cat control Kalalau valley 30 live feral traps, 24 conibears, 20 legholds - checking once open & rebaiting	8	all
2H	Feral cat control Kalalau valley - camera trap (20) check (change cards and batteries)	1	all
2G	Vegetation monitoring (veg plots), seabird habitat modifier removal, outplanting of native species if required	1/year	outside seabird season
2G, 2B	Maintain low vegetation in predator defense zone	2	
2C-F	Seabird monitoring - auditory surveys with night vision 2 x a night (am and pm), 4 locations, 4 nights	4/month x twice a day	inside breeding season only, Jun-Aug
2C-F	Seabird monitoring - camera traps (20) cards and battery changed	1	inside breeding season only, 15 Mar – 15 Dec
2C-F	Seabird monitoring - song meter (1) cards and battery changed.	1	Jun 01 –Nov 30 only
2C-F	Seabird monitoring - burrow searching (incubation to fledging)	1	Jun - Nov
2C-F	Seabird monitoring - burrow monitoring (100 artificial, tba natural), annual cleaning	1	Mar - Dec
2C-F	Seabird monitoring - chick banding (during burrow monitoring, 2-4 weeks before fledging only; also adhoc banding of any adults encountered.)	1	Oct - Dec
2A,C, D	Check speaker system & song meter alternation system	1	Mar - Dec
	Office		
2B	Rodent trapping - Log results from Goodnature (transf. from iPad) / analysis	1	all
2B-F	Camera traps - watch cameras (20) and log data (30 mins per camera) / analysis	1	all
2B	Ink card tracking tunnel (25)	1	all
2H	Feral cat trapping - log results (tranf. from iPad) / analysis	1	all

2H	Feral cat trapping – Reconyx camera trap - watch cameras and log data (20 mins per camera) / analysis (included with rodent work)	2	all
2H	Barn owl reduction - trapping (6) - log results (transf. from iPad) / analysis	1	all
2H	Barn owl reduction - shooting - log results (transf. from iPad) / analysis	1	all
2G	Invasive plant monitoring and removal - log results / analysis	1	outside breeding season
2G	Vegetation monitoring - veg plots and transect - log results (transf. from iPad) and analysis	1	outside breeding season
2C-F	Seabird monitoring - auditory surveys. Log data (transf. from iPad) and analysis	1	during breeding season only
2C-F	Seabird monitoring - song meter (1) cards to CM, review results	1	Jun 01 –Nov 30 only
2C-F	Seabird Monitoring - burrow searching. Log results (tranf. from iPad) and analysis	1	Jun-Nov
2C-F	Seabird monitoring - burrow monitoring (100 artificial, tba natural). Log results (tranf. from iPad) and analysis	1	Mar - Dec
2C-F	Seabird monitoring - chick banding (during burrow monitoring, 2-4 weeks before fledging). Log results (tranf. From iPad) and analysis	1	Oct - Dec
	Project management, including annual reports, progress reports, stakeholder management, staff management, budgeting	4	
	Permit & certification renewals (e.g. pesticide, rodenticide, firearms)	1	
	RCUH training / first aid etc.	1	
	ESCR presentations – one per year		
	Other admin	1	

13. MAXIMIZE PROJECT EFFICIENCY

In order to ensure that the deliverables are met to provide mitigation for incidental take as outlined in the KSHCP, it is important that the Kahuamaʻa Seabird Preserve is run efficiently. Staffing is a key part of that. Final decisions on the staffing or contractual consultant required to complete all Management Plan tasks will be decided by the Prime Contractor, but a possible outline is provided below.

Staff will be recruited in the first quarter of the first year and will be appropriately trained and equipped. Both staff members will be trained as a conservation firearm specialist (training provided).

14.1 Staffing - Program Manager

The Program Manager is the lead staff member implementing the KSHCP on behalf of the Participants. This is likely to be a part-time position. The responsibilities for this position include implementing the Management Plan for the Kahuamaʻa Seabird Preserve but also encompass other KSHCP duties. The incumbent will have expertise in conservation biology as well as proven project management experience. Position will be both field and office based.

Duties will include overall project management, budget management, hiring Prime Contractor staff members, personnel supervision compiling data and writing annual reports on project progress, ensuring that mitigation goals are achieved, implementing adaptive management if required, coordinating with SOS (or other qualified veterinarian) as needed, presenting at ESRC and other professional conferences, serving as a liaison between the mitigation project, regulatory agencies and participants. Field duties include working with fence contractor, supervising technicians and overseeing / carrying out monitoring fieldwork and predator removal efforts.

14.2 Staffing - Technician

The Technician is a field position posted primarily at the Kahuamaʻa Seabird Preserve. The Technician will have experience in conservation, field work, monitoring and reporting. Primary duties will also include effectiveness monitoring for mitigation work, monitoring breeding of covered species on site, long term biosecurity at the mitigation site, feral cat and barn owl predator control and non-native plant removal.

14.3 Staff Training

Staff will receive training as follows:

- Wilderness First Aid
- Firearms
- Vegetation monitoring
- Seabird monitoring, management and predator control

14.4 Equipment and Office

IE will purchase and maintain appropriate equipment. For a full list of equipment, see budget Appendix H in the KSHCP.

IE will source appropriate office space. Options include moving into an agency office.

14.5 Stakeholder and Partner Management

IE will ensure cooperation amongst stakeholders by:

- Maintaining a website
- Setting up a Facebook page for the project which will be updated quarterly, and encouraging stakeholders to follow it.
- Answering stakeholder queries as they arise.

IE will manage any conflict between stakeholders, project and other users of the area and employ stakeholder conflict resolution techniques if required.

14.6 Fulfill Reporting Obligations

IE will initiate regular reporting schedule to participants and regulatory agencies, including financial reporting.

14.7 Fulfil Accounting Obligations

IE will keep a full accounting record of the project.

14.8 Review and Revise Management Plan Every 5 Years

IE will review and revise (as needed) the management plan every 5 years, in conjunction with the agencies.

14. BUDGET SUMMARY

The budget is a key section of the Management Plan, outlining project expenditure and income for every category and action. However, the budget for the Kahuamaʻa Seabird Preserve is also important for the KSHCP as income is dependent upon Applicant take. For that reason, the full budget has been included as an appendix to the KSHCP (Appendix G). An introduction and explanation of Management Plan costed items can be found there.

15. ADAPTIVE MANAGEMENT SOLUTIONS

The adaptive management process for the KSHCP is outlined in Section 6.9 of that document. The biological objectives of the KSHCP set triggers for initiating adaptive management by specifying actions that must be accomplished by target years. If these targets are not met, the actions described this Management Plan may be altered to better achieve program outcomes.

While it is not possible to consider every alternative, Table 16.1 lists potential adaptive management solutions, though other solutions may be more appropriate at the time of implementing adaptive management. Across all actions, if alternate technology becomes available that is within stated budget and will achieve objectives more efficiently or cost effectively, this may be employed. Costs associated with potential solutions below are presented in Appendix H of the KSHCP.

Table 16.1. Adaptive Management Scenarios

KSHCP Objectives	Scenario requiring adaptive management	Potential Solutions
2.A. Construct a predator-proof fence and install social attraction equipment (nest boxes, speakers) within the fenced area at the mitigation site in Year 1 of KSHCP implementation.	Fence construction. delayed by unforeseen event	Additional funds to contractor - 15% more labor @ low cost
	Fence design not adequate to exclude predators & repairs needed	Additional materials & labor needed to rebuild fence
	Additional rare plants found, work delayed	Additional funds to contractor - 15% more labor
	Archaeological remains found, work delayed	Additional funds to contractor - 15% more labor
	No suitably qualified fence contractor available in US to build fence in year one	Fly team from NZ or elsewhere
2.B. Remove predators from within the fenced enclosure with monitoring confirmation of their absence, and activation of the social attraction equipment by Year 2; predator eradication within fenced enclosure maintained for the life of the project	Predator removal unsuccessful at 1st attempt	Double trapping efforts inside fence - equipment

		Fly in and/ or consult with predator control expert
	Fence breach from tree fall, predators enter	Repair fence
		Repeat trapping effort inside fence
2.C. Ground activity by Covered Seabirds documented at the mitigation site by Year 4 of KSHCP implementation.	Monitoring insufficient	Increase camera trap effort by 20%
	Birds not attracted to site	Double speaker system & change soundtrack
	Birds not attracted to site	Fly in and/ or consult with expert from NZ
	Birds not attracted to site	Install decoys
2.D. Breeding activity by Covered Seabirds documented at the mitigation site by Years 5-7 of KSHCP implementation.	Monitoring insufficient	Increase camera trap effort by 20%
	Birds not breeding at site	Add new artificial burrows within fence
	Birds not breeding at site	Fly in and/ or consult with expert from NZ
	Birds not breeding at site	Survey for additional invasive plants that may be modifying habitat to make it unsuitable
	Birds not breeding at site	Replace all artificial burrows
2.F. Continued cumulative upward trend in Covered Seabird breeding documented at the mitigation site by Year 20 of KSHCP program implementation.	see 2D	
2.G. Maintain high quality seabird habitat at the mitigation site by removal of habitat modifying invasive plants in Year 1 and annually throughout the 30-year duration of the KSHCP.	Initial pass at habitat modifier removal fails	Repeat
	Additional invasive plant found	Removal effort

	Habitat modifiers persist despite technician maintenance work	Repeat removal pass
	Removal work is more expensive than predicted due to e.g. presence of additional rare plants	Additional funds
2.H Protect nesting birds inside mitigation fence and in nearby source colonies by implementing predator control of 1) barn owls within the area surrounding the fenced enclosure and the Kalalau Valley, and 2) feral cats at ingress points to source colonies in the Kalalau Valley, beginning in year 1 and annually throughout the 30-year duration of the KSHCP.	No barn owls removed	Additional shooting nights
		Alternative trapping/luring techniques
	Barn owls kills still occurring in preserve	Additional shooting nights / new techniques

16. BEST MANAGEMENT PRACTICES

To avoid any adverse effects to species and habitats of conservation concern, Best Management Practices will be employed at all times at the project site for the following species and specific concerns:

- **Covered Species** – ʻAʻo, ʻuaʻu and ʻakēʻakē. The benefits to these species of the Kahuamaʻa Seabird Preserve have been outlined above. See individual BMPs on each activity for further details on how harm will be completely avoided.
- **Ōpeʻapeʻa**: This is a listed species (Federal and State). It could be present at the Kahuamaʻa Seabird Preserve. Overall, the creation of the Preserve will provide a potential benefit to the ʻōpeʻapeʻa through conservation of the native habitat and control of non-native predators. The amount of disturbance that will occur while conducting conservation measures is minimal, temporary, and of limited duration. See individual BMPs on each activity for further details on how harm will be completely avoided.
- **Forest Birds:** Several candidate and listed native forest birds and pueo may use the Preserve as territories and / during the breeding season Jan to Jun (see section 3.1.4). Overall, the creation of the Preserve will provide a potential benefit to forest birds and

pueo through removal of non-native habitat and control of non-native predators - both are identified as primary threats to native forest bird species in Hawaiʻi (VanderWerf 2012). The amount of disturbance that will occur while conducting conservation measures is minimal, temporary, and of limited duration. See individual BMPs on each activity for further details on how harm will be completely avoided. It should be noted that KESRP located a pueo nest that had been predated by cats in Pihea in 2015, indicating that cat control will be beneficial to this species.

- **Listed or Rare Plants and native plant habitat:** Several listed or rare species of plant have been observed in the project area. Overall, conservation activities in the Kahuamaʻa Seabird Preserve are anticipated to result in dramatically improved habitat and reduced habitat modification that could otherwise occur from the negative effects of non-native animals and plants (see Section 12 - Vegetation Restoration - for a fuller explanation). The preserve's proximity to the road, and proximity to lookouts frequented by high numbers of tourists, presence of feral animals such as pigs and rats and current habitat degradation means that the area is already exposed to the risk of invasive species. Specifically, botanists have reported that the fence will be of direct conservation benefit to one individual of *Myrsine knudsenii* (E, PEP), four individuals of *Exocarpos luteolus* (E), one *Lobelia yuccoides* (SOC), one *Polyscias flynnii* (E, PEP), and a large occurrence (unknown number of individuals) of *Euphorbia remyi* var. *remyi* (E) (A. Williams, Pers. Comm.) Plant monitoring will not be limited to endangered species; changes to more common plant species that form the bulk of the native habitat will also be monitored. See individual BMPs on each activity for further details on how harm will be completely avoided.
- **Soil Erosion:** In the longer term, with re-vegetation and removal of ungulates, soil stability is expected to improve. Improved soil stability is expected to reduce erosion in the mitigation area which will reduce surface water runoff and water turbidity. In the short term, however, erosion might compromise the exclusion of predators from the fence as well as affecting Listed and Rare Plant species. See individual BMPs on each activity for further details on how harm will be completely avoided.
- **Rapid ʻŌhiʻa Death (ROD),** a fungal disease, is currently attacking and killing ʻōhiʻa (*Metrosideros polymorpha*), the most abundant native tree in the state of Hawaiʻi. The fungus *Ceratocystis* was first detected in 2014 on the island of Hawaiʻi killing hundreds of thousands of ʻōhiʻa across thousands of acres on the island. It has more recently been found on the islands of Kauaʻi, Maui, and Oʻahu and has the potential to devastate the native forest. *Ceratocystis lukuohia* (destroyer of ʻōhiʻa) and *Ceratocystis huliohia* (disruptor of ʻōhiʻa), the two fungal pathogens causing ROD have been confirmed on both Hawaiʻi Island and Kauaʻi. Both species of *Ceratocystis* will kill ʻōhiʻa, however the more aggressive form has not been found on Maui or Oʻahu, and is extremely limited on Kauaʻi. In July 2019, a single tree was detected on Maui and another tree on the island of Oʻahu. Both were infected by *C. huliohia*. Sanitation protocols will occur to prevent the introduction and spread of ROD. See individual BMPs on each activity for further details on how harm will be completely avoided.
- **Cultural Resources**: There is currently no evidence of archaeological remains at the Kahuamaʻa Seabird Preserve as noted in section 7.2. In 1997, prior to the construction of

the nearby Kalalau Rim Endangered Plant Exclosure, State Park archaeologists conducted a reconnaissance survey in the area of the Kahuamaʻa Flat and did not encounter archaeological sites or features. Nonetheless, archaeologist guidelines will be followed as specified in the BMPs for individual actions. See individual BMPs on each activity for further details on how harm will be completely avoided.

KSHCP conservation program activities in the Management Plan for the Kahuamaʻa Seabird Preserve will not result in take under section 10(a)(1)(B). The Prime Contractor will have conservation biology and project management experience and will hold recovery permits necessary to conduct its work under Section 10(a)(1)(A) of the Endangered Species Act and Sections 13-124-4 and 13-124-6 of the Hawaiʻi Administrative Rules.

To ensure that BMPS are followed during construction, a suitably fence qualified contractor will be engaged through a bids process. As part of the contract, contractor will agree orally and in writing to all BMPs. The Prime Contractor will be made aware that failure to follow BMPs may result in legal and financial penalties. The Prime Contractor and staff will receive training on BMPs. A concrete timeline for the delivery of the fence will be established in the contract. A construction deadline will be established during contract negotiations with monetary penalties.

The following sections outline in detail how BMPs will be used to avoid causing harm to listed species and to habitats. All staff, including biologists and technicians, entering the enclosure will be trained and follow the BMPs or will not be permitted to enter the enclosure. Any visitation to the mitigation area will be limited to what is absolutely necessary to accomplish objectives of the management plan and for compliance monitoring.

17.1 SEABIRDS

16.1.1. BMPs – Seabird Protection During Pre-construction & Construction

Pre-construction monitoring is critical to ensure that no seabird burrows are damaged during fence construction and sling-load drops. No burrows were found in 2016 or 2017 during auditory surveys, but no active burrow searching was carried out on site. Further surveys will be carried out in 2018.

If burrows were to be present, risks to covered seabirds through clearing of vegetation, increased risk of soil erosion, increased human presence, low altitude helicopter traffic and equipment drops could be:

- Damage to or destruction of burrows
- Disturbance to breeding seabirds (potentially leading to abandonment of nesting sites)

Impacts will be completely avoided using BMPs as follows:

- Work most likely to damage seabird burrows will occur during the period December to April (e.g. outside the breeding season, namely vegetation clearance, pole installation and other ground disturbing work). Fence construction may only commence during this period if it is reasonable to expect that work that could affect seabirds will be completed on the sloping sections of the fenceline (i.e. those most favorable to seabird colonization) before the seabird breeding season commences. If the project is delayed for any reason, the second phase of construction will only go ahead if it does not affect the covered species.

- However, work may continue into the breeding season to complete the fence provided it is either on the flat areas of the site or does not include ground disturbing work noted above that would damage potential burrows or birds in burrows. If construction occurs during the breeding season, 8 auditory surveys will be carried out in advance (see section 12.3.4) within 10m of the fenceline to ensure that there is no ground activity in the immediate area of the fenceline.
- The proposed fence lines and sling load drop zones will be thoroughly searched for seabird burrows by trained personnel before or during the onsite meeting. Training will be provided by KESRP or other qualified trainers. Staff will check all tree roots within 10m of the fence line. Any suitable holes within 10m of the fence line will be checked for guano, scent, feathers, eggshell, digging.
- Any burrows located will be marked on a GPS, cattle tagged and obviously flagged.
- If burrows likely to have been recently active (within last breeding season) are found along the proposed fence alignment route, the fence will re-routed if practically possible or the fence installation will work around burrows so that they are not destroyed.
- Buffer zone between the burrow and the fence will depend on the angle of the burrow and the slope that the burrow is situated upon, but is expected to be no less than 5m and up to 20m if near a possible take-off zone. If a burrow is present in a proposed sling-load drop zone, the zone will be relocated.
- A seabird biologist will be present during all vegetation clearing by the contractor.
- After vegetation has been removed along the fence line, a further burrow search will be carried out. Vegetation removal should not be necessary on sling load drop zones.
- A pre-construction monitoring report will be completed outlining how the above conditions have been satisfied.
- As the fence is being installed, a Prime Contractor staff member will be on site at all times to monitor the immediate environs to ensure that no seabird burrows are present. They will look for suitable holes and will also note the presence of seabird signs such as guano, footprints, scent, presence of feathers, down or eggshell and nesting material that might have appeared since the pre-construction surveys. They will also check all tree roots as these are often the site of burrows.
    - It is highly unlikely, given the provisions in the pre-construction section, that burrows will be located along the fence line by the Prime Contractor monitor once construction commences. If this occurs, however, Prime Contractor staff will consult with the regulatory agencies and the fence contractor so that impacts to the burrows are avoided.
- Sling load drop zones will most likely not be used post construction, but if required, they will be re-assessed for burrows before each post-construction use.

- All personnel (including the fence contractor) working in the mitigation sites will be trained to follow the seabird protection BMPs and given oral and written instructions. Training will be provided by the KESRP or other qualified trainers. Both project staff and fence contractors will be required to carry paper and / or GPS maps showing the locations of any known burrows and will know how to recognize burrow tagging.

16.1.2. BMPs - Seabird Protection during Rodent Eradication (inside fence)

The eradication of predators is likely to have a highly positive effect on breeding success once the Kahuamaʻa Seabird Colony is colonized. However, risks to covered seabirds could be:

- Damage to or destruction of burrows during monitoring of traps
- Disturbance to breeding birds (potentially leading to abandonment of nesting sites)
- A bird being killed or injured by a trap

Impacts will be completely avoided using BMPs as follows:

- Goodnature traps were designed to be used in seabird colonies. They are difficult for birds to trigger when placed 12cm off the ground and in addition, are not attractive to birds (Goodnature 2017). It is exceptionally unlikely that a seabird would be killed by a Goodnature and in 5 years of using this method in Kauaʻi by KESRP and other projects, no seabird deaths have been recorded (A Raine, 2017, pers. comm.) Other brands can be used provided they will not affected listed species.
- Snap traps have the potential to cause harm or death to Covered or Listed Species. This will be prevented by enclosing the trap in a boxed housing that cannot be accessed by the seabirds. Boxed housings will be inspected and repaired immediately prior to a planned trapping effort.
- Stationary bait boxes are designed in such a way that they cannot be accessed by seabirds. Poison bait may be removed by rats and left outside the box, however the bait is not appealing to seabirds and therefore the risk of ingestion is considered to be zero.
- All field workers and technicians will receive training to recognize potential seabird breeding burrows, (both active and inactive) and recognize burrow markers and program them into a GPS. They will be required to have a map of burrows and / or GPS points on them at all times at project site. Any burrows will be reported to KESRP.
- Workers will route trails around burrows and place traps and bait stations at least 10m away from known breeding burrows to avoid inadvertent trampling (and predator attraction from the scent of the bait) during the course of setting and checking traps and bait stations.
- Training will emphasize the use of due caution when walking off trail to avoid the trampling of burrows, particularly in areas which look suitable for seabird breeding activity.

16.1.3. BMPs - Seabird Protection – Collision Avoidance

The curved hood of the predator-proof fence is prominent and likely improves visibility. Similar projects for petrels and shearwaters in New Zealand have not encountered any problems related to seabirds colliding with the fence (SWCA 2011). Nonetheless, risks to covered seabirds could be:

- Injury or death due to collision with conservation fencing during the hours of darkness
- Downing of adult birds resulting in an ability to take off; this could lead to starvation of parent and chick
- Impeding take-off ability of chicks, leading to starvation

Impacts will be completely avoided using BMPs during construction work as follows:

- The fence will not be erected within 20m of a known seabird burrow
- Fencing will be installed without barbed wires, or similar sharp pieces, which could snag the birds (Hodges and Nagata 2001).
- A stripe of white reflective paint will be applied to increase the visibility of the fence to incoming and outgoing seabirds (Swift 2004). Commercial bird reflectors will be hung every 20m if appropriate.

16.1.4. BMPs – Seabird Protection during Cat Control

Cats will be removed from inside the fence before social attraction commences and the trapping of cats outside the fence (in the predator defense zone) will reduce the risk of reinvasion. However, as live feral cat traps sit on the ground, the risk to covered seabirds could be:

- A bird being caught, injured or killed by a trap

Impacts will be completely avoided using BMPs as follows:

- Live trap placement will be ≥25m away from known seabird burrows
- Conibears will be placed in bird excluding boxes
- All field workers and technicians will receive training to recognize potential seabird breeding burrows, (both active and inactive) and recognize field markers. They will be required to have a map of burrows and / or GPS points on them at all times at the site. Any burrows will be reported to KESRP.
- Live Traps will be checked every 24 hours.
- In the rare and unlikely event that a seabird does become caught, the live traps are well concealed and spacious enough that a seabird will not become harmed from exposure or damage from the trap itself. If a bird is found in the trap during daylight hours, then it will be released into the nearest potential seabird burrow where it has sufficient space to hide for the rest of the day (i.e., workers will not release birds into vegetation or attempt to get a bird to fly away).

16.1.5. BMPs - Seabird Protection during Barn Owl Trapping and Shooting

The trapping / reduction of barn owls is expected to have a positive effect on breeding success in the preserve and the source colonies for the Kahuamaʻa Seabird Colony as this species is a known seabird predator on Kauaʻi. However, the risk to Covered Species could be:

- Damage to or destruction of burrows during monitoring of traps
- Disturbance to breeding birds (potentially leading to abandonment of nesting sites)
- A seabird being caught, injured or killed by a trap
- A seabird being mistaken for a barn owl and shot

Impacts will be completely avoided using BMPs as follows:

- Existing paths will be utilized as much as possible to minimize local impact and barn owl trapping will be combined with other predator control activities to reduce trips.
- Barn owl control will maintain a greater than 25m distance from known nesting seabirds to avoid impacts to the birds. Prime Contractor staff will be required to carry a map and or GPS points with known burrow locations.
- There is potential that Covered Seabirds could be mistaken for barn owls and shot. This risk will be completely avoided by 1) providing appropriate training to technicians 2) using a spotlight at all times 3) requiring positive identification before shooting.

16.1.6. BMPs - Seabird Protection during Monitoring Work

Risks to listed seabird species could be:

- Injury during banding
- Trampling of natural burrows during burrow searching
- Trampling of natural burrows or crushing of birds during auditory and visual surveys

Impacts to Covered Species will be completely avoided by following BMPs as follows:

Banding

- Biologists conducting banding of seabirds will be required to be covered under Bird Banding Lab banding permits and be authorized by the DLNR to band or otherwise handle seabirds on Kauaʻi.
- Chicks will not receive bands until approximately 4 to 2 weeks from fledging.
- Only individuals trained in seabird handling and banding will be allowed to touch birds, unless an emergency occurs in which a bird requires rescuing.
- The amount of time a bird is handled during banding will be kept to a minimum, typically less than 2 minutes.
- If harm to an individual seabird does occur, due to an unexpected event or an accident while conducting the conservation measures, the regulatory agencies will be notified

within 24 hours or as soon as practically possible, and a report filed within 3 days. Technicians and field workers will deliver injured birds to the Save Our Shearwaters (SOS) project or other qualified veterinarian or rehab center immediately for rehabilitation and potential release.

Burrow searching

- If burrows are located along the fenceline post construction, locations will be clearly marked with flagging and an individually numbered cattle tag, and the fence-monitoring trail will be re-routed to avoid unnecessary disturbance to burrows during regular fence maintenance activities.
- Staff will be trained to look for and recognize burrows (active and inactive) as they are searching the site to ensure that they do not inadvertently trample a burrow. If this occurs, staff will excavate the burrow and ensure that any bird inside was not injured (if injury occurs, see point above). Staff will attempt to repair the burrow using any means possible to ensure that it is still usable, whether or not a bird is inside. Burrow locations will be programed into a GPS and shared with all other project staff. Staff will be required to have a map of burrows and / or GPS points on them at all times at the site. Any burrows will be marked with a cattle tag and reported to KESRP.

Auditory and Visual Surveys

- To avoid damage to seabirds at night by trampling during auditory and visual surveys, staff will stay in one place as much as possible and when moving, will take care to avoid stepping on birds. Training will be supplied by KESRP or other qualified body.

16.1.7. BMPs – Seabird Protection during Restoration and Monitoring

Risks to listed seabird species could be:

- Trampling of or damage to natural burrows during invasive species removal and nature vegetation restoration
- Presence of herbicide residue near burrows

Impacts will be completely avoided through BMPs as follows:

- Vegetation removal and restoration activities will not occur during seabird breeding season (01 Apr to 15 Dec)
- Herbicides will not be used within 3m of a known burrow.
- Where shrubs and / or trees need to be removed within 10m of a known burrow, the burrow will be inspected first to see if removal might compromise the structural integrity of the burrow. If the burrow is known to have been used, it may be appropriate to simply trim the invasive plant species rather than risk damaging the burrow through removal. Where the burrow has shown no signs of recent use (guano, feathers,

excavations, eggshell, scent) every care will be taken to prevent burrow damage and the shrub/tree removal will go ahead.

- Existing paths will be utilized as much as possible to minimize local impact
- All personnel working on invasive species removal and vegetation restoration must be trained to follow the seabird protection BMPs and given oral and written instructions. Training will be provided by KESRP or other qualified trainers.
- All staff will be required to carry a map and / or GPS showing the seabird burrows located in the Kahuamaʻa Preserve and to take particular care not to crush them. Known burrows will also be clearly marked with a cattle tag and reported to KESRP.

16.2. BATS

16.2.1. BMPs – Bats – Pre-Construction, Construction & Operation

Risks to ʻōpeʻapeʻa from activities such as tree trimming, removal of woody plants greater than 4.6m, fence construction and invasive species removal could be:

- Inadvertently harming or by disturbing roosting sites during the roosting and pup-rearing season (June 1 through September 15).

Impacts will be completely avoided using BMPs during pre-construction work as follows:

- The proposed fence lines will be thoroughly searched for trees which would be suitable for bat roosts (4.6m or above).
- Where trees over 4.6m need to be removed for construction, a Fluke Ti400 thermal imager (or similar) will be used to scan the tree or a contractor will be hired, in conjunction with an acoustic survey using bat detectors and a visual survey to ensure that no bats with pups are present.
- If there are trees 4.6m or above in the proposed sling load drop zones they will be scanned for bats as above and only removed outside the pupping season.
- Tree trimming and invasive species removal / vegetation restoration will take place outside the roosting and pup-rearing season (June 1 through September 15). If this is not possible, a Fluke Ti400 thermal imager (or similar) will be used to scan the tree, in conjunction with an acoustic survey using bat detectors and a visual survey to ensure that no bats with pups are present. If bats or pups are found, work will stop and the regulatory agencies will be consulted.
- All personnel (including the fence contractors) in the mitigation sites must be trained to follow the bat protection BMPs and given oral and written instructions.

16.2.2. BMPs - Bat Protection during Barn Owl Control

Barn owls are known to prey on bats in other locations (Speakman 1991) so it is possible that they may be a predator of the ʻōpeʻapeʻa. Therefore, their trapping or suppression is likely to be beneficial or neutral to bats. Since bats fly at night however, the risk to them could be:

- Accidental shooting

This risk will be completely avoided using BMPs as follows:

- providing appropriate training to technicians
- using a spotlight at all times
- requiring positive identification before shooting
- no shooting when bats are seen flying in the immediate environs (i.e. within 500m)

The activities carried out in the rodent eradication, cat trapping, and monitoring work are expected to have no potential to negatively affect the ʻōpeʻapeʻa.

16.3. FOREST BIRDS AND PUEO

16.3.1. BMPs – Forest Birds and Pueo – Pre-Construction and Construction

Forest birds are known to be in the area, including ʻiʻiwi (*Drepanis coccinea*) (federally listed as threatened under the ESA), ʻapanane (*Himatione sanguinea*), Kauaʻi ʻelepaio (*Chasiempis sandwichensis)*, Kauaʻi amakihi (*Hemignathus Kauaiensis*) and ʻanianiau (*Magumma parva*). ʻAnianiau and Kauaʻi ʻamakihi were observed singing which may be an indication of breeding in the area. The pueo, a native Hawaiian owl, has also been sighted several times in the area. Pueo have relatively wide home ranges and as such, it is possible that the Kahuamaʻa Seabird Reserve is part of the range several pueo.

Risks to listed forest birds and pueo through tree trimming and fence construction, could be:
- Disturbance of breeding birds and nests
- Removal of nesting habitat and feeding habitat in the form of large trees, especially ʻōhiʻa.

Impacts will be completely avoided using BMPs during pre-construction work as follows:

- Consultation with KFBRP will occur before the start of construction to exchange the most current information on the distribution and status of candidate and listed forest birds at the site.
- All personnel (including the fence contractors) working in the mitigation sites must be trained to follow BMPs and given oral and written instructions.
- A baseline survey will be completed to establish use of the area by forest birds during the breeding season January through June and to locate any nests. Pueo nest throughout the year, so a search for their nests would be necessary all year round.
- Pre-construction, surveys will be conducted at areas proposed for conducting conservation activities including installing fences, creating helicopter landing zones, installing social attraction equipment, trapping and baiting, and monitoring.

- Any candidate or listed forest bird species (trees) or pueo (ground nesters) nests found nesting in the vicinity of these areas must be marked via GPS and identified on maps and the information transmitted to managers, other staff and the regulatory agencies.
- Pueo nests will be given a buffer of 20m that will be marked with flags. No disturbance of these nests should occur in that buffer area and if not already occurring, predator control should be initiated. Trees with forest bird nests will be flagged. (Project staff will be required to know these locations and to recognize nest markers in the field.
- Fencing & helicopter sling-load drop zone: For listed forest birds or pueo found nesting along the proposed fence line, the trees supporting nests will be marked and/or fenced off (forest birds) and the ground area of the nest marked and / or fenced off (pueo) and the fence re-routed to avoid impacts to the forest bird species and pueo. Drop zones will be relocated if candidate or listed forest bird nests or pueo are found to be within 50m.
- Workers are required to know the location of marked and identified nests and maintain a 5-meter buffer around the nesting area for candidate or listed forest birds. Clearing and trimming activities are not to occur within this area. For pueo, a 100m buffer would be required. If that is not possible, incubation and nesting is complete within 35-55 days in total and it may be necessary to delay work that would cause disturbance until the birds have fledged.
- Every effort will be made to avoid removing large trees, especially ‘ōhi‘a. However, it is recognized that the benefits of the predator proof fence will outweigh any potential habitat loss for forest birds, since this would be of negligible size.
- It is unlikely, given the provisions of the pre-construction monitoring, that nests will be discovered in the vicinity of the fence line. As a precaution, when the fence is being installed, a Prime Contractor staff member will be onsite at all time to monitor the immediate environs for candidate or listed forest bird or pueo nests, or breeding pairs in a territory. If nests are found, the tree will be flagged and no activity likely to disturb the nest will take place within a 100m buffer zone or until after fledging. This includes vegetation / tree removal. However, in the case that a nest is empty and birds are not actively breeding (based on expert advice, which will be sought) trees can be removed.
- Little is known about the breeding biology of pueo, but their nests, which are on the ground, have been found throughout the year (DLNR 2005). If nests are found, the nest will be flagged and no activity will take place within a 20m buffer zone. This includes vegetation and tree removal. A mini fence will be erected to ensure that someone does not accidentally step on the nest.
- All personnel (including the fence contractors) working in the mitigation sites must be trained to follow the forest bird and pueo protection BMPs and given oral and written instructions.

16.3.2. BMPs - Forest Bird Protection during Predator Control and Invasive Species Removal

The eradication of predators and vegetation restoration work is likely to have a positive effect on any forest birds that make a breeding attempt inside the Kahuamaʻa Seabird Colony. However, the risks from project work could be:

- Disturbance of nests.

Impacts will be completely avoided using BMPs as follows:

- KRBRP or other qualified person will provide training to project staff annually or as required on identification of forest birds by call and sight as well as nest finding.
- Any nests will be marked and the Prime Contractor staff will be required to carry a paper map and or GPS with nests marked.
- Ongoing monitoring of trapping and baiting will occur year-round, encompassing the forest bird breeding season. Areas for trapping and baiting will be surveyed monthly during the breeding season to confirm the presence or absence of forest bird nests. Any nests will be clearly marked and trails used to access traps and bait stations will be re-routed if necessary to avoid disturbance to any nesting candidate or listed forest bird species. Survey results will be reported to KFBRP.
- When placing, setting, and checking traps and bait stations workers are required to know the location of any nesting candidate or listed forest birds and pueo and to maintain a 5m buffer around the nests, each of which will be marked (e.g., with flags and with GPS coordinates).
- When placing, setting, and checking traps and bait stations workers are required to know the location of any nesting candidate or listed forest birds and pueo and to maintain a 10m buffer around the nests for forest birds and 20m for pueo, each of which will be marked (e.g. with flags and GPS coordinates).
- Areas for seabird monitoring will be surveyed monthly during the breeding season to confirm the presence or absence of candidate or listed forest bird and pueo nests. Any nests will be clearly marked (buffer area will be marked in the case of the pueo) and trails used to access traps and bait stations will be re-routed if necessary to avoid disturbance to any nesting forest bird species. Survey results will be reported to KFBRP.
- If burrows need to be checked in the vicinity of a nest, extra care will be taken not to disturb the candidate or listed forest bird or pueo nest, such as keeping noise to a minimum and having only one person check the burrow quickly.
- Cameras will not be placed on burrows within 10m of forest bird nests and 100m within pueo nests as this requires extra disturbance.
- Invasive plant removal and habitat restoration will not take place within 25m of the nest.

16.3.3. BMPs - Pueo Protection during Eradication (inside fence)

Diphacinone is noted to have a 'moderate' risk of secondary poisoning to birds by the National Pesticide Information Centre although large amounts of the poison would need to be ingested. The risk from the predator control work to pueo could be:

- Secondary poisoning from pueo consuming rodents which have ingested poison.

The following protocol will be followed to ensure that impacts are completely avoided:

- Project staff will collect any dead rodents and dispose of them off site. Whenever stationary rodent bait traps are in use, staff will monitor the project site weekly to increase the likelihood of finding carcasses.
- Stationary bait stations will only be used inside the fence and for the minimum time possible to achieve zero rat sign on ink-card tracking tunnels and signs of bait take for three months (slightly longer than the average reproductive cycle for rats).
- Secondary poisoning to animals other than rodents as well as any occurrences of damaged or vandalized bait boxes will be reported to the U.S. Fish and Wildlife Service, DLNR and Pesticides Branch of the Hawaiʻi Department of Agriculture within 24 hours of being discovered.

16.3.4. BMPs – Pueo Protection during Barn Owl Trapping and Shooting

Since pueo are similar in flight to barn owls, there risk to this species could be:

- Accidental shooting

Impacts will be completely avoided using BMPs as follows:

- Providing appropriate training to technicians
- Using a spotlight at all times
- Requiring positive identification before shooting
- No shooting when pueo are seen flying in the immediate environs

16.4. PLANTS

16.4.1. BMPs - Plant Protection – Pre-construction and construction

Removal and disruption to some native plant species will be unavoidable during construction but will be kept to a minimum. It is important to note that the site was specifically selected to minimize damage to listed and rare plants.

Risks to listed or rare plant species during fence construction could be:

- Uprooting, trampling, soil erosion, crushing
- Damage to *E. remyi* var*. remyi (E)*, (a vining, weakly branched plant whose stems are growing on top of and through the mats of uluhe fern).

- Damage to other PEP plants within the fenceline
- Alteration to native habitat

The only Endangered species that occurs close to the proposed fenceline that might be affected is to *E. remyi* var. *remyi* and appropriate precautions will be taken (as listed below) to ensure that damage does not occur.

Impacts will be completely avoided using BMPs during pre-construction & construction work as follows:

- Prior to fence alignment and sling load drop zone creation, staff (including the fence contractors) will receive training from a botanist (either from the regulatory agencies or a consultant) on identification of rare plants in the area and be given oral and written instructions.
- Pre-construction baseline monitoring will be carried out to identify and / or confirm all listed and rare plants and their locations (see Section 12 – Vegetation Restoration - for full details.)
- A botanist or member of the Prime Contractor staff trained in plant identification for the localized area will be present at all times during alignment and sling load drop zone discussions on site as well as during construction.
- Within the enclosure, unknown number of individuals of *E. remyi* var. *remyi* are growing. This is a vining, weakly branched plant whose stems are growing on top of and through the great mats of ‘uluhe fern that dominate the area and as such, is at risk of being cut or trampled during fence construction. During pre-construction surveys, the plants will be indicated by flagging and staff will be provided with a map showing the location, as well as GPS points (these flags will not be left permanently as botanists are concerned that this will incite vandalism or theft, so after construction, nearby plants will be flagged instead to indicate to staff their location).
- If necessary, outplanting of propagules from the same population inside the fenced enclosure will occur. This is likely to be out-sourced to a consultant such as NTBG.
- An example of *Dubautia kalalauensis*, a PEPP plant, occurs well away from the entire project. No fence or project activities will occur in this area.
- A specimen of *Polyscias flynnii* (E, PEP) is safely within the fenceline and will not be damaged during construction. The plant or an adjacent plant will be marked with tape during pre-construction surveys. Prime Contractor staff and fence contractors will be required to carry, at all times, a map showing the location and or GPS points. No trimming of the tree will be allowed. A 10m buffer zone around the tree will be observed, with no construction activities allowed in that area.
- A culvert will be inserted into the fence if required in areas that might act as a watercourse during heavy rain, to avoid flooding which might wash out plants.
- BMPs to protect against the ingress of invasive species are outlined in section 17.4.3.
- Proper footwear (spiked/corked boots or tabis) will be worn by personnel (applies to all BMPs)
- There will be strategic placement of wood or plastic boards, webbing, or other simple trail infrastructure in areas where mud pits or slides may form (applies to all BMPs)

16.4.2. BMPs - Plant Protection– Rapid ʻŌhiʻa Death (ROD)

The spread of Rapid ʻōhiʻa Death (ROD) to local ʻōhiʻa trees could lead to a major ecological disaster through Kauaʻi. Local trees could potentially contract ROD due to staff or contractors bringing the disease to Kauaʻi through tools or clothes. Impacts will be completely avoided using BMPs during construction work outlined by the College of Tropical Agriculture and Human Resources, UH at Manoa:

- Staff and contractors will not move ʻōhiʻa wood or ʻōhiʻa parts inter-island. If ʻōhiʻa trees need to be removed as part of fence construction, they will be taken to the nearest location suitable for incineration immediately.
- Tools used for cutting ʻōhiʻa will be cleaned with 70% rubbing alcohol, a proven cleaning measure. This is particularly important if the tools may have come into contact with infected trees, but should happen regardless. A freshly prepared 10% solution of chlorine bleach and water can be used as long as tools are oiled afterwards, as chlorine bleach will corrode metal tools. Chainsaw blades will be brushed clean, sprayed with cleaning solution, and run briefly to lubricate the chain.
- Gear (including shoes, packs and clothes) will be cleaned before and after entering forests in a non-forest environment with running water. All soil will be brushed off shoes then sprayed with 70% rubbing alcohol. Clothes will be washed with hot water and soap. This will also help to reduce the spread of invasive species. A buddy system will be initiated where partners check each other's gear.
- Vehicles will be washed with soap after off-roading or after picking up mud from driving. A pressure washer with soap will be used to clean all soil off the tires and vehicle undercarriage.
- If staff have visited infected islands, they will take additional precautions of washing all field clothing, boots and tools in Sterigene before returning to the site. Staff will be asked to sign an agreement to this effect, since the severity of the consequences if ROD reaches Kaua'i.

16.4.3. BMPs - Plant Protection– Invasive Species

Risks to native plant ecosystems could occur should non-native invasive plants be accidentally introduced/reintroduced by staff or contractors. This could lead to the spread of invasive species to surrounding forested areas.

Impacts will be completely avoided using BMPs during construction work as follows:

- Cleaning boots, clothes, packs and gear between site visits to ensure that seeds are not carried from or to other areas and using a buddy system to ensure that this occurs.
- Keeping soil and vegetation disturbance to a minimum
- Where disturbance is unavoidable, staff will monitor bare ground and ensure invasive species are removed.

- Invasive species monitoring and removal within the fence will happen on a quarterly basis with waste hauled off site and destroyed
- Staff will be trained to recognize invasive species and to report them to project manager so that an action plan can be drawn up if new invasive species are encountered, if necessary.
- Vehicles will be washed with soap after off-roading or after picking up mud from driving. A pressure washer with soap will be used to clean all soil off the tires and vehicle undercarriage.
- Tools used in other areas will be cleaned thoroughly before use in or around the site.

16.4.4. BMPs - Plant Protection during Predator Control

As noted above, the overall effect on plants of the Kahuamaʻa Seabird Preserve is likely to be positive. However, the risk to rare and listed plants from the need to enter the preserve to monitor rodent eradication equipment, especially during the initial phase of eradication, could be:

- Trampling, erosion, disturbance
- Alteration to native habitat
- Frequently traveled transects will experience increased disturbance and erosion risk
- Listed or rare plants risk being trampled or disturbed

Impacts will be completely avoided using BMPs as follows:

- Listed or rare plants will be identified and flagged. Prime Contractor staff will be required to have a map and or GPS point of listed or rare plants with them at all time while in the field.
- Personnel will be encouraged to tread lightly and to remain on trails rather than cutting through vegetation.
- If listed or rare plants are thought to be at particular risk of trampling because of their location near a trap or bait box, the trap or bait box will be moved. If this is not possible, the plant will be protected by a small fence.
- No live feral cat trapping or barn owl control will occur within 10m of known listed plant species to avoid harm to those species.

16.4.5. BMPs - Plant Protection during Monitoring Work

Risks to listed or rare plants could be:

- Listed or rare plants risk being trampled or disturbed during burrow monitoring, camera installation and auditory / visual surveys.

Impacts will be completely avoided using BMPs as follows:

- Prior to the commencement of the work, pre-construction surveys will have identified the presence of any rare or listed plants. These will be marked and mapped and staff will be required to carry a map and / or GPS will the location of the plants. If necessary, protective mini-fences will be placed around specimens to ensure that they are not accidentally trampled.
- Cameras will not be placed on natural burrows within 10m of listed plant species to reduce traffic and disturbance.

16.4.6. BMPs - Plant Protection during Habitat Restoration

Risks to listed and rare plant species during invasive species removal and vegetation restoration could be:

- Disturbance and uprooting.
- Loss of sediment
- Soil instability
- Erosion
- Risk being trampled or disturbed during invasive plant species removal
- Accidental introduction of additional invasive species
- Bare ground following invasive removal being recolonized by invasive species
- Herbicide affecting native plants
- *Myrsine knudsenii* being mistaken for strawberry guava

Impacts will be completely avoided through the following BMPs for erosion control.

- In steep grade areas (>25%), clearance will be conducted by hand rather than with machinery.
- Vegetation clearance will be timed for periods of good weather as far as practically possible.
- To minimize risk of increased erosion in freshly disturbed areas during rainfall events, re-vegetation will occur as soon as possible after clearing and within 3 months, using with suitable native grass outside the fence.
- Clearing will not be conducted during heavy rain.
- If damage to vegetation and substrate is likely to occur during monitoring activities in certain areas, boardwalk sections will be placed over the area.
- Control of key seabird habitat modifiers especially in the maintenance phase will be accomplished by mechanical means (i.e. physically removing) with hand tools over the use of herbicides where possible. Large patches of seabird habitat modifiers will not be removed all at once to avoid leaving large areas of bare soil. Where this is not possible, erosion and weed control cloths will be put down if appropriate.

- Where required, herbicides will be applied following instructions at minimum volumes, rather than broadcast, and during prolonged spells of dry weather where possible and never during periods of heavy rainfall. Whenever possible (expected to be most cases), small volume bottle applicators, which delivers herbicide in very small quantities, will be used
- These identified herbicides are classified as ‘general use’ and not ‘restricted use’ but will need to be applied under a herbicide application permit. Personnel conducting these activities will adhere to all label restrictions and guidelines. Non-native vegetation removal BMPs may be improved or adapted as new technologies become available.
- All plant waste will be black bagged at the point of removal (rather than carrying off site and dropping seeds) then removed and destroyed off site in a lowland facility. Dead blackberry stalks will be left in situ to deter in ingress of other non-natives.
- Specific plant locations (e.g., UTM coordinates) will not be revealed in the public review.
- Where invasive species are within 10m of listed plant species, herbicides will not be used.
- Currently, trails at the site are based on botany surveys and lead to rare plants. Prime Contractor staff will discontinue the use of these trails to avoid rare plants and establish a new route to and around the site.
- DOFAW/PEPP staff will continue to monitor individual plants long term.
- Project staff will be trained on plant identification by State or Federal botanists.
- Care will be taken not to introduce new non-native plants through construction and or monitoring activities by cleaning boots, clothes, packs and gear between site visits to ensure that seeds are not carried from other areas
- Vehicles will be washed with soap after off-roading or after picking up mud from driving. A pressure washer with soap will be used to clean all soil off the tires and vehicle undercarriage.
- Tools used in other areas will be cleaned thoroughly before use in and around the site..
- Every effort will be made to ensure that the area remains visually and structurally intact. Soil and vegetation disturbance will be kept to a minimum. Where damage to the ground cover is unavoidable from invasive species removal, replanting with native plants will be carried out.
- Staff will receive training so that they can tell the difference between native / listed plants and invasive plants. Staff will carry an identification guide while undertaking plant work.

16.5. WATER COURSE, DRAINAGE & EROSION

16.5.1. BMPs – Watercourse, Drainage, Erosion Protection

During fence construction, BMPs will be employed to minimize erosion, sedimentation and contamination of aquatic environments (e.g. streams) in the project area.

Contaminations
The proposed bait for the rat stations is diphacinone. The project site is more than 200m from any known water source and diphacinone in this bait form is almost insoluble in water.

Erosion and Sedimentation
Figure 17.1 shows the topography at the site which contributes to the risk of erosion.

Figure 17.1. 3D Map showing topography at the site.

Risks to listed and rare plant species, listed seabirds and natural habitat could be:

- Disturbance and uprooting.
- Erosion might compromise the exclusion of predators from the fence
- Erosion of soil particles into watercourse could damage fish and other freshwater habitat species
- Bait dragged out of the boxes by rodents could fall into water courses and drainage areas.

Impacts will be completely avoided as follows:

Erosion

- In steep grade areas (>25%), fence clearing will be conducted by hand rather than with machinery.
- To minimize risk of increased erosion in freshly disturbed areas during rainfall events, clearing will not occur more than 1 week prior to construction.
- Clearing will not be conducted during heavy rain.

- Prior to disturbance, erosion control devices including (but not limited to) sand bag barriers, trenches, geotextile, filter fabric, vegetation matting, and rubber water guides will be put in place if required. Small trenches (≤ 2 m in length) will be dug from the fenceline during the fence installation process to divert water away from the fence if required.
- Sandbags, trenches, and water guides will be inspected daily during construction activities and monthly for the 30-year duration of the Program.
- Cleared areas will be outplanted within 3 months after construction with native grass.
- BMPs to protect against the ingress of invasive species are outlined in section 17.4.3.

Contamination

- The minimum amount of bait will be used to achieve additional rat eradication.
- Project staff will remove all bait found outside of the bait stations and either dispose of it or replace it in a bait box
- Bait stations will only be used inside the fence
- Bait will be placed on metal sticks inside the bait boxes
- Fueling of project related equipment (chainsaws) will take place away from the aquatic environment. Absorbent pads should be stored on-site to facilitate clean-up of accidental petroleum spill should a release occur.

16.6. CULTURAL /ARCHAEOLOGICAL

16.6.1. BMPs – Cultural / Archeological – all aspects of project

Risks to any possible sites could be:

- Damage or destruction to archaeological remains and features

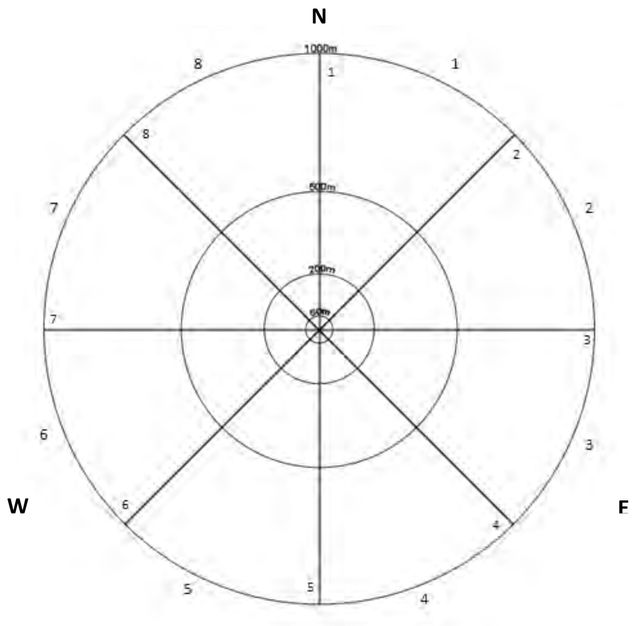
Impacts will be completely avoided using BMPs during pre-construction work as follows:

- All ground disturbing clearing efforts will be monitored by an archaeologist so that any potential surface archaeological sites are not disturbed, especially in the event that heavy equipment is used. Alternately, all clearing activities that do not disturb the ground surface will be inspected by an archaeologist immediately following the clearing to determine the presence or absence of sites;
- The installation of fences will be monitored by an archaeologist to assure that potential surface features as well as potential subsurface cultural deposits are not disturbed by these activities;
- If at any time during development of the mitigation site archaeological features are encountered, State Parks archaeologists will be notified. If activities could impact any archaeological feature, these activities will cease until such time as the feature is evaluated by a qualified archaeologist; and

- If activities extend into the steep cliff portion of the project area, the potential for encountering rock shelters or caves (features known to be used by Hawaiians for interment of the dead) does exist. In the event that human remains are inadvertently discovered, those remains shall not be disturbed and the State Historic Preservation Division (SHPD) immediately notified in accordance with HRS Chapter 6E.
- All staff (including the fence contractors) will be given oral and written instructions pertaining to archaeological and cultural sites.

17. APPENDICES

Appendix 1: KESRP Data Sheet



Time start and survey duration: Dusk surveys start at sunset, and survey duration is 2 hours. Dawn surveys start 2 hours before sunrise and duration is 90 min. Surveys are split into 30 minute sessions, with 5 minutes allotted for weather data, 25 for auditory, and 5-10 for concurrent night vision if available.
Location: Use a GPS and record ~ error in m. Create a waypoint for your location with year (2 digits), Julian date (3 digits), initials (2 letters), and time (AM/PM), e.g. **09125JHPM**
Weather: Use code descriptions. Use geographic reference points (how high are adjacent cliffs compared to clouds?) and make comments about cloud activity at height.
The target circle: Take 5 min to draw in major features and bearings. Confirm major directions to geographic features.
What is a call? A call is a single **unbroken** note or series of notes. Where there is a pause any subsequent call is treated as a new and separate call (regardless of if you perceive it to be the same bird). ≥2 birds calling at the same time are treated as separate calls. If a site is so active that it is impossible to accurately count calls/minute, 25 is recorded in the multiplier column and "uncountable" is recorded in the comments.
Data to be collected:

1. **Time:** 2400 clock, min scale. Tally calls with same distance and direction in that minute.
2. **Quadrat:** One of 8 regions you heard the call based on direction.
3. **Distance:** The approximate distance from the listener to the caller. Distance is broken into 5 basic categories – 0-50m (1), 51-200m (2), 201 – 500m (3), 501-1000m (4). Distance can also be recorded in 100m (e.g. 1=100). NOTE: *also include 50m as* (0.5). Data will be treated in 4 basic categories. ***If you find that this scale (i.e. calls up to 1000m) is inappropriate (e.g. birds calling on ground close by) include additional distance estimate in comments.***
4. **Behavior:** The direction the bird is flying TOWARDS if it is possible to determine. This can become somewhat subjective to determine if the call is > 500m, or if only partial notes are heard. 1=North, 2=NE, 3=East, etc.. 9=circling, 10=stationary/ground, 11=transit. ***If you hear ground calling, record a bearing!***
5. **Elevation:** Either below (1), same / approx. equal height to observer (2) or above (3). Leave blank if unknown or indeterminate.
6. **Species:** Leave blank if NESH. If any other species record as 4-letter codes based on first and second names.
7. **Comments:** Based on footnote system – use numbers in cell and record comments in space below**.**

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19. PERSONAL COMMUNICATIONS

Katie Cassel, 2017, Founder and Manager, Kōkeʻe Resource Conservation Program.
Spencer Engler, 2017, Habitat Conservation Plan Compliance Technician for First Wind, Makamaka'ole Seabird Preserve.
Wendy Kishida, 2017, Kauaʻi PEPP Coordinator, Kauaʻi Plant Extinction Prevention Program.
Dr. Andre Raine, 2017, Manager, Kauaʻi Endangered Seabird Recovery Project.
Galen Reid, 2016, Predator Control Specialist, DOFAW.
Kyle Pias, 2017, Co-ordinator, Hono O Nā Pali Seabird Mitigation Project.
Adam Williams, 2017, DOFAW.
Dr. Lindsay Young, 2017, Vice President and Executive Director, Pacific Rim Conservation.

Appendix B:
Biological Details

APPENDIX B: COVERED SPECIES BIOLOGICAL DETAILS

1. COVERED SPECIES BIOLOGICAL DETAILS

This appendix to the KSHCP contains the biological details on distribution, abundance, population trends, life history, habitat and threats to the Covered Species in the KSHCP. The information presented in this appendix serves to support the conservation actions and assumptions of the Program.

1.1. ‘A’o

The ‘aʻo or Newell’s Shearwater (*Puffinus newelli*) is endemic to Hawaiʻi and most of the current-day population breeds on the island of Kauaʻi. The species is listed as ‘Threatened’ under Federal and State of Hawaiʻi endangered species laws and ‘Endangered’ on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (Birdlife International 2010). The ‘aʻo belongs to the *Puffinus* genus of small shearwaters which includes the Manx shearwaters (*Puffinus puffinus*) and the Townsend’s Shearwaters (*Puffinus auricularus*).

The ‘aʻo is a small, black and white shearwater with a dark tail (**Figure 1-1**). As with most shearwater species, the ‘aʻo has a dark narrow bill with a slightly hooked tip. While some taxonomists describe it as a Manx-type shearwater based on size and general plumage similarities, others describe it within the Little/Audubon’s group based on the extent of white plumage on the sides of the rump and black upperparts (Onley and Scofield 2007). In flight, the ‘aʻo displays rapid wing beats, often flies close to the water and with little soaring (Onley and Scofield 2007).

Figure 1-1. The ʻaʻo – Newell's Shearwater. Photo B Speigel, SOS.

The ʻaʻo was thought to be extinct by 1908 but was later rediscovered in 1947. In 1967, the species was confirmed breeding on Kauaʻi when a hunter's dog killed one and brought it to the hunter. He reported it to the authorities. John Sincock and Gerald Swedberg then searched for the birds, finding their burrows and further predations.

In subsequent years, fledglings became attracted to, and disoriented by, an increase in urban lighting and became grounded (King and Gould 1967, Sincock and Swedberg 1969). An effort to decrease mortalities associated with light attraction led to the formation of the "Save Our Shearwater" (SOS) rehabilitation center in 1978 by the U.S. Fish and Wildlife Service and the State of Hawaiʻi, Department of Land and Natural Resources. Records from the ~30,000 shearwaters to go through SOS from 1978-2016 have been used in population modeling and to understand population trends (Ainley et al. 2001a, Day et al. 2003b, Raine et al. 2017c). Initial colony monitoring was done on low elevation colonies in the early 1980s (Telfer 1986) and some of these same sites were later revisited in the 1990s in studies assessing reproduction (EPRI 1995a, b). Radar surveys began in 1993 to quantify Newell's movement from sea to land at several locations around the island and are continue to this day.

This long-term data set has been used to plot population trends (Raine et al. 2017c). Since 2006, regular auditory surveys, acoustic monitoring, and nest searching by the Kauaʻi Endangered Seabird Recovery Project led to the discovery of large colonies of ʻaʻo in the northwest mountains of Kauaʻi (KESRP, unpubl. data) A large amount of research and monitoring of ʻaʻo colonies from 2011 to the present has been funded through the KIUC Short Term Habitat Conservation Plan (HCP), as well as through the National Fish & Wildlife Foundation, State Wildlife Grants and additional funding sources. Through this program, and due to increased focus on species recovery, there has been a significant effort to locate all breeding colonies on public lands and where private landowners allow access. The largest gap in data is on land owned by the Robinson family (~20% of total land mass on the island of Kauaʻi), where no surveys have been permitted.

1.1.1. Distribution, Abundance, and Population Trends of the ʻAʻo

The ʻaʻo is endemic to the Southeastern Hawaiian Islands. The island of Kauaʻi supports the largest current-day breeding population of the ʻA'o, estimated at up to 90% of the total population (Ainley et al. 1995a, USFWS 2011), while smaller populations are known to breed on the islands of Hawaiʻi and Maui. Oʻahu, Lānaʻi, and Moloka'i (Day and Cooper 1995, Reynolds and Ritchotte 1997, Day et al. 2003a, Onley and Scofield 2007, VanderWerf et al. 2007, Natividad Bailey 2009, McKown and Savage 2015).

The Kauaʻi Endangered Seabird Recovery Project (KESRP), the program primarily responsible for conducting research on the ʻaʻo and ʻuaʻu on Kauaʻi, has conducted auditory surveys to detect ʻaʻo breeding calls and track relative calling densities. This information, in conjunction with identified breeding colonies provides the known distribution of the ʻaʻo on Kauaʻi. The ridges and slopes along the northwest coast of Kauaʻi display the highest levels of ʻaʻo breeding activity (**Figure 1-2**) (Banfield et al. 2013, Raine and McFarland 2014b, a).

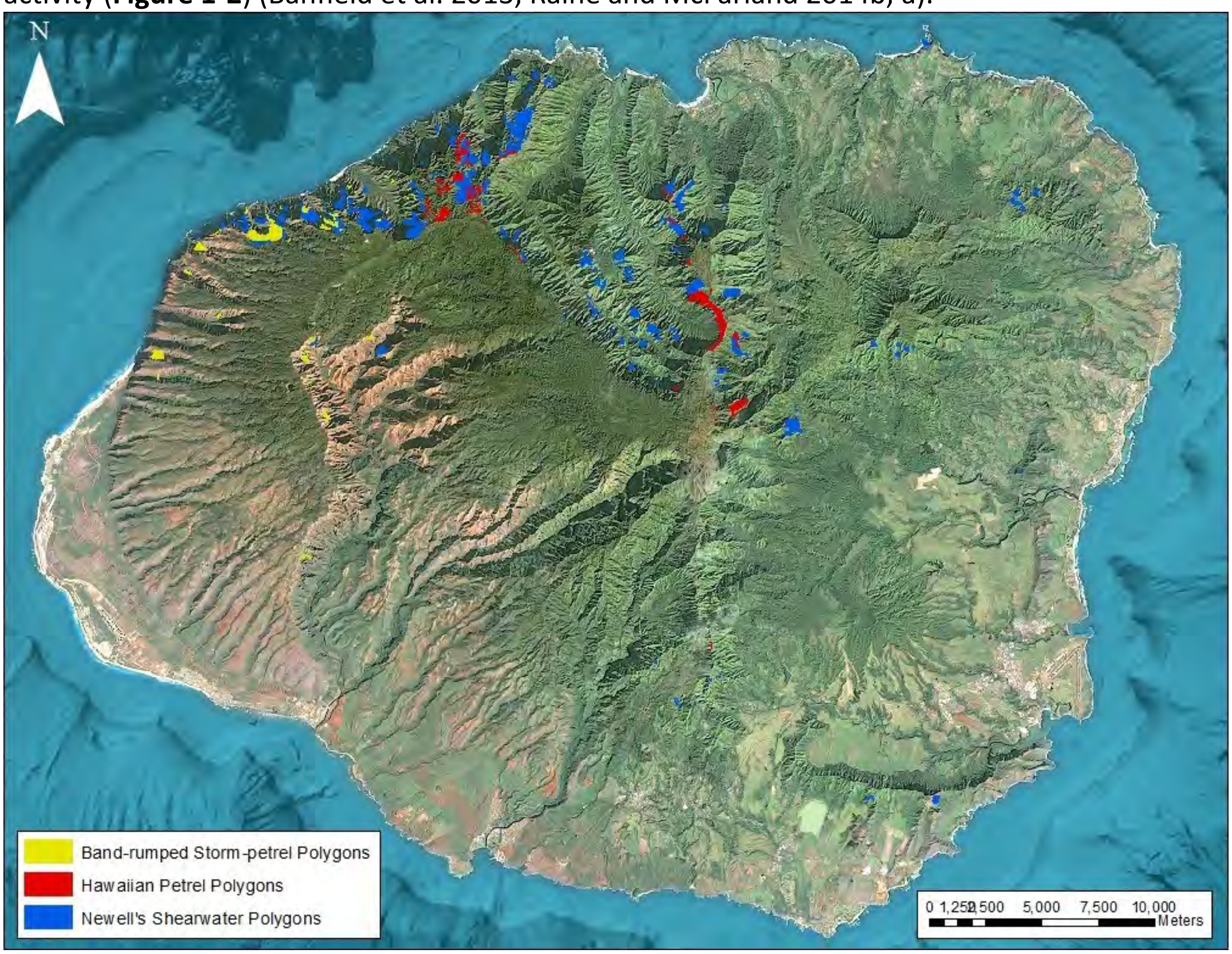

Figure 1-2. Map of ground calling locations, indicating Calling Hotspots and breeding activity on Kauaʻi. ʻAʻo (in blue), the ʻuaʻu (in red), and the ʻakēʻakē (in yellow) (KESRP).

The species' pelagic range is not fully understood. During the breeding season the species is typically found foraging on the ocean a short distance to the west and north of the southeastern Hawaiian Islands (Onley and Scofield 2007). ʻAʻo are observed at sea in warmer areas of the Tropical Pacific with a strong, deep thermocline, more cloud cover, less mixing in the water column and where trade winds are less developed. They are typically found foraging approximately 800 miles south and east from nesting colonies on Kauaʻi in the deep-water regions of the Equatorial Counter Current, and more specifically, the Inter-tropical Convergence Zone, to the north (up to 25º N), and east (to about 120ºW) of the Hawaiian chain (Spear et al. 1995). Juvenile ʻaʻo have been tracked after fledging at over 1,400 miles to the southwest of Kauaʻi with longer tracks extending to over 2,700 miles to the southwest. Adult ʻaʻo have been tracked taking differing routes from the fledglings after the breeding season, with one individual following the Northwest Hawaiian Islands, and the other moving southeast of the main Hawaiian Islands (Raine et al. 2015a, Raine et al. 2017a).

At-sea surveys conducted in the central and eastern tropical Pacific between 1980 and 1994 (Spear et al. 1995) estimated the total ʻaʻo population at 84,000 (95% CI = 57,000-115,000) including juveniles and subadults. An updated assessment based on survey data collected by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA-NMFS) Southwest and Pacific Islands Fisheries Science Centers from 1998 to 2011, estimated the total ʻaʻo population at 27,011 (95% CI = 18,254-37,125) including juveniles and subadults (Joyce 2013). With an approximate 90% of the total population based on Kauaʻi, this estimate can be adjusted to 24,310 individuals on Kauaʻi. It should be noted that these studies consisted of different data sampling techniques and statistical analyses from each other, therefore the studies are not directly comparable. Each study provides an estimate of the at-sea population of Newell's Shearwaters during the respective sampling periods.

The population of ʻaʻo is estimated to have declined by 94% (at an average rate of ~13% per year) from 1993-2013 (Raine et al. 2017c) and is predicted to continue to decline (Griesemer and Holmes 2011b). Populations of ʻuaʻu are estimated to have declined by 78% (at an average rate of ~6% per year) during the same period (Raine et al. 2017c).

In line with these measurements, auditory surveys have confirmed a restriction of the species' breeding range. Surveys have shown significantly lower levels of breeding activity at three previously highly active colonies (Kalaheo, Anahola, and Makaleha), and the probable extirpation of others (e.g., Kaluahonu) (Ainley et al. 1995b, Holmes and Troy 2008)(KESRP, unpublished data).

Reducing the population estimate based on a range of presumed predation rates (see Appendix E: Social Attraction Estimator Model) yields a current 2016 population estimate of 13,049-17,172 individuals. Assuming a stable age distribution (Ainley et al. 2001b), the population size range presented above would include approximately 8,312-10,938 birds of breeding age.

1.1.2. Life History and Habitat Selection of the ‘A‘o

The ‘a‘o breeding season begins in late March/early April, when birds return to colonies (Ainley et al. 1997a, Zaun 2007, Deringer and Holmes 2009) (**Figure 1-3**). The ‘a‘o exhibits high site and mate fidelity. Higher rates of ‘a‘o calling are detected during this period when non-breeding individuals are also concentrating at breeding areas (Deringer 2009).

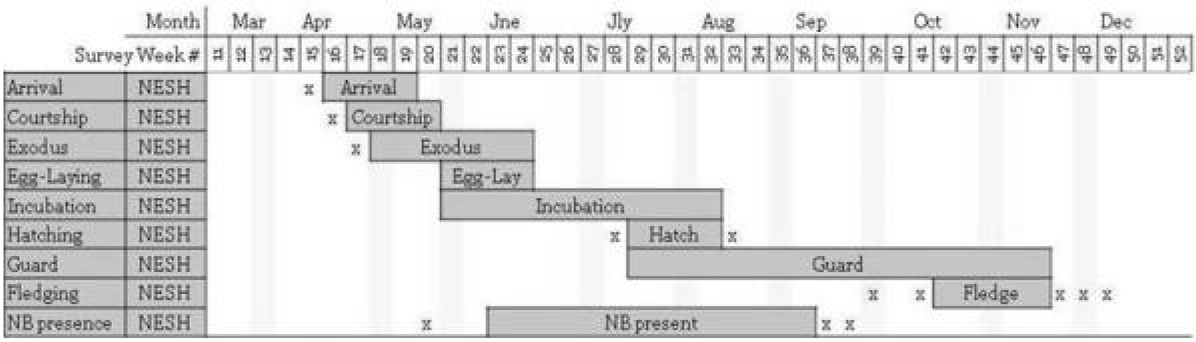

Figure 1-3: Breeding phenology of the ‘ua‘u (HAPE) and the ‘a‘o (NESH) on Kaua‘i adapted from Deringer (2009). NB = non-breeders. Outlier observations indicated with “X”s.

A pre-egg laying exodus follows in late April, and egg-laying occurs in June. Pairs produce a single white egg with an average incubation period of between 53 and 55 days. Incubation is shared by both parents (Ainley et al. 1997b). After hatching, both parents participate in feeding their chick , with one adult making short foraging trips (every 1-3 days) while the other adult makes long trips (can be away for up to 12 days) (Zaun 2007) (KESRP unpublished data).

Juveniles will not emerge from the burrow until just 12-20 days before fledging. The fledging period ranges anywhere from 81 to 94 days after hatching (Zaun 2007). Fledging occurs between late September through early December with peak fledging levels in October (Ainley et al. 1997b, Raine and McFarland 2014b, a). Fledglings depart nests from after sunset to before sunrise with a peak in the first few hours after dark (KESRP, unpublished data).

Juveniles will spend the majority of time at sea, returning to their natal areas only to prospect for mates and burrow sites between year two to five. ‘A‘o begin reproducing at 6 years of age (Brooke 1990, Ainley et al. 2001b).

Shearwater reproductive success, measured as the percentage of successful fledglings per eggs laid, per year, ranges between 40-70% in similar species around the world (Brooke 2004). Griesemer and Holmes (2011b) report that the mean reproductive success of burrowing Procellariformes for studies equal to or greater than three breeding seasons was 0.32 ± 0.17SD (n=17) in areas where predators were present and was 0.62 ± 0.08SD (n=9) for areas where predators were eradicated. KESRP conducted a study in Upper Limahuli Preserve, a site in Kaua‘i protected by an ungulate proof fence (from 2009) and managed by NTBG, where predator control for rats and cats is taking place. Fledging success for ‘a‘o went from 54.5% in 2011 to a high of 88.2% in 2015 from nests where breeding was confirmed; ‘ua‘u breeding fledging success went from 0.01% in 2011 to a high of 64.5% in 2016. The study looked at over 100 nests. During this time period, predator eradication has increased steadily in effort and efficiency (Raine et al. 2017g). In the modeling efforts of Ainley et al. (2001b), a breeding probability of 54.7% was determined. This is low when compared to reported values for other Procellariformes and it is likely to be caused by mortality from adult predations and powerline collisions (Telfer 1986, Ainley et al. 2001b).

Survivorship of ʻaʻo has been estimated in population viability modeling efforts at 0.905 (Ainley et al. 2001a) to 0.92 (Griesemer and Holmes 2011a, USFWS 2017b, a). Juvenile (sub-adult) survivorship was estimated at 0.333 by Ainley et al. (2001a) based on long term studies on the Manx shearwater (Brooke 1990) and other species related to the ʻaʻo.
ʻAʻo capture prey by diving after fish schools and are often seen in association with big predatory fish, such as tuna that cause smaller prey species to swim up to the surface. When under water, ʻaʻo can swim to depths of over 45m to pursue prey. An analysis of the stomach contents of ʻaʻo fledglings collected dead beneath power lines showed a composition of 0.1-0.3% shrimp-like crustaceans, 0.1-4% fish, and 96-99% squid, most of which were ommastrephid (flying) (37-57%) and pyroteuthid (fire) squid (7-16%), and exocoetid (flying) fish (<0.1-1.7%) (USFWS 1983, Harrison 1990, Ainley et al. 1997b, Ainley et al. 2014, USFWS 2016b).

Breeding colonies are typically located at high elevations in areas of open native forest dominated by ʻōhiʻa lehua (*Metrosideros polymorpha)* with a dense understory of ʻuluhe fern (*Dicranopteris linearis*) (**Figure 1-4**). Current-day breeding sites are restricted both geographically and in terms of elevation from what they once were, and historically the ʻaʻo may have bred at lower-elevation sites (Mitchell et al. 2005, Pyle and Pyle 2009).

Nests, consisting of burrows dug into the ground, are most commonly placed at the base of trees, where the substrate may be easier for the birds to excavate. Some colonies on Kauaʻi are located in steep slopes above sheer cliffs (Wood and Holmes 2008), where birds are presumed to nest in rock crevices rather than burrows.

Vegetation at active ʻaʻo breeding colonies was composed of 25-35% native tree canopy, and 75-85% native shrub and fern layers (Holmes and Troy 2008, Holmes et al. 2009). Studies investigating the microhabitat characteristics of known colonies suggest that sites distinguished by steep slopes, moderately rocky hard soils, and low nonnative vegetation are the most suitable nesting habit (Troy et al. 2014, Troy et al. 2016).

Figure 1-4: ʻAʻo and ʻuaʻu habitat: ōhiʻa lehua tree root structure for burrows. Photo: P Belson.

Figure 1-6: ʻAʻo and ʻuaʻu habitat: ʻuluhe fern with burrow. Photo: A Raine.

Figure 1-5: ‘Aʻo and ‘uaʻu habitat”: intact native montane forest (Upper Limahuli Preserve). Photo: Y Reiss, left. A Raine, right.

1.1.3. Threats to the Continued Existence of the ‘Aʻo

The primary threats to the ‘aʻo population include: light attraction; collisions with utility structures predation at their breeding sites by introduced mammalian and avian predators; breeding habitat loss and alteration caused by invasive plants and introduced ungulates; public use; urban development; at-sea factors affecting their prey-base; global climate change; and stochastic events.

Other threats include climate change and its affects to both seabird adult survivorship and recruitment by generally affecting food availability (Oro 2014). Each of these factors is discussed below in more detail in **Section 1.1.4**.

1.2. ‘Uaʻu

The ‘uaʻu, or Hawaiian Petrel (*Pterodroma sandwichensis)* is endemic to the Southeastern Islands of Hawaiʻi. The ‘uaʻu is listed as ‘Endangered’ under Federal and State of Hawaiʻi endangered species laws and is classified as ‘Vulnerable’ on the IUCN Red List of Threatened Species (Birdlife International 2007). The ‘uaʻu was once considered a subspecies of the Dark-rumped Petrel (*Pterodroma phaeopygia*) but was split taxonomically based on morphology and breeding range (Brooke 2004, Onley and Scofield 2007). The Dark-rumped Petrel has since been renamed and is now referred to as the Galapagos petrel (*Pterodroma phaeopygia*), a species endemic to the Galapagos Islands.

The ‘uaʻu is a stout, medium-sized petrel with light underparts, dark upperparts, and white feathers on the forehead, around the bill, lower cheeks, chin and throat (**Figure 1-7**). It is one of the larger species in the *Pterodroma* group, with longer, more pointed wings than congeners but with heavier shorter wider wings, shorter deeper bill, and a shorter dark tail than Galapagos Petrel (Onley and Scofield 2007). The grayish-black bill is relatively short and stout, with a sharp, decurved tip. In flight, ‘uaʻu demonstrate characteristic *Pterodroma* dynamic soaring with high-sweeping arcs and a rhythmic rocking “pendulum” motion (Onley and Scofield 2007).

Figure 1-7: The ʻUaʻu – Hawaiian Petrel. Photo A. Raine, KESRP

1.2.1. Distribution, Abundance and Population Trends of the ʻUaʻu

The ʻuaʻu only breeds in the Southeastern Hawaiian Islands. It is thought that the species once bred on all the main islands of Hawaiʻi, except Niʻihau (Simons 1985, Mitchell et al. 2005). Current-day breeding populations are primarily on the island of Maui, particularly in Haleakalā National Park, and on the island of Kauaʻi at high-elevation nesting colonies. Smaller populations breed on the islands of Hawaiʻi and possibly Molokaʻi (this has not been confirmed). There is also a large breeding population on the island of Lānaʻi (Day et al. 2003a, Onley and Scofield 2007, Tetra Tech 2008, Holmes and Joyce 2009, Natividad Bailey 2009, Pyle and Pyle 2009, Raine et al. 2017h).

KESRP has conducted auditory surveys on Kauaʻi which indicate calling concentrations and breeding locations. This information, in conjunction with breeding colonies identified on the ground provides the currently known distribution of the ʻuaʻu on Kauaʻi. The ridges and slopes along the northwest coast of Kauaʻi display the highest levels of ʻuaʻu breeding activity. Figure 1-2 illustrates calling hotspots and the sites where breeding activity was documented by KESRP (Banfield et al. 2013, Raine and McFarland 2014b, a).

Based on at-sea survey data, Spear et al. (1995) estimated a total ʻuaʻu population of 19,000 (10,600 – 34,400) individuals and an estimate of 4,500 to 5,000 breeding pairs (Spear et al. 1995, Ainley et al. 1997a). Joyce (2013) estimated a population abundance equal to an average of 52,000 individuals using at-sea data collected over the more recent sampling period of 1998-

2011 (Joyce 2013). The estimates from Joyce (2013) and Spear et al. (1995) are not directly comparable due to difference in survey locations (i.e., longitudinal and latitudinal) and timing in regards to breeding phenology; however, together the studies provide an estimate of the at-sea population of ʻuaʻu at the different time periods.

The Kauaʻi subpopulation was estimated at 1,200 (Pyle and Pyle 2009) to 1,600 breeding pairs (Ainley et al. 1997a). Overall population estimates are currently being revised, but recent data suggests that Kauaʻi may contain a much more significant portion of the world breeding population of the ʻuaʻu than the predicted by early earlier estimates (Raine, 2017, pers. comm).

Studies informing the population trends of the Hawaiian Petrel on the island of Kauaʻi indicate the population has declined. Recent radar data analyses for Kauaʻi indicate a >78% decline in ʻuaʻu numbers during the period from 1993-2013 (Raine et al. 2017c)

1.2.2. Life History and Habitat Selection of the ʻUaʻu

The ʻuaʻu breeding season on Kauaʻi begins in April when birds return to the island to commence breeding. The ʻuaʻu, like many petrels, displays a high degree of site and mate fidelity; nesting pairs return to the same nesting burrow year after year. They enter and exit their burrows only under the cover of night as a defense against potential predators (Simons 1985). Most pairs visit burrows for just a few nights at the beginning of the season before going on exodus. **Figure 1-8 s**ummarizes the annual breeding phenology for the Kauaʻi population of the ʻuaʻu, adapted from (Deringer 2009); ʻuaʻu is coded as “HAPE” in this figure.

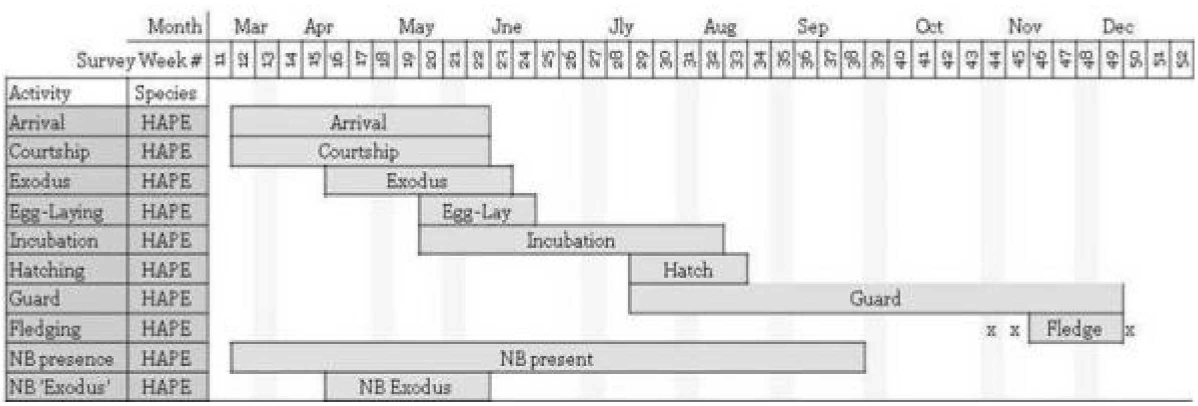

Figure 1-8: Breeding phenology of the ʻuaʻu (HAPE) on Kauaʻi adapted from Deringer (2009). NB = non-breeders. Outlier observations indicated with “X”s.

Prior to egg- laying and incubation, adult ʻuaʻu depart the nest for approximately three weeks to build up fat and nutrient reserves prior to egg laying (females) and incubation (males) (Harris 1966, Perrins and De L. Brooke 1976). Parental care from both sexes is necessary to rear a single nestling.

Egg laying begins at the end of April. Breeding females lay a white egg each year. Incubation typically begins immediately after laying and lasts 54-58 days (Simons and Hodges 1998). Both adults take shifts lasting several days at a time, thus relieving the other adult to feed.

Once a chick hatches, in July or August, it remains in the nest and depends on parental care for approximately four months (Simons 1985, Simons and Hodges 1998, Mitchell et al. 2005). Fledgling occurs in the fall months; adults and juveniles depart the breeding colony in late November-mid December, remaining at sea for several months before adults and sub-adults return the following spring. ʻUaʻu breeding on the islands of Hawaiʻi, Maui, and Lānaʻi fledge young earlier (early November) than those breeding on Kauaʻi (mid November, early December) (Simons and Hodges 1998, Natividad Bailey 2009, Raine et al. 2017h). Fledglings will not return to land for 2-5 years. The Hawaiian petrel begins reproducing at 6 years of age (Simons and Hodges 1998).

Petrel diets typically include squid, fish, crustaceans and plankton found at the surface (Simons and Hodges 1998). Largely nocturnal in their hunting habits, ʻuaʻu skim the upper surface of the water for prey driven to the surface by other seabirds and marine predators. Studies of breeding petrels at Haleakalā National Park on Maui found ten different prey types obtained from three classes of marine organisms (Simons 1985, Harrison 1990).

The ʻuaʻu nests in burrows, crevices in lava, and under ferns. Nesting habitat on Kauaʻi appears structurally similar to known breeding sites on Lānaʻi (Penniman 2010, Wiley et al. 2012). On Lānaʻi, ʻuaʻu burrow primarily in fern beds (VanZandt et al. 2014, Raine et al. 2017h). In comparison, nest burrows on Maui and Hawaiʻi islands are found at high elevation sub-alpine sites (e.g., at Haleakalā: 3000m elevation and <10% vegetation coverage) between lava rocks. Based on auditory surveys and burrow searching conducted by KESRP on Kauaʻi, the ʻuaʻu burrows at high-elevation sites comprised of predominantly wet montane forest of native vegetation, under ʻŌhiʼa and Lapa lapa trees, similar to that of used by the ʻaʻo but typically higher in elevation (Holmes and Joyce 2009).

As described by Troy et al. (2016), when compared to ʻAʼo, ʻuaʻu burrows are associated with softer soils, lower surrounding vegetation and are closer to wind exposed ridges. ʻUaʻu burrows also show a wider range in habitat characteristics. As with other forest-dwelling seabirds around the world, a fern-dominated understory provides a softer landing for petrels, and the interspersed tree roots provide suitable soil structure for burrow excavation (Holmes and Wood 2007).

1.2.3. Threats to the Continued Existence of the ʻUaʻu

The primary threats to the ʻuaʼu population on Kauaʻi include power line collisions, light attraction, predation at breeding sites, breeding habitat loss and alteration, disease, and at-sea factors affecting prey availability, global climate change, and stochastic events. Each of these factors is discussed in more detail below.

1.3. ʻAkēʻakē

The ʻakēʻakē, or Band-rumped Storm-petrel (*Oceanodroma castro*), is a small, highly pelagic storm-petrel of the Family Hydrobatidae. The ʻakēʻakē is listed as endangered under the Federal ESA, as well as the State of Hawaiʻi endangered species law. The Hawaiian population of the ʻakēʻakē was once recognized as a distinct subspecies. However, taxonomists now consider this population as sympatric with various other Pacific Ocean populations (Onley and Scofield 2007).

In 2011, the USFWS, as part of its review of the species for potential listing, determined that the Hawaiian breeding population of the Band-rumped Storm-Petrel constitutes a distinct population segment (DPS) based on geographic and distributional isolation from other Band-rumped Storm-Petrel breeding populations in Japan, the Galapagos Islands, and the Atlantic Ocean. Further, the USFWS determined that and the Hawaiʻi population segment is considered "significant" in that its loss would constitute a significant gap in the range of the taxon (USFWS 2015). The Hawaiian population of the Band-rumped Storm-Petrel is the only population within U.S. borders or under U.S. jurisdiction.

The ʻakēʻakē is a very small seabird with a total length of about 20cm and weighs 33-67g. The plumage of the ʻakēʻakē is overall blackish-brown, with a sharply defined narrow white band across the "rump." Its tail is slightly notched and may appear almost squared, unlike most other members of Hydrobatidae, which are more deeply notched (Harrison 1990) (**Figure 1-9)**. Its bill is dark and long.

Figure 1-9: ʻAkēʻakē – Band-rumped Storm-petrel. Photo T Anderson, SOS.

1.3.1. Distribution, Abundance, and Population Trends

The ʻakēʻakē species is widely distributed, occurring in both the Atlantic and Pacific oceans and in both tropic and sub-tropic waters. However, the Atlantic and Pacific breeding populations are considered distinct and are unlikely to intermingle due to the species' aversion to overland flights.

ʻAkēʻakē populations across the Pacific are isolated from each other. Extensive at-sea surveys of the Pacific near Hawaiʻi have revealed a broad gap in distribution of the ʻakēʻakē to the east and west of Hawaiʻi (del Hoyo et al. 1992, Slotterback 2002, Naughton et al. 2005). The Hawaiʻi population of the species is considered a distinct breeding population (USFWS 2015).

In addition, KESRP in 2016, KESRP participated in genetic study with the Queens University, Ontario. In the study, ʻakēʻakē from Kauaʻi were compared with other ʻakēʻakē from around the world. The results suggest that birds from Kauaʻi are genetically distinct from other populations (Taylor et al. in prep).

The ʻakēʻakē is thought to have been common on all the Main Hawaiian Islands when Polynesians arrived about 1,600 years ago (Mitchell et al. 2005, Naughton et al. 2005, Spear and Ainley 2007). As evidenced by abundant ʻakēʻakē bones found in middens on the island of Hawaiʻi, and in excavation sites on Lehua, Oʻahu, and Molokaʻi, ʻakēʻakē once were numerous enough to be used as a source of food and possibly for feathers (Mitchell et al. 2005, VanderWerf et al. 2007). The arrival of humans in the islands likely contributed to the decline of ʻakēʻakē populations (Naughton et al. 2005).

The total global population of the Band-rumped Storm Petrel is estimated at approximately 150,000 individuals (Brooke 2004). Kauaʻi supports most of the breeding population of Hawaiʻi although the exact number is unknown. The small size of the birds and the cryptic nature of their burrows, assumed to be on steep rocky cliffs and within the crevices of old lava flows, makes burrow searching through the usual means difficult and has further hampered population estimates (Raine et al. 2017b).

Though no nest has yet to be identified, human auditory surveys, automated acoustic surveys and mist netting data were used by Raine (Raine et al. 2017b) to create a predictive distribution model based on key habitat variables. Based on these and previous survey data, breeding is occurring primarily in the steep, remote cliffs areas of the Nā Pali coast in the northwest region of the island, Waimea Canyon, Hanapēpē Valley, rocky cliff faces of the vegetated valleys of Wainiha and Lumahai, and Lehua Islet (Wood et al. 2002, Raine et al. 2017b). KESRP has captured multiple birds along the Na Pali coast and Waimea Canyon in recent years with brood patches, strongly suggesting multiple breeding colonies on Kauaʻi. Additionally, retrieval of downed fledglings on Kauaʻi in the fall further points to local nesting locations (VanderWerf et al. 2007, Holmes and Joyce 2009).

There is evidence of potential breeding also on Maui, Hawaiʻi, Lehua and Kahoʻolawe (Johnston 1992a, b, Wood et al. 2002). Breeding has recently been confirmed on the slopes of Mauna Loa on Hawaiʻi (Galase et al. 2016), and on Lehua Islet a single, mummified fledgling was found in 2002 (VanderWerf et al. 2007). Specimens of the ʻakēʻakē have been collected from Niʻihau and Lehua and small numbers of adults (less than 10) have been heard on or seen flying around Lehua in 2002, 2003, and 2004 (Slotterback 2002, VanderWerf et al. 2007). Small breeding populations of unknown size are assumed to exist within barren lava flows at the tops of volcanoes like Haleakalā on Maui and Mauna Loa on Hawaiʻi (Harrison 1990).

1.3.2. Life History and Habitat Selection

Breeding phenology of the ʻakēʻakē on Kauaʻi is derived from the same data sources described above for distribution (Raine et al. 2017b). Breeding birds return to nest sites in May and complete egg laying by mid-June, and incubate until the beginning of August (Raine et al. 2017). The incubation period averages 42 days and fledging occurs 70 to 78 days after hatching (Harris 1969). Fledglings typically depart the nest site between mid-September and late November, with peak fledging in October (Raine et al. 2017b). ʻAkēʻakē reach breeding age in 3-7 years (Ainley 1984, Harrison 1990). Based on acoustic data, adults are believed to leave the nesting grounds in October as well (Raine et al. 2017b).

During the non-breeding season, some birds apparently remain near their breeding islands, while others undertake long-distance movements of unknown extent. The ʻakēʻakē has been detected west of the Galapagos Islands during spring but not during autumn counts; >620 miles north of Hawaiian Islands during summer surveys; and >990 miles south of Hawaiʻi in the Phoenix Islands, as well as the entire distance from the Hawaiian Islands to Japan (Slotterback 2002, Mitchell et al. 2005).
ʻAkēʻakē are classified as part of the nocturnal petrel feeding guild that catch prey by dipping into the ocean surface on the wing, or pattering the water with their feet, frequently consuming prey while floating on the water (Harrison 1990). Observations of foraging birds indicate the species feeds at internal wave crests, where prey is caught at or just below the surface (Spear and Ainley 1997, Mitchell et al. 2005). Its preferred foraging habitat may coincide with ocean depth or upwellings based on observations that 90% of individuals and 75% of all occurrences of the ʻakēʻakē were at upwellings (del Hoyo et al. 1992, Mitchell et al. 2005, Naughton et al. 2005). Based on stomach samples, prey includes small fish, squid, and crustaceans. These samples contain prey normally found in deeper water that migrate vertically to the surface at night (Slotterback 2002). Stomach samples from the Galapagos consist primarily of small fish (1.4-1.9 inches long) and squid with few crustaceans. No stomach samples have been collected from ʻakēʻakē of the Hawaiian Islands (Mitchell et al. 2005).

Preferred nesting habitat for the ʻakēʻakē breeding population on Kauaʻi include crevices and holes, often located along protected ledges on sheer cliffs and dry mesic cliffs. (Wood et al. 2002, Raine et al. 2017b). Plant communities in the vicinities of possible nesting areas include shrubs and grasses, common herbs, randomly distributed tree species, and dry mesic cliff species (Wood et al. 2001a, Wood et al. 2001b). Raine et al. (2017b) predicts highest occurrence of breeding in areas with low rainfall, little to no vegetation and greater than 40-degree slopes.

1.3.3. Threats to the Continued Existence of the ʻAkēʻakē

The primary threats to the ʻakēʻakē population on Kauaʻi include predation at breeding sites, breeding habitat loss and alteration, light attraction and power line collisions, disease, and at-sea factors affecting prey availability, global climate change, and stochastic events that are inherently a hazard to populations with a limited range. Each of these factors is discussed in more detail below.

1.4. Threats Affecting Covered Seabirds

Present day populations of seabirds in Hawaiʻi are much smaller than the previously rich and abundant avifauna that originally evolved on the isolated Hawaiian Islands with no terrestrial predators (Olsen and James 1982, Mitchell et al. 2005). The primary threats to the seabird populations on Kauaʻi include predation on breeding areas, breeding habitat loss and alteration, light attraction and power line collisions, disease, at-sea factors affecting the seabird prey-base, global climate change, and stochastic events. These factors are discussed below. The following sections describe threats that apply to ʻaʼo, ʻuaʻu, and ʻakēʻakē populations on Kauaʻi.

1.4.1. Predation at Breeding Colonies

One of the most serious threats to the survival of seabirds on Kauaʻi and the other MHI is depredation of adults, eggs, and chicks by introduced predatory species, including rats, cats, mongoose, pigs, and the barn owl (Mitchell et al. 2005, Griesemer and Holmes 2011b, Holmes et al. 2011). Rats prey on seabird eggs and chicks, and populations of storm-petrels in New Zealand and Japan have been completely extirpated due to rat predation alone (Jones and Byrd 1979, Hasegawa 1984). Feral cats, as well as barn owls, are known to kill the adults and nestlings of the endangered seabirds of Kauaʻi (Telfer 1986, Ainley et al. 1997a, Ainley et al. 1997b, Holmes et al. 2011, Raine et al. 2017b). Based on colony monitoring data from several breeding seasons, Ainley et al. (1995) and Telfer (1986) report concluded evidence that cats, rats, and owls were responsible for a decrease in adult and juvenile shearwater survival. Evidence of seabird predation by rats, cats, barn owls, and pigs was documented at all sites monitored by KESRP from 2011 through 2016 (Raine and Banfield 2015, Raine et al. 2017f, d, g, e, Raine et al. 2017h).

Seabird breeding burrows monitored by KESRP were commonly frequented by rats; in Upper Limahuli Preserve, one seabird burrow was visited by a rat 490 times over the span of 5,015 hours of recording (Raine and McFarland 2014a). Cats frequented seabird burrows to a lesser extent than rat visitations, though individual cats have been documented on cameras predating the adults and chicks from multiple nests in a matter of days (Raine and Banfield 2015). Depredation by feral cats at nesting sites on Kauaʻi has been heavily documented on camera by

KESRP, with an individual predator able to decimate a nesting colony and lead to colony extirpation, particularly when adults are affected (Igual et al. 2009, Raine and Banfield 2015). Several non-native animals, which can access the dry cliff nesting sites, are thought to prey on the ʻakēʻakē. These include feral cats, the small Indian mongoose on the Hawaiian Islands other than Kauaʻi, the non-native barn owl, and both Black and Polynesian Rats. A dead adult ʻakēʻakē was discovered in Nualolo Aina in 2014 that had been depredated by a Barn Owl (A. Raine, 2017, pers. comm.). Rat bones were also collected at abandoned ʻakēʻakē nest sites on Kauaʻi and storm-petrel species elsewhere in the Pacific have been significantly affected by predation (Wood et al. 2002).

The mongoose (*Herpestes javanicus*) has decimated seabirds and other native fauna on the other MHI and poses a high level of threat to all native fauna on Kauaʻi if the species becomes established on the island. To date, the mongoose has not been reported as present at active seabird conservation sites despite intensive camera monitoring. Historically, a female mongoose was reportedly found dead along a road in 1976 near Kalaheo, and sightings have since been reported intermittently all over Kauaʻi. Until recently it was thought that the mongoose was not established on the island of Kauaʻi. However, in 2012 two mongoose were captured in the vicinity of the Nāwiliwili harbor, with another recently captured at the Lihue airport in October 2016 (http://www.kauaiisc.org/mongoose/). The Kauaʻi Invasive Species Committee (KISC) encourages the public to report sightings of mongoose and each year lists multiple sightings as ʻcredible'. Early detection of new threats, and management of introduced predators and feral animals will continue to be vital to the recovery of the ʻuaʻu, ʻaʻo, and the ʻakēʻakē on Kauaʻi and elsewhere in the MHI (Hodges and Nagata 2001, Mitchell et al. 2005, Holmes et al. 2011).

Ungulate species such as feral pigs, goats, and deer, roaming forests and mountain slopes, can destroy or damage burrows and the vegetation surrounding them. In addition, feral pigs also eat eggs, chicks, and adults, and destroy the entire burrow in the process of reaching the birds at the end (Raine and McFarland 2014a). These feral species have played a significant role in modifying the breeding habitat of the ʻuaʻu and the ʻaʻo populations, and in exterminating seabird colonies in the Pacific and many locations worldwide (Harrison 1990, Le Corre et al. 2002, Igual et al. 2009, Furness 2012).

1.4.2. Habitat Degradation

Seabird nesting habitats on Kauaʻi and the other MHI have been severely degraded by the presence of invasive plants (Mitchell et al. 2005, Naughton et al. 2005, Holmes and Troy 2008). Plants such as *Cyathea cooperi, Hedychium spp., Albizia falcataria, Psidium spp*., and *Rhodomyrtus tomentosa* continue to displace and out-compete native vegetation in some of Kauaʻi's native mesic and wet forest areas. The presence of feral ungulates facilitates the spread and establishment of invasive plants, and accelerates soil erosion and habitat degradation which can destroy important breeding habitat. Grazing and trampling caused by pigs, goats, and deer both alter the vegetation structure and composition, which then can facilitate the dispersal of non-native predators into new areas following ungulate trails.

Many historic petrel and shearwater nest sites on Kauaʻi are no longer active due to both the presence of introduced predators and the alteration of native vegetation structure and composition. For example, the Kaluahonu seabird colony located in southeastern Kauaʻi once thrived but is now dominated by nearly pure and impenetrable stands of *Psidium spp., Hedychium spp.,* and *Rhodomyrtus tomentosa*. In the early 1980's this colony was found to be active and was monitored (Telfer 1986, Ainley et al. 2001a). However, a decade later biologists documented a significant drop in the number of breeding pairs at the Kaluahonu (Ainley et al. 2001a). Intensive surveys conducted by KESRP between 2006 and 2008 indicated that the colony has since been extirpated (Holmes and Troy 2008).

Holmes and Troy (2008) report that non-native vegetation cover was greater at inactive seabird colonies colony sites (Z=-1.98, P=0.047). When habitat composed of native vegetation is invaded by non-native plant species, vegetation structure is often dramatically altered, and shearwaters cannot access the ground readily to undertake breeding activities (e.g., burrow excavation, mate attraction). Non-native vegetation may also be a proxy for higher abundance of pigs, cats, and rats. Invasive plants, such as Strawberry Guava, provide food that support higher numbers of seabird predators. Proximity to human disturbed areas is another factor that accelerates habitat degradation and loss by increasing both light levels and the relative abundance of invasive plants and predators.

1.4.3. Light Attraction

Artificial lights can disorient and alter normal nocturnal flight behaviors in seabirds. This phenomenon, known as "light attraction," is characterized initially by an alteration in the birds intended flight path and circling of the light source, often ending with "fallout" when a bird is grounded at a location that it normally would not have landed (Reed et al. 1985, Telfer et al. 1987, Hallman and Holmes 2010). Once grounded, birds may experience difficulty taking flight again without clear "runways", cliffs, and updrafts. Grounded birds can suffer injury, starvation, predation, or collision (e.g., with vehicles).

Petrels and shearwaters around the world are negatively affected by "light attraction," (Montevecchi et al. 2006) - seabirds have been documented flying towards open fires and lighthouses and colliding with lights and nearby structures for hundreds of years (Avery 1979, Reed et al. 1985, Montevecchi et al. 2006). Fledglings are more affected than adults - most downed birds are fledglings grounded during their first flights from their natal nests towards the ocean (Rodríguez et al. 2017). Light-induced fatality of seabirds is recorded worldwide on at least 47 islands and three continental locations, across all oceans (Rodríguez et al. 2017). At least 56 out of the 113 burrow-nesting petrel species have been recorded grounded by lights (Rodríguez et al. 2017) and twenty-four grounded species are globally threatened according to IUCN criteria. Approximately 21 of 80 species in the order Procellariiformes are reported as being attracted to lights; many of those affected are endangered or threatened petrels and shearwaters (Imber 1975, Reed et al. 1985, Montevecchi et al. 2006).

Attraction and disorientation of seabirds at sea have also been reported, primarily on ships using artificial lighting for fisheries purposes, but also at oil platforms (Rodríguez et al. 2017) and at cruise ships (Rodríguez et al. 2015).

On the island of Kauaʻi, seabird fallout from the effects of light attraction has been known to occur for more than three decades (Telfer et al. 1987). In 1978, the State of Hawaiʻi Department of Land and Natural Resources (DLNR) initiated a community-based conservation effort, called Save Our Shearwaters (SOS), in which members of the public are asked to pick up fallout seabirds and turn them into "aid stations" located around the island (Telfer et al. 1987). The effort has continued since, currently funded by KIUC and slated to be continued under the long-term KIUC HCP. SOS has proven successful at engaging the island residents to retrieve fallout seabirds; since its inception, SOS has received some 32,000 seabirds (DLNR 2012). Moreover the SOS has program provided valuable information regarding the patterns and trends of seabird fallout over the years (DLNR 2016).

Of the Covered Seabirds, the ʻaʻo is the species most affected by light attraction fallout and is recovered by the SOS program. ʻAʻo make up over 90% of downed seabirds found on Kauaʻi each year, but ʻuaʻu are also turned into the SOS program. The petrels are less affected by light attraction, or may be breeding in colonies where their flight path to the ocean does not intersect with bright lights (Raine et al. 2017c). Far fewer ʻuaʻu and ʻakēʻakē are found grounded in comparison to the ʻaʻo (Telfer et al. 1987, Day et al. 2003a, DLNR 2016). Between the years 2000-2015, 24 ʻakēʻakē were recovered on Kauaʻi by SOS, likely from the effects of light attraction. It is possible that many more are affected since their small size may make them especially susceptible to scavenging and increasingly difficult to find and report after fallout events.

A wide range of light pollution sources can individually and cumulatively affect seabird behavior including those at athletic parks and stadiums, airports, harbors, streets, parking lots, resorts, industrial facilities, cruise ships, individual homes, and car head lights (Reed et al. 1985, Le Corre et al. 2002, Raine et al. 2007).

While cause and effect relationships are complex and not fully understood, some factors appear to contribute directly, indirectly and cumulatively to the relative sensitivity of petrels and shearwaters to artificial night lights. These factors include physiology, nocturnal behavior, behavioral experience (i.e., age), weather, lunar phase, and light intensity (Reed et al. 1985). Light attraction is a complex phenomenon and there may be factors other than those listed above that have yet to be discerned.

1.4.3.1. Physiology and Nocturnal Behavior

Nocturnal seabirds often feed on bioluminescent prey, a feeding strategy that is associated with high light sensitivity (Montevecchi et al. 2006). Nocturnal species, like the ʻaʻo, tend to have larger eyes that contain more rods and rhodopsin than diurnal species, (McNeil et al. 1993). In addition, nocturnal species orient flights with specific star patterns (Reed et al. 1985). Artificial light is thought to reduce or interfere with a nocturnal seabird's ability to navigate using celestial cues.

1.4.3.2. Age

Fledglings are significantly more sensitive to light attraction than adult seabirds as they take their first flight from nest sites to the sea (Telfer et al. 1987, Ainley et al. 1995b, Le Corre et al. 2002). Adults experience attraction to lights, based on observation of circling birds prior to the fallout season, but there are many fewer adult birds turned into the SOS program, suggesting less fallout from more experienced birds. However, adult seabirds may be more vulnerable to the effects of light attraction when bright lights are present close to breeding colonies, such as the significant fall-out events at the Koke'e Air Force Station in 2015 (Raine 2015, Raine et al. 2015b).

1.4.3.3. Lunar Phase

Lunar phase is undoubtedly a critical component of the life history of nocturnal seabirds (Imber 1975, Telfer et al. 1987, Montevecchi et al. 2006, Rodriguez and Rodriguez 2009). Nocturnal departure from nest sites provides a survival advantage for adults and fledglings. However, the presence of artificial lights at night appears to interfere with these natural behaviors. Holmes (2010) compared SOS program fallout data and moon phase over 30 years showing that moon cycles and SOS program peak fallout levels are significantly correlated. SOS program data indicate that fledgling fallout increases during the new moon phase, when artificial light intensity is higher relative to moon light, and decreases during the full moon phase while the small numbers of adults downed increases during the full moon period (**Figure 1-10**; DLNR 2012, (Telfer et al. 1987, Rodriguez and Rodriguez 2009, DLNR 2016).

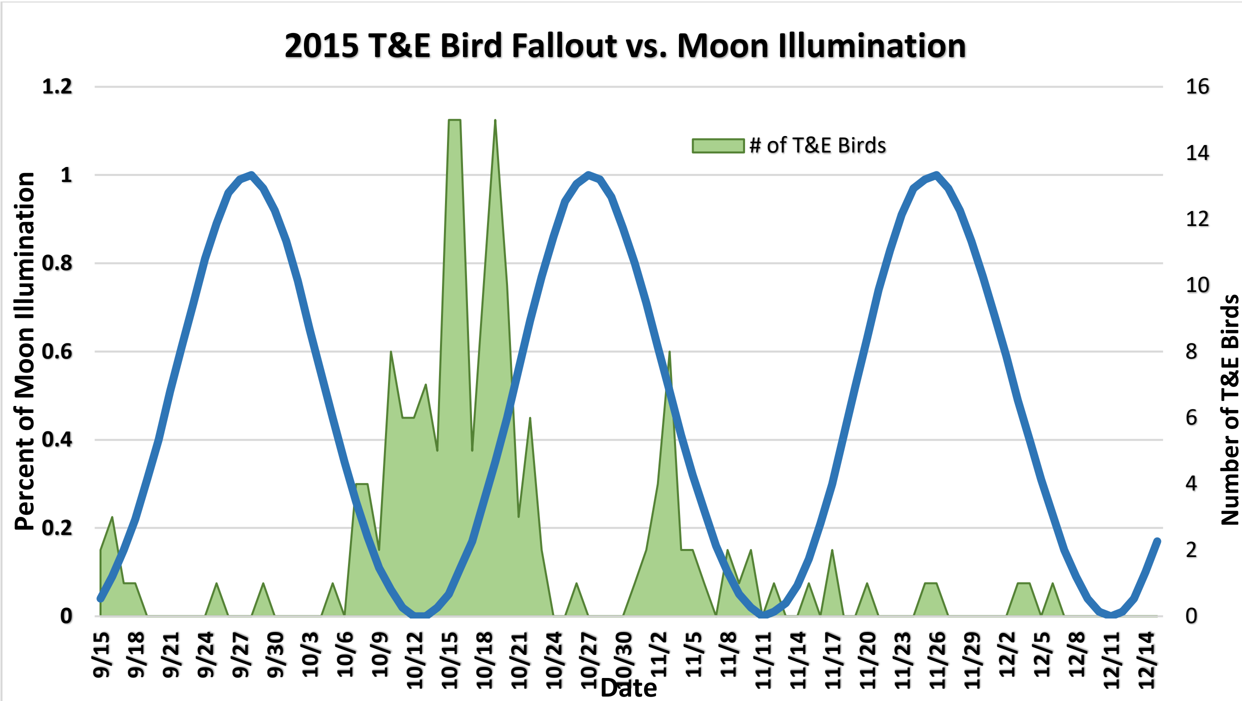

Figure 1-10: 2015 Threatened and Endangered (T&E) seabird fallout and moon illumination**.**

1.4.3.4. Light Intensity

Telfer et al. (1987) report that the number of fledgling seabirds that fallout and are turned into the SOS program on Kauaʻi is strongly related to the number and distribution of lights (i.e., light intensity or amount of upward radiation) that attract seabirds. The Covered Seabirds appear most attracted to the actual source of the light (i.e., the bulb), but are also affected by ambient, or reflected, light (Reed et al. 1985, Telfer et al. 1987). Additionally, multiple sources of high intensity lights can draw birds down to lit areas (Hailman 1979, Reed et al. 1985, Reed 1987, Telfer et al. 1987, Podolsky et al. 1998).

Hallman and Holmes (2010) conducted a short pilot study on Kauaʻi with ornithological radar to measure changes in the numbers and flight behavior of ʻaʻo and ʻuaʻu in the presence and absence of a major artificial light source. On nights before and after the use of high intensity lights, 90 and 97% of radar targets (i.e., individual seabirds) were observed flying in a straight line. This would be defined as a “normal” flight pattern. However, on nights when high intensity lights were used, 79% of the birds flew in straight lines but 21% displayed circling and erratic flight behavior associated with light attraction and fallout.

Troy et al. (2011) developed a GIS-based method to model the intensity of artificial light and aerial visibility to fledgling seabirds as they fly to the ocean (to estimate the degree of threat that artificial light poses to these birds). The two models suggest that there are few to no portions of Kauaʻi from which young birds could fledge and not view light on their post-natal nocturnal flights. Although the north shore of the island is among the darkest, it also supports the highest densities of Covered Seabird breeding colonies and therefore represents a high risk area to fledglings if light visibility is not reduced and managed. The GIS models developed by Troy et al. (2011) can facilitate risk assessment at the colony scale so that land managers can more efficiently determine where to allocate limited resources to protect birds.

The areas on Kauaʻi with the lowest light intensities are those that support the largest remaining ʻaʻo and ʻuaʻu breeding populations (**Figure 1-11**). Areas on the northwest coast are the farthest away from areas with highest light intensities. Currently efforts are being made to define a No Light Conservation Zone (NLCZ) located on the northwest quadrant of Kauaʻi (USFWS 2016). The NLCZ would essentially encompass the largest contiguous area on the island with no viewable lights and access to the coast. This would help to identify sites that are most suitable for management.

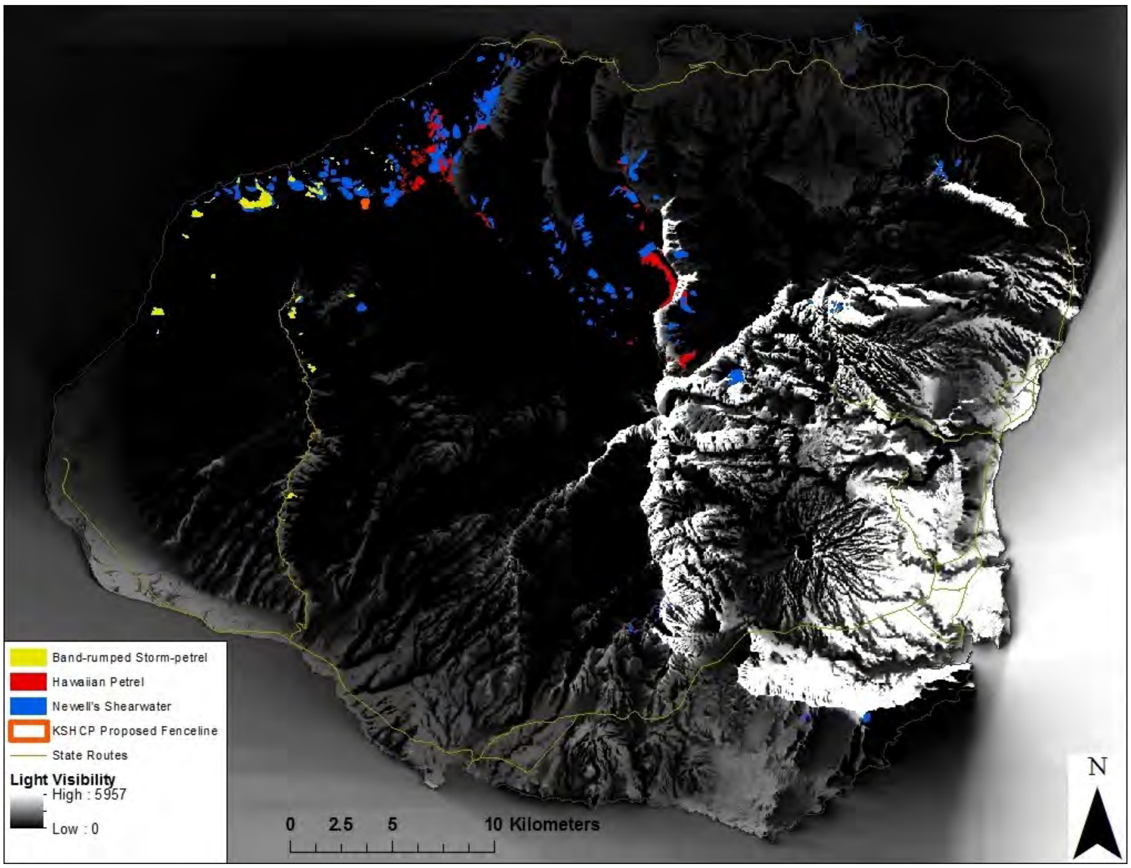

Figure 1-11: Light pollution measured via satellite overlaid with locations of active and inactive shearwater colonies. Source of light information: Troy et al. (2011); Source for colony locations: KESRP.

1.4.4. Collisions with Utility Structures

Collisions with utility structures are a known threat to seabirds in the Hawaiian Islands. On Kauaʻi, utility structures include power lines (energy electrical transmission and distribution lines) and associated structures. Specifically, the power lines traverse the island and are largely above ground, consisting of poles and wires that extend to more than 100 feet tall. Collisions between birds and these facilities have been documented and the effects of these collisions on the population have been estimated to negatively impact the Covered Seabirds (Ainley et al. 1995a, Griesemer and Holmes 2011a, Travers et al. 2012, Travers et al. 2014, Travers et al. 2016). Areas in the northwest region of Kauaʻi were evaluated as the least likely to be impacted from threats of lights and power lines, based GIS mapping for proximity to overhead power lines, monitoring data, and wildlife agency analysis.

The types of injures that have been documented on downed birds of the Covered Seabirds include broken spines vertebrae and limbs, and concussions, often leading to death. Loss of plumage waterproofing due to shearing off of feathers during a collision can also negatively impact seabird survival (T. Anderson, 2016, pers. comm.). When a breeding adult is killed or injured during the incubation or chick provisioning period, the likelihood of complete nest failure is very high because the remaining adult is not able to incubate or care for the chick alone. Seabird nestlings depend on a steady supply of food from both parents. In cases when this does not occur, fledgling survival is reduced, as during chick-rearing, the chick would receive less food and the survival of the chick would be lower because fledgling survival increases directly with body mass (Brooke 1990). Unfortunately, power line collisions are more likely to occur with breeding adults, as they are transiting back and forth from the colony to the ocean feeding grounds on a nightly basis to provision chicks.

1.4.5. Disease

Introduced avian diseases, such as avian malaria, pose threats to all native Hawaiian fauna (Mitchell et al. 1995). Human activities, as well as those of ungulates and non-native birds and mammals, can facilitate the spread of disease. After finding evidence of avian malaria in a blood sample of a juvenile ʻuaʻu in the 1960’s (Warner 1968) posited that avian malaria and other mosquito borne diseases may have had serious impacts to already the vulnerable native Hawaiian seabird populations. Subsequent testing of a small number of ʻuaʻu by van Riper III and Barbee (1978) and Simons (1985) did not find any evidence of avian malaria infection. Although the extent to which avian malaria has impacted the survival of the Covered Seabirds is unknown, recent research suggests that blood parasites are often absent or rare in seabirds (Quillfeldt et al. 2010). However, in recent years the SOS program has opportunistically recorded avian malaria in a ʻuaʻu and avian pox in individuals of the Covered Seabirds and further research is planned to better assess this potential threat.

1.4.6. At-sea Threats

During their time at sea, the Covered Seabirds encounter many dangers that include threats posed by the fishing industry, the presence of marine debris, light pollution, oil spills, and the presence of persistent chemical pollutants such as heavy metals and organochlorines in the food chain (Olsen and James 1982, Harrison 1990, Mitchell et al. 2005).

The true extent of impacts from fisheries on the Covered Seabirds is unknown, but many seabird species are heavily affected by mortality and injury (termed “bycatch”) caused by fishing methods and equipment (Furness 2003). Fishing can also cause reduced density of prey aggregations available to seabirds (Spear and Ainley 2007). Overharvesting of skipjack *(Katsuwonus pelamis),* and yellowfin tuna (*Thunnus albacares*) could eliminate predatory fish needed to drive small prey species to the surface where they are available to foraging seabirds. Such a factor would increase required prey searching and foraging effort by seabirds to provision offspring, ultimately affecting annual reproductive success and adult seabird survival. The ʻaʻo is not as efficient in flight as other 'tuna birds' (Spear and Ainley 1997), therefore increasing prey search is especially perilous to this species.

Ocean debris harms a variety of marine biota, including fishes, turtles, birds, and mammals by causing entanglement and ingestion (Azzarello and Van Vleet 1987, Laist 1987). Industrial and user-plastics composed of polystyrene, polypropylene, polyethylene, Styrofoam, and polyvinyl chloride have become widespread sources of marine pollution that disperse and accumulate in response to surface currents, wind patterns, and different geographic inputs (Azzarello and Van Vleet 1987). Procellariformes are most vulnerable to the effects of plastic ingestion due to their smaller gizzard and their inability to regurgitate ingested plastics. The recent work by Kain et al. (2016), found that the frequency of ingestion of plastics in ʻaʻo fledglings has increased since the 1980's from 11%-50%, with 70% of the plastics classified as microplastics. The physiological effects related to the ingestion of plastics include obstruction of the gastro-intestines, blockage of gastric enzyme secretion, diminished feeding stimulus, lowered steroid hormone levels, delayed ovulation and reproductive failure (Azzarello and Van Vleet 1987).

Oil spills and pollution events within the water column and on the surface can cause mortality of adult and juvenile seabirds at any time of the year and are best managed through effective prevention plans and rapid response and containment. Oil spills can have particularly devastating effects on small populations when a release occurs at locations and times of the year when species are congregated in a small area, such as in waters near breeding colonies, or at sea where seabirds feed or raft. Though heavy metal content in the Covered Species has not been investigated, seabirds feeding on mesopelagic prey, as the Covered Species do, have been found to have increased mercury levels (Ochoa-Akuna et al. 2002, Elliot and Elliot 2016). Sources of light pollution at sea include lights on fishing vessels, cruise ships, as well as offshore petroleum and gas facilities (IDA 2003, Van De Laar 2007, Rich and Longcore 2013). These types of at- sea facilities can affect the normal foraging and predator avoidance behaviors of seabirds (Weir 1977, Wiese et al. 2001).

1.4.7. Global Climate and Biome Changes

Anthropogenic environmental changes are one of the most pressing contemporary threats to global biodiversity. Changes in the earth's climate and biomes from human industrial activity are expected to result in regional changes in weather patterns and ocean productivity that are further predicted to affect seabird populations as well as other plant and animal communities in Hawaiʻi.

Changes anticipated in Hawaiʻi may include, but are not limited to, increased thermal stratification of the ocean, increased frequency of El Niño conditions, and changes in ocean productivity (Sarmiento et al. 2004). Rising average temperatures on the islands in the last 30 years, in line with global trends, has also been documented (Giambelluca et al. 2008). Furthermore, seabird breeding habitat could be affected by increasingly severe weather events (e.g., increased storm frequency caused by increased El Niño frequency, increased drought intensity). Invasive plant species are also expected to spread with increased temperatures (IPCC 2014). A rise in sea level of approximately 1m is anticipated by the end of the 21st century within the State of Hawaiʻi (Fletcher 2009), but this rise in sea level is not expected to directly affect known nesting habitat of the Covered Seabirds.

1.4.7.1. Changing Ocean Conditions and Seabird Foraging

An El Nino/Southern Oscillation (ENSO) event is characterized by anomalous sea surface temperature warming along the equator in the eastern Pacific Ocean and cooling in the west (Philander 1990). These events have global impacts on climate and usually occur every three to seven years. In Hawaiʻi, ENSO events are characterized by dry winter conditions, weaker trade winds, and increased frequency of hurricanes near the islands (Chu 1995, Chu and Wang 1997, Cao et al. 2007). With climate change, there is an expected increase in frequency of extreme ENSO events and associated disastrous weather events (Cai et al. 2013, Latif et al. 2015). The frequency of tropical cyclones is expected to increase ~20-40% during ENSO events (Chand et al. 2017). While changes to natural systems globally and regionally are generally predicted with a degree of confidence (Bernstein et al. 2007), predicting effects at a local scale and to specific species is difficult. However, some predicted climate change scenarios could impact the Covered Species. One of the most likely things to be directly impacted via changes in climate patterns is at-sea foraging. Polovina et al. (2011) present a useful "biome" change model to analyze changes in ocean productivity relating to climate change. Their "biomes" correspond to distinct areas of phytoplankton density which is associated with different physical drivers like gyres and upwelling (**Figure 1-12**).

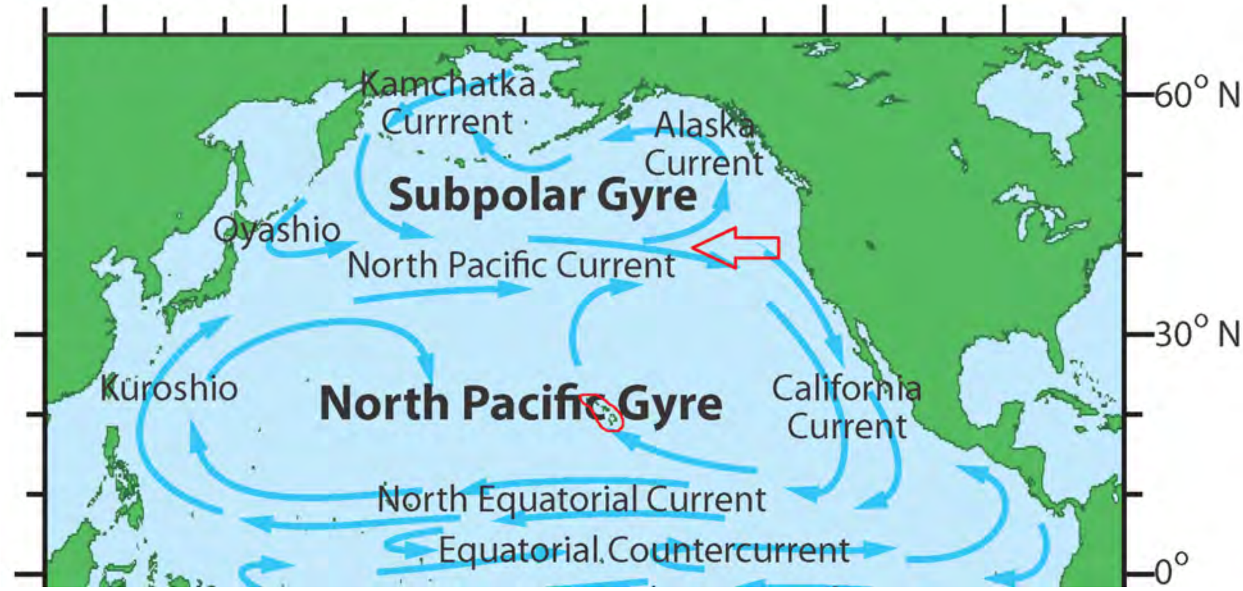

Figure 1-12: System of gyres and currents in the North Pacific. The main Hawaiian Islands are circled in red. The red arrow points to the Transition Zone where the subpolar and subtropic gyres mix. Figure credit: http://www.seos-project.eu/modules/oceancurrents/oceancurrents-c02-p04.html

With regards to the temperate feeding grounds of the ʻuaʻu and possibly the ʻakēʻakē, Polovina et al. (2011) predict that the productive temperate biome of the North Pacific, which corresponds with the subpolar gyre productivity zone, could contract by 34% by year 2100. Decreasing arctic sea ice during the summer appears to be decreasing winter winds across the North Pacific (Jaiser et al. 2012). This leads to less sea surface cooling during winter and less mixing at the transition zone (TZ) between the nutrient rich subpolar gyre and nutrient poor subtropic gyre which leads to less primary production and a north shifted TZ (Bond et al. 2015, Whitney 2015). Shifting of known ʻuaʻu foraging areas at the TZ would take place with a projected 30% subtropical biome expansion, and the previously mentioned temperate biome reduction (Polovina et al. 2011). In short, Hawaiian Petrels would have to fly farther north to reach historically used foraging locations.

Change in wind patterns and evidence of shifting biome size has already been observed (Polovina et al. 2008, Polovina et al. 2011, Bond et al. 2015, Whitney 2015). Ichii et al. (2011) found that flying squid populations, a preferred prey of the Covered Seabirds, have been shown to respond quickly to shifts in productivity zones. These shifts can have dramatic results for higher trophic level predators. In 2014, large scale die-offs of Cassin's Auklets, a species that relies on the productive food web, were documented related to warming (Opar 2015). Many other anomalies, like large whale and sea lion mortalities, have been documented in other species related to this period of warming oceans (Bond et al. 2015, Di Lorenzo and Mantua 2016).

With regards to the known feeding areas of the ʻaʻo, ʻuaʻu, and ʻakēʻakē along the Equatorial Counter Current, the size of the biome is expected to contract by 28% by year 2100. Primary production is expected to increase by 17.1% within this biome but the reduction in area could shift productive zones and make foraging more difficult for the Covered Seabirds. Production is also expected to shift east, and tuna, a predator that ʻaʻo associate with when foraging, are expected to decrease in waters west of 170°E (Bell et al. 2013). There is known foraging habitat of the ʻaʻo west of 170°E and the act of tuna driving prey closer to the surface is very important to Newell's foraging success (Au and Swedberg 1966, Spear et al. 1995, Raine et al. 2015a, Raine et al. 2017a). The subtropical biome, which likely provides more local foraging for the Covered Species, is also expected to increase primary production by 26% by 2100. Though with an increase in total area of 30%, productive zones could be more patchy and foraging success could be affected (Polovina et al. 2011).

Surman et al. (2012) found that migratory bird species appear to have more difficulties adapting foraging to oceanographic variability. Also, increases in sea surface temperature, even at smaller temporal scales (i.e. daily), appear to impact foraging success and chick growth in the related Wedge-tailed Shearwater (Peck et al. 2004).

Changes in marine organism distribution is also likely to occur in response to expanding low oxygen, low productivity zones in the ocean (IPCC 2014). With warming surface waters, growth of low oxygen zones is more likely to occur (Altieri and Gedan 2015). Expansion of low oxygen zones that already occur in the North Pacific and around the Northwestern Hawaiian Islands would directly impact the Covered Species (Polovina et al. 2008). These factors are also expected to cause the body mass of a variety of fishes to decline (Cheung et al. 2013). This could also affect the food abundance and availability for the Covered Seabirds.

Ocean acidification is another outcome of human industrial activity. Since the beginning of the industrial revolution, atmospheric carbon dioxide has increased by nearly 40% from burning fossil fuels and deforestation. Oceans have taken in about a third of the carbon dioxide produced and this has disrupted chemical balances in the oceans and made them more acidic (Doney et al. 2009). Marine ecosystems are expected to be impacted by the predicted increase in ocean acidification, though with different responses from different taxonomic groups (Kroeker et al. 2013). From experimentation, mollusks, including squid, show slowed development and decreases in larval survival, growth, and abundance with increased acidification (Kaplan et al. 2013, Kroeker et al. 2013). Other groups, like diatoms and fish, may benefit from acidification though it is difficult to predict how all these groups will respond in the complexity of a natural system (Kroeker et al. 2013).

1.4.8. Changing Habitat Conditions and Nesting

Climate change is expected to bring an increase in the intensity of storms (Knutson et al. 2010). Hurricanes can have a large effect on the native species of Hawaiʻi. The impact of Hurricane Iniki may have pushed three endangered forest bird species to extinction. Hurricanes also have an impact on the Covered Species, as Hawaiian hurricane season is during their breeding season. Downed trees and debris could easily block birds from burrows or trap them inside. Following Hurricane Iniki in 1992, aerial surveys were conducted that found heavy vegetation damage and landslides at known ʻaʻo colonies. At Kilauea Point, the closely related Wedge-tailed Shearwater was found to have suffered 30-40% chick loss from the hurricane (Day and Cooper 2002).

In the cloud forests of Maui, native and non-native plant species "temperature tolerance zones" are expected to shift upward approximately 400m (Loope and Giambelluca 1998), assuming the projected rise in air temperature at sea level of 2-2.5°C likely by 2060 (Joshi et al. 2011). This is likely to occur as the documented warming on Hawaiʻi continues (Giambelluca et al. 2008, Keener et al. 2012). Additionally, trade winds, which bring precipitation to Hawaiian windward coasts, have decreased since the 1970s (Collins et al. 2010).

Although difficult to predict, studies suggest a decrease in rainfall across the Hawaiian Islands, with a larger contrast in precipitation between the drier leeward sides versus the wetter windward sides (Timm et al. 2016). Decreases in precipitation combined with higher temperatures could increase the spread of non-native species which has potential to alter the breeding habitat of the Covered Seabirds (Bernstein et al. 2007, IPCC 2014). This will allow more invasive plant species to live in montane forests than currently do. The warmer temperatures may also be beneficial to introduced plants that are better adapted for nighttime respiration at higher temperatures than the native plants of the cloud forests (Alward et al. 1999).

This decreased rainfall has the potential to increase drought resulting in increases in forest fires (Hawaiʻi 2014). Along with the aforementioned increase in cyclones, these types of disturbances are more dramatic and can allow faster colonization by invasive species. All of these changes are expected to allow invasive species to more easily invade native forests and alter habitats (Loope and Giambelluca 1998).

1.5. Honu – Green Sea Turtle

1.5.1. Distribution and Population Trends of the Honu

The honu is one of seven sea turtle species found globally (Eckert et al. 1999). In 1978, the honu (*Chelonia mydas*) was listed as threatened under the Endangered Species Act (ESA) throughout its global range (NMFS and USFWS 1998, 2007). This listing was revised in 2016 with a ruling that designated a status for 11 "distinct population segment (DPS);" the Hawaiian population that is in the North Pacific population DPS was listed as threatened (USFWS 2016a). Honu are fully protected under Hawaiʻi Revised Statues Chapter 195D and Hawaiʻi Administrative Rules 13-124. The Hawaiian honu as a "subpopulation" is currently listed as "least concern" by the International Union for the Conservation of Nature (IUCN) a change in status from "endangered" that reflects updated scientific evaluation of the honu population in Hawaiʻi (Pilcher et al. 2012).

Adult honu average 3 to 4 feet in length and can weigh up to 200 pounds (NMFS and USFWS 1998). Honu can live up to 80 years of age. The term "green" applies not to the external coloration, but to the color of the turtle's sub-dermal fat (NMFS and USFWS 1998). The color of an adult carapace (shell) is light to dark brown, sometimes shaded with olive, with radiating wavy or mottled markings of a darker color or with large blotches of dark brown (**Figure 1-13**).

Figure 1-13: Female honu or Hawaiian Green Turtle laying a nest. Photo www.turtletracks.org.

The honu in Hawaiʻi nests primarily in the French Frigate Shoals of the Northwestern Hawaiian Islands and to a lesser degree on the main Hawaiian Islands (Balazs et al. 2015, NMFS and USFWS 2015). The French Frigate Shoals population constitutes 96% of the total Hawaiian Islands population, with the nesting habitat on the main Hawaiian Islands having been severely contracted by habitat loss and modification for commercial construction (USFWS 2016a).

Long-term monitoring of honu populations has been undertaken in Hawaiʻi, with over 40 years of data showing that the Hawaiʻi population has increased at a rate of approximately 5.7% annually since the harvest limits were imposed in 1974, (under State of Hawaiʻi regulation 36), following near extinction (Chaloupka and Balazs 2007, Maison et al. 2010, Tiwari et al. 2010). In 2015, the current number of breeding females was estimated at around 4,000 individuals (Balazs et al. 2015). The number of nesting Green Sea Turtles at East Island at French Frigate Shoals has tripled since monitoring began in 1973 (**Figure 1-12**) (NMFS and USFWS 1998, Balazs and Chaloupka 2004b).

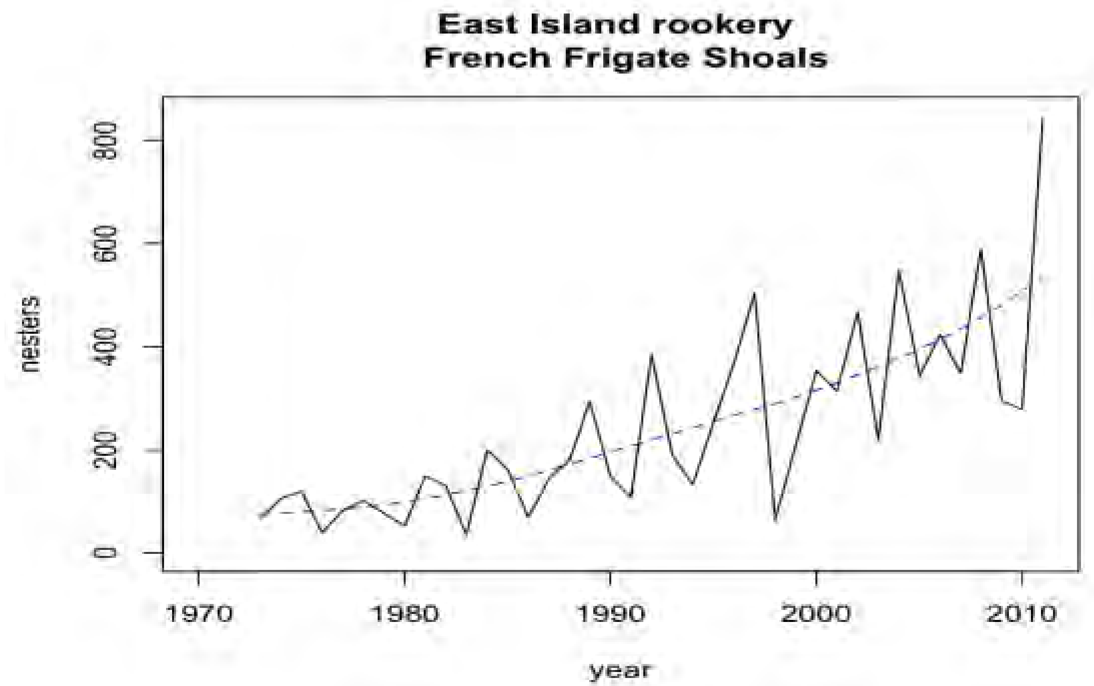

Figure 1-5: Estimated number of Hawaiian green turtles nesting at East Island, French Frigate Shoals, NWHI, 1973-2011. Table source: NMFS Pacific Islands Fisheries Science Center Marine Turtle Research.

Habitats needed for honu nesting, basking, underwater resting, and foraging are found along the shores of all the main Hawaiian Islands. Monitoring by State of Hawaiʻi staff biologists and NOAA volunteer observers has documented increasing levels of honu nesting on Kauaʻi. Terrestrial basking by honu is also reportedly on the rise in the other main Hawaiian Islands. On Kauaʻi, there are an estimated eight basking and twenty nesting beaches used by honu (Parker and Balazs 2015). Some of the known nest locations are near urbanized coastal areas along the east and south shores of Kauaʻi where coastal light pollution exists.

1.5.2. Life History and Habitat Selection of the Honu

Hawaiian honu reach breeding age at approximately 25 years. Females return to the same beach, or region of coastline, where they hatched to lay their eggs (Balazs 1980, NMFS and USFWS 1998, Balazs and Chaloupka 2004b). Females return to nesting beaches on Kauaʻi from mid-May through late August to lay eggs in the nests excavated in beach sand. During the cool of the night, females arrive on the beach and upon reaching the high-tide mark use front flippers to dig a wide pit, into which they carefully dig an egg chamber using rear flippers. Within the chamber approximately 100 leathery-skinned ping-pong-ball-sized eggs are deposited and covered with sand.

Once finished laying eggs, the female returns to the sea and will not return to care for the eggs or hatchlings. Female honu lay eggs every two to three years and will deposit three to six clutches per nesting season with an average of twelve days in between. The eggs will incubate in the sand for 60-65 days (Balazs 1980, NMFS and USFWS 1998, Balazs and Chaloupka 2004a). Depending on the lay date, hatchlings can emerge from nests in July through late November-early December (Balazs 1980).

Honu hatchlings dig upward in a communal effort to reach the surface, an effort that may take 2-3 days to complete. Hatchlings typically emerge from the sand at night (Balazs 1980; NMFS and USFWS 1998). Newly emerged hatchlings are strongly photopositive and can be disoriented away from their path to the sea by artificial lighting (Witherington 1992, NMFS and USFWS 1998). Hatchling mortality levels are high particularly during the first hours of emergence due to many causes (Gyuris 1994). The young turtles are thought to stay in the open ocean for the next 5 to 10 years before they begin foraging in nearshore habitat (Parker et al. 2011).

Young oceanic turtles and adults, which occasionally forage in the open ocean, feed on pyrosomes, various species of sea snails, amphipods, and different species of cnidarians (Parker et al. 2011). In nearshore habitat, the preferred foraging areas are generally protected or partially protected bays where benthic macroalgae grows, a preferred food source (Balazs et al. 1987, NMFS and USFWS 1998). Honu that have grown large enough to reside in the nearshore benthic environment have an almost entirely herbivorous diet consisting of selected macroalgae and sea grasses.

Honu feed most actively at dawn and dusk and alternate between periods of active foraging and rest (Balazs et al. 1987, NMFS and USFWS 1998). During these rest periods, they retreat to deeper water and seek out shelter in caves and outcroppings. These resting areas are usually within 1.2 miles of foraging areas and at the edge of the coastal bench surrounding the Hawaiian Islands. Turtles may also rest in vertical holes or crevices in the reef flat. Turtles can spend long periods underwater while resting; resting times up to 2.5 hours have been recorded for adult turtles (Balazs et al. 1987).

Behavioral changes have been observed in the population over time, which are probably a direct consequence of the success of management and conservation actions in Hawai‘i. For example there have been changes since the early 1980’s in foraging strategies and habitat use from predominately deep night-time foraging to daytime nearshore waters and an increased scope and magnitude of basking events and tolerance to humans (Whittow and Balazs 1982, Balasz 1996, Parker and Balazs 2010).

1.5.3. Threats Affecting the Honu

The 2016 final listing ESA ruling by the USFWS identified the biggest threats facing the population of honu found in the Hawaiian Islands as habitat loss and degradation, fisheries bycatch, ingestion of marine debris, vessel activities, disease, and predation. Predation of hatchlings by feral cats is known to be a problem for sea turtles in other nesting sites around the world (Seabrook 1989, Hilmer et al. 2010). The limited nesting range of the honu has made the Hawaiian Islands population more vulnerable to habitat loss from increased stochastic events and sea level rise associated with climate change. The adult population in the main Hawaiian Islands is at risk from fisheries interactions, marine debris, and vessel strikes. Nearshore foraging habitat is also impacted by pollution and development. The main disease impacting Hawaiian honu is *fibropapilloma* which causes large tumors and is the main cause of strandings in the Hawaiian population (Work et al. 2015). The tumors can block vision, disrupt locomotion, disrupt organ function if they are internal, and impede breathing if they are located in the throat. The prevalence of the disease in turtles of the MHI appears to be associated with coastal pollution and invasive macroalgae (Van Houtan et al. 2010).

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3. PERSONAL COMMUNICATIONS

Tracy Anderson, 2016, SOS Coordinator, Kauaʻi Humane Society.
Don Heacock, 2012, Biologist, Division of Aquatic Resources, Kauaʻi.
Dr. Andre Raine, 2017, Manager, Kauaʻi Endangered Seabird Recovery Project.

Appendix C:
Social Attraction Benefit Estimator

Appendix C. Social Attraction Benefit Estimator

MODEL TO ESTIMATE SOCIAL ATTRACTION SITE (SAS) BENEFIT TO THE NEWELL'S SHEARWATER (*Puffinus newelli*)

INTRODUCTION:

The Kauaʻi Seabird Habitat Conservation Program (KSHCP) is an island-wide program to coordinate mitigation for permitted light attraction "take" of Newell's Shearwater. The KSHCP aims to offset take and provide conservation benefit to this species by increasing productivity at breeding colonies. The primary mitigation strategy proposed for the KSHCP is to fund a predator-proof fence enclosure as a social attraction site, and the question arose as to how to determine the estimated benefit to seabirds from the selected project. KSHCP staff requested to work with Adam Vorsino (USFWS) directly on development of this social attraction site (SAS) estimator model. The KSHCP and USFWS have worked collaboratively to refine and improve the SAS estimator model.

In this document we describe the components of the SAS estimator model, and also the inputs that were used to assess mitigation benefit for a social attraction site at a selected location on the Kalalau Rim, on the north shore of Kauaʻi . The Hawaiian name for this area of land is Kahuamaʻa, and thus this project is to be named the Kahuamaʻa Seabird Preserve. At this site, a predator proof fence will be installed, predators will be eradicated, native vegetation maintained and restored as needed, and social attraction for Newell's Shearwater will be conducted over the 30 permit term of the KSHCP. The document describes how the model could be used to assess other locations as well.

MATERIALS AND METHODS

The basic premise of the SAS estimator model is to compare productivity of a "colony" of Newell's Shearwaters within a predator proof enclosure to productivity outside of it (in a full predation scenario). The difference in production between the sites is the measure of benefit to the species from conducting the social attraction project. The model assumes that birds flying in could land and initiate breeding either within the fence, or in a simulated "parallel" site of the same size with no predator control. This model assumes that other threats to the population are not present (i.e. light attraction fallout and line collisions). This is based on the criteria of selecting a social attraction site located away from the threats of lights and lines so that maximum production can be achieved within the fenced area.

Some of the parameters are numerical inputs derived from various sources including project plans, literature citations, calculations from relevant data, and other supporting evidence. Details on these adjustable model parameters are described below, and summarized in Table 4. These parameters are designed for simple user input into R-studio, or other R-code program, allowing the user to make quick adjustments and run multiple model iterations, often necessary during the planning process.

Other important components of the SAS estimator model have been written into the R code by the program author (A. Vorsino, USFWS) and require edits to the model R code to adjust. Details on these set model parameters are also described below, and summarized in Table 5.

ADJUSTABLE MODEL PARAMETERS

Fencing completion year/Start broadcasting year:

Description:

This parameter defines the start of audio broadcasting to begin attracting Newell's Shearwater. The model assumes that the project starts in Year 1, and the user determines what year the fencing and predator eradication will be complete, and what year you will begin broadcasting seabird calls to initiate social attraction to the site. The importance of delineating this parameter is that seabird benefit will not be derived until fencing, predator eradication and audio broadcasting is complete, so it is critical to identify a starting point.

Input for KSHCP model:

Fence completion and start of audio broadcasting will be by Year 2 of the KSHCP implementation. Year 1 of the project will consist of preparing the site, initiating fence construction, and working to remove predators from the site. Broadcasting of seabird calls will begin once predator eradication is complete, and we expect predators to be removed by the end of Year 1. For the KSHCP, we are assuming Year 0 is the time the model was run (2016), Year 1 is 2017 and Year 2 is 2018. The model is not specific to the month, and represents a calendar year, not directly tied to a seabird breeding season. Fortunately, a breeding season is typically encapsulated within a calendar year (March 15 April-–December 15).

Predation estimate:

Description:

The predation scenarios used in the SAS estimator model to assess the Kahuamaʻa Seabird Preserve were created to specifically reflect estimated levels of predation for Newell's Shearwater on the Island of Kauaʻi. The predation scenarios define the baseline condition outside the fenced social attraction site. The predation scenarios used in this social attraction site model were derived from two primary data sources, KESRP monitoring data and Griesemer & Holmes (2011). Predation impacts are expressed in the model as changes to the species' demographic life history parameters (see description in set model parameters below).

Predation scenario 1 is based on analysis of KESRP data from colony monitoring 2011-2013 at several sites on the north shore of Kauaʻi (Hono O Nā Pali, Upper Limahuli Preserve). KESRP estimated predation effects for 100 breeding pairs per specific predator. Total population is assumed to be a composite of egg/chick (year 0-1), sub-adult (year 2-5) and adult (year 6+). Using stable age distribution and reproductive probability, total number of eggs/chicks, sub-adults, and non-breeding adults was extrapolated from the breeding pair estimates, and predation effects for these age classes was defined. Any predation of a breeding adult would translate to loss of a chick as well, so chick predation rates reflect direct and indirect mortality.

This estimate needs to be updated with most recent data (2014-2016) to reflect more extensive sampling and predation effect.

Predation scenarios 2, 3 & 4 are based on Griesemer & Holmes (2011) predation estimates for low, medium and high effects. These estimates are mainly derived from data collected by Ainley et al. (2001) in the Kalaheo colony on the south shore of Kaua'i.

Input for KSHCP model:
The model was run for predation scenarios 2, 3 & 4 described above, and results from each are presented below. Predation scenario 1 was not used in the assessment of the Kahuama'a Seabird Preserve because the associated lambda (.988) was felt to be too high to accurately represent predation impacts to the metapopulation. This predation scenario could be adjusted and used for future model runs. Modifications should be made based on the most recent KESRP data and predation estimates.

Flight path buffer:
Description:
Flight paths are based on the USFWS population viability (PVA) model, which is being developed to evaluate all terrestrial threats to Newell's Shearwaters, including risk of collisions with powerlines. To assess powerline collisions it is necessary to predict flight paths, in order to determine where birds are likely to intersect with powerlines during flight. The "least cost" flight path assessment is based on assumed colony locations (derived from KESRP auditory data) as the "source" and a series of 500 points (every 250 m^2) along the coast as the "sink". The two factors considered in defining the least cost path from source to sink are Topography and Coastal Access. The least cost pathway results from the shortest distance from colony to coast, with the least topographic "friction". Variance in pathway results was accounted for using a weighted average. (For more detail on this analysis, see PVA Materials and Methods, USFWS, in prep). For the SAS estimator model, it is assumed that Newell's Shearwater will use least cost flight paths, as derived from this USFWS PVA modeling data (USFWS, in prep).

Flight path buffer, in the context of SAS estimator model, refers to the overlap between audio broadcasting coverage and flight paths of prospective recruits to the site. The parameter is measured in distance (meters) from the fence that birds can be successfully recruited.

Input for the KSHCP model:
To determine our input value for this model parameter we explored various options to measure sphere of influence for audio broadcasting. One option was to estimate how far the broadcasting system could be heard by seabirds. This is based on the assumption that birds are transiting on their flight paths and will not deviate. The second (selected) option was based on localized topography. Given seabird circling patterns, and the exploratory nature of prospecting behavior (Brooke 2010, KESRP unpublished data), we assumed that all birds that entered the Kalalau Valley could come into auditory contact with our broadcasts. Thus we measured the maximum width of the Kalalau Valley (3000 meters) and used this as our input value.

Juvenile site fidelity:

Description:

This parameter determines what proportion of the birds whose flight path (+ buffer) intersects with the audio broadcasting will be available for recruitment to the social attraction site. The parameter applies to prospecting sub-adults, ages 2-5 years old. These are birds that are returning to Kauaʻi during the breeding season to prospect for nest sites and potential breeding partners (Ainley et al. 1995, Griesemer & Holmes 2011).

Site fidelity determines what portion of the prospecting sub-adults will "stray" from their natal colonies. This parameter is applied to birds from other colonies that may be available to recruit, and also birds born within the fenced site that will stray to other colonies when they return to Kauaʻi, though these two measures of site fidelity may be defined independently. Adults that establish nesting within the fenced site are assumed to have 100% site fidelity, and likewise, adults that have established nesting within other colonies are assumed to be unavailable for recruitment to the social attraction site. Seabird published literature supports this pattern of relatively higher rates of straying in juveniles, and high site fidelity for adult, breeding birds (Thibault 1993; Steiner & Gaston 2005; Robert et al. 2014).

Input for the KSHCP model:

To derive an estimate of juvenile site fidelity, we relied on research from other, similar species of shearwater. The most relevant study was on Cory's shearwater (*Calonectris borealis*) off the coast of Spain, by Munilla et al. (2016). Here populations of Atlantic colonies were examined using microsatellite genetic markers to determine proportion of migrants within an established colony. Genetic assignment determined 5%, 10% and 30% migrants present in the three colonies reported on. In addition, genetic data for newly established colonies supported straying from multiple colonies throughout the study area, versus one large migration event.

The question of site fidelity to a colony requires defining the scale and spatial extent of a "colony". There are multiple scales of fidelity that can be examined to explain patterns of nesting behavior. For example, likelihood of returning to Kauaʻi to breed, to the north shore of Kauaʻi, to the Kalalau Valley, and to specific breeding clusters (colonies) within the Kalalau Valley. Many studies of seabird nesting patterns describe site fidelity patterns by measuring number of meters of the natal burrow (Pyle et al. 2001; Steiner & Gaston 2005; Sugawa et al. 2014). In a study of streaked shearwaters (*Calonectris leucomelas*; Sugawa et al. 2014) straying is described as nesting within another breeding aggregate ~200 meters away. Thus, it seems appropriate to describe fidelity at the smallest scale, though we do not have genetic information for Newell's Shearwaters to support these breeding patterns.

In the context of the proposed KSHCP social attraction site, we may be attracting birds from "colonies" anywhere within the Kalalau Valley. Though breeding colonies in the Kalalau Valley are within a relatively close proximity to one another, initiation of nesting within the fence enclosure (assuming there is no nesting currently) represents a colonization event in terms of island metapopulation dynamics (Matthiopoulos et al. 2005).

We used conservative estimates of juvenile site fidelity of 95%, 90% and 85% to represent a range of potential proportion of birds available for recruitment. These numbers can be tied to estimates of straying rates in the literature (Munilla et al. 2016), and assume that localized clusters of breeding represent “colonies”, or sub-populations, in terms of genetic or population structure. Currently we do not have genetic data for Newell’s Shearwater to determine differentiation at a colony scale, or even among islands. Literature for similar species suggests that the population substructure, natal philopatry, and breeding site fidelity is likely high.

The SAS model allows for differentiating site fidelity for recruitment as described above versus fidelity of birds born within the fence that may stray to other colonies. For the KSHCP model we assumed a higher, and more constant site fidelity for birds born within the fence. We set this parameter at 95% across all model runs. This was done to reflect assumed patterns of behavior as outside colonies are extirpated. For example, using Predation Scenario 4, the total island metapopulation of Newell’s Shearwaters outside the fence is 141 individuals by Year 50. Within the fence in this same scenario, the population at Year 50 is between 67-189 individuals, representing either a significant portion of the total population, or more birds within the fence than outside the fence. In this scenario, we assume that site fidelity to the social attraction site is high, as there are very few outside colonies with calling birds. Setting this site fidelity measure at 95% prevented the model from projecting a declining population within the fence as the outside population declines, reflecting the belief that this site could provide an extinction refugia.

Run Time:
Description:
This model parameter determines the number of years for which the population within the fence and outside of the fence is predicted. The standard run time set for the social attraction estimator model is 50 years.

Input for the KSHCP model:
The KSHCP model was run for the standard run time (50 Years), but cumulative fledgling productivity was calculated until Year 30, the proposed duration of the KSHCP.

Burrow Capacity:
Description:
Burrow capacity is determined by the amount of suitable habitat multiplied by the assumed burrow density. There may be separate inputs for natural burrow capacity versus artificial burrow density/capacity, if there are plans to install artificial burrows to increase productivity of social attraction.

Characterizing suitable habitat using large scale GIS-based metrics has been attempted by multiple researchers. The USFWS Ecological Niche Model (ENM) found the strongest correlation for Newell’s Shearwater habitat to five variables: isothermality, precipitation seasonality, slope, topographical roughness and wind speed at 50 meters (USFWS, in prep). Troy et al. (2014) found the best predictive variables in determining suitable habitat for Newell’s Shearwater nesting to be slope, native vegetation, and soil/rock composition. Borelle et al. (2015) modeled habitat suitability for multiple burrow nesting shearwaters and petrels, and found vegetation, soil quality, induration and slope to be the most relevant for determining suitability.

The multiple factors used to predict suitable nesting habitat can be analyzed remotely using GIS, or data can be collected in the field in identify or verify suitable habitat classifications. Relying on GIS layers assumes these data are reliable at a localized, site-specific scale. In some cases, it may be more appropriate to collect data on site.

The habitat suitability parameter for the SAS estimator model is a simplified adaptation of the modeling efforts described above. Vegetation, soil quality and other predictive factors are assumed to be sufficient based on field visits to the site. Slope is the main variable with multiple input options. Slope data collected at burrow sites by KESRP technicians was sorted into Minimum, First Quartile, Median, Third Quartile and Maximum (KESRP, unpublished data). The resulting slopes for this are presented in Table 1. A digital elevation model (DEM) raster, with a resolution of 30 meters or greater, is analyzed for each model run, and the selected range of slopes is applied to the social attraction site to delineate suitable habitat. For example, if 1st Quartile is selected, all terrain with a slope of 14.9% or greater is included in the suitable habitat estimate.

Table 1: KESRP burrow data and associated slope occupancy range.

	Associated Slope (%)
Minimum	.62
1st Quartile	14.9
Median	21.6
3rd Quartile	29.9
Maximum	45

Burrow density must also be defined for the site to determine site burrow capacity, using available data and supporting literature.

The model provides two options for inputting burrow capacity:

1. Provide a burrow density estimate, slope occupancy range and a DEM raster for the proposed social attraction site. Suitable habitat hectares and total site burrow capacity will be calculated.
2. Provide a site-specific burrow capacity, calculated from other sources.

Input for the KSHCP model:

Due to the small size of the Kahuamaʻa Seabird Preserve, we chose to estimate hectares of suitable habitat from field measurements versus relying on GIS data layers. We determined that all of the fenceable area (1.2 ha) was suitable, given condition of soil, slope and presence of native vegetation.

There is unpublished data of burrow densities within managed colonies of Newell's Shearwaters on Kauaʻi (Andre Raine, pers comm). However, these colonies are subject to predation and are presumed to be greatly diminished from former densities. Instead, we relied on Manx shearwater (*Puffinus puffinus*) burrow densities from inland colonies in Wales, where the largest colony in the world is present (Smith et al. 2001). We selected only densities from inland colonies (versus coastal) as these are more likely to represent nesting conditions for the inland-breeding Newell's Shearwater. Two colony densities were presented: 0.070 burrows per meter squared, and 0.046/m². The average of these two colony densities is 0.058, which was used to calculate total burrow capacity for the KSHCP site.

The KSHCP proposes to install 100 artificial burrows within the fenced social attraction site. These burrows are in addition to the overall burrow capacity for natural burrows. Installation of artificial burrows can expedite the process of establishing breeding at a new site because burrow excavation by a newly established breeding pair can take a year or more (Bancroft et al. 2004). Artificial burrows are also easier to monitor.

Thus the total burrow capacity for the site is 796 burrows (Table 2).

Table 2: Calculating burrow capacity for the KSHCP model.

Model parameter	**Calculation**	**Input for KSHCP model**
Burrow Capacity	[Total hectares suitable habitat * estimated natural burrow density] + proposed number of artificial burrows to be installed	1.2 ha * 0.058 burrows/m² = 696 + 100 (artificial burrows) = 796 (Total burrow capacity at site)

Starting metapopulation size:
Description:
The population size for all Newell's Shearwaters on Kauaʻi (metapopulation) is a critical model input as this is what defines number of birds that are available for recruitment into the social attraction site. The most recent and widely used population estimate is from Joyce (2013), an at-sea estimate using data from 1998-2011. The total Newell's Shearwater median population size was estimated at 27,011 individuals. An estimated 90% of the total population (Griesemer & Holmes 2011, Spear et al. 1995) nests on the island of Kauaʻi, thus the total metapopulation size for Kauaʻi would be 24,310 birds. However, since the social attraction estimator model relies on known colonies to model recruitment, we must exclude potential colonies on lands that are inaccessible for surveys. This represents ~21% of the total population, and reduces the potential metapopulation for modeled for recruitment to 19,691 birds. This effectively reduces the number of birds available for recruitment by 21%, and thus the production estimates should be considered an underestimate, since in reality birds from these inaccessible colonies are still available, they are just not part of the model estimates.

The Newell's Shearwater population is experiencing a precipitous decline annually, and we felt it was inappropriate to assume that this did not further reduce the metapopulation size in the period from sampling to 2016 (year of model run). Since the sampling was conducted over a 14 year period, we assigned the median data estimate (27,011) to 2006, the median sampling for the Hawaii portion of the dataset (T. Joyce, pers comm, 2016). Thus the expected decline, associated with the various predation scenarios, was used to estimate a starting metapopulation size for Year 1 (Table 3). As mentioned above, line collision and light attraction fallout mortality is not part of this modeled decline, so these numbers likely represent an overly optimistic metapopulation number for 2016.

Table 3: Calculating starting metapopulation size for Newell's Shearwater on Kauaʻi.

Model parameter	**Calculation**	**Input for KSHCP model**
Starting metapopulation size	[Joyce 2011 at-sea population estimates * .90 (% of total pop that is on Kauaʻi) * .80 (% of total Kauaʻi pop that is represented in flight path estimates)] – Estimated decline between 2006-2016	Year 1 Starting Metapopulation: Predation Scenario 2: 14,976 Predation Scenario 3: 11,184 Predation Scenario 4: 8647

Input for the KSHCP model:
The model was run for each of the starting metapopulations from Table 3.

Table 4 is a summary of the inputs for the social attraction estimator model described in detail above.

Table 4: Summary of all input parameters for the KSHCP model.

Parameter	**Input used for KSHCP model**	**Notes**
Fencing completion year	Year 2	Conservative estimate based on prep required
Start broadcasting year	Year 2	Conservative estimate based on prep required
Predation estimate	All scenarios were run	**Scenario 2**= Griesemer & Holmes (2011) low predation **Scenario 3**= Griesemer & Holmes (2011) medium predation **Scenario 4** = Griesemer & Holmes (2011) high predation
Flight path buffer	3000 m	Distance from fence whereby prospecting birds may be attracted
Juvenile site fidelity	From outside the fence recruits: 85%; 90%; 95%	Thus 5%, 10% or 15% of the prospecting birds are potentially available for recruitment. Estimate derived from literature review.

	Inside the fence: 95%	Thus 5% of birds born within the fence will stray to other colonies to establish breeding.
Run time (in years)	50	

Size, location and topography of social attraction site	1.2 hectares	Derived from proposed fenceline at KSHCP social attraction site; linked to GIS file.
Artificial burrows to be installed	100	Estimated from field visits; accommodating 100 artificial burrows.
Total burrow capacity	796	See Table 2
Starting metapopulation size	Varies by Predation Scenario	See Table 3
Flight Path Overlap	For proposed Kahuamaʻa Seabird Preserve = 0.0311	Linked to GIS shapefile with site location and flight path .tif file provided by USFWS

SET MODEL PARAMETERS

The adjustable model parameters described above are run using the framework of an underlying deterministic population viability analysis (PVA) with set model parameters (Table 5). This PVA relies on life history components developed via previous work, specifically Ainley et al. (2001), and Griesemer & Holmes (2011).

The methodology is described in detail in the USFWS PVA modeling (in prep) but the basic modeling strategy is the use of a Leslie matrix to compile fecundity and survivorship for each age class to estimate population growth rates (lambda). The three age classes used are egg/chick (year 0-1), sub-adult (year 2-5) and adult (year 6+). The model estimates a lambda in the absence of predation, line collisions, light attraction fallout, and any other threats to the population. Then mortality rates associated with each of these threats are applied to reduce the lambda accordingly.

It is important to note that for the model analysis of the Kahuamaʻa Seabird Preserve, meta-population line collisions and light attraction were assumed to be zero, as the likely flight path to the coast, and the colony itself, are assumed to be unaffected by these anthropogenic mortality factors (at and around this site). Because this colony is situated in an area on Kauaʻi that likely does not have these mortality events, populations with sub-adults that could be recruited into this preserve would also likely be unaffected by these elements. The lambda used to define the growth of the population (as applied to the overall meta-population) reflects this geographic difference, as such the predicted meta-population size is not a realistic estimate, but a bi-product of the modeling exercise for this specific site. It is well-known that these mortality factors have a large affect elsewhere in the meta-population. This is addressed thoroughly in the Fish and Wildlife Site by Site PVA.

Table 5: Set model parameters for KSHCP social attraction estimator model.

PARAMETER	NOTES	MODEL INPUT
Breeding probability	Estimated from the average of 15 data sets for Newell's Shearwater and proxy species (Griesemer & Holmes 2011).	0.88
Reproductive success	Estimated from the average of 38 data sets for proxy species (Griesemer & Holmes 2011)	Within fence = 0.81 Outside of fence = 0.35-0.52 (varies with predation scenario)
Age of first reproduction	Griesemer & Holmes 2011	6 years old
Age of last reproduction	Ainley et al. 2001	36 years old
Survivorship per age class	Griesemer & Holmes 2011	Year 0-1: 0.654 Year 1-2: 0.78 Year 2-3: 0.89 Years 3-5: 0.905 Year 6+: 0.92

RESULTS

Data that are available from the model output include:

- Number of birds in each age class for the population within the fence enclosure in any given year of time (0-50 years)
- Number of birds in each age class for a parallel population outside of the fence enclosure in any given year of time (0-50 years)
- Population lambda (within fence enclosure and outside fence enclosure)
- Total population size at Year 50 (within fence enclosure)

Table 6 presents results of population size within and outside the fence in 50 years. This is total number of individuals present, including all age classes. The population number for outside the fence represents the total metapopulation of Newell's Shearwaters on Kaua'i. The estimated number of birds in 50 years ranges from 141-3811 individuals. Within the fence there is a positive growth rate (lambda >1.0) and thus this population goes from the initial starting point of zero to a range of 63-877 birds over the 50 year time period. The "within fence" population is directly correlated to population numbers outside of the fence because the model assumes continuous recruitment through the 50 year time frame. When less birds are available for recruitment, population within the fence does not grow as quickly. Final population estimate within the fence assumes social attraction calls are broadcast for the life of the project, and that birds added each year are both new prospectors and returning prospectors/breeders.

The population outside of the fence experiences a negative growth rate in all predation scenarios, with a lambda ranging from 0.921-0.973. In the most optimistic predation scenario (2), the population declines from a starting metapopulation size of 14,976 (see Table 3) to 3811. However, in the most drastic predation scenario (4), the total metapopulation for Kauaʻi declines from from 8647 individuals in 2016, to 141 individuals in 50 years, almost identical to the population within the 1.2 hectare fence enclosure (63-189 birds).

Table 6: Population size at 50 years within the fence and outside the fence, comparing various predation scenarios and site fidelities.

			Population size at 50 Years	**Population size at 50 Years**	**Population size at 50 Years**
	Predation Scenario:	**Population Lambda**	**85% Site Fidelity**	**90% Site Fidelity**	**95% Site Fidelity**
Within fence	**2**	**1.08**	877	534	292
Outside fence	**2**	**0.973**	3811	3811	3811
Within fence	**3**	**1.08**	372	248	124
Outside fence	**3**	**0.945**	661	661	661
Within fence	**4**	**1.08**	189	126	63
Outside fence	**4**	**0.921**	141	141	141

			Population size at 50 Years	**Population size at 50 Years**	**Population size at 50 Years**
	Predation Scenario:	**Population Lambda**	**85% Site Fidelity**	**90% Site Fidelity**	**95% Site Fidelity**
Within fence	**2**	**1.02**	499	509	409
Outside fence	**2**	**0.973**	4370	4370	4370
Within fence	**3**	**1.02**	231	252	216
Outside fence	**3**	**0.945**	877	877	877
Within fence	**4**	**1**	149	133	130
Outside fence	**4**	**0.921**	213	213	213

The primary result of interest for the KSHCP social attraction site is a comparison of the cumulative number of fledglings produced within the predator proof fence enclosure and outside the fence. Fledglings produced are the “currency” by which permitted take in the HCP is offset and mitigated. Table 7 presents the comparison of fledglings produced in the predator free fence area versus how many would have been produced in a similar area (in size, terrain, slope etc.) outside of fence. Unlike Table 6, where outside the fence represents total Kaua'i metapopulation, the results presented in Table 7 represent the production in a similar area outside the fence only. Though model outputs are for 50 years, the anticipated KSHCP permit term is 30 years, so the results for the first 30 years were extracted from the total.

Table 7: Number of fledglings produced in 30 years within fence enclosure and outside fence enclosure, comparing various site fidelities and predation scenarios.

			Number of fledglings produced in 30 years	**Number of fledglings produced in 30 years**
	Predation Scenario:	**85% Site Fidelity**	**90% Site Fidelity**	**95% Site Fidelity**
Within fence	**2**	1385	923	462
Outside fence	**2**	340	226	114
DIFFERENCE:		**1045**	**697**	**348**
Within fence	**3**	762	508	254
Outside fence	**3**	131	87	44
		631	**421**	**210**
Within fence	**4**	457	304	152
Outside fence	**4**	58	38	19
DIFFERENCE:		**399**	**266**	**133**

The cumulative number of fledglings produced within the fence varies greatly by site fidelity rates. As more birds are available for recruitment into the site, cumulative fledgling production increases. These model results show that maximum fledgling production is achieved when 15% of the birds whose flight path come within 3000 meters of the site are available for recruitment, and the total metapopulation is declining less steeply.

The cumulative number of fledglings produced within the fence during the 30 year permit term does not vary based on modeled burrow capacity scenarios (Table 8). To look at the effect of expanding fence size or over-estimating burrow density, we ran several burrow capacity scenarios, using fixed predation scenario and site fidelity inputs and assuming all other model parameters are stable. The results demonstrate the overall slow production rates of this seabird species. Fledgling production over 30 years does not reach, and therefore is not limited by, site burrow capacity. Similarly, total “within fence” population size at 50 years does not reach carrying capacity in any of the modeled scenarios.

Table 8: Comparison of 30 year cumulative fledgling production with various burrow capacity assumptions.

Modeled burrow capacity scenarios	Within fence total burrow capacity	Number of fledglings produced in 30 years within the fence (Predation scenario 2; Site fidelity 85%)	Within fence population size at 50 years (total individuals)
Estimated burrow capacity for 1.2 ha KSHCP site (see Table 2)	796	1045	877
Estimated burrow capacity for an expanded site (in same location) of 2.15 ha (0.058 burrows/m²	1253	1045	877
Estimated burrow capacity for 1.2 ha KSHCP site if burrow density was half (0.026 vs 0.058)	400	1045	877

DISCUSSION

The main of goal of this modeling exercise is to determine whether the selected mitigation option (predator proof fence enclosure and seabird social attraction site on the Kalalau rim) is likely to sufficiently offset the anticipated take request of Newell's Shearwater fledglings in the KSHCP. It is valid to look at a range of results, to account for uncertainty in selected model inputs for each parameter.

For example, with the predation scenarios, the most drastic scenarios (3 & 4) result in a total Kaua'i metapopulation of <1000 birds by the end of 50 years (see Table 6). Scenario 2 is an intermediate decline (total metapopulation of 3,811 birds in 50 years). For comparison, the USFWS NESH Landscape Strategy (USFWS, in prep) presents a projected population estimate at the end of 30 years to be 148-4,452 birds.

However, neither of these population projections takes into account large-scale conservation projects that may slow decline and aid recovery. Large-scale mitigation work implemented as part of the KIUC long term HCP, Kaua'i Watershed Alliance management plan, DOFAW's Native Ecosystem Protection and Management Program (NEPM) and others is expected to occur concurrently with the KSHCP social attraction site. These efforts are likely to contribute to increased productivity within Newell's Shearwater breeding colonies. This would result in less drastic decline to the metapopulation, and also increased recruitment and growth within the social attraction site.

Conversely, these population estimates do not take into account threats at-sea, such as changes in prey base due to climate change, fishing lines or overfishing, etc. Given the layers of uncertainty on impacts of predation, lights, line collisions and at-sea threats, effect of colony protection efforts, and even uncertainty about starting metapopulation estimates, presenting a range of possible outcomes for the social attraction site is prudent.

One important result of the social attraction estimator model that is worth discussion is the fact that the most influential parameters in the model are aspects of the program that cannot be managed. For example, the most logical way to adaptively manage the mitigation project to create more fledgling production would be to increase the size of the fence enclosure. In the long term (50+ years), this will result in more production, assuming social attraction is successful and maximum burrow densities are realized. However, within the 30-50 year period modeled, increasing the fence size does not positively influence cumulative production of fledglings. This is due to slow growth rates for seabirds and long generation time.

Instead, maximum production in the modeling is heavily influenced by juvenile site fidelity, predation estimates outside of the fence, and flight path buffer. Juvenile site fidelity is optimized when it allows for successful recruitment of birds and yet enough natal site fidelity from birds born within the fenced area. Predation estimates are optimized when there is an assumption of large-scale conservation efforts altering current patterns of steep population decline. Recruitment is determined by sufficient intersection of assumed flight paths. Future data may inform our estimates on these parameters, but we are not able to manage populations to increase them.

One exception to this is in comparing site locations. Since the model is actively linked to GIS data on site location and corresponding seabird flight paths, certain areas of the island will have a higher overlap with presumed flight paths, and thus will have more birds available for recruitment. This could have useful management implications when deciding on future social attraction site locations.

Through the duration of the KSHCP social attraction project, biological monitoring will be key for validating or updating model assumptions. Data will be collected on auditory seabird activity at the site, occupied burrows, fledglings produced etc. Off-site monitoring data collected by other entities (KESRP, USFWS, USGS, NARS etc) on metapopulation trends, effectiveness of predator control and other large-scale conservation efforts, and on impacts of other threats will be incorporated as well.

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Appendix D:
Participant Inclusion Plan (PIP) Template

Kauaʻi Seabird Habitat Conservation Program (KSHCP)

Participant Inclusion Plan (PIP) Template

Name of Applicant/Participant

[Insert Name]

PART 1: Landowner & Property Information; Description of the Facilities; Avoidance & Minimization Measures; Monitoring of Take

Item 1. Provide the name of the landowner, business, agency, or institution and complete contact information. If the applicant/participant is different from the landowner, please attach power of attorney (or other documentation) allowing the party to act on the landowner's behalf.

Participant/Applicant Name:

Physical Address/Location of Facility:

Mailing Address:

Primary Contact:	Ownership Name: Address: Email: Telephone:
Alternate Contact:	Name: Address: Telephone: Email:
Preparer Contact:	Name: Address: Email: Telephone:

Item 2. Provide the legal description of the property at which the existing facilities and Covered Activities are located, including Tax Map Key (TMK) number. Provide a survey of the property and site plan drawings showing the locations of the Covered Activities (lights), property boundaries, buildings & structures, and site features. If properties containing the Covered Activities comprise separate parcels please include all Tax Map Key numbers and maps.

Item 3. Describe the existing Covered Activities for which incidental take authorization is sought. Include list of buildings, type and description of lights present, purpose and location of lights and current seabird lighting accommodation in place (e.g. shielding, downward pointing, switched off during fledging season etc.). For "Types of lights" please use the following categories:

- **Parking Lights**
- **Signage Illumination**
- **Wall-pack Building Lights**
- **Landscaping/Grounds/Accent/Bollards**
- **Indoor lights visible from outdoors**
- **Roof Floodlights**
- **Other Lights**

Facility lighting plan may be submitted as lighting inventory. Photos may be attached. The suggested light table, and Green Sea Turtle assessment table below may each be modified as needed to provide the necessary information.

Table 1: Lighting at Facilities

List of Buildings	Type/Description of Lights Present	Location	Purpose of the Lights	Describe any measures implemented to avoid or minimize take impacts to Covered Species

Table 2: Green Sea Turtle Assessment for the Site & Facility

Please provide the information requested below to help determine if measures to avoid impacts to the Green Sea Turtle(s) from the effects of light attraction are required to be implemented at any of the facility(s), parcel(s), or site(s) included in this PIP. Please consult with staff from the DLNR and the USFWS to arrange a site visit, if needed, discuss measures to avoid impacts to the Green Sea Turtle, and provide further guidance.		
Are any of the facilities located adjacent to a beach?	**Yes / No**	**If yes, provide length of beach frontage & brief description of facilities & lights adjacent to the beach**
Are any of the Covered Activities (lights) visible from a beach?	**Yes / No**	**If yes, describe the specific lights (type, , height, purpose) & specific location; provide map & photos showing distance from beach**
Have green sea turtles been known to nest on any beaches adjacent to the facilities?	**Yes / No**	**If yes, provide information about nesting occurrences, if known, including location and date and any other information**

Item 4. If applicable, describe any lighting standards (e.g., foot candles/area) required for facility operations or other requirements that necessitate the use of lighting (e.g., required for security, safety, operations). Describe the relevant standard, or regulation, and the areas and Covered Activities at the site (e.g., type of lighting) to which it applies.

Item 5. Describe any plans/proposals for future facilities or expansion of existing facilities. Include any proposed structures and lighting by type, purpose, and location. Plans (architecture and site plans), photos, and drawings can be attached.

Item 6. Pursuant to the Endangered Species Act (ESA), Section 10 (a)(2)(A)(iii), describe alternatives to avoid the taking considered and evaluated. Provide reasons why those alternatives are not being utilized. Alternatives can include operational or facility design changes (attach pages as needed). The tables below may be altered as needed.

Table 3: Light Attraction Alternatives to the Taking

Artificial Light Attraction Alternatives to the Taking Considered	Reasons Alternatives are not Being Utilized (provide justification)
▪ Deactivate all outdoor artificial lights from dusk to dawn during the fledgling fall-out season September 15 to December 15	
▪ Change operations to eliminate the need for outdoor artificial lighting (e.g., from nighttime to daylight hours)	
▪ Shield all lights from visibility from the beach, or screen all Green Sea Turtle nests, from May 15 to December 15 to avoid impacting the green sea turtle (Green Sea Turtle)	
▪ Other alternatives to the taking considered, if any. If facility is proposed, include alternative designs considered	

Item 7. Describe all site-specific seabird minimization measures considered for the Covered Activities. This item should follow KSHCP minimization objectives and measures as specified in *Appendix E (Guidelines for Adjusting Lighting at Facilities)* of the KSHCP document. Please consult with staff from the DOFAW and the USFWS as needed. The suggested tables below can be altered as needed.

Minimization measures modify the Covered Activities to reduce the effects of the activity on the Covered Species. KSHCP Participants will be required to implement minimization measures that apply to the facility to the "maximum extent practicable" per applicable state and federal laws which regulate incidental take license/permit issuance by the DLNR and the USFWS.

Minimization also entails searching and recovering grounded seabirds to minimize the chance of mortality. In addition, the presence of on-site predators (i.e. feral cats, dogs) should be controlled and removed because these animals can prey on grounded seabirds.

Provide justification, such as policies, regulations, or other rationale for measures that will not be implemented.

Table 4: Seabird Light Attraction Minimization Measures Considered

Minimization Measures Considered	Feasible? (Y / N)	If not Feasible to Implement Measures, Provide Reason
▪ Change time of light use (lights off earlier)	Yes / No	
▪ Deactivate unnecessary lights	Yes / No	
▪ Replace all outdoor lights with full cut-off fixtures	Yes / No	
▪ Shield all outdoor lights with full cut-off shields	Yes / No	
▪ Angle all lights downward	Yes / No	
▪ Lower intensity (lumens) of outdoor lights	Yes / No	
▪ Change bulb color to non-white spectrum	Yes / No	
▪ Prohibit/control unleashed predatory animals; prohibit outdoor feeding of animals; require sealed rubbish containers	Yes / No	
▪ Provide Worker Seabird Awareness Training to staff	Yes / No	
▪ Provide outreach materials to staff & guests	Yes / No	
▪ Host Save Our Shearwaters (SOS) Aid Station	Yes / No	

Item 8. <u>Minimization Plans</u>. Provide a plan to minimize the effects to the Covered Seabirds due to the Covered Activities. KSHCP Participants will be required to minimize the effects of the Covered Activities to the "maximum extent practicable" per applicable state and federal laws which regulate take license/permit issuance. The KSHCP document provides minimization objectives and measures to follow.

The Minimization Plans should include the proposed minimization measures, timeline, and estimated cost for each facility. In this item, the Participant can include measures already completed or in place (new lights, shields, operational changes). Timeline should include estimated completion schedule, and annual schedule for minimization that will occur only during fledging season.

Minimization measures not yet determined but anticipated to occur at the facility; this section should include an estimated cost that will be earmarked for future minimization measures.

If applicable, the participant must provide the reasoning why certain measures will not be implemented. The suggested table below may each be altered to best describe the Minimization Plan. Attach additional pages, photos, and drawings as needed.

Table 5: Lighting Minimization Measures

List of Buildings	Minimization Measures	Cost to Implement	Responsible Staff	Timeline

Table 6: Seabird Mortality Minimization Plan

Minimization Measures	Describe minimization method (e.g. trapping, outreach, enact policy)	Cost to Implement	Responsible Staff
Remove & control loose predatory animals at the facility. (Loose animals can kill grounded seabirds and this measure aims to prevent seabird mortality by animals.)			
Prohibit outdoor feeding of predatory animals. (Feeding animals attracts them to the site and this measure aims to reduce the presence of animals that can cause seabird mortality.)			
Conduct nightly/morning searches to recover downed birds at the property & turn them into SOS following protocols (see monitoring plan below).			
Train staff to follow minimization measures.			

Item 9. Take Monitoring Plan. Provide a plan to monitor take of the Covered Seabirds at the facilities proposed to be covered by the incidental take permit/license. The take monitoring plan describes how the property will be searched for downed Covered Seabirds. The KSHCP document provides standards and guidelines for take monitoring to ensure that take of the species is accurately measured and recorded.

The regulatory agencies will make the final determination as to the adequacy of the take monitoring plan.

Table 7: Covered Seabird Take Monitoring Protocols

Please provide the following information for the protocol items below		
Item	**Protocol** (fill in protocol & provide reasons)	**KSHCP Guideline**
Percentage of the total property that will be searched & the total area to be searched		Search as much area as possible
Frequency of searches (# per day or per week)		Twice daily
Time of day of searches		2-3 hours after sunset, and within 3 hours after sunrise
Number of searchers per search area		Depends on site conditions and safety considerations and vegetation, nearby hazards/threats
Proposed training		Annual training covering seabird identification, seabird handling, response procedures, verified and documented

Item 10. Components of the Green Sea Turtle Minimization and Monitoring Plan (if required). Monitoring and minimization for the Green Sea Turtle is in two parts: A) Monitoring to detect nests and B) Monitoring and minimizing impacts to nests detected.

Part A: Monitoring to detect Green Sea Turtle Nests
Please provide the following information; the table below may be used and altered as needed.

1) Detailed location and description of beaches, including linear distance, at which searching for nests of the green sea turtle will take place. Searches should take place at any beach from which light at the facility can be viewed;

2) Monitoring protocols indicating:
    a) Annual training of searchers;
    b) Frequency of searches;
    c) Conduct active searching (searching the beach width);
    d) Sufficient number of trained searchers to cover the area; and
    e) Record results of search monitoring.

3) All Participants are required to record the results of search efforts. Records should provide:
    a) Evidence (what was seen). Include description and provide photographs
    b) Location on the beach (GPS) and physically mark the location if possible
    c) Date and time of day
    d) Description of surrounding land use (e.g., vacant, or developed), and
    e) Proximity to the facility.

Part B: Monitoring of Identified Green Sea Turtle Nests

Each identified nest of the green sea turtle should be monitored and protected from light attraction. Please provide the following monitoring protocols; the tables below may be used and altered as needed.

1. Light avoidance measure for identified nests (either shield/deactivate lights at the facility or install and maintain a light shield around each identified nest);
2. Frequency of searches;
3. Number of searches monitoring the nests. The number of needed to monitor active nests will depend on number of nests identified and amount of beach needed to be covered;
4. Record the results of nest monitoring. Monitoring should provide:
    a. Evidence of hatchling emergence (description and photos):
    b. Date and time of emergence,
    c. Direction of tracks,
    d. Condition of the nest area (e.g., disturbed or not).

Table 8: Green Sea Turtle Monitoring Protocols – Part A: Monitoring to Detect Nests

Please provide search protocols for detecting nests of the green sea turtle (Attach pages as needed)		
Item	**Protocol** (fill in protocol & provide reasons)	**KSHCP Guideline**
Location & description of the beach, or beaches, surveyed and the linear distance of the beach		Beach area surveyed should coincide with visibility from the facility with the lights
Frequency of searches (# per day or per week)		Weekly during nesting season (typ. May 15 to end of August)
Number of searchers per search area		Depends on site conditions and safety considerations
Proposed training		Searchers should receive annual training conducted by the DLNR or the USFWS, or their designee (See **item 9a)**

Table 9: Green Sea Turtle Monitoring Protocols – Part B: Monitoring of Identified Nests & Minimization

Please provide search protocols to monitor identified nests (from Part A) of the green sea turtle (Attach pages as needed)		
Item	**Protocol** (fill in protocol & provide reasons)	**KSHCP Guideline**
Frequency of checks (# per day or per week)		Active nests should be monitored every 1-2 days; then daily during expected hatching date
Light avoidance		If lights cannot be deactivated or shielded from the nest, each nest should be screened from visible light
Number of searchers per search area		Depends on site conditions and safety considerations

Item 11. Describe the schedule that will be followed to provide training for staff. Training must be provided to those that will conduct and oversee the searches at the facility.

The training should include:

1. Summary of regulations protecting the Covered Species;
2. Search procedures, route, frequency and timing specific to the facility's monitoring plan, for seabirds and green sea turtle nests (if applicable);
3. Response procedures including safe and proper techniques for handling seabirds;
4. Recognizing evidence of green sea turtle nests, proper nest light screening, and hatchling activity (if green sea turtle minimization and monitoring plan is applicable);
5. Procedures to document the results of searches;
6. Downed wildlife agency contacts; and
7. Nearest SOS aid station.

Rescuing Downed Seabirds—Standard Operating Procedures (SOP)

The following steps provide the procedure for recovering downed seabirds found:

1. Take the seabird recovery kit and pet carrier to the downed seabird.
2. Put on gloves.
3. Using towel to gently cover the bird, pick up the seabird with wings folded in a natural position.
4. Place the seabird in the pet carrier, and close the pet carrier.
5. Put the gloves and towel back in the seabird rescue kit.
6. Take the bird and pet carrier to an SOS Aid Station.
7. Transfer the bird to the Aid Station's pet carrier.
8. Call SOS at 632-0610 or 635-5117.
9. Return the seabird rescue kit and pet carrier.
10. Complete the Bird Take Field Report.
11. Give the completed "Bird Take Field Report" to the General Manager, or other responsible staff person at the facility.

Contents of Seabird Recovery Kit

1. Latex or nitrile gloves;
2. Three towels;
3. Hand sanitizer;
4. Flashlight or headlamp;
5. Clipboard, pen and blank "Bird Take Field Reports", or similar; and
6. Pet carrier –medium sized. If a box is used it must be well ventilated and marked conspicuously "LIVE ANIMAL".

Item 12. Describe any outreach conducted (e.g., handing out pamphlets on seabird awareness to facility employees or guests, etc):

PART 2. Take Estimate, Requested Amount of Take Authorization, and Funding

Item 1. Show the calculation of estimated take for each of the Covered Species.

Following the take estimation methods in the KSHCP for estimating a Participant's take (Section 6.2.2), the tables below show the take estimate calculation for the facility(s) for each of the Covered Seabirds.

The KSHCP take estimate method utilizes the average of the most recent 5 years of SOS recovery data for the facility. Applied to the data is an adjustment for downed birds not found, based on a 50% discovery rate and an adjustment based on SOS mortality (birds dead on arrival or those that die in care) – average SOS mortality is 12%.

If the landowner-applicant submits a take estimate with an alternate discovery rate, they must provide the reasons why an alternate rate was used to estimate take, including relevant information supporting their reasoning (% of searchable area, search protocols that will be used, any searcher efficiency trials that have been or will be conducted at facilities and/or demonstration of quick, effective recovery of birds). Please include narrative and/or photos and maps to support this.

Table 10: Annual Take Calculation

	Newell's Shearwater	Hawaiian Petrel	Band-rumped Storm-petrel
1. Annual average number (SOS data – or – monitoring data) of downed NESH (5 most recent years), HAPE or BRSP (15 most recent years)			
2. Annual observed lethal take estimate (12% of 1, all downed birds)			
3. Annual unobserved lethal take estimate (e.g. 100% of 1, all downed birds if 50% searcher efficiency assumed)			
4. Total estimated annual lethal take from light attraction (2+3)			
Requested Annual Lethal Take			
Requested Take Over Permit Term			

Item 2. Select the requested take authorization and permit/license term coverage for each of the Covered Species.

Table 11: Newell's Shearwater:

Age Class	Annual Take Estimate: Fledglings	Annual Take Estimate: Adults or Sub-Adults	Take Limit for License/Permit Term
Mortality (Lethal)			
Injury (Non-lethal)			

Table 12: Hawaiian Petrel:

Age Class	Annual Take Estimate: Fledglings	Annual Take Estimate: Adults or Sub-Adults	Take Limit for License/Permit Term
Mortality (Lethal)			
Injury (Non-lethal)			

Table 13: Band-Rumped Storm Petrel:

Age Class	Annual Take Estimate: Fledglings	Annual Take Estimate: Adults or Sub-Adults	Take Limit for License/Permit Term
Mortality (Lethal)			
Injury (Non-lethal)			

Item 3. Funding Assurance. Provide proof of adequate funding (see KSHCP document). All participants must demonstrate requisite funding prior to permit/license approval to ensure that the proposed measures and actions, including monitoring, will be undertaken in accordance with the terms and schedule of the KSHCP.

Signature of Participant:

____

Date:___________________

Printed Name :

____

The undersigned affirms that all the information included is true and accurate to the best of the participant's knowledge and that this PIP is voluntarily submitted.

☐ check to waive confidentiality

Appendices

Appendix A –

Appendix B –

Appendix C –

Appendix D –

Appendix E –

Appendix F –

Appendix G –

Appendix H –

Appendix E:
Guidelines for Adjusting Lighting at Facilities

APPENDIX E: Guidelines for Adjusting Lighting at Facilities

1. Guidelines for Adjusting Lighting at Facilities

This appendix provides detailed guidelines to inform minimization measures that can be customized to address an array of possible lighting issues at Participant facilities. A lighting minimization plan to achieve the maximum extent practicable will be included in each Participant PIP.

These guidelines represent best available science at the time of KSHCP permit issuance. Over the life the plan, likely new information and new technologies will be available, and this appendix may be updated accordingly.

Not all lighting guidelines are appropriate for all types of facilities. Some represent long term, infrastructure solutions, and others may be implemented on a seasonal basis.

1.1. Deactivate Non-Essential Lights

Prioritization of seabird and honu light attraction minimization measures involves evaluating light needs to determine if non-essential lights can be deactivated during the seabird fallout season (September 15 to December 15) and turtle nesting season (May 15-December 15). Deactivating the lights avoids the potential for light attraction that those lights could otherwise cause. Turning off a subset of lights, both unshielded and shielded, during the fallout season (September 15 to December 15) can assist with minimizing the risk of seabird light attraction, if those lights are not necessary. In their PIPs, Applicants must provide rationale for any facility lights that cannot be deactivated during seabird fallout season, and detail what other minimization practices will be implemented on lights that will remain illuminated. The regulatory agencies will review the evaluation and justification as provided in applicant PIPs.

Similarly, turning out lights that shine directly on beaches during the turtle nesting season (May 15-December 15) can prevent hatchling disorientation. Avoid use of the following lamp styles on beachside or shore perpendicular to sides of a structure**:** private balcony lights, up lights; decorative lighting, not necessary for human safety or security; pond lights; and beach lighting. Timers or other similar devices should be used to ensure the selected lights remain off during the turtle nesting season. This measure may require the installation of independent light switches. Conversely, to prevent accidental activation, light fixtures can be removed for lights that will no longer be needed at a facility.

1.2. Install Full Cut-off Light Fixtures

A full cut-off fixture refers to a light fixture which that does not shine light above a 90 degree horizontal plane. For lights necessary to be activated, full cut-off fixtures provide an effective measure to achieve light minimization because they prevent light from shining directly upward.

These types of lights house the light bulb up within the fixture so that no bulb protrudes below (**Figure 1)**. Such fixtures must be mounted at appropriate angle so they point directly down to the ground. Many light manufacturers provide light fixture information along with the light specifications to indicate if a fixture is a full cut-off design. The International Dark Sky Association (www.darksky.org) is a good source for information on full cut-off lights and provides additional references to light engineering resources and light manufactures.

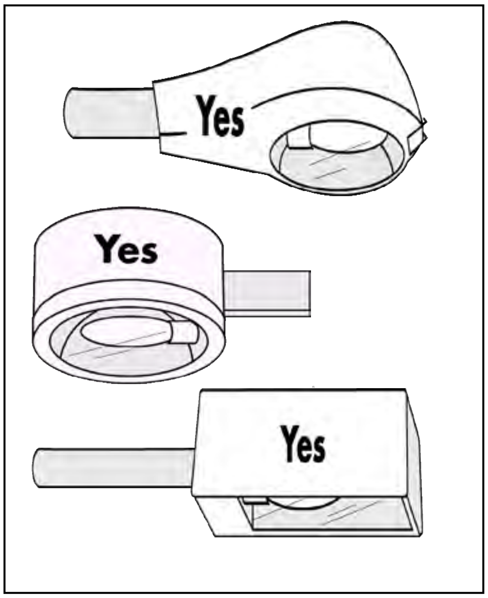


Figure 1: Examples of full cut-off light fixtures. Source: www.darksky.org.

Along shorelines, exterior fixtures on the seaward (makai) and the shore perpendicular sides of the building (and on the landward side of the building if they are visible from the beach) should be down-lit fixtures, fully shielded and full cut-off, louvered, or recessed fixtures that do not have reflective inner surfaces. These fixtures should use low wattage bulbs (e.g.,< 50w). All exterior fixtures on the landward (mauka) side of the building should be directed downward only (Witherington & Martin 2003).

1.3. Shielding Light Fixtures

This minimization measure aims to achieve the functional equivalent of a full cut-off light fixture by installing a shield, visor, hood or similar on an existing light fixture to prevent light from shining upward and reducing trespass. In addition to the shielding, to achieve the functional equivalent of a full cut-off fixture, a light fixture should be adjusted so that it points directly down perpendicular to the ground to create a level, horizontal plane between the fixture and the ground, and have the bulb housed within the light fixture (**Figures 2** & **3**). Reed et al. (1985) suggest that in areas where other light sources are rare, the shielding of principal lights would likely have a larger effect in decreasing seabird light attraction.

Figure 2: Installation of an appropriately sized floodlight shield. Source: www.darksky.org.

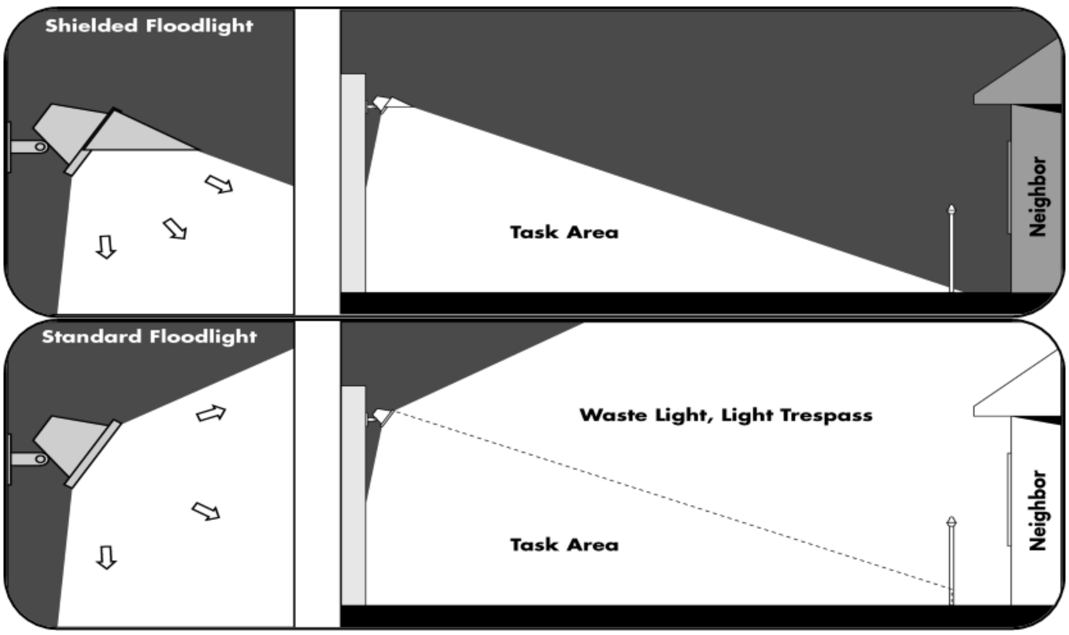


Figure 3: Before and after effects of shielding and light management designed to minimize light attraction risk to seabirds and to decrease light pollution. Source: www.darksky.org.

1.4. Angle Lights Downward

Angling and repositioning lights presents a potential alternative to shielding or replacing light fixtures and may be sufficient to make lights fully cut-off and eliminate light shining horizontally and vertically (**Figure 4**). To achieve the functional equivalent of a full cut-off fixture, a light fixture should be adjusted so that it points directly down perpendicular to the ground to create a level, horizontal plane between the fixture and the ground, and have the bulb housed within the light fixture. Tree strap downlights may be used to minimize seabird light attraction unless turtles may be present on the adjacent beach.

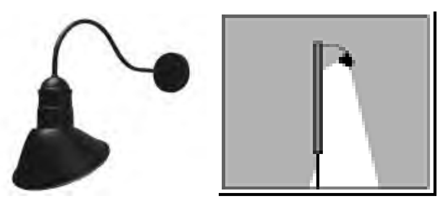
a)  b)  c) 

Figure 1-: (a) Wall mount cylinder down-light, (b) bollards with downward-directed louvers, and (c) sign lights angled downward. From http://myfwc.com/media/418417/SeaTurtle_LightingGuidelines.pdf (FWC 2011).

1.5. Place Lights Under Eaves

Light fixtures placed under building eaves can achieve the functional equivalent of a full cut-off fixture. The architectural eave acts as shield to prevent light from shining directly upward.

1.6. Shift Lighting According to the Moon Phase

This minimization measure addresses lighting for which the need, or purpose, for the lighting can be shifted in timing each year to coincide with the moon phase. Because a reduction in light attraction has been correlated with the full phase of the moon (Reed et al. 1985; Telfer et al. 1987) lights for essential functions, and for which that function can be shifted in timing, should coincide with the full phase of the moon and avoid the dark phase of the moon. It is important to note that a full moon that is obscured by heavy cloud cover could simulate the dark phase of the moon. By not activating those lights during the dark phase of the moon the effect of those lights is reduced. Examples of activities that could be minimized with this measure include scheduling of night time events, such as festivals or sporting events.

1.7. Install Motion Sensors for Motion-activated Lighting

Motion sensors switch lights on only when triggered, thereby limiting the time that the light stays on and reducing its potential for seabird light attraction. If a sensor light is required for security purposes, the light equipped with the sensor should be at low light levels. For example, Light Emitting Diode (LED) streetlights and parking lot lights can be activated when needed and dim when no activity is detected nearby. However for those fixtures, full cut-off designs or the functional equivalents are recommended because of the possibility of light attraction occurring when the motion-sensor light is activated or in the event that the motion sensor equipment malfunctions and the light remains on.

Where motion sensors are impractical (eg at sporting events), stadium lights should be turned off as soon as the public leaves the stadium.

1.8. Decrease Lighting Levels

This measure addresses lowering light intensity levels (e.g., measured in lumens) while still meeting the need to safely complete tasks and serve the purpose of the light. Guidance on standards for the appropriate lighting level for a particular light function should be followed as provided by the appropriate agency or professional and technical organization. For example the Illuminating Engineering Society of North America (IESNA) provides recommendations for light levels for several applications including parking lots, walkways, and roads. In addition individual entities may have standards and best practices for lighting needs.

For many applications where lighting is needed, brighter lighting may not always provide the best lighting for the needed function. It is often the case where reduced lighting levels can provide for the needed function of the lighting. For example, for security purposes overly bright lights tend to create blind spots, or very dark shadows, outside the lit area that preclude effective visibility. Well placed, but reduced lighting can provide for more effective security. Therefore, when Participants seek to enhance onsite visibility for security, while reducing risk to seabirds, the appropriate reduction of light levels (along with shielding and re-angling lights) forms a starting point to accomplish both purposes.

1.9. Decrease Visibility of Interior Lights

Facilities with large and/or numerous windows, tall building profiles, or large glass facades may also pose a risk of light attraction to Covered Seabirds on Kaua'i. The following measures are based, in part, on efforts in cities in Canada and the mainland USA to decrease harmful effects of buildings on birds and apply to seabirds in that they can decrease the amount of light escaping from within buildings (City of Toronto 2007; Evans Ogden 2002):

- Install screens or shades over large windows that are lowered nightly during the fallout season;
- Modify buildings and decrease or eliminate light glow from within a facility;
- Create glass opacity to prevent the escape of internal light. Tinted glass or film with a visible light transmittance value of 45 percent or less should be applied to all windows and doors within line of sight of the beach;
- Install physical screens outside a building;
- Install landscaping in front of large windows;
- Close all window blinds after daylight hours until sunrise;
- Stagger the operation of lights in the evening or morning hours so that not all lights are turned on at once; and
- Maximize the number of offices or indoor rooms that turn off all lights after sunset;

- Place reminder notices on switches to turn out lights or draw curtains/blinds in oceanfront rooms. This should include coastal areas that are on the perpendicular sides of the structure;

    a. Turn off room and lanai lighting that are not needed;

    b. Relocate moveable lamps away from windows that are visible from the beach; and

    c. Close opaque curtains or blinds after dark to block inside light from shining outside.

1.10. Use Light-less Technologies

Where conditions and facility needs permit, technologies that do not use light, such as closed-circuit television (CCT) with infrared illuminators, may be effectively employed to "see" at night thus enabling some of the lights to be turned off. For example, any fenced areas or the dark sides of facilities can be monitored with CCT so that lights do not need to be used or installed.

1.11. Plant Vegetation Around Lights to Reduce Light Visibility

Trees and shrubs can be planted so that they over-arch lights or shield side visibility of lights along the coast or along a ridge, for example. Whether the lights are mounted on 20-foot poles, walkways, or within landscaped areas, having adjacent or overarching vegetation would further reduce the risk of seabird light attraction that any residual light scatter may pose. Long-term planning and maintenance of screening vegetation is encouraged, where appropriate to the uses and needs of the affected lights.

1.12. Lower Height of Lights

Light that is low in height has potential to reduce the effect of light attraction because lower lights may be less visible to passing seabirds. Installing ground-level lighting, such as along walkways, and reducing pole height can decrease light waste and trespass.

1.13. Use Longer Light Wavelengths

In coastal areas, use of acceptable lights such as: LPS 18w, 35w, red, orange or amber LEDs (true red, orange or amber diodes, but not filters), true red neon, and other lighting sources that produce light wavelengths of 560 nm or longer (Witherington et al. 2014). Long wavelength lights, e.g., those that produce light that measures greater than 560 nanometers on a spectroscope, are required for all construction visible from and adjacent to sea turtle nesting beaches. Turtles are most sensitive to short wavelengths of light, probably because they live in a marine environment that filters out long wavelengths. Green turtles are least attracted to longer wavelength light in the yellow-orange to red end of the spectrum (630 to 700 nm) (Witherington and Martin 2000). In the absence of other light sources, however, turtles may still be attracted to long wavelength light.

Filters designed to exclude transmission of short wavelengths (<570nm) can be fitted to high pressure sodium (HPS) vapor lights. Such filters have been found to be effective at avoiding disruption of nesting females (Salmon, 2006) but even filtered HPS light has been found to attract hatchlings, although not as strongly as unfiltered HPS lights (Sella et al, 2006). Filtering alone is thus not sufficient to avoid attraction and disruption of hatchling orientation. Bright white light fixtures, such as metal halide, halogen, fluorescent, mercury vapor and incandescent lamps, are not approved for beachside or shore perpendicular sides of a structure. Limited use of shorter wavelength lights may be approved in areas where direct and indirect light or glow could not possibly be visible from the beach due to installation of opaque “light fencing” (see below).

Appendix F:
Training and Outreach Materials

Appendix F. Training and Outreach Materials

The Worker Seabird Awareness and Response Training materials that will be provided by the KSHCP are updated and will be available to Participants upon request. Materials consist of a slide presentation and handouts.

Handouts include:

- How to Pick Up a Seabird
- Seabird Recovery Protocols
- Seabird Identification Guide
- Green Sea Turtle Nest Searching Guide

How to Pick Up a Seabird

- Approach bird from behind, if possible
- Wrap a small towel around back and wings
- Gently pick up bird

Use gloves if needed
Disinfect hands after handling birds

- Always keep bird away from your face
- Birds are docile, but be aware of pointed bill

- Cover bird's head
- Speak quietly & keep noise down

- Place bird in pet carrier or vented box
- Take birds to SOS Aid Station and place inside
- Fill out SOS information board

- Do not feed birds!
- Do not release birds!

Call SOS 635-5117

Contact Information:
Save Our Shearwaters: 808.632.0610 ext. 109; 808.635.5117
Provided by: DOFAW Kaua'i Seabird Habitat Conservation Program Office 808.245.9160
4272B Rice Street, Lihue HI 96766 - www.kauaiseabirdhcp.com

Photos courtesy of DLNR and Brenda Zaun USFWS

Kaua'i Seabird Identification Guide

Hawaiian petrel – 'ua'u
Endangered species
Fledges Nov. to Dec.
Breeds in mountain areas

Newell's shearwater – 'a'o
Threatened species
Fledges Sept. to Nov.
Only breeds on Kaua'i; mostly in mountains

Band-rumped storm petrel – 'ake'ake
Candidate endangered species
Fledges in fall months
Uncommon & rare; breeds in cliff areas

Wedge-tailed shearwater – 'ua'u kani
Protected under Migratory Bird Treaty Act
Fledges Nov. to Dec.
Moderately aggressive - use safe handling
Commonly found at coastal areas

KAUAI SEABIRD HABITAT CONSERVATION PLAN

Contact Information:
Save Our Shearwaters: 808.632.0610 ext. 109; 808.635.5117
Provided by: DOFAW Kaua'i Seabird Habitat Conservation Program Office 808.245.9160
4272B Rice Street, Lihue HI 96766 www.kauaiseabirdhcp.com

Photos courtesy of DLNR (band-rumped storm petrel) and Brenda Zaun USFWS

Seabird Recovery Protocols Handout

1. Maintain supplies and recovery forms

1. Medium-size pet carrier or ventilated box
2. Small towel to wrap bird
3. Flashlight/head lamp (for searching during dark)
4. Protective gloves
5. Gallon-size ziplock bags (for dead birds)
6. Hand disinfectant
7. Seabird recovery forms and identification sheets

2. Search actively; designate observers

1. Look under objects and vegetation – birds will hide
2. Nocturnal seabirds are most active 1—3 hours after sunset and before sunrise but can be grounded at any time during the night or early morning

3. Pick up downed seabirds immediately & put in safe place (pet carrier or ventilated box) – refer to "how to pick up a seabird" handout

4. For dead seabirds found, place carcass in ziplock bag, store in freezer or cool place, call SOS to coordinate transfer: 635-5117

5. Deliver seabirds to Save Our Shearwaters (SOS) Aid Station – located at fire stations; call SOS 635-5117

6. Record information on forms & turn into management

7. Management submit forms to wildlife agencies

Save Our Shearwaters SOS, Kaua'i Humane Society: 632-0610 (x109); 635-5117
Kaua'i Seabird HCP office: 245-9160 office; 346-3489 mobile

Honu – Green Sea Turtle: Nesting and Hatching Season

Nesting season - Mid-May through Late-August:

Females return to nesting beaches to excavate nests and lay eggs. Females often return the same area that they hatched from and known nesting areas on Kaua'i include beaches in Po'ipu, Lihu'e, and Princeville.

During the cool of the night, female honu arrive on the beach and upon reaching the high-tide mark, dig their nest and lay their eggs. Nesting activity can be identified by the paths that females make from the ocean to the nest site.

Hatching season - July through late November-early December:

The date the female lays eggs will determine when the eggs hatch. It takes 60-65 days from when the female lays her eggs for them to hatch. A few days before the hatchlings emerge, there will be a depression above the nest from where the newly hatched turtles are digging to the surface of the sand.

If nesting is found on a beach adjacent to your property, please contact ____ for assistance blocking the nest site from beachgoers. If artificial light from your property is illuminating the beach, a light shield will need to be built around the nest. Contact ____ for assistance with the light shield. Hatchling turtles are disoriented from their path to the sea by artificial light.

Appendix G: Budget Details

APPENDIX G: KSHCP BUDGET DETAILS

This Appendix gives detailed information about the budget for the KSHCP mitigation project, including contingency items and other costs such as inflation and compliance monitoring. This appendix is for the Implementing Fund only, it does not include the Reserve Account for funding assurances, changed circumstances, and adaptive management.

Cost for implementing minimization, monitoring and other facility-specific actions by individual Applicants is not included in this Appendix, but is also required to meet KSHCP permit criteria.

Given the selected mitigation project (predator proof fence and social attraction site), and the importance of beginning mitigation benefit as soon as possible, Year 1 cost for the KSHCP is substantially higher than subsequent years due to initial fence construction and predator removal costs that will occur in Year 1 of the Program.

The budget tables presented in this Appendix were derived estimates based on 2019 costs, and an assumed rate of inflation at 3% will be applied annually. Project costs will not be finalized until a formal bid process has been completed by the primary contractor. All of these budgetary items should be considered as estimates.

Budget Tables

Table 1. Overview of funding for the KSHCP mitigation project, reflecting initial higher costs for Year 1 (fence construction and predator removal).

Item	Year 1	Annual cost
Salaries	$170,000.00	$97,500
Subcontracted expenses	$31,200.00	$3,800
Capital costs	$228,440.00	$2,000
Materials	$78,361.00	$20,827
Training	$3,000.00	$3,000
Travel	$11,815.00	$11,815
Misc	$2,670.00	$2,670
Contingency	$14,910.24	
Subtotal	$540,396.24	$141,612
Overhead	$81,059.44	$21,242
Contractor Total	**$621,455.68**	**$162,854**
State	$10,000.00	$10,000
NFWF	$12,429.00	$3,355
Overall total	$643,884.68	

Note: annual cost will increase by 3% each year to account for inflation.

Table 2. Potential responses and estimated costs for Changed Circumstances/Adaptive Management.

SCENARIO	ITEM	ESTIMATED COST	SOURCE/NOTES	POTENTIALLY APPLICABLE YEAR
Fence delay	Increased cost to build fence	$42,426	Fence costs 25% more than expected	Year 1
Predators not eradicated in first attempt	Double effort (2X equipment)	$13,550		Year 1
TOTAL that may be needed in Year 1		**$55,976**		
Birds not attracted to site	Double speaker system & change soundtrack	$2,500		Year 3-4
	Install decoys	$4,000		Year 3-4
TOTAL that may be needed in Years 3-4		**$6,500**		
Birds not breeding at site	Replace all artificial burrows	$10,000		Years 4-7
TOTAL that may be needed in Years 4-7		**$10,000**		
SOS not available	Vet care for non-lethal take birds	$500/bird	Cost depends on Participant take	Any year
Natural disaster destroys fence	Fence and social attraction equipment replacement & repeat predator control (labor only)	$243,440	$213,440 + inflation + $15,000 + $15,000 X2 replacement threshold	Any year
Natural disaster requires vegetation restoration	Replanting, invasive plant control & erosion control	$25,000	Estimate from NTBG for plant survey and outplanting of native plants	Any year
Vandalism creates need for additional monitoring	Additional cameras and signage	$4,375	5 cameras & mounts; signs	Any year
No continuation of site beyond 30 year term	Fence decommissioning	$42,438	50% of original cost (labor)	Year 30
Barn Owl removal not successful	Additional shooting nights/alt equip/expert help	$15,000		Any year
Fence breach	Repeat of predator eradication (labor cost)	$15,000		Any year
Monitoring insufficient	Increase camera effort by 20%	$4,823		Any year
Total that may be needed in any year		**$350,076**		