State of Hawai'i
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Forestry and Wildlife
Honolulu, Hawaii 96813

June 12, 2020

Chairperson and Members
Board of Land and Natural Resources
State of Hawai'i
Honolulu, Hawai'i

SUBJECT: REQUEST FOR APPROVAL OF THE FINAL ENVIRONMENTAL ASSESSMENT FOR THE KAUAI SEABIRD HABITAT CONSERVATION PLAN

AND

REQUEST AUTHORIZATION FOR THE CHAIRPERSON TO ISSUE A FINDING OF NO SIGNIFICANT IMPACT (FONSI)

BACKGROUND:

The proposed action is for the implementation of the Kauai Seabird Habitat Conservation Plan (KSHCP)[1], which will enable qualifying Applicants to request Incidental Take Licenses (ITLs) for the placement and operation of a range of artificial, nighttime lighting on Kaua'i. Each ITL issued by State of Hawai'i Department of Land and Natural Resources would authorize incidental taking of threatened and endangered seabirds, including the threatened Newell's shearwater (*Puffinus auricularis newelli*, Hawaiian name: 'a'o), the endangered Hawaiian petrel (*Pterodroma sandwichensis*, Hawaiian name: 'ua'u), and the endangered Hawai'i distinct population segment (DPS) of the band-rumped storm-petrel (*Oceanodroma castro*, Hawaiian name: 'akē'akē) (collectively referred to as the Covered Species).

The area addressed under the KSHCP includes any location on the island of Kaua'i where light structures may attract seabirds, and State Lands where the proposed mitigation preserve will be implemented. The ITLs may cover all types of artificial lighting, including land-based lights at parks, retail stores, resorts, condominium complexes, agribusiness and industrial facilities, as well as lighting on ocean-going vessels such as cruise ships. Artificial lighting includes the placement and operation of current light structures, as well as the placement and operation of new or future lights that have similar effects. Mitigation areas include a 2-hectare (ha) seabird preserve to be established in Kōke'e State Park along the Kalalau rim, and disbursed areas where downed seabirds are recovered, evaluated, rehabilitated and released to sea. The duration

[1] The KSHCP can be found here: https://dlnr.hawaii.gov/wildlife/hcp/draft-hcps/

of each ITL would be 30 years.

The Proposed Action is the preferred alternative because it provides the greatest net conservation benefit for the Covered Species. Note that the Final Environmental Assessment incorporates an update to the amount of take requested by the eight Applicants, based on corrections to their take calculations in their Participant Inclusion Plans (PIPs). The corrected level of take for these eight applicants (KSHCP tables 4.2,4.3,4.4) remains less than the maximum described for the KSHCP.

DLNR anticipates that implementation of the KSHCP will result in net conservation benefits that will contribute toward the recovery of the Covered Species. The KSHCP will offset the impacts of the taking of Newell's shearwater anticipated to occur on Kauaʻi through establishment and management of the Kahuamaʻa Seabird Preserve (Preserve), also on Kaua'i. The 2-ha Preserve will be enclosed by a predator proof fence, protected from terrestrial predators, and restored to create native plant dominated nesting habitat. It is located at a similar elevation to occupied Newell's shearwater nesting colonies already established in that region of the island, and would benefit multiple generations of Newell's shearwater.

LEGAL REFERENCE

Chapter 343, Hawaii Revised Statutes, and Section 11-200-12, Hawaii Administrative Rules.

LOCATION(S)

The proposed Seabird Preserve comprises about 5 acres along the Nā Pali Coast at about 4,000 feet above sea level. The site occupies a portion of an area known as "Kahuamaʻa Flat," on Conservation District land owned by the State of Hawaiʻi and managed by DLNR Division of State Parks (por. 5-9-001:016 (Kōkeʻe State Park (Resource subzone)) and por. 5-9-001:001 (Nāpali Coast State Wilderness Park (Protective subzone))).

Additional locations include areas where facilities and/or infrastructure is located that are owned or operated by the participants of the Kauai Seabird Habitat Conservation Plan.

PUBLIC INVOLVEMENT:

A 30-day public review period of the Draft Environmental Assessment (DEA) and Anticipated Finding of No Significant Impact was initiated with publication in April 8, 2020 edition of *The Environmental Notice*, the bi-monthly bulletin of the Hawaii Department of Health, Office of Environmental Quality Control. The Draft EA and AFONSI were available at:

http://oeqc2.doh.hawaii.gov/Doc_Library/2020-04-08-KA-DEA-Implementing-the-Kauai-Seabird-HCP.pdf

An e-mail address was provided in the notice for comments. The two responses were received, from Earth Justice and State Department of Health, and are appended to the FEA.

The FEA can be found here: https://dlnr.hawaii.gov/wildlife/hcp/draft-hcps/

DETERMINATION

Hawai'i Administrative Rule §11-200-11.2 establishes procedures for determining if an environmental impact statement (EIS) should be prepared or if a Finding of No Significant Impact (FONSI) is warranted. In determining whether the proposed action will have a significant impact on the environment, DLNR considers the phases of the proposed action, the expected consequences, and the cumulative as well as the short and long-term effects of the action, specifically considering the following 13 significance criteria, as provided in HAR §11-200-12. The potential effects of the proposed project described throughout this document were evaluated using these significance criteria. The findings with respect to each criterion are summarized below:

1. *Involves an irrevocable commitment to loss or destruction of any natural or cultural resource.*

Implementation of the KSHCP does not involve an irrevocable commitment to loss or destruction of any natural or cultural resources. Instead, the KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Nighttime lighting is an essential activity in many homes, businesses, and industry centers, and the KSHCP is an umbrella habitat conservation plan developed to ensure that entities that have the potential for causing unavoidable injury or harm to Kauai's seabirds minimize that harm and mitigate for any harm that cannot be avoided. Maintaining and potentially increasing the overall populations of the Covered Species is the goal of the KSHCP.

2. *Curtails the range of beneficial uses of the environment.*

Implementation of the KSHCP is not anticipated to curtail the range of beneficial uses of the environment. The KSHCP outlines measures to minimize the effects of artificial lighting and proposes the creation and maintenance of the Kahuama'a Seabird Preserve and barn and feral cat control around Kalalau Valley to mitigate for unavoidable take. The KSHCP will enable the continuation of existing nighttime opportunities that require artificial lighting.

3. *Conflicts with the State's long-term environmental policies or goals and guidelines as expressed in Chapter 344, HRS, and any revisions thereof and amendments thereto, court decisions, or executive orders.*

The KSHCP is consistent with the environmental policies and guidelines established in HRS Chapter 344 and contributes to the conservation of threatened and endangered species, pursuant to HRS Chapter 195D. HRS § 344-3 provides that it shall be the policy of the State to "conserve the natural resources, so that land, water, mineral, visual, air and other natural resources are protected by controlling pollution, by preserving or augmenting natural resources, and by safeguarding the State's unique natural environmental characteristics in a manner which will foster and promote the general welfare, create and maintain conditions under which humanity and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of the people of Hawai'i". HRS § 344-4(3)(A) further provides that all agencies shall consider the following guidelines: "protect endangered species of indigenous plants and animals."

The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Nighttime lighting is an essential activity in many homes, businesses, and industry centers, and the KSHCP is an umbrella habitat conservation plan developed to ensure that entities that have the potential for causing unavoidable injury or harm to Kauai's seabirds minimize that harm and mitigate for any harm that cannot be avoided. Maintaining and potentially increasing the overall populations of the Covered Species is the goal of the KSHCP.

4. *Substantially affects the economic welfare, social welfare, or cultural practices of the community or State.*

The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Nighttime lighting is an essential activity in many homes, businesses, and industry centers, and the KSHCP is an umbrella habitat conservation plan developed to ensure that entities that have the potential for causing unavoidable injury or harm to Kauai's seabirds minimize that harm and mitigate for any harm that cannot be avoided. Maintaining and potentially increasing the overall populations of the Covered Species, native seabirds with cultural significance, is the goal of the KSHCP.

Implementation of the KSHCP is not anticipated to negatively affect the economic welfare, social welfare or cultural practices of the community or State. While the economic and social welfare of the community and state will be positively impacted by the implementation of the KSHCP through continuation of existing legitimate activities, through expenditures associated with the implementation of light minimization measures, and through expenditures and jobs associated with the creation and maintenance of the Kahuamaʻa Seabird Preserve, the impact is anticipated to be minor in the context of the State economy.

5. *Substantially affects public health.*

Implementation of the KSHCP Plan is not anticipated to substantially affect public health in any adverse way.

6. *Involves substantial secondary impacts, such as population changes or effects on public facilities.*

Implementation of the KSHCP is not anticipated to involve substantial secondary impacts (such as population changes or effects on public facilities).

7. *Involves a substantial degradation of environmental quality.*

Implementation of the KSHCP is not anticipated to involve a substantial degradation of environmental quality. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Nighttime lighting is an essential activity in many homes, businesses, and industry centers, and the KSHCP is an umbrella habitat conservation plan developed to ensure that entities that have the potential for causing unavoidable injury or harm to Kauai's seabirds minimize that harm and mitigate for any harm that cannot be avoided. Maintaining and potentially increasing the overall populations of the Covered Species is the goal of the KSHCP.

8. *Is individually limited but cumulatively has considerable effect upon environment or involves a commitment for larger actions.*

The duration of the KSHCP is 30 years. In and of itself, it does not involve a cumulative adverse effect upon the environment or a commitment for larger actions.

9. *Substantially affects a rare, threatened or endangered species, or its habitat.*

Implementation of the KSHCP is not anticipated to negatively affect a rare, threatened or endangered species, or its habitat. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Nighttime lighting is an essential activity in many homes, businesses, and industry centers, and the KSHCP is an umbrella habitat conservation plan developed to ensure that entities that have the potential for causing unavoidable injury or harm to Kauai's seabirds minimize that harm and mitigate for any harm that cannot be avoided. Maintaining and potentially increasing the overall populations of the Covered Species is the goal of the KSHCP.

Implementation of the KSHCP provides for the long-term protection of endangered seabirds from the negative impacts of light attraction. Best management practices associated with the installation of light shielding devices and with the creation and maintenance of the Kahuamaʻa Seabird Preserve will minimize negative short-term impacts to listed species and habitat (e.g., botanical and wildlife surveys along fence or trail corridors to identify rare plants, host plants for rare invertebrates, or roosting or nesting sites for native birds or the ʻōpeʻapeʻa for protection). Rare species protocols (e.g., flagging plants, identifying buffer zones, etc.) would be implemented to avoid negative impacts to any rare plant species at the Kahuamaʻa Seabird Preserve site. This protected area of native habitat would be anticipated to benefit Covered Species as available predator-free breeding habitat, while also benefitting other rare species such as rare plants, native forest birds, and native invertebrates.

10. *Detrimentally affects air or water quality or ambient noise levels.*

Implementation of the KSHCP is not anticipated to detrimentally affect air or water quality or ambient noise levels.

11. *Affects or is likely to suffer damage by being located in an environmentally sensitive area such as a flood plain, tsunami zone, beach, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal waters.*

Implementation of the KSHCP does not affect nor is likely to suffer damage by being located in an environmentally sensitive area such as a floodplain, tsunami zone, beach, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal waters.

12. *Substantially affects scenic vistas and view planes identified in county or State plans or studies.*

Implementation of the KSHCP does not substantially affect scenic vistas or viewplanes identified in county or State plans or studies. Modifications to existing lighting facilities is not anticipated to impact scenic vistas or view planes. The siting and design of the Kahuamaʻa Seabird Preserve predator-proof fencing was specifically planned to limit its visibility by visitors of Kōkeʻe State Park. The fencing will not be visible from roadways and will not block viewplanes or scenic vistas or seem obtrusive; however, it may be visible at times from scenic lookouts, by those looking back along the cliff-face.

13. *Requires substantial energy consumption.*

Implementation of the KSHCP is not anticipated to require substantial energy consumption. Petroleum fuels would be used by equipment utilized for fence construction but this energy consumption is not anticipated to be substantial, especially in comparison to island-wide energy consumption.

STAFF COMMENTS:

Based on the EA analysis, and considering the context and intensity of anticipated environmental effects, the Division of Forestry and Wildlife (DOFAW) has determined that the proposed action will have no significant impacts on the quality of the human or natural environment. Consequently, and EIS is not required. DOFAW seeks the Board's concurrence with the FONSI (EXHIBIT A), following which the Final EA will be published in The Environmental Notice.

RECOMMENDATION:

That the Board of Land and Natural Resources:

1. Approve the Final Environmental Assessment (FEA) for the Kauai Seabird Habitat Conservation Plan
2. Authorize a Finding of No Significant Impact (FONSI) for this project.
3. Authorize the Chairperson to publish the FONSI for the project in the OEQC Environmental Notice.

Respectfully Submitted,

DGS

David G. Smith, Administrator
Division of Forestry and Wildlife

APPROVED FOR SUBMITTAL:

Suzanne D. Case

SUZANNE D. CASE, Chairperson
Board of Land and Natural Resources

Final
Environmental Assessment

addressing
Effects of Implementing the
Kaua‘i Seabird Habitat Conservation Plan
under
Associated Applications for Incidental Take Permits/Licenses

June 2020

HRS Chapter 343 Document

prepared for

Department of Land and Natural Resources
Division of Forestry and Wildlife
State of Hawai‘i

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List of Acronyms

BLNR	Board of Land and Natural Resources
CEQ	Council of Environmental Quality
CZM	Coastal Zone Management
DBEDT	Department of Business, Economic Development, and Tourism
DLNR	Department of Land and Natural Resources
DOFAW	Division of Forestry and Wildlife
EA	Environmental Assessment
ESA	Endangered Species Act
ESRC	Endangered Species Recovery Committee (State of Hawai‘i)
GCP	General Conservation Plan
GIS	Geographic Information Systems
HAR	Hawai‘i Administrative Rules
HCP	Habitat Conservation Plan
HEPA	Hawai‘i Environmental Policy Act
HRS	Hawai‘i Revised Statutes
ITL	Incidental Take License
ITP	Incidental Take Permit
KESRP	Kaua‘i Endangered Seabird Recovery Project
KIUC	Kaua‘i Island Utility Cooperative
KSHCP	Kaua‘i Seabird Habitat Conservation Plan
MBTA	Migratory Bird Treaty Act
NAR	Natural Area Reserve
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NTBG	The National Tropical Botanical Garden
OEQC	Office of Environmental Quality Control
PIP	Participant Inclusion Plan
SHPO	State Historic Preservation Officer
SOS	Save Our Shearwaters
TMK	Tax Map Key
TNC	The Nature Conservancy
US	United States of America
USFWS	U.S. Fish and Wildlife Service

Environmental Assessment of the Federal Action of Issuance of Incidental Take Permits to Qualifying Applicants

Introduction

This environmental assessment (EA) evaluates the effects of a no-action alternative and two action alternatives.

The Proposed (preferred) Action Alternative presented in this EA is for the State of Hawaiʻi Department of Land and Natural Resources (DLNR) to issue Incidental Take Licenses (ITLs) and for the U.S. Fish and Wildlife Service (USFWS) issuance of Incidental Take Permits (ITPs) to qualifying Applicants that request take authorization for the Newell's shearwater (*Puffinus auricularis newelli*, Hawaiian name: ʻaʻo), Hawaiian petrel (*Pterodroma sandwichensis*, Hawaiian name: ʻuaʻu), and the Hawaiʻi distinct population segment (DPS) of the band-rumped storm-petrel (*Oceanodroma castro*, Hawaiian name: ʻakēʻakē, hereafter band-rumped storm-petrel) (collectively referred to as "Covered Species") caused by Covered Activities based on the Applicants' commitment to implement the Kauaʻi Seabird Habitat Conservation Plan (KSHCP) under individual Habitat Conservation Plan (HCP) permit applications. Implementation of the KSHCP is likely to result in the implementation of actions to minimize and fully offset the impacts of the taking of up to 1,738 ʻaʻo, 73 ʻuaʻu, and 26 ʻakēʻakē over 30 years due to light attraction. Under the KSHCP, minimization measures emphasize reducing the amount of artificial, night-time light that shines upward and reducing the amount of light output or intensity, which have been shown to reduce the effects of light attraction on the Covered Species. Under the KSHCP, mitigation activities include creating and managing the Kahuamaʻa Seabird Preserve (Preserve), conducting barn owl (*Tyto alba*) control in Kalalau Valley, and conducting feral cat (*Felis catus*) control along the Kalalau Valley rim to reduce depredation on existing seabirds and colonies near the Preserve.

The No-action Alternative involves not issuing ITPs and ITLs to qualifying Applicants, which may result in implementation of reasonable minimization measures but no mitigation offset for any continued unavoidable, unauthorized take.

The Translocation Alternative consists of the issuance of ITPs and ITLs by the USFWS and DLNR (Agencies) in association with modified HCP permit applications that augment KSHCP preferred-alternative mitigation measures to include translocation of chicks of the Covered Species from remote breeding sites in the mountains into the Preserve to augment recruitment and productivity of breeding seabirds at the Preserve. All other aspects of the proposed action would remain the same under the Translocation Alternative.

The Draft EA was submitted to Office of Environmental Quality Control and posted in the April 8 Environmental Notice for a 30-day public review. Comments received are included below in Appendix 12.

1. Purpose and Need

1.1. Purpose and Need of Action

The proposed Federal action considered in this EA is issuance of ITPs in response to permit applications submitted under this HCP in accordance with the requirements of section 10(a)(1)(B) of the Endangered Species Act (ESA). If approved, these ITPs would each authorize incidental take of the Covered Species caused by Covered Activities.

The USFWS's purpose is to fulfill its ESA section 10 conservation obligations. Non-Federal Applicants whose otherwise lawful activities may result in take of ESA-listed wildlife can apply to the USFWS for an ITP so that their activities may proceed without potential violation of the ESA section 9 prohibition against such take.

In considering ITP applications, the USFWS must comply with a number of Federal laws and regulations, Executive Orders, and agency directives and policy. As the USFWS fulfills these responsibilities and obligations, it will strive to ensure that issuance of any ITP and implementation of the HCP achieve long-term conservation objectives for the Covered Species and ecosystems over the long-term or for a period commensurate with the scope of the take impacts caused by Covered Activities on the Covered Species.

The USFWS's need for the action is to respond to the applications for ITPs. Once applications are received, the USFWS needs to review each application to determine if it meets issuance criteria.

The USFWS also needs to ensure that if it decides to issue ITPs pursuant to the associated HCP that these ITPs comply with other applicable Federal laws, regulations, and treaties such as the National Environmental Policy Act (NEPA), the National Historic Preservation Act (NHPA), the Migratory Bird Treaty Act (MBTA), and Executive Orders 11998, 11990, 13186, 12630, and 12962, as appropriate.

The State also needs to evaluate the environmental impacts associated with the use of State or County funds and the use of Conservation District land to implement the KSHCP supporting the issuance of incidental take license, pursuant to Hawaii Revised Statutes (HRS) chapter 343 (HEPA).

As of October 17, 2019, the Agencies received draft documents from eight initial Applicants under the KSHCP. If these applications are approved, and the Agencies issue associated ITPs and ITLs, the permits would authorize take of the Covered Species caused by Covered Activities as stipulated on those permits.

Applications and draft documents for the issuance of ITLs were received from the following entities:

Alexander & Baldwin, Inc.
County of Kaua'i
Hawai'i Department of Transportation
Kaua'i Marriott Resort (Essex House Condominium Corporation)
Kaua'i Coffee Company, LLC
Norwegian Cruise Lines (Bahamas) Ltd.
The Princeville Resort Kaua'i
Sheraton Kauai Resort (Starwood Resorts)

As such, this document was prepared to meet the requirements of NEPA and HEPA, and to:

- Inform the public of the proposed and alternative actions, and their effects on the human environment;
- Seek relevant information from the public;
- Inform the agencies of the environmental effects of their proposed actions and, under NEPA and HEPA, aid the USFWS and the State in each determining whether to prepare an Environmental Impact Statement (EIS) for the proposed action of issuance of the permits or whether a finding of no significant impact (FONSI) is appropriate; and to
- Use the information collected and analyzed to help make informed decisions concerning the ITP and ITL applications.

1.2. Authority for Action and Authorities Governing the Action

The proposed action would be carried out in compliance with various Federal and State laws including those listed below.

1.2.1. Authorizing Federal Laws, Executive Orders, and Supporting Agency Guidelines

National Environmental Policy Act of 1969 (NEPA), as amended. NEPA requires that Federal agencies evaluate the impacts of their proposed actions on the human environment, that these impacts be considered by the decision maker(s) prior to implementation, and that the public be informed of these impacts. This EA was prepared in compliance with NEPA (42 USC Section 4231, et seq.) and the President's Council for Environmental Quality Regulations, 40 CFR Section 1500 – 1508.

National Historic Preservation Act of 1966 (54 U.S.C. 300101 et seq.)(NHPA). NHPA requires Federal agencies: (1) evaluate the effects of any Federal undertaking on historic properties; (2) consult with the State Historic Preservation Office; and (3) consult with appropriate American Indian tribes or Native Hawaiians. The USFWS may use its public involvement procedures under NEPA or other program requirements to satisfy the public involvement requirements for NHPA. Cultural resources are resources examined under NEPA, and the NHPA regulations encourage coordination and integration of the NHPA compliance process with the NEPA process.

Fish and Wildlife Act of 1956 (16 U.S.C. 742a-742j, not including 742 d-l, 70 Stat. 1119), as amended. This Act provides general guidance, which can be construed to include consideration of alien species control that requires the Secretary of the Interior to take steps "required for the development, management, advancement, conservation, and protection of fish and wildlife resources."

ESA of 1973, as amended (16 U.S.C. 1531-1544, 87 Stat. 884). The ESA requires that all Federal agencies shall seek to conserve endangered and threatened species and shall utilize their authorities in furtherance of the purposes of the ESA (Sec.2(c)). Section 7 consultations with the USFWS are conducted based on best available information to ensure that any proposed Federal action to be authorized, funded, or carried out by a Federal agency is not likely to jeopardize the continued existence of any endangered or threatened species or to destroy or adversely modify designated critical habitat.

Migratory Bird Treaty Act of 1918 (16 USC § 703-712), as amended (MBTA). The MBTA protects more than 1,000 species of birds by implementing U.S. obligations under four treaties within the United States. Under the MBTA, it is unlawful to pursue, hunt, take, capture, kill, possess, sell, purchase, barter, import, export, or transport any migratory bird, or any part, nest, or egg of any such bird, unless authorized under a permit issued by the Secretary of the Interior. In Hawaiʻi, all native birds are protected by the MBTA.

Executive Order 13186 Responsibilities of Federal Agencies to Protect Migratory Birds (66 FR 3853, Jan. 17, 2001) – This order requires Federal agencies, to the extent practicable, to avoid or minimize adverse impacts on migratory bird resources when conducting agency actions, and to restore and enhance the habitat of migratory birds. Specifically, it requires Federal agencies to develop and use principles, standards, and practices that will lessen the amount of unintentional take reasonably attributed to agency actions.

1.2.2. Applicable Hawaiʻi State Laws and Supporting Agency Regulations

Hawaiʻi Environmental Impact Statement (Hawaiʻi Revised Statutes (HRS) Chapter 343). HRS Chapter 343 and its associated regulations (HAR chapter 11-200) provides guidance to develop an informational document which discloses the environmental effects of a proposed ITL action, the effects of that action on the economic welfare, social welfare, and cultural practices of the affected community and State, the effects of economic activities arising out of the proposed action, measures proposed to minimize adverse effects, and the alternatives to the proposed action and their environmental effects. In this case, the triggers for HRS Chapter 343 compliance are the proposed use of Conservation District land for implementation of mitigation measures proposed in this HCP, and the use of State and County lands and funds as both State and County agencies are among the nine applicants seeking an ITP/ITL under the KSHCP. HRS Chapter 343 contains comprehensive environmental policy to encourage productive and enjoyable harmony between people and their environment, to promote efforts which will prevent damage to the environment, and to enrich the understanding of ecological systems and natural resources important to the people of Hawaiʻi.

HRS Chapter 6E (Historic Preservation). This chapter and its associated regulations (HAR chapters 13-198 and 13-276) provide guidance to identifying, evaluating, and assessing the adverse effects of undertakings on cultural resources under State law.

HRS Chapter 195D (Conservation of Aquatic Life, Wildlife, and Land Plants). HRS Chapter 195D provides general agency authority to the DLNR to conserve, manage and protect indigenous Hawaiian species, including the authority to review and approve HCPs and issue ITLs. The DLNR is also authorized to acquire by purchase, donation or otherwise, lands or interests therein needed to carry out the programs relating to the intent and purpose of this chapter.

HRS Chapter 183D (Wildlife). HRS Chapter 183D authorizes the DLNR to manage and administer the wildlife and wildlife resources of the State. Additionally, it allows the DLNR to enact and enforce all laws relating to the protecting, taking, hunting, killing, propagating, or increasing wildlife within the State and within waters subject to its jurisdiction.

1.3. Purpose of this Analysis

This document serves as the analysis of the proposed action of implementation of the KSHCP on the human environment.

This document discusses the following topics:

- The purpose and need of the proposed action;
- A description of the proposed action alternative, no-action alternative, and a translocation alternative;
- The natural and physical environment potentially affected by the action; and
- The range of potential environmental impacts caused by the proposed action, no-action, and translocation alternatives.
- Additional information and analysis required to be considered under Hawaii law, including environmental analysis related to use of Conservation land and use of State and County lands and funds.

The authorized decision-maker can use this EA to determine which alternative best meets the purpose of the proposed action, identify significant environmental impacts of the proposed action, and respond to unresolved environmental issues.

1.4. Resource Areas to be Analyzed

Based on the USFWS's scoping process and coordination with the Hawai‘i Department of Land and Natural Resources, this EA considers a range of resources: Covered Species and other federally listed species and critical habitat; Fauna; Flora; Hydrology and Water Resources; Air Quality; Soils; Archaeological, Historic and Cultural Resources; Recreational Activities. These resources were selected based on their potential to be affected by the Federal and State actions (proposed approval of the ITP/ITL applications, including implementation of minimization and mitigation measures under the HCP) or its alternatives, and the likely extent of the effect. Consistent with NEPA and HEPA, potential impacts to these resources are described in terms of direct and indirect effects of each alternative evaluated separately, and cumulatively with other known and foreseeable impacts.

The potential effects of the action on other resources of the human environment were considered and determined that detailed discussion of these resources is not warranted because there would be no or negligible effects. A complete list of these other resources, and the reasons they are excluded from detailed analysis, are as follows.

- Scenic Resources: Issuance of ITPs and ITLs, and implementation of the KSHCP does not substantially affect scenic vistas or viewplanes. Modifications to existing lighting facilities is not anticipated to impact scenic vistas or view planes. The siting and design of the Kahuamaʻa Seabird Preserve predator-proof fencing was specifically planned to limit its visibility by visitors of Kōkeʻe State Park. The fencing will not be visible from roadways and will not block viewplanes or scenic vistas or seem obtrusive; however, it may be visible at times from scenic lookouts, by those looking back along the cliff-face. Under the no action alternative (Alternative A), the impact to scenic resources in the form of improved nighttime aesthetics associated with darker skies is difficult to quantify, but would be anticipated to remain similar to current conditions. Under the Proposed Action (Alternative B), impacts related to minimization measures at existing Applicant facilities would be similar to Alternative A; potential impacts to scenic resources associated with the proposed mitigation site is anticipated to be minor (localized, small and of little consequence). Impacts under the translocation alternative (Alternative C) would be similar in scale and intensity as Alternative B.
- Effects on Demographics, Economics, Land Use, and Infrastructure: Under Alternative A, the economic impact associated with voluntary light minimization measures, including the potential exposure to fines or penalties associated with unauthorized take of Covered Species would be anticipated to remain similar to current conditions. Under Alternative B, impacts related to minimization measures at existing Applicant facilities would be similar to Alternative A. The development and management of Kahuamaʻa Seabird Preserve as a mitigation site does not change the existing land use or require improvements to existing infrastructure. Impacts of Alternative C would be similar in scale and intensity as Alternative B.

1.5 Permit Issuance Criteria

Under provisions of the ESA, the USFWS (under authority delegated by the Secretary of the Interior) would issue an ITP if the application meets the following issuance criteria identified in section 10(a)(2)(B) of the ESA and its implementing regulations:

- The taking of the listed species would be incidental to an otherwise legal activity;
- The Applicant would, to the maximum extent practicable, minimize and mitigate the impacts of such taking on the listed species;

- The Applicant would ensure that adequate funding for the implementation of the HCP would be provided, including for procedures to deal with unforeseen circumstances;
- The taking would not appreciably reduce the likelihood of survival and recovery of the species in the wild; and
- Other measures required by the USFWS as being necessary or appropriate for purposes of the HCP would be implemented.

The USFWS will document its assessment of the ITP and HCP in an ESA section 10 findings document, which will include a determination of consistency with the issuance criteria. If the USFWS makes the requisite findings, the USFWS will issue an ITP and approve the Applicant's HCP. In such cases, the USFWS will decide whether to issue an ITP conditioned on implementation of the proposed HCP as submitted, or as amended to include the other measures the USFWS determines are necessary or appropriate. If the USFWS finds that the requisite criteria are not satisfied, the permit request will be denied.

Under the Hawaii Revised Statutes §195D-4(g), the Board of Land and Natural Resources may issue a license as part of a habitat concervation plant to allow take otherwise prohibited by subsection (e) if the take is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity; provided that:

(1) The applicant, to the maximum extent practicable, shall minimize and mitigate the impacts of the take;

(2) The applicant shall guarantee that adequate funding for the plan will be provided;

(3) The applicant shall post a bond, provide an irrevocable letter of credit, insurance, or surety bond, or provide other similar financial tools, including depositing a sum of money in the endangered species trust fund created by section 195D-31, or provide other means approved by the board, adequate to ensure monitoring of the species by the State and to ensure that the applicant takes all actions necessary to minimize and mitigate the impacts of the take;

(4) The plan shall increase the likelihood that the species will survive and recover;

(5) The plan takes into consideration the full range of the species on the island so that cumulative impacts associated with the take can be adequately assessed;

(6) The measures, if any, required under section 195D-21(b) shall be met, and the department has received any other assurances that may be required so that the plan may be implemented;

(7) The activity, which is permitted and facilitated by issuing the license to take a species, does not involve the use of submerged lands, mining, or blasting;

(8) The cumulative impact of the activity, which is permitted and facilitated by the license, provides net environmental benefits; and

(9) The take is not likely to cause the loss of genetic representation of an affected population of any endangered, threatened, proposed, or candidate plant species.

Alternatives

NEPA and HEPA regulations require, among other things, that agencies examine a range of reasonable alternatives to a proposed action, including a “No Action” alternative (40 CFR 1500.02). In addition to the requirements of 40 CFR 1502.14, reasonable alternatives include alternatives that are technically and economically practical or feasible and meet the purpose and need of the proposed action (43 CFR 46.420(b)). To comply with NEPA requirements, the alternatives that the USFWS must analyze in the EA are alternatives to the Federal action of issuing ITPs based on the proposed KSHCP including terms and conditions to comply with the KSHCP. The NEPA alternatives should meet the purpose and need of the action, which essentially is to fulfill USFWS conservation obligations under the ESA while responding to each Applicant’s request for authorization of take incidental to Covered Activities.

HEPA requires the identification and analysis of impacts and alternatives considered. The level of detail required is commensurate with the importance of the impact and the degree to which site specific impacts are discernable. HAR § 11-200.1-18.

This chapter will describe three alternatives, including the No-Action Alternative.

1.5. Alternatives Development

Section 102(e) of NEPA states that all Federal agencies shall “study, develop, and describe appropriate alternatives to recommend courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources.” In addition to responding to unresolved conflicts, an environmental analysis must “rigorously explore and objectively evaluate all reasonable alternatives.” (40 CFR 1502.14(a)).

The alternatives detailed below were developed to focus on the issues identified by USFWS and DLNR biologists, the Kauaʻi Endangered Seabird Recovery Project (KESRP) seabird biologists, State and Federal regulatory agencies, and the general public.

1.6. Scoping and Public Involvement

DLNR received grant funds through the USFWS’s Cooperative Endangered Species Program, which administers HCP planning grants under Section 6 of the ESA, to develop an island-wide conservation plan as an approach to reconcile the complex issue of widespread ongoing take of listed seabirds on the island of Kauaʻi. Public involvement and agency coordination served as an integral component of the development of the KSHCP and this draft EA. For over a decade, DLNR has been working with numerous entities on Kauaʻi regarding the longstanding problem of seabird light attraction, the causes of light attraction, the regulatory status of seabirds, and opportunities to avoid and minimize the effects of light attraction on the listed species. In the course of that decade, over 100 businesses and other entities were contacted, resulting in many voluntary changes at facilities to avoid and minimize take of the Covered Species by installation of seabird-friendly lighting and an overall reduction in the number of lights on Kauaʻi. Changes to lighting at some specific facilities were the result of litigation and settlement agreements. During the subsequent decade-long development process for the KSHCP, some entities have determined that minimization alone will not completely avoid incidental take, and these entities are among the Applicants seeking an ITP/ITL under the KSHCP.

The KSHCP was developed through the collaborative efforts of staff from the USFWS, DLNR, KESRP, and potential Applicants. Additional advice and guidance was received from The Nature Conservancy (TNC), The National Tropical Botanical Garden (NTBG), and Save Our Shearwaters (SOS). Additional agencies, organizations and individuals consulted in the development of the KSHCP are listed in Appendix A.

The formal NEPA scoping process began on November 9, 2010, with the publication of a notice of a meeting to conduct public scoping for the proposed KSHCP, Hawaiʻi (Federal Register Volume 75, Number 216 at 688619 [November 9, 2010]). The notice provided information on the project (which at that time the purpose of the KSHCP was to address the incidental take of the ʻaʻo, ʻuaʻu, and ʻakēʻakē due to existing and planned artificial lights as well as overhead utility lines and associated structures that were broader in scope than now proposed), announced the date, time and location of the scoping meeting, and requested written comments by December 9, 2010.

Legal notices, a press release, and an advertisement in two local newspapers were published prior to the public scoping meeting. The names and dates of publications are as follows:

- Legal notice: The Garden Island News, October 31, 2010;
- Press release: The Garden Island News, November 3, 2010;
- Midweek News: published in the November 10, 2010 issue that was distributed November 8, 2010; and
- KKCR community radio played on-air announcements during the week prior to the event.

In addition, a news release was sent to the following media outlets: KHNL television, KHON television, Hawaiʻi Tribune-Herald, Hawaiʻi Public Radio, Big Island Weekly, West Hawaiʻi Today, Star Advertiser, Hawaiʻi News Now, Maui News, Molokaʻi News, Environmental News Service, University of Hawaiʻi newspaper (Ka Leo), and the Associated Press. The USFWS also placed a notification on their website listing the date, time, and location of the public scoping meeting.

The USFWS conducted one public scoping meeting on the KSHCP on November 10, 2010, at the Chiefess Kamakahelei Middle School Cafeteria, Līhuʻe, Kauaʻi.

The State of Hawaiʻi Endangered Species Recovery Committee (ESRC) conducted public meetings on December 6, 2010, October 23, 2014, December 17, 2015, February 25, 2016, June 9, 2016, and December 9, 2016, where the development and status of the KSHCP was an agenda item for discussion and subject to public comment. More recently, the State published the availability of the draft KSHCP and Applicants' Participant Inclusion Plans (PIPs) in the Environmental Notice published by the Office of Environmental Quality Control (OEQC). These were made available for public review and comment for a 60-day period beginning on September 8, 2019. The State ESRC conducted public meetings to discuss the draft KSHCP, conduct site visits, and discuss the PIPs on September 30, 2019, October 7-8, 2019, and on October 23, 2019, respectively.

In addition, Kaua‘i County has afforded multiple opportunities for public comment and involvement between January 2009 and May 2019, at Council meetings on issues related to the KSHCP, including:

- Preparation of applications for ITPs/ITLs and associated HCPs;
- Stadium facilities lighting retrofits;
- ESA and MBTA liabilities at County facilities;
- The *United States of America vs. County of Kaua‘i* court decision, No. 10-00614, and the terms and conditions of probation; and
- The relationship of the shearwater fledgling season to evening football games.

In summary, the public and many agencies have been invited to provide comments on and engage in dialogue with the USFWS as well as State and County agencies on the matter of ongoing lighting impacts to seabirds on the island of Kaua‘i, including the impact of lighting at public facilities such as the County’s football stadiums. The public and the Kaua‘i community have played an integral role in addressing this matter thus far, and the USFWS and DLNR will continue to involve them in the public review of the draft KSHCP, this draft EA, and accompanying draft ITP/ITL applications.

1.7. Alternatives Being Considered

The following alternatives are considered in this EA:

- Alternative A: No-Action;
- Alternative B: The Proposed Action, which involves the USFWS and DLNR issuing ITPs and ITLs to qualifying Applicants who will implement avoidance, minimization, and mitigation measures set forth in the KSHCP. This alternative is the preferred alternative;
- Alternative C: This alternative consists of Alternative B with the addition of seabird translocation as part of the mitigation measures.

Note: section 2.7 of the EA describes alternatives that were considered but not analyzed in detail and explains why those alternatives were excluded from detailed analysis.

1.8. Alternative A: No-Action Alternative

Under the No-Action Alternative, the neither the USFWS nor DLNR would issue ITPsor ITLs to multiple, qualifying non-agency entities on Kaua‘i for incidental take of the Covered Species from the effects of light attraction, and the conservation program under the KSHCP would not be implemented. This alternative assumes that prospective Applicants would implement all possible reasonable avoidance or minimization measures to reduce the risk of take of the Covered Species. The “No-Action Alternative” provides a benchmark to compare the magnitude of environmental effects of the action alternatives, and to determine the significance of effects resulting from issuance of ITPs under the other two alternatives.

The KSHCP is designed to address impacts on the Covered Species caused by existing facilities. Nighttime lighting supports operational needs at existing facilities and provides for human health, safety and general welfare for island residents and visitors. Ongoing (unauthorized) take due to light attraction inspired the development of this HCP, but also resulted in legal actions for unpermitted take of listed seabirds. As a result of previous legal action, the County of Kaua‘i entered into a plea agreement with the U.S. Department of Justice which stipulated that the County of Kaua‘i contribute funds ($111,000) to benefit the ‘a‘o, restrict the use of sports stadium lighting during the seabird fledgling season for a probationary period, conduct an inventory of County lighting and develop a plan to minimize the impacts of lighting, and conduct educational public outreach and seabird awareness and response training for County employees. Kaua‘i Island Utility Cooperative (KIUC) also entered into a plea agreement with the U.S. Department of Justice and developed their Short-Term HCP specifying certain research, minimization, and mitigation actions, and the USFWS issued a 5-year ITP to KIUC that authorized the take of the ‘a‘o, the ‘ua‘u, and the ‘akē‘akē over the 5-year period. The St. Regis Princeville Resort (now Princeville Resort Kaua‘i) came to a settlement on the legal action with an agreement to fund seabird conservation on Kaua‘i for the ‘a‘o, and to reduce the impacts of lighting at its resort. Non-governmental organizations have also filed lawsuits to enforce the ESA prohibition on incidental take of listed species absent a valid ITP.

During the planning process for developing the KSHCP, many entities have been implementing measures to avoid or minimize the adverse effects of nighttime lighting at their facilities on the Covered Species. These actions include installing light shields, re-directing lights downward, shifting the use of lights during fledging fallout season, and replacement of lights with full cut-off features. For example, the County of Kaua‘i replaced existing lighting with full cut-off fixtures at several stadiums and parks, and made scheduling changes to nighttime activities (such as ending night football games). The USFWS assumes these measures would remain in place under the No-Action Alternative.

Measures to minimize the adverse effects of lighting on the Covered Species vary in complexity and cost, generally according to the type of lighting present at a facility, the amount of effort required to alter the lighting, and the effectiveness of the measure to reduce seabird light attraction. Replacing and retrofitting high-intensity lights can incur high costs; simpler measures, such as installing shields on existing light fixtures, are less expensive.

The cost, degree of effort, and anticipated benefit of additional measures to the Covered Species affect whether individuals or groups would enact such measures. The effectiveness provided by existing minimization measures have not been catalogued or evaluated. The extent to which additional minimization measures might take place under the No-Action Alternative cannot be known with certainty, but for purposes of the No-Action Alternative, the USFWS and DLNR assumes that parties that might otherwise have been participants in an HCP and been issued an ITP would implement all additional reasonable minimization measures in light of the history of legal actions on this matter.

Under the No-Action Alternative, individual entities with the continued potential for the unauthorized take of the Covered Species at their facility due to light attraction, despite their implementation of reasonable avoidance and minimization measures, would have to make a choice: continue to operate, exposing themselves to potential civil and criminal penalties for any (future) unauthorized take, or eliminate sources of artificial lighting during the seabird fallout season. In some situations, this may be possible but difficult, but in other situations it may not be feasible due to economic or public safety and security requirements. Under this alternative, any incidental take of Covered Species would not be authorized, and the responsible party would assume all legal liability for operating without an ITP. Under the No-Action Alternative, it is foreseeable that some unauthorized take would continue to occur, and the effects would not be mitigated.

1.9. Alternative B: Proposed Action Alternative (implementation of the proposed KSHCP)

The Proposed Action consists of the issuance of ITPs by the USFWS and ITLs by the DLNR to qualifying Applicants that would authorize the incidental taking of Covered Species that may result from Covered Activities, provided the Applicants implement avoidance, minimization, and mitigation measures as outlined in the KSHCP and committed to under individual Participant Inclusion Plans (PIPs).

Nighttime lighting is an essential activity in most homes, businesses, and industry centers. The KSHCP was developed to provide an efficient and effective process for implementing an island-wide seabird conservation program and for obtaining regulatory compliance for Applicant activities that are likely to incidentally take listed seabirds. In addition, the KSHCP identifies avoidance and minimization measures to avoid take of the endangered Central North Pacific distinct population segment (DPS) of the green sea turtle (honu or *Chelonia mydas*, hereafter referred to as honu).

Applicants seeking ITPs or ITLs (also referred to below as a “permit” or “permits”) under the KSHCP would be seeking authorization for incidental take of the Covered Species under specific terms and conditions defined by the Plan and included in PIPs. Each permit application identifies the estimated incidental take associated with that Applicant’s facilities; the maximum take amounts for each Covered Species as proposed under the KSHCP is shown in Table 2.1. The maximum total take requested under the KSHCP is shown in Table 4.4 (see Section 4.2). Under the KSHCP, the impacts of any authorized incidental taking of the Covered Species is intended to be minimized and mitigated, and offset with a net recovery benefit to the affected Covered Species. The duration of the HCP is 30 years; however, the term of individual permits issued under the Plan may vary within that 30-year period.

Table 2.1. Maximum Take Amounts of Covered Species as Proposed under the KSHCP.

Species	Total Annual		Total 30-Year	
	Mortality (Lethal)	**Injury (Non-lethal)**	**Mortality (Lethal)**	**Injury (Non-lethal)**
‘A‘o				
fledglings	30	45	900	1,350
adults or sub-adults	0.33	0.33	10	10
eggs/chicks	<0.1		2	
‘Ua‘u				
fledglings, adults, or sub-adults	2	2	60	60
eggs/chicks	0.33		10	
‘Akē‘akē				
fledglings, adults, or sub-adults	1	1	30	30
eggs/chicks	0.1		3	
Honu	0	0	0	0

1.9.1. KSHCP Conservation Strategy

The KSHCP is an island-wide conservation program under which individual Applicants may receive a separate Federal ITP and State ITL authorizing take of the Covered Species. The KSHCP “bundles” multiple Applicants, recognizing that many entities on Kaua‘i have a desire to comply with Federal and State endangered species statutes and to address effects of light attraction on the Covered Species. This approach facilitates coordinated, cost-efficient mitigation actions to achieve long-term biological goals and objectives needed to offset incidental take impacts and to provide a net conservation benefit to the Covered Species.

Under the KSHCP, as of October 17, 2019, eight initial Applicants on Kaua‘i that conduct actions with the potential to cause incidental take of the Covered Species have submitted draft PIPs as appropriate to their site-specific situations and facilities. The total, 30-year incidental take levels requested by these initial Applicants are presented below in Table 4.3 and Table 4.4.

Over the 30-year term of the HCP, additional Applicants will have the opportunity to prepare and submit a complete application for an ITP (including a PIP) covering their activities and requesting take coverage pursuant to the KSHCP, as long as there is sufficient mitigation “cushion” to accommodate them. After public review and comment on their draft PIP, if applicable issuance requirements are met and the inclusion of the additional Applicant does not exceed the maximum take threshold established under the KSHCP, an ITP will be issued to the Applicant authorizing incidental take of the Covered Seabirds. New ITPs will be granted, as appropriate, on a first come/first served basis, until the maximum take allowed for under the KSHCP has been fully assigned to individual Applicants. If the addition of a new Applicant would exceed that maximum total take number, then an amendment to the KSHCP would be required before issuance of any additional ITPs.

1.9.2. Covered Activities

The KSHCP covers incidental take requests involving a full range of artificial nighttime lighting types present on Kaua‘i. Kaua‘i contains a variety of lighting types. The specific type and intensity depends upon the purpose for the lighting. Under the KSHCP, all types of artificial lighting, including land-based lights found at parks, retail stores, resorts, condominium complexes, agribusiness, and industrial facilities, can be covered, as well as lighting on ocean-going vessels such as cruise ships. Artificial lighting includes the placement and operation of current light structures as well as the placement and operation of new or future lights that have similar effects. Outdoor lighting fixtures may include, but are not limited to parking lot lights; security lights; spotlights, and floodlights; building and structural or architectural lights; landscape lighting; recreational lights; and signage lights.

Each PIP submitted in support of an ITP would need to identify the specific lights to be covered, the specific combination of minimization strategies to be implemented at the covered facility, and the level of funding the Applicant will provide to support implementation of KSHCP conservation measures to mitigate for the effects of their unavoidable take of the Covered Species. Conservation measures to mitigate for the maximum level of take covered by the KSHCP will be implemented by a contracted party, even if the total requested take by Applicants is less than the maximum provided for under the KSHCP.

1.9.3. KSHCP Avoidance and Minimization Measures

Measures to avoid and minimize the adverse impacts of light attraction on the Covered Species are an integral part of the KSHCP. Initial Applicants have each submitted an applicant-specific PIP which provide specific detailed information on outdoor lighting, including: light type, quantity, location, purpose, and light output. The PIPs describe the lighting standards required for facility operations or other requirements that necessitate the use of lighting (e.g., required for security, safety, or operations), and any plans for future lights. Finally, the PIPs describe the measures to avoid or minimize the impacts of light attraction specific to their facilities on the Covered Species, using the *Guidelines to Adjusting Lighting at Facilities* in Appendix E of the KSHCP. These guidelines were prepared using best available science on seabird friendly lighting. Possible avoidance and minimization measures include, but are not limited to, deactivation of non-essential lights, installation of full cut-off light fixtures, shielding of light fixtures, moving the light fixtures, decreasing lighting levels, and installation of motion sensors to trigger light activation. The PIPs will identify the timing for implementation of take avoidance and minimization measures, and compliance with the minimization plan will be monitored yearly.

Seabirds that are downed at Applicant facilities are vulnerable to direct mortality from depredation by free-roaming dogs, cats, rats, and other predators, so individual PIPs are expected to describe facility-specific planned measures to minimize such mortality. These measures may include actions to reduce on-site populations of potential predators, the development and use of appropriate searching strategies targeted to finding downed birds quickly, and outreach and training for hotel workers and guests to ensure proper responses to detections of downed seabirds. All downed seabirds will be turned in to the “Save our Shearwaters” Program for evaluation, treatment, rehabilitation, and possible release. The KSHCP conservation measure of recovering, evaluating, rehabilitating (if needed), and releasing Covered Seabirds in adequate condition is also anticipated to minimize the injury or harm of the affected individual caused by light attraction when the individual released meets the SOS release standard and is released within 48 hours (2 days) of being grounded.

1.9.4. KSHCP Mitigation Measures

Mitigation measures to offset the impacts of taking Covered Species are an integral part of the KSHCP. Instead of each Applicant doing small-scale individual mitigation projects with limited benefit, Applicants will contribute funding, and using the pooled resources, a contracted implementation entity (referred to below as the "Prime Contractor") will: (1) create and manage the Kahuamaʻa Seabird Preserve; (2) conduct barn owl control in Kalalau Valley; and (3) conduct feral cat control along the rim of the Kalalau Valley to reduce depredation at existing seabird breeding colonies, and to deter cat presence in the vicinity of the Preserve. The conservation measures described below were developed to offset the maximum level of seabird incidental take covered by the KSHCP and are required to be implemented even if the actual collective level of requested incidental take is less than than the maximum level. Over the 30-year term of the KSHCP, these actions are anticipated to increase seabird breeding probability, breeding success, and survival of the Covered Species and to provide a net conservation benefit to these species.

Kahuamaʻa Seabird Preserve

The goal of the Kahuamaʻa Seabird Preserve is to create a new protected breeding colony of ʻaʻo through the use of predator-proof fencing and social attraction. Social attraction techniques will be used to lure prospecting seabirds to breed at restoration sites by utilizing acoustic playbacks of vocalizations and the use of decoys, mirrors, scents and artificial burrows, all of which replicate features of an established seabird breeding colony from a distance (Jones and Kress 2012). Because ʻaʻo are most heavily impacted by light attraction, the development of the Preserve is designed primarily to mitigate for unavoidable take of ʻaʻo.

The Kahuamaʻa Seabird Preserve is anticipated to increase the productivity of breeding ʻaʻo to levels that support colony growth and result in a positive ʻaʻo population growth rate on Kauaʻi, vitally important for a K-selected species with a marginalized baseline condition. K-selected species are characterized by relatively low reproductive output as it is late to reach sexual maturity, and produces at most one young per year. In addition, creating a "new" colony serves to expand the ʻaʻo's distribution, which is recognized as important to increasing the likelihood of its persistence and survival in the wild (USFWS 2017b, a; USFWS 1983).

Based on observations at Kīlauea Point National Wildlife Refuge (NWR) and at Makamakaʻole on Maui, it is believed that social attraction will be effective to lure ʻaʻo to the predator-free site. At Makamakaʻole, acoustic attraction successfully lured a prospecting ʻaʻo to land and investigate a burrow (SunEdison 2015), with attempted breeding in 2017 (TerraForm 2017). These positive milestones have been achieved despite a very small Maui population estimated by Pyle and Pyle (2009) at 50 breeding pairs.

Appendix A of the KSHCP contains the Kahuamaʻa Seabird Preserve Management Plan, which provides a detailed description of planned activities from pre-construction through post-construction at the Preserve, including best management practices associated with the construction and operation of the site. The bullet points below summarize specific planned actions:

- *Construction of predator-proof fencing*. Installing a predator-proof fence entails trimming woody vegetation along the delineated fence route, installing posts, and attaching the metal grid paneling. Clearing vegetation within a corridor up to six feet wide using hand tools is necessary to facilitate fence construction. The fence route will avoid large native trees and rare plant species to the greatest extent possible. The fence posts will be sunk into the ground about 1 meter (3 feet). Wire mesh panels consisting of mesh with spacing small enough to prevent 3-day old mice from getting through, will be attached to the posts. The bottom of the mesh panels will be buried about 15 centimeters (6 inches) under ground or attached firmly to the ground depending on site conditions to prevent animals from digging under the fence. A rolled "hood" will extend outward from the top of the fence to prevent animals from climbing over the fence. The total fence height above grade will be approximately 2 meters (6-8 feet). Reflective metal materials may be colored dark to minimize any visual impacts, such as glare. After fence construction, additional vegetation clearing may be required on the outside of the fencing along a 6-foot wide corridor to remove overhanging branches or tree saplings, and to prevent predators from entering the fenced unit (e.g., by jumping from overhead limbs).

  During construction, best management practices will be employed to minimize the potential for erosion. These practices include: hand-clearing of vegetation along the fence corridor rather than with machinery in steep grade areas; cessation of clearing activities during periods of heavy rain; placing control devices (e.g., sand bag barriers) in place prior to ground disturbance and inspecting these devices daily; restoring disturbed areas; restricting the window for vegetation clearing to 1 week prior to fence construction; and ensuring soil and vegetation stabilization (re-vegetation) is put into place immediately after construction or as soon as practicable.

- *Predator removal*. It is assumed that most large predators (pigs, dogs, and cats) will leave the fenced unit during construction. If any pigs or dogs remain after the closure of the fence, they will be driven out through the gate, trapped, or removed by other methods as necessary. If any cats remain after the closure of the fence, they will be removed through the use of traps that are checked every 24-48 hours. Rodents will be removed through a combination of methods, including the use of automatic self-resetting traps, snap traps, and the use of rodenticide (diphacinone) in bait boxes used in accordance with all label instructions. After predator eradication, a subset of bait stations and self-resetting traps would be used in combination with a system of tracking tunnels as part of ongoing monitoring actions to ensure rapid responses to any rodent re-entry. In addition, a low-pest buffer zone would be established along the length of the exterior of the fence, using bait boxes and traps, to reduce the potential for predator incursion in the event of a fence breach.

- *Implementation of seabird social attraction methods*. Because ‘a‘o come and go from colonies under cover of full darkness, social attraction techniques may consist primarily of acoustic playback from a solar-powered sound system playing non-aggressive vocalizations from dusk to dawn from late February through November, and the installation of approximately 100 artificial burrows. These burrows follow the designs used in New Zealand and Hawai‘i for similar projects and consist of enclosed insulated boxes with open tubes to simulate a seabird burrow. Nest boxes will be buried approximately 15-30 cm (6-12 in) into the ground to ensure appropriate insulation and ventilation for nesting birds and chicks.

  Long-term management and monitoring. Long-term management is necessary to maintain the suitability of the site as seabird nesting habitat. Management personnel will periodically walk the fence to check for any breaches in the integrity of the fence. Remote cameras and tracking tunnels placed strategically within the site will be used to confirm predator eradication and to detect re-invasions. Control of invasive plants by hand and where appropriate, replanting of native vegetation, will occur to enhance the site as seabird breeding habitat. Monitoring the use of the site by Covered Seabirds, particularly ‘a‘o, will be done remotely as much as possible to minimize disturbance of the birds, and incorporate the use of night vision instruments, song meters (to record seabird calls), hand binoculars, and cameras, to monitor use and reproductive success. Unbanded birds will be banded whenever possible by trained personnel.

- *Barn owl control.* Barn owl control in Kalalau Valley will be conducted beginning in year one and continue throughout the term of the KSHCP to reduce the threat of depredation on the Covered Species by non-native barn owls at the Preserve and the surrounding area. Barn owls are aerial predators with a large home range of up to 31 square kilometers (km^2) (Martin et al. 2014). Control actions are anticipated to enhance adult seabird survivorship and the reproductive success of ‘a‘o, ‘ua‘u, and ‘akē‘akē breeding in the vicinity of the Kahuama‘a Seabird Preserve, including populations nesting along the Nā Pali coast and along the Pihea side of the Kalalau rim. Control of the predatory barn owl will involve monitoring for roosting areas, the use of bal chatri or goshawk traps, the playing of owl or prey calls, and shooting individual owls at dusk and dawn. Technicians will be trained in the use of firearms and in identifying the non-native barn owl to avoid causing harm to the native Hawaiian owl (pueo) (*Asio flammeus sandwichensis*). Best management practices to be incorporated include use of existing footpaths, maintaining distance from known seabird nesting areas, and closing traps each morning to prevent non-target effects.

- *Feral cat control.* Feral cat control in Kalalau Valley will be conducted beginning in year one and continue throughout the term of the KSHCP. Control actions would be anticipated to enhance adult survivorship and the reproductive success of ‘a‘o, ‘ua‘u, and ‘akē‘akē breeding in the vicinity of the Kalalau Valley. Feral cats utilize the roads and trails in Kōke‘e as ingress points to prey upon established seabird colonies in the Kalalau Valley and rim, Pihea, and Honopū valleys. Feral cats are voracious predators of seabirds and are regularly documented visiting known colonies (Ainley et al. 2001, Hodges and Nagata 2001, Raine and Banfield 2015, Raine et al. 2017). Control of feral cats will involve linear trapping lines off roadways between the Kalalau and Pu‘u o Kila lookouts, trapping lines along likely cat trails into neighboring seabird colonies, and ad hoc trap placement based on monitoring information. It is anticipated that trapping will remove individual cats, reduce migration towards existing colonies, and reduce feline breeding in the area. Technicians will be trained in the use of a variety of traps, lures, and baits to maximize effectiveness of the control actions.

Adaptive Management

The KSHCP identifies potential actions that may be implemented in response to monitoring results and changed circumstances. Compliance and effectiveness monitoring will be conducted to ensure that authorized amounts of incidental take are not exceeded and to enable the wildlife agencies to determine if mitigation actions are meeting the conservation goals of the Plan. Adaptive Management procedures will be implemented in the event that monitoring indicates the mitigation actions are not likely to meet the conservation goals of the KSHCP.

If the adaptive management provisions are triggered, from that point, all future covered actions would involve coordination with USFWS and DLNR staff to determine if adaptive management actions are practicable and appropriate and monitoring is in place to measure the success or effectiveness of the adaptive management measures. Such measures may include:

1) Incorporation of additional minimization and avoidance actions that were not detailed in the initial PIP for an Applicant facility if initial minimization actions are determined to be insufficient to reduce the level of incidental take to the amount authorized by the ITP and ITL.
2) Substituting new actions for initial minimization measures, to allow for adoption of new technologies, different lighting designs, or more effective searching strategies for downed birds.
3) Incorporation of additional mitigation actions if results of monitoring indicate that initial predator control methods are not adequately controlling predators in the Kalalau area.
4) Substituting new actions for initial mitigation actions for management of the social attraction site, such as expanded predator control of barn owls, feral cats, or rats or funding of other conservation efforts implemented by DOFAW, the Kaua‘i Watershed Alliance (KWA), the KESRP, or another entity approved by the USFWS and DLNR that provide direct benefit to the Covered Seabirds, if the social attraction site fails to meet identified objectives that would lead to a breeding colony.

The above changes to management protocols or the scope of the mitigation actions may need to be addressed as an amendment to the KSHCP, as determined by the USFWS and DLNR. An amendment would require compliance with applicable requirements, potentially including a supplemental NEPA analysis.

1.9.5. Actions related to the Honu

The KSHCP provides that Applicants identify in their PIPs whether their facility includes beachfront property with suitable honu habitat. If so, the PIP needs to include an evaluation of whether there is light from the facility that will likely impinge on honu habitat. If the facility does not include beachfront property, no suitable honu habitat is present, and/or no light is likely to impinge on honu habitat, then there is no potential for take of the honu. If beachfront habitat suitable for the honu is present and would be exposed to nighttime light, Applicants will need to identify light minimization measures to be implemented under their PIP, outline a plan for monitoring for honu nests, and specify specific actions to be taken on their property if nests are found to protect hatchlings from the effects of light disorientation. Such actions could include turning off lights, shielding lights so that they don't shine on honu nests, or erecting a temporary light-proof silt fence to shield the nest from nighttime light. Under the KSHCP, such measures are considered sufficient to avoid incidental take of the honu, and under those circumstances an ITP or ITL for the honu would not be needed.

1.9.6. Cost to Implement the KSHCP

The KSHCP utilizes both individual and shared costs to enable Applicants to take advantage of economies of scale for the mitigation actions. Costs associated with avoidance and minimization measures and on-site take monitoring are costs specific to each permit recipient. The cost of implementing program-level mitigation actions and the cost of compliance with State requirements and review is shared by the permit Applicants. Applicants requesting higher levels of take are expected to fund a correspondingly higher amount of the shared costs.

The total 30-year cost associated with the development and management of Kahuamaʻa Seabird Preserve as a mitigation site, the implementation and maintenance of barn owl and feral cat control, and compliance monitoring of the HCP is approximately $8.4 million dollars. This cost would be shared among the Applicants, based on their proportion of estimated annual take of the Covered Species. Required payments under the KSHCP are broken down as follows:

1) Annual payments addressing the cost to implement mitigation measures on an annual basis. These funds will be paid by Participants into the KSHCP Conservation Measures Implementing Funding Account. The first year's payment is higher than subsequent years due to the initial up-front cost associated with fence construction, predator removal, and social attraction and site equipment;

2) Participants will collectively provide funds into a KSHCP reserve account to provide for financial assurances (three years of annual payments) and to provide for costs associated with changed circumstances and adaptive management at a level necessary to cover the cost of one complete fence and social attraction equipment replacement.
    a. To provide financial assurances, Participants will collectively pay three times the anticipated annual payments after year one. The collective anticipated annual payment after year one is approximately $200,000. Therefore, the financial assurances payment will be $200,000 x 3 = $600,000. This fund is available to be drawn upon by the other Participants if a Participant does not make its annual payment or elects to withdraw from the KSHCP. This will allow the remaining Participants to cover the mitigation costs that the delinquent or withdrawing

participant would have paid. The collective financial assurances payment will be made to the KSHCP reserve fund with half ($300,000) to be paid in year 1 and the other half ($300,000) to be paid in year 2.

b. Participants will fund a reserve to provide for changed circumstances and adaptive management measures that exceed the annual payments. Up to two events requiring complete replacement of the fence and social attraction equipment are considered a changed circumstance. The reserve fund shall be funded initially in the amount of one complete fence and social attraction equipment replacement. This collective payment will be $225,000. These funds may be used if there are changed circumstances or adaptive management measures that require the expenditure of funds beyond those available from the annual payments. This collective payment will be made in year 2 (as the first year cost includes a cushion for increased costs in year 1). The reserve fund shall be replenished following withdrawals so that there are sufficient funds to pay for one complete replacement of the fence and social attraction equipment, provided that the changed circumstances reserve, as replenished, does not exceed the cost of up to 2 events requiring complete replacement of the fence and social attraction equipment. Notwithstanding any limits on replenishment of the changed circumstances/adaptive management reserve fund, the Participants remain responsible for meeting the biological goals of the KSHCP (in other words, although there is a stated limit on the reserve fund in the HCP, the HCP also recognizes that additional funding may be required to meet the biological goals of the HCP).

c. No later than Year 28 of the KSHCP, the Participants will determine whether they wish to seek an amendment to extend the term of the KSHCP. If the Participants conclude they will seek an amendment to extend the term, collective annual payments shall be made and the reserve fund maintained pending consideration of the Plan amendment. If the Participants conclude they will not seek an amendment to extend, they will advise the USFWS and DLNR accordingly. At the end of year 28, one year of the three years of financial assurance funds in the KSHCP Reserve Account ($200,000) shall be transferred to the KSHCP conservation measures implementing fund and shall offset the collective annual Participant payment for year 29 to the extent of the funds transferred. At the end of year 29 of the KSHCP, one year of the three years of financial assurance funds in the KSHCP Reserve Account ($200,000) shall be transferred to the KSHCP conservation measures implementing fund and shall offset the annual payment for year 30 to the extent of the funds transferred. At the end of the original term of the HCP, or any sooner termination, any interest accrued and remaining monies in both the KSHCP reserve account and the KSHCP conservation measures implementing fund will be paid to the Participants remaining in the HCP based on their proportional share of the authorized take.

3) Inflation payments, will be managed by the Participants and the Prime Contractor to implement the KSHCP. The budget includes inflation at three percent (3%) per annum for the annual payments. Both the KSHCP conservation measures implementation funding account and the KSHCP reserve account will be invested by the National Fish

and Wildlife Foundation (NFWF) in one or more investment portfolios or an interest-bearing account maintained by NFWF. Changed circumstances/adaptive management funds will be replenished following withdrawals so that there are sufficient funds in then-current dollars to pay for one complete replacement of the fence and social attraction equipment, provided that the changed circumstances reserve, as replenished, shall not exceed the cost of up to 2 such events.

For the financial assurances portion of the reserve account, the Participants will have funded an initial three years of payments into a NFWF investment account. In the event of an early withdrawal of a Participant, the remaining Participants will replenish their individual pre-withdrawal shares for inflation, taking into account investment income, so that their three years of financial assurance payments are in then-current dollars.

The Prime Contractor shall have the right, but not the obligation, to accept payment in kind for materials or labor needed to implement the KSHCP from a Participant in satisfaction of its annual payment(s). The Participants shall have the right, but not the obligation, to provide a Letter of Credit in lieu of the Financial Assurances payment, provided that the Letter of Credit shall be made payable to NFWF or the KSHCP accounts, as directed by NFWF.

Issuance of permits to Applicants/Participants after the eight initial Applicants may occur up to the maximum take mitigated for under the KSHCP. As new Applicants apply for and receive permits, annual shared costs will be adjusted among the Participants. A Participant may withdraw from the KSHCP and surrender its permit before the conclusion of the permit term. In that circumstance, the early withdrawal payment will be forfeited, and no refund is available for previously paid shared costs. Shared costs for remaining Participants will be adjusted to cover all shared costs. There are no refunds for mitigation costs if actual incidental take is lower than estimated.

1.10. Alternative C: Translocation

1.10.1. Summary

The Translocation Alternative consists of the issuance of ITPs and ITLs by the USFWS and DLNR, respectively, in association with a modified KSHCP that incorporates translocation of chicks of the Covered Species from remote mountain breeding sites into the Kahuamaʻa Seabird Preserve. The objective of the translocation is to augment recruitment and productivity of breeding seabirds at the Preserve as an additional element of the mitigation measures. All other aspects of the proposed action under this alternative would remain the same as for Alternative B.

1.10.2. Conservation Measures to Mitigate for Authorized Incidental Take

Conservation measures to mitigate for the authorized incidental take of the Covered Species consists of activities to increase their breeding probability, breeding success and survival to an extent that provides a net conservation benefit to these species over the 30-year duration of the KSHCP. To achieve this objective, translocation of ‘a‘o would be implemented in addition to social attraction at the Kahuama‘a Seabird Preserve, to increase the overall potential for or to accelerate the establishment of a stable breeding colony (Jones and Kress 2012) at this site.

Burrow-nesting seabird chicks are thought to gain cues from their surroundings during the emergence period shortly before fledging, and then use that information to imprint on their natal colony (locality imprinting). Chicks that have never ventured outside their natal burrows can be successfully translocated to a new colony location where after locality imprinting, fledging and returning from their time at sea, they would return to the new colony location to breed. Because success is optimized if chicks spend the greater proportion of the rearing period with their parents, under this approach, monitoring of the chick and source colony is necessary to maximize the time spent with the parent while minimizing the likelihood of emergence before translocation (Jones and Kress 2012).

Additional elements associated with this alternative include identification of source donor colonies, collection and retrieval of chicks from source locations, chick care after translocation, and translocation monitoring and assessment. Identification of source donor colonies would utilize the best available information regarding the status of existing colonies and suitability as a source population, using criteria such as the presence of a breeding colony, the number of known burrows, the threat level to the colony, the existence of on-site predator control, accessibility, and proximity (Young and Raine 2015).

Best management practices used on New Zealand and Hawai‘i would be utilized in all aspects of the translocation to prevent accidental injury to chicks during transfer and to ensure the highest level of care possible. Logistics would be coordinated to minimize the overall transfer time. After transfer, each individual translocated chick would be banded and placed in its own artificial burrow. The chicks would be hand-fed, weighed, and monitored daily until they fledge. The use of acoustic attraction techniques (playback of calls) would be used to provide auditory stimuli to the developing chicks. Monitoring of all facets of the translocation would be incorporated, from the long-term effect of chick removal on source colonies to monitoring the health of translocation chicks to long-term monitoring of the translocation site to determine the proportion of chicks that return after fledging (Young and Raine 2015).

Chick translocation would be anticipated to contribute to a sustainable breeding population at Kahuama‘a Seabird Preserve earlier than with social attraction alone by increasing the number of potential breeders at the mitigation site as translocated chicks mature and return. However, translocation takes time. Return rates and breeding success of translocated ‘a‘o chicks is unknown, though additional information should be available from the translocations at Kīlauea Point NWR over the next ten years as the chicks translocated from 2016 begin to return. At minimum, it will take three to six years from fledging for the chicks to survive at sea, mature, and return to the site to prospect; it may take as long as ten years for the first translocated chick to return and successfully breed.

1.10.3. Cost of Translocation

Based on cost estimates from other translocations on Kaua'i, translocation would add an estimated $100,000 per year to the estimated cost of Alternative B for each year chicks are proposed for translocation. These costs reflect helicopter time, labor, and supply costs associated with chick transport and care until fledging. Some costs could be reduced by collaborating with existing endangered seabird conservation work.

1.11. Alternatives Considered but not Analyzed in Detail

The Council on Environmental Quality (CEQ) regulations, which implement NEPA, require that agencies discuss alternatives which were eliminated from detailed study, and briefly discuss the reasons why such alternatives were eliminated (40 CFR 1502.14). The DLNR and USFWS considered many additional alternatives to the Proposed Action as ways to meet both the purpose and need of the action. The following alternatives were considered but not analyzed in detail because they do not meet both the need and purpose for agency action. The sections below briefly describe each alternative and explain why the alternative was not analyzed in detail.

1.11.1. Achieving Zero Incidental Take

The "No Incidental Take" alternative would require all take associated with lawful activities to stop. This alternative was removed from further consideration for several reasons. No technology currently exists to completely prevent light attraction. Modifying lights may reduce the effects of light attraction on the listed seabirds (i.e., reduce the amount of take) but cannot reduce the amount of take to zero.

Thus, to completely avoid impacts to Covered Species would mean eliminating or restricting the use of artificial nighttime lighting during the fallout season. This is not feasible in practice. Artificial nighttime lighting expands the visibility of public spaces beyond the hours of natural daylight and extends the period of the day that a facility or area is usable (e.g., recreational facilities). Artificial nighttime lighting is also intended to enhance safety and security at night, and is utilized for this reason in many portions of Applicant facilities (including parking lots, roads, walkways, near buildings, etc.), as well as general welfare for the island residents and visitors. Changes which reduce lighting attract considerable public and media concern centering on impacts to personal safety, fear of crime, and potential for road accidents (Green et al. 2015).

In addition, eliminating lighting sources entirely during the seabird fallout season would be economically infeasible for some Applicant facilities. For example, eliminating artificial lighting associated with a hotel would require closure during the fallout season because of safety and security concerns associated with operating a hotel with no outdoor lighting. It is impractical for hotel guests to stay within their rooms absent light sources during nighttime hours for dining, recreational activities, or other activities. Similarly, shifting airport operations to daytime use during the fallout season could impact airlines and cargo operations by restricting the number of flights daily, which may have secondary impacts as well. Additionally, nighttime lighting for general welfare of island residents and visitors includes operation of facilities that are important cultural activities for the Kauaʻi community (e.g., nighttime football games).

The duration of an HCP should be commensurate with the biological and conservation needs of the Covered Species (USFWS and NMFS 2016) and one of the purposes is to provide long-term conservation for the affected species. The life history of the listed seabird species requires long-term conservation to realize benefits to the species; long-term funding has been shown to provide the most effective conservation for seabirds (Jones and Kress 2012). The listed seabirds are long-lived and individuals do not reach breeding age until year 6. A breeding pair produce only one chick in a breeding season and some seasons a breeding pair will not breed. These life history parameters mean that the seabird species do not reproduce quickly and therefore a short duration HCP would not enable conservation measures to achieve the conservation goals. In order for conservation measures to effectively mitigate for the effects of the take and benefit the species, those measures and activities should take place over a relatively long term. The HCP calculates that the cumulative fledglings produced by the mitigation efforts at Kahuamaʻa Seabird Preserve will meet and exceed the total fledgling take and loss of productivity in year 27 of the 30-year term.

1.11.2. Different-Sized Fence Enclosure Alternative

The potential for a smaller or larger fence enclosure was considered to determine if a smaller or larger sized unit could achieve an appropriate mitigation offset more efficiently and at reduced cost. Biological considerations included the need to incorporate sloped terrain to encourage fledging take-off, the size needed to support artificial burrows, the need to incorporate a perimeter buffer to prevent predator incursion, and the desire to support natural growth if the colony is successful. Practical considerations included existing land uses, landowner permission, cost savings associated with different-sized fences.

After considering the above factors, it was determined that a smaller unit would not support the installation of artificial burrows and the habitat restoration required for potential natural burrows would have increased costs when considered on a per hectare basis, as the fencing costs are primarily related to labor and materials and the diameter of a fence enclosing a smaller area would not reduce costs significantly.

A larger enclosure would increase costs associated with fence materials and construction and with predator eradication (requiring more linear feet of fencing and additional bait boxes and traps) and would increase the complexity and potential time required to remove all predators. Landscape features in the surrounding area constrain feasible fence alignments and the future success of long-term management as a predator-free area. Nearby gulches increase the likelihood for potential failure to fence stability during rain events, making a larger fence enclosure infeasible.

Affected Environment

1.12. Location

The island of Kaua‘i is the northernmost and oldest of the eight Main Hawaiian Islands. Measuring 549 square miles, Kaua‘i is roughly circular in shape, running 32 miles east-to-west and 22 miles north-to-south. Kaua‘i is characterized by steep cliffs and deeply eroded canyons and valleys. The north and east coasts receive wind and moisture carried on the trade winds and support lush vegetation, streams, and waterfalls, while the south and west coasts receive minimal moisture and are typically hot and arid. The island supports unique natural plant and animal communities from montane bogs, montane wet forest, lowland mesic forest, lava tube caves, long stretches of sandy beach, and many streams and rivers. Because of the age of the island and its relative isolation, Kaua‘i contains higher levels of species endemism than elsewhere in the State (Mitchell et al. 2005).

Because the scope of the KSHCP covers impacts occurring island-wide, the affected environment encompasses the island of Kaua‘i. However, specific measures and activities of the KSHCP will take place at certain, identified locations on Kaua‘i. Avoidance and minimization actions will take place at the location of existing facilities, located primarily in populated and developed areas. Mitigation measures outlined in the preferred alternative (alternative B) are proposed in the northwest section of Kaua‘i along the Kalalau rim (“Kahuama‘a Seabird Preserve” and barn owl and feral cat control).

The proposed Kahuama‘a Seabird Preserve comprises about 2 hectares (5 acres) along the Nā Pali Coast of Kaua‘i with an elevation of about 1,200 meters (4,000 feet) above sea level (Figure 3.1). The site occupies a portion of an area known as “Kahuama‘a Flat,” on Conservation District land owned by the State of Hawai‘i and managed by DLNR Division of State Parks (por. 5-9-001:016 (Kōke‘e State Park (Resource subzone)) and por. 5-9-001:001 (Nāpali Coast State Wilderness Park (Protective subzone))).

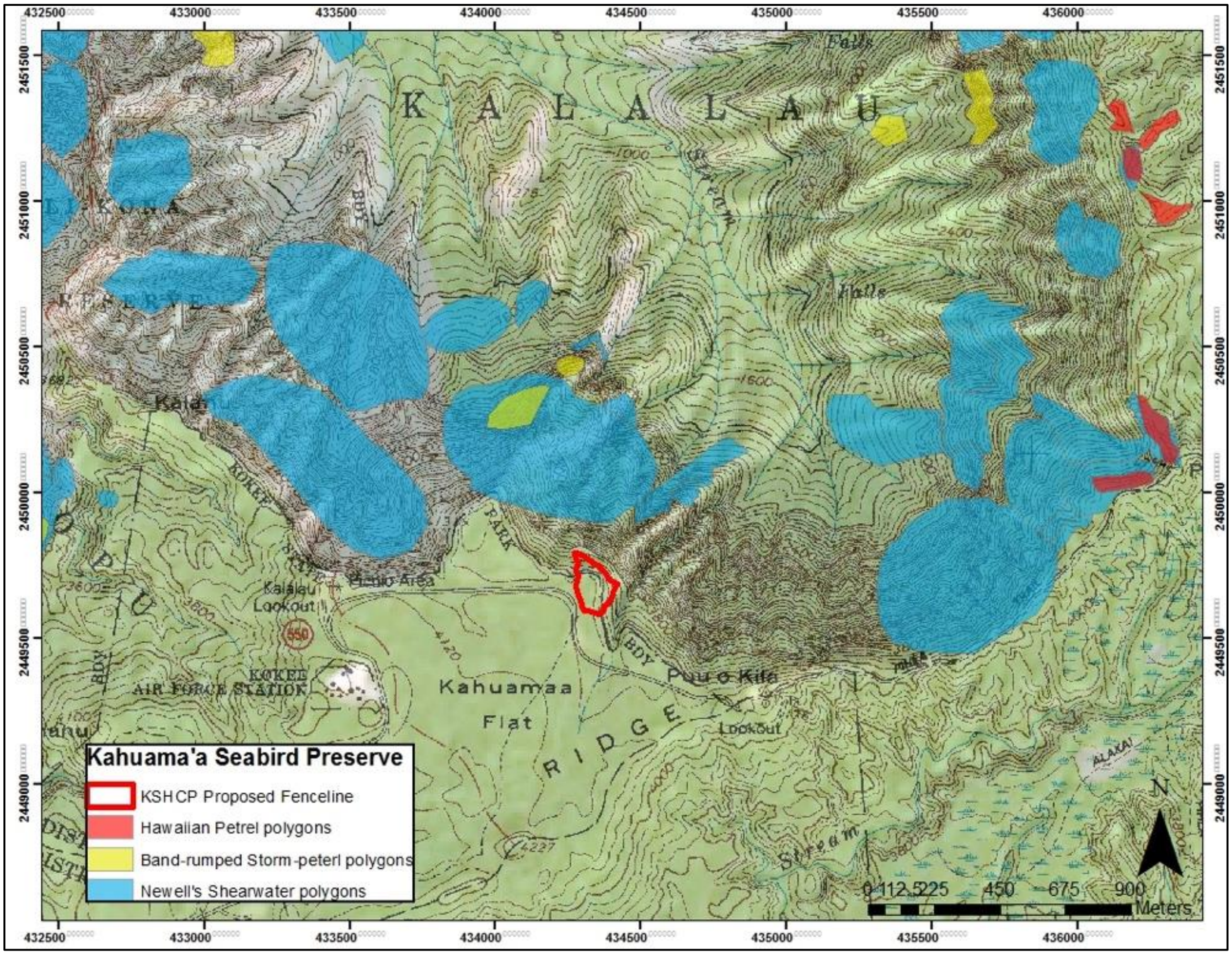

Figure 3.1. Area map of the proposed Kahuamaʻa Seabird Preserve.

1.13. Covered Species: ʻAʻo, ʻUaʻu, and ʻAkēʻakē

ʻAʻo, or Newell's Shearwater

The ʻaʻo is endemic to Hawaiʻi and most of the current-day breeding population breeds on the island of Kauaʻi. It is a small, black and white shearwater with a dark pointed tail and a dark narrow bill with a hooked tip. The species is listed as threatened under Federal and State endangered species laws and endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (Birdlife International 2010b).

Kauaʻi supports the largest breeding population, estimated at 75 to 90% of the total population (USFWS 2011), while smaller populations are thought to breed on the islands of Molokaʻi, Hawaiʻi, and Maui. Oʻahu, Lānaʻi, and possibly Lehua Islet (Day and Cooper 1995, Day et al. 2003a, Onley and Scofield 2007, VanderWerf et al. 2007, Natividad Bailey 2009).

ʻAʻo breed in burrows among dense vegetation located in steep mountainous terrain and are active during periods of darkness, making breeding colonies difficult to locate and monitor. The KESRP has conducted auditory surveys to detect ʻaʻo breeding calls and track relative calling densities indicating potential breeding locations. This information, in conjunction with identified breeding colonies, provides the currently known distribution of ʻaʻo on Kauaʻi. Currently, the ridges and slopes along the northwest coast of Kauaʻi display the highest levels of ʻaʻo breeding activity (Banfield et al. 2013, Raine and McFarland 2014b, a).

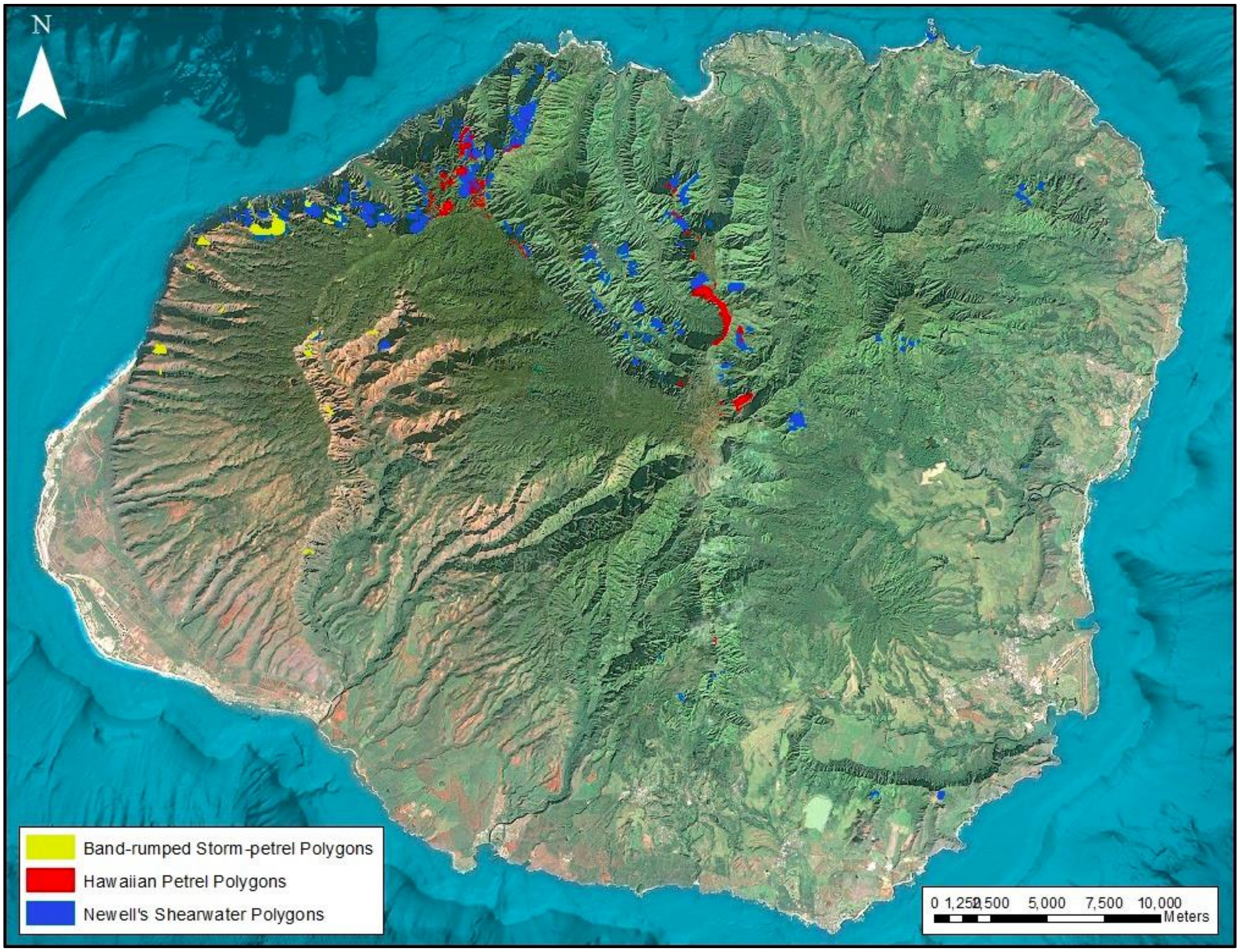

Figure 3.2. Map of seabird activity. Polygons refer to areas where seabird activity has been detected (high calling rates, suspected ground activity, or confirmation of breeding). Source: KESRP.

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 main Hawaiian Islands (Onley and Scofield 2007). It is observed at sea in warmer areas of the Tropical Pacific with a strong deep thermocline, more cloud cover, less mixing and where trade winds are less developed (Spear et al. 1995). They are typically found approximately 800 miles south and east from nesting colonies on Kauaʻi in the deep water regions of the Equatorial countercurrent, 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 1400 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 another moving southeast of the main Hawaiian Islands (KESRP unpublished report).

At-sea surveys conducted in the central and eastern tropical Pacific between 1980 and 1994 (Spear et al. 1995) estimated the total Newell's Shearwater population at 84,000 (95% CI = 57,000-115,000) including juveniles and sub-adults. 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 ‘a‘o population at 27,011 (95% CI = 18,254- 37,125) including juveniles and sub-adults (Joyce 2013). With an approximate 90% of the total population based on Kaua‘i, this estimate can be adjusted to 24,310 individuals on Kaua‘i. This estimate is not representative of current abundance, rather, it estimates the average at-sea abundance during the entire sampling period. It is important to note that while the estimates from Joyce (2013) and Spear et al. (1995) are comparable in certain respects, they are not directly comparable due to differences in survey locations (i.e., longitudinal and latitudinal) and timing of survey (in regards to breeding phenology). Those studies consisted of different data sampling techniques and statistical analyses, however together the studies provide an estimate of the at-sea population of ‘a‘o at different time periods.

From 1993 to 2013, the ‘a‘o population on Kaua‘i declined by approximately 80% as measured by two independent population indices: ornithological radar and SOS data (Day et al. 2003b, Holmes et al. 2009, Raine et al. 2016). 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 (Kalāheo, Anahola, and Makaleha), and the extirpation of others (e.g., Kaluahonu) (Ainley et al. 1995, Holmes and Troy 2008) (KESRP unpublished data). This is largely due to habitat loss, or degradation, high levels of depredation, and/or proximity to urbanized areas that radiate artificial light, as well as man-made structures such as power lines spanning their flight paths that impede their movement to and from montane breeding areas (Holmes et al. 2009). Reducing the population estimate based on a range of presumed depredation rates yields a current 2016 population estimate of 13,049-17,172 individuals. Assuming a stable age distribution (Ainley et al. 2001), the population size range presented above would include approximately 8,312-10,938 birds of breeding age.

The ‘a‘o breeding season begins in late March/early April, when birds return to search for nest sites (Ainley et al. 1997, Zaun 2007, Deringer and Holmes 2009). 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). Nests consist of a burrow that is dug into suitable soils. Both mates participate in digging, and nest excavation may take several years, but excavated burrows will be used multiple times.

A pre-laying exodus follows in late April, and highly synchronized egg-laying occurs in June (Zaun 2007). Pairs produce a single white egg, the average incubation period is between 53 and 55 days. 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 up to 12 days) (Zaun 2007, KESRP unpublished data). Radar detections of adults moving between breeding areas and oceanic foraging sites peak during the first month following hatching, are consistent with the high provisioning demands of early chick rearing and the presence of non-breeders (Deringer 2009). 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 mid-October and November (Ainley et al. 1997). Fledglings depart nests from after sunset to before sunrise (KESRP unpublished data).

Similar to all pelagic seabirds given the difficulties in tracking individuals, little is known about the life history of ‘a‘o from fledging to breeding age. Long-term banding studies on the closely related Manx shearwater (*P. puffinus*) by Brooke (1990) help to clarify that period. Juveniles will spend the majority of time at sea for the next several years, returning to their natal areas only to prospect for mates and burrow sites in years two to five, and finally returning to begin breeding in years six and beyond (Brooke 1990, Ainley et al. 2001).

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 (2011) report that the mean reproductive success of burrowing Procellariformes for studies equal to or greater than three breeding seasons was 0.32 Å} 0.17SD (n=17) in areas where predators were present and was 0.62 Å} 0.08SD (n=9) for areas where predators were eradicated. Like other burrow nesting seabirds, the breeding probability of ‘a‘o is difficult to measure given the uncertainty in determining breeding success in deep burrows. In the modeling efforts of Ainley et al. (2001), a breeding probability of 54.7% was determined. This is low when compared to reported values for other Procellariformes and mortality from adult depredations and powerline collisions is thought to be a factor in this (Telfer 1986, Ainley et al. 2001). Survivorship of non-breeding and breeding age ‘a‘o is currently unknown, though long term studies on the Manx shearwater (Brooke 1990) have been used in population modeling (Ainley et al. 2001, Griesemer and Holmes 2011)(USFWS in prep 2016).

The primary threats to the ‘a‘o population include depredation at their breeding sites by introduced mammalian and avian predators, breeding habitat loss and alteration caused by invasive plants, public use, and urban development, light attraction, collisions with utility structures, at sea factors affecting their prey-base, global climate change, and stochastic events that are inherently a hazard to populations with a limited range.

The ‘ua‘u, or Hawaiian petrel

The ‘ua‘u 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. It is endemic to Hawai‘i, and is listed as endangered under Federal and State endangered species laws and is classified as “vulnerable” on the IUCN Red List of Threatened Species (Birdlife International 2010a). The ‘ua‘u 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 the Galapagos petrel (*Pterodroma phaeopygia*), a species endemic to the Galapagos Islands.

The ‘ua‘u only breeds in the main Hawaiian Islands. It is thought that the species once bred on all the main islands of Hawai‘i, except Ni‘ihau (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 Kaua‘i at high-elevation nesting colonies. Smaller populations breed on the islands of Hawai‘i and Moloka‘i. There is also a large breeding population on the island of Lāna‘i, of perhaps 1,000 breeding pairs (Day et al. 2003a, Onley and Scofield 2007, Tetra Tech 2008, Holmes and Joyce 2009b, Natividad Bailey 2009, Pyle and Pyle 2009).

Direct observations of breeding populations are difficult due to the remote and mountainous terrain in which ‘ua‘u breed, their nocturnal behavior, and the fact that they breed in underground burrows in dense vegetation. However, the KESRP has conducted auditory surveys on Kaua‘i which indicate calling concentrations and suspected breeding locations. This information, in conjunction with identified breeding colonies, provides the currently known distribution of ‘ua‘u on Kaua‘i. Currently, the ridges and slopes along the northwest coast of Kaua‘i display the highest levels of ‘ua‘u breeding activity.

Highly pelagic, the ‘ua‘u is known to travel over large areas of the northern Pacific Ocean to forage during the breeding season. Densities of Hawaiian birds appear to decrease with increased sea surface temperatures (ranging from 25 to 28 °C), increase with wind speeds (above 12.5-25 mph) and show a general preference for waters of the North Equatorial Current (Spear et al. 1995, Simons and Hodges 1998, Mitchell et al. 2005). Foraging ‘ua‘u have been observed in the MHI waters out to the French Frigate Shoals (FFS) within the Northwestern Hawaiian Islands (NWHI) (Onley and Scofield 2007). They have also been tracked well north of the Hawaiian Islands during the breeding season, on feeding routes that approach the Aleutian Islands off Alaska and west towards the Marianas Islands (KESRP, unpublished data). During the non-breeding season, the ‘ua‘u occur well away from land, dispersing out into the vast equatorial waters of the eastern tropical Pacific generally between 20 °N and 10 °S (Spear et al. 1995, Mitchell et al. 2005).

Total ‘ua‘u population estimates are based on at-sea counts. The Spear et al. (1995) at-sea count estimated a total ‘ua‘u population of 19,000 (10,600 – 34,400) individuals. Separated by spring and fall, Spear’s estimate includes 16,300 birds (95% Confidence Interval: 10,600 – 23,300) in spring and 22,700 birds (95% Confidence Interval: 13,500 – 34,400) in autumn. Population abundance equal to an average of 52,000 individuals was estimated based on at-sea surveys 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 ‘ua‘u at different time periods.

It is unknown what portion of the total ‘ua‘u population breeds on the island of Kaua‘i. Ainley et al. (1997a) estimated 1,600 breeding pairs on Kaua‘i. This estimate was updated to 1,200 breeding pairs by Pyle and Pyle (2009). Overall population estimates are currently being revised, but recent data suggests that Kaua‘i may contain a much more significant portion of the breeding population of the ‘ua‘u than predicted by earlier estimates (Raine et al. 2016).

Population trends of the ‘ua‘u on the island of Kaua‘i have been less studied than for the ‘a‘o, though Holmes and Joyce (2009b) note that the species face similar threats. Fallout recovery records of the ‘ua‘u from SOS since 1979 show very little change, averaging about 10 ‘ua‘u birds recovered annually, although, it is thought that the species is not highly susceptible to light attraction (Ainley et al. 1995, Raine et al. 2016). Recent radar data analyses indicate a potential >75% decline in ‘ua‘u numbers during the period from 1993-2013 (Raine et al. 2016). Additionally, the KESRP reports that the species is impacted by habitat degradation and high levels of depredation at breeding colonies (Holmes and Joyce 2009b, Raine and Haber 2012, Raine and McFarland 2014b, a). ‘Ua‘u also appear to suffer a higher rate of depredation by feral cats, black rats, and feral pigs than ‘a‘o (Raine and Banfield 2015).

The ‘ua‘u breeding season on Kaua‘i begins in April when birds return to the island to commence breeding. The ‘ua‘u, like many petrels, displays a high degree of site and mate fidelity; nesting pairs return to the same nesting burrow year after year, entering and exiting 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. After returning, they have been observed excavating the burrow and removing debris (Simons and Hodges 1998).

Prior to egg laying and incubation, adult ‘ua‘u 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 is synchronous within colonies (Simons and Hodges 1998). Breeding females lay a single white egg each year. Incubation typically begins immediately after laying and lasts 54-58 days (Simons and Hodges 1998) with both adults taking shifts lasting several days at a time, thus relieving the other adult to feed. Not all nesting pairs produce a chick. Pairs may “divorce” and seek a new partner, or breed at a new location if the egg is predated or infertile (Simons 1985, Mitchell et al. 2005). 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. ‘Ua‘u breeding on the islands of Hawai‘i, Maui, and Lāna‘i fledge young earlier (early November) than those breeding on Kaua‘i (late November, early December) (Simons and Hodges, 1998, Natividad Bailey 2009, KESRP Lāna‘i report, undated). Fledglings leaving the colony will not return to land for 2-5 years.

The primary threats to the ‘ua‘u population on Kaua‘i include depredation 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.

The ‘akē‘akē or band-rumped storm-petrel

The ‘akē‘akē is a very small storm-petrel with blackish-brown plumage, a sharply defined narrow white band across the “rump,” and a slightly notched tail. The species is listed as endangered under Federal and State endangered species laws and is considered the smallest and rarest seabird that breeds in Hawai‘i (Mitchell et al. 2005, Swift and Burt-Toland 2009). The

Hawaiian population of the band-rumped storm-petrel (referred to in this document as 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 constitutes a DPS based on geographic and distributional isolation from other band-rumped storm-petrel breeding populations in Japan, the Galapagos Islands, and the Atlantic Ocean. In addition, USFWS found that the Hawaiian population is the only population within U.S. borders or under U.S. jurisdiction and considered "significant" in that its loss would constitute a significant gap in the range of the taxon (USFWS 2015).

Abundance estimates for the worldwide population of the band-rumped storm-petrel are unknown, as are estimates for the current ʻakēʻakē population in Hawaiʻi. Kauaʻi is currently thought to support most of the breeding population in Hawaiʻi with an estimated 171-221 breeding pairs on the island, although there is evidence of potential breeding also on Maui, Hawaiʻi, Lehua, and Kahoʻolawe (Johnston 1992a, b, Wood et al. 2002). 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). 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.

The ʻakēʻakē is thought to have been common on all of 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).

Though no nest has yet been identified, human auditory surveys, automated acoustic surveys, and mist netting data were used by Raine et al. (2016) 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 cliff 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 Lumahaʻi, and Lehua Islet (Raine et al. 2016; Wood et al. 2002). The KESRP has captured multiple birds along the Nā 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 2009a).

Information on the population trends of the species in Hawaiʻi and Kauaʻi is lacking, although its historical range is restricted from what it once was. As with many native seabird species, it is assumed that a major current threat includes the effects of non-native species on breeding areas, including habitat alteration and depredation on young and nesting adults. Similar to the ʻaʻo and ʻuaʻu, the ʻakēʻakē is adversely affected by light attraction. 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. The species may also be impacted by collisions with utility structures and lines; however, due to the bird's small size and the fact that many power lines are located away from human populations, it is possible that collisions occur but are not detected.

The breeding behaviors and nest phenology of the ʻakēʻakē are not well-known. Evidence of extant nesting populations on Kauaʻi and elsewhere in Hawaiʻi is indirect because occupied/active nests have not been found (Banko et al. 1991, VanderWerf et al. 2007). Based on the same data used to determine distribution, breeding birds return to nest sites in May and complete egg laying by mid-June. The incubation period averages 42 days and fledging occurs 70 to 78 days after hatching (Harris 1966). Fledglings typically depart the nest site between mid-September and late November, with peak fledging in October (Raine et al. 2016). 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. 2016).

During the non-breeding season, some birds apparently remain near their breeding islands, while others undertake long-distance movements of unknown extent. The band-rumped storm-petrel 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 Hawaiian Islands to Japan (Slotterback 2002, Mitchell et al. 2005).

The primary threats to the ʻakēʻakē on Kauaʻi include depredation 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.

1.14. Other Federally Listed Species & Critical Habitat

1.14.1. Designated Critical Habitat

Hawaiʻi is home to more threatened and endangered plants than any other state in the nation. Many of these species are found on Kauaʻi, often in the mountainous interior away from development pressures. Critical habitat to protect threatened and endangered species has been designated on Kauaʻi over the past two decades: 4,479 acres (1,812 ha) of riparian habitat and 12 miles (nearly 20 km) of stream channel in 2002 for Newcomb's snail (*Erinna newcombi*); 52,549 acres (21,266 ha) in 2003 for 83 plant species; 272 acres (110 ha) in 2003 for the Kauaʻi cave wolf spider (*Adelocosa anops*) and Kauaʻi cave amphipod (*Spelaeorchestia koloana*); 794 acres (321 ha) in 2008 for *Drosophila musaphila*; and 26,582 acres (10,757 ha) in 2010 for 44 plants, two birds (ʻakekeʻe (*Loxops caeruleirostris*) and ʻakikiki (*Oreomystis bairdi*)) and one fly (*D. sharpi*). Much of the acreage covered by later designations overlaps with acreage within earlier critical habitat designations. Nearly all of the designated critical habitat is in uninhabited, remote areas. Generally speaking, the Applicants own and operate facilities and will conduct minimization measures in areas of Kauaʻi that are not located within designated critical habitat; proposed mitigation measures are located in areas within existing designated critical habitat.

1.14.2. Listed Mammals

Only two mammals are known as native to Kauaʻi, the endemic Hawaiian monk seal (*Monachus schauinslandi*, Hawaiian name: ʻīlio-holo-i-kauaua) and the Hawaiian hoary bat (*Lasiurus cinereus semotus*, Hawaiian name: ʻōpeʻapeʻa). Both species are state and federally listed as endangered.

The total worldwide monk seal population is estimated at fewer than 1,200 animals (NMFS 2007). The majority of the monk seal population resides in the Northwest Hawaiian Islands, but regular sightings occur in the main Hawaiian Islands. Although primarily ocean mammals, monk seals spend part of their life on land and can be seen hauled out on the beaches of Kauaʻi. Threats affecting this species include food limitation, entanglement, and shark depredation. Land-based threats to pup survival include attacks by dogs and disease.

The ʻōpeʻapeʻa is considered the only native land mammal of Hawaiʻi. There is limited data on the life cycle, distribution, or population estimates of the ʻōpeʻapeʻa, but they have been observed island-wide on Kauaʻi, occurring seasonally from sea level to the summit of Mount Waiʻaleʻale where they commonly roost alone in trees and leaf litter (Bonaccorso et al. 2005). Primarily a nocturnal species, they forage on flying insects using ultrasonic echolocation.

3.3.3 Listed Birds

Several species of threatened and endangered birds inhabit Kauaʻi. Listed forest birds include the endangered puaiohi (*Myadestes palmeri*), ʻakikiki, and ʻakekeʻe, and the threatened ʻiʻiwi (*Drepanis coccinea*), all of which are found in upland (above 3,500 ft elevation) in areas of intact native forest. These native forest bird species face threats of depredation from non-native animals, degradation and destruction of habitat by non-native species (both destruction by pigs uprooting or goats eating native vegetation or degradation of forest through spread of invasive plants displacing native flora), and disease (spread by non-native mosquitoes) (USFWS 1983).

Five species of endangered water birds inhabit Kauaʻi year-round: the nēnē (*Branta sandvicensis*, Hawaiian goose), the kōloa maoli (*Anas wyvilliana*, Hawaiian duck), the ʻalae keʻokeʻo (*Fulica alai*, Hawaiian coot), the ʻalae ʻula (*Gallinula chloropus sandvicensis*, Hawaiian moorhen), and the aeʻo (*Himantopus mexicanus knudseni*, Hawaiian stilt) (USFWS 1999).

The nēnē on Kauaʻi frequent scrubland, grassland, golf courses, sparsely vegetated slopes and open lowland country (including agricultural fields). The nēnē diet consists of seeds of grasses, herbs, as well as leaves, buds, flowers and fruits of various plants. The other water birds typically inhabit perennial and seasonal wetlands, ponds, and a variety of manmade landscapes including golf courses, landscape ponds and streams, reservoirs, aquaculture ponds, and agricultural areas. Major threats to water birds as a group include drainage of marshes and other wetlands, introduced predators and diseases, invasive plants, and environmental pollution (e.g. non-point sources, debris, toxic material spills, pesticides) (USFWS 1999). Water birds are active during the daytime and do not appear to be attracted by artificial lights.

3.3.4 Listed Invertebrates

Two endangered subterranean species inhabit the island, the Kauaʻi cave wolf spider and the Kauaʻi cave amphipod which inhabit mesocaverns and caves. Both species are thought to only inhabit the Poʻipū and Kukuiʻula areas of the island (USFWS 2003), with approximately 110 hectares (272 acres) designated as critical habitat for these species. *Drosophila musaphilia* is an endangered picture wing fly endemic to Kauaʻi. It was historically known at three sites: Mt. Kāhili (Alexander Reservoir) in the south and two sites within Kōkeʻe State Park. Occurring in mesic to wet forest, it breeds in fermenting sap fluxes of *Acacia koa*. *Drosophila sharpi* is an endangered large brown fly endemic to Kauaʻi. It was historically known from two sites, Mt. Kāhili in the south and Kōkeʻe in the northwest. Occurring in mesic to wet forests, the breeding host is unknown but based on its close similarity to sister species *D. primaeva*, it is likely *D. sharpi* also breeds in species of *Cheirodendron* and *Tetraplasandra* (USFWS 2010).

The threatened Newcomb's snail inhabits stream habitat of Kauaʻi. The current known range of Newcomb's snail is limited to very small sites located within six stream systems in north-and east-facing drainages on Kauaʻi including: Kalalau Stream, Lumahaʻi River, Hanalei River, Waipaheʻe Stream (a tributary to Keālia Stream), Makaleha Stream (a tributary to Kapaʻa Stream), and the North Fork Wailua River (USFWS 2002).

3.3.5 Honu

The honu is listed as threatened under Federal and State law. Long-term monitoring of honu populations over nearly 40 years shows that the population in Hawaiʻi has increased at a rate of approximately 5.7% annually since the harvest limits were imposed in 1974 (Chaloupka and Balazs 2007; Maison et al. 2010; Tiwari et al. 2010). Habitats needed for nesting, basking, underwater resting, and foraging are found along the shores of all the main Hawaiian Islands, with numerous basking and nesting beaches on Kauaʻi (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. 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 (NMFS and USFWS 1998; Witherinton 1992).

3.3.6 Listed Plants

Multiple rare plant species occur on the island of Kauaʻi, with over 150 plants listed as threatened or endangered and critical habitat designated for over 128 (USFWS 2002, USFWS 2010). Many of these species are found in the mesic habitats of western Kauaʻi, in the Alakaʻi Swamp region, in the wet summit areas, and in other areas of intact native vegetation. Listed plants face threats from feral ungulates (hooved animals) that consume and trample native understory plants, create conditions favoring non-native plant infestation and establishment, prevent the establishment of ground-rooting native plants, and disrupt soil nutrient cycling; from introduced invertebrates that directly threaten native pollinators; from plant disease; from competition from invasive habitat-modifying plants; and from seed-eating rodents and other omnivores.

A botanical survey was conducted for the Kahuamaʻa Seabird Preserve. At least eight rare and listed plants have been observed in or near the mitigation site (*Cryptocarya mannii*, *Euphorbia remyi* var. *remyi*, *Exocarpos luteolus*, *Lobelia yuccoides*, *Myrsine knudsenii*, *Polyscias flynnii*, *Pritchardia minor*, and *Zanthoxylum dipetalum* var. *dipetalum*).

3.4 Fauna

3.4.1 Native Animals

Kauaʻi hosts several State-endemic species of forest birds: the ʻaniauniau (*Hemignathus parvus*) (endemic to Kauaʻi), the Kauaʻi ʻelepaio (*Chasiempis sandwichensis sclateri*), the ʻapapane (*Hemignathus sanguinea*), and the Kauaʻi ʻamakihi (*Hemignathus kauaiensis)*. These birds are typically found in remnant montane mesic and wet native forest dominated by ʻōhiʻa (*Metrosideros polymorpha*) and koa (*Acacia koa*) and face the same threats as the listed forest birds (depredation, habitat degradation, and disease).

The native pueo occurs on all the main Hawaiian Islands and is listed by the State as endangered on Oʻahu only. The pueo is a ground-nester, found from sea level to high elevations across most habitats (including both forest and grasslands). Unlike the non-native barn owl (which is nocturnal) the pueo is active during the day and at dusk and dawn. Primary threats include depredation by introduced rodents and cats and habitat loss.

The indigenous ʻaukuʻu (*Nycticorax nycticorax*, black-crowned night heron) is relatively widespread and found throughout Kauaʻi.

Forty different seabird species have been observed in the Hawaiian Islands, with at least 20 known to breed in Hawaiʻi. Many of these are found on Kauaʻi, including the mōlī (*Phoebastria immutabilis*), ʻiwa (*Fregata minor*), brown booby (*Sula leucogaster)*, and red and white-tailed tropicbirds (*Phaethon rubricauda* and *P. lepturus*) (DLNR 2011). Primary threats to seabirds while on Kauaʻi include depredation by feral cats, rodents (*Rattus* spp. and *Mus musculus*.), dogs (*Canis lupus familiaris*), and pigs (*Sus scrofa*), loss or degradation of habitat due to habitat modifying invasive plants or animals, and human-caused disturbances (SWAP 2015).

Numerous migratory shorebird species seasonally inhabit wetlands and coastal areas of Kauaʻi. Of these, the kōlea (*Pluvialis fulva*, Pacific golden plover), the ʻakekeke (*Arenaria interpres*, ruddy turnstone), the ʻūlili (*Heteroscelus incanus*, wandering tattler), and the kioea (*Numenius tahitiensis*, bristle-thighed curlew) are regular migrants. They have been identified as important (by the U.S. Shorebird Conservation Plan) because populations in the State are hemispherically significant or relatively large (DLNR 2015b). Primary threats include loss or degradation of habitat and depredation by feral cats and dogs.

Hawaiʻi contains close to 8,000 species of insects including some 5,300 endemic species, 84 indigenous, and over 2,600 alien species (Mitchell et al. 2005). Kauaʻi contains a diverse number of terrestrial invertebrates, most of which have been poorly studied. Notable invertebrates found in the montane wet forest of Nā Pali include endemic seed bugs in the genus *Nysius*, members of an endemic lineage of spiders in the genus *Tetranagtha*, native damselflies in the genus *Megalagrion*, and a new endemic species of long-legged fly *Sigmatineurum napali* (DLNR 2011, DLNR 2015b). Native insects evolved important ecological roles such as pollinating native plants, serving as food sources for native birds and other animals, and contributing to terrestrial nutrient cycles. Today, many native insect species are declining or have gone extinct due to the combined effects of invasive non-native organisms and human alteration of habitats.

3.4.2 Non-native Animals

Several introduced terrestrial mammals have become naturalized on Kauaʻi, including black-tailed deer (*Odocoileus hemiomus columbianus*), feral pig, goats (*Capra hircus*), dogs, cats, and rodents. Deer, pig and goats offer recreational hunting resource, but also eat, destroy, and trample native vegetation and facilitate weed invasion. Dogs, cats, and rodents are known predators of seabirds and other native fauna. Small Indian mongoose (*Herpestes javanicus*) is not established on Kauaʻi; however, credible mongoose sightings from 2012 to the present indicate that mongoose could eventually become established. To date, only 3 live mongoose have been reported captured on Kauaʻi, in 2012 (near Līhuʻe airport and near Nāwiliwili port) and in 2016 (Līhuʻe airport) (KISC 2017).

Numerous non-native birds are present on the island, including Japanese white-eye (*Zosterops japonicus*), hwamei or melodious laughing-thrush (*Garrulax canorus*), white rumped shama (*Copsychus malabaricus*), the common myna (*Acridotheres tristis*), northern cardinal (*Cardinalis cardinalis*), house finch (*Carpodacus mexicanus*), Japanese bush-warbler (*Cettia diphone*), feral fowl (*Gallus gallus*), zebra dove (*Geopelia striata*), nutmeg manikin (*Lonchura punctulata*), ring-necked pheasant (*Phasianus colchicus*), red-crested cardinal (*Paroaria coronata*), spotted dove (*Spilopelia chinensis*), and barn owl.

3.5 Flora

3.5.1 Native Plant Communities

As the oldest of the main Hawaiian Islands, the island of Kauaʻi developed the highest levels of floristic diversity and endemism in the Hawaiian archipelago. The remote, high elevation moist and wet ecosystems contain the majority of the remaining native forests and flora communities on Kauaʻi. Many native plant communities have been highly altered and modified as a result of past and present land uses and the introductions of non-native plants and animals. Today in most areas of Kauaʻi, non-native species of flora dominate the landscape, with upwards of 4,600 such species. While just over one-third of the island remains dominated by native vegetation, many native-dominated areas contain smaller pockets of non-native species that became established following Hurricanes ʻIwa and ʻIniki.

In addition to the threatened and endangered plants identified previously, another 56 rare plant taxa on Kauaʻi are targeted under the Plant Extinction Prevention Program (PEPP). PEPP was developed by DLNR and USFWS to protect Hawaiʻi's rarest native plants (species with fewer than 50 individuals remaining in the wild); the program is not regulatory in nature but focuses on active management (e.g., seed collection, monitoring, re-introductions) to prevent extinction.

Within the Kahuamaʻa Seabird Preserve, vegetative land cover is classified as open ʻōhiʻa lehua and ʻuluhe fern (*Dicranopteris linearis*) dominated forest with a predominance of introduced and native vegetation cover. The upper, flat portion is montane wet ecosystem which changes to dry cliff at the lower elevation portion, towards the Kalalau Valley. Native plants dominate (many endemic) interspersed with several invasive species (kāhili ginger (*Hedychium gardnerianum*), fire tree (*Morella faya*), banana poka (*Passiflora mollisima*), strawberry guava (*Psidium cattleyanum*), and sawtooth blackberry (*Rubus argutus*).

3.6 Soils

The site consists of approximate 2 hectares 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)". Rough mountainous land-rough broken land-rock outcrop association characterized as well-drained to excessively drained, very steep to precipitous lands of mountains and gulches (Foote et al. 1972). Foote et al. (1972) describe the soil material as very shallow to deep over hard, weathered basic igneous rock; rock outcrop more than 90% bedrock; and occurring on very steep slopes or on steep cliffs. Kōkeʻe series are used for water supply, wildlife habitat, and woodland with vegetation consisting of native ʻōhiʻa-lehua (*Metrosideros polymorpha*), pūkiawe (*Leptecophylla tameiameiae*), koa (*Acacia koa*), ʻukiʻuki (*Dianella sandwicense*); nonnative blackberry (*Rubus* spp.), yellow foxtail (*Setaria pumila*), plantain (*Musa* spp.), redwood (*Sequoia* spp.); and associated plants (Foote et al. 1972).

3.7 Hydrology and Water Resources

The hydrology of Kauaʻi is characterized by streams that radiate out from the Waiʻaleʻale-Kawaikini massif in all directions. As the streams flow through intrusive dikes that retard the groundwater movement toward the ocean, they receive large influxes of groundwater and gain flow as they descend. Kauaʻi has 61 streams, 45 of which are perennial. Figure 3.3 illustrates perennial and non-perennial streams of Kauaʻi. All significant slopes on Kauaʻi, except the west slope, carry perennial streams.

3.8 Air Quality

Generally, the air quality on Kauaʻi is considered good because of the island's isolated ocean location combined with persistent northeast trade winds and a lack of substantial industry.

Winds from the south and east can bring periods of vog (volcanic smog) to Kauaʻi which can result in haze. One monitoring station on Kauaʻi located in Niumalu collects data and measures Sulfur Dioxide (SO_2), Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), and fine particulate matter ($PM_{2.5}$). This station is considered a "special purpose monitoring" location intended to monitor pollutants from ships located in the harbor. At no time in 2012 did the station measure fine particulate matter or pollutants exceeding Federal or state air quality standards and averages recorded were well below standards (State of Hawaiʻi 2013).

3.9 Archaeological, Historic, and Cultural Resources

Avoidance and minimization measures identified in the KSHCP correspond to existing facilities, located in already developed areas. Mitigation measures identified in the KSHCP correspond to development of the Kahuamaʻa Seabird Preserve, in an area of Kōkeʻe State Park that was previously identified as a potential native plant sanctuary to be protected by ungulate-proof fencing. As part of the planning for the native plant sanctuary, State Parks Archaeologists Alan Carpenter and Martha Yent conducted an archaeological reconnaissance survey of the Kahuamaʻa Flats area in 1994 (see Appendix B).
There are few archaeological sites recorded in the uplands of Kōkeʻe, and the area is generally thought to have been a resource-gathering zone rather than an area of permanent habitation (Carpenter and Yent 1994). Only two properties listed on the National Register of Historic Places are currently documented in the Kōkeʻe area: Camp Sloggett and the Civilian Conservation Corps Camp, and these are located some distance away from the Kahuamaʻa Seabird Preserve. However, review of previous surveys and reports provide evidence that potentially significant sites, such as *heiau*, may be located in isolated upland areas where there was little or no permanent habitation (Carpenter and Yent 1994). No archaeological sites or features were encountered during the archaeological reconnaissance survey of Kahuamaʻa Flats, supporting use of the general area as a resource gathering zone with no permanent habitation (Carpenter and Yent 1994). However, due to the dense vegetation growth, the survey could not conclude no sites were present.

The following section utilizes information gathered from (1) review of the Archaeological Reconnaissance Survey (Carpenter and Yent 1994) conducted of the area of the proposed mitigation site, (2) review of previous assessments, including review of the Cultural Impact Assessments included in the 2013 Final EA for the Hono O Nā Pali NAR Management Plan and in the 2014 Kōkeʻe and Waimea Canyon State Parks Master Plan and review of information contained in EAs for previous ʻaʻo and ʻuaʻu conservation work on Kauaʻi; and (3) informal consultation with organizations and individuals with additional information or insight.

3.9.1 Cultural Significance of Covered Species

"In Hawaiian culture, natural and cultural resources are one and the same. Native traditions describe the formation (literally the birth) of the Hawaiian Islands and the presence of life on and around them, in the context of genealogical accounts. All forms of the natural environment, from the skies and mountain peaks, to the plateau lands, watered valleys and lava plains, and to the shoreline and ocean depths are believed to be embodiments of Hawaiian gods and deities" (Maly and Maly 2006).

Native seabirds have value in traditional Hawaiian culture and practice. Some families consider the seabirds as their ancestors or guardians, called the ‘aumākua in Hawaiian language. This is particularly true of families that engage in fishing and have ties to the ocean. More broadly native seabirds are important symbols in Hawaiian culture and are considered special because they inhabit all three realms: land (because they nest in burrows), air, and sea. Seabirds were also of practical value to Native Hawaiians for feathers and food (Rose et al. 1993; Boynton 2004; Xamanek Researches 1989). Seabirds that feed at sea and return to shore at night were used to navigate back to land from fishing or trading voyages. Hawaiians observed seabird behavior to indicate changing weather patterns (KESRP 2016).

Hawaiian proverbs also reflect the role of seabirds and finding fish: “Ka i‘a ‘imi i ka moana, na ka manu e ha‘i mai,” or “The fish sought for in the ocean, whose presence is revealed by birds” and “Pōhai ke manu maluna, he i‘a ko lalo” or “When the birds circle above, there are fish below” (Pukui 1983). In modern times, seabirds continue to play a role for aku (skipjack tuna) fishermen, as the behavior of seabirds at sea tells what is happening in the ocean miles away, providing valuable information for a successful fishing trip (Boynton 2004).

Native Hawaiian culture is intimately linked to physical places, many of which have a special significance in relation to a particular god, legend, song, or historical occurrence.

3.9.2 Archaeological and Cultural Significance of Kahuama`a Seabird Preserve (Mitigation Site)

Human settlement of Hawai‘i by Polynesians dates back to as early as the fourth to fifth centuries based on archaeological evidence, and by 800 A.D. settlements were established and expanded in location, including evidence of agricultural activity on Kaua‘i. The Polynesians that first settled Hawai‘i most likely came from the Marquesas Islands or the Society Islands (or both), about 4,400 and 3,800km to the south, respectively (Kirch 2000; 1985). The older islands of Kaua‘i and O‘ahu likely supported the initial extensive Hawaiian settlements because they provided a greater variety of resources than the younger islands of the chain: abundant freshwater streams, fertile valleys and slopes to support crops, and coral reefs along the coastlines which provided marine food resources (Kirch 2012).

Pre-contact Native Hawaiians inhabited the island of Kaua‘i and established a successful culture and society that persisted for hundreds of years. The island of Kaua‘i was unique among the Main Hawaiian Islands in that the culture developed distinctive features found in artifacts based on archaeological findings, perhaps due to geographic isolation of Kaua‘i compared to the other islands (Joestring 1984). Archaeology from Kaua‘i demonstrates unique local development characteristics such as the shaping of stone, stone grinders of unknown purpose, uniquely shaped poi pounders, and distinctive fish hook designs (Kirchh 1985).

Early Hawaiian communities settled in small villages at zones with favorable conditions, typically coastal areas with plentiful water and close to ocean resources (Kirch 2000). Upper elevation zones consisted of cloud forest and forest zones. In these high-elevation, cooler and typical wet areas Hawaiians accessed timber for construction, firewood, canoes, tools and other wooden objects, hunted birds and gathered plants. Village settlements typically did not occur in these mountainous areas. In the lower-elevation zones crops were cultivated including terraced taro (*Colocasia esculenta*) patches irrigated by ditches as well as tree crops of breadfruit (*Artocarpus altilis*), bananas (*Musa acuminate*), and coconut (*Cocos nucifera)*. Plant resources were gathered and cultivated for use not only for food, but also for healing, decoration and tools, building and construction, and cultural practices (Abbott 1992). Hawaiian habitation settlements occurred in these lowland zones which extended to coastal areas. Coastal sites provided ready access to reef resources and near-shore and off-shore fishing, and aquaculture fish ponds (Mueller-Dombois 2007; Kirch and Sahlins 1992).

Ritual-spiritual practices involved temple or shrine structures, or the Hawaiian term *heiau*, of varying sizes and compositions comprised of placed stones often at locations with good vantage points of the surrounding area. These were considered places of offerings and sacrifices of a variety of types (e.g. agricultural, fertility) in Hawaiian spiritual-religious practice. The most elaborate heiau were constructed over long periods of time, perhaps over centuries, developed in stages upon prior efforts, increasing in size and complexity (Kirch 1985).

Hawaiian settlement and land use consisted of tiered land divisions which were overseen as chiefdoms. Large sections of islands constituted districts, or moku, and were ruled by high chiefs. The island of Kauaʻi contained five historic moku (Kirch 1985). Moku were divided into smaller land management divisions, or ahupuaʻa, which were overseen by lesser chiefs. The ahupuaʻa formed the functional, traditional Hawaiian pattern of land use and settlement of land. In the ahupuaʻa land was divided and land use was allocated along resource zones extending from the upper mountainous regions down in elevation to the coastal areas, including near-shore ocean resources and fringing reefs. Residents and families of the ahupuaʻa worked the land according to a set of protocols and practices. Boundaries commonly consisted of watersheds (Kaneshiro et al. 2005). Ahupuaʻa provided food and materials to support life in a communal, structured sharing of rights to upland and coastal production as well as establishing dwellings. Hawaiian beliefs also connoted a spiritual connection and obligation to care for the ahupuaʻa lands and Hawaiʻi law grants Hawaiians with ancestral links to ahupuaʻa lands certain rights, including access for gathering and cultural and religious practice associated with the land (Kirch 1985; Garovoy 2005).

This traditional system of land tenure and management of old Hawaiʻi was formally abolished with the establishment of the Land Commission in 1845 and division of lands as fee-simple parcels. Native Hawaiians that worked and lived on the land could receive a title to their land under the Kuleana Act (1850), referred to as Kuleana lands; however, very few Hawaiians actually claimed land. The subsequent passing of laws and auctioning off of large tracts of lands meant that by the end of the 19th century, most lands were in the possession of non-Hawaiians (Garavoy 2005).

Kōkeʻe and Waimea Canyon State Parks contain a diversity of archaeological, historical and cultural resources from both pre-contact (1778) and post-contact (1778 to present) periods. There are a number of overland trails connecting the uplands of Kōkeʻe with the Nā Pali valleys (RM Towill 2014). Archival research and archaeological surveys to date, including the 1994 survey of Kahuamaʻa Flat, indicates that the uplands, e.g., the Kahuamaʻa Seabird Preserve, the locations of existing seabird colonies, and surrounding area, were used largely as a resource gathering zone with limited habitation (RM Towill 2014, DLNR 2005).

3.10 Demographics, Economics, Land Use, and Infrastructure

The 2010 Census counted the Kauaʻi total population at 67,091 persons. This represents an increase of almost 15% from the year 2000 Census count of 58,463. In addition to the resident population, on any given day about 20,000 visitors are on the island, making the "de-facto" population upwards of 87,000. Most residents live in towns around the perimeter of the island, primarily along the east and south sides of Kauaʻi, with smaller populations living in towns on the north shore. Visitor accommodations are located throughout the island, but are primarily at Poipu, Princeville, and Waimea/Kapaʻa.

Historically the principal economic driving forces on Kauaʻi have shifted dramatically. Prior to western contact, the economy of Kauaʻi consisted of subsistence agriculture and fishing. Taro, sweet potato, and breadfruit were among the important agriculture staples augmented by fish ponds and marine resource gathering. With the onset of western contact, trade of market goods was initiated. Trade in sandalwood dominated in the early 19th century which on Kauaʻi came almost exclusively from the upland gulches of Waimea Canyon and Kōkeʻe and were largely depleted by the mid-1830s. Kauaʻi also became a trading stop for whaling ships, supporting cattle ranching, but the cattle industry declined as whaling declined.

The "Great Mahele of 1848" created fee-simple ownership of land; by the end of the 19th century most lands were under the control of non-Hawaiians (Garavoy 2005). Pineapple as a cash crop began in the early 20th century, but the sugar industry had the greatest influence, economically, politically, and socially, on Kauaʻi until at least the middle part of the 20th century. Beginning in the late 1800s, the upland streams were tapped to irrigate the sugarcane fields on the west side. Sugar on Kauaʻi peaked in production in the 1960s and then began fading; many mills closed in the 1970s and 1980s. This shift coincided with the emerging visitor industry; the Kauaʻi Surf opened in 1960, and others soon followed. By the 1970s people working in the tourism sector outnumbered those in the sugar industry (Cook 2000). As tourism increased, Kauaʻi experienced a boom in construction and development.

Today, tourism and the visitor industry remains the dominant economic factor for the island of Kauaʻi. Since the late 1990s, the annual number of visitors to Kauaʻi has been about 1 million. The service sectors (many supporting tourism), diversified agriculture, government and military are the main source of jobs on the island. Most of the labor force on Kauaʻi works in the service-oriented fields. The number of people in the workforce for the year 2014 was 34,600 (not including military) with an unemployment rate of 4.9%, the lowest since 2008 (DBEDT 2015). Agriculture on Kauaʻi has shifted from large single-crop plantations (e.g., sugar) to diversified agricultural industries. Several agribusiness companies have established research and development facilities on the west side of the island, typically growing non-food crops for seed (e.g. bio-fuel corn). From 1990 to 2008, total farm acreage fell and the total number of agriculture workers hired decreased. During roughly the same period, the number of individual "farms" increased, suggesting perhaps diversification and the establishment of smaller farms with a movement away from a concentration of agriculture business (DBEDT 2012). Agriculture products produced on Kaua'i include coffee, fruits, flowers and nursery products, and vegetables for local markets, stores, and restaurants.

Land use development patterns have potential to influence the scale and degree of future additional impacts to the Covered Species during the term of the KSHCP. Land development typically includes artificial outdoor lighting. The degree and type of lighting depends on the needs of the development; generally, but not always, more intensive development requires a higher amount of lighting. Over the next 10 years, the County of Kauaʻi Planning Department expects most of the growth on the island to be located in Kukuiʻula and Poʻipū along the south shore, Līhuʻe, Wailua, and Kapaʻa on the windward east side, the Princeville area on the island's north shore, other existing urban centers, and some agricultural subdivisions. The County anticipates little or no growth in the mountainous interior of the island (County of Kauaʻi 2000).

3.11 Recreational Activities

The island of Kauaʻi contains several park and recreation sites at multiple locations on the island, encompassing 400 acres of parklands with 67 individual parks (County of Kauaʻi 2000). These facilities accommodate diverse activities and users and vary greatly in the facilities available (from passive undeveloped parks with limited amenities to lighted fields and courts with restrooms and community centers). Nighttime sports and recreation use at parks can be described as two general types: organized with teams and schedules, and casual use, including tennis courts and basketball courts.

The State DLNR operates and maintains 10 parks on the island, totaling 13,727 acres (130 developed). These facilities are typically more remote and used to support activities such as hiking, hunting, horseback riding, mountain biking, nature study and quiet contemplation. DLNR also manages 20 designated public hunting areas for game mammal and game bird hunting on Kauaʻi (DBEDT 2015). All hunting in the State requires a hunting license; 11,958 hunting licenses were sold statewide in 2015 (DBEDT 2015).

The Kahuamaʻa Seabird Preserve (mitigation site) is located on State Park land within Kauaʻi Hunting Unit K. Hunting Unit K allows hunting by archery only July through December on weekends and State holidays. A goat archery permit or deer archery permit is required depending on the season, and firearms are not permitted. Unit K is not open for hunting from January to June (HAR Chapter 13-123).

3.12 Scenic Resources

The Kauaʻi County General Plan notes that the island is known for the beauty and the great variety of its landscape. It further notes that these land features, some of which can be seen from many places around the island, attract visitors to Kauaʻi and therefore have substantial economic value (County of Kauaʻi 2000). In addition to views of the ocean available from multiple locations around the island, the island has several scenic "destinations." Waimea Canyon is a major visual attraction, with dramatic cliffs and vegetation, and numerous waterfalls and hints of streams many of which can be seen from different vantage points. The view of Kalalau Valley and the Nā Pali Coast, as seen from the top of Kōkeʻe State Park, from the ocean, and from the air (by helicopter) is another rich scenic landscape. The lush greenery and changeable cloud cover of the Alakaʻi Plateau are yet another important visual seen from multiple different vantage points. The Kahuamaʻa Seabird Preserve (mitigation site) is located within Kōkeʻe State Park, within this rich scenic landscape.

4 Environmental Consequences and Mitigation

4.1 Overview of Effects Analysis

This chapter assesses the potential effects to the physical and biological environment and to cultural and socio-economic resources as a result of implementing each alternative. For the resources evaluated, effects to the resources are assessed in terms of intensity and duration within thresholds of potential impact to the resource (Table 4.1).

Table 4.1. Threshold of Impact (Effect).

Effect Threshold	Description of Threshold
No effect	Activity does not come into contact with or incur any change to the resource. If a resource is not discussed, activity is assumed to have no effect on that resource.
Negligible effect	Effects would be at or near the lowest level of detection. Resource impacts would be so slight there would not be any measureable or perceptible consequence to a population, wildlife or plant community, recreation opportunity, visitor experience, or cultural resource.
Minor effect	Effects would be detectable but localized, small and of little consequence to a population, wildlife or plant community, other natural resources, social and economic values, including recreational opportunity and visitor experience; or cultural resources. Mitigation, if needed to offset adverse effects, would be easily implemented and successful based on knowledge and experience.
Moderate effect	Effects would be readily detectable and localized with measurable consequences to a population, wildlife or plant community, or other natural resources, social and economic values, including recreational opportunity and visitor experience; or cultural resources. Mitigation measures would be needed to offset adverse effects and could be extensive, moderately complicated to implement, and probably successful based on knowledge and experience.
Major effect	Larger-scale effects would be obvious and would result in substantial consequences to a population, wildlife or plant community, or other natural resources; social and economic values, including recreational opportunity and visitor experience; or cultural resources. Extensive mitigating measures may be needed to offset adverse effects and would be large-scale in nature, possibly complicated to implement, and may not have a high probability of success. In some instances, major effects would include the irretrievable loss of the resource.

4.2 Effects on the Covered Seabirds

Alternative A: No Action Alternative

Under Alternative A, potential participants would take all reasonable minimization measures to avoid legal liability to the extent feasible. However, take of covered seabirds, particularly ʻaʻo, would continue as a result of attraction to artificial lighting, even with the implementation of reasonable take-avoidance measures.

Covered Species that are grounded due to light attraction are considered "take" under State and Federal law; however, not all grounded seabirds experience the same level of injury or mortality. The conservation measure of recovering, evaluation, rehabilitating (if needed), and releasing Covered Species in adequate condition is anticipated to mitigate the injury or harm of the affected individual caused by light attraction when that individual is released within 48 hours (2 days). Seabirds that receive this treatment are considered to have been taken, but in a "non-lethal" manner. Grounded seabirds that are not recovered (i.e., undiscovered seabirds) would be considered to be taken in the form of harm, yet these seabirds are anticipated to eventually suffer mortality due to depredation, vehicle collision, or starvation and dehydration. Covered Species that are killed due to collisions and grounded seabirds that are not recovered are considered "lethal take." Covered Species that cannot be rehabilitated and released (e.g., due to severe injury or poor body condition) are euthanized. Those seabirds and those that die during rehabilitation are also considered to be taken in the form of harm, and considered "lethal take" due to their death.

Of the ʻaʻo recovered by SOS in the ten-year period between 2006 to 2016, 88% were evaluated, deemed to be in good condition, and released back into the wild (SOS, unpublished data). This leaves a 12% mortality of downed ʻaʻo which includes seabirds that were turned in dead, those that died in care, and those deemed unfit for release back into the wild (i.e., euthanized).

This statistic is generalized for all birds turned in to SOS, and does not account for site-specific circumstances. It is anticipated that the annual take of Covered Species will remain constant based on recent trends of SOS recoveries island-wide on Kauaʻi. Between 1993 and 2013, the population of ʻaʻo is estimated to have declined by 94% and the population of ʻuaʻu is estimated to have declined by 78% (Raine et al. 2017). While this suggests the potential for a decline in fallout numbers, over the past five years (2011-2015), SOS recoveries of the ʻaʻo, island-wide, with the exception of one large fallout event in 2015 near Kōkeʻe Air Force Base, have been stable since 2000 (DLNR 2016). Considerably fewer ʻuaʻu and ʻakēʻakē are impacted by light attraction, based on SOS recovery records (DLNR 2016). Of the total SOS recoveries of the Covered Species between 2011 to 2015, approximately 5% of retrieved birds were ʻuaʻu and 0.6% of retrieved birds were ʻakēʻakē.

The majority of light attraction take involves fledgling seabirds. However, adults and sub-adults are occasionally found in association with bright lights. Table 4-2 presents the estimated island-wide take (both lethal and non-lethal) associated with light attraction, calculated from average

SOS recoveries (2011-2015) and using a 50% searcher efficiency rate to account for grounded birds present but not found (Ainley et al. 1995). Table 4-3 presents the lethal and non-lethal take request by the Applicants over the permit term.

Under this Alternative, potential Participants would take all reasonable minimization measures to avoid legal liability to the extent feasible. These measures would include actions to minimize light attraction (e.g., modify lighting or restrict nighttime activities during fallout season) and actions to convert potential lethal take of downed birds into non-lethal take (e.g., employee training, development of search protocols, participation in SOS, conduct predator control on-site under lighting facilities). Quantifying the exact species' benefit from light minimization actions is difficult in part due to year-to-year variation in fledgling fallout from light attraction evident from SOS recovery records (DLNR 2015a) and the ad-hoc manner in which minimization has and would take place. Few scientific studies provide measures of the effects of minimization actions on the Covered Seabirds. One study conducted in the mid-1980s found that shielding reduces the effect of light attraction on seabirds substantially, by as much as 40%, with the results varying over the two-year study (Reed et al. 1985). However, without an approved HCP and subsequent ITP, mitigation measures described in the HCP would not occur and the anticipated benefits to the Covered Species would not be gained under the No-Action Alternative.

Table 4.2. Annual Island-wide Take (Lethal and Non-Lethal) Estimates due to Light Attraction.

ʻAʻo	Annual	30-year		**ʻUaʻu**	Annual	30-year		**ʻAkēʻakē**	Annual	30-year
Total island-wide take estimate	322	9,660		Total island-wide take estimate	17	516		Total island-wide take estimate	2	60
Take Amount requested by Applicants	62	1,846		Take Amount requested by Applicants	3	72		Take Amount requested by Applicants	1	31

Table 4.3. Total (30-year) Lethal and Non-Lethal Take Request by Applicants.

Species	Mortality (Lethal)	Injury (Non-Lethal)
ʻAʻo fledgling adults or sub-adults eggs/chicks	 786 0 0	 1060 0
ʻUaʻu fledglings, adults, or sub adults egg/chicks	 39 0	 33
ʻAkēʻakē fledglings, adults, or sub-adults eggs/chicks	 17 0	 14

Alternative B: Proposed Alternative (Implementation of Kaua‘i Seabird HCP)

Under this Alternative, Applicants will identify specific avoidance and minimization measures that have been or will be implemented at their facility. Minimization measures to avoid or minimize take associated with light attraction would be anticipated to reduce the amount of lethal and non-lethal take associated with that structure.

The total amount of take (lethal and non-lethal) requested under the KSHCP and corresponding ITP/ITL (see Table 4.3) would be less than the total island-wide light attraction effects to the Covered Species (see Table 4-2). Of the total island-wide light attraction fallout of the Covered Seabirds, if the maximum take allowed under the KSHCP were authorized, the KSHCP would address about 18% of existing ‘a‘o take, 16% of existing ‘ua‘u take, and 45% of existing ‘akē‘akē take. Under the Proposed Alternative, this portion of take would be legally permitted through the ITP/ITLs and mitigated for as provided in the KSHCP.

The KSHCP functions as a plan under which multiple entities may apply for incidental take authorization, but it has the potential to change based on an Applicant’s request for early withdrawal and discontinuance of permitted activity, revised incidental take request, and another potential Applicant’s late enrollment. Therefore, this EA analyzes the impact of the maximum amount of take of each species that could be permitted under the 30-year term of the KSHCP.

Table 4.4. Lethal Take Requested by Applicants for ITPs and ITLs.

Species	Total (30-year) lethal take request by Initial Applicants	Maximum 30-year lethal take under KSHCP	Remaining “available” 30-year lethal take under KSHCP
‘A‘o			
fledgling	786	900	114
adults or sub-adults	0	10	10
eggs/chicks	0	2	2
‘Ua‘u			
fledglings, adults, or sub adults	39	60	21
egg/chicks	0	10	10
‘Akē‘akē			
fledglings, adults, or sub-adults	17	30	13
eggs/chicks	0	3	3

The mitigation measures proposed under this Alternative (the seabird social attraction project at Kahuama‘a Seabird Preserve, the barn owl control, and feral cat control) are expected to result in a positive ‘a‘o reproduction output trajectory (15 fledglings) relative to the take impacts in the first year of the KSHCP. Barn owl and feral cats predate on adults and chicks at their colonies.

Control of these predators at the Kalalau Valley are anticipated to enhance adult survivorship by protection of adult birds that are already breeding in the affected area. The loss of a breeding adult also results in the loss of its egg or chick. In addition, feral cats have the ability to predate on multiple adults and chicks in a matter of days. Controlling feral cats is therefore important in providing a benefit to multiple adults and chicks.

The same immediate reproductive benefit is not anticipated in the social attraction scenario. Although the benefits from social attraction will benefit the Covered Species, the social attraction is expected to provide a delayed benefit due to a combination of factors. These primarily include: (1) the conservative estimate of the starting population within the fenced 2-hectare site (zero); (2) the several years to recruit breeding adults and increase breeding adult numbers at the social attraction site; and (3) the time delay to breeding age (6 years old) of fledgling birds that return to breed at the site. Due to this expected delay in successful initial breeding of the Kaua‘i ‘a‘o population at Kahuama‘a Seabird Preserve, the mitigation would be estimated to be delayed in fledglings not being mitigated in the same year take occurs. This delay results in a projected productivity loss due to the loss of the fledglings that would have returned to breed as adults. This partial in-year offset of ‘a‘o take is anticipated in the first 12 years of the KSHCP implementation.

Under the KSHCP, the standard for mitigating take of the ‘a‘o resulting in mortality will be as follows: increasing ‘a‘o reproduction by one fledgling will be necessary to offset each fledgling or egg/chick mortality, and by 3 fledglings to offset the mortality of one adult, given an juvenile/sub-adult survivorship of 0.33 (Ainley et al. 2001). One out of the 15 ‘a‘o fledglings produced annually as a result of barn owl and feral cat control provides for a complete in-year offset for the adult ‘a‘o mortalities anticipated to be covered under the KSHCP (1 adult every 3 years or 0.33 annually). This means the reproductive benefits of the seabird social attraction project increases each year beginning in year 4 (*Appendix C: Social Attraction Benefit Estimator*). When these benefits are added to the remaining benefits of the barn owl and feral cat control (14 fledglings annually), there is a partial in-year offset of fledgling mortalities in years 1 through 12 of the KSHCP, a complete in-year offset in year 13, followed by a greater than in-year offset in years 14-30 (Figure 4.1).

The delay in achieving mitigation benefits for the ‘a‘o as a result of the seabird social attraction project (*Appendix C: Social Attraction Benefit Estimator*) and the partial in-year offset of ‘a‘o fledgling take in years 1 to 12 results in a loss of ‘a‘o productivity over the term of the KSHCP. Because of the delay, the Kaua‘i ‘a‘o population is likely to experience a loss in breeding productivity due to the mortality of fledglings that would have returned to breed as adults and the loss of productivity of their progeny and subsequent progeny. The number of ‘a‘o fledglings subject to take impacts that are not mitigated for in the same year as the take impact is shown in Figure 4.1, including 16 fledglings in year 1, with a decreasing, in-year mitigation deficit from years 4 until year 12.

The loss in ‘a‘o reproduction represented by these impacts that are not mitigated in-year, represents progeny that would have survived to breeding as well as the loss in reproduction of their progeny and subsequent progeny. These effects were calculated for each year of the 30-year KSHCP, based on an ‘a‘o juvenile to adult survival of 0.28, breeding probability of 70%, and reproductive success of 50% (*Appendix C: Social Attraction Benefit Estimator*; Griesemer and Holmes (2011) low depredation). The number of ‘a‘o fledglings that the surviving breeding adults, their progeny, would have produced is equal to 81 fledglings over 30 years.

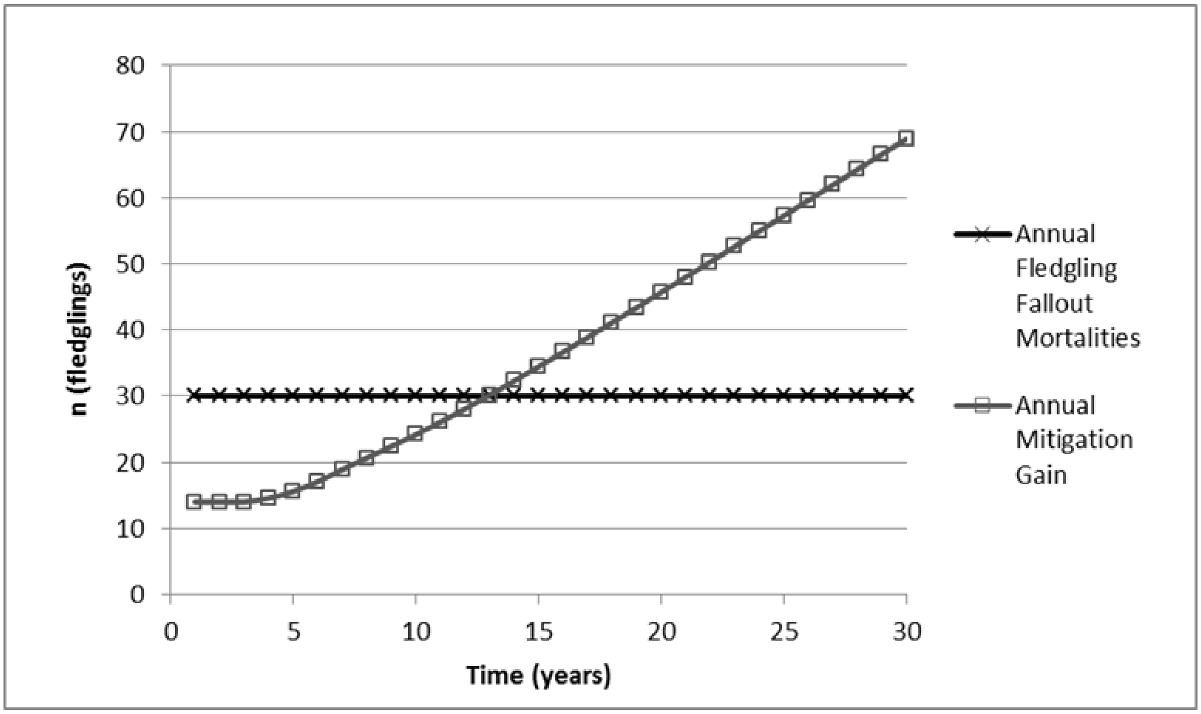

Figure 4.1. Annual take of fledgling ‘a‘o and annual increase in ‘a‘o fledglings (i.e. annual mitigation gain) likely to result from KSHCP conservation program*#

*Note: An annual increase of one out of the 15 fledgling ‘a‘o is not included in the annual mitigation gain, because the one ‘a‘o fledgling is anticipated to mitigate the proposed annual adult take of 0.33.
#This is a graph of a simplistic deterministic assessment to show the probable projected population increase in growth rate given the 5 year lag time that a protected fledgling reaches reproductive age.

The overall effects of the take and the conservation program on the ‘a‘o population would result in a total net benefit of 134 fledglings over the 30-year period. At year 30, it is anticipated that a population of approximately 372 ‘a‘o, growing at a rate of 8% per year, would reside within the predator-free fenced area. This represents approximately 6% of the projected island-wide Kaua‘i ‘a‘o population at year 30 (6,200 individuals) within the Kahuama‘a Preserve, including the colonies along the Kalalau rim. While the annual level of ‘a‘o take under the KSHCP represents 1.44% of the anticipated total fledgling production and less than 0.01% of the Kaua‘i adult population, the mitigation actions would result in the protection of approximately 6% of the Kaua‘i population by year 30.

In addition to the seabird social attraction project at the Preserve, this alternative would include predator control efforts included in the HCP. Depredation on seabirds has long been of concern. Barn owls have been depredating ‘a‘o and ‘ua‘u for many years. Barn owls have been documented on burrow cameras within breeding colonies on Kaua‘i (Raine et al. 2019). Studies have demonstrated how feral cats negatively affect the survival of shearwater chicks. A study by

Smith, Polhemus, & VanderWerf (2002) examined wedge-tailed shearwater chicks on Oʻahu at three sites chosen along a distance gradient from a cat colony feeding area at Mālaekahana, and compared to a cat-free site on the isolated Mokuʻauia Island. Nest survival among sites at Mālaekahana had a rate of 20%, compared to the cat-free Mokuʻauia Island that had a survival rate of 62%. Cats regularly show up in areas monitored by trail cameras within active ʻaʻo burrows, in breeding colonies on Kauaʻi where they have documented significant mortalities. Remote sensing collared cats in Hono O Nā Pali seabird colonies has revealed that cats have a depredation range of 1,300 hectares (13 km^2) (Dutcher 2017 in Pias & Dutcher 2018). Within Hono O Nā Pali at Hanakāpīʻai in 2015, prior to implementation of the predator control program, reproductive success of ʻuaʻu at the site was 51%. After the predator control program was initiated in 2016, reproductive success increased to 76 % in 2016 and 84% in 2017.

The barn owl and feral cat control in Kalalau Valley is anticipated to have a beneficial effect on the range-wide population of the ʻuaʻu and ʻakēʻakē, beginning in the first year of the KSHCP. The Kalalau Valley is a strategic location to control wide-ranging predators as it geographically positioned to provide protection to multiple known breeding colonies. ʻUaʻu and ʻakēʻakē mitigation activities is expected to provide benefits to the breeding colonies by reducing depredation of wide ranging cats and barn owls, minimizing depredation on sub adults, breeding adults and thereby increasing survival, increased nesting and fledging success. Thirty years of barn owl and feral cat control is estimated to provide a total net benefit to the Kauaʻi ʻuaʻu population of up to 82 individuals and a total net benefit to the Kauaʻi ʻakēʻakē of up to 44 individuals. The benefit is derived from increased breeding capacity and success within multiple colonies in Kalalau Valley as a result of these barn owl and cat control efforts. Although the magnitude of the range-wide beneficial effect of the mitigation on the ʻuaʻu and ʻakēʻakē is small, it is positive and commensurate with the impact of the issuance of ITPs and ITLs for these species.

Adaptive management measures specify that alternate mitigation would be implemented if the social attraction site fails to meet identified objectives that would lead to a breeding colony, or if results of monitoring indicate that initial predator control methods are not adequately controlling predators in the Kalalau area. Alternative mitigation would include, but is not limited to, expanded predator control or funding of other conservation efforts that provides a direct benefit to Covered Seabirds.

The minimization and mitigation measures included in the Proposed Alternative were developed to fully offset the maximum level of incidental take requested and are required to be implemented even if the actual level of incidental take requested by future Applicants is less than estimated in the HCP.

Alternative C: Implementation of Kauaʻi Seabird HCP and the additional action of translocation of chicks

Impacts would be similar to Alternative B. Social attraction is a long-term (5–10 year) management action that may require multiple years to attract enough prospecting subadult birds to begin breeding. However, when birds are within range, prospectors may respond within months or minutes (Sawyer and Fogle 2010), and these prospectors are subadults returning to land to breed. This technique is biologically non-invasive, and its cost is relatively low, consisting of the acquisition and maintenance of a solar-powered sound system and decoys (if used). Although the costs are approximately one-tenth that of chick translocation, “it may take longer to establish a breeding colony using these methods [acoustic attraction and provision of artificial burrows]” (Sawyer and Fogle 2010). Buxton et al. (2014) suggests the most influential variable affecting recolonization is a source colony within a range of 25 km. Kalalau Valley is proximal to many breeding birds so it is anticipated that bird will be attracted to the site rather quickly after constructed. However, because translocated chicks that fledge from the mitigation site would be anticipated to return to the site to breed, the translocated chicks would supplement the potential breeders lured by social attraction methods. Over the long-term, this would be anticipated to result in a larger population breeding within the fenced unit, so under this Alternative, the overall cumulative benefit of the mitigation site would be anticipated to be larger, and offset of actual take could occur earlier (than year 27) if the social attraction does not occur right away. There would still be delay as result of the initial birds fledging and the delay to reach reproductive maturity. The return rate, the timing of return, and the future breeding success for translocated ‘a‘o is unknown, making the precise long-term benefit associated with this Alternative unquantifiable at this time. Based on location of mitigation site there is equal chance based on current knowledge of social attraction that the site could be occupied within the first year post construction of mitigation infrastructure.

Table 4.5. Summary of Anticipated Take and Benefits to Covered Species Under Each Alternative**

Alternative	Species	Total 30-Year Take	Total 30-Year Anticipated Mitigation (Net Benefit)
Alternative A: No-Action Alternative	**‘A‘o**	912*	0
	‘Ua‘u	70*	0
	‘Akē‘akē	33*	0
Alternative B: Proposed Alternative (Implementation of KSHCP)	**‘A‘o**	912	1,046 (134)
	‘Ua‘u	70	120 (50)
	‘Akē‘akē	33	60 (27)
Alternative C: Implementation of KSHCP and additional action of translocation of ‘a‘o chicks	**‘A‘o**	912	1,046 (134)+
	‘Ua‘u	70	120 (50)
	‘Akē‘akē	33	60 (27)

*Actual take could be less as Applicants would be expected take reasonable minimization measures to avoid legal liability to the extent feasible, but actual reduction from current take estimates is speculative and unquantifiable.
**Table only includes anticipated take incidental to Covered Activities and participating Applicants – not anticipated island-wide take (see Table 4.2).
+Under Alternative C, the anticipated benefit is expected to be higher based on supplementing additional birds.

4.3 Effects on Threatened and Endangered Species

Species listed as threatened or endangered by the State or Federal government require additional consideration whenever an activity permitted by USFWS or DLNR may have an effect on these species or their habitats. Listed species found on the island of Kauaʻi include the ʻōpeʻapeʻa, the ʻilio-holo-i-ka-uaua, the nēnē, forest birds and water birds, the honu, listed invertebrates, and over 80 species of plants. This section addresses effects to listed species other than the Covered Species (ʻaʻo, ʻuaʻu, and ʻakēʻakē) that are considered above.

Alternative A: No Action Alternative

Under Alternative A, potential participants would take all reasonable minimization measures to avoid legal liability to the extent feasible. These avoidance and minimization measures (e.g., modifying existing lighting, changing time of use, nighttime searches and predator control at Applicant facilities) are not anticipated to negatively impact listed species, because these facilities are located in already developed areas and minimization activities should not involve changes to existing habitat. These minimization measures would be anticipated to have a short and long-term positive impact on the honu. It is unknown how many turtle hatchlings are currently impacted by artificial light disorientation. The requirement that Applicants evaluate the potential for their facilities to impact honu and to identify and implement specific measures as necessary to prevent disorientation attributable to their facilities will provide a short and long-term benefit to this species in comparison to the existing condition. This planning step should prevent accidental but avoidable take relating to Applicant facilities.

Alternative B: Proposed Alternative (Implementation of Kauaʻi Seabird HCP)

Under Alternative B, Applicants will implement specific avoidance and minimization measures to avoid or minimize take associated with light attraction at their facility and jointly implement mitigation measures (the seabird social attraction project at Kahuamaʻa Seabird Preserve, the barn owl control, and feral cat control) to mitigate for unavoidable take.

Impacts to threatened and endangered species under the Proposed Alternative related to minimization measures at Applicant facilities would be similar to Alternative A.

The mitigation actions associated with the Proposed Alternative may impact other listed species as discussed below:

The ʻōpeʻapeʻa has been observed in the general Kōkeʻe area. At Kīlauea Point NWR, ʻōpeʻapeʻa were observed at the Nihoku restoration site only after habitat restoration and predator removal, so they could potentially similarly benefit from the creation of the Kahuamaʻa Seabird Preserve, removal of predators, and habitat enhancement. Activities associated with social attraction (playing of seabird calls, monitoring for birds) would not be expected to negatively impact ʻōpeʻapeʻa, and negative interactions between ʻōpeʻapeʻa and existing seabird colonies have not been reported. Biological monitoring of the mitigation site will include observation for ‘ōpe‘ape‘a to identify any unanticipated impacts.

Kaua‘i supports the largest concentration of nēnē in the State. Endangered nēnē do not currently breed at the Kahuama‘a Seabird Preserve, but could potentially in the future, especially if habitat restoration and management enhance the area as nēnē habitat. Biological monitoring of the mitigation site will include observation for nēnē to identify their presence. Peak breeding occurs mainly October to March and molting March to June, when adults become flightless for four to six weeks while they grow new flight feathers. During this period, they become secretive and are extremely vulnerable to attacks by introduced predators. If nēnē do nest in the Kahuama‘a Seabird Preserve, the mitigation site would provide a long-term benefit to the nēnē by providing protected predator-free breeding habitat. Activities associated with social attraction (playing of recorded calls) would overlap with peak nēnē breeding season (October – March); to minimize negative impacts to nēnē, all future nests and broods that occur would be mapped and monitored and any pairs or family groups in the area would be avoided during regular site management (predator control, fence inspection, etc.) and colony monitoring. With these measures in place, if nēnē settle at Kahuama‘a, short-term negative impacts to the nēnē would be avoided and long-term positive impacts (associated with breeding in a predator-free area) would be expected.

Listed forest birds are not anticipated to be impacted by the proposed Kahuama‘a Seabird Preserve, as it is outside the core habitat area for the puaiohi, ‘akikiki, akeke‘e, and ‘i‘iwi. Endangered water birds are not anticipated to be impacted by the proposed Kahuama‘a Seabird Preserve, as they do not nest in mountainous regions.

None of the listed invertebrates (Kaua‘i Cave Amphipod, Kaua‘i Cave Spider, Newcomb’s snail, *D. sharpi, D. musaphilia*) have been found at or near the Kahuama‘a Seabird Preserve; thus, no negative impacts to these species are anticipated.

The Kahuama‘a Seabird Preserve is within designated critical habitat for multiple species of plants (USFWS 2002, USFWS 2010), and listed plants have been observed in proximity to the Kahuama‘a Seabird Preserve. During fence construction, predator removal, implementation of social attraction measures, and monitoring, the following best management practices will be incorporated to prevent unintentional damage or harm to these plants. Such practices are field surveys before finalizing fence alignments or locations for artificial burrows and before construction/installation to prevent damage or harm to rare plants, the incorporation of rare species protocols (e.g., flagging plants, identifying buffer zones), the avoidance where possible of the removal of large native plants and shrubs, the minimization of the overall removal of native vegetation, and the incorporation of invasive species prevention and biosecurity measures to reduce the potential for inadvertent introduction of non-native species to the Kahuama‘a Seabird Preserve. To the greatest extent possible, the conservation fencing will include rare and listed plant species within the fenced area because this action will protect and enhance the plants’ survival and propagation. With the incorporation of best management practices, it is anticipated that the short-term negative impact of fencing, predator and invasive plant species removal, and seabird habitat enhancement on rare plants and on plant critical habitat is minor. Over the long-term, minor positive impacts to rare plants and associated critical habitat would be anticipated because the fencing and predator removal would protect plants and critical habitat from depredation by rodents and degradation by ungulates.

Alternative C: Implementation of Kaua'i Seabird HCP and the additional action of translocation of chicks

Alternative C would be anticipated to have similar impact as Alternative B on threatened and endangered species because this alternative involves substantially the same activities as Alternative B. During translocation activities at existing seabird colonies located within critical habitat, the following best management practices for conservation field work will be incorporated to minimize negative impacts to rare plants and avoid adverse modification of critical habitat. These practices include existing trails for all surveys and monitoring, minimize removal of vegetation for installation of remote monitoring equipment, training to develop familiarity with native and non-native plant species, to avoid unintentional harm to rare plants; and the incorporation of invasive species prevention and biosecurity measures to reduce the potential for inadvertent introduction or movement of non-native species.

4.4 Effects on Fauna

Under all of the proposed alternatives, there would be no prolonged or intensive negative impact to the native fauna, including native migratory birds.

Alternative A: No Action Alternative

Under Alternative A, potential participants would take all reasonable minimization measures to avoid legal liability to the extent feasible. Although SOS operates for the purpose of assisting endangered seabirds, members of the public regularly turn in other downed bird species. For example, in 2015, 104 ‘ua‘u kani (*Puffinus pacificus*, wedge-tailed shearwater) were impacted from the effects of light attraction according to the amount of birds recovered by SOS; typically, about 80% of those birds are released back into the wild. White-tailed tropicbirds are also regularly turned into SOS; an average of 25 birds of that species have been turned into SOS since 2008. Typically, about half of those birds are released back into the wild. In smaller numbers, other birds handled by SOS have included ‘ā (red-footed booby, *Sula sula*), ‘ā (brown booby), mōlī, black noddy (*Anous minutes*), and the ‘iwa. Typically, a low percentage of these birds are released back into the wild; most have to be euthanized. In some years, unique species not usually encountered have been handled by SOS. For example, a Tahiti petrel (*Pseudobulweria rostrata*) and a Bulwer's petrel (*Bulweria bulwerii*) were recovered and released by SOS in 2012. Negative impacts to these native seabird species from light attraction would be reduced as Applicants implement reasonable minimization measures to reduce their liability for take of Covered Seabirds, which may result in a minor long-term benefit to other species of native seabirds.

Impacts to other native wildlife is anticipated to be negligible because minimization actions involve facilities located in already developed areas and should not involve interaction with wildlife or changes to existing habitat.

Alternative B: Proposed Alternative (Implementation of Kaua'i Seabird HCP)

Under Alternative B, Applicants will implement specific avoidance and minimization measures to avoid or minimize take associated with light attraction at their facility and jointly implement mitigation measures (the seabird social attraction project at Kahuama'a Seabird Preserve, the barn owl control, and feral cat control) to mitigate for unavoidable take.

Impacts to threatened and endangered species under the Proposed Alternative related to minimization measures at Applicant facilities would be similar to Alternative A.

The mitigation site is located in habitat of mixed native and alien flora along the Nā Pali coast, an area which supports native fauna, including native migratory bird populations (forest birds, seabirds, pueo) and native invertebrates, as well as non-native wildlife, including barn owls and non-native invertebrates. No native birds are known to currently breed at the mitigation site, but additional surveys for breeding birds will be performed prior to the construction phase of the project.

Best management practices for fence construction, predator removal, and habitat enhancement would be incorporated to avoid or minimize negative impacts on native animals, including migratory birds. Such practices would include surveys of the fence alignment for nests prior to construction, adjustments to alignments as necessary to minimize disturbance to nesting birds, timing construction outside the nesting season for native, trimming rather than removing native vegetation wherever possible, incorporating reflective tape and similar materials into the fence design to enhance visibility to transiting native animals and prevent collisions, following existing trails whenever possible, and using all pesticides in strict accordance with label instructions.

Barn owl control under Alternative B would be conducted consistent with the control order for barn owls, an invasive migratory bird species in Hawai'i (USFWS 2017). Barn owls were intentionally introduced to Hawai'i in the late 1950s, and depredation by barn owls is recognized as having a direct detrimental impact on numerous threatened and endangered species in the Hawaiian Islands (USFWS 2017). To avoid negative impacts to the pueo and other native migratory bird populations, the following practices will be implemented during all barn owl control actions: training of technicians to distinguish between pueo and barn owls; timing control activities to avoid periods of pueo activity (pueo are active during the day, while barn owls are nocturnal); regular monitoring of traps and leaving traps closed when not in active use; prompt release of non-target birds to prevent injury to unintentionally trapped birds; use of non-toxic shot or bullets; and prompt reporting of any non-target take. Any pueo accidentally trapped will be evaluated and released or rehabilitated as necessary.

The development and management of the Kahuamaʻa Seabird Preserve and feral cat control activities may have a minor, long-term positive impact on native fauna, including native migratory bird populations. Other species of overflying native seabirds might colonize the Kahuamaʻa Seabird Preserve on their own without species-specific management intervention (i.e., use of acoustic attraction) and would benefit from the eradication of predators from within the unit and the removal of cats from the general area. The native pueo, as a ground-nesting bird, could benefit from the existence of a predator-free fenced area in which to breed. Other native species (e.g., native insects, forest birds) would be anticipated to benefit from the exclusion of feral ungulates that modify native habitats, the removal of rodents and cats that may predate on insects or on host plant species, and by the enhancement of native habitat.

Alternative C: Implementation of Kauaʻi Seabird HCP and the additional action of translocation of chicks

Impacts of Alternative C would be similar in scale and intensity as Alternative B, because this alternative involves substantially the same activities as Alternative B. During translocation activities at existing seabird colonies, the following best management practices for conservation field work will be incorporated to minimize negative impacts to native migratory bird populations: follow existing trails for all surveys and monitoring, minimize removal of vegetation for installation of remote monitoring equipment; and the incorporation of invasive species prevention and biosecurity measures to reduce the potential for inadvertent introduction or movement of non-native species.

4.5 Effects on Flora

Under all of the proposed alternatives, there would be no prolonged or intensive negative impact to the native vegetation.

Alternative A: No Action Alternative

Under Alternative A, potential participants would take all reasonable minimization measures to avoid legal liability to the extent feasible. For the most part, Applicant facilities are located in developed areas of Kauaʻi that have been modified, landscaped, and generally dominated by non-native plant species. These areas do not typically contain rare and listed native plant species. Minimization measures which alter lights do not involve any actions with potential to affect native flora because the actions do not involve any interaction with native flora or involve ground disturbing activities or clearing of vegetation.

Alternative B: Proposed Alternative (Implementation of Kauaʻi Seabird HCP)

Under Alternative B, Applicants will implement specific avoidance and minimization measures to avoid or minimize take associated with light attraction at their facility and jointly implement mitigation measures (the seabird social attraction project at Kahuama‘a Seabird Preserve, the barn owl control, and feral cat control) to mitigate for unavoidable take.

Impacts to threatened and endangered flora species under the Proposed Alternative related to minimization measures at Applicant facilities would be similar to Alternative A.

Mitigation measures, specifically the development and management of the Kahuama‘a Seabird Preserve, may have a minor, short-term negative impact and a minor, long-term positive impact on native vegetation. Fence construction and installation of artificial burrows will result in some disturbance to native flora. A corridor along the fence route will be cleared to allow the installation of the fence. The disturbance will be localized to the fence corridor and limited in duration to the construction period, about six months. Where possible workers will trim vegetation, rather than completely remove native plants within the corridor, to limit impacts to native flora. About 100 nest boxes will be placed about 15-30 centimeters (6-12 inches) in the ground, with a footprint of about 120 cm^2 (4 ft^2). Construction may also involve some trampling of native vegetation by workers. However, any effect will be short term and minor because workers will move from one area to the next, large areas will not be left bare, and areas disturbed (especially surrounding the artificial burrows) will be revegetated with appropriate native plants.

Fence maintenance, predator control and colony monitoring may cause limited damage to native vegetation from trampling by technicians evaluating the integrity of the fencing and pruning vegetation overhanging the fencing, checking traps bait stations, and monitoring burrows. Best management practices to minimize overall impact to native vegetation include use established trails where possible, cleaning gear of invasive plant seeds, and use of remote monitoring techniques where possible.

Technicians will implement actions to control the spread of non-native invasive plants to enhance the nesting habitat. Best management practices to prevent harm to native plants include training in native plant identification, invasive plant removal by hand and using hand tools, and use of herbicides only on specific individual plants, in accordance with the label, when required to strategically prevent spread of target invasive species on specific individual plants.

Over the long-term, the construction and maintenance of predator proof fencing would be anticipated to have a minor positive impact on native flora by excluding feral ungulates that dig up and trample native plants and spread invasive plants, by removing rodents that predate on seeds and other native plant parts, and by controlling non-native plants that outcompete native plants.

Alternative C: Implementation of Kaua‘i Seabird HCP and the additional action of translocation of chicks

Impacts of Alternative C would be similar in scale and intensity as Alternative B.

4.6 Effects on Soils

Alternative A: No Action Alternative

Under Alternative A, potential participants would take all reasonable minimization measures to avoid legal liability to the extent feasible. Light minimization measures do not involve any potential to impact topography or soils because the facilities are located in already developed areas and avoidance/minimization measures do not involve digging, grading, earth moving or similar activities. Some minimal trampling of soils could occur resulting from staff monitoring for fallout and conducting predator control at Applicant facilities. Based on observations from similar activities occurring throughout the state, these impacts are extremely limited in area (near existing artificial lights), duration (during fallout season), and intensity (foot traffic, no use of heavy equipment).

Alternative B: Proposed Alternative (Implementation of Kaua‘i Seabird HCP)

Under Alternative B, Applicants will implement specific avoidance and minimization measures to avoid or minimize take associated with light attraction at their facility and jointly implement mitigation measures (the seabird social attraction project at Kahuama‘a Seabird Preserve, the barn owl control, and feral cat control) to mitigate for unavoidable take.

Impacts to soils under the Proposed Alternative related to minimization measures at Applicant facilities would be similar to Alternative A.

Mitigation measures may impact soils as follows. Minor disturbance of soils would be anticipated related to the mitigation measure of creating and maintaining the Kahuama‘a Seabird Preserve. Fence construction would result in some minor soil disturbance, but the disturbance would be localized to the fence corridor and limited in duration to the construction period. The approximate length of the fence line is 579 meters (1900 feet). During construction, a corridor along the fence route, at maximum of 1.8 m (6 ft) wide, will be cleared to allow the installation of the fence. Limited digging will occur to sink fence posts and bury the protective mesh screen. Where possible the vegetation will be trimmed, rather than completely removed, to limit bare soil exposure and minimize potential for erosion. Constructing the fence will not involve large scale earth moving or soil disturbance and will utilize hand tools in areas of steep grades (>25%) for any digging and clearing rather than heavy machinery. Best management practices to be incorporated during construction include avoidance of vegetative clearing during rain events, timing vegetation clearance in close proximity with construction, the use of erosion control devices such as geotextiles, rubber matting, and water guides to restrict water runoff, and replanting disturbed areas within three months of construction. Maintaining fences, once constructed, will involve routinely walking the fence lines and checking for fence integrity. It is anticipated that overall effects to soils from fence construction would be minor, because of the limited scope of soils to be disturbed (< 1 acre) and the incorporation of best management practices. Effects would be temporary, as fence construction would only last two to four months. Over the long term, the fencing could have a minor positive impact on soils within the fenced unit by protecting the area from the digging and rooting associated with feral pigs.

Minor disturbance of soils would also be anticipated at the Kahuamaʻa Seabird Preserve related to the removal of predators. Specific actions include placing, setting and checking traps and bait stations, noting patterns of animal movement, and monitoring and recording results, which could result in slight soil disturbance and soil compaction from staff movement. Traps and bait stations are placed on the ground and do not involve digging or other soil disturbance. The incorporation of automatic, self-setting traps where possible will reduce the number of trips required to check and replace traps. Once predators have been eradicated (estimated at 6 months' time), trapping of non-native predators will cease unless it is found that predators have re-entered the site. Based on observations from similar activities occurring throughout the state, these impacts are limited in area (within and directly adjacent to Kahuamaʻa Seabird Preserve), duration, and intensity (foot traffic, limited staff).

Minor disturbance of soils would be anticipated at the Kahuamaʻa Seabird Preserve related to removal of invasive plants to enhance the area as seabird breeding habitat. Minor soil disturbance may occur when non-native plants are removed and native plants reintroduced through activities such as uprooting and planting. Technicians will employ non-native plant control actions to remove invasive species through mechanical means (by hand and with hand tools) (preferred method) and through the application of herbicide to strategically control target species and prevent them from becoming further established. Herbicide would be used in low level amounts with medical bottle applicators following application directions for forestry management use, on specific individual plants (rather than broad application). Workers will use herbicide in dry weather conditions and not during periods of heavy rain. These measures will minimize the potential for herbicide to contact soils. In particularly sensitive areas, specific erosion control techniques such as staking down fence cloths or utilizing vegetative buffers (e.g., coconut coir or straw bales) may be used for soil stabilization after removal of invasive plants. Based on observations from similar activities occurring throughout the state, these impacts are limited in area (within the Kahuamaʻa Seabird Preserve), duration, and intensity (removal of individual plants, no exposure of bare soil). Over the long-term, habitat enhancement could have a minor positive impact on soils within the fenced unit, by reducing the volume of non-native plants which can reduce the stability of soils through weaker root structure.

Minor disturbance of soils would be anticipated at the Kahuamaʻa Seabird Preserve related to the monitoring and management of the area as a social attraction site. Installation of social attraction equipment entails placing artificial nest boxes and installing loudspeaker equipment. About 100 nest boxes will be placed approximately 15-30 cm (6-12 in) in the ground. Each nest box is about 60 cm (~20 in.) square and has a footprint of about 120 cm^2 (~4 ft^2) each. Loudspeakers will be placed on or above ground and would not involve soil disturbance. Long-term monitoring of the colony would employ non-disturbing remote techniques where possible. Tools for monitoring will include call, play-back response, thermal imaging and night vision, Passive Integrated Technology (PIT) tags to measure nest attendance, automated auditory monitoring to record bird calls, and use of trail cameras. None of these activities involves digging or soil disturbance. Based on observations from similar activities occurring throughout the state, these impacts are limited in area (within Kahuamaʻa Seabird Preserve), duration (one month for installation of nest boxes; monitoring during nesting season only), and intensity (limited footprint for nest boxes, limited repeat visits along established trails for monitoring).

Alternative C: Implementation of Kaua'i Seabird HCP and the additional action of translocation of chicks

Alternative C would result in similar impacts to soils as Alternative B, with additional minor disturbance of soils related to activities required for chick translocation. This would include limited soil compaction related to foot traffic during site visits to existing colonies to identify, monitor, and remove eligible chicks for translocation, and soil compaction related to daily visitation to artificial nest boxes to feed and monitor the health of translocated chicks. Based on observations from similar activities at Kīlauea Point NWR, these impacts are limited in area, duration (during nesting season only), and intensity (limited repeat visits along established trails).

4.7 Effects on Hydrology and Water Resources

Alternative A: No Action Alternative

Under Alternative A, potential participants would take all reasonable minimization measures to avoid legal liability to the extent feasible. Light minimization measures do not involve any potential to impact water quality or quantity because the actions are not anticipated to alter drainage, runoff, or result in any discharges into existing streams or the ocean because Applicant facilities are located in already developed areas and minimization actions do not involve digging, grading, earth moving or similar activities.

Alternative B: Proposed Alternative (Implementation of Kaua'i Seabird HCP)

Under Alternative B, Applicants will implement specific avoidance and minimization measures to avoid or minimize take associated with light attraction at their facility and jointly implement mitigation measures (the seabird social attraction project at Kahuama'a Seabird Preserve, the barn owl control, and feral cat control) to mitigate for unavoidable take.

Impacts to hydrology and water resources under the Proposed Alternative related to minimization measures at Applicant facilities would be similar to Alternative A.

Mitigation measures may impact hydrology and water resources as follows. While short-term soil disturbance at the mitigation site would be unavoidable during site preparation, fence construction, removal of invasive plants, and installation of artificial nest boxes, the fencing will not cross any perennial or intermittent streams within Kahuama'a Seabird Preserve and normal patterns in the area consist mainly of stormwater runoff and percolation. Best management practices would be incorporated into all aspects of the creation and maintenance of the Kahuama'a Seabird Preserve to minimize the potential for erosion and to maintain normal runoff patterns, and these include phasing construction and invasive plant control to reduce exposed ground areas, avoiding earthwork during inclement weather, using herbicide on individual plants in dry weather conditions and not during periods of heavy rain, restricting activities near streams, and the use of vegetative buffers.

Given the distance (in elevation) of the project site from the ocean, the limited acreage (<1 ac) to be disturbed, the incorporation of best management practices, and the lack of streams in the project area, it is anticipated that effects to hydrology and water resources would be minor. No lasting changes to existing patterns of runoff or percolation are expected, and impacts to existing surface water features and on marine waters are expected to be negligible or minor. Over the long-term, the enhancement of the area through fencing, native plant restoration, and establishment of a breeding colony of Covered Species could contribute to improved soil stability and reduce the potential for erosion and stream degradation in the general area resulting from ungulate activity.

Alternative C: Implementation of Kauaʻi Seabird HCP and the additional action of translocation of chicks

Alternative C would be anticipated to result in similar impacts to hydrology and water resources as Alternative B. Additional activities related to chick translocation (site visits to existing colonies, additional visits to Kahuamaʻa Seabird Preserve for chick care) would not be anticipated to contribute noticeable impacts to hydrology and water resources, based on observations from similar activities at Kīlauea Point National Wildlife Refuge.

4.8 Effects on Air Quality

Alternative A: No Action Alternative

Under Alternative A, potential participants would take all reasonable minimization measures to avoid legal liability to the extent feasible. Light minimization measures do not involve any potential to impact air quality because the actions are located in already developed areas and do not involve emissions.

Alternative B: Proposed Alternative (Implementation of Kauaʻi Seabird HCP)

Under Alternative B, Applicants will implement specific avoidance and minimization measures to avoid or minimize take associated with light attraction at their facility and jointly implement mitigation measures (the seabird social attraction project at Kahuamaʻa Seabird Preserve, the barn owl control, and feral cat control) to mitigate for unavoidable take.

Impacts to air quality under the Proposed Alternative related to minimization measures at Applicant facilities would be similar to Alternative A.

Mitigation measures may impact air quality as follows. At the mitigation site, fence construction would require the use of heavy equipment and small power tools to prepare the site and install the fence. Transportation of personnel and materials to the site will result in minor emissions of greenhouse gases through the burning of fossil fuels from ground vehicles. Helicopters may be used but only to drop supplies at the site during construction, a total of approximately four trips. Ground vehicle use will be limited to routine vehicle use to visit and monitor the site with very few vehicles and therefore is not anticipated to alter air quality in any measureable way. It is anticipated that any use of herbicides would be directly applied to the target species (e.g., hand application or squirt bottles), and approved herbicides would be used in accordance with recommendations on the label attached to the product (e.g., applying large droplets for sufficient coverage or avoid application on windy days or certain times of day).

There is a lack of data on ambient air quality specific to the Kahuamaʻa Seabird Preserve mitigation site. Because use of heavy equipment and power tools would be temporary, because tradewinds dissipate any equipment emissions or spray, because protocols are in place regarding the use of herbicide spray, and given the narrow width and relatively short distance of the fence corridor, it is anticipated that the impact on air quality of implementing Alternative B would be negligible.

Alternative C: Implementation of Kauaʻi Seabird HCP and the additional action of translocation of chicks

Alternative C would be anticipated to result in similar impacts to air quality resources as Alternative B. Additional helicopter trips would be required for monitoring and retrieval of chicks as part of the translocation process. Because the use of helicopters would be localized, away from urban or residential areas, limited in number (no more than six additional trips per year), and of short-term duration, the anticipated impact on air quality of implementing Alternative C would be negligible.

4.9 Effects on Historic Properties

Alternative A: No Action Alternative

Actions to minimize light attraction by Applicants will not involve any potential to affect historic properties because none of the affected Applicant facilities are on or eligible for listing on the National Register of Historic Places.

Alternative B: Proposed Alternative (Implementation of Kauaʻi Seabird HCP)

Under Alternative B, Applicants will implement specific avoidance and minimization measures to avoid or minimize take associated with light attraction at their facility and jointly implement mitigation measures (the seabird social attraction project at Kahuamaʻa Seabird Preserve, the barn owl control, and feral cat control) to mitigate for unavoidable take. Impacts to historic resources under the Proposed Alternative related to minimization measures at Applicant facilities would be the same as Alternative A.

Historic properties either nominated or registered with the National Register of Historic Places (maintained by the National Park Service) are unlikely to be within the immediate vicinity of the mitigation site. Only two such properties are currently documented in the Kōkeʻe area: Camp Sloggett and the Civilian Conservation Corps Camp (NRHP 2017). Neither of those properties are in close proximity to the Kahuamaʻa Seabird Preserve and, therefore, those properties are unlikely to be considered within the Area of Potential Effect.

Although no archaeological sites or features were noted during the course of a 1993 survey of the mitigation site, the dense vegetation of the area hindered the ability to conclude definitively that no sites were present. Because of the inability to accurately survey the area and the slight potential for unrecorded archaeological sites being encountered during installation of fencing, the 1993 survey recommended the following precautions below. If these recommendations are followed, the 1993 survey anticipated that implementation of conservation actions at the mitigation site would have no adverse effect on the cultural resources of the area.

1) All ground disturbing clearing efforts should 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 should be inspected by an archaeologist immediately following the clearing to determine the presence or absence of sites;
2) The installation of fences should be monitored by an archaeologist to assure that potential surface features as well as potential subsurface cultural deposits are not disturbed by these activities;
3) If at any time during development of the mitigation site archaeological features are encountered, State Parks archaeologists should be notified. If activities could impact any archaeological feature, these activities would cease until such time as the feature is evaluated by a qualified archaeologist; and
4) The potential for encountering human remains is extremely slight. But 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.

Mary Jane Naʻone, Kauaʻi Lead Archaeologist for the State Historic Preservation Division (SHPD), and Victoria Wichman of Hawaiʻi Division of State Parks visited the APE in the late 2010s. While no record of their visit is available, the USFWS had individual phone conversations with each to discuss the undertaking and APE on February 24, 2020. Consistent with the findings of Carpenter and Yent (1994), both confirmed there were no cultural resource sites observed within the APE, although, dense vegetation obscured the surface. However, the USFWS is conducting Section 106 consultation with SHPD (pursuant to NHPA §106), the Office of Hawaiian Affairs, and the Kauaʻi Burial Council concurrently with this NEPA process.

Alternative C: Implementation of Kauaʻi Seabird HCP and the additional action of translocation of chicks

Impacts of Alternative C would be similar in scale and intensity as Alternative B, as activities associated with translocation are not anticipated to involve or have additional impact on historic, archaeological, or cultural resources.

4.10 Effects on Cultural and Archaeological Resources

Alternative A: No Action Alternative

Under Alternative A, potential participants would take all reasonable minimization measures to avoid legal liability to the extent feasible. Actions to minimize light attraction by Applicants will not involve any potential to affect archaeological and cultural resources because of the limited nature of such actions and because these actions only involve above-ground work on existing light fixtures and foundations. No impacts to cultural and archaeological resources are expected.

Alternative B: Proposed Alternative (Implementation of Kaua'i Seabird HCP)

Under Alternative B, Applicants will implement specific avoidance and minimization measures to avoid or minimize take associated with light attraction at their facility and jointly implement mitigation measures (the seabird social attraction project at Kahuama'a Seabird Preserve, the barn owl control, and feral cat control) to mitigate for unavoidable take. Impacts to archaeological and cultural resources under the Proposed Alternative related to minimization measures at Applicant facilities would be similar to Alternative A.

As discussed previously (section 4.9), certain precautions will be followed during implementation of mitigation measures at Kahuama'a Seabird Preserve to avoid impacts to historic properties, which would also avoid or minimize harm to extant archaeological or cultural features.

The Hawaiian ecosystem and the native species found therein are an essential part of the overall cultural landscape. For many indigenous communities, natural resources are cultural resources. Seabirds, and in particular the 'a'o, have cultural importance to Native Hawaiians and fishermen. The goal of the KSHCP is to address and mitigate for ongoing take of these species and provide an overall net benefit to these species over the term of the KSHCP and associated ITP/ITLs. By benefitting native species, the KSHCP would benefit cultural resources.

No specific cultural practices have been identified during development of the KSHCP that may be impacted by the development and maintenance of the Kahuama'a Seabird Preserve. Conservation fieldwork will not impact materials used for traditional gathering purposes. Plants and other natural resources used for traditional cultural gathering would be conserved through habitat protection activities thereby providing a benefit to those resources. For cultural practices such as gathering, the applicable State Park rules and procedures would remain as currently applied (HAR Chapter 13-146); the permit process is not intended to restrict constitutionally protected cultural practices, but is in place to ensure protection of unique natural resources and avoid overcollection of a particular resource, minimize the potential for user conflict, and to provide safety or resource information.

Alternative C: Implementation of Kaua‘i Seabird HCP and the additional action of translocation of chicks

Impacts of Alternative C would be similar in scale and intensity as Alternative B, as activities associated with translocation are not anticipated to involve or have additional impact on historic, archaeological, or cultural resources.

4.11 Effects on Demographics, Economics, Land Use, and Infrastructure

Alternative A: No Action Alternative

Under Alternative A, potential participants would take all reasonable minimization measures to avoid legal liability to the extent feasible. The economic impact associated with voluntary light minimization measures, including the potential exposure to fines or penalties associated with unauthorized take of Covered Species, is difficult to quantify, but would be anticipated to remain similar to current conditions.

Alternative B: Proposed Alternative (Implementation of Kaua‘i Seabird HCP)

Under Alternative B, Applicants will implement specific avoidance and minimization measures to avoid or minimize take associated with light attraction at their facility and jointly implement mitigation measures (the seabird social attraction project at Kahuama‘a Seabird Preserve, the barn owl control, and feral cat control) to mitigate for unavoidable take. Impacts related to minimization measures at existing Applicant facilities would be similar to Alternative A.

Mitigation measures may impact economic resources as follows. The total 30-year cost associated with the development and management of Kahuama‘a Seabird Preserve as a mitigation site, the implementation and maintenance of barn owl and feral cat control, and compliance monitoring of the HCP is approximately $14 million dollars. This cost would be shared among the proposed permit recipients, based on their proportion of estimated annual take. It is estimated that the cost for individual entities would range from approximately $23,000 to $230,000 in the first year (reflecting a take request of between 1 and 10 birds) and $10,000 to $220,000 per year in later years (again, a range, reflecting a take request between 1 and 10 birds and 3% inflation over the 30-year HCP).

The ultimate funding source depends upon the specific Applicant: the funding source for the County of Kaua‘i would be county taxpayers, while the funding source for condo associations and private businesses would be property owners, who could in some cases pass the expense on in the form of higher rents or increased prices.

A portion of the spending to implement this Alternative would remain on-island, in the form of labor needed to construct the fencing, remove predators, and continued biological monitoring. In addition, this Alternative could generate secondary benefits by providing jobs in other industries where monies are spent. Successful implementation could encourage additional related conservation spending – such as related conservation actions within the fenced unit (e.g., restoration of rare plant taxa). However, given the size of the project relative to the overall State budget or to other economic inputs into the local economy, impacts on economic resources under this Alternative would be expected to be minor.

The development and management of Kahuamaʻa Seabird Preserve as a mitigation site does not change the existing land use or require improvements to existing infrastructure. The Preserve is located on land in the Conservation District, owned and managed by the State of Hawaiʻi, DLNR Division of State Parks. One portion of the site is located in Kōkeʻe State Park (Resource subzone) and the other portion is in the Nāpali Coast State Wilderness Park (Protective subzone). The proposed use of the site for seabird conservation is consistent with both subzone designations for the parcels; which encourage the protection and conservation of natural resources. It is located off the roadway in Kōkeʻe State Park, such that construction and management of the Kahuamaʻa Seabird Preserve is not anticipated to impact traffic or access to Kōkeʻe State Park.

Alternative C: Implementation of Kauaʻi Seabird HCP and the additional action of translocation of chicks

Impacts of Alternative C would be similar in scale and intensity as Alternative B. While translocation requires additional expenditures associated with the monitoring of nests for potential donor chicks and chick care after translocation, these additional expenditures would only occur during years in which translocation would occur. The additional cost associated with translocation (approximately $100,000 per year) is relatively minor in relation to the overall State budget or to other economic inputs into the local economy.

4.12 Effects on Recreational Activities

Alternative A: No Action Alternative

Under Alternative A, potential participants would take all reasonable minimization measures to avoid legal liability to the extent feasible. Recreational activities could be impacted by voluntary light minimization measures that restrict timing and usage of nighttime lights at park, sports, and recreation facilities, condominium complexes, and hotels. Light minimization measures that deactivate the nighttime lighting or restrict the schedule of use (to avoid fallout season or specific moon phases) would reduce or eliminate opportunities for sporting events or exercise. Examples of restrictions include no nighttime fall football games, no evening tennis at County facilities or hotels, no nighttime baseball games, etc. The impact to recreational resources is difficult to quantify, but would be anticipated to remain similar to current conditions.

Alternative B: Proposed Alternative (Implementation of Kauaʻi Seabird HCP)

Under Alternative B, Applicants will implement specific avoidance and minimization measures to avoid or minimize take associated with light attraction at their facility as identified in their PIP and jointly implement mitigation measures (the seabird social attraction project at Kahuamaʻa Seabird Preserve, the barn owl control, and feral cat control) to mitigate for unavoidable take. Specific Applicants may seek take authorization associated with nighttime use of lighting of recreational facilities (e.g., tennis courts, sports stadiums) instead of deactivating lights or restricting nighttime usage of facilities. As a result, there may be a reduced impact on recreational activities under Alternative B.

The development and management of the Kahuama‘a Seabird Preserve seabird social attraction project is not likely to impact hiking and naturalist activities. While the fencing will limit public access into the fenced unit, the site is not located along an existing hiking trail and is not known to be currently used for recreation or nature-watching. The proposed Seabird Preserve is located with Kaua‘i Hunting Unit K and the creation of the predator-free fenced unit would necessarily remove some acreage from public hunting. Detailed hunter use or success in the area immediately surrounding the proposed Seabird Preserve is not available, and it is not known how many individual hunters regularly visit this area. Because of the small size of the fenced unit (2 ha), the ability for feral pigs, goats, and deer to continue to move around in the general area outside the fenced unit, and the continued availability of the surrounding acreage for public hunting, the negative impact on hunting is anticipated to be minor.

Alternative C: Implementation of Kaua‘i Seabird HCP and the additional action of translocation of chicks

Impacts of Alternative C would be similar in scale and intensity as Alternative B, as activities associated with translocation are not anticipated to involve or have additional impact on recreational activities.

4.13 Effects on Scenic Resources

Alternative A: No Action Alternative

Under Alternative A, potential participants would take all reasonable minimization measures to avoid legal liability to the extent feasible. The night sky is valued as a scenic resource that the public enjoys, in ways similar to ocean and mountain vistas. In addition, a dark sky has scientific benefits to both amateur and professional astronomers (e.g., International Dark-Sky Association www.darksky.org). A dark night has societal value, and lighting has benefits as well as detrimental consequences (Klinkenborg 2008). Light minimization measures to reduce or eliminate the effects of artificial lights would also have the result of reducing the amount of up-lighting, commonly referred to as “light pollution,” considered perhaps the easiest form of pollution to remedy (Klinkenborg 2008). With less light directed upward, the night time sky will become more visible and potentially more visible as a resource. The impact to scenic resources in the form of improved nighttime aesthetics associated with darker skies is difficult to quantify, but would be anticipated to remain similar to current conditions.

Alternative B: Proposed Alternative (Implementation of Kaua‘i Seabird HCP)

Under Alternative B, Applicants will implement specific avoidance and minimization measures to avoid or minimize take associated with light attraction at their facility as identified in their PIP and jointly implement mitigation measures (the seabird social attraction project at Kahuama‘a Seabird Preserve, the barn owl control, and feral cat control) to mitigate for unavoidable take.

Impacts related to minimization measures at existing Applicant facilities would be similar to Alternative A.

Potential impacts to scenic resources associated with the proposed mitigation site is as follows. The Kahuamaʻa Seabird Preserve is situated along the Kalalau rim and a portion of the proposed conservation fencing could be visible from a popular lookout point in Kōkeʻe State Park called the Puʻu O Kila Lookout. Puʻu O Kila looks out onto the Kalalau Valley, approximately 3 kilometers wide. From the lookout, a viewer would have to look to the farthest western part of the viewshed (to the left) for the site to be viewable. The fencing would be located approximately 2,200 ft away (670m) and partially be obscured by surrounding trees and other vegetation. To mitigate any visual impact of the fence, the fence will be colored to blend into the hillside and reduce any reflective impact of metal surfaces. Because the fence would not be located within the primary view, would consist of a small portion of the 3-kilometer viewshed, and would be obscured by vegetation and painted to blend into the background, the degree of visual impact to the scenic resources is anticipated to be minor. If necessary, interpretive signage could be incorporated into the lookout to turn any remaining visual impact into a learning experience for visitors, to increase understanding and support for conservation efforts.

Alternative C: Implementation of Kauaʻi Seabird HCP and the additional action of translocation of chicks

Impacts of Alternative C would be similar in scale and intensity as Alternative B, as activities associated with translocation are not anticipated to involve or have additional impact on scenic resources.

4.14 Cumulative Effects

The CEQ regulations for implementing the provisions of NEPA requires a discussion of the cumulative effects of a proposed action. The CEQ regulations (at 40 CFR § 1508.7) provide the following definition of cumulative effects:

"The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions."

Cumulative effects are the overall, net effects on a resource within the affected environment that arise from multiple actions. Spatial and temporal boundaries are the two critical elements to consider when deciding which actions to include in a cumulative effects analysis. Spatial and temporal boundaries set the limits for selecting those actions that are most likely to contribute to a cumulative effect. Impacts can accumulate spatially, when different actions affect different areas of the same resources. They can also accumulate over the course of time, from actions in the past, the present and the future. The effects of those actions overlap in space and time with the effects of the issuance of the ITPs and implementation of the KSHCP for there to be potential cumulative effects. Occasionally, different actions counterbalance one another, partially cancelling out each other's effect on a resource. But more typically, multiple effects add up, with each additional action contributing an incremental impact on the resource. In addition, sometimes the overall effect is greater than merely the sum of the individual effects, such as when one more reduction in a population crosses a threshold of reproductive sustainability, and threatens to extinguish the population.

In order to accurately assess cumulative effects, the effects of past, present, and reasonably foreseeable future actions that affect the same resources as the proposed action or alternatives need to be identified. Past, present, and reasonably foreseeable future actions are not limited to USFWS actions, but could be actions taken or proposed by any Federal, State, or local government or a private entity, and are actions that are not included in the proposal or alternatives under consideration. To be considered under the cumulative effects section of the EA, past actions should have ongoing impacts that are presently occurring. Reasonably foreseeable future actions include those Federal and non-Federal activities not yet undertaken, but are sufficiently likely to occur, that a decision-maker should take such activities into consideration in reaching a decision regarding the effects of the proposed Federal action on the human environment. This consideration includes, but is not limited to, activities for which there are existing decisions, funding, or proposals. Reasonably foreseeable actions do not include those actions that are highly speculative or indefinite (see 43 CFR 46.30).

For the purposes of this analysis, the temporal extent used to identify projects to be considered in the cumulative effects analysis is the proposed term of the KSHCP (30 years). The spatial extent used to identify projects to be considered in the cumulative effects analysis does not vary by resource, and is the same as the project area, the island of Kaua‘i. The analysis area is substantially larger than the footprint(s) of individual KSHCP Applicant facilities and mitigation areas in order to consider an area large enough to encompass likely effects from other projects on the same resource. The analysis area is the geographic area occupied by the affected resources. Although the Covered Species nest on other islands, individuals of these species are impacted by actions occurring on the same island in which they nest and not actions on other islands. When attracted to artificial lights, fledgling seabirds originating from these nesting sites on Kaua‘i become confused and may suffer temporary night blindness. They often fly into utility wires, poles, trees, and buildings and fall to the ground. Adult seabirds can also be attracted to lights located near their breeding grounds on Kaua‘i and affected in a similar manner. Power lines and structures and communication towers create a potential for seabirds to collide with these structures while flying between their Kaua‘i nesting grounds and feeding grounds at sea.

4.14.1 Past, Present, and Reasonably Foreseeable Future Actions that Contribute to Cumulative Effects on the Covered Species

The primary threats to the populations of the Covered Species include depredation at their breeding sites by introduced mammalian and avian predators, breeding habitat loss and alteration caused by invasive plants, public use, and urban development, light attraction, collisions with utility structures, at sea factors affecting their prey-base, global climate change, and stochastic events that are inherently a hazard to populations with a limited range. The impacts of public use, urban development, at sea factors affecting their prey-base, global climate change, and stochastic events that are inherently a hazard to populations with a limited range threats will likely remain the same and continue to impact the species at similar extent under all the action alternatives.

Introduced Mammalian and Avian Predators. One of the most serious threats to the survival of the Covered Species is depredation of adults, eggs, and chicks by introduced predatory species, including rats, cats, mongoose, pigs, and the barn owl. Rats prey on seabird eggs and chicks. Feral cats, as well as barn owls, are known to kill adults and nestlings of the Covered Species. Colony monitoring data from several breeding seasons indicate concluded evidence that cats, rats, and owls were responsible for a decrease in adult and juvenile survival of the Covered Species. Evidence of seabird predation by rats, cats, barn owls, and pigs was documented at all sites monitored by KESRP from 2011 through 2016.

Seabird breeding burrows monitored by KESRP were commonly frequented by rats; in ULP, one seabird burrow was visited by a rat 490 times over the span of 5,015 hours of recording. 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. 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.

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. These feral species have played a significant role in modifying the breeding habitat of the Covered Species, and in exterminating seabird colonies in the Pacific and many locations worldwide.

Breeding Habitat Loss and Alteration by Invasive Plants. Seabird nesting habitats on Kauaʻi and the other main Hawaiian Islands have been severely degraded by the presence of invasive plants. 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 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 by biologists. However, a decade later biologists documented a significant drop in the number of breeding pairs at the Kaluahonu. Intensive surveys conducted by KESRP between 2006 and 2008 indicated that the colony has since been extirpated.

When habitat composed of native vegetation is invaded by non-native plant species, vegetation structure is often dramatically altered, and Covered Species 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 (*Psidium cattleianum*), 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.

Artificial nighttime lighting. Seabird attraction and fallout due to nighttime lighting is a long-standing threat to the Covered Species. Over a 37-year period (1979-2016), the SOS program documented a total of 30,552 ‘a‘o recovered, injured, or killed due to artificial nighttime lighting (DOFAW 2018). This represents the known number of birds that have been collected as a result of fallout, but likely only represents a portion of total fallout numbers due to eluding detection by seeking cover after being downed, or succumbing to depredation (Travers et al. 2018). In the 1980s through 1990s, an average of 1,200 ‘a‘o were processed by the SOS program each year, where carcasses were documented or injured birds were rehabilitated and released (DOFAW 2018). ‘A‘o and ‘ua‘u populations rapidly declined from 1993 to 2013 (94% for ‘a‘o and 78% for ‘ua‘u; Raine et al. 2017) to current extremely low populations.

The KSHCP was developed to address artificial nighttime lighting threats. The total amount of light attraction caused take of the Covered Species potentially covered under the KSHCP, however, will be less than the total island-wide light attraction take impacts to these species. Approximately 50% of the total downed birds recovered by SOS are not currently attributable to any specific, consistent, or known source of light attraction. For this portion of light attraction impact, there is currently no identifiable entity to apply for take authorization, though future efforts may be more successful in identifying such entities. Additionally, there are several entities with identified ongoing take that will be mitigated through other means (e.g., KIUC, see below; and Federal agencies as described in the EA section on Federal actions). Finally, not all of the eligible entities identified by DLNR expressed interest in participating in the KSHCP. Of the total island-wide light attraction fallout of the Covered Seabirds, the following is expected to be covered and mitigated for directly by the KSHCP: about 18% of ‘a‘o fallout, 16% of ‘ua‘u fallout, and 45% of ‘akē‘akē petrel fallout (See Section 4.2).

KIUC nighttime lighting and collisions with power lines and structures. In addition to effects caused by attraction to artificial nighttime lighting, Covered Species are subject to collisions with power lines while flying between their nesting colonies and at-sea foraging areas (Cooper and Day 1998, p. 18; Podolsky *et al.* 1998, p. 21). Nestlings are indirectly affected as they rely on provisioning from both parents in order to survive, thus the loss of either parent due to collision results in nestling fatality. Based upon recent information collected from passive acoustic song meters by the Kaua‘i Endangered Seabirds Underline Monitoring Program, the USFWS has conducted modeling to extrapolate the amount of documented take (i.e., collisions with power lines) to the entire power system on Kaua‘i (USFWS 2017). As a result of covered activities under the KIUC STHCP, the USFWS estimates that approximately 1,875 ‘a‘o, 765 ‘ua‘u, and 26 ‘akē‘akē mortalities are occurring per year as a direct result of power line strikes under the KIUC STHCP and ITP, based on updated observational data proportions provided by KESRP in 2019 and USFWS 2016 strike projections from scenarios IV, VB, and VIA selected in the USFWS Newell’s Shearwater Landscape Strategy, Appendix 2 (2017b).

KIUC has worked to address impacts to Covered Species caused by its streetlights, its other facilities with nighttime lighting, and collisions with power lines and structures under the KIUC Short-Term Habitat Conservation Plan (STHCP) and Incidental Take Permit (ITP). Under the KIUC STHCP, mitigation measures were designed to compensate for an impact to ‘a‘o, ‘ua‘u, and band-rumped storm petrels by replacing individuals or providing substitute resources or environments critical to the species' survival. The management under the HCP likely fully offsets the annual light attraction impacts to ‘a‘o (72 fledglings) and ‘ua‘u (2 fledglings), considering the predicted range of the numbers of nestlings that fledge from the Upper Limahuli breeding site alone (115-167 ‘a‘o and 27-46 ‘ua‘u fledglings; Raine et al. 2018); however, the management does not fully offset take impacts due to collisions with power lines and structures. The mitigation measures identified in the STHCP and required under the terms of the original ITP are summarized below.

• KIUC funded Covered Species colony monitoring, predator control, invasive plant control, and fence maintenance within the 148-hectare Upper Limahuli Preserve (ULP), owned and managed by the National Tropical Botanical Garden.

• KIUC funded Covered Species colony monitoring and predator control at known breeding colonies within the State's Hono O Nā Pali Natural Area Reserve (HNP NAR).

• KIUC is continuing to assess the suitability of nesting locations for conservation fencing for the Covered Species in the Upper Mānoa Valley (UMV) and ULP. Within the UMV, KIUC initiated interm predator and weed control.

• KIUC funded Covered Species colony monitoring and predator monitoring at UMV Mānoa Valley including biological and botanical surveys, social attraction, landing zones, and weatherports related to the proposed predator-proof fence for KIUC's Long-Term HCP.

• KIUC funded auditory surveys of the Covered Species in Hanalei Valley, Nā Pali Coast, La‘au Ridge, Wainiha, and Lumaha‘i Valley since 2006, on an annual basis, in an effort to identify key breeding areas for the Covered Species. The objective of the surveys are to further establish the breeding range of the Covered Species with a purpose of identifying colonies suitable for predator control.

• KIUC funded DOFAW to continue its annual seabird radar monitoring efforts, including radar data analyses, at each of the 13 historical reference sites to continue seabird population monitoring.

KIUC submitted a permit renewal request to the USFWS for its STHCP and ITP to cover the period until USFWS renders a decision on their Long-Term HCP, which is currently under development. In the interm, KIUC continues to implement these conservation actions under the agreements of STHCP. The amount of take and minimization and mitigation measures that will be included under the KIUC Long-Term HCP is unknown as it continues to be under active development.

Federal actions– Several Federal actions involving artificial nighttime lighting, powerlines, and communication towers affects one or more of the Covered Seabirds:

Project	*Federal Entity*	*Covered Seabird Take*	*Duration*	*Mitigation to Offset Take?*
Pacific Missile Range Facility (PMRF) Base-wide Operations	Navy	ʻaʻo -3 juveniles per year; ʻuaʻu -1 juvenile every 10 years; ʻakēʻakē -2 juveniles every 10 years	2014-2015	No
Kōkeʻe Air Force Station	Air Force	ʻaʻo -2 adults/juveniles, 1 egg/chick per year; ʻuaʻu -1 adult/juvenile, 1 egg/chick per year; ʻakēʻakē -1 adult/juvenile, 1 egg/chick every 10 years	2017-foreseeable future	Yes-barn owl control in seabird colonies
Kalepa Comm. Tower	Coast Guard	ʻaʻo -4 adults, 2 eggs/chicks; ʻuaʻu -2 adults, 1 egg/chick	2013-2033	Yes- seabird colony mgmt.
Kalaheo Comm. Tower	FCC	ʻaʻo -3 adults, 2 eggs/chicks; ʻuaʻu -1 adult, 1 egg/chick	2013-2033	Yes-seabird colony mgmt.
PMRF Base-wide Reinitiation for effects on Newell's Shearwater	Navy	ʻaʻo -Total maximum of 63 fledglings, 450 adults, 63 chicks or eggs over 50 years	2018-2068	Yes-seabird colony mgmt.

Other management of seabird colonies - Management actions to benefit the species that have occurred in the last five years in addition to actions related to HCPs and ongoing Federal actions include:

• HNP NAR occupies 1,448 hectares on the northwest coast and was designated in 1983 and expanded in 2009 to preserve native natural communities in the Hanalei and Waimea Districts, including the Hanakāpīʻai, Hanakoa, and Waiahuakua ahupuaʻa. The remote mountains and steep slopes in the HNP NAR provide vital breeding sites for the Covered Species.

• A partnership and funding from the USFWS, Pacific Rim Conservation, the Kauaʻi Endangered Seabird Recovery Project (KESRP), American Bird Conservancy (ABC), NFWF, DLNR-DOFAW and Kauaʻi Natural Area Reserves System staff (with funding from KUIC), NTBG, and the David and Lucille Packard Foundation created the Nihoku Ecosystem Restoration Project. Completion of the 3-hectare predator exclusion fence occurred in 2014, at the Nihoku conservation unit within Kīlauea Point National Wildlife Refuge. ʻUaʻu nestling translocations began in 2015, and the first ʻaʻo nestling translocations began in 2016. Translocations will continue through the 2020 breeding season for each species with the goal of establishing a new ʻuaʻu and ʻaʻo breeding colony within a fully protected predator-free area on Kauaʻi.

• In 2014, the National Fish and Wildlife Foundation (NFWF) assisted the USFWS in funding the development and validation decision support tool to be used by conservation and exosystem managers for planning, threat mitigation and strategic habitat prioritization to help define conservation efforts for ʻaʻo and ʻuaʻu. This project will identify areas of conservation concern and will model the efficacy of threat management approaches to increase the long-term viability of the populations.

• In 2016, NFWF provided funds to the American Bird Conservancy (ABC) through the end of the 2019 breeding season to support predator control work to protect the Covered Species at newly identified sites, Hanakāpīʻai and Hanakoa, and to develop a "rapid response team" to target control efforts throughout the HNP NAR on Kauaʻi during the seabird breeding season where hot spots of predator activity were identified.

• In 2018, NFWF provided funding to Pacific Rim Conservation (PRC) to identify, visit and assess the conservation fencing potential adjacent to three nesting locations of ʻaʻo, and ʻuaʻu on Kaua'i and provide implementation plans for these fences to serve both as social attraction sites, and hopefully capture active burrows within. The project identified preferred fencing alignment, and assess the feasibility, cost and benefits of various fencing strategies for the preferred fencing alignment and the initiation of necessary compliance in anticipation of building the fence.

• As part of the Kawailoa Wind HCP and the Kahuku HCP mitigation funds were provided to the Kauaʻi Endangered Seabird Recovery Project (KESRP) to conduct auditory surveys ʻaʻo and ʻuaʻu nesting colonies in 2013 and 2014. Both HCPs funded KESRP for barn owl predator control throughout the 2014 through 2017 breeding seasons.

• The Kawailoa Wind HCP Amendment will provide mitigation funds for predator control and burrow monitoring at the Hanakāpīʻai and Hanakoa seabird colonies within the Hono O Nā Pali NAR in 2020. This is anticipated to increase survival and successful fledgling for the population of ʻuaʻu within these colonies.

• A 5-year partnership (Honopū Seabird Conservation Initiative) supported with funding from the Department of Defense Readiness and Environmental Protection Integration (REPI) program began in 2019 to establish an effective predator control program in Honopū Valley on Kauaʻi. The purpose of the initiative is to construct a 3 acre predator-proof fence, within a 214 acre ungulate fence, to eradicate and control predators, to restore native habitat, to use social attraction with the goal of establishing and protecting a new breeding colony of ʻaʻo, ʻuaʻu, and ʻakēʻakē within a fully protected predator-free area on Kauaʻi.

4.14.1.1 <u>Covered Species – No Action Alternative</u>

Impacts from artificial lighting, when combined with other ongoing past, present, and reasonably foreseeable future actions would result in continuing major effects to the Covered Species. Under this Alternative, potential KSHCP Participants would take reasonable minimization measures where feasible to limit their legal liability of unauthorized take of listed species. These measures would include actions to minimize light attraction (e.g., modify lighting or restrict nighttime activities during fallout season) and actions to convert potential lethal take of downed birds into non-lethal take (e.g., employee training, development of search protocols, participation in SOS, conduct predator control on-site under lighting facilities). ITPs would not be issued and no off-site mitigation at the Kahuamaʻa Preserve and Kalalau Valley seabird colonies described in this EA would occur.

Depredation of adults, eggs, and chicks by rats, cats, mongoose, pigs, and barn owls are expected to continue. Feral pigs, goats, and deer, would continue roaming forests and mountain slopes, destroying or damaging burrows and the vegetation surrounding them. In addition, feral pigs could also continue to eat eggs, chicks, and adults, and destroy the entire burrow in the process of reaching the birds at the end. The spread and establishment and degredation of nesting habitats by invasive plants is expected to continue. It is expected that feral ungulates will continue to be present on the landscape, and thus soil erosion and destruction of important breeding habitat is expected to continue. Because it's expected that invasion by non-native plant species will continue, vegetation structure will also be altered and limit the ability for Covered Species to readily access their breeding habitats. Thus, breeding activities will continue to be impacted.

Under this Alternative, these serious threats would continue contributing to the existing degraded condition of the Covered Species. Cumulative impacts to the Covered Species would be expected from adding this unmitigated take of potential Participants to negative impacts of the past, present, and future actions. The unmitigated take impacts are likely to continue contributing to the existing degraded condition of the Covered Species.

Under the No Action Alternative, ITPs would not be issued for any of the potential Participants and the KSCHP would not be implemented. As such, the KSHCP would contribute to the cumulative negative effects on the Covered Species.

4.14.1.2 __Covered Species – Proposed Action Alternative__

As described in this EA, under the Proposed Action Alternative, qualified Participants in the KSHCP would implement facility-specific avoidance and minimization measures to reduce lighting impacts on the Covered Seabirds. In addition, nesting habitats of the Covered Species would be enhanced by implementing mitigation at the Kahuamaʻa Seabird Preserve. Vegetation work will include removing invasive plants that negatively affect the ability of seabirds to nest and impede breeding activities such as take-off and landing, prospecting, courtship and burrow excavation. Restoring native vegetation at the site is likely to offer suitable appropriate vegetative structure to facilitate breeding. For the 30-year duration of the KSHCP, habitat modifying plants will be removed 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).

Furthermore, the mitigation under the KSHCP is likely to result in a positive impact on the range-wide population of the ʻaʻo by more than offsetting the adverse take impacts covered under the KSHCP. However, a delay in the mitigation for the loss of fledgling ʻaʻo is likely because: (1) the conservative estimate of the starting population within the fenced 2-hectare site is zero; (2) several years are needed to recruit breeding adults and increase breeding adult numbers at the social attraction site; and (3) there is a 6-year time delay between fledging and breeding by seabirds that return to breed at the site. This is not the case for anticipated reproductive benefits from barn owl and feral cat control in the Kalalau Valley, for which the increase in ‘a‘o reproduction (15 fledglings) begins in the first year of the KSHCP. Largely due to the biology of the ‘a‘o and the overall effects of the take, the conservation program would result in a total net benefit of 134 ‘a‘o fledglings over the 30-year period. The barn owl and feral cat control in Kalalau Valley is anticipated to have a positive impact on the range-wide population of the ‘ua‘u, ‘akē‘akē, and adult breeding ‘a‘o beginning in the first year of the KSHCP. Thirty years of barn owl and feral cat control is estimated to provide a total net benefit to the Kaua‘i ‘ua‘u population of up to 82 individuals, and a total net benefit to the Kaua‘i ‘akē‘akē of up to 44 individuals, which is 61% and 59% of a benefit to the Covered Species higher than the anticipated take requested. This, therefore, more than offsets the impacts from the requested take.

For the reasons discussed above, the Proposed Action Alternative will have a minor to moderate beneficial cumulative effect to the Covered Species given the mitigation of the KSCHP, as compared with the no Action Alternative.

4.14.1.3 *__Covered Species – Translocation Alternative__*

Under the Translocation Alternative, participants of KSHCP would implement facility-specific avoidance and minimization measures to reduce lighting impacts to Covered Seabirds, the same as under the Proposed Action Alternative. Also, mammalian and avian predator control and enhancement of breeding habitats is expected to provide a similar positive benefit to Covered Species as the Proposed Action Alternative. Under the Translocation Alternative, however, because translocated chicks that fledge from the mitigation site would be anticipated to return to the site to breed, the translocated chicks would supplement the potential breeders lured by social attraction methods. Over the long-term, this would be anticipated to result in a larger population breeding within the fenced unit. Under this Alternative, the overall cumulative beneficial benefit of the mitigation site would be anticipated to be larger, and offset of actual take could occur earlier (than year 27) if social attraction is successful right away. There would still be a 6-year delay associated with maturation of translocated fledgling seabirds to breeding adults. The return rate, the timing of return, and the future breeding success for translocated ‘a‘o is unknown, making the precise long-term benefit associated with this Alternative unquantifiable at this time. However, considering the rarity of the ‘a‘o, the number of active and accessible source burrows is the primary limiting factor for translocation in any given year. Despite ongoing efforts to identify other breeding areas and locate active burrows, only five stable breeding colonies are considered appropriate as a source for chicks for translocation (due to existing predator control and colony monitoring) but, all available chicks from these colonies are already being considered for another existing long-term translocation effort. If, however, these source colonies become available, a large effort is required to ensure selection of appropriate source chicks. This includes extensive monitoring of remote colonies to locate nest sites that may be available for chick removal, predator control in these remote locations to offset human traffic during monitoring, and an extended period of care for translocated chicks. All of the above are costly, time intensive, and not likely necessary given the proximity of source seabird colonies to the Kahuama‘a Seabird Preserve. Finally, unlike other translocation sites, the Kahuama‘a site is located adjacent to the highest concentration of ‘a‘o nesting colonies on the island of Kaua‘i, thus providing high confidence that social attraction alone will attract birds to nest within the fence site. It is anticipated that social attraction at the Preserve will provide beneficial seabird production earlier than translocation would, because it attracts juvenile and breeding birds to the site immediately, instead of waiting five to seven years for the translocated chicks to return to begin prospecting and breeding. Mitigation action under this Alternative would be similar to the beneficial impacts as those described in the Propose Action Alternative (Section 4.10.1.2) but with more of a potential jump start. Cumulative impacts from the Translocation Alternative would also be similar to those described under the Proposed Action Alternative and would add minor to moderate beneficial effects to the past, present, or future cumulative effects of the Covered Species.

4.14.2 Past, Present, and Reasonable Foreseeable Future Actions that Contribute to Cumulative Effects of Listed Plants and Critical Habitat.

Primary past, current, and future actions that have impacted and continue to impact listed plants and critical habitat include feral ungulates (hooved animals) that consume and trample native understory plants, create conditions favoring non-native plant infestation and establishment, prevent the establishment of ground-rooting native plants, and disrupt soil nutrient cycling; introduced invertebrates that directly threaten native pollinators; plant disease; competition from invasive habitat-modifying plants; and seed-eating rodents and other omnivores.

4.14.2.1 <u>Listed Plants and Critical Habitat – No Action</u>

The vegetation at the Kahuamaʻa Preserve is a subtype of ʻŌhiʻa Lowland Mesic Forest, with ʻuluhe fern (*Dicranopteris linearis*) and is habitat that is important for Listed Plants and Critical Habitat. A number of rare and endangered plant species have in fact been recorded within and around the site. Currently, there is degradation from the encroachment of invasive and non-native plants, particularly in the understory (see Appendix A). Many of these plant species pose threats to Listed Plants because of their ability to modify the habitat. In addition, feral pigs, black-tailed deer and feral goats inhabit the area and are having a negative impact upon the vegetation community.

Under the No Action Alternative, the KSHCP would not be expected to impact Listed Plants or Critical Habitat and would not contribute to the cumulative impacts associated with other past, present, and reasonable foreseeable future actions.

4.14.2.2 <u>Listed Plants and Critical Habitat – Proposed Action Alternative</u>

During a preliminary site visit by botanists, several listed plants were observed within the boundaries of the site. Two federally Endangered Species and 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. This represents a very high concentration of rare and endangered plants (see Appendix A) and is important habitat for Listed Plants. Feral pigs (*Sus scrofa*), black-tailed deer (*Odocoileus hemionus columbianus*), and feral goats (*Capra hirca*) inhabit the area and are having a negative impact upon the vegetation community. It is anticipated that the Kahuamaʻa fence will be of direct conservation benefit to Listed Plants because the fence will exclude feral ungulates that consume and trample native understory plants, create conditions favoring non-native plant infestation and establishment, prevent the establishment of ground-rooting native plants, and disrupt soil nutrient cycling within the 2 hectare fence.

The Kahuamaʻa fence will also remove the black rat (*Rattus rattus*), Norway rat (*R. norvegicus*), and Polynesian rat (*R. exulans*) that are seed predators on native vegetation and Listed Plants inside the 2 hectare fence and will be controlled along a 50 meter zone outside the fence.

The site is currently dominated by native plants; the degradation from the encroachment of habitat modifying invasive and non-native plants, particularly in the understory (see Appendix A) will be removed directly within the 2 hectare fence. Additionally, vegetation control along a 50 meter zone outside the fence will help to prevent encroachment into the fenced area. Furthermore, monitoring at the mitigation site will provide early detection of any new invasive plants or animals that have the potential to impact Listed Plants and Critical Habitat.

Together, the removal of feral ungulates and habitat modifying invasive plants will create a montane ecological system that provides a benefit to Listed Plants and species that rely on the physical and biological features that are provided in designated Critical Habitat. Because of these reasons discussed above, under the Proposed Action Alternative, potential KSHCP applicants would implement the KSHCP and beneficial impacts to Listed Plants and Critical Habitat would be expected. The proposed mitigation for the KSHCP under this Alternative is expected to have minor beneficial impacts to Listed Plants and Critical Habitat.

4.14.2.3 Listed Plants and Critical Habitat – Translocation Alternative

Under the Translocation Alternative, cumulative impacts would be similar to those described under the Proposed Action Alternative and will add minor beneficial effects to the past, present, or future cumulative effects of Listed Plants or Critical Habitat.

4.15 Climate Change

Global climate change is supported by a continuously growing body of unequivocal scientific evidence. Global forecasting models offer a variety of predictions based on different emission scenarios. The U.S. Government agency Overseas Private Investment Corporation suggests that a further increase in greenhouse gas emissions could double atmospheric concentrations of CO2 by 2060 and subsequently increase temperatures by as much as 2-6.5°F over the next century. Recent model experiments by the IPCC show that if greenhouse gases and other emissions remain at 2000 levels, a further global average temperature warming of about 0.18°F per decade is expected. Sea level rise is expected to accelerate by two to five times the current rates due to both ocean thermal expansion and the melting of glaciers and polar ice caps. Recent modeling projects sea level to rise 0.17 - 0.59m (0.6 – 1.9ft) by the end of the 21st century. These changes may lead to more severe weather, shifts in ocean circulation (currents, upwelling), as well as adverse impacts to economies and human health. The extent and ultimate impact these changes will have on Earth's environment remains under considerable debate (IPCC 2014).

Small island groups are particularly vulnerable to climate change. The following characteristics contribute to this vulnerability: (1) small emergent land area compared to the large expanses of surrounding ocean; (2) limited natural resources; (3) high susceptibility to natural disasters; and (4) inadequate funds to mitigate impacts (IPCC 2014). Thus, Hawaiʻi is considered to have a limited capacity to adapt to future climate changes.

Though none of the management alternatives would contribute to climate change, the activities associated with them would provide enhanced protection for vulnerable species anticipated to be affected by climate change.

5 Required Approvals and Permits

Certain permits and approvals are required before implementation of the Proposed Alternative.

Table 5.1. Required Permits and Approvals for the Proposed Action

Permit or Approval	**Issuing Agency**	**Notes**
Endangered Species Act Section 10 Incidental Take Permit (ITP)	U. S. Fish & Wildlife Service	Approved May 2020
State Endangered Species Incidental Take License (ITL)	Department of Land and Natural Resources	
Conservation District Site Plan	Department of Land and Natural Resources	For creation of Kahuamaʻa Seabird Preserve
Diphacinone use permit	Hawaiʻi Department of Agriculture	For rodent control
Endangered Species Recovery Permit for bird banding and monitoring	U. S. Fish & Wildlife Service	For monitoring of Covered Species attracted to Kahuamaʻa Seabird Preserve
Depredation permit	U. S. Fish & Wildlife Service	For barn owl control

6 List of Preparers

DLNR-DOFAW received grant funds from the USFWS through the Cooperative Endangered Species Program, which administers Habitat Conservation Planning (HCP) planning grants under Section 6 of the ESA, to develop the draft KSHCP and this draft EA. The USFWS and the DLNR-DOFAW subsequently completed this draft EA.

7 Determination and Findings

DLNR, In view of the following Findings that the proposed project will not have a significant adverse impact on the environment, has determined that a **Finding of No Significant Impact** (FONSI) declaration pursuant to HRS Chapter 343 is warranted.

Hawai‘i Administrative Rule §11-200-11.2 establishes procedures for determining if an environmental impact statement (EIS) should be prepared or if a Finding of No Significant Impact (FONSI) is warranted. In determining whether the proposed action will have a significant impact on the environment, DLNR considers the phases of the proposed action, the expected consequences, and the cumulative as well as the short and long-term effects of the action, specifically considering the following 13 significance criteria, as provided in HAR §11-200-12. The potential effects of the proposed project described throughout this document were evaluated using these significance criteria. The findings with respect to each criterion are summarized below:

1. *Involves an irrevocable commitment to loss or destruction of any natural or cultural resource.*

Implementation of the KSHCP does not involve an irrevocable commitment to loss or destruction of any natural or cultural resources. Instead, the KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Nighttime lighting is an essential activity in many homes, businesses, and industry centers, and the KSHCP is an umbrella programmatic habitat conservation plan developed to ensure that entities that have the potential for causing unavoidable injury or harm to Kauai’s seabirds minimize that harm and mitigate for any harm that cannot be avoided. Maintaining and potentially increasing the overall populations of the Covered Species is the goal of the KSHCP.

2. *Curtails the range of beneficial uses of the environment.*

Implementation of the KSHCP is not anticipated to curtail the range of beneficial uses of the environment. The KSHCP outlines measures to minimize the effects of artificial lighting and proposes the creation and maintenance of the Kahuama‘a Seabird Preserve and barn and feral cat control around Kalalau Valley to mitigate for unavoidable take. The KSHCP will enable the continuation of existing nighttime opportunities that require artificial lighting.

3. *Conflicts with the State's long-term environmental policies or goals and guidelines as expressed in Chapter 344, HRS, and any revisions thereof and amendments thereto, court decisions, or executive orders.*

The KSHCP is consistent with the environmental policies and guidelines established in HRS Chapter 344 and contributes to the conservation of threatened and endangered species, pursuant to HRS Chapter 195D. HRS § 344-3 provides that it shall be the policy of the State to “conserve the natural resources, so that land, water, mineral, visual, air and other natural resources are protected by controlling pollution, by preserving or augmenting natural resources, and by safeguarding the State’s unique natural environmental characteristics in a manner which will foster and promote the general welfare, create and maintain conditions under which humanity and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of the people of Hawai‘i”. HRS § 344-4(3)(A) further provides that all agencies shall consider the following guidelines: “protect endangered species of indigenous plants and animals.”

The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Nighttime lighting is an essential activity in many homes, businesses, and industry centers, and the KSHCP is an umbrella programmatic habitat conservation plan developed to ensure that entities that have the potential for causing unavoidable injury or harm to Kauai’s seabirds minimize that harm and mitigate for any harm that cannot be avoided. Maintaining and potentially increasing the overall populations of the Covered Species is the goal of the KSHCP.

4. *Substantially affects the economic welfare, social welfare, or cultural practices of the community or State.*

The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Nighttime lighting is an essential activity in many homes, businesses, and industry centers, and the KSHCP is an umbrella programmatic habitat conservation plan developed to ensure that entities that have the potential for causing unavoidable injury or harm to Kauai’s seabirds minimize that harm and mitigate for any harm that cannot be avoided. Maintaining and potentially increasing the overall populations of the Covered Species, native seabirds with cultural significance, is the goal of the KSHCP.

Implementation of the KSHCP is not anticipated to negatively affect the economic welfare, social welfare or cultural practices of the community or State. While the economic and social welfare of the community and state will be positively impacted by the implementation of the KSHCP through continuation of existing legitimate activities, through expenditures associated with the implementation of light minimization measures, and through expenditures and jobs associated with the creation and maintenance of the Kahuama‘a Seabird Preserve, the impact is anticipated to be minor in the context of the State economy.

5. *Substantially affects public health.*

Implementation of the KSHCP Plan is not anticipated to substantially affect public health in any adverse way.

6. *Involves substantial secondary impacts, such as population changes or effects on public facilities.*

Implementation of the KSHCP is not anticipated to involve substantial secondary impacts (such as population changes or effects on public facilities).

7. *Involves a substantial degradation of environmental quality.*

Implementation of the KSHCP is not anticipated to involve a substantial degradation of environmental quality. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Nighttime lighting is an essential activity in many homes, businesses, and industry centers, and the KSHCP is an umbrella programmatic habitat conservation plan developed to ensure that entities that have the potential for causing unavoidable injury or harm to Kauai's seabirds minimize that harm and mitigate for any harm that cannot be avoided. Maintaining and potentially increasing the overall populations of the Covered Species is the goal of the KSHCP.

8. *Is individually limited but cumulatively has considerable effect upon environment or involves a commitment for larger actions.*

The duration of the KSHCP is 30 years. In and of itself, it does not involve a cumulative adverse effect upon the environment or a commitment for larger actions.

9. *Substantially affects a rare, threatened or endangered species, or its habitat.*

Implementation of the KSHCP is not anticipated to negatively affect a rare, threatened or endangered species, or its habitat. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Nighttime lighting is an essential activity in many homes, businesses, and industry centers, and the KSHCP is an umbrella programmatic habitat conservation plan developed to ensure that entities that have the potential for causing unavoidable injury or harm to Kauai's seabirds minimize that harm and mitigate for any harm that cannot be avoided. Maintaining and potentially increasing the overall populations of the Covered Species is the goal of the KSHCP.

Implementation of the KSHCP provides for the long-term protection of endangered seabirds from the negative impacts of light attraction. Best management practices associated with the installation of light shielding devices and with the creation and maintenance of the Kahuamaʻa Seabird Preserve will minimize negative short-term impacts to listed species and habitat (e.g., botanical and wildlife surveys along fence or trail corridors to identify rare plants, host plants for rare invertebrates, or roosting or nesting sites for native birds or the ʻōpeʻapeʻa for protection). Rare species protocols (e.g., flagging plants, identifying buffer zones, etc.) would be implemented to avoid negative impacts to any rare plant species at the Kahuamaʻa Seabird Preserve site. This protected area of native habitat would be anticipated to benefit Covered Species as available predator-free breeding habitat, while also benefitting other rare species such rare plants, native forest birds, and native invertebrates.

10. *Detrimentally affects air or water quality or ambient noise levels.*

Implementation of the KSHCP is not anticipated to detrimentally affect air or water quality or ambient noise levels.

11. *Affects or is likely to suffer damage by being located in an environmentally sensitive area*

such as a flood plain, tsunami zone, beach, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal waters.

Implementation of the KSHCP does not affect nor is likely to suffer damage by being located in an environmentally sensitive area such as a floodplain, tsunami zone, beach, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal waters.

12. *Substantially affects scenic vistas and view planes identified in county or State plans or studies.*

Implementation of the KSHCP does not substantially affect scenic vistas or viewplanes identified in county or State plans or studies. Modifications to existing lighting facilities is not anticipated to impact scenic vistas or view planes. The siting and design of the Kahuamaʻa Seabird Preserve predator-proof fencing was specifically planned to limit its visibility by visitors of Kōkeʻe State Park. The fencing will not be visible from roadways and will not block viewplanes or scenic vistas or seem obtrusive; however, it may be visible at times from scenic lookouts, by those looking back along the cliff-face.

13. *Requires substantial energy consumption.*

Implementation of the KSHCP is not anticipated to require substantial energy consumption. Petroleum fuels would be used by equipment utilized for fence construction but this energy consumption is not anticipated to be substantial, especially in comparison to island-wide energy consumption.

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9 Appendix A: List of Agencies and Persons Consulted

Governmental Agencies

U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. Department of Agriculture
National Oceanic and Atmospheric Administration
Hawaiʻi Department of Transportation
Hawaiʻi Division of State Parks
Hawaiʻi Division of Forestry and Wildlife
County of Kauaʻi

Non-Governmental Organizations and Individuals

Alexander & Baldwin, LLC
Aliʻi Kai Resort and Condos
Anaina Hou, LLC
Beach House Restaurant
Bull Shed Restaurant
Chevron
DOW Agrosciences
Grand Hyatt
Hanalei Bay Resort, Scott Pacer, General Manager
Kamehameha Schools
Kauaʻi Beach Resort
Kauaʻi Coffee
Kauaʻi Island Utility Cooperative
Kauaʻi Marriott
Kauaʻi Sheraton
Kukui Grove Mall
McDonald, ʻEleʻele
National Tropical Botanical Garden
Norwegian Cruise Line
Oceanic Time Warner Cable
Pahio Development, Princeville
Pali Ke Kua
Pioneer Hi-Bred International
Princeville Shopping Center
Puʻu Poa Association of Apartment Owners
Ric Berry, Landowner Upper Mānoa Valley
Save Our Shearwaters
The Cliffs at Princeville
The Nature Conservancy
Walmart Līhuʻe

Westin Princeville Resort
Wyndham Shearwater Resort

10 Appendix B: Archaeological Reconnaissance Survey of a Portion of Kahuama‘a Flat

ARCHAEOLOGICAL RECONNAISSANCE SURVEY OF A PORTION OF KAHUAMA‘A FLAT

KOKE‘E STATE PARK, HANALEI DISTRICT, ISLAND OF KAUA‘I
TMK: 5-9-01:1 (POR.) & 16 (POR.)

State of Hawaii
Department of Land and Natural Resources
DIVISION OF STATE PARKS

Archaeological Reconnaissance Survey of a Portion of Kahuama'a Flat, Koke'e State Park, Hanalei District, Island of Kaua'i.
TMK: 5-9-01:1 (por.) & 16 (por.).

Prepared By:

Alan Carpenter
and
Martha Yent, M.A.

ARCHAEOLOGY SECTION

State of Hawaii
Department of Land and Natural Resources
DIVISION OF STATE PARKS

February 1994

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INTRODUCTION

At the request of the Division of Forestry and Wildlife (DOFAW), State Parks Archaeologists Alan Carpenter and Martha Yent conducted an archaeological reconnaissance survey of a parcel of land located within Koke'e and Na Pali Coast State Parks, Hanalei District, Kaua'i. This area is being considered for the creation of a native plant sanctuary which will encompass a portion of these two State Park areas. The portion of the project area located within Na Pali Coast State Park is at the upper rim of Kalalau Valley. This proposed "Kalalau Rim Plant Sanctuary" will set aside approximately 115 acres of land for a plant sanctuary to be developed, maintained, and managed by the Division of Forestry and Wildlife through a Memorandum of Agreement with the Division of State Parks (Telfer 1993). The survey was conducted on December 8 and 9, 1993. Proposed developments for the area consist of the installation of fences to deter feral pig and goat traffic through the area and manual weeding out of non-native plant species. An additional long-term goal of the project is to construct a boardwalk or fenced walkway to guide visitors through the area on an interpretive nature trail. While no archaeological sites were known to exist in this area, the installation of fences could potentially impact sites if they did exist. Koke'e is rather poorly understood archaeologically, and essentially all areas of the Hawaiian Islands were visited and utilized, if not inhabited, by Hawaiians in prehistory and therefore potentially contain evidence of this use in the form of archaeological sites.

PROJECT LOCATION AND DESCRIPTION

The project area is located at the extreme northern extent of Koke'e State Park in an area known as Kahuama'a Flat, which extends to the upper rim of Kalalau Valley, and continues down the steep side of the valley to the 3000 foot contour. This steep portion of the project area is located within the Na Pali Coast State Park (Figure 1). This area is located between the Kalalau Lookout and the Pu'u o Kila Lookout on the north side of Pu'u o Kila Road, specifically extending from a drainage located .3 mile east of the Kalalau Lookout to a drainage located .15 mile west of the Pu'u o Kila Lookout. The southern boundary of the project area is defined by the road and

FIGURE 1: Survey Project Area on Upper Edge of Kalalau Valley (USGS 7.5 minute series, Waimea Canyon Quad, 1"=2000').

the northern boundary is defined by the 3000 foot contour. This comprises an area approximately 115 acres in size. The upper, flat portion of the project area is at an elevation of approximately 4100 feet above sea level.

Vegetation in the project area is characterized as Lowland Mesic Forest (Wagner et. al. 1990), dominated by a canopy of *Ohia* (*Metrosideros polymorpha* var. *dieteri*), and an understory of dense *Uluhe* fern (*Dicranopteris linearis*), which can reach heights of five feet, making survey extremely difficult (Photo 1). Additional vegetation consists of introduced blackberry (*Rubus* sp.), Daisy fleabane (*Erigeron karvinskianus*) which grows in low dense mats, and a variety of other native and introduced ferns, shrubs, and low-growing trees.

Soil for this area is classified as Koke'e silty clay loam on the upper flat (well-drained soils weathered from igneous rock, probably mixed with volcanic ash), and rough,

PHOTO 1: Typical Project Area Vegetation of *Ohia* and Fern

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). Rainfall averages 60-70 inches annually (Foote et. al. 1972).

The extremely steep nature of the slope of the valley wall prevented survey of that portion of the project area, therefore the survey encompassed only the upper flat area, which coincides to the Koke'e State Park portion of the project area. Due to the steepness of the slope, the likelihood of finding archaeological sites in the Na Pali (Kalalau) portion of the project area is very small.

PREVIOUS ARCHAEOLOGY

There are few archaeological sites recorded in the uplands of Koke'e. This area is generally thought to have been a resource-gathering zone rather than an area of permanent habitation. The nearest recorded archaeological sites are in the valleys of the Na Pali coast, most notably Kalalau. While these areas are spatially very near to each other, they are isolated from each other by 3000 or more feet of sheer cliffs.

Thomas Thrum conducted an island-wide survey of *heiau* sites in 1906, and recorded the following sites in the Koke'e area:

Ahuloulu Heiau:

> At the foot of the crater cone of Puukapele is a series of three platforms. On account of the conformation of the mountain these are irregular in shape. The lower platform is of earth. It seems to have had no regular sides or edges, the ground being simply leveled off to give a place to stand on. The longest axis is about 60 feet. The longest at right angle to this is about 50 feet. Rising four feet above this is a walled enclosure 12x30, but not exactly rectangular. The stone walls are about three feet high, and badly dilapidated. The third platform is a small niche in the mountain side about 8x10, evidently only a house floor. No special significance seems to be attached to this so-called heiau.

Ka-unu-aiea Shrine:

> Ka-unu-aiea is a small shrine in the dense koa forest of Milolii. It was only an "unu", or shrine, for the shifting population of the forest belt. There is no platform left to indicate its existence (Thrum 1906).

Thrum described the location of this site as Kaunuohua Ridge, in the forest of Miloli‘i. The exact location is not known, but it would seem from this description that it was situated relatively near our present project area. Kaunuohua Ridge runs roughly northeast to southwest immediately south of the project area (see Figure 1). The site may have been located approximately where the NASA tracking station is presently, as indicated by the forest name of Miloli‘i.

Wendell Bennett, in his 1928-29 survey of Kauai archaeological sites, further described this site, calling it a *heiau*, and giving its name as Kaumuaiea. Bennett claims the name applies to a small clearing containing a line of stones forming no outline or platform. He also describes its location as being "in the forest above Halemanu" (Bennett 1931).

These sites are of special interest in that they provide evidence that potentially significant sites can be located in isolated upland areas where there was little or no permanent habitation.

Bennett did not record any additional sites in Koke‘e, although he did record two house site complexes on or near Pu‘u Ka Pele crater in addition to Ahuloulu Heiau. The nearest sites to the project area recorded by Bennett are in Kalalau Valley, which was extensively terraced for agriculture and contained numerous habitation sites and two *heiau*. However, the upland portion of our project area and the valley floor of Kalalau are separated by three to four thousand feet of steep cliffs, and the amount of contact between the two areas is unclear.

An archaeological reconnaissance survey along ridge roads in the Koke‘e uplands was conducted by Nancy McMahon of the State Historic Preservation Division in 1993 (McMahon 1993). This included the ridges of Lapa, Ha‘ele‘ele, Polihale, Ka‘aweiki, Kuaaho, Makaha, Miloli‘i, and Pu‘u Opae. A single archaeological site (State site # 50-30-05-499) was found at the end of Polihale Ridge Road. It consisted of a 5 meter long stone alignment one to two courses high interpreted to be a sweet potato planting area because of the soil fill behind the facing. No other sites were found, although the possible locations of several plantation camps and house sites associated with the development of sugarcane cultivation in the late 1800's were recorded. No surface remains were noted at these camp locations. A great deal of ground disturbance has taken place in this century due to the the cane plantation and the military, which may have destroyed evidence of archaeological sites in the survey area.

A single archaeological site (State site # 50-30-06-707) was recorded in the area of the Waimea Canyon Lookout by State Parks archaeologists in 1993 (Carpenter 1993). This site, located about 80 meters southwest of the men's restroom at the lookout, consists of a clear, level area atop a ridge outlined by a single row of stones on three sides. This site was likely a temporary habitation site, possibly even a shelter related to the sandalwood trade. It could also represent a canoe making site, as the uplands in this area were known for logging and working of canoe wood (Handy and Handy 1972).

Brief reconnaissance surveys by Ching (1978a, b), Kikuchi (1982), Yent (1982), Walker and Rosendahl (1990), and Chaffee and Spear (1993) recorded no new archaeological sites.

HISTORICAL BACKGROUND

As previously conjectured, the upland area of Koke'e and the Alakai Swamp were likely utilized in prehistory as resource gathering zones, as opposed to areas of permanent habitation or agriculture. Several legends refer to this area to suggest this use. One attributes the road of sticks through the Alakai Swamp to the *menehune* (Rice 1923). Another refers to Lahi (or Lauhaka), a young man who would eat only birds, and traveled to the top of Kilohana (a lookout at the edge of the Alakai Swamp) where the *Uwa'u* bird nested to satisfy his hunger (ibid). Pu'u ka Pele is referred to as an area for gathering *koa* canoe logs and other building materials:

> At one time the Menehune built two canoes of koa in the mountains near Puu-ka-Pele. As they were dragging them down to the lowlands, they were caught by a heavy rain-storm, and were forced to leave the canoes across the little valley. the storm covered the canoes with debris, and later, a road was built across them, over which all the materials to build the village of Waimea were hauled (ibid).

Further evidence for the gathering of canoe logs from the uplands comes from the narrative of the Dutch merchant Captain Jacobus Boelen, who visited Waimea in 1828. While his ship was being loaded with sandalwood, he spent some time exploring the region and included the following observation:

> On that day we visited Quequaheva's [Kaikio'ewa's] shipyard, which consisted of large sheds where the largest and most beautiful canoes that can be found in the islands were made. We were assured that the island of Atooi [Kauai] had always been the principal workshop of the islands in these matters. Under one very neatly made roof I saw two of the largest double canoes I have ever seen . . . Long, narrow, and lightly built, although of a strong and heavy type of wood [*koa*], they have only a shallow draught. . . some of these vessels - especially those double canoes of the largest sort, which the highest chiefs use - are up to seventy or eighty feet long . . . (Broeze 1988).

It is obvious from this description that *koa* trees of exceptional size were being harvested in the uplands, where they were undoubtedly being partially worked to lessen their weight prior to transport to the coast.

Handy (1940) does not specifically mention Koke‘e with respect to Hawaiian agriculture, although he does state that “the upper gulches and forests in and above Waimea Canyon should be favorable localities for yams” (p. 171) He also mentions that boggy areas in the uplands were utilized for the cultivation of *olona*.

There are trails recorded which ran from the Na Pali valleys to Koke‘e and Waimea Canyon. Bennett (1931) recounted several trails connecting different areas of the Na Pali coast with the uplands. Handy and Handy (1972) recount the following:

> More anciently the old Hawaiians used a number of overland trails. The Kamaile trail descended into Nu‘ulolo [Nualolo] Valley inland. There was a trail connecting Nu‘ulolo with Honopu. A good trail overland connects Kalalau with Ha‘ena. There is a trail from Koke‘e in the mountains above Kekaha down into Kalalau. From Polihale travelers could go on foot, with a little swimming, to Miloli‘i, and a trail connected Miloli‘i with Nu‘ulolo flats. Another trail connects Miloli‘i with Koke‘e. And there was the path (*ala*), said to have been built by King ‘Ola, that led from Waimea Delta up the canyon to Koke‘e, over the Alaka‘i Swamp, where it was said to have been paved with sticks (*kipapa*), and thence down Maunahina ridge into Wainiha by way of Koke‘e [Handy and Handy 1972]

This trail system suggests a connection between the north and south sides of the island, although whether the trails facilitated trade or simply travel between the two areas is not known. It can be assumed that the upland forests were utilized as resource gathering zones for such items as hardwoods, bird feathers, and medicinal plants, as well as freshwater resources such as *o‘opu* and *opae.* Undoubtedly a substantial trail existed between the upper Waimea Canyon and Waimea Village to facilitate the transport of large canoe logs.

The Reverend Hiram Bingham traveled from Waimea to Hanalei in 1821 along the old established route passing through Koke‘e. The trail consisted of a “narrow, winding, slippery foot-path, sometimes on sharp ridges, here ascending and there descending rugged steeps”. He described the uplands as being uninhabited, but mentioned several temporary shelters along the way which he attributed to sandalwood cutters, and reported abundant sandalwood forests still in existence at that time (Bingham 1981).

Queen Emma, in 1871, made a trek from Waimea to the "Kilohana of Hanalei", at the edge of Wainiha Valley. A party of about one hundred people accompanied the queen, along a route which again likely followed the old trail. At that time the trail was very overgrown but still recognizable. Among the more interesting anecdotes of the trip was a stop the party made on the edge of Kauaikinana Valley where Queen Emma, overcome by the beauty of the spot, insisted upon a hula performance. The trip then continued through the Alaka'i Swamp where the party spent the night. The trail through the swamp was described as a "corduroy road", built of tree-fern logs placed side by side. They reached the Kilohana the next morning and then retraced their steps to Waimea (Knudsen 1940).

The sandalwood trade dominated the Kaua'i economy in the early nineteenth century. Beginning in 1810 and reaching a peak in 1821-22, commoners were forced to leave their taro fields and head into the mountains to cut the precious wood. The resource was controlled by King Kaumuali'i, who exchanged the commodity for ships and other western luxuries. Unfortunately, this took a great toll upon the people as well as the sandalwood forests, which were all but depleted by the mid-1830's. Waimea was the sole port of export on Kaua'i for the wood, which came almost exclusively from the upland gulches of Waimea Canyon and Koke'e (Joesting 1984).

Valdemar Knudsen obtained a lease to much of the present day Koke'e State Park in the mid-1800's. He used the land to run cattle, which provided beef to provision the whaling vessels. The cattle industry on Kaua'i diminished greatly by 1900 due to the decline of the whaling business (Joesting 1984).

The decline of cattle overlapped with the onset of the sugar industry. Beginning in the late 1800's and continuing into early this century, an irrigation system tapping the uplands (the Waimea Canyon-Kekaha ditch) was constructed to irrigate the cane lands of Kaua'i's west side. In conjunction with this development, plantation camps were constructed in the uplands to house the mainly Chinese workers who built and maintained the ditch ststem.

Land use in Koke‘e during this century consists mainly of recreational and military activities (Heathcote 1993). Wealthy sugar plantation owners built vacation cabins in Koke‘e to escape the summer heat of the lowland plains. Hunters traveled on horseback to the uplands in search of pigs and goats. A large network of trails was built and existing trails were refurbished by the Civilian Conservation Corps following the Great Depression. During World War II, the Army laid a telephone line through the Alaka‘i Swamp and down to Hanalei, as well as establishing a radar station in Koke‘e. In the 1940's, the road to Koke‘e was improved, and the lookouts at Waimea Canyon and Kalalau were constructed. The Koke‘e Museum and Lodge were established in the 1950's. The last major developments in Koke‘e were in the 1960's with the establishment of a Hawai‘i Air National Guard installation and a NASA tracking station constructed as part of the National Space Program.

SURVEY RESULTS

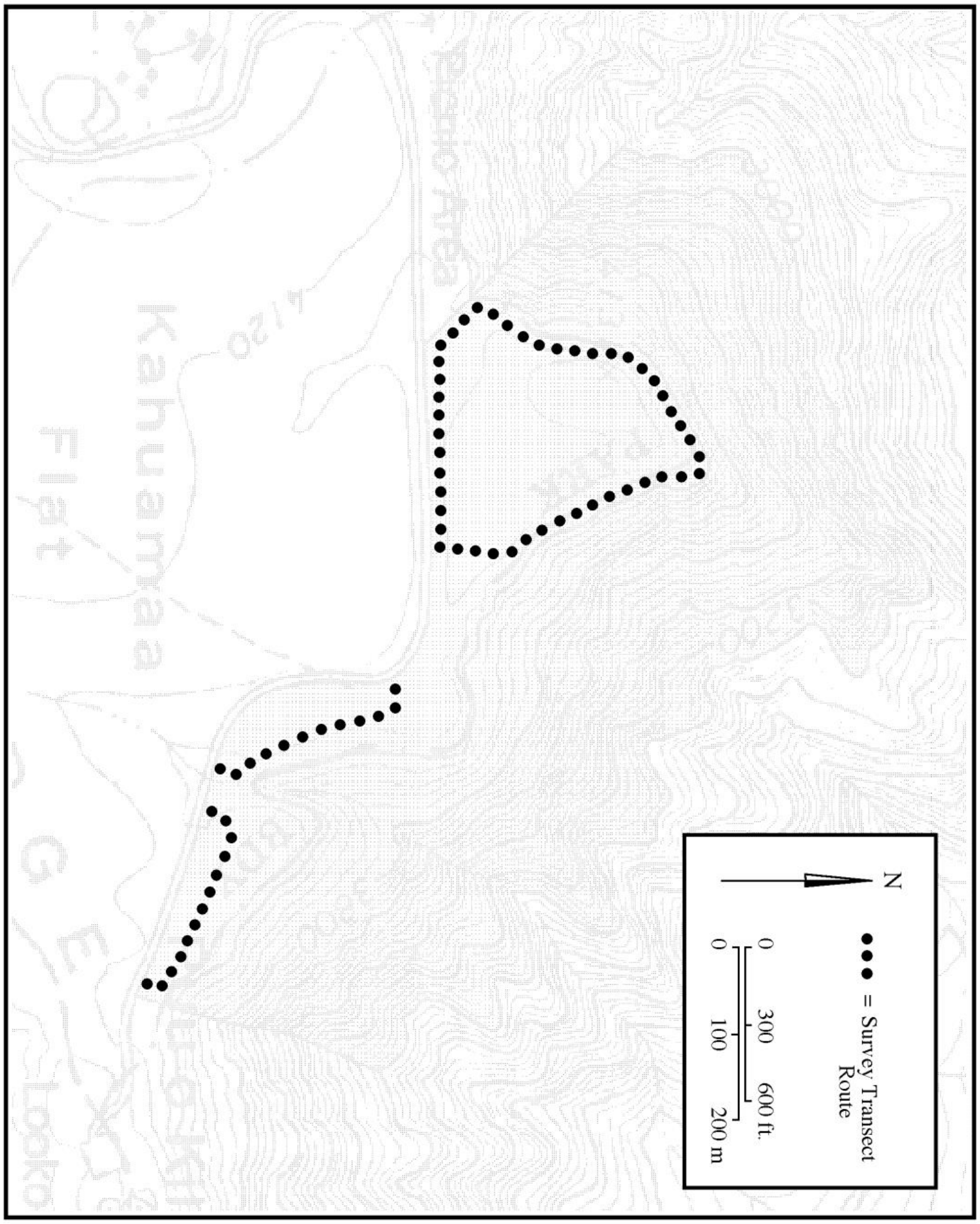
Methodology

The survey area consists in great part of extremely steep cliffs on the southwest side of Kalalau Valley. These cliffs, as previously mentioned, precluded survey of that portion of the project area. The remainder of the project area consists of the upper flat on the rim of the valley, representing perhaps one third (roughly 40 acres) of the project area. This upper area was divided into three sections, defined by two drainages which were too steep to be passable. Each was surveyed in a separate transect, aimed at covering a cross-section of each area (Figure 2). In addition to State Parks archaeologists Alan Carpenter and Martha Yent, Nevin Reinard, a volunteer from the Koke‘e Museum assisted in the two-day field survey. As previously mentioned, the dense vegetation was a prohibiting factor in terms of locating sites. While we did not expect to find sites in the area, if they were present we would have had to literally walk over them to locate them in most areas. Special attention was paid to a 100 foot wide corridor to the immediate north of the Pu‘u o Kila Road, as that is where a proposed fence would be installed as the first measure to attempt to control feral pig access to the sanctuary area. A more intensive survey would not likely have produced any more accurate results due to the aforementioned dense vegetation (see Photo 1).

Findings

No archaeological sites or features were encountered during the survey, which supports use of this area by Hawaiians as a resource gathering zone, with no permanent habitation. Evidence for this type of use could include trails and small temporary habitation features, which would easily be deteriorated by the ravages of time, especially in an area of such high rainfall and dense vegetation growth. The upper edge of the valley rim was traversed in several places, and the relatively barren steep slopes also showed no evidence of use. No caves or rockshelters were noted on the cliffs. Once again, the nature of the vegetation would likely have prevented us from seeing all but the most impressive of sites, and we cannot

FIGURE 2: Survey Transect Routes.



unequivocally state that there are no archaeological sites located within the project area.

Additionally, large trees unearthed during Hurricane Iniki provided an opportunity to examine the upper layer of the soil stratigraphy throughout the area. Nothing other than natural reddish brown clay deposits were noted, and no cultural materials were observed within this matrix.

RECOMMENDATIONS

Although no archaeological sites or features were noted during the course of this survey, the potential for significant sites in this area has been documented (Thrum 1906, Bennett 1931 - see *Previous Archaeology* above). As previously outlined, the dense vegetation in this area greatly hindered adequate survey of this parcel. Although the likelihood of encountering sites appears to be very small, nonetheless the possibility does exist. Because of the inability to accurately survey the area and the slight potential of unrecorded archaeological sites being encountered during development of the plant sanctuary, the following precautions should be adhered to:

-All ground disturbing clearing efforts should be monitored by an archaeologist so that any potential surface archaeological sites are not disturbed, especially in the event that heavy equipment is utilized. Alternately, all clearing activities that do not disturb the ground surface should be inspected by an archaeologist immediately following the clearing to determine the presence or absence of sites.

-The installation of fences for feral animal control should 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 the development of the plant sanctuary archaeological features are encountered, DOFAW will notify the Division of State Parks archaeologists. Additionally, if DOFAW activities could impact any archaeological feature, those activities will cease until such time as the feature is evaluated by an a qualified archaeologist.

-The potential for encountering human remains is judged to be extremely slight. However, if activities extend into the steep cliff portion of the project area which was not surveyed, the potential for encountering rockshelters or caves (features known to be used by Hawaiians for interment of the dead) does exist. In the advent that human remains are inadvertently discovered, those remains shall not be disturbed and the Burials Program of the State Historic Preservation Division shall be immediately notified in accordance with Hawaii Revised Statutes, Chapter 6E.

SUMMARY

State Parks archaeologists conducted a reconnaissance survey in the area of Kahuama'a Flat in Koke'e State Park, Kaua'i at the request of the State Division of Forestry and Wildlife. This area is being considered for the creation of a native plant sanctuary to be developed and maintained by DOFAW. No archaeological sites or features were encountered during this survey. However, due to the dense vegetation and steep slopes found in the project area, a complete evaluation of the area was not possible. While it is unlikely that any significant archaeological sites exist in this area, it is nonetheless possible. Therefore, recommendations were made to assure that any potential sites are not impacted by the minimal construction proposed in conjunction with the development of this preserve. If these recommendations are adhered to, we feel that the project will have no adverse effect on the cultural resources of the area. Furthermore, we feel that the development of such a sanctuary will add to the interpretive resources of Koke'e State Park, and the long term goal of establishing a nature trail through the sanctuary for educational purposes (Telfer 1993:2) would heighten the public's awareness of Hawai'i's unique botanical resources.

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11 Appendix C: Additional Information and Analysis Required for State Environmental Assessment Under HRS Chapter 343

This section provides further analysis of the environmental effects associated with use of Conservation District land for the proposed mitigation site and with use of State and County lands and funds during implementation of the KSHCP.

11.1 Relationship to Land Use Plans, Policies and Controls

Consistency with applicable Federal, State of Hawaiʻi, and County of Kauaʻi planning and land use objectives, policies, principles and guidelines is discussed below.

11.1.1 Consistency with Existing Plans Relating to Covered Species

The KSHCP and associated issuance of ITP/ITLs is consistent with published planning documents specific to the Covered Seabirds:

Table 11-1. Consistency of KSHCP with Existing Species-Specific Planning Documents

Planning Document	Comment
Hawaiian Dark-Rumped Petrel and Newell's Manx Shearwater Recovery Plan (USFWS 1983)	30+ year-old Recovery Plan for the ʻuaʻu and ʻaʻo (using the previously recognized names for these species) provides specific recovery objectives and identifies the need for additional nesting colonies, translocation of chicks, and the development of additional colony establishment techniques (like acoustic attraction or use of decoys) as recovery objectives.
Newell's Shearwater, Hawaiian Petrel, and Band-Rumped Storm-Petrel Recovery: Five-Year Action Plan (Bailey et al. 2015)	Action plan to guide research and management and develop funding for a unified and standardized approach to the recovery of ʻaʻo, ʻuaʻu, and ʻakēʻakē. Objective #2 is "Re-establish/expand distribution through social attraction and/or translocation."
KIUC STHCP (Planning Solutions et al. 2011)	Short-Term HCP (STHCP), approved by USFWS in 2011, in conjunction with incidental take authorization for the continued operation and maintenance of all KIUC facilities for a period of up to five years for ʻuaʻu, ʻaʻo, and ʻakēʻakē. Much of the current data about the Covered Seabirds' population and status has been gathered under this HCP. KSHCP is designed to build on and complement the actions undertaken by KIUC.
Regional Seabird Conservation Plan, Pacific Region (USFWS 2005)	Region-wide plan to identify USFWS priorities for seabird management, monitoring, research, outreach, planning and coordination.

Hawai‘i Statewide Wildlife Action Plan (DLNR 2015b), updating the Hawai‘i Comprehensive Wildlife Conservation Strategy (Mitchell et al. 2005)	Statewide strategy for the conservation of native wildlife and plants. Identifies species of greatest conservation need, which includes the ‘a‘o, ‘ua‘u, and ‘akē‘akē and outlines priority actions.

11.1.2 Hawai‘i State Plan (HRS Chapter 226)

The Hawai‘i State Plan (HRS Chapter 226) establishes a statewide planning system that sets forth goals, objectives, policies and priority directions to provide for the wise use of Hawaii's resources and guide he future long-range development of the State.

The goal of the State is to achieve the following:

- A strong, viable economy, characterized by stability, diversity and growth, that enables the fulfillment of the needs and expectations of Hawai‘i's present and future generations.
- A desired physical environment, characterized by beauty, cleanliness, quiet, stable natural systems, and uniqueness, that enhances the mental and physical well-being of the people.
- Physical, social, and economic well-being, for individuals and families in Hawai‘i, that nourishes a sense of community responsibility, of caring, and of participation in community life.

The KSHCP and associated issuance of ITP/ITLs is consistent with the Hawai‘i State Plan as outlined below:

Table 11-2. Consistency of KSHCP with Hawai‘i State Plan

HRS Section	Objective and Policies	Discussion
226-5	Population	Not applicable. The KSHCP is not anticipated to increase the State's overall population.
226-6	Economy – in general	The KSHCP is consistent with the State's objective of increased and diversified employment opportunities to achieve full employment, increased income and job choice, and improved living standards, while also stimulating the development of economic activities captializing on defense, dual-use, and science and technology assets, particularly on the Neighbor Islands. The KSHCP will support limited continued employment on Kaua‘i associated with developing and maintaining the Kahuama‘a Seabird Preserve, providing ongoing barn owl and feral cat control along Kalalau Valley, and monitoring over the duration of the KSHCP.

226-7	Economy – agriculture	Not applicable. The KSHCP is not anticipated to affect the viability of Hawaii's sugar and pineapple industries, the growth and development of diversified agriculture in the State, or the continuation of a dynamic agriculture industry.
226-8	Economy – visitor industry	The KSHCP is consistent with the State's objective of a visitory industry that constitutes a major component of steady growth for Hawaii's economy. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of nighttime lighting in areas used or frequented by visitors and residents.
226-9	Economy – Federal expenditures	The KSHCP is consistent with the State's objective of a stable Federal investment base as an integral component of Hawaii's economy. The KSHCP is a jointly developed document involving both USFWS and DLNR, and implements the policy of strengthening "Federal-state-county communication and coordination in all Federal activities that affect Hawai'i."
226-10	Economy – potential growth and innovative activities	Not applicable. The KSHCP is not anticipated to contribute to the development or expansion of potential growth and innovative activities that serve to increase and diversity Hawaii's economic base.
226-10.5	Economy – information industry	Not applicable. The KSHCP is not anticipated to affect broadband and wireless communication capability and infrastructure.
226-11	Physical environment – land-based, shoreline and marine resources	The KSHCP is consistent with the State's objective of the prudent use of Hawaii's land-based, shoreline, and marine resources and effective protection of Hawaii's unique and fragile environmental resources. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of nighttime lighting in areas used or frequented by visitors and residents. The light minimization measures outlined in the KSHCP are designed to avoid or reduce incidental take of Covered Seabirds, and the Kahuama'a Seabird Preserve and barn owl and feral cat control are designed to mitigate for unavoidable take and provide a benefit to Covered Species by creating a new protected nesting area and reducing depredation in existing colonies. Overall, the KSHCP seeks to pursue

		compatible relationships among activities, facilities, and natural resources.
226-12	Physical environment - scenic, natural beauty, and historic resources	The KSHCP is consistent with the State's objective to enhance Hawaii's scenic assets, natural beauty, and multi-cultural/historical resources. The light minimization measures outlined in the KSHCP are designed to avoid or reduce incidental take of Covered Species and will have an additional benefit of reducing light pollution impacting views of night skies. The Kahuamaʻa Seabird Preserve is designed to mitigate for unavoidable take and will provide a new protected nesting area for Covered Seabirds; siting and design of the fencing was developed to minimize impacts to viewplanes and scenic assets within Kōkeʻe State Park.
226-13	Physical environment - land, air and water quality	The KSHCP is consistent with the State's objective of maintenance and pursuit of improved quality in Hawaii's land, air and water resources, and greater public awareness and appreciation of Hawaii's environmental resources. The light minimization measures outlined in the KSHCP are designed to avoid or reduce incidental take of Covered Species and will have an additional benefit of reducing light pollution impacting views of night skies. The conservation mitigation action establishing the Kahuamaʻa Seabird Preserve involves the removal of non-native mammalian predators and restoration of native species. Over time, outreach associated with the KSHCP and the success of the conservation mitigation action is anticipated to increase public awareness and appreciation for Hawaii's environmental resources.
226-14	Facility systems – in general	The KSHCP is consistent with the State's objective of water, transportation, waste disposal, and energy and telcommunication systems that support statewide social, economic, and physical objectives. The KSHCP encourages flexibility in the design and development of facility systems (specifically nighttime lighting) to promote prudent use of resources and accommodate changing public demands and priorities, while minimizing impact on Covered Species.
226-15	Facility systems – solid and liquid wastes	Not applicable. The KSHCP does not involve basic public health and sanitation standards or the provision of adequate sewerage facilities.

226-16	Facility systems – water	Not applicable. The KSHCP does not involve and is not anticipated to impact the provision of water to adequately accommodate domestic, agricultural, commercial, industrial, recreational, and other needs within resources capacities.
226-17	Facility systems – transportation	The KSHCP is consistent with the State's objectives of an integrated multi-modal transportation system that services statewide needs and promotes the efficient, economical, safe and convenient movement of people and goods, and a statewide transportation system that is consistent with and will accommodate planned growth objectives throughout the State. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of nighttime lighting in areas used for transportation of people and goods. The light minimization measures outlined in the KSHCP are designed to avoid or reduce incidental take of Covered Seabirds, and the Kahuamaʻa Seabird Preserve and barn owl and feral cat control are designed to mitigate for unavoidable take.
226-18	Facility systems – energy	Not applicable. The KSHCP is not anticipated to affect the State's objectives of 1) dependable, efficient and economical statewide energy systems capable of supporting the needs of the people, 2) increased energy security and self-sufficiency through the reduction and ultimate elimination of Hawaiʻi's dependence on imported fuels for electrical generation and ground transportation, 3) greater diversification of energy generation in the face of threats to Hawaiʻi's energy supplies and systems, 4) reduction, avoidance or sequestration of greenhouse gas emissions for energy supply and use, and 5) utility models that make the social and financial interests of Hawaiʻi's utility customers a priority.
226-18.5	Facility systems – telecommunications	Not applicable. The KSHCP is not anticipated to affect the achievement of dependable, efficient, and economical statewide telecommunications systems capable of supporting the needs of the people.
226-19	Socio-cultural advancement - housing	Not applicable. The KSHCP is not anticipated to affect the State's objectives of 1) greater opportunities for Hawaii's people to secure

		reasonably priced, safe, sanitary and livable homes, 2) the orderly development of residential areas sensitive to community needs and other land uses, or 3) the development and provision of affordable rental housing by the State.
226-20	Socio-cultural advancement - health	Not applicable. The KSHCP is not anticipated to impact the State's objectives of 1) fulfillment of basic individual health needs of the general public, 2) maintenance of sanitary and environmentally healthful conditions in Hawaii's communities, or 3) elimination of health disparities by identifying and addressing social determinants of health.
226-21	Socio-cultural advancement – education	Not applicable. The KSHCP is not anticipated to impact the State's objective of providing a variety of educational opportunities to enable individuals to fulfill their needs, responsibilities, and aspirations.
226-22	Socio-cultural advancement – social services	Not applicable. The KSHCP is not anticipated to impact the State's objective of improved public and private social services and activities that enable individuals, families, and groups to become more self-reliant and confident to improve their well-being.
226-23	Socio-cultural advancement – leisure	The KSHCP is consistent with the State's objective of the adequate provision of resources to accomodate diverse cultural, artistic, and recreational needs for present and future generations. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of nighttime lighting in areas used for cultural, artistic and recreational activities. The light minimization measures outlined in the KSHCP are designed to avoid or reduce incidental take of Covered Species associated with nightime use of recreational facilities such as stadiums or tennis courts and the development and maintenance of the Kahuama‘a Seabird Preserve and barn owl and feral cat control are designed to mitigate for unavoidable take associated with these facilities, so that nightime use of these facilities may continue.
226-24	Socio-cultural advancement – individual rights and personal well-being	Not applicable. The KSHCP is not anticipated to impact the State's objective of increased opportunities and protection of individual rights to enable individuals to fulfill their socio-economic needs and aspirations.

226-25	Socio-cultural advancement – culture	The KSHCP is consistent with the State's objective of enhancement of cultural identities, traditions, values, customs, and arts of Hawaii's people. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of nighttime lighting. The light minimization measures and conservation mitigation actions outlined in the KSHCP are designed to support the long-term protection of Covered Seabirds, native species with cultural significance.
226-26	Socio-cultural advancement – public safety	The KSHCP is consistent with the State's objectives of 1) assurance of public safety and adequate protection of life and property for all people, 2) optimum organizational readiness and capability in all phases of emergency management, and 3) promotion of a sense of community responsibility for the welfare and safety of Hawaii's people. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of nighttime lighting associated with the security and safety of people and structures. The light minimization measures and conservation mitigation actions outlined in the KSHCP are designed to support the long-term protection of Covered Seabirds.
226-27	Socio-cultural advancement – government	The KSHCP is consistent with the State's objectives of 1) efficient, effective, and responsive government services at all levels in the State or 2) fiscal integrity, responsibility, and efficiency in the state and county governments. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of nighttime lighting. The light minimization measures and conservation mitigation actions outlined in the KSHCP are designed to support the long-term protection of Covered Seabirds, utilitizing a fiscally responsible approach and avoiding exposure to future financial risk associated with fines and penalties for unpermitted take.

11.2 Consistency of KSHCP with Hawai‘i Coastal Zone Management

11.2.1 Hawai‘i Coastal Zone Management Program (HRS Chapter 205A)

The Coastal Zone Management (CZM) Program is a comprehensive nationwide program that establishes and enforces standards and policies to guide the development of public and private lands within the coastal areas. HRS Chapter 205A, the Hawai‘i Coastal Zone Management Act, outlines State CZM objectives and policies for ten subject areas: recreational resources, historic resources, scenic and open space resources, coastal ecosystems, economic uses, coastal hazards, managing development, public participation, beach protection, and marine resources. All state and county agencies are directed to enforce the coastal zone management objectives and policies.

The KSHCP and associated issuance of ITP/ITLs is consistent with the CZM objectives and its supporting policies set forth in HRS §205A-2 as follows:

Table 11-3. Consistency of KSHCP with Hawai‘i CZM.

Subject Area	Objective	Discussion
Recreational resources	Provide coastal recreational opportunities accessible to the public	Not applicable. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Implementation of the KSHCP does not involve new development adjacent to the shoreline or beach and is not anticipated to change existing conditions at an ocean recreation area, swimming area, surf site, fishing area or boating area.
Historic resources	Protect, preserve, and, where desirable, restore those natural manmade historic and prehistoric resources in the coastal zone management area that are significant in Hawaiian and American history and culture	Consistent. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Implementation of the KSHCP does not involve new actions within a designated historic or cultural district, in areas listed or nominated to the Hawai‘i or National Register of Historic Places, or within or adjacent to a Hawaiian fishpond or historic settlement area. Implementation of the KSHCP does have the goal of enhancing long-term protection of native seabird species – animals with cultural value and significance.
Scenic and	Protect, preserve, and, where	Consistent.

open space resources	desirable, restore or improve the quality of coastal scenic and open space resources	The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Implementation of the KSHCP will not alter any natural landforms or existing public views and does not involve the construction of a multi-story structure, a structure visible from the nearest coastal roadway, or a structure in waters seaward of the shoreline. It does involve undeveloped land (e.g., the Kahuamaʻa Seabird Preserve), but the KSHCP is specifically directed at the long-term protection of the Covered Species and enhancing the natural open character of their coastal habitat, to maintain its suitability as future breeding habitat.
Coastal ecosystems	Protect valuable coastal ecosystems, including reefs, from disruption and minimize adverse impacts on all coastal ecosystems	Consistent. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Actions implemented under the KSHCP do not involve dredge and fill activities, the discharge or placement of material into a body of water or wetland, earthwork, grading, or grubbing, or the construction of waste treatment facilities. While some existing lighting facilities are located in the Special Management Area or the Shoreline Setback Area, light minimization measures are proposed to reduce the adverse impact of artificial lighting on the coastal ecosystem. Implementation of the HCP is specifically directed at the long-term preservation of the Covered Species.
Economic uses	Provide public or private facilities and improvements important to the State's economy in suitable locations	Consistent. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Implementation of the KSHCP seeks to minimize the impact that artificial lighting at harbors, ports, recreational facilities, and other facilities used by residents and visitors at night have on Covered Species and

		mitigating for unavoidable take. This HCP does not relate to commercial fishing or seafood production, energy production or transmission, or seabed mining and is not anticipated to affect agricultural lands or lands designated for such use.
Coastal hazards	Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, subsidence, and pollution	Not applicable. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. Implementation of the KSHCP is not anticipated to change existing conditions relating to hazards associated with tsunami, storm waves, stream flooding, erosion, subsidence, or pollution. The proposed Kahuamaʻa Seabird Preserve is not on or abutting a sandy beach, is not located within a potential tsunami inundation area, is not within a flood hazard area according to FEMA Flood Insurance Rate Maps, and is not within a subsidence hazard area.
Managing development	Improve the development review process, communication, and public participation in the management of coastal resources and hazards	Consistent. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. The proposed KSHCP will undergo a public review process, under both HRS Chapter 195D and HRS Chapter 343. In addition, the HCP will be reviewed by the Endangered Species Recovery Committee and the Board of Land and Natural Resources, with opportunities for public participation at both stages. The public has been notified: the HCP has been developed over the past decade in consultation with potential Applicants, a website informs on the substance and process, and public meetings have been held discussing draft plan content.
Public participation	Stimulate public awareness, education, and participation in coastal management	Consistent. As noted above, information about the KSHCP has been disseminated to the public, and the public has been provided an

		opportunity to comment during the development and approval process of the KSHCP.
Beach protection	Protect the beaches for public use and recreation	Consistent. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. The KSHCP incorporates both light minimization actions to reduce the impact of artificial lighting on Covered Species and conservation mitigation actions to mitigate for unavoidable take. Implementation of the KSHCP is not anticipated to affect natural shoreline processes or public access to and along the shoreline.
Marine resources	Promote the protection, use, and development of marine and coastal resources to assure their sustainability.	Consistent. The KSHCP provides a mechanism to permit unavoidable incidental take associated with the lawful use of existing nighttime lighting. The KSHCP incorporates both light minimization actions to reduce the impact of artificial lighting on Covered Species and conservation mitigation actions to mitigate for unavoidable take. Implementation of the KSHCP is not anticipated to involve or affect the development of marine or coastal resources and does not involve research of ocean processes or resources.

11.2.2 Hawai‘i 2050 Sustainability Plan

Act 8 of the 2005 Hawai‘i State Legislature established the Hawai‘i 2050 Sustainability Task Force to develop a statewide sustainability plan for the 21st century – the Hawai‘i 2050 Sustainability Plan. The long-term strategy of the Hawai‘i 2050 Sustainability Plan is supported by its main goals and objectives of respect for culture, character, beauty, and history of the State’s island communities; balance among economic, community, and environmental priorities; and an effort to meet the needs of the present without compromising the ability of future generations to meet their own needs.

The 2050 Plan outlines five goals towards a sustainable Hawai‘i accompanied by strategic actions for implementation and indicators to measure success or failure. The KSHCP and associated issuance of ITP/ITLs is consistent with the 2050 Sustainability Plan, in that the KSHCP proposes actions designed to reduce impacts to Covered Species, mitigate for unavoidable take, and support the long-term protection of the Covered Species over the next thirty years. Specifically, the KSHCP is consistent with the goals of the 2050 Plan as follows:

Goal One: *Living sustainably is part of our daily practice in Hawaiʻi.*

Discussion: Implementation of the KSHCP contributes to more sustainable living by reducing the negative impact of artificial lights on Covered Species and the coastal environment and by collecting information that can be used to monitor trends and conditions in Hawaii's economy, society and natural systems.

Goal Two: *Our diversified and globally competitive economy enables us to meaningfully live, work, and play in Hawaiʻi.*

Discussion*:* Implementation of the KSHCP facilitates the continuation of existing economic activities in coastal areas by reducing the negative impact of artificial lights on Covered Species and supporting the building blocks for economic stability and sustainability.

Goal Three: *Our natural resources are responsibly and respectfully used, replenished, and preserved for future generations*.

Discussion: Implementation of the KSHCP provides greater protection for air, and land-fresh water- and ocean-based habitats and by seeking to ensure that the Covered Species are preserved for future generations.

Goal Four: *Our community is strong, healthy, vibrant and nurturing, providing safety nets for those in need.*

Discussion*:* Not applicable. The KSHCP does not affect social safety nets, public transportation infrastructure and alternatives, public education, or access to diverse recreational facilities and opportunities.

Goal Five: *Our Kanaka Maoli and island cultures and values are thriving and perpetuated.*

Discussion*:* Implementation of the KSHCP honors Kanaka Maoli culture and heritage by proposing measures to reduce harm to endangered native seabirds, species of cultural significance.

11.2.3 Hawaiʻi Conservation District Use (HRS Chapter 183C)

The Kahuamaʻa Seabird Preserve is located within the State Conservation District, Resource and Protective Subzones. Land uses in the Conservation District are regulated by the DLNR pursuant to HRS Chapter 183C and HAR §13-5-30. It is anticipated that a Conservation District Use Departmental permit will be required for this project as identified land uses associated with Land and Resource Management, category P-13 (installation of a new fence) and Removal of Invasive Species, category P-4 (removal of invasive species in an area of greater than one acre)

(HAR §13-5-22). In evaluating the merits of a proposed land use, DLNR considers the following criteria, as provided in HAR §13-5-30.

1. *The proposed use is consistent with the purpose of the conservation district.*

The purpose of the Conservation District is to conserve, protect and preserve the important natural and cultural resources of the State through appropriate management and use to promote their long-term sustainability and the public health, safety and welfare. The creation and maintenance of the Kahuamaʻa Seabird Preserve as a mitigation site is for the direct benefit of Covered Species. The primary anticipated benefit is for ʻaʻo, but other native species, including native plants, other native seabirds, and native invertebrates, would also be anticipated to benefit from the creation and management of a predator-free fenced unit.

2. *The proposed use is consistent with the objectives of the subzone of the land on which the use will occur.*

The Kahuamaʻa Seabird Preserve is located partially within the Protective subzone and partially within the Resource Subzone. The objective of the Protective subzone is "to protect valuable natural and cultural resources in designated areas such as restricted watersheds, marine, plant, and wildlife sanctuaries, significant historic, archaeological, geological, and volcanological features and sites, and other designated unique areas" (HAR §13-5-11). The objective of the Resource subzone is "to ensure, with proper management, the sustainable use of the natural resources of those areas" (HAR § 13-5-13). The creation and maintenance of the Kahuamaʻa Seabird Preserve as an area protected from the damaging impacts of introduced predators such as rodents, cats, dogs, and pigs, is for the direct benefit of natural resources. As such, the proposed use is consistent with the objective of both subzones.

3. *The proposed use complies with the provisions and guidelines contained in HRS Chapter 205A, where applicable.*

As discussed in detail in Section 7.3 above, the KSHCP and the creation and maintenance of the Kahuamaʻa Seabird Preserve complies with and is consistent with the provisions and guidelines of HRS Chapter 205A.

4. *The proposed land use will not cause substantial adverse impact to existing natural resources within the surrounding area, community, or region.*

The KSHCP and the creation of the Kahuamaʻa Seabird Preserve is not anticipated to cause substantial adverse impact to existing natural resources within the surrounding area, community, or region. Instead, the goal is to protect and enhance the existing natural resources and support the development of a new protected breeding colony of ʻaʻo, an endangered native seabird.

5. *The proposed land use, including buildings, structures, and facilities, shall be compatible with the locality and surrounding areas, appropriate to the physical conditions and capabilities of the specific parcel or parcels.*

The KSHCP and the creation of the Kahuama‘a Seabird Preserve is compatible with the locality and surrounding area. The Preserve is entirely consistent with the surrounding character of the area as State Park. The siting and design of the fencing was specifically planned to limit its visibility by visitors of Kōke‘e State Park. The fencing will not be visible from roadways and will not block viewplanes or scenic vistas or seem obtrusive; however, it may be visible at times from scenic lookouts, by those looking back along the cliff face. It is anticipated that the predator-proof fencing can provide an educational opportunity to deepen the appreciation of visitors for actions that conserve native species.

6. *The existing physical and environmental aspects of the land, such as natural beauty and open space characteristics, will be preserved or improved upon, which is applicable.*

The KSHCP and the creation of the Kahuama‘a Seabird Preserve is anticipated to preserve or improve upon the existing physical and environmental aspects of the land by supporting the use of the area as a new protected breeding site for ‘a‘o, through the removal of introduced predatory mammals, the removal of invasive plants, the restoration of native vegetation, and the playing of bird calls to lure prospecting birds to the site.

7. *Subdivision of land will not be utilized to increase the intensity of land uses in the conservation district.*

Subdivision of land is not proposed.

8. *The proposed land use will not be materially detrimental to the public health, safety, and welfare.*

The KSHCP and the creation of the Kahuama‘a Seabird Preserve is not anticipated to be materially detrimental to the public health, safety or welfare.

11.2.4 County of Kaua‘i General Plan

The *Kaua‘i General Plan* provides the long range planning direction for development of the County. An update to the 2000 General Plan received Planning Commission approval in June 2017 and was transmitted to the County Council for its deliberation in August 2017 (County of Kaua‘i 2017, plankauai.com). Based on public input gathered during an 18-month public involvement process, the Departmental Draft of the General Plan adopts the theme of “Kaua‘i Kākou”, recognizing that everyone must work together to define and implement a shared vision for the island. The General Plan establishes priorities for managing growth and community development over a 20-year planning timeframe, and guides County decision-making by mapping land use patterns, describing what type of development is desirable, and by setting high-level priorities for infrastructure and programs.

The 2017 Plan outlines 19 policies to articulate the County’s path forward toward meeting the community’s vision and goals of sustainability, unique character, resilience, and equity. In addition, the Plan outlines actions, organized by ten sectors (watershed, housing, transportation, critical infrastructure, shared spaces, heritage resources, energy sustainability, public safety and hazards resiliency, and opportunity and health for all), to represent what is needed to move policy forward. Under the Watershed Sector, the Plan specifically recognizes the importance of Kauaʻi as a "global hotspot for biodiversity" and sets forth an objective "to protect the flora and fauna unique to Kauaʻi and Hawaiʻi and to mitigate the impact of invasive species." The ʻuaʻu and ʻaʻo are specifically mentioned in the Plan, and "Complete and implement native species Habitat Conservation Plans, such as the Kauaʻi Seabird Habitat Conservation Plan and the Kauaʻi Nēnē Habitat Conservation Plan, which address legal issues regarding human-wildlife interaction while allowing for economic development" is included as an identified Action for the Watershed. As such, the KSHCP and subsequent issuance of an ITL/ITP is entirely consistent with the pending 2017 update to the Kauaʻi General Plan.

12 Appendix D: Response to Comments

Earth Justice Comments	**RESPONSE**
We appreciate the tremendous amount of time and effort that have gone into developing the KSHCP and, ultimately, would like to see it move forward and succeed. As discussed in further detail below, we are unable to support the KSHCP in its current form due to several deficiencies that fail to ensure that Applicants will "minimize and mitigate" incidental take "to the maximum extent practicable." 16 U.S.C. § 1539(a)(2)(B)(ii). This is particularly so for the state agency Applicants—the County of Kaua'i and the Hawai'i Department of Transportation— which have broad authority over a wide range of properties, facilities, and infrastructure, and are responsible for a significant portion of take of Covered Seabirds throughout Kaua'i. Moreover, the draft DA fails to consider reasonable alternatives that would reduce harm to Covered Seabirds by restricting the use of outdoor lighting fixtures with a high amount of short-wavelength light.	Thank you for your comments.
Outdoor Lighting (KSHCP Section 5.3.1) The KSHCP lacks meaningful standards to minimize lighting impacts on Covered Species. Although the KSHCP contains "Guidelines for Adjusting Lighting at Facilities," this menu of *options* is too vague and should instead include more specific *requirements* to minimize take. The island of Kaua'i has become brighter over the past 20 years due to population growth, and also over the last few years due to the widespread adoption of light-emitting diode (LED) lights. The County has been replacing its older, yellow-colored, long-	 Section 5.3.1 now states: "*These recommendations for light minimization are based on current published scientific literature and represents the best available science available. However, the best available science regarding light attraction behavior and the variations between the Covered Species' sensitivity to light color and intensity remains extremely limited. As new information becomes available regarding new technologies, different lighting designs, and/or identifying appropriate light attraction minimization measures, they will be incorporated into the KSHCP as practicable.*

wavelength streetlight fixtures with LED fixtures that are whitish, emit a high amount of short-wavelength light, and are hotter (in terms of lumens). These sweeping changes have exacerbated nighttime lighting problems island-wide. The spectral composition of artificial lighting can affect the degree of harm to wildlife, including seabirds and sea turtles. Lighting with a high percentage of short wavelength, or blueish light, is generally more harmful to wildlife, including seabirds and sea turtles, than lighting with longer wavelength, or warmer colored light. The draft KSHCP acknowledges the harmful impact of short wavelengths of light, but only for sea turtles, improperly ignoring the body of peer-reviewed scientific literature establishing harm to seabirds from such lighting. Shielding lights—without also controlling the color spectrum and power output—fails to minimize seabird attraction. For example, a shielded white, hot light can reflect off of white surfaces such as walls or cars and create a massive nighttime lighting problem. The KSHCP should, therefore, include mandatory outdoor lighting requirements that specify: the required color spectrum — no greater than 2200 Kelvin (K) (for non-filtered LEDs) or a blue-light percentage of less than 2% (or the sum of energy between 400 and 500 nanometers divided by the sum of energy between 400 and 700 nanometers), (2) the maximum lumens – no greater than 1000 lumens for any individual exterior light, and (3) that full shielding and full cut-off are required. Should an Applicant need to install a specific light that does not meet these standards, the Applicant must be required to justify the specific need for this type of light. The goal for each Applicant's PIP should be to	*Adaptive management will be recommended to incorporate these minimization measures as part of each Permitted Participant's annual review*." Buildings or facilities that are light colored or are made of shiny surface material can reflect light from nearby light sources. All minimization measures must be implemented within Year 1 of an ITP/ITL and maintained throughout the life of the permit/license. Compliance with the avoidance and minimization measures in PIPs will be monitored and reported at the onset of the KHSCP, and annually thereafter (section 5.3.1) The KSHCP uses the best available information to evaluate measures to minimize incidental take of Covered Species, and can incorporate through adaptive management new minimization measures to reduce impacts to the Covered Species that may be introduced over the course of the KSHCP. Participants may consult at any time with USFWS and DLNR to determine if implementation of new technologies is practicable and appropriate, and develop monitoring protocols to measure the effectiveness of new measures. This might include a different design of lighting, different bulbs or more effective searching strategies. DLNR recognizes that there is variation in sensitivity to light color between species, and future research may provide additional solutions for attraction minimization. New technologies, different lighting designs, and other relevant scientific information will be added to the HCP as it becomes available to improve minimization,

substantially reduce the overall brightness of their facilities, as measured by a high-quality light meter detector, and maintain these reductions for the life of the KSHCP.	mitigation and adaptive management methods with the ultimate goal of preserving Kauai's listed seabirds.
The KSHCP should also require Applicants to implement a two-week dark skies period during which outdoor lighting is further restricted (*i.e.*, the maximum number of lights are shut off and non-essential activities are curtailed) to minimize to the extent practicable the take of Covered Seabirds during the peak of fledging season, *i.e.*, during the 2- to 3-week period around the October new moon.	Applicants are expected to minimize to the maximum extent practicable throughout the fallout season.
Moreover, we strongly object to the assertion in the KSCHP that "[a]pproximately 50% of the total downed birds recovered by [Save Our Shearwaters] are not currently attributable to any specific, consistent, or known source of light attraction. For this portion of light attraction impact, there is currently no identifiable entity to apply for take authorization … ." The County has broad authority and responsibility to regulate outdoor lighting across the island and, therefore, is responsible for incidental take caused by inadequate regulation of outdoor lighting. The County, therefore, should in its PIP commit to adopting outdoor lighting standards as well as outdoor lighting zoning ordinances for new and existing structures. Relatedly, the County should hire a full-time employee to: (1) conduct lighting audits during the non-seabird season (December through March), (2) conduct education and outreach training sessions during the early seabird season (March through August), and (3) conduct nighttime island-wide patrols for problematic lighting that has recently come online during the peak seabird fallout	The Applicants that are applying for inclusion in the KSHCP are addressing their facility lights at their facility locations. The County of Kaua'i has included their facilities under this HCP. Currently, eight Applicants have applied for participation and are addressing their impacts to the Covered Species. Other entities that have not expressed intent to be part of this HCP are responsible for addressing their impacts and are outside the scope of this HCP. Furthermore, new technologies, different lighting designs, and other relevant scientific information will be added to the HCP as it becomes available in order to improve minimization, mitigation and adaptive management methods with the ultimate goal of preserving Kauai's listed seabirds. The County PIP states: "*the County is investigating the possibility of adding advisory language to certain building and development permit forms that will inform applicants that all property owners*

season (September through November). In other words, this employee's position would be to ensure that the County makes continuous progress over time to reduce problematic lights, rather than backsliding whenever a new building is built, or a light bulb is replaced. For example, when the new Ross Store opened on Kaua'i several years ago, no one flagged for that business that the seaward-facing lights it had installed just two blocks from the ocean would harm seabirds. Simple education to the owners of that store could have immediately alleviated another bad exterior lighting situation, but there was simply no one available to do so. If the County had an employee whose job was to educate businesses, then this could have been avoided. Likewise, in October of 2017, there was a large concert at the Cabana Bar and Grill in Po'ipū on October 20th (the date of the new moon). The concert had set up five horizontal floodlights to illuminate the parking areas. These floodlights could be seen for miles around. Within minutes of arriving there, staff from the Center for Biological Diversity observed several Newell's shearwaters circling these lights. This particular concert event illustrates that, without dedicated staff paid by the County to address seabird lighting, the Newell's shearwaters will continue declining towards extinction.	*must comply with federal and state endangered species requirements*."
Outdoor Lighting (PIPs) Given the precipitous declines in the populations of the Covered Seabirds and the impact of artificial light on adult and fledging	 See Section 5.3.1: "*Under the KSHCP, all minimization measures must be implemented within Year 1 of an ITP/ITL and maintained*

birds, there is an urgent need for each Applicant to take immediate action to minimize light hazards at each site to the maximum extent possible, with special attention to the highest risk areas (*i.e.*, those with the greatest light footprint). For each site, priority should be given to removal, replacement, shielding or modification of light fixtures that are known to pose the greatest risk to over-flying seabirds (*i.e.*, documented attraction/collision). Prior to each breeding season, Applicants should ensure staff are trained on how to respond to and rescue downed birds and follow the appropriate reporting protocols.	*throughout the life of the permit/license. Compliance with the avoidance and minimization measures in PIPs will be monitored and reported at the onset of the KHSCP, and annually thereafter*". Many of the current Applicants have already been extensively minimizing their take, through lighting changes and other measures, and with the implementation of the HCP in accordance with their issued ITLs, are required to implement remaining minimization before the first fledgling season after permit issuance which includes changes to facility lights. Additional effectiveness monitoring visits by the regulatory agencies may take place as necessary to inform Adaptive Management for the KSHCP. New technologies, different lighting designs, and other relevant scientific information will be added to the HCP as it becomes available in order to improve minimization, mitigation and adaptive management methods with the ultimate goal of preserving Kauai's listed seabirds.
Predator Control (KSHCP Section 5.3.2) The KSHCP's requirements for predator control are too simplistic and vague. Although the KSHCP requires that Applicants prohibit loose, free-roaming animals, and conduct a trapping and removal program, the KSHCP should include more specific standards for predator control, especially in light of the fact that many of the PIPs lack adequate details or commitments to control predators. For example, the County's PIP lacks any commitments to control feral cats, which is unacceptable.[7] In addition to requiring that trapped and removed feral cats and dogs "not be returned to the facility even if neutered," the KSHCP should additionally prohibit these predators from being released anywhere	Section 5.3.2. of the KSHCP has been modified to state: *1) Prohibit loose, free-roaming cats and dogs (e.g. leash and/or restrain). This prohibition will be clearly communicated with appropriate signage; and* *2) Prohibit the feeding of loose, free-roaming cats or dogs throughout the Covered Property. This prohibition will be clearly communicated with appropriate signage; and* *3) Conduct a predator trapping and removal program throughout the Covered Property immediately prior to and throughout the fallout season; feral animals should be humanely removed. Permittees will not release predators trapped during the implementation of these measures.* *4) Systematically monitor for predator presence immediately prior to and throughout the fallout season. Records should*

on Kauaʻi or any other Hawaiian island that has nesting seabirds. These trapped predators should either be humanely euthanized or be placed in permanent facilities where they cannot harm wildlife and will be treated humanely. We are cognizant that costs for "no-kill" options may be substantial particularly in relation to the limited conservation benefit derived from this humane alternative. Furthermore, we are very concerned regarding the requirement that trapped animals be brought to the Kauaʻi Humane Society, since it is currently charging high fees to accept feral animals, which effectively makes this option impracticable. The KSHCP should include an alternative that would allow for feral animals to be humanely put down.	*include the type and date of predators sighted, and the timing of response actions and outcome.* *5) Applicants will evaluate the efficacy of their predator control programs to ensure the Covered Species discovery rate, as defined in their approved PIP, is met. Applicants will report on predator control monitoring and removal effort as part of their annual review.* *Measures to reduce presence of predators must be implemented within Year 1 of an ITP/ITL, and as needed throughout the life of the permit/license, if predators are present at Participant facilities* Applicants are responsible for implementing minimization measures to reduce the potential for Covered Seabird predation at their facilities.
METHODS FOR DETERMINING TAKE (KSHCP SECTION 6.2.2.1) For the purposes of estimating unobserved lethal take as part of the incidental take authorization process, the KSHCP requires Applicants to assume that only half (50%) of the seabirds that fallout are actually found and turned in to Save Our Seabirds. However, Applicants have the option of demonstrating that their searcher efficiency rate is greater than 50% to justify lowering their projections for unobserved lethal take. Some of the Applicants, in their PIPs, have deviated from the 50% searcher efficiency rate without providing adequate data to justify	Section 6.2.2.1 d(3) now states regarding discovery rate: "*Prior to the end of the 2nd seabird fallout season of the Permit term, DOFAW will develop and implement a discovery rate validation program for all Permitted Participants. The validation program will vary as needed to meet the specific needs of each Covered Property. Each Participant will coordinate with DOFAW to develop the site-specific protocols (including tools and methodology) and facilitate implementation (coordination of timing and validation team access)*". "*Results of the validation will be provided to the participant within 1 week of implementation. The validation program will be used to inform adaptive management as described in Section 6.9.1. If the*

these deviations. These Applicants—*i.e.*, Norwegian Cruise Lines (100%), Princeville Resort Hotel (90%), and Sheraton (90%)—should provide data to support these search efficiency rates, which appear unreasonably high.	*results from the validation program indicate a Participant's discovery rate is lower than the discovery rate identified in their approved PIP, the agencies will recommend measures that could be undertaken to raise the discovery rate to the approved level (i.e., updated search protocols, staff training, predator control actions). Following implementation of adaptive management measures, a follow-up validation trial will be conducted to determine whether the measures were effective in raising the discovery rate to the approved level*"
A. Compliance Monitoring (KSHCP Section 6.8.1) It appears that the KSHCP proposes to monitor compliance with minimization and mitigation actions annually, with the *potential* for follow up site visits to validate compliance. Annual compliance monitoring based on predictable, annually submitted reports, would be inadequate for ensuring compliance with minimization and mitigation measures and limits the ability for mid-season course correction. The KSHCP should specify that this annual review occur *pre- fallout season* (March-May) and include unscheduled, third-party compliance monitoring during peak fallout season to better ensure that minimization and mitigation measures are properly implemented.	 Section 6.8.2. Effectiveness monitoring visits by the regulatory agencies may take place as necessary to inform validation for the KSHCP. Section 6.7. The season for reporting will fall during the interim season when seabirds are not present on the island (December-April), and the final annual report will be due April 15th and the annual review meeting will be in March.
B. Take Monitoring (KSHCP Section 6.8.3) The KSHCP appears to include two options for monitoring take: (1) self-monitoring, and (2) DLNR monitoring, which "requires Participant funding & DLNR consultation;" however, the KSHCP	 Section 6.2.2.1 d(3) now states regarding discovery rate: "*Prior to the end of the 2nd seabird fallout season of the Permit term, DOFAW will develop and implement a discovery rate*

lacks any detail on what DLNR take monitoring would entail or how much it would cost. Moreover, given the choice, all Applicants have selected self-monitoring. Self-monitoring would be ill-advised and inadequate given Applicants' and their employees' inherent bias to under-report take. The KSHCP should instead require that take monitoring be conducted by a third-party, and possibly provide a DLNR or other government agency option for take monitoring.	*validation program for all Permitted Participants. The validation program will vary as needed to meet the specific needs of each Covered Property. Each Participant will coordinate with DOFAW to develop the site-specific protocols (including tools and methodology) and facilitate implementation (coordination of timing and validation team access*)". "*Results of the validation will be provided to the participant within 1 week of implementation. The validation program will be used to inform adaptive management as described in Section 6.9.1. If the results from the validation program indicate a Participant's discovery rate is lower than the discovery rate identified in their approved PIP, the agencies will recommend measures that could be undertaken to raise the discovery rate to the approved level (i.e., updated search protocols, staff training, predator control actions). Following implementation of adaptive management measures, a follow-up validation trial will be conducted to determine whether the measures were effective in raising the discovery rate to the approved level*" Furthermore, the Agencies receive weekly reports of SOS collection data and additional effectiveness monitoring visits may take place as necessary to inform management actions under the KSHCP. For these reasons, the Agencies consider self-monitoring to be a viable option for the KSHCP.
FAILURE TO CONSIDER REASONABLE ALTERNATIVES IN ENVIRONMENTAL ASSESSMENT The National Environmental Policy Act (NEPA) requires FWS to "study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves	 Section 5.3.1 now states: "*These recommendations for light minimization are based on current published scientific literature and represents the best available science available. However, the*

unresolved conflicts concerning alternative uses of available resources." 42 U.S.C. § 4332(2)(E); *see also id.* § 4332(2)(C)(iii). The alternatives section "is the heart of the environmental impact statement," 40 C.F.R. § 1502.14, and "applies whether an agency is preparing an [environmental impact statement] or an EA." *Native Ecosystems Council v. U.S. Forest Serv.*, 428 F.3d 1233, 1245 (9th Cir. 2005). The purpose of the alternatives requirement is to "inform decisionmakers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment." 40 C.F.R. § 1502.1. FWS's draft EA for the KSHCP considers only two action alternatives: (1) the proposed action, as reflected in the draft KSHCP, and (2) the proposed action "with the addition of seabird translocation as part of the mitigation measures." Draft EA at 8. The draft EA fails to consider any alternatives that would minimize adverse impacts on Covered Seabirds by controlling the color spectrum and power output of outdoor lighting fixtures used by Applicants; requiring Applicants to implement a two-week dark skies period during the peak of fledging season; requiring the County of Kaua'i to adopt outdoor lighting standards as well as outdoor lighting zoning ordinances for new and existing structures and to conduct lighting audits; and requiring effective control of feral cats and other predators. FWS's failure to evaluate any alternatives that include these feasible, reasonable measures to minimize adverse impacts to Covered Seabirds violates NEPA.	*best available science regarding light attraction behavior and the variations between the Covered Species' sensitivity to light color and intensity remains extremely limited. As new information becomes available regarding new technologies, different lighting designs, and/or identifying appropriate light attraction minimization measures, they will be incorporated into the KSHCP as practicable. Adaptive management will be recommended to incorporate these minimization measures as part of each Permitted Participant's annual review*." Applicants are expected to minimize to the maximum extent practicable throughout the fallout season. The County PIP states: "*the County is investigating the possibility of adding advisory language to certain building and development permit forms that will inform applicants that all property owners must comply with federal and state endangered species requirements*." Predator requirements at Applicant facilities are discussed in 5.3.2
Andrea Erichsen Comments (included in Earth Justice comment letter):	
Adjusting Lighting at Facilities (KSHCP Section 5.3.1)	

To this section's bullet list, I recommend refining criteria and information related to the last bullet "use longer wavelengths," which could also be inserted as an update to Appendix E item 13. Minimization of lights should indicate which lamp types and wavelength spectra to avoid (e.g. blue-white) as well as what wavelengths to use (e.g. yellow-orange), balancing needs for color rendering and light intensities needed for Covered Activities. The addition of more guidelines/criteria related to this topic seems to be particularly important when evaluating LED lamps that tend to emit light in the shorter blue wave- lengths. Longcore et al. (2018) discusses models that can help to assess the ecological effects of lights with varying spectral characteristics. For current PIP adjustments and future lighting planning, one approach may include avoiding use of lamps with high actinic power and evaluating lamp effects using the actinic power/lux model and CCT model values for Newell's Shearwater. Updating this information will complement what is in Appendix E item 13.	Section 5.3.1 now states: "*These recommendations for light minimization are based on current published scientific literature and represents the best available science available. However, the best available science regarding light attraction behavior and the variations between the Covered Species' sensitivity to light color and intensity remains extremely limited. As new information becomes available regarding new technologies, different lighting designs, and/or identifying appropriate light attraction minimization measures, they will be incorporated into the KSHCP as practicable. Adaptive management will be recommended to incorporate these minimization measures as part of each Permitted Participant's annual review*." Buildings or facilities that are light colored or are made of shiny surface material can reflect light from nearby light sources. All minimization measures must be implemented within Year 1 of an ITP/ITL and maintained throughout the life of the permit/license. Compliance with the avoidance and minimization measures in PIPs will be monitored and reported at the onset of the KHSCP, and annually thereafter (section 5.3.1) The KSHCP uses the best available information to evaluate measures to minimize incidental take of Covered Species, and can incorporate through adaptive management new minimization measures to reduce impacts to the Covered Species that may be introduced over the course of the KSHCP. Participants may consult at any time with USFWS and DLNR to determine if implementation of new technologies is practicable and appropriate, and develop

	monitoring protocols to measure the effectiveness of new measures. This might include a different design of lighting, different bulbs or more effective searching strategies. New technologies, different lighting designs, and other relevant scientific information will be added to the HCP as it becomes available in order to improve minimization, mitigation and adaptive management methods with the ultimate goal of preserving Kauai's listed seabirds.
Reducing Predators at Facilities (KSHCP Section 5.3.2, Items 1 and 2) The requirements for reducing predation are too general and vague. Because many of the PIPs lack adequate detail or plans to reduce predation, these requirements should be strengthened to contain more specific minimum standards. Regarding the trapping and removal of feral cats and dogs (Item 2), the KSHCP should specify that trapping must occur year-round, rather than only around fallout season, to ensure that feral animal populations are more effectively controlled. Regarding prohibiting loose, free- roaming cats and dogs, the KSHCP should specify how this prohibition will be monitored and enforced. The KSHCP should require Applicants to bring animals to licensed animal care facilities where they will be treated humanely and not released anywhere on Kaua'i, thus providing more options rather than just recommending the Kaua'i Humane Society.	 This HCP addresses lighting impacts to the covered species. The control of non-native predatory species outside of fallout season is beyond the scope of this HCP. Section 5.3.2. of the KSHCP has been modified to state: 1) *Prohibit loose, free-roaming cats and dogs (e.g. leash and/or restrain). This prohibition will be clearly communicated with appropriate signage; and* 2) *Prohibit the feeding of loose, free-roaming cats or dogs throughout the Covered Property. This prohibition will be clearly communicated with appropriate signage; and* 3) *Conduct a predator trapping and removal program throughout the Covered Property immediately prior to and throughout the fallout season; feral animals should be humanely removed. Permittees will not release predators trapped during the implementation of these measures.* 4) *Systematically monitor for predator presence immediately prior to and throughout the fallout season. Records should include the type and date of predators sighted, and the*

	timing of response actions and outcome. 5) *Applicants will evaluate the efficacy of their predator control programs to ensure the Covered Species discovery rate, as defined in their approved PIP, is met. Applicants will report on predator control monitoring and removal effort as part of their annual review.*
Conducting Seabird Awareness Training and Outreach (KSHCP Section 5.3.3) The second paragraph, first sentence states: "Under approved PIPs, each Participant is required to conduct annual outreach and training for workers at their facilities that is specific to Covered Seabirds beginning in Year 1 of the KSHCP." This sentence should be clarified to reflect that Participants must conduct facility-wide outreach to guests/customers and also provide Seabird Awareness and Response Training to workers so they can help spot downed seabirds and know how to respond in a timely manner. Workers should also be required to communicate to supervisors about problems with lights. The KSHCP should specify that such Seabird Awareness and Response Training must be completed prior to September 15 of each year and within the first day of employment for new employees hired within the fallout season. The second paragraph, second sentence states: "*A detailed slideshow presentation was developed on this subject will be provided by the Prime Contractor staff on request*." The meaning of this sentence is unclear but it seems the intent is for the Prime Contractor to develop and provide a detailed slide presentation. What is the purpose of this presentation? Is it required or just a guide? The KSHCP should state	 Section 5.3.3 has been modified to include: *Under approved PIPs, each Participant is required to conduct annual outreach and training for workers at their facilities that is specific to Covered Seabirds, beginning in Year 1 of the KSHCP. Seabird Awareness and Response Training for workers will help them to spot downed seabirds and know how to respond in a timely manner. Participants' employees will also be instructed to communicate to supervisors about problems with lights. Seabird Awareness and Response Training must be completed prior to September 15 of each year and within the first day of employment for new employees hired within the fallout season. A detailed slideshow presentation was developed on this subject and is included in this document under Appendix F: Training and Outreach Materials, and will be updated by the agencies as needed. Other presentations or programs may be developed to meet this objective, subject to approval by the agencies. The goal is to properly train workers who will be responsible for the monitoring of downed seabirds at facilities, and who may find a downed seabird incidentally while performing other duties.*

that the Participants will receive a copy for use. The training must emphasize effective and required search techniques.	
Compliance Monitoring (6.8.1) Merely reviewing annual compliance reports, with the possibility for follow-up site visits, would be inadequate to ensure that Participants' plans and obligations to minimize and mitigate take are being implemented and effective. This annual review of compliance reports should occur *pre-season* (March-May) to better ensure compliance before the Covered Seabirds return to the island and are at risk. Moreover, the KSHCP should include unscheduled third-party monitoring of site conditions (e.g. lighting and predator control) during peak fallout season. Waiting until review of the following year's annual compliance review would eliminate the ability to correct deficient minimization and mitigation measures immediately, mid-season. Perhaps it could be an additional function of the Prime Contractor to evaluate details of monitoring plans and predator control efforts (duties are listed in Table 6-1).	 See 6.8.1 and 6.8.2; Regulatory agency staff may visit sites as needed to validate compliance and effectiveness monitoring. See Section 6.9.1: Adaptive Management See table 6-1: Prime Contractor will arrange site visits as needed See table 6-3: Annual Review meeting will be in March to allow time for implementing applicable adaptive management recommendations.
Take Monitoring (KSHCP Section 6.8.3) There are discrepancies between the KSHCP's template Monitoring Plan (Item 9) and the PIPs. The template should be clarified and the PIPs updated to specify what is meant by self-monitoring (Option 1) and DLNR-sourced monitoring (Option 2). Given the choice between self-monitoring and DLNR-sourced monitoring, all applicants have selected self-monitoring. Based on my regulatory and monitoring experience, self-monitoring is not reliable or effective because of Participants' and their employees' inherent bias	 Section 6.2.2.1 d(3) now states regarding discovery rate: "*Prior to the end of the 2nd seabird fallout season of the Permit term, DOFAW will develop and implement a discovery rate validation program for all Permitted Participants. The validation program will vary as needed to meet the specific needs of each Covered Property. Each Participant will coordinate with DOFAW to develop the site-specific protocols (including tools and*

against effectively documenting take. Thus, the KSHCP should justify why self-monitoring is deemed sufficient and how DLNR-sourced monitoring would differ in effectiveness and cost. Because the PIPs' monitoring plans lack sufficient details to ensure adequate search of harder to search areas, the KSHCP's "guidelines" for take monitoring, Table 6-4, should include more specific search re- quirements. Specifically, the KSHCP should require that searches be extremely thorough and include looking under and within ground cover, landscaping, drainage ditches, and around water features, for example. Morning searches should occur within 1 hour before sunrise, and if up to 3 hours is deemed sufficient (e.g. open areas, no prevalence of loose predatory animals), the searches (and training) must clearly include how to search all vegetation and structures/vehicles. Employees must search underneath all vehicles before they are moved at night and first thing in the morning. The guidelines for monitoring of loose predatory animals in Table 6-4 must be clarified to better define when to inform management and how (*i.e.*, immediately via email or phone) and what actions management will take within a specific timeframe. It is important to act immediately during the fallout season.	*methodology) and facilitate implementation (coordination of timing and validation team access*)". "*Results of the validation will be provided to the participant within 1 week of implementation. The validation program will be used to inform adaptive management as described in Section 6.9.1. If the results from the validation program indicate a Participant's discovery rate is lower than the discovery rate identified in their approved PIP, the agencies will recommend measures that could be undertaken to raise the discovery rate to the approved level (i.e., updated search protocols, staff training, predator control actions). Following implementation of adaptive management measures, a follow-up validation trial will be conducted to determine whether the measures were effective in raising the discovery rate to the approved level*" Furthermore, the Agencies receive weekly reports of SOS collection data and additional effectiveness monitoring visits may take place as necessary to inform management actions under the KSHCP. For these reasons, the Agencies consider self-monitoring to be a viable option for the KSHCP. Table 6-4 has been modified to include: *The peak of fallout generally occurs around 2 hours after sunset –* ***searches should therefore commence 3-4 hours after sunset****. An additional search should take place within* ***1 hour before sunrise*** *to find birds that were grounded during the night*
Participant Inclusion Plans	 See modified language in section 5.3.2, which is also set forth above

With the exception of Norwegian Cruise Lines (which does not have feral animals aboard its vessels), all PIPs lack adequate methods to reduce and manage the presence of loose/feral/fed animals—predominantly cats. In addition to DLNR including clearer minimum standards in the KSHCP, discussed above, the Participants must include more detailed information in their PIPs regarding how they will monitor and humanely control loose/feral/semi-tamed cat colonies within and adjacent to their facilities during the fallout season or throughout the year. My specific comments on each of the eight PIPs are included in the attached table. My general comments on ways to improve or verify self-monitoring apply. Staff training must really focus on how to search non-paved areas and under vehicles prior to use.	
NCL: 1) Page 360: description of facility. 1. NCL is seeking coverage for all activities associated with operating its vessels, including but not limited to the Pride of America, in Hawaiian waters and says that all vessels have similar lighting. SOS on Kauai is the only rehabilitation facility mentioned. Table 5, page 369, states: under hosting an SOS station: "Not applicable on an ocean going ship – there is a SOS Aid Station at the harbor where any downed birds are placed." The A&M plan should discuss/clarify SOS type services/plans for other islands such as Maui, Honolulu and Big Island in case a seabird is recovered during transit.	NCL Response: 1 *1. The coverage requested by NCL is set forth in Section 1, Item 2 of its PIP. As stated in that section, NCL only operates one vessel in Hawaiian waters, the NCL Pride of America.* *1. NCL has not had a downed Newell's Shearwater in more than five years. Should there be a downed bird, NCL has a preference for delivering birds to Kauai where SOS stations are more reliable and SOS delivers better quality care for the birds than care that is available on other islands.* *2. As indicated above, NCL only operates one vessel in Hawaii. Tables 12 – 14 in Section 2 of NCL's PIP have been completed.* 2 *2. As indicated above, NCL only operates one vessel in Hawaii. Data collected is reported in Section 2, Table 11 of NCL's PIP.*

2) Part 2, Page 381-82, Tables 11-14: Take estimates for all species seem low and are not broken down by vessel. Tables 12-14 are empty. NCL should provide the data it has collected on its own as part of its seabird monitoring and recovery efforts and report take estimates by vessel. It seems certain that some birds that collide with the ship at night will fall into the ocean. Therefore, search efficiency would not be 100% unless NCL has a method to document this. In addition, birds that fall off the ship, must be attributed as lethal take since the outcome of the bird's survival is unknown. Tables 12-14 should be completed. 3) Some lights do not satisfy the requirement to avoid take to the maximum extent practicable in that they are not fully shielded, full cutoff lights, e.g., globe lights (Page 405) and half-moon lights (Page 389). Globe lights and half-moon lights should be modified/replaced to be fully shielded with full cutoff.	*3. As indicated in NCL's Table 1 (Exterior Ship Lighting Inventory), all of NCL's lights avoid take to the maximum extent practicable and are fully shielded. Half-moon lights were removed from NCL's vessel years ago. Language confirming this removal has been added to Section 1, Item 3 of NCL's PIP.* *3. Globe lights and half-moon lights were removed from NCL's vessel years ago. Language confirming this removal has been added to Section 1, Item 3 of NCL's PIP.*
Princeville Kauai Resort: Item 2, Page 469, Tables 11-13: Requested Take: Tables 11-13 are empty and application of a 90% search efficiency seems unjustifiably high. Tables 11-13 should be completed. Application of a 90% searcher efficiency seems high. The Participant should provide the map data and discussion as to why the analysis used is sufficient for that site. Based on my assessment of the site, I think the searcher efficiency should be lower, particularly if cats live in unsearchable vegetation or adjacent facilities.	Princeville has completed Tables 11-13. See modification to section 6.2.2.1 d(3): Discovery rates will be independently validated
Kauai Marriott Resort:	

Item 2, Page 550, Tables 11-13: Requested Take: Tables 11-13 are empty. Tables 11-13 should be completed.	Tables have been completed
Kauai Coffee: 1. Item 3 Table, Page 578-79, Item 8 Table, Page 587: Some lights are not listed as fully shielded, with full cutoff, including those needed for Korvan Harvester machines. The lights on these machines should be shielded. Item 8 Table needs more detailed information on light adjustments particularly the harvesters since it is not clear at this time. For example, can harvester lights be shielded? 2. Take Monitoring, Page 591 and Item 9a, #2, Page 592: Page 591, Table first row, should provide more detailed information regarding percentage of property to be monitored/searched. Same Table states monitoring will occur twice daily at 5:30 a.m. (which is fine), and 5:30 p.m., which violates KSHCP guidelines. Item 9a, #2 lacks adequate details of monitoring during night harvest operations. Overall this table needs more details of areal coverage, protocols, and reasons as listed in the header of the table. Evening monitoring must occur 1-2 hours after sunset and more frequently during harvesting operations. The PIP must better specify how staff working during harvesting and processing operations will monitor fallout. For example the number of monitors (10 during harvesting and 20 for processing) may be sufficient depending on the scale of the searched areas, but more information must be provided on when	 PIP has been updated to reflect that harvester lights are angled down and out, and are shielded. Table 7 now states: *A perimeter search will be conducted around the Factory processing buildings and grounds which is approx. 5.0 ac, or 0.17 % of the total property.* *Harvested fields that will be monitored and searched are approx. 18 ac, or 0.60 % of the total property.* *This accounts for all portions of the property that conduct overnight, lighted operations* *Factory perimeter search will be conducted at 10:00 PM and 5:30 AM.* *Harvest field search will be conducted at 5:30 AM, and the skies will be continually monitored for seabirds by all personnel throughout the night shift.*

and how they will work. Monitoring during the harvest is key. Twice per day during harvesting does not seem adequate. 3. Item 3 Funding Assurance, Page 597. Funding assurance section is empty. 4. Checklist, Page 598: some items in table not complete	
Sheraton Kauai Resort: 1. Tables 1 and 2, Pages 619-20, 623-24 were included twice. Remove the duplicate or inaccurate tables 2. Table 4, Page 627 and Table 5, Page 629: The avoidance and minimization measure to replace all outdoor lights with fully shielded full cutoff fixtures and shields has not been implemented. For example, there are unshielded sets of bright string lights out in the open in the Makai side courtyard. The pagoda lights (N=18) outside the Garden wing reception area are numerous and shine a lot of light out the sides of the lamps, thus resulting in a glow in this area. When out in the open, the large ones especially should not be considered fully shielded full cutoff fixtures or down lights. Floodlights on the roof above the east side eave of the Lava Pool Bar do not point down far enough. There are indoor lights on second and third story common areas that shine out through windows and likely do not meet the A&M standards. These should be re-evaluated to see how window treatments may be used to prevent lights shining out laterally into the sky because the lights are on all night.	 1. Tables have been corrected. 2. See section 5.3.1: Under the KSHCP, all minimization measures must be implemented within Year 1 of an ITP/ITL and maintained throughout the life of the permit/license. 3. All participants will comply with the measures described in section 5.3.2. Under the KSHCP, all minimization measures must be implemented within Year 1 of an ITP/ITL and maintained throughout the life of the permit/license. 4. Sheraton PIP discovery rate has been modified to 50%

Existing, used facilities are not addressed completely in practice and in the PIP and therefore the PIP does not meet KSHCP A&M standards or maximum extent practicable. 3. Predator Control, Table 6, Page 630: The PIP states that the Resort implements this measure, staff is trained that this is not allowed, and security monitors compliance. More detail on these topics is needed. Numerous feral cats were noted in Sheraton parking lots adjacent to Kiahuna Plantation in October 2019. Table 6 needs to provide more concrete details as to how this minimization will be monitored and managed. The PIP must address humane trapping and data collection on cats around the grounds, which must be active year round. Procedures for managing feral cats must be developed, posted, and enforced. 4.Take Estimate and Search Efficiency, Table 10, Page 638: Search efficiency of 90% seems unjustifiably high. The Participant should provide maps and data to support the 90% search efficiency. On the map, please identify areas with "rank" vegetation. Data regarding the presence of cats will inform the survival rate of downed seabirds that are not detected. This will increase the lethal take estimate, further calling into question the claimed 90% search efficacy.	
County of Kauai 1. Item 7, Page 674: County staff to check timers at Category 4 facilities 2x/month. There is no timeframe for fixing broken timers and or any explanation of how use will be managed until repairs are completed. County staff should check timers more frequently than 2x/month, i.e., 2x/week for Category 4 lights being used. The PIP should	 1. The County revised its PIP to provide clarification. See Item 7. For the past decade all lights at Category 5 and Category 4 facilities are off during the entire fledgling season with the exception of certain Category 5 facilities under a Memorandum of Understanding with the U.S. Fish and Wildlife Service in 2017, 2018, and 2019.

provide a timeframe for fixing timers and protocol for controlling use until timers are fixed.	The lights are inoperable when timers are inoperable.
2. Predator Control, Table 5, Page 673: Description of predator control at County facilities is too vague, particularly at Category 4 and 5 locations. The table merely lists statutes regarding loose animals and refuse removal, but does not specify whether/how they will be enforced. The PIP needs to contain more detailed information regarding the methods for monitoring and managing feral animals on County lands and partnering perhaps with adjacent landowners. It may be of value to prioritize more intensified predator control efforts at Category 4 and 5 facilities, for example.	2. All participants will comply with the measures described in section 5.3.2. Under the KSHCP, all minimization measures must be implemented within Year 1 of an ITP/ITL and maintained throughout the life of the permit/license. County PIP Item 7: The County will deploy as necessary traps or other appropriate mechanisms during the seabird fallout period to reduce the presence of predators at facilities where minimization measures are not likely to result in the avoidance of seabird take.
3. Light shielding, Page 676: The PIP states that shielded lights may not be used at DUI checkpoints where motorists are subject to unannounced traffic stops, or emergency rescue and response where the use of full cutoff fixtures would make it impossible to meet the operational requirements and that they will consider the use of other types of Lighting There should be a way to ensure that all portable floodlights for emergency uses are shielded. The PIP needs to provide details as to what these “other types of lighting” are.	3. County Response: It is the policy of the County of Kauaʻi to manage the use of temporary flood lights on County of Kauaʻi roads and facilities during the fledgling season of the endangered seabirds that nest on the island (principally Newell’s Shearwaters and Hawaiian Petrel) by limiting extraneous light insofar as it is reasonably practicable. The amount of light used will be the minimum required to complete the emergency repairs in a safe and efficient manner and lighting fixtures shall be shielded and directed downwards to the maximum extent practicable.
4. Lighting Ordinance, Page 677, #4: The PIP states that the County declined to adopt a county-wide or facility-wide lighting ordinance without providing justification for this decision or analysis to support their conclusions. Second, the statement that the County is investigating the possibility of adding advisory language to certain building and development permit forms does not go far enough.	4. County Response: The County has already implemented procedures to minimize use of all of its lights at all of its facilities. Please see Attachments A-F for details on the County’s minimization measures. In addition, all minimization measures described in Items 7 and 8 will be applied to any new facilities constructed, acquired, and operated by the County during the term of the take authorization. Proposing such a measure would not in any way ensure that it would become law since the Kauaʻi County Council would ultimately vote on any such measure. In addition, imposing such a

The County's PIP should provide more detailed information on its analysis regarding development of a lighting ordinance, how it will identify future opportunities and mechanisms to address this topic. Even without an ordinance, the County should include permitting and planning requirements, not merely advisory suggestions as provided currently in the PIP. The County should include in their PIP their policy to ensure that new and existing permitted facilities implement seabird friendly lighting. 5. Monitoring, Table 8, Page 682: Table is missing headers. For Category 4, monitoring not frequent enough. For Category 5, timing is not frequent enough. Monitoring at Category 4 and 5 facilities should expand from 10' radius to at least a 30' radius of a likely sighting, particularly where there is landscaping or other structures. For Category 4 facilities, searching for fallout only in the morning will result in higher mortality and undetected birds. Therefore, the PIP must specify at time of use in addition to the first hour of the morning. For Category 5 facilities, County should conduct ongoing monitoring during light use and after lights are off as written.	requirement on the people of Kauaʻi differs from other commitments that are part of the County's application in two fundamental ways: First, it would impose requirements on parties (such as individual home and business owners seeking building permits) other than the County itself. Second, it would burden the County with a costly enforcement role that it does not presently have. Moreover, if the County were to impose such requirements on parties other than itself, it would constitute substantial "mitigation" that should offset unavoidable take by County-owned facilities. In the absence of a mechanism by which the magnitude of that benefit could be fairly judged, it could not be adequately addressed in any decision related to the adequacy of the overall avoidance, minimization, and mitigation package. As an implemented policy, the County now requires all of its new facilities to comply with KSHCP recommendations for full cut-off fixtures to minimize light pollution. As illustrated in Table 4. Further, the County has committed to retrofitting existing facilities. 5. County Response: The County has revised its PIP to address this comment. (table heading row). The County PIP addressed this comment. See Item 7, Item 8, and Item 9.
Hawaii Dept. of Transportation – Harbors and Airports Divisions 1. Lihue Airport avoidance and minimization Table 4, Page 842: Airports table on avoidance and minimization-provide seabirds awareness training to staff lists April instead of August. Correct Table 4 to read August to match Harbors	 HDOT Response: 1. HDOT has revised its PIP, Table 4 Lihue Airport, to indicate seabird awareness training will be provided in August rather than April.

2. Predator Control Kauai Harbors Table 11, page 848 Nawiliwili Harbor and Pt. Allen Table 12, page 849, Lihue Airport Table 6, page 853: These tables are sufficient in that they list information on contractors, costs, and time period for predator control. Other participants should do the same. Monitoring is improved with third party verification, as I have recommended for all PIPs. The DOT PIPs are therefore setting a good standard by including this information and costs. However, the PIP monitoring plan should make it clear that intensive monitoring will be implemented in areas containing vegetation/landscaping and various types of vehicles and movable equipment (e.g. rental car areas and parking lots as well as vehicles within the secured areas). Practices such as trimming vegetation will also help locate birds that have fallen or crawled under vegetation. In addition, random in-season verification monitoring should be included in the plan.	2. HDOT has revised its PIP to indicate intensive monitoring will be implemented in areas containing vegetation/ landscaping and various types of vehicles and moveable equipment.
Alexander & Baldwin 1. Table 1(k), page 1083: Table 1(k), page 1083 states that a lighting plan for the Shops at Kukuiula is underway/planned and therefore is incomplete for this draft. The PIP contains a good list including many varied facilities and reasonable A&M for lights at each although some sites are not addressed completely and therefore the PIP does not meet KSHCP A&M standards or maximum extent practicable. For example, there are numerous unshielded and bright/string lights currently in use at two main areas within the Kukuiula Shopping Center. These are not within KSCHP guidelines. These exposed lights need to be shielded, full cutoff downward facing fixtures. Similarly, light improvement plans are pending for the 1(f) Pt. Allen Marine Center.	A&B Response*:* 1. *KSHCP Table 5-1 (Biological Goals) requires that lighting avoidance and minimization be implemented "by the end of Year 1." A&B's lighting minimization plan is underway. A&B will complete its lighting and minimization by the end of Year 1.* *There are no cat colonies on A&B's property. As stated in Tables 4(a) through 4(f) of A&B's PIP, outdoor feeding of animals is prohibited at A&B's Port Allen properties. There are known cat colonies on nearby properties that do not belong to A&B. As explained at the ESRC meeting on October 23, 2019, these cat colonies will always contribute more cats to A&B's properties unless the colonies are eliminated. A&B will meet the biological*

Predator control methods are weak, particularly at Pt. Allen sites where the need is highest (e.g. cat colonies on property) Include a timeframe for completion of the pending lighting plan for the Shops at Kukuiula, Pt Allen Marine Center and any other locations where plans are pending. Predator monitoring and humane control methods need to be more explicitly defined and scheduled, particularly prior to and during the fallout season. Otherwise, seabirds that fallout at the intersection of Waiaolo Road and Aka Ula Street, for example, will be quickly dispatched by feral cats. 2.Take Monitoring, Item 7a (page 1152) Item 7b (page 1153): 7a Training is provided, but monitoring is not. The solar farm is close to several facilities such as KIUC's power plant, Chevron, and Pt. Allen. Birds may fallout on property despite the low risk of on-site lights. 7b Says 1-2 "searches." Should this be "searchers"? 7a-A&B should monitor daily at solar farm. It is near the KIUC power plant, Chevron, and Pt. Allen, and birds may fall there. A&B should assess localized presence of cats and other loose predatory animals and take appropriate actions to remove them. 7b-Correct typo to "searchers" if that is the intended meaning. For sites where predator control is deemed infeasible, if the results of monitoring show depredation of downed seabirds, adaptive management should trigger humane predator control actions. 3. Item 2, Tables 11-13, Page 1199: Tables 11-13 are empty.	*goals stated in KSHCP Table 5-1 which requires "implementing actions to reduce presence of free-roaming seabird predators such as cats and dogs at Participant facilities"* 2. *As set forth in Table 3(a) in the A&B PIP, "Lights are not turned on except when a nighttime emergency requires maintenance." With only emergency lighting at the solar farm, A&B's PIP states in Table 6(a), "Properties with lights which are normally turned off and rarely or never used, will not be searched." Birds falling out from lighting at nearby facilities are attributable to third party lighting, and not to A&B's lighting. A&B is willing to give access to KIUC, as needed, to allow KIUC to search A&B's property in connection with KIUC's adjacent power plant lights.* *"Searches" has been revised to "searchers" in Table 7(b) of A&B's PIP.* 3. *Tables 11-13 of A&B's PIP have been completed.*
Dept. of Health, Clean Air Branch If your proposed project: Requires an Air Pollution Control Permit You must obtain an air pollution control permit from the Clean Air Branch and comply with all applicable conditions and requirements.	Thank you for your comments

If you do not know if you need an air pollution control permit, please contact the Permitting Section of the Clean Air Branch. Includes construction or demolition activities that involve asbestos You must contact the Asbestos Abatement Office in the Indoor and Radiological Health Branch. Has the potential to generate fugitive dust You must control the generation of all airborne, visible fugitive dust. Note that construction activities that occur near to existing residences, business, public areas and major thoroughfares exacerbate potential dust concerns. It is recommended that a dust control management plan be developed which identifies and mitigates all activities that may generate airborne, visible fugitive dust. The plan, which does *not* require Department of Health approval, should help you recognize and minimize potential airborne, visible fugitive dust problems. Construction activities must comply with the provisions of Hawaii Administrative Rules, §11-60.1-33 on Fugitive Dust. In addition, for cases involving mixed land use, we strongly recommend that buffer zones be established, wherever possible, in order to alleviate potential nuisance complaints. You should provide reasonable measures to control airborne, visible fugitive dust from the road areas and during the various phases of construction. These measures include, but are not limited to, the following: a) Planning the different phases of construction, focusing on minimizing the amount of airborne, visible fugitive dust-generating materials and activities, centralizing on-site vehicular traffic routes,	

and locating potential dust-generating equipment in areas of the least impact; b) Providing an adequate water source at the site prior to start-up of construction activities; c) Landscaping and providing rapid covering of bare areas, including slopes, starting from the initial grading phase; d) Minimizing airborne, visible fugitive dust from shoulders and access roads; e) Providing reasonable dust control measures during weekends, after hours, and prior to daily start-up of construction activities; and f) Controlling airborne, visible fugitive dust from debris being hauled away from the project site.	

13 Appendix E: Comments Received

Standard Comments for Land Use Reviews
Clean Air Branch
Hawaii State Department of Health

If your proposed project:

Requires an Air Pollution Control Permit

You must obtain an air pollution control permit from the Clean Air Branch and comply with all applicable conditions and requirements. If you do not know if you need an air pollution control permit, please contact the Permitting Section of the Clean Air Branch.

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Includes construction or demolition activities that involve asbestos

You must contact the Asbestos Abatement Office in the Indoor and Radiological Health Branch.

Has the potential to generate fugitive dust

You must control the generation of all airborne, visible fugitive dust. Note that construction activities that occur near to existing residences, business, public areas and major thoroughfares exacerbate potential dust concerns. It is recommended that a dust control management plan be developed which identifies and mitigates all activities that may generate airborne, visible fugitive dust. The plan, which does *not* require Department of Health approval, should help you recognize and minimize potential airborne, visible fugitive dust problems.

Construction activities must comply with the provisions of Hawaii Administrative Rules, §11-60.1-33 on Fugitive Dust. In addition, for cases involving mixed land use, we strongly recommend that buffer zones be established, wherever possible, in order to alleviate potential nuisance complaints.

You should provide reasonable measures to control airborne, visible fugitive dust from the road areas and during the various phases of construction. These measures include, but are not limited to, the following:

a) Planning the different phases of construction, focusing on minimizing the amount of airborne, visible fugitive dust-generating materials and activities, centralizing on-site vehicular traffic routes, and locating potential dust-generating equipment in areas of the least impact;
b) Providing an adequate water source at the site prior to start-up of construction activities;
c) Landscaping and providing rapid covering of bare areas, including slopes, starting from the initial grading phase;
d) Minimizing airborne, visible fugitive dust from shoulders and access roads;
e) Providing reasonable dust control measures during weekends, after hours, and prior to daily start-up of construction activities; and
f) Controlling airborne, visible fugitive dust from debris being hauled away from the project site.

If you have questions about fugitive dust, please contact the Enforcement Section of the Clean Air Branch

Clean Air Branch (808) 586-4200 cab@doh.hawaii.gov	Indoor Radiological Health Branch (808) 586-4700

April 1, 2019

EARTHJUSTICE

April 13, 2020

Via Electronic Mail

U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
KauaiSeabirdHCP@fws.gov

Re: Kauaʻi Seabird Habitat Conservation Plan and Draft Environmental Assessment, Kauaʻi, Hawaiʻi, 85 Fed. Reg. 14,497 (Mar. 12, 2020)

To Whom It May Concern:

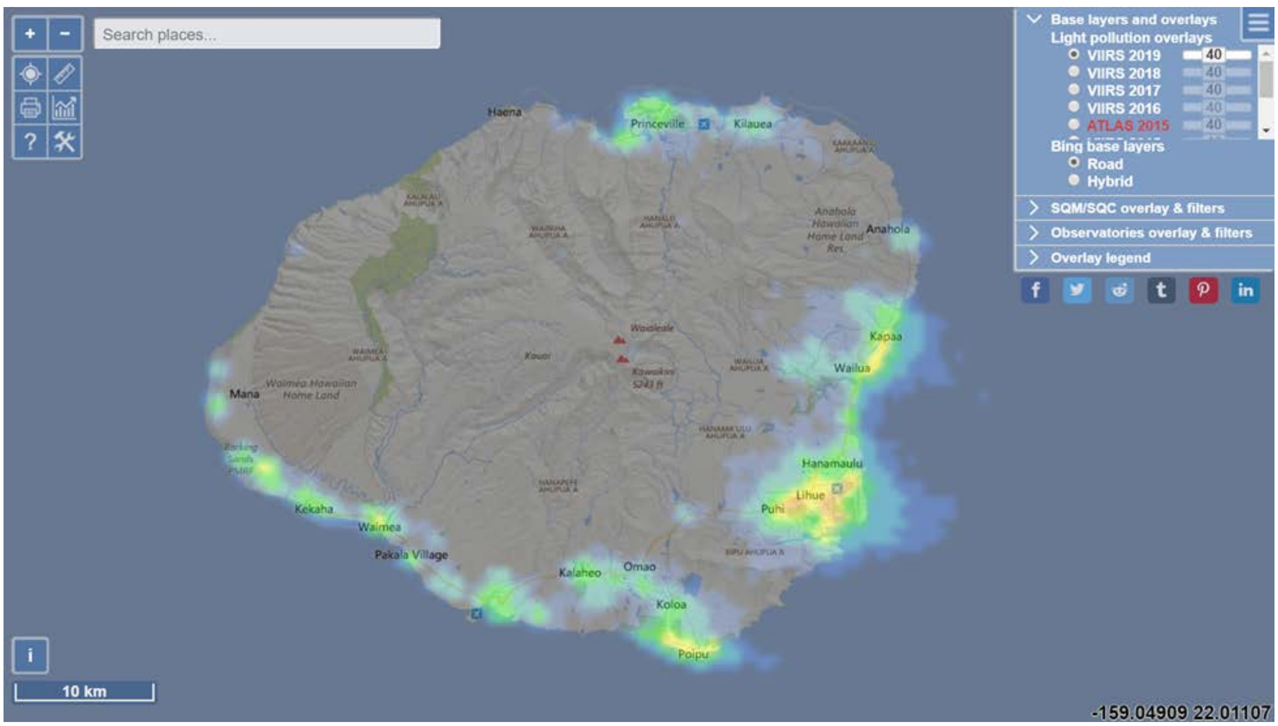
Earthjustice submits these comments on behalf of Hui Hoʻomalu i Ka ʻĀina, Conservation Council for Hawaiʻi, Center for Biological Diversity, and American Bird Conservancy in response to the U.S. Fish and Wildlife Service's (FWS's) request for comments on the draft Kauaʻi Seabird Habitat Conservation Plan, dated March 2020 (KSHCP) and associated draft environmental assessment (EA). *See* 85 Fed. Reg. 14,497 (Mar. 12, 2020). We incorporate by reference the comments that Andrea Erichsen submitted last November on the State of Hawaiʻi Division of Forestry and Wildlife's (DOFAW's) version of the draft KSHCP (attached) and submit the following additional comments for your consideration.

We appreciate the tremendous amount of time and effort that have gone into developing the KSHCP and, ultimately, would like to see it move forward and succeed. As discussed in further detail below, we are unable to support the KSHCP in its current form due to several deficiencies that fail to ensure that Applicants will "minimize and mitigate" incidental take "to the maximum extent practicable." 16 U.S.C. § 1539(a)(2)(B)(ii). This is particularly so for the state agency Applicants—the County of Kauaʻi and the Hawaiʻi Department of Transportation—which have broad authority over a wide range of properties, facilities, and infrastructure, and are responsible for a significant portion of take of Covered Seabirds throughout Kauaʻi. Moreover, the draft DA fails to consider reasonable alternatives that would reduce harm to Covered Seabirds by restricting the use of outdoor lighting fixtures with a high amount of short-wavelength light.

I. MINIMIZATION

A. Outdoor Lighting (KSHCP Section 5.3.1)

The KSHCP lacks meaningful standards to minimize lighting impacts on Covered Species. Although the KSHCP contains "Guidelines for Adjusting Lighting at Facilities,"[1] this menu of *options* is too vague and should instead include more specific *requirements* to minimize take. The island of Kaua'i has become brighter over the past 20 years due to population growth, and also over the last few years due to the widespread adoption of light-emitting diode (LED) lights. The County has been replacing its older, yellow-colored, long-wavelength streetlight fixtures with LED fixtures that are whitish, emit a high amount of short-wavelength light, and are hotter (in terms of lumens). These sweeping changes have exacerbated nighttime lighting problems island-wide.



2019 Light Pollution Levels[2]

The spectral composition of artificial lighting can affect the degree of harm to wildlife, including seabirds and sea turtles. Lighting with a high percentage of short wavelength, or blueish light, is generally more harmful to wildlife, including seabirds and sea turtles, than lighting with

[1] KSHCP at 56 & Appendix E.

[2] https://www.lightpollutionmap.info/#zoom=10&lat=2518510&lon=-17754133&layers=B0TFFFFFFFFFF

longer wavelength, or warmer colored light.[3] The draft KSHCP acknowledges the harmful impact of short wavelengths of light, but only for sea turtles, improperly ignoring the body of peer-reviewed scientific literature establishing harm to seabirds from such lighting.[4]

Shielding lights—without also controlling the color spectrum and power output—fails to minimize seabird attraction. For example, a shielded white, hot light can reflect off of white surfaces such as walls or cars and create a massive nighttime lighting problem.

Picture taken in 2018 by the Center for Biological Diversity

[3] *See* Longcore, T, *et al.*, "Rapid assessment of lamp spectrum to quantify ecological effects of light at night," J. Exp. Zool. 2018:1-11; Rodríguez, A., *et al.*, "Reducing light-induced mortality of seabirds: High pressure sodium lights decrease the fatal attraction of shearwaters," J. for Nature Conservation 39 (2017) 68–72; *see also* Draft National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds, Commonwealth of Australia (2019). These studies are attached.

[4] *See* KSHCP Appendix E, § 1.13 (requiring "[l]ong wavelength lights … for all construction visible from and adjacent to sea turtle nesting beaches").

The KSHCP should, therefore, include mandatory outdoor lighting requirements that specify: (1) the required color spectrum — no greater than 2200 Kelvin (K) (for non-filtered LEDs) or a blue-light percentage of less than 2% (or the sum of energy between 400 and 500 nanometers divided by the sum of energy between 400 and 700 nanometers), (2) the maximum lumens – no greater than 1000 lumens for any individual exterior light, and (3) that full shielding and full cut-off are required. Should an Applicant need to install a specific light that does not meet these standards, the Applicant must be required to justify the specific need for this type of light. The goal for each Applicant's PIP should be to substantially reduce the overall brightness of their facilities, as measured by a high-quality light meter detector, and maintain these reductions for the life of the KSHCP.

The KSHCP should also require Applicants to implement a two-week dark skies period during which outdoor lighting is further restricted (*i.e.*, the maximum number of lights are shut off and non-essential activities are curtailed) to minimize to the extent practicable the take of Covered Seabirds during the peak of fledging season, *i.e.*, during the 2- to 3-week period around the October new moon.

Moreover, we strongly object to the assertion in the KSCHP that "[a]pproximately 50% of the total downed birds recovered by [Save Our Shearwaters] are not currently attributable to any specific, consistent, or known source of light attraction. For this portion of light attraction impact, there is currently no identifiable entity to apply for take authorization … ."[5] The County has broad authority and responsibility to regulate outdoor lighting across the island and, therefore, is responsible for incidental take caused by inadequate regulation of outdoor lighting. The County, therefore, should in its PIP commit to adopting outdoor lighting standards as well as outdoor lighting zoning ordinances for new and existing structures. Relatedly, the County should hire a full-time employee to: (1) conduct lighting audits during the non-seabird season (December through March), (2) conduct education and outreach training sessions during the early seabird season (March through August), and (3) conduct nighttime island-wide patrols for problematic lighting that has recently come online during the peak seabird fallout season (September through November). In other words, this employee's position would be to ensure that the County makes continuous progress over time to reduce problematic lights, rather than backsliding whenever a new building is built, or a light bulb is replaced.

For example, when the new Ross Store opened on Kauaʻi several years ago, no one flagged for that business that the seaward-facing lights it had installed just two blocks from the ocean would harm seabirds. Simple education to the owners of that store could have immediately alleviated another bad exterior lighting situation, but there was simply no one available to do so. If the County had an employee whose job was to educate businesses, then this could have been avoided.

[5] KSHCP at 37.

Likewise, in October of 2017, there was a large concert at the Cabana Bar and Grill in Poʻipū on October 20th (the date of the new moon). The concert had set up five horizontal floodlights to illuminate the parking areas. These floodlights could be seen for miles around. Within minutes of arriving there, staff from the Center for Biological Diversity observed several Newell's shearwaters circling these lights. This particular concert event illustrates that, without dedicated staff paid by the County to address seabird lighting, the Newell's shearwaters will continue declining towards extinction.

Floodlights at Poʻipū Concert on new moon of October 2017

B. Outdoor Lighting (PIPs)

Given the precipitous declines in the populations of the Covered Seabirds and the impact of artificial light on adult and fledging birds, there is an urgent need for each Applicant to take immediate action to minimize light hazards at each site to the maximum extent possible, with special attention to the highest risk areas (*i.e.*, those with the greatest light footprint). For each site, priority should be given to removal, replacement, shielding or modification of light fixtures that are known to pose the greatest risk to over-flying seabirds (*i.e.*, documented attraction/collision). Prior to each breeding season, Applicants should ensure staff are trained on how to respond to and rescue downed birds and follow the appropriate reporting protocols.

C. Predator Control (KSHCP Section 5.3.2)

The KSHCP's requirements for predator control are too simplistic and vague. Although the KSHCP requires that Applicants prohibit loose, free-roaming animals, and conduct a trapping and removal program,[6] the KSHCP should include more specific standards for predator control, especially in light of the fact that many of the PIPs lack adequate details or commitments to control predators. For example, the County's PIP lacks any commitments to control feral cats, which is unacceptable.[7]

In addition to requiring that trapped and removed feral cats and dogs "not be returned to the facility even if neutered," the KSHCP should additionally prohibit these predators from being released anywhere on Kauaʻi or any other Hawaiian island that has nesting seabirds.[8] These trapped predators should either be humanely euthanized or be placed in permanent facilities where they cannot harm wildlife and will be treated humanely. We are cognizant that costs for "no-kill" options may be substantial particularly in relation to the limited conservation benefit derived from this humane alternative. Furthermore, we are very concerned regarding the requirement that trapped animals be brought to the Kauaʻi Humane Society, since it is currently charging high fees to accept feral animals, which effectively makes this option impracticable. The KSHCP should include an alternative that would allow for feral animals to be humanely put down.

II. METHODS FOR DETERMINING TAKE (KSHCP SECTION 6.2.2.1)

For the purposes of estimating unobserved lethal take as part of the incidental take authorization process, the KSHCP requires Applicants to assume that only half (50%) of the seabirds that fallout are actually found and turned in to Save Our Seabirds.[9] However, Applicants have the option of demonstrating that their searcher efficiency rate is greater than 50% to justify lowering their projections for unobserved lethal take.[10]

Some of the Applicants, in their PIPs, have deviated from the 50% searcher efficiency rate without providing adequate data to justify these deviations. These Applicants—*i.e.*, Norwegian

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[6] *Id.* at 47.

[7] County of Kauaʻi PIP at 12, Table 5.

[8] KSHCP at 47.

[9] *Id.* at 64.

[10] *Id.*

Cruise Lines (100%), Princeville Resort Hotel (90%), and Sheraton (90%)—should provide data to support these search efficiency rates, which appear unreasonably high.

III. MONITORING

A. Compliance Monitoring (KSHCP Section 6.8.1)

It appears that the KSHCP proposes to monitor compliance with minimization and mitigation actions annually, with the *potential* for follow up site visits to validate compliance.[11] Annual compliance monitoring based on predictable, annually submitted reports, would be inadequate for ensuring compliance with minimization and mitigation measures and limits the ability for mid-season course correction. The KSHCP should specify that this annual review occur *pre-fallout season* (March-May) and include unscheduled, third-party compliance monitoring during peak fallout season to better ensure that minimization and mitigation measures are properly implemented.

B. Take Monitoring (KSHCP Section 6.8.3)

The KSHCP appears to include two options for monitoring take: (1) self-monitoring, and (2) DLNR monitoring, which "requires Participant funding & DLNR consultation;"[12] however, the KSHCP lacks any detail on what DLNR take monitoring would entail or how much it would cost. Moreover, given the choice, all Applicants have selected self-monitoring.[13] Self-monitoring would be ill-advised and inadequate given Applicants' and their employees' inherent bias to under-report take. The KSHCP should instead require that take monitoring be conducted by a third-party, and possibly provide a DLNR or other government agency option for take monitoring.

IV. MISSING TEXT IN KSHCP APPENDICES

In both Appendix A and Appendix C, there are several tables where it appears that FWS inadvertently deleted information from various cells where information was provided in the draft KSHCP that DOFAW circulated last year, leaving those cells blank. Examples of this include: (1) Table 13.1 in Appendix A, where all information related to "Pre-Construction" actions and the first entry for "Rodent Trapping Post Construction Actions" have been deleted; (2) Table 6 in Appendix C, where some values for "within fence" scenarios have been deleted; and (3) Table 7 in Appendix C, where the "Difference" values have been deleted.

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[11] *Id.* at 76.

[12] *See, e.g.*, County of Kaua'i PIP, at 19.

[13] *See, e.g.*, *id.*

We assume that these deletions were inadvertent and encourage FWS carefully to review the final version of the KSHCP to ensure that all information is provided.

V. FAILURE TO CONSIDER REASONABLE ALTERNATIVES IN ENVIRONMENTAL ASSESSMENT

The National Environmental Policy Act (NEPA) requires FWS to "study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources." 42 U.S.C. § 4332(2)(E); *see also id.* § 4332(2)(C)(iii). The alternatives section "is the heart of the environmental impact statement," 40 C.F.R. § 1502.14, and "applies whether an agency is preparing an [environmental impact statement] or an EA." *Native Ecosystems Council v. U.S. Forest Serv.*, 428 F.3d 1233, 1245 (9th Cir. 2005). The purpose of the alternatives requirement is to "inform decisionmakers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment." 40 C.F.R. § 1502.1.

FWS's draft EA for the KSHCP considers only two action alternatives: (1) the proposed action, as reflected in the draft KSHCP, and (2) the proposed action "with the addition of seabird translocation as part of the mitigation measures." Draft EA at 8. The draft EA fails to consider any alternatives that would minimize adverse impacts on Covered Seabirds by controlling the color spectrum and power output of outdoor lighting fixtures used by Applicants; requiring Applicants to implement a two-week dark skies period during the peak of fledging season; requiring the County of Kaua‘i to adopt outdoor lighting standards as well as outdoor lighting zoning ordinances for new and existing structures and to conduct lighting audits; and requiring effective control of feral cats and other predators. FWS's failure to evaluate any alternatives that include these feasible, reasonable measures to minimize adverse impacts to Covered Seabirds violates NEPA.

Mahalo for the opportunity to provide these comments. Should you wish to discuss these comments, please do not hesitate to contact the undersigned or David L. Henkin at (808) 599-2436, kwager@earthjustice.org, or dhenkin@earthjustice.org.

Sincerely,

Kylie W. Wager Cruz

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November 7, 2019

Via Email

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Re: ***Comments on the Kauaʻi Seabird Habitat Conservation Plan – DRAFT August 2019***

Dear Mr. Cogswell:

Mahalo for the opportunity to submit comments on the draft Kauaʻi Seabird Habitat Conservation Plan (KSHCP), dated August 2019. I am an ornithologist, behavioral ecologist and environmental toxicologist who has worked on a wide range of wildlife and avian projects in the private, public and academic sectors across the country. From 2005-2013, I coordinated the development, planning and writing for the KSHCP and provided technical assistance to public and private sectors regarding seabird conservation and best practices to reduce light pollution across the state. I have spent thousands of hours observing lights across the state as well as seabird behaviors. As part of this process, I have become very familiar with facilities and lights across Kauaʻi as well as the fallout associated with locations across the island.

Overall, I appreciate the tremendous amounts of time and effort that have gone into preparing the KSCHP. This draft is a critical first step toward bringing the Applicants into compliance with federal and state endangered species laws. There are, however, fundamental areas of the KSHCP in need of improvement, such as monitoring as well as predator control. Moreover, although the Participant Inclusion Plans (PIPs) contain some essential information for assessing their incidental take applications, there are several critical areas that require clarification and/or improvement. My comments on the KSHCP and the PIPs are discussed in further detail, below.

Measures To Avoid and Minimize Take Impacts (KSHCP Section 5.3)

Below are some questions and suggestions regarding certain aspects of the proposed avoidance and mitigation strategies.

Adjusting Lighting at Facilities (KSHCP Section 5.3.1)

To this section's bullet list, I recommend refining criteria and information related to the last bullet "use longer wavelengths," which could also be inserted as an update to Appendix E item 13. Minimization of lights should indicate which lamp types and wavelength spectra to avoid (e.g. blue-white) as well as what wavelengths to use (e.g. yellow-orange), balancing needs for color rendering and light intensities needed for Covered Activities. The addition of more guidelines/criteria related to this topic seems to be particularly important when evaluating LED lamps that tend to emit light in the shorter blue wavelengths. Longcore et al. (2018) discusses models that can help to assess the ecological effects of lights with varying spectral characteristics.[1] For current PIP adjustments and future lighting planning, one approach may include avoiding use of lamps with high actinic power and evaluating lamp effects using the actinic power/lux model and CCT model values for Newell's Shearwater. Updating this information will complement what is in Appendix E item 13.

Reducing Predators at Facilities (KSHCP Section 5.3.2, Items 1 and 2)

The requirements for reducing predation are too general and vague. Because many of the PIPs lack adequate detail or plans to reduce predation, these requirements should be strengthened to contain more specific minimum standards. Regarding the trapping and removal of feral cats and dogs (Item 2), the KSHCP should specify that trapping must occur year-round, rather than only around fallout season, to ensure that feral animal populations are more effectively controlled. Regarding prohibiting loose, free-roaming cats and dogs, the KSHCP should specify how this prohibition will be monitored and enforced. The KSHCP should require Applicants to bring animals to licensed animal care facilities where they will be treated humanely and not released anywhere on Kauaʻi, thus providing more options rather than just recommending the Kauaʻi Humane Society.

Conducting Seabird Awareness Training and Outreach (KSHCP Section 5.3.3)

The second paragraph

- **The first sentence states**: "*Under approved PIPs, each Participant is required to conduct annual outreach and training for workers at their facilities that is specific to Covered Seabirds beginning in Year 1 of the KSHCP.*" This sentence should be clarified to reflect that Participants must conduct facility-wide outreach to guests/customers and also provide Seabird Awareness and Response Training to workers so they can help spot downed seabirds and know how to respond in a timely manner. Workers should also be required to communicate to supervisors about problems with lights. The KSHCP should specify that such Seabird Awareness and Response Training must be completed prior to September 15 of each year and within the first day of employment for new employees hired within the fallout season.

- **The second paragraph, second sentence states**: "*A detailed slideshow presentation was developed on this subject will be provided by the Prime Contractor staff on request*." The meaning of this sentence is unclear but it seems the intent is for the Prime Contractor to develop and provide a detailed slide presentation. What is the purpose of this presentation? Is it required or just a guide? The KSHCP should state that the Participants will receive a copy for use. The training must emphasize effective and required search techniques.

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[1] Longcore, T, Rodriguez A, Witherington B, Penniman JF, Herf L, Herf M. Rapid assessment of lamp spectrum to quantify ecological effects of light at night. J. Exp. Zool. 2018:1-11.

Monitoring (KSHCP Section 6.8)

The most significant weakness of the KSHCP is monitoring (Section 6.8).

<u>Compliance Monitoring (KSHCP Section 6.8.1)</u>

Merely reviewing annual compliance reports, with the possibility for follow-up site visits, would be inadequate to ensure that Participants' plans and obligations to minimize and mitigate take are being implemented and effective. This annual review of compliance reports should occur *pre-season* (March-May) to better ensure compliance before the Covered Seabirds return to the island and are at risk. Moreover, the KSHCP should include unscheduled third-party monitoring of site conditions (e.g. lighting and predator control) during peak fallout season. Waiting until review of the following year's annual compliance review would eliminate the ability to correct deficient minimization and mitigation measures immediately, mid-season. Perhaps it could be an additional function of the Prime Contractor to evaluate details of monitoring plans and predator control efforts (duties are listed in Table 6-1).

<u>Take Monitoring (KSHCP Section 6.8.3)</u>

There are discrepancies between the KSHCP's template Monitoring Plan (Item 9) and the PIPs. The template should be clarified and the PIPs updated to specify what is meant by self-monitoring (Option 1) and DLNR-sourced monitoring (Option 2). Given the choice between self-monitoring and DLNR-sourced monitoring, all applicants have selected self-monitoring. Based on my regulatory and monitoring experience, self-monitoring is not reliable or effective because of Participants' and their employees' inherent bias against effectively documenting take. Thus, the KSHCP should justify why self-monitoring is deemed sufficient and how DLNR-sourced monitoring would differ in effectiveness and cost.

Because the PIPs' monitoring plans lack sufficient details to ensure adequate search of harder to search areas, the KSHCP's "guidelines" for take monitoring, Table 6-4, should include more specific search requirements. Specifically, the KSHCP should require that searches be extremely thorough and include looking under and within ground cover, landscaping, drainage ditches, and around water features, for example. Morning searches should occur within 1 hour before sunrise, and if up to 3 hours is deemed sufficient (e.g. open areas, no prevalence of loose predatory animals), the searches (and training) must clearly include how to search all vegetation and structures/vehicles. Employees must search underneath all vehicles before they are moved at night and first thing in the morning.

The guidelines for monitoring of loose predatory animals in Table 6-4 must be clarified to better define when to inform management and how (*i.e.*, immediately via email or phone) and what actions management will take within a specific timeframe. It is important to act immediately during the fallout season.

Participant Inclusion Plans

With the exception of Norwegian Cruise Lines (which does not have feral animals aboard its vessels), all PIPs lack adequate methods to reduce and manage the presence of loose/feral/fed animals—predominantly cats. In addition to DLNR including clearer minimum standards in the KSHCP, discussed above, the Participants must include more detailed information in their PIPs regarding how they will monitor and humanely control loose/feral/semi-tamed cat colonies within and adjacent to their facilities during the fallout season or throughout the year. My specific comments on each of the eight PIPs are included in the attached table.[2]

Please contact me should you have any questions regarding my comments on the draft KSHCP.

Sincerely,

Andrea Erichsen

Attachment

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[2] The descriptions of site conditions in the table are based on my personal observations made in October 2019.

Applicant	Section (of PIP) and/or Page (of KSHCP PDF)	Observation	Recommendation/Question
Norwegian Cruise Lines	1. Page 360: Description of facility 2. Part 2, Page 381-82, Tables 11-14: Take estimates 3. Appendix B: Manufacturers specification sheets for exterior lighting fixtures	1. NCL is seeking coverage for all activities associated with operating its vessels, including but not limited to the Pride of America, in Hawaiian waters and says that all vessels have similar lighting. SOS on Kauai is the only rehabilitation facility mentioned. Table 5, page 369, states: under hosting an SOS station: "Not applicable on an ocean going ship – there is a SOS Aid Station at the harbor where any downed birds are placed." 2. Take estimates for all species seem low and are not broken down by vessel. Tables 12-14 are empty. 3. Some lights do not satisfy the requirement to avoid take to the maximum extent practicable in that they are not fully shielded, full cutoff lights, e.g., globe lights (Page 405) and half-moon lights (Page 389).	1. The A&M plan should discuss/clarify SOS type services/plans for other islands such as Maui, Honolulu and Big Island in case a seabird is recovered during transit. 2. NCL should provide the data it has collected on its own as part of its seabird monitoring and recovery efforts and report take estimates by vessel. It seems certain that some birds that collide with the ship at night will fall into the ocean. Therefore, search efficiency would not be 100% unless NCL has a method to document this. In addition, birds that fall off the ship, must be attributed as lethal take since the outcome of the bird's survival is unknown. Tables 12-14 should be completed. 3. Globe lights and half-moon lights should be modified/replaced to be fully shielded with full cutoff.

Applicant	Section (of PIP) and/or Page (of KSHCP PDF)	Observation	Recommendation/Question
Princeville Resort Kaua'i	1. Item 2, Page 469, Tables 11-13: Requested Take	1. Tables 11-13 are empty and application of a 90% search efficiency seems unjustifiably high.	1. Tables 11-13 should be completed. Application of a 90% searcher efficiency seems high. The Participant should provide the map data and discussion as to why the analysis used is sufficient for that site. Based on my assessment of the site, I think the searcher efficiency should be lower, particularly if cats live in unsearchable vegetation or adjacent facilities.
Kaua'i Marriott	1. Item 2, Page 550, Tables 11-13: Requested Take	1. Tables 11-13 are empty.	1. Tables 11-13 should be completed. My general comments on ways to improve or verify self-monitoring apply. Staff training must really focus on how to search non-paved areas and under vehicles prior to use.
Kaua'i Coffee	1. Item 3 Table, Page 578-79, Item 8 Table, Page 587 2. Take Monitoring, Page 591 and Item 9a, #2, Page 592 3. Item 3 Funding Assurance, Page 597 4. Checklist, Page 598	1. Some lights are not listed as fully shielded, with full cutoff, including those needed for Korvan Harvester machines. The lights on these machines should be shielded. 2. Page 591, Table first row, should provide more detailed information regarding percentage of property to be monitored/searched. Same Table states monitoring will occur twice daily at 5:30 a.m. (which is fine), and 5:30 p.m., which violates KSHCP guidelines. Item 9a, #2 lacks adequate details of monitoring during night harvest operations. 3. The Funding Assurance section is empty.	1. Item 8 Table needs more detailed information on light adjustments particularly the harvesters since it is not clear at this time. For example, can harvester lights be shielded? 2. Overall this table needs more details of areal coverage, protocols, and reasons as listed in the header of the table. Evening monitoring must occur 1-2 hours after sunset and more frequently during harvesting operations. The PIP must better specify how staff working during harvesting and processing operations will monitor fallout. For example the number of monitors (10 during harvesting and 20 for processing) may be sufficient depending on the scale of the searched areas,

Applicant	Section (of PIP) and/or Page (of KSHCP PDF)	Observation	Recommendation/Question
		4. Some items in table not complete.	but more information must be provided on when and how they will work. Monitoring during the harvest is key. Twice per day during harvesting does not seem adequate. 3. Provide information under Item 3 regarding funding assurances. 4. Complete outstanding items on checklist. My general comments for most PIPs on ways to improve or verify self-monitoring apply. Staff training must really focus on how to search non-paved areas and under vehicles prior to use.
Sheraton Kaua'i Resort	1. Tables 1 and 2, Pages 619-20, 623-24 2. Table 4, Page 627 and Table 5, Page 629 3. Predator Control, Table 6, Page 630 4.Take Estimate and Search Efficiency, Table 10, Page 638	1. These tables were included twice. 2. The avoidance and minimization measure to replace all outdoor lights with fully shielded full cutoff fixtures and shields has not been implemented. For example, there are unshielded sets of bright string lights out in the open in the Makai side courtyard. The pagoda lights (N=18) outside the Garden wing reception area are numerous and shine a lot of light out the sides of the lamps, thus resulting in a glow in this area. When out in the open, the large ones especially should not be considered fully shielded full cutoff fixtures or down lights. Floodlights on the roof above the east side eave of the Lava Pool Bar do not point down far enough.	1. Remove the duplicate or inaccurate tables. 2. Existing, used facilities are not addressed completely in practice and in the PIP and therefore the PIP does not meet KSHCP A&M standards or maximum extent practicable. 3. Table 6 needs to provide more concrete details as to how this minimization will be monitored and managed. The PIP must address humane trapping and data collection on cats around the grounds, which must be active year round. Procedures for managing feral cats must be developed, posted, and enforced. On a related topic, because feral/loose cats are present currently in certain areas around the resort and adjacent lands, staff training must strongly focus on how to search non-paved areas and under vehicles prior to use.

Applicant	Section (of PIP) and/or Page (of KSHCP PDF)	Observation	Recommendation/Question
		There are indoor lights on second and third story common areas that shine out through windows and likely do not meet the A&M standards. These should be re-evaluated to see how window treatments may be used to prevent lights shining out laterally into the sky because the lights are on all night. 3. The PIP states that the Resort implements this measure, staff is trained that this is not allowed, and security monitors compliance. More detail on these topics is needed. Numerous feral cats were noted in Sheraton parking lots adjacent to Kiahuna Plantation in October 2019. 4. Search efficiency of 90% seems unjustifiably high.	4. The Participant should provide maps and data to support the 90% search efficiency. On the map, please identify areas with “rank” vegetation. Data regarding the presence of cats will inform the survival rate of downed seabirds that are not detected. This will increase the lethal take estimate, further calling into question the claimed 90% search efficacy.
County of Kauaʻi	1. Item 7, Page 674 2. Predator Control, Table 5, Page 673 3. Light shielding, Page 676 4. Lighting Ordinance, Page 677, #4 5. Monitoring, Table 8, Page 682	1. County staff to check timers at Category 4 facilities 2x/month. There is no timeframe for fixing broken timers and or any explanation of how use will be managed until repairs are completed. 2. Description of predator control at County facilities is too vague, particularly at Category 4 and 5 locations. 3. The PIP states that shielded lights may not be used at DUI checkpoints where motorists are subject to unannounced traffic stops, or emergency rescue and response where the use of full cut-off fixtures would make it impossible to meet the operational requirements and that they will	1. County staff should check timers more frequently than 2x/month, i.e., 2x/week for Category 4 lights being used. The PIP should provide a timeframe for fixing timers and protocol for controlling use until timers are fixed. 2. The table merely lists statutes regarding loose animals and refuse removal, but does not specify whether/how they will be enforced. The PIP needs to contain more detailed information regarding the methods for monitoring and managing feral animals on County lands and partnering perhaps with adjacent landowners. It may be of value to prioritize more intensified predator control efforts at Category 4 and 5 facilities, for example.

Applicant	Section (of PIP) and/or Page (of KSHCP PDF)	Observation	Recommendation/Question
		consider the use of other types of lighting. 4. The PIP states that the County declined to adopt a county-wide or facility-wide lighting ordinance without providing justification for this decision or analysis to support their conclusions. Second, the statement that the County is investigating the possibility of adding advisory language to certain building and development permit forms does not go far enough. 5. Table is missing headers. For Category 4, monitoring not frequent enough. For Category 5, timing is not frequent enough.	3. There should be a way to ensure that all portable floodlights for emergency uses are shielded. The PIP needs to provide details as to what these "other types of lighting" are. 4. The County's PIP should provide more detailed information on its analysis regarding development of a lighting ordinance, how it will identify future opportunities and mechanisms to address this topic. Even without an ordinance, the County should include permitting and planning requirements, not merely advisory suggestions as provided currently in the PIP. The County should include in their PIP their policy to ensure that new and existing permitted facilities implement seabird friendly lighting. 5. Monitoring at Category 4 and 5 facilities should expand from 10' radius to at least a 30' radius of a likely sighting, particularly where there is landscaping or other structures. For Category 4 facilities, searching for fallout only in the morning will result in higher mortality and undetected birds. Therefore, the PIP must specify at time of use in addition to the first hour of the morning.

Applicant	Section (of PIP) and/or Page (of KSHCP PDF)	Observation	Recommendation/Question
Hawaiʻi Dept. of Transportation – Harbors and Airports Divisions	1. Lihue Airport avoidance and minimization Table 4, Page 842 2. Predator Control Kauai Harbors Table 11, page 848 Nawiliwili Harbor and Pt. Allen Table 12, page 849, Lihue Airport Table 6, page 853	1. Airports table on avoidance and minimization-provide seabirds awareness training to staff lists April instead of August. 2. These tables are sufficient in that they list information on contractors, costs, and time period for predator control. Other participants should do the same.	For Category 5 facilities, County should conduct ongoing monitoring during light use and after lights are off as written. 1. Correct Table 4 to read August to match Harbors. 2. Monitoring is improved with third party verification, as I have recommended for all PIPs. The DOT PIPs are therefore setting a good standard by including this information and costs. However, the PIP monitoring plan should make it clear that intensive monitoring will be implemented in areas containing vegetation/landscaping and various types of vehicles and movable equipment (e.g. rental car areas and parking lots as well as vehicles within the secured areas). Practices such as trimming vegetation will also help locate birds that have fallen or crawled under vegetation. In addition, random in-season verification monitoring should be included in the plan.
Alexander & Baldwin	1. Table 1(k), page 1083 2.Take Monitoring, Item 7a (page 1152 Item 7b (page 1153) 3. Item 2, Tables 11-13, Page 1199	1. Table 1(k), page 1083 states that a lighting plan for the Shops at Kukuiula is underway/planned and therefore is incomplete for this draft. The PIP contains a good list including many varied facilities and reasonable A&M for lights at each although some sites are not addressed completely and therefore the PIP does not meet KSHCP A&M standards or maximum extent practicable. For example, there are numerous unshielded and bright/string lights	1. Include a timeframe for completion of the pending lighting plan for the Shops at Kukuiula, Pt Allen Marine Center and any other locations where plans are pending. Predator monitoring and humane control methods need to be more explicitly defined and scheduled, particularly prior to and during the fallout season. Otherwise, seabirds that fallout at the intersection of Waiaolo Road and Aka Ula Street, for example, will be quickly dispatched by feral cats.

Applicant	Section (of PIP) and/or Page (of KSHCP PDF)	Observation	Recommendation/Question
		currently in use at two main areas within the Kukuiula Shopping Center. These are not within KSCHP guidelines. These exposed lights need to be shielded, full cutoff downward facing fixtures. Similarly, light improvement plans are pending for the 1(f) Pt. Allen Marine Center. Predator control methods are weak, particularly at Pt. Allen sites where the need is highest (e.g. cat colonies on property) 2. 7a Training is provided, but monitoring is not. The solar farm is close to several facilities such as KIUC's power plant, Chevron, and Pt. Allen. Birds may fallout on property despite the low risk of on-site lights. 7b Says 1-2 "searches." Should this be "searchers"? 3. Tables 11-13 are empty.	2. 7a-A&B should monitor daily at solar farm. It is near the KIUC power plant, Chevron, and Pt. Allen, and birds may fall there. A&B should assess localized presence of cats and other loose predatory animals and take appropriate actions to remove them. 7b-Correct typo to "searchers" if that is the intended meaning. For sites where predator control is deemed infeasible, if the results of monitoring show depredation of downed seabirds, adaptive management should trigger humane predator control actions. 3. These tables should be completed. My general comments for most PIPs on ways to improve or verify self-monitoring apply. Staff training must really focus on how to search non-paved areas and under vehicles prior to use.

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RESEARCH ARTICLE

WILEY JEZ-A ECOLOGICAL AND INTEGRATIVE PHYSIOLOGY

Rapid assessment of lamp spectrum to quantify ecological effects of light at night

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Abstract

For many decades, the spectral composition of lighting was determined by the type of lamp, which also influenced potential effects of outdoor lights on species and ecosystems. Light-emitting diode (LED) lamps have dramatically increased the range of spectral profiles of light that is economically viable for outdoor lighting. Because of the array of choices, it is necessary to develop methods to predict the effects of different spectral profiles without conducting field studies, especially because older lighting systems are being replaced rapidly. We describe an approach to predict responses of exemplar organisms and groups to lamps of different spectral output by calculating an index based on action spectra from behavioral or visual characteristics of organisms and lamp spectral irradiance. We calculate relative response indices for a range of lamp types and light sources and develop an index that identifies lamps that minimize predicted effects as measured by ecological, physiological, and astronomical indices. Using these assessment metrics, filtered yellow-green and amber LEDs are predicted to have lower effects on wildlife than high pressure sodium lamps, while blue-rich lighting (e.g., K $\geq$ 2200) would have greater effects. The approach can be updated with new information about behavioral or visual responses of organisms and used to test new lighting products based on spectrum. Together with control of intensity, direction, and duration, the approach can be used to predict and then minimize the adverse effects of lighting and can be tailored to individual species or taxonomic groups.

KEYWORDS

action spectrum, behavioral response, light pollution, phototaxis

1 | INTRODUCTION

It has long been known that artificial night lighting affects wildlife through attraction and disorientation (Allen, 1880), and recent research has documented the extent of the adverse consequences of artificial night lighting to include, for example, plant phenology (Somers-Yeates et al., 2016), predator–prey relations (Minnaar, Boyles, Minnaar, Sole, & McKechnie, 2015), circadian rhythms (Dominoni, 2015), and nocturnal rest and recovery (Gaston, Bennie, Davies, & Hopkins, 2013). Importantly, light attraction and disorientation results in direct mortality of many groups of insects (Eisenbeis & Hänel, 2009), birds (Longcore et al., 2012), including seabirds (Rodríguez et al., 2017b), and sea turtles (Salmon, 2003), contributing to species decline (Fox, 2013; Wilson et al., 2018). The degree of influence of outdoor electric lighting is determined by the direction, intensity, duration, and spectrum of the lights (Gaston, Davies, Bennie, & Hopkins, 2012; Longcore and Rich, 2017). For many years, only a handful of lamp types were economically viable for widespread deployment and their spectral characteristics were limited. For example, low pressure sodium lamps, with nearly all emissions in the yellow/orange at 589 nm became the lamp of choice around astronomical observation sites and near sea turtle nesting beaches because both night sky observation and sea turtle orientation benefit from a narrow-band light in the longer wavelengths (Witherington, 1992). Other lamps were similarly deployed in different situations and consequently most studies of ecological effects are on these types—low-pressure sodium, high-pressure sodium, metal halide, and mercury vapor (although this lamp type has largely been phased out) (Eisenbeis & Eick, 2011; Rich and Longcore, 2006). In the past decade, however, light-emitting diode (LED) lamps have become economically viable, bringing a range of new spectral characteristics to the marketplace (Boyce, Fotios, & Richards, 2009; Gaston, 2013) along with concerns about their differential effects on wildlife species (Davies, Bennie, Inger, de Ibarra, & Gaston, 2013; Gaston, 2013).

In the early days of commercial LEDs for outdoor lighting, full spectrum light was achieved through coating a blue LED with a phosphor, which produced light across the visual spectrum (Hecht, 2012). These lamps had a high correlated color temperature (CCT), indicating a high proportion of blue and violet in the emissions, as a result of the underlying blue LED. This blue hue became more dramatic as the phosphor aged. Many in the general public and scientific community may have developed the perception that all light from LEDs was a "cool" white (high CCT) at this time. Technological innovation in the LED industry has, however, been rapid, because the energy savings from LEDs are so attractive that replacement lamp types that address a range of color spectrum specifications have been developed (Dudley, Erkintalo, & Genty, 2015). While earlier efforts to develop LEDs with lower color temperatures came with a penalty of less efficiency, by 2015, LEDs at 2700 K and 3000 K were commercially available that matched the energy efficiency of 5000 K lamps. Furthermore, the development of different colors of LEDs and different filtering technologies has led to a range of different spectral signatures for lamps that are all economically competitive in terms of energy efficiency.

Conservation scientists need to keep up with the changing array of outdoor lighting options to provide guidance to officials and managers around the world who are faced with the obvious economic choice of switching to high-efficiency lighting such as LEDs (Hecht, 2016). Such a switch can be catastrophic for the effects on other species, or it can be a benefit, depending on the spectrum, duration, direction, and intensity of the new lamps (Gaston et al., 2012; Longcore et al., 2015; Rodríguez, Dann, & Chiaradia, 2017a). The same applies to sky glow (Kinzey et al., 2017). Some ecologists have voiced generic concerns about LEDs in general, questioning whether they pose a risk across the board (Pawson and Bader, 2014; Stone, Jones, & Harris, 2012), and noting the unfortunate "rebound effect" in which more efficient lighting leads to deployment of even more light (Kyba et al., 2017; Kyba, Hänel, & Hölker, 2014). Similar concerns about the adverse effects of the rapid spread of full spectrum LED lighting are voiced by dark sky advocates (Bierman, 2012). The spectrum of light used will greatly affect the amount of scattering of light at different distances from a source (Kinzey et al., 2017). The extent of these effects depends in part on the spectral characteristics of the LEDs used, and many opportunities are available to evaluate the performance of the wide array of LED spectral configurations, such as investigating multiple spectral configurations of 2700 K LEDs to reduce attraction of flying insects (Longcore et al., 2015) or comparing LEDs of different color temperatures (Eisenbeis & Eick, 2011).

Differences between the spectral response curve for human vision (both photopic and scotopic) and the visual sensitivity and measured behavioral responses of animals indicate an opportunity to configure outdoor lighting that avoids sensitive regions of the spectrum while providing needed visibility for humans. For example, many insects are attracted to shorter wavelengths (blue, violet, and ultraviolet) more than longer wavelengths (Eisenbeis, 2006; Eisenbeis & Hänel, 2009). Light sources that have low blue and shorter wavelength emissions attract fewer insects (Cleve, 1964; Eisenbeis & Eick, 2011; Eisenbeis & Hänel, 2009; Menzel & Greggers, 1985) and consequently, fewer bats that forage on insects (Stone, Harris, & Jones, 2015). The lower behavioral response of hatching sea turtles to longer wavelengths of light (Witherington, 1992) has become the basis to limit the permissible spectral characteristics of lights on and near nesting beaches in many jurisdictions. Such regulations to minimize adverse effects of lighting on nature are always compromises and usually driven by the species or species group with regulatory protection in a particular situation.

The current challenge for conservationists is that assessing the effects of different spectral distributions on wildlife in experimental or field situations is time consuming and an increasing number of lamp types are being developed, while jurisdictions are making decisions about replacement of aging fixtures every day (Hecht, 2016). Once such decisions are made, new lamps will be in place for years to come. Tools are therefore needed to assess the potential adverse effects of newly developed lights compared with existing technologies in a rapid manner and in a way that allows tradeoffs between adverse effects on wildlife and human needs to be compared. In this paper, we assemble a series of spectral response curves from the literature and a series of spectral emission curves for established and new outdoor lighting sources, develop a standardized index that weights the spectral output by the response curves, provide a matrix of lighting performance measures (e.g., color rendering index, correlated color temperature, Star Light Index), and present these results on a website that can be periodically updated to serve as a clearinghouse for this information.

2 | METHODS

We obtained spectral power distribution curves for a wide range of lamp types and calculated indices representing the degree of overlap with a series of spectral response curves for different organisms. Following recommendations of the Bureau International des Poids et Mesures (BIPM), action spectra are dimensionless, while spectral irradiance is measured in $\mu W \cdot cm^{-2} \cdot nm^{-1}$, from which we calculate the weighted sum across wavelengths (BIPM, 2006, Appendix 3, Section 2). We treat spectral response curves like action spectra even if they do not meet the high standards for a true action spectrum (Björn, 2015). Species response curves were converted from photons to spectral power ($\mu W \cdot cm^{-2} \cdot nm^{-1}$) because organismal responses are dependent on the number of photons, not the energy of the light (Johnsen, 2012) while light is frequently measured with power units.

Spectral power distributions were obtained in $\mu W \cdot cm^{-2} \cdot nm^{-1}$ and resampled to 1 nm increments from 350 nm (well in the ultraviolet, which is still the visual spectrum for some insects) (Menzel & Greggers, 1985) through 780 nm to encompass the full range of vision for organisms. Spectral response curves were normalized to 1 at the maximal value, and multiplied by the emissions at each wavelength and then summed over all wavelengths, yielding three metrics.

1. A standard "effective irradiance" metric, computed by multiplying spectral irradiance at each wavelength by the spectral response ("actinic power"). (BIPM, 2006, Appendix 3 and CIE, 2007)

$$E_{eff} = \int E_{\lambda} S_i(\lambda)\, d\lambda,$$

where E_λ represents the source spectral irradiance and S_i is the actinic spectrum.

2. The actinic power per lux (the human photopic response, $V(\lambda)$):

$$E_{lux} = \frac{\int E_\lambda S_i(\lambda)\, d\lambda}{\int E_\lambda V(\lambda)\, d\lambda}.$$

The resulting measurement is thereby standardized in terms of the effect on each species per lux produced by the lamp and can be referred to as the taxonomic (e.g., turtle, salmon) action factor of the light source (CIE, 2014).

3. To allow comparison across species, we scaled the action factor relative to the response that would be elicited by daylight.

$$a_{D65} = \frac{E_{lux}(E)}{E_{lux}(D65)}.$$

The resulting values indicate the increase of effects on species relative to sunlight for each additional lux. A metric indexed to daylight allows actinic response metrics to be compared across species, even when the "shape" of the action spectra varies.

This approach allows comparison across lamp types and for different intensities by isolating the effect of spectrum. These methods follow the overall approach of Aubé, Roby, and Kocifaj (2013) and the recommendations of the BIPM (2006) and CIE (2014).

We used measured spectral distributions for mercury vapor, metal halide, high pressure sodium, low pressure sodium, incandescent, phosphor-coated amber LED, and 3000 K LED from Elvidge, Keith, Tuttle, and Baugh (2010). We also obtained spectral power distributions for three filtered LED systems (warm white LED with integrated filter) from C&W Energy Solutions, a filtered LED from LED Living Technology (LLT) and three lamps used in an experiment with attraction of shearwaters to light (Rodríguez et al., 2017a; Table 1; Figure 1).

For the species responses, we used spectral response curves developed for a range of organisms, including insects, sea turtles, and birds (Table 2). Some response curves represent behavioral responses to light of different wavelengths (e.g., moths and hatchling sea turtles) while others represent the visual sensitivity of the eyes of the organisms or physiological response (photosynthesis). For visual sensitivity curves, we used $\log_{10}$ transformed values, which were then normalized, because perceptual responses to visual cues are widely seen to be on a log scale as suggested by Stevens' power law (Stevens, 1961) and its application to sensory phenomena in insects (Ruchty, Roces, & Kleineidam, 2010).

To evaluate the potential effect of each lamp on night sky pollution, we calculated the Star Light Index proposed by Aubé et al. (2013) using the spreadsheet provided as an electronic supplement, which tracks human scotopic vision. We also calculated indices to evaluate the effect of spectrum on Rayleigh scattering, which would be prevalent near cities, and Mie scattering, which would predominate in indirect skyglow >80 km from city centers (Aubé, 2015; Luginbuhl, Boley, & Davis, 2014; see Figure 2).

Finally, we calculated photometric indices for each light source that are important to lighting engineers and end users. These include the correlated color temperature (CCT), color rendering index (CRI), and M/P ratio (melanopic/photopic ratio), using the spreadsheet from Lucas et al. (2014).

We then calculated the ratio of the actinic power of each lamp per lux of output compared to a D65 standard. This measurement compares the effect on each species response or light pollution metric of an additional lux of each lamp type, compared with an additional lux of daylight (the D65 standard). We also calculated ratio of the actinic power of each lamp compared with the total power of the lamp. This measurement indicates how much of the energy output of the lamp will affect each species or light pollution metric.

To illustrate the tradeoffs between minimizing effects on different groups of wildlife and optimizing performance for outdoor lighting, we calculated mean values for each lamp, consisting of: 1) animal response by taxonomic group (insect mean, sea turtle mean, Newell's

TABLE 1 Lamps and spectral output curves included in study, by type, correlated color temperature (CCT), and color rendering index (CRI)

Lamp/Standard	Type	CCT	CRI
D65 (Daylight)	Natural	6504	100
CIE Illuminant A	Lighting Standard	2856	100
Kerosene Oil	Combustion	1913	99
Full moon	Natural	4134	98
Philips TL950	Fluorescent	4684	96
SORAA Vivid	LED	4965	93
CFL Greenlite 13 W	Fluorescent	2892	81
Philips AmbientLED	LED	2601	81
LLT Telescope Light	Filtered LED	1908	81
3000K LED	LED	3262	80
OCTRON 32 W	Fluorescent	4012	79
Metal Halide 70W	Metal Halide	3071	79
LSG Good Night 2016	LED	2266	76
LEDway Streetlight CW 54W	LED	6270	75
City of Los Angeles Streetlight	LED	4310	73
LED VBLFL-855-4-40	LED	4663	70
Cosmopolis 60W	Metal Halide	2879	66
Yard Blaster	LED	4164	64
PC Amber Cree	PC Amber LED	1717	59
AEL 75W	PC Amber LED	1743	58
CWES 74 WW CW7	Filtered LED	2448	54
Iwasaki 60W	Mercury Vapor	3757	53
MH MASTER HPI-T Plus 400W/645 E40 1SL	Metal Halide	3808	51
CWES 74 WW CW10	Filtered LED	2096	49
CWES Anna's Light	Filtered LED	1193	26
HPS SON-T 400W/220 E40 1SL	High Pressure Sodium	1947	18
150 W HPS	High Pressure Sodium	2059	17
18 W LPS	Low Pressure Sodium	1810	−44

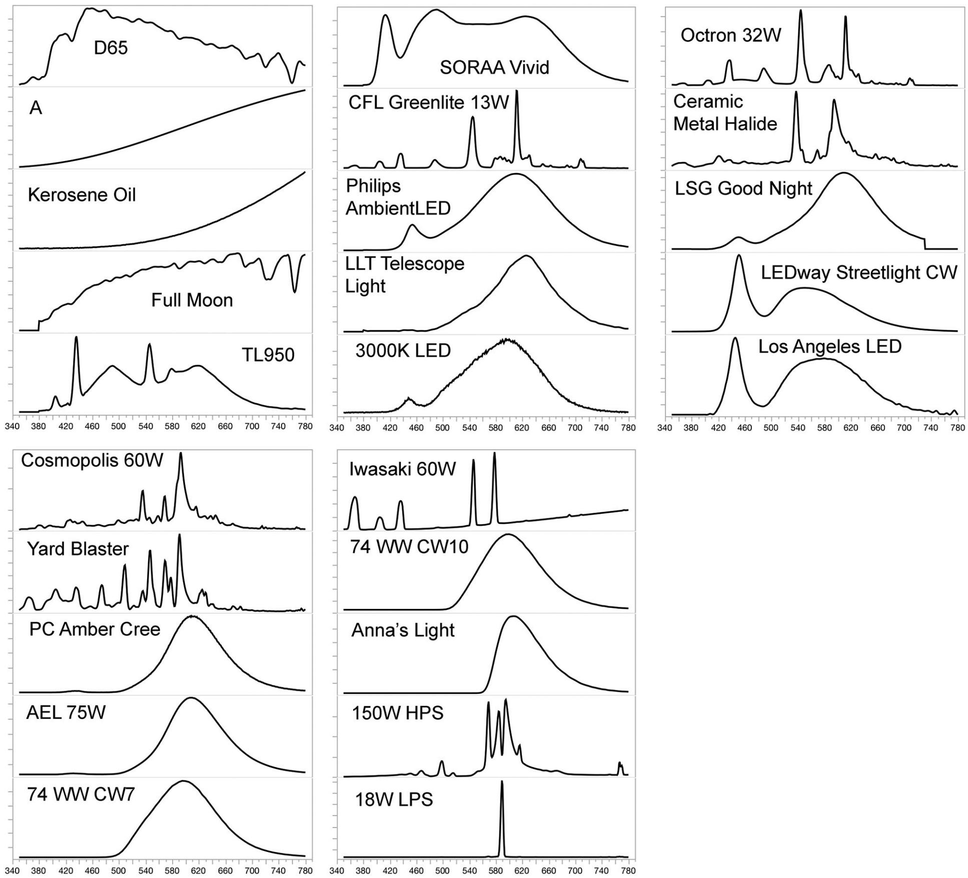

FIGURE 1 Spectral power distributions of light sources investigated. The five panels are in order of decreasing CRI from top left to lower middle

TABLE 2 Organismal response spectra

Taxon	Response	Format	Notes and Source
Moths (Lepidoptera)	Behavioral	Digitized by CIE	(Cleve, 1964)
Bee (Hymenoptera)	Behavioral	Digitized by CIE	(Menzel & Greggers, 1985)
Insects (Class Insecta)	Behavioral	Modeled	Composite metric for all Insecta (Donners et al., 2018)
Green turtle hatchlings (*Chelonia mydas*)	Behavioral	Digitized	(Witherington, 1992)
Green turtle adults (*Chelonia mydas*)	Visual sensitivity	Digitized	(Midolo, 2011) See also (Levenson, Eckert, Cognale, Deegan, & Jacobs, 2004)
Loggerhead hatchlings (*Caretta caretta*)	Behavioral	Digitized	(Witherington, 1992)
Juvenile Atlantic salmon (*Salmo salar*)	Visual sensitivity	Digitized	(Hawryshyn, Ramsden, Betke, & Sabbah, 2010)
Newell's shearwater (*Puffinus newelli*)	Visual sensitivity	Digitized	(Reed, 1986)
Photosynthesis (Plantae)	Physiological	Digital	(DIN, 2016)

shearwater, juvenile salmon, or the mean of all four), 2) Star Light Index, 3) melatonin suppression, and 4) visual performance. For visual performance, we assumed that CRI greater than 75 was acceptable and assigned values as follows:

$$\text{If}\begin{pmatrix} \text{CRI} > 75 \Rightarrow 1 \\ \text{else} \quad \Rightarrow \quad 1 - \dfrac{(75 - \text{CRI})}{150} \end{pmatrix}.$$

This approach is necessary to account for the −44 CRI of low pressure sodium lamps so that all values of the index range 0–1. We calculated which lamps performed best as an average of the four categories, running the average once for each of the organismal responses (to match a scenario where that species or species group was most important) and for all organismal responses with a weight of 1 for each of the major taxonomic groups. For comparison with a ranking that considers only environmental factors, we

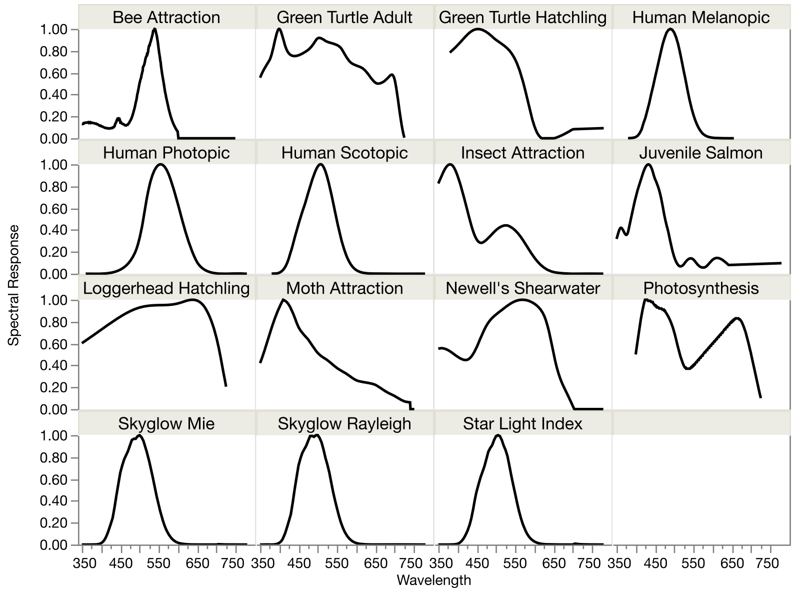

FIGURE 2 Response curves that can be used to estimate influence of light sources [Color figure can be viewed at wileyonlinelibrary.com]

calculated performance for each lamp in the same manner but without incorporating CRI.

To test this approach with experimental data, we compared the results of the light hazard for shearwaters in an experiment comparing light attraction of short-tailed shearwaters for metal halide, high pressure sodium, and 4536 K LED lamps (Rodríguez et al., 2017a). We modeled relative attraction using the same approach of generalized linear mixed models with night as a random factor and actinic power, lamp type, brightness, and CCT each in separate models as an independent factor. We compared models using Akaike's Information Criterion and visualized the fit using scatterplots. Pearson Product-Moment Correlation between responses and photometric indices, and all other statistics were calculated using JMP Pro 13 (SAS, Inc., Cary, NC).

All of the calculations and visualization of the intersection of light spectrum and human and animal response curves can be viewed at a website (https://github.com/herf/ecological) that will be updated with new lamp spectra and response curves and will allow users to submit spectra for analysis.

3 | RESULTS

Actinic power as a percent of total power describes the amount of energy from each lamp spectrum that affects the various species and photometric indices. For some lamps this proportion is relatively high for most action spectra, and for some species responses the proportion is high for most lamps (Table 3). For example, a high proportion of the power from all lamp types is calculated to influence loggerhead hatchlings, while few lamps concentrate their power in the areas of the spectrum most attractive to juvenile salmon (Table 3).

Actinic power per lux compared with daylight calculates the effect on species of increasing or decreasing illumination (in lux). For example, each additional lux of light from a low pressure sodium lamp has 20% of the effect on moths as would an additional lux of daylight, while an additional lux of a mercury vapor lamp would have 72% of the effect of an additional lux of daylight (Table 4).

The tested lamp types ranged in CRI from −44 (low pressure sodium) to 99, and CCT from 1193 (Anna's light) to 6270 (LEDway Streetlight). CCT and CRI were significantly but not strongly correlated (95% CI = 0.10–0.73). The variation in relative actinic power for lamps varied most for juvenile salmon (range, 0.15–1), substantially for insects (range, 0.33–1.16) and sea turtles (range, 0.38–1.02), and least for Newell's shearwaters (range, 0.65–1). For three of the four species groups tested, narrow band lamps with restricted emissions in the shorter wavelengths had the lowest actinic power relative to daylight. Only for Newell's shearwater did one narrow spectrum lamp (CWES Anna's Light) score higher than full spectrum lamps (Figure 3).

Composite assessments that gave equal weight to a wildlife group response, melatonin suppression, and Star Light Index showed lowest effects for lamps with low emissions in the shorter wavelengths (Figure 4a), with low pressure sodium showing the lowest impacts. When CRI was included as a factor, low pressure sodium lamp did not perform as well (Figure 4b), despite low actinic power for wildlife, because of its low CRI. Instead, PC Amber and two filtered LEDs scored lowest overall.

Correlations between photometric values for lamps and resulting light pollution effects were positive and strongest for CCT and both melanopic effect and Star Light Index, positive but weak for CRI and other metrics and modestly strong and positive for CCT and equally weighted wildlife effects (Table 5). Most importantly to our approach, although CCT has a high correlation with the aggregate wildlife effects (95% CI = 0.57–0.90), the correlation between CRI and wildlife effects is lower (95% CI = 0.43–0.86). The same is true for nearly all of the individual responses; CCT predicts wildlife effects more than CRI, with higher CCT values more likely to have higher effects on the wildlife assessed in this study than higher CRI values.

TABLE 3 Actinic power as a percent of total power for each of the taxonomic-specific responses

Light source	Photosynthesis	Moth	Bee	Insect index	Green turtle behavior	Green turtle visual	Loggerhead behavior	Salmon	Shearwater
D65	56	43	22	30	50	66	78	30	60
A	44	22	12	11	23	45	62	14	41
Kerosene Oil	34	13	4.9	4.6	12	31	47	10	25
Full moon	53	31	19	19	37	57	74	20	54
TL950	65	42	27	26	52	72	90	26	75
SORAA Vivid	65	43	25	27	51	71	88	27	70
LLT Telescope Light	61	26	14	13	19	61	90	11	69
CFL Greenlite 13 W	58	38	30	27	40	72	91	22	81
Philips AmbientLED	61	30	20	17	31	65	90	15	72
3000K LED	57	35	25	24	39	67	87	18	73
OCTRON 32 W	62	43	32	29	52	74	91	28	81
Metal Halide 70W	56	37	25	27	39	68	87	22	73
Ceramic Metal Halide 70 W	56	37	25	27	39	68	87	22	73
LSG Good Night 2016	62	30	18	17	27	66	93	13	75
LEDway Streetlight CW 54W	65	45	32	28	61	75	91	31	79
Los Angeles LED	64	41	29	26	51	72	91	27	77
Cosmopolis 60W	58	38	24	27	41	70	90	21	79
Yard Blaster	56	47	28	37	53	75	87	29	76
PC Amber Cree	61	25	12	13	17	61	92	11	73
AEL 75W	61	25	12	13	17	61	91	10	72
CWES 74 WW CW7	58	28	23	18	27	66	93	10	80
Iwasaki 60W	41	30	17	24	29	51	65	20	48
CWES 74 WW CW10	59	27	18	16	22	64	93	10	78
CWES Anna's Light	64	23	3.8	8.7	8.4	59	92	10	71
150 W HPS	57	30	15	19	29	65	89	14	82
LPS 18 W	55	28	13	20	25	68	95	8.7	97

The reanalysis of shearwater grounding data shows that actinic power per lux provides at least an equally valid model (AICc 546.83, effect 95% CI 3.69–61.84) as a categorical analysis with lamp type (AICc 547.59, LED effect 95% CI –1.07 to 0.45, MH 95% CI 0.20–1.72) (Figure 5). The model for CCT had a higher AICc (549.13) with an effect 95% CI intersecting 0, while the model for brightness had a still higher AICc (551.44) and a 95% CI for effect also intersecting 0.

4 | DISCUSSION

Our effort extends the approach presented by Aubé et al. (2013) to develop a method to calculate indices for any organismal response to lighting spectrum assuming equal visual light intensity to humans. These calculations can be easily repeated and updated with additional organismal response curves or with additional lighting products. We included the ultraviolet part of the spectrum because many other light sources do include ultraviolet and it is important for animal responses, although it is not a significant issue for most LEDs used for outdoor lighting.

The approach described here establishes appropriate units for measuring ecological responses to light that are consistent with international standards and thereby provides a basis for comparison that is replicable and testable. Quantification of actinic power can be used to develop hypotheses to test in the field, such as the comparison of lamp types undertaken by Rodríguez et al. (2017a) that we revisited. Furthermore, it allows the rapid and easily updatable comparison of new lamp types so that the most promising spectral configurations for a particular situation can be identified and tested in the field.

Our approach is, however, only as accurate as the action spectra and as applicable as the number of different species groups for which action spectra are available. These response curves are scatted in the literature and although many physiological response curves could be calculated from, for example, peak opsin sensitivities (Davies et al., 2013), behavioral response curves derived from field and laboratory tests are more rare. In at least one instance (loggerhead sea turtle hatchlings) there may be behavioral response differences between

TABLE 4 Actinic power per lux of each lamp type, compared with a lux of daylight (D65)

Light source	Photosynthesis	Moth	Bee	Insect index	Green turtle behavior	Green turtle visual	Loggerhead behavior	Salmon	Shearwater
D65	1	1	1	1	1	1	1	1	1
A	1	0.639	0.681	0.482	0.588	0.865	1.010	0.587	0.867
Kerosene Oil	1.360	0.673	0.494	0.340	0.558	1.050	1.340	0.754	0.924
Full moon	0.922	0.704	0.821	0.597	0.72	0.841	0.917	0.642	0.874
TL950	0.827	0.691	0.858	0.611	0.736	0.774	0.815	0.618	0.876
SORAA Vivid	0.927	0.793	0.891	0.711	0.822	0.860	0.894	0.720	0.920
LLT Telescope Light	0.772	0.425	0.458	0.306	0.275	0.660	0.818	0.259	0.812
CFL Greenlite 13 W	0.573	0.487	0.746	0.490	0.445	0.606	0.648	0.410	0.748
Philips AmbientLED	0.716	0.464	0.593	0.375	0.408	0.648	0.756	0.33	0.785
3000K LED	0.647	0.522	0.714	0.515	0.497	0.655	0.714	0.392	0.778
OCTRON 32 W	0.632	0.573	0.847	0.556	0.599	0.648	0.670	0.534	0.773
Metal Halide 70W	0.656	0.568	0.732	0.576	0.512	0.673	0.723	0.481	0.788
Ceramic Metal Halide 70 W	0.656	0.568	0.732	0.576	0.512	0.673	0.723	0.481	0.788
LSG Good Night 2016	0.696	0.431	0.526	0.343	0.343	0.625	0.743	0.284	0.779
LEDway Streetlight CW 54W	0.715	0.645	0.900	0.574	0.748	0.697	0.713	0.629	0.800
Los Angeles LED	0.688	0.579	0.782	0.510	0.614	0.657	0.700	0.545	0.771
Cosmopolis 60W	0.603	0.519	0.644	0.518	0.485	0.622	0.668	0.415	0.764
Yard Blaster	0.646	0.701	0.821	0.783	0.686	0.729	0.717	0.624	0.816
PC Amber Cree	0.718	0.387	0.361	0.273	0.223	0.613	0.768	0.232	0.792
AEL 75W	0.711	0.383	0.366	0.274	0.225	0.609	0.762	0.229	0.785
CWES 74 WW CW7	0.542	0.342	0.539	0.309	0.283	0.530	0.624	0.178	0.695
Iwasaki 60W	0.771	0.731	0.806	0.822	0.613	0.817	0.869	0.715	0.827
CWES 74 WW CW10	0.581	0.342	0.446	0.285	0.246	0.540	0.653	0.186	0.715
CWES Anna's Light	0.876	0.414	0.131	0.221	0.129	0.681	0.898	0.266	0.898
150 W HPS	0.529	0.368	0.365	0.335	0.307	0.517	0.593	0.243	0.705
LPS 18 W	0.375	0.254	0.221	0.254	0.193	0.393	0.462	0.112	0.615

populations of the same species (Fritsches, 2012), meaning that caution should be used in universally applying action spectra. The emergence of highly configurable outdoor lighting demonstrates the need for research to produce more action spectra and to compile them in a repository. This is a central research need from experimental zoologists to provide the information necessary for lighting designers and especially regulators to act quickly in response to new lighting technologies. Peak opsin sensitivity provides a first pass on behavioral responses, and indeed, behavioral response curves can be calibrated from opsin response curves (Donners et al., 2018). Workers in the field and with captive animals should, however, prioritize research to obtain behavioral response information for sensitive species and to test the generalizable patterns in responses within clades where visual systems are conserved.

We are aware of the limitations of using spectral information that may only be applicable within a certain range of intensity values. Some species respond to spectrum differently depending on its intensity (Wiltschko, Stapput, Thalau, & Wiltschko, 2010). Also, mitigation schemes that depend on spectrum can be undermined by brightness. Any approach to reduce ecological effects of lights must keep intensity to a minimum and can then perhaps further reduce adverse effects through tuning of the spectrum used.

We also note that the influence of lamps of different spectra will be affected by atmospheric conditions that influence the amount and nature of reflection and scattering of light (Aubé, Kocifaj, Zamorano, Lamphar, & de Miguel, 2016; Kyba, Ruhtz, Fischer, & Hölker, 2011). Our wildlife response assessments do not include any shifts in spectral distribution of light that would result from scattering in the atmosphere and therefore are most relevant to situations where direct effects are being evaluated (e.g., local attraction and disorientation). Additional calculations could be added to our approach to address different propagation patterns of light under varying weather conditions.

Our use of CRI as a metric for performance of lamps for human vision should not be taken as a blanket endorsement of CRI as an excellent metric, which it is not (Galadí-Enríquez, 2018). It is, however, widely understood and used in the lighting design community and therefore provides a means to incorporate human design preferences into a composite metric of lighting performance. Furthermore,

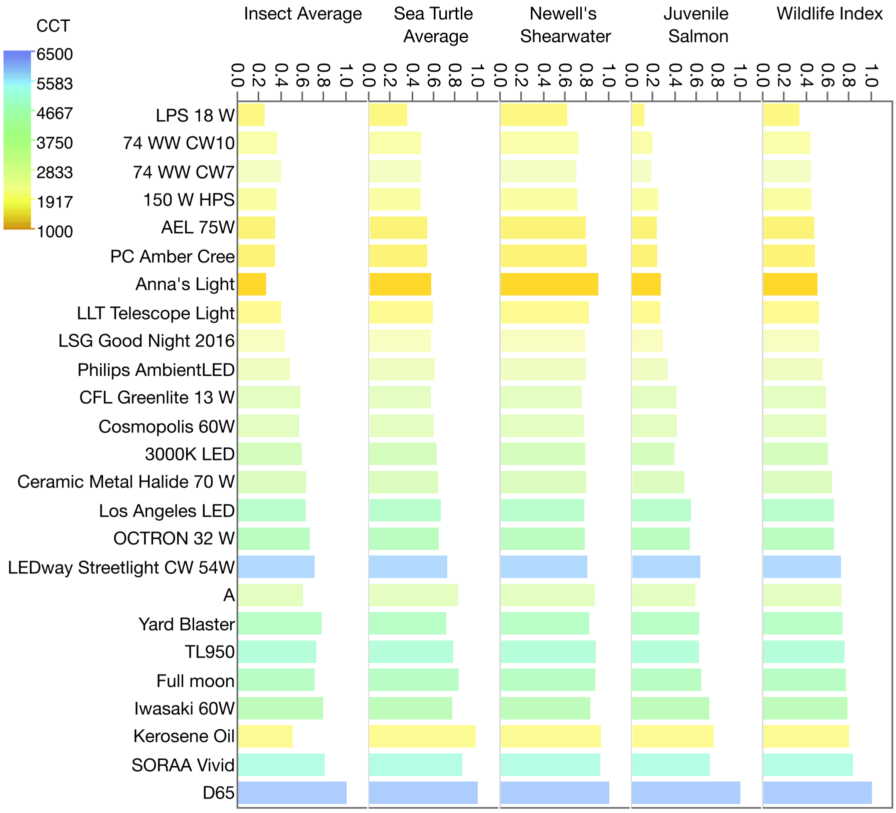

FIGURE 3 Relative modeled impact on insects, sea turtles, shearwaters, and juvenile salmon per additional lux from different light spectra compared with a D65 (6500 K) standard. Colors indicate CCT from low (orange) to high (blue) [Color figure can be viewed at wileyonlinelibrary.com]

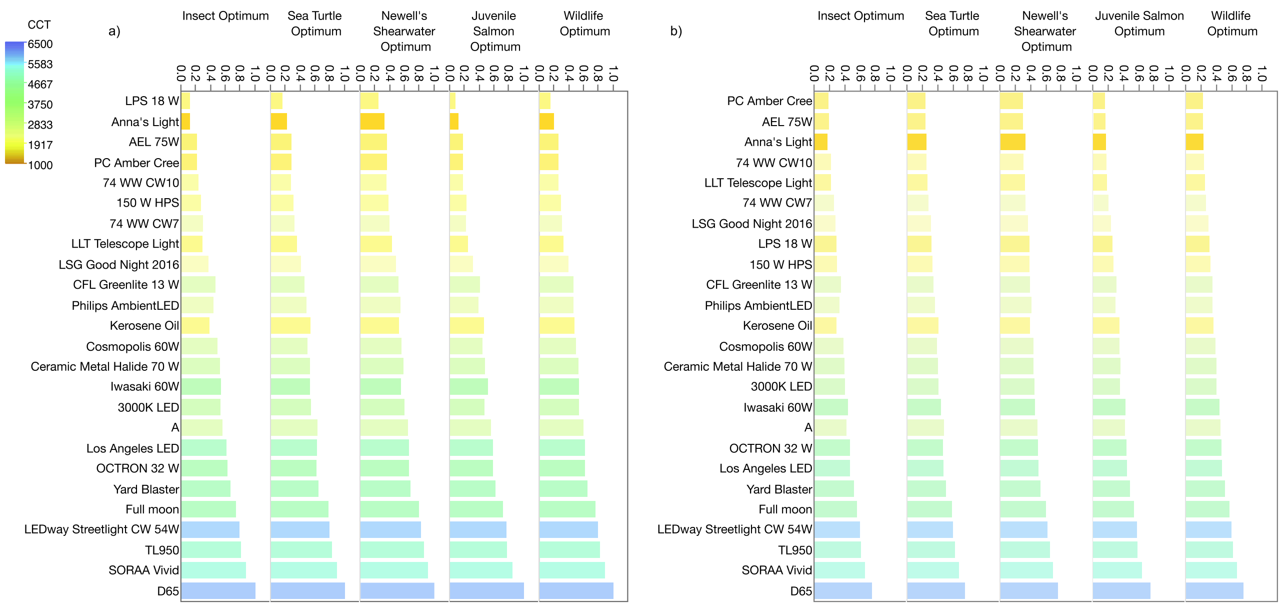

FIGURE 4 Nighttime light performance index balancing Star Light Index, melatonin suppression, and a wildlife impact score (a) and incorporating CRI (b) for equal lux from different light spectra compared with a D65 (6500K) standard. Lower values indicate lower predicted impacts and greater CRI. Colors indicate CCT from low (orange) to high (blue) [Color figure can be viewed at wileyonlinelibrary.com]

this approach can be updated to use other metrics as desired by an end user.

As a conservation tool, our assessments assume that it is a valuable approach to minimize the intersection between the wavelengths that affect sensitive wildlife species and the output of lamps and that it is worthwhile to balance those adverse effects against desirable characteristics of outdoor lighting for human use. Lamps that perform well in this assessment would represent a conservation compromise—no light on a sea turtle nesting beach, on a penguin colony, or on the route a fledgling seabird takes to the sea would be optimal, but if there is

TABLE 5 Pearson's product moment correlation between CCT, CRI, Star Light index, Melanopic response, and average wildlife response. Above diagonal, correlation estimates. Below diagonal, 95% confidence intervals

	CCT	CRI	Star light index	Melanopic	Wildlife
CCT	–	0.48	0.94	0.94	0.78
CRI	0.10–0.73	–	0.64	0.67	0.71
Star Light Index	0.87–0.97	0.40–0.84	–	1.00	0.85
Melanopic	0.87–0.97	0.33–0.83	0.99–1.00	–	0.85
Wildlife	0.57–0.90	0.43–0.86	0.69–0.93	0.69–0.93	–

to be a light nearby, minimizing the wavelengths in the part of the spectrum to which turtles or seabirds are most sensitive is preferable (Rodríguez et al., 2017b, 2018), so long as intensity is also minimized. Such hierarchical minimizing approaches might ignore other more complete solutions such as embedded roadway lighting, which provides guidance to drivers and virtually no light on nearby beaches (Bertolotti & Salmon, 2005), but they do provide guidance for reducing adverse effects from existing lighting infrastructure, which will be replaced with full-spectrum lights in the absence of guidance from ecologists and consideration of wildlife responses.

Given the rapid pace of replacement of street and other outdoor lighting motivated by energy savings (Hecht, 2016), an approach to minimize the adverse effects of lighting through choice of spectrum that is endorsed by conservation scientists is desperately needed. Laws available to reduce the ecological effects from light pollution that are in place around the world are focused predominantly on the direction and intensity of lighting; very few legislators saw the dramatic change in color on the technological horizon. Those jurisdictions that have taken steps to use energy efficient lighting with a spectrum designed to minimize adverse environmental effects have been motivated mostly by particular species protection laws (e.g., the Endangered Species Act in the United States) and by the economic considerations associated with astronomical observatories.

The State of Florida requires that new coastal construction limit lighting near beaches to sources that emit wavelengths only greater than 560 nm to protect sea turtles. Our calculations suggest that several of the filtered LEDs that we assessed would be less attractive to hatchling sea turtles than existing HPS lamps, but none of the filtered

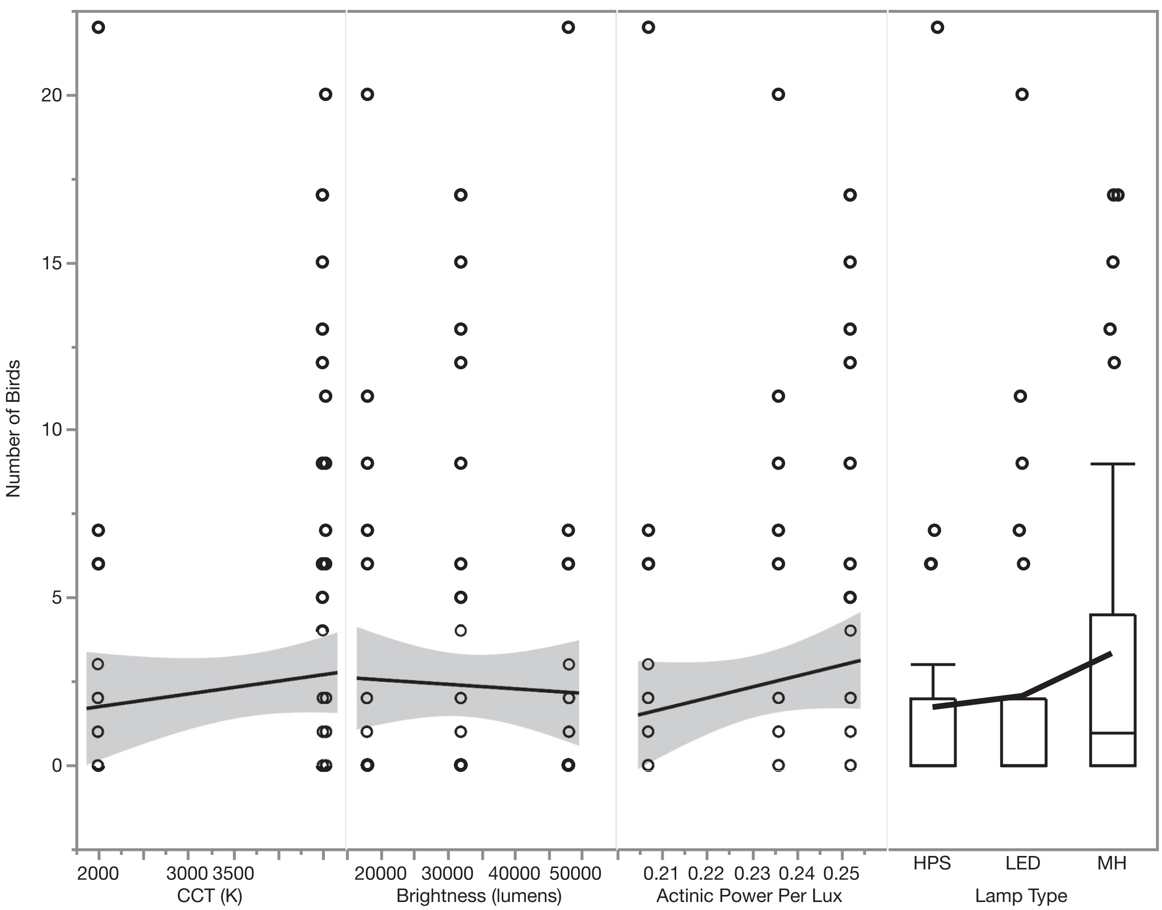

FIGURE 5 Analysis of birds grounded from Rodríguez et al. (2017a), comparing Actinic Power per Lux with CCT, brightness, and lamp type as explanatory variables

lamps meets the 560 nm cutoff. This raises the interesting regulatory question of whether it might be acceptable to modify the strict 560 nm cutoff in favor of a whole-spectrum assessment that we have proposed here, which would lead to approving lamps for street and outdoor lighting (e.g., at ports) that we predict would be less disruptive to turtles, increase color rending when replacing existing HPS, and save significant energy. Of course, to fully address outdoor light management, additional techniques to control light intensity, direction, and duration would need to be employed (Longcore and Rich, 2017), such as use of shields, baffles, and louvers to reduce spill light (Mizon, 2002).

Decision-making power for new lighting types is often vested in street lighting agencies and departments of transportation. When regulations exist to control lighting to reduce harms to certain species, these agencies must comply with relevant laws. They also answer to public opinion on the aesthetics of lighting, as has been shown for many LED projects around the USA that have raised the ire of local residents because the high CCT lamps produce significant glare and were displeasing to residents (Hecht, 2016). For those governmental actors trying to balance considerations for wildlife, the night sky, and safety, clear advice on spectrum is needed to navigate the many available choices. This information is also necessary for regulators facing these issues.

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Short communication

Reducing light-induced mortality of seabirds: High pressure sodium lights decrease the fatal attraction of shearwaters

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ABSTRACT

The use of artificial light at night and its ecological consequences are increasing around the world. Light pollution can lead to massive mortality episodes for nocturnally active petrels, one of the most threatened avian groups. Some fledglings can be attracted or disoriented by artificial light on their first flights. Studies testing the effect of artificial light characteristics on attractiveness to seabirds have not provided conclusive results and there is some urgency as some endangered petrel species experience high light-induced mortality. We designed a field experiment to test the effect of three common outdoor lighting systems with different light spectra (high pressure sodium, metal halide and light emitting diode) on the number and the body condition of grounded fledglings of the short-tailed shearwater *Ardenna tenuirostris*. A total of 235 birds was grounded during 99 experimental hours (33 h for each treatment). 47% of birds was grounded when metal halide lights were on, while light emitting diode and high pressure sodium lights showed lower percentages of attraction (29% and 24%). Metal halide multiplied the mortality risk by a factor of 1.6 and 1.9 respectively in comparison with light emitting diode and high pressure sodium lights. No differences in body condition were detected among the birds grounded by the different lighting systems. We recommend the adoption of high pressure sodium lights (or with similar spectra) into petrel-friendly lighting designs together with other light mitigation measures such as light attenuation, lateral shielding to reduce spill and appropriate orientation.

1. Introduction

The increasing use of artificial light at night is causing a loss of the natural nightscapes worldwide (Falchi et al., 2016). Light pollution is an emerging threat to biodiversity conservation by disrupting circadian rhythms, affecting natural behaviours, reproduction, animal movement or endocrine systems, and finally, influencing the ecosystem functioning by cascading effects (Gaston, Duffy, Gaston, Bennie, & Davies, 2014; Hölker, Wolter, Perkin, & Tockner, 2010; Longcore & Rich, 2004). Although marine environments are mostly free of artificial light, most coastal areas are affected by light pollution at night (Davies, Duffy, Bennie, & Gaston, 2014). Artificial lights along the coast can cause direct and incidental mass mortality events in endangered marine taxa, e.g. turtles or seabirds (Rich & Longcore, 2006; Rodríguez, Holmes et al., 2017). Despite the multiple effects on human health and biodiversity, artificial light is steadily proliferating in the night environment led by improvements in luminous efficiency (Kyba, Hänel, & Hölker, 2014). Thus, the determination of the impact of the different artificial lighting systems on biodiversity should be a priority for developing appropriate lighting policies to enable better coastal planning and conservation practices.

Fledglings of nocturnal petrel species (including shearwaters and storm-petrels) are attracted to artificial lights during their first flights from nest-burrows to the ocean, often colliding with human structures or the ground. If they survive the collision, they are grounded in artificially lit areas and susceptible to being killed by incidental threats (vehicle collision, predation, starvation or dehydration) (Ainley, Podolsky, Deforest, & Spencer, 2001; Le Corre, Ollivier, Ribes, & Jouventin, 2002; Rodríguez, Rodríguez, Curbelo et al., 2012; Rodríguez et al., 2014). To mitigate light-induced mortality of petrels, rescue programs have been implemented in several locations around the world (Rodríguez, Holmes et al., 2017). However, pre-emptive measures, that reduce the attractiveness of artificial lighting to seabirds, would be much more effective at the population level. To our knowledge, there is no published information on whether seabird attraction to artificial lights is related to the type of lights or individual traits of the seabirds. Here, we test the effect of three commonly used lighting systems with different

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light spectra (metal halide – MH, high pressure sodium – HPS – and light emitting diode – LED) on the attraction of short-tailed shearwater (*Ardenna tenuirostris*) fledglings, a species severely affected by light pollution (Rodríguez et al., 2014). We also test if body condition of grounded fledglings differs among lighting systems. Why petrels are attracted to lights is not entirely understood, but it may be related to food as petrels could confuse lights with natural bioluminescent prey or associate light with food during the nestling period at their nest-burrows (see Rodríguez, Holmes et al., 2017). Although short-tailed shearwater fledglings attracted by artificial lights do not seem handicapped, as their body condition is similar to those of adults (Rodríguez, Moffett et al., 2017), degree of attraction to lighting systems could be mediated by body condition. Body condition at fledging is a proxy to greater likelihood of survival and recruitment in long-lived seabirds (Becker & Bradley, 2007; Maness & Anderson, 2013). Thus, attraction of birds in good condition, i.e. those with higher survival and recruitment probabilities, to a particular lighting system would worsen the impact of such light for petrel populations. Apart from lighting systems, other factors appear to play a role in the number of seabirds attracted to lights. First, birds tend to fledge early in the night (Reed, Sincock, & Hailman, 1985; Rodríguez, Rodríguez, & Negro, 2015), and therefore, it was expected that the number of grounded birds would increase during the first nocturnal hours. Second, fledging is a synchronous process leading to high number of birds fledging around a peak date (27–28 April for the short-tailed shearwater; Rodríguez et al., 2014). Third, fledging date is favoured by strong winds which give a lift to flight-inexperienced fledglings (Rodríguez et al., 2014; Skira, 1991). Fourth, the number of grounded birds is reduced during full moon nights (Le Corre et al., 2002; Rodríguez & Rodríguez, 2009; Telfer, Sincock, Byrd, & Reed, 1987). Fifth, the number of attracted birds in a year is related to the number of fledglings produced by the population in that particular year, i.e. the higher breeding success the higher the numbers of grounded birds (Day, Cooper, & Telfer, 2003; Rodríguez, Rodríguez, & Lucas, 2012).

2. Material and methods

Our study was conducted on Phillip Island, south-eastern Australia, where natural night skyscapes unpolluted by artificial lights are available adjacent to short-tailed shearwater breeding colonies (Fig. 1*a*). Phillip Island is relatively low with a maximum altitude about 112 m above sea level. It holds around 543,000 breeding pairs of short-tailed shearwaters (Harris, Brown, & Deerson, 1980), which is more than 1% of its global breeding population (BirdLife International, 2017), mainly distributed along the south coast (Fig. 1*a*). The short-tailed shearwater nests in dense colonies generally in sandy soils. Adults start migration before their chicks fledge and consequently fledglings depart the colony in the absence of their parents. Fledglings try to reach the ocean on their first flights.

Our experiment was conducted in the overflow car park at Phillip Island Nature Parks on the Summerland Peninsula (−38.505942°S, 145.149486°E), which is a 13,000 m^2 grassed area surrounded by some unlit buildings and short-tailed shearwater colonies (Fig. 1*b*). At the experiment site, masts held the three types of lamps (MH, HPS and LED) at the same height and orientation at each mast. Five masts of 3–5 m high supported the lamps used during the experiment (Fig. 1*b*, *c*). The three light types employed in our study are commonly used in outdoor facilities (e.g. car parks, sport stadiums and industrial areas) and they emit different spectra (Fig. 2*a*; Table 1). MH and HPS bulbs emit light in 360° in every direction, and for this reason they were housed in similar luminaries. In contrast, LED emits light in one direction.

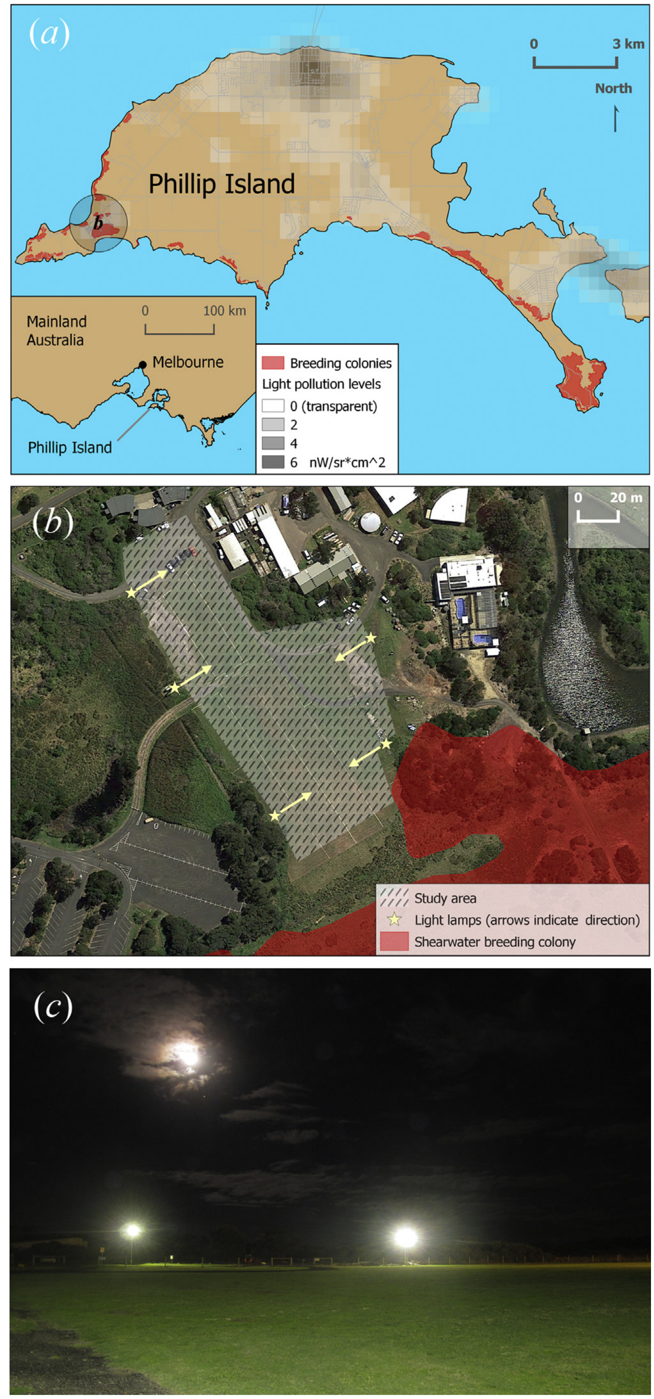

Fig. 1. (*a*) Phillip Island map showing distribution of breeding colonies, study site (grey circle) and light pollution levels taken from a nocturnal satellite imagery; NOAA National Geophysical Data Center; available at http://ngdc.noaa.gov/eog/viirs/download_monthly.html. (*b*) Map of the study area showing the light posts and the lit area. (*c*) Nocturnal picture showing two light-posts and the moon.

To assess the potential attraction of shearwater fledglings to the three lighting types, we designed an experiment in which every treatment (light type) was replicated every night. We lit the area at night during the fledging period and counted the number of grounded birds on the lit field. The experiment was repeated over three fledging seasons (2014: 22 April-4 May; 2015: 19 April-5 May; 2016: 26–29 April). To account for the high variability in number of groundings from night to night, we turned on each lighting type for one hour in a random order each night. The same type

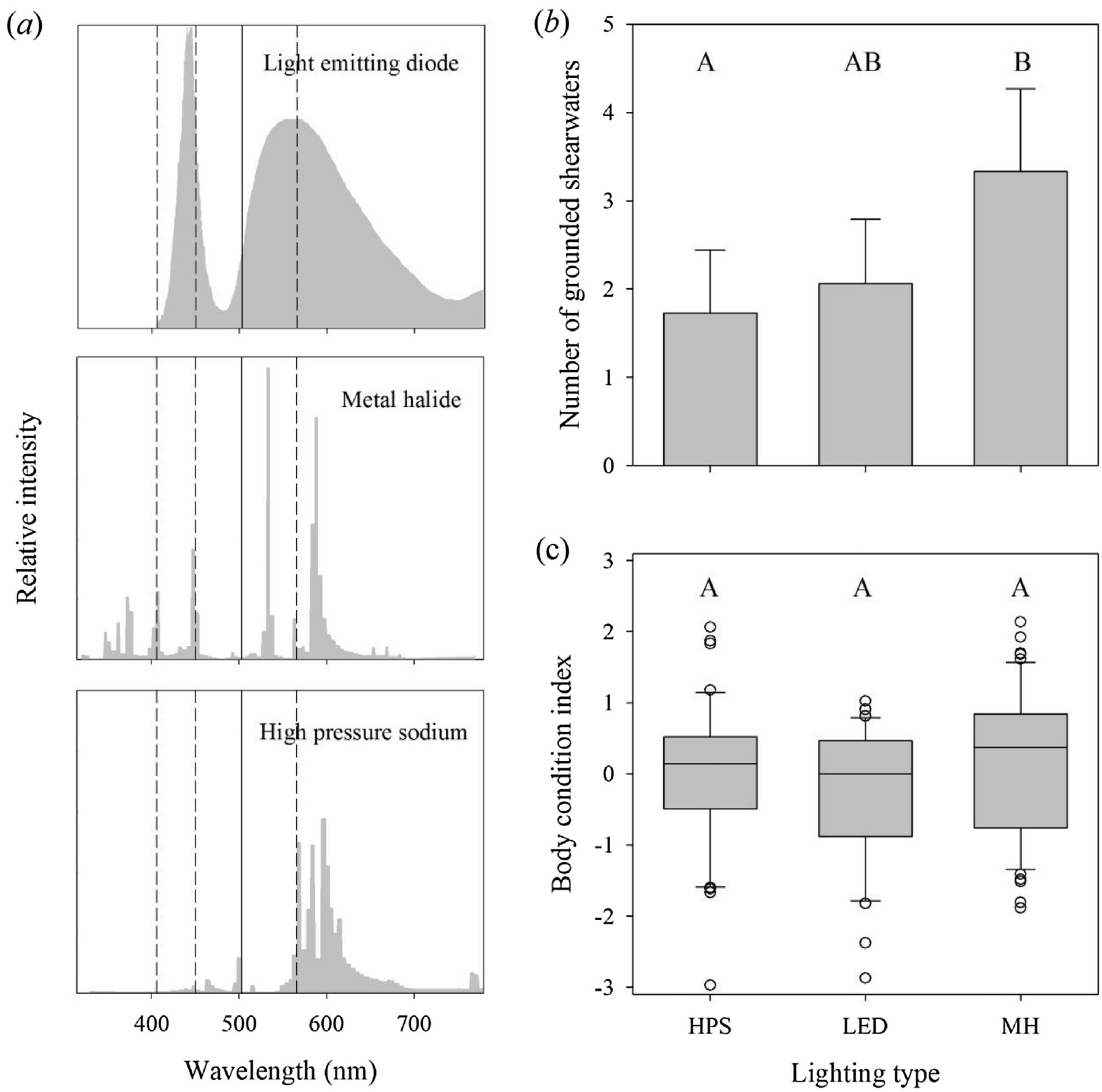

Fig. 2. Spectral composition (*a*) of the lighting types used (data provided by manufacturer). Vertical dashed and solid lines indicate the wavelength of maximum absorbance of visual pigment of cones and rods for *Ardenna pacifica* (Hart, 2004). Mean number per hour (*b*) and body condition (*c*) of short-tailed shearwater fledglings grounded by lighting types. In (*b*) bars show mean ± s.e. Different capital letters indicate significant differences between levels.

Table 1
Characteristics of light systems used in the experiment.

Light	Comercial reference	Lamp Wattage (W)	Color Temperature (K)	Luminous Flux (Lm)
High pressure sodium (HPS)	SON-T 400W/220 E40 1SL	400	2000 (warm)	48000
Metal halide (MH)	MASTER HPI-T Plus 400W/645 E40 1SL	400	4500 (cool)	32000
Light emitting diode (LED)	VBLFL-855-4-40	200	4536 (cool)	18111

of light (MH, HPS and LED) was on in the five masts during each experimental hour. We also had a period of 15-min in darkness between treatments to avoid potential attractive effects of the previous treatment on the birds. First light-treatment was turned on 45–60 min after sunset. We ran the experiments in the first hours of darkness (three experimental hours in total plus two 15-min gaps) as they coincide with the peak of fledging time (Reed et al., 1985; Rodríguez et al., 2015). By randomly sequencing the three treatments, we controlled for any changes in hourly fledgling rate through the night.

Grounded birds were collected and kept in boxes. Each individual was marked with a permanent marker pen on the toe webbing for identification and released in the closest colony at the end of each experimental night. Recaptured birds (five birds) were not included in the analyses. In 2015, body mass (g) and four biometric variables (wing, tarsus, bill length and bill length) were measured from grounded birds in the treatments of the experiment. The biometric variables were taken using an electronic balance (nearest 5 g), a ruler (nearest 1 mm) and an electronic calliper (nearest 0.01 mm). To obtain a size indicator of the grounded birds, we ran a principal component analysis (PCA) on centered and scaled morphometric variables (wing, tarsus and bill length, and bill depth) and the first principal component was used as a body size index (BSI). The first principal component retained 54% of variation. The four morphometric variables showed positive factor loadings (factor loadings: 0.47, 0.51, 0.49 and 0.52 for wing, tarsus, and bill length, and bill depth) and highly significant correlations to the first principal component (Fig. S1). Then, we run a linear model of body mass on BSI (the first principal component). This regression showed a $R^2 = 0.33$ and it was statistically significant ($F_{1,133} = 65.2$, $P < 0.001$). Diagnostic plots indicated that model assumptions were not violated (see Fig. S2). Finally, we extracted the standardized residuals of this model and used them as a body condition index (BCI), where positive and negative values indicate that birds are heavier and lighter than the average in the population, respectively (Green, 2001; Rodríguez, Rodríguez, Curbelo et al., 2012; Rodríguez, Moffett et al., 2017).

To control for the confounding variables noted in the introduction, i.e. fledging time/order and wind strength, moon light and inter-annual breeding success, we added five predictors: 1) Order of light treatment (three-level factor: first, second and third). 2) Quadratic term of fledging date (continuous variable ranging from 19 April to 5 May). 3) Wind speed (km/h) taken from an automated meteorological station located at Rhyll, Phillip Island, and distant 15 km from the study area (Bureau of Meteorology reference: 086373). The station provides wind data every 30 min and we calculated the average for the two readings of each experimental hour (treatment). 4) Moon light or luminance (continuous variable) measured as the percentage of luminance at full moon at zenith at distance equal mean equatorial parallax (Austin, Phillips, & Webb, 1976). We calculated moon luminance for each 10-min periods by using the moonlight Fortran software (Austin et al., 1976) and we assigned the maximum moon luminance to each experimental hour. 5) Year as a three-level factor to account for annual variation in breeding success.

We used generalised linear mixed models (GLMMs) with log link and Poisson error distributions to assess whether the number of grounded birds differs between light treatments (three-level factor). To control for the dependence in the number of grounded birds per light treatment in a single night, night was included as a random factor. To control for confounding variables, i.e. variables affecting the number of attracted birds (see above), we conducted GLMMs adding these predictors plus light treatment factor. To avoid over parameterization, only two predictors were included in each model (light treatment plus predictor). To assess whether body condition of grounded birds differs between lighting types, a linear model was conducted including body condition index as response variable and light treatment as a factor. Models were compared to null models, i.e. including only the intercept, using the 'anova' function (stats package) and assumptions were checked using diagnostic plots (Supplementary material). Statistical analyses were conducted in R version 3.3.2 (R Core Team, 2016). The function 'prcomp' (stats package) was employed to conduct the principal component analysis (PCA). Linear models and generalised linear mixed models were conducted using the functions 'lm' (stats package) and 'glmer' (lme4 package) (Bates, Mächler, Bolker, & Walker, 2015). Model assumptions of generalised linear mixed models were checked through a simulation-based approach using the 'DHARMa' package (Hartig, 2016).

3. Results

A total of 235 short-tailed shearwater fledglings were grounded during the 33 experimental nights (99 h; 33 h for each treatment) in the three annual fledging periods. Pooling all nights, the highest number of grounded fledglings was reached when MH lights were on ($\chi^2_2 = 19.974$; $P < 0.001$; 110, 68 and 57 birds for MH, LED and HPS lights, respectively). Eight out of the 235 birds were killed or subsequently euthanized after fatal collision with the ground or light-posts (4, 3 and 1 birds for MH, LED and HPS lights). The GLMM including just the light treatment was significant with regard to the null model, i.e. including only the intercept term ($\chi^2_2 = 19.209$; $P < 0.001$; Fig. 2*b*). Light treatment was also significant in all the GLMMs including additional variables (all P-values < 0.003; Supplementary material). In 2015, 135 grounded shearwaters were captured and measured. Body condition was similar between the shearwaters grounded by the different lighting types (Fig. 2*c*), as the model was not better than the null model ($F_{2,132} = 1.908$; $P = 0.153$).

4. Discussion

The number of grounded birds differed among light types, with MH being the light type attracting the highest number of the short-tailed shearwater fledglings. LEDs were second highest light type in causing grounded birds, although no statistical differences were apparent in comparison with HPS. Body condition of birds grounded by each lighting type was similar, indicating that attraction power of each lighting type did not depend on body condition, and more interestingly that no lighting system selectively attracted birds with higher survival and recruitment probabilities, i.e. birds in good body condition.

Differences in the number of grounded birds per light type may be explained by the visual systems of shearwaters. The retina of the congeneric wedge-tailed shearwater (*Ardenna pacifica*) have five visual pigments with maximum absorbance at 406–566 nm (Hart, 2004). Assuming a similar visual system, short-tailed shearwater fledglings could be more sensitive to MH and LED lighting, which produce a very cool light (blue) and a wider emission spectrum, than HPS which produces warmer light (red/orange) and low emissions under 550 nm (Table 1; Fig. 2*a*). Thus, shearwaters are likely to perceive lights differently. Given they display an attraction response, heightened perception may lead to heightened attraction. Our results on the higher number of grounded birds by MH and LED than HPS lights, agree with the possibility that MH and LED lights are appreciably brighter for shearwaters than HPS lights, thus increasing the attraction response.

Our results agree with other studies on other taxa in which HPS lights affect behaviour less than MH or LED lights, e.g. bats (Stone, Wakefield, Harris, & Jones, 2015) or invertebrates (Pawson & Bader, 2014), but contrast with those found for songbirds at off-shore platforms. Nocturnal migrating songbirds are more attracted by light with visible long-wavelength radiation (red and white) than by light with less or no visible long-wavelength radiation (blue and green) (Poot et al., 2008). Thus, adopting taxa-specific recommendations for the effect of artificial lights is crucial.

Designing experiments to study the potential attraction of different light types to seabirds is a challenging task, due to the intrinsic seabird natural traits, the low number of colonies and the vast extensions of cities and their associated light pollution (Reed, 1987, 1986; Reed et al., 1985). Reed et al. conducted two field experiments changing light characteristics (polarization and spectra), but failed to reduce light attraction in Newell's shearwaters *Puffinus newellii* (Reed, 1987, 1986). Despite these inconclusive results, light signatures (wavelength and intensity) have been changed around nesting colonies around the world to mitigate light-induced mortality. However, these actions have been conducted without any scientific evidence and their effectiveness has not been appropriately assessed (Rodríguez, Holmes et al., 2017). Our experimental study sheds some light on the potential effect of commercially available lighting systems, providing first-hand information for the lighting management around seabird breeding grounds. If artificial lights cannot be completely avoided, we strongly recommend that HPS lights, or filtered LED and MH lights with purpose-designed filters for lower emission spectra, should be the only external lights used in proximity to shearwater colonies. The type of light must be adopted together with other light reduction actions (KSHCP, 2017). Light should be as dim as possible to be fit the purpose, and should be correctly oriented towards the target area or object to avoid skyward light spill. Shielding and cut-off designs for luminaries can also help to avoid unnecessary light spread and reduce shearwater attraction (Reed et al., 1985). Finally, turning off the lights when not required or using motion sensors to turn on/off the lights would contribute to reducing light pollution (for a complete list of light mitigation actions see KSHCP, 2017). More research is needed to further understand the role of emission spectra on the potential attraction of seabirds and the impact of seabird-friendly lighting on sympatric organisms.

Competing interests

The authors declare no competing interests.

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Ethics

Procedures were approved by the Animal Ethics Committee, Phillip Island Nature Parks (Project 1.2014), and the Department of Environment and Primary Industries, Victorian State Government (Permit 10007170).

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jnc.2017.07.001.

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Australian Government
Department of the Environment and Energy

DRAFT Light Pollution Guidelines

National Light Pollution Guidelines for Wildlife

Including marine turtles, seabirds and migratory shorebirds

September 2019

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Front cover images: Clown fish - DESEPaC; Loggerhead Turtle hatchling – Scott Whitting; Mountain Pygmy Possum - Linda Broom; Black Browed Albatross – Alan Danks; Curlew Sandpiper – Brian Furby; Fleshfooted Shearwater - Richard Freeman.

Contents

National Light Pollution Guidelines

Introduction

Natural darkness has a conservation value in the same way that clean water, air and soil has intrinsic value. Artificial light at night is increasing globally by about two per cent per year[1]. Animals perceive light differently from humans and artificial light can disrupt critical behaviour and cause physiological changes in wildlife[2]. For example, hatchling marine turtles may not be able to find the ocean when beaches are lit[3], and fledgling seabirds may not take their first flight if their nesting habitat never becomes dark[4]. Tammar wallabies exposed to artificial light have been shown to delay reproduction[5] and clownfish eggs incubated under constant light do not hatch[6].

Consequently, artificial light has the potential to stall the recovery of a threatened species. For migratory species, the impact of artificial light may compromise an animal's ability to undertake long-distance migrations integral to its life cycle.

Artificial light at night also provides for human safety, amenity and increased productivity. Australian legislation and standards regulate artificial light for the purpose of human safety. These Guidelines do not infringe on human safety obligations. Where there are competing objectives for lighting, creative solutions may be needed that meet both human safety requirements for artificial light and threatened and migratory species conservation.

The Guidelines outline the process to be followed where there is the potential for artificial lighting to affect wildlife. They apply to new projects, lighting upgrades and where there is evidence of wildlife being affected by existing artificial light.

The technology around lighting hardware, design and control is changing rapidly and biological responses to artificial light vary by species, location and environmental conditions. It is not possible to set prescriptive limits on lighting. Instead, these Guidelines take an outcomes approach to assessing and mitigating the effect of artificial light on wildlife.

Figure 1 Pink anemone fish and marine turtle laying eggs. Photos: Nigel Marsh and Robert Thorn.

How to use these Guidelines

These Guidelines provide users with the theoretical, technical and practical information required to assess if a lighting project is likely to affect wildlife and the management tools to minimise and mitigate that affect. These techniques can be applied regardless of scale, from small, domestic projects to large-scale industrial developments.

The aim of the Guidelines is that artificial light will be managed so wildlife is:

1. **Not disrupted within, nor displaced from, important habitat**
2. **Able to undertake critical behaviours such as foraging, reproduction and dispersal.**

The Guidelines recommend:

1. Always using Best Practice Lighting Design to reduce light pollution and minimise the effect on wildlife.

2. Undertaking an Environmental Impact Assessment for Effects of Artificial Light on Wildlife for listed species for which artificial light has been demonstrated to affect behaviour, survivorship or reproduction.

Technical Appendices

The Guidelines are supported by a series of technical appendices that provide additional information about Best Practice Lighting Design, What is Light and How Wildlife Perceive it, Measuring Biologically Relevant Light, and Artificial Light Auditing. There is also a checklist for artificial light management, and species-specific information for the management of artificial light for Marine Turtles, Seabirds and Migratory Shorebirds. The range of species covered in taxa-specific appendices will be broadened in the future.

Regulatory Considerations for the Management of Artificial Light around Wildlife

These Guidelines provide technical information to guide the management of artificial light for *Environment Protection and Biodiversity Conservation Act (1999)* (EPBC Act) listed threatened and migratory species, species that are part of a listed ecological community, and species protected under state or territory legislation for which artificial light has been demonstrated to affect behaviour, survivorship or reproduction.

Environment Protection and Biodiversity Conservation Act (1999)

The EPBC Act regulates any action that will have, or is likely to have, a significant impact on a Matter of National Environmental Significance (MNES), including listed threatened and migratory species. Any action likely to have a significant impact on a MNES must be referred to the Australian Government for assessment. Further, it is an offence under the EPBC Act to kill, injure, take or trade a listed threatened, migratory or marine species in a Commonwealth area. Anyone unsure of whether the EPBC Act applies, is strongly encouraged to seek further information.

State and territory legislation and policy

State and territory environmental legislation and policy frameworks may also have provisions for managing threats, such as light, to protected species. For example, artificial light is a form of pollution regulated for impacts on humans and the environment under the Australian Capital Territory *Environment Protection Act 1997*. Consideration should be given to the function of relevant state and territory environment and planning legislation and policy concerning the protection of wildlife from artificial light.

Local and regional government requirements

Advice should also be sought from local government as to whether specific requirements apply in the area of interest concerning artificial light and wildlife. For example, the Queensland Government *Sea Turtle Sensitive Area Code* provides for local governments to identify sea turtle sensitive areas within local government planning schemes. Development in these areas will need to avoid adverse effects to sea turtles from artificial lighting.

Australian standards

Australian standards provide agreed limits for various lighting scenarios, generally for the purposes of human safety and for the provision of amenity. For example, Australian Standard DR AS/NZS 1158.3.1:2018 *Lighting for roads and public spaces pedestrian area (Category P) lighting* provides minimum light performance and design standards for pedestrian areas.

More recently, Australian standards have also provided for consideration of environmental concerns. Australian Standard *AS/NZS 4282:2019 Control of the obtrusive effects of outdoor lighting* provides information in Appendix C about the impact of artificial light on biota.

These Guidelines should be followed to ensure all lighting objectives are adequately addressed. This may require solutions to be developed, applied and tested to ensure lighting management meets the needs of human safety and wildlife conservation. The Case Studies illustrate examples of how a liquefied natural gas processing plant, a transport authority and a marine research vessel have addressed this challenge.

Associated guidance

These Guidelines should be read in conjunction with:

- EPBC Act 1999 Significant Impact Guidelines 1.1 Matters of National Environmental Significance
- EPBC Act 1999 Significant Impact Guidelines 1.2 Actions on, or impacting upon, Commonwealth land and Actions by Commonwealth Agencies;
- Recovery Plans and approved conservation advice for listed threatened species
- approved Wildlife Conservation Plans for listed migratory species
- state and territory environmental legislation, regulations, and policy and guidance documents
- up-to-date scientific literature
- local and Indigenous knowledge.

Wildlife and Artificial Light

Vision is a critical cue for wildlife to orient themselves in their environment, find food, avoid predation and communicate[7]. An important consideration in the management of artificial light for wildlife is an understanding of how light is perceived by animals, both in terms of what the eye sees and the animal's viewing perspective.

Animals perceive light differently from humans. Most animals are sensitive to ultra-violet (UV)/violet/blue light[8] and some snakes, for example, can detect infra-red wavelengths[9] (Figure 2). Understanding the sensitivity of wildlife to different light wavelengths is critical to assessing the potential effects of artificial light on wildlife.

The way light is described and measured has traditionally focused on human vision. To manage light appropriately for wildlife, it is critical to understand how light is defined, described and measured and to consider light from the wildlife's perspective.

For a detailed explanation of these issues see What is Light and how do Wildlife Perceive it? The Glossary provides a summary of terms used to describe light and light measurements and notes the appropriate terms for discussing the effects of light on wildlife.

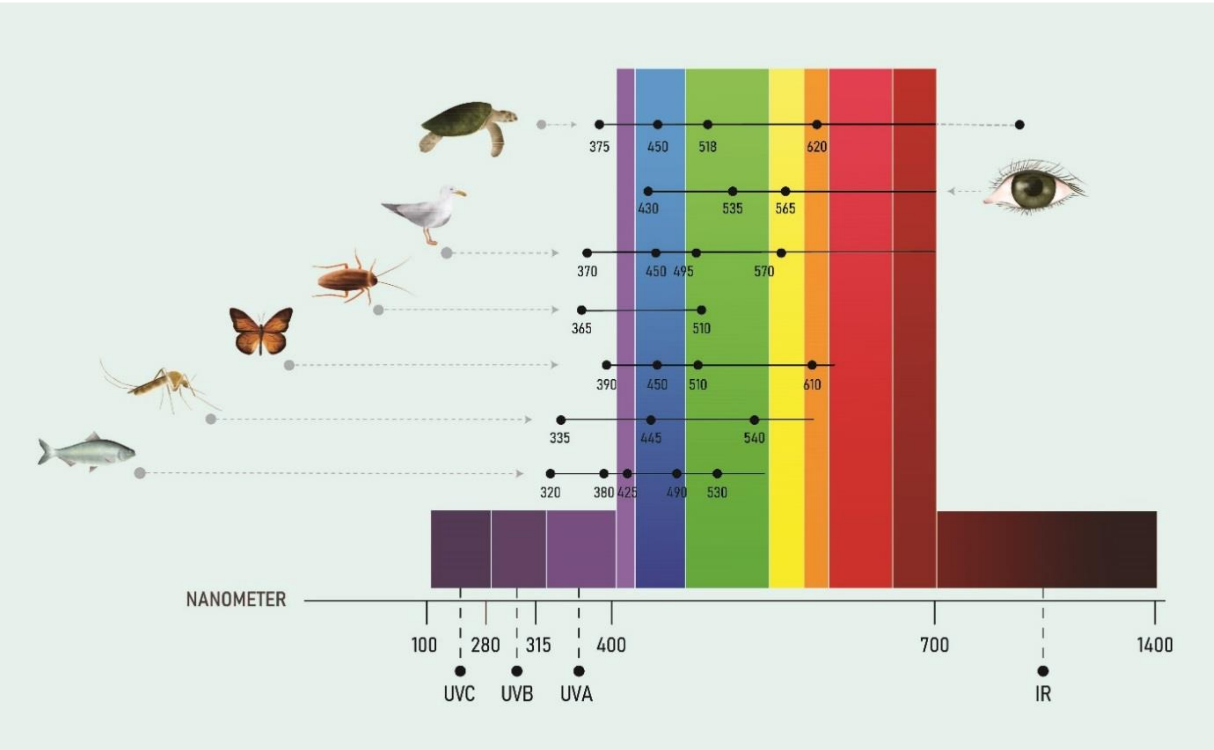

Figure 2 Ability to perceive different wavelengths of light in humans and wildlife. Note the common sensitivity to ultraviolet, violet and blue light across all wildlife.
© Pendoley Environmental, adapted from Campos (2017)[10].

Artificial light is known to adversely affect many species[2,11] and ecological communities[12,13]. It can change behaviour and/or physiology, reducing survivorship or reproductive output. It can also have the indirect effect of changing the availability of habitat or food resources. It can attract predators and invasive pests, both of which may pose a threat to listed species.

Behavioural changes in wildlife have been well described for some species. Adult marine turtles avoid nesting on beaches that are artificially lit[14], and adult and hatchling turtles can be disoriented and unable to find the ocean in the presence of direct light or sky glow[3]. Similarly, lights can disorient flying birds and cause them to collide with infrastructure[15]. Birds may starve when artificial lighting disrupts foraging, and fledgling seabirds may not be able to take their first flight if their nesting habitat never becomes dark[4]. Migratory shorebirds may use less preferable roosting sites to avoid lights and may be exposed to increased predation where lighting makes them visible at night[4].

Physiological changes have been described in Tammar Wallabies exposed to artificial light, resulting in delayed reproduction[5], and clownfish eggs incubated under constant light do not hatch[6]. Plant physiology can also be affected by artificial light with changes to growth, timing of flowering and resource allocation. This can then have flow-on affects for pollinators and herbivores[13].

The indirect effects of artificial light can also be detrimental to threatened species. The Mountain Pygmy Possum, for example, feeds primarily on the Bogong Moth, a long distance nocturnal migrator that is attracted to light[16]. Recent declines in moth populations, in part due to artificial light, have reduced the food supply for the possum[17]. Changes in food availability due to artificial light affect other animals, such as bats[18], and cause changes in fish assemblages[19]. Lighting may also attract invasive pests such as cane toads[20], or predators, increasing pressure on protected species[21].

These Guidelines provide information on the management of artificial light for Marine Turtles, Seabirds and Migratory Shorebirds in technical appendices. Consideration should be given to the direct and indirect effect of artificial light on all listed species for which artificial light has been demonstrated to negatively affect behaviour, survivorship or reproduction.

Light Emitting Diodes (LEDs)

During the life of these Guidelines, it is anticipated that light technology may change dramatically. At the time of writing, LEDs were rapidly becoming the most common light type used globally. This is primarily because they are more energy efficient than earlier light sources. LEDs and smart control technologies provide the ability to control and manage the physical parameters of lighting, making them an integral tool in managing the effects of artificial light on wildlife.

Whilst LEDs are part of the solution, consideration should be given to some of the characteristics of LEDs that may influence the effect of artificial light on wildlife. White LEDs generally contain short wavelength blue light and most wildlife is sensitive to blue light (Figure 2). More detailed consideration of LEDs, their benefits and challenges for use around wildlife are provided in the Technical Appendix What is Light and how does Wildlife Perceive it?

When to Consider the Impact of Artificial Light on Wildlife?

Is Artificial Light Visible Outside?

Any action or activity that includes externally visible artificial lighting should consider the potential effects on wildlife (refer Figure 3 below). These Guidelines should be applied at all stages of management, from the development of planning schemes to the design, approval and execution of individual developments or activities, through to retrofitting of light fixtures and management of existing light pollution. Best Practice Lighting Design is recommended as a minimum whenever artificial lighting is externally visible.

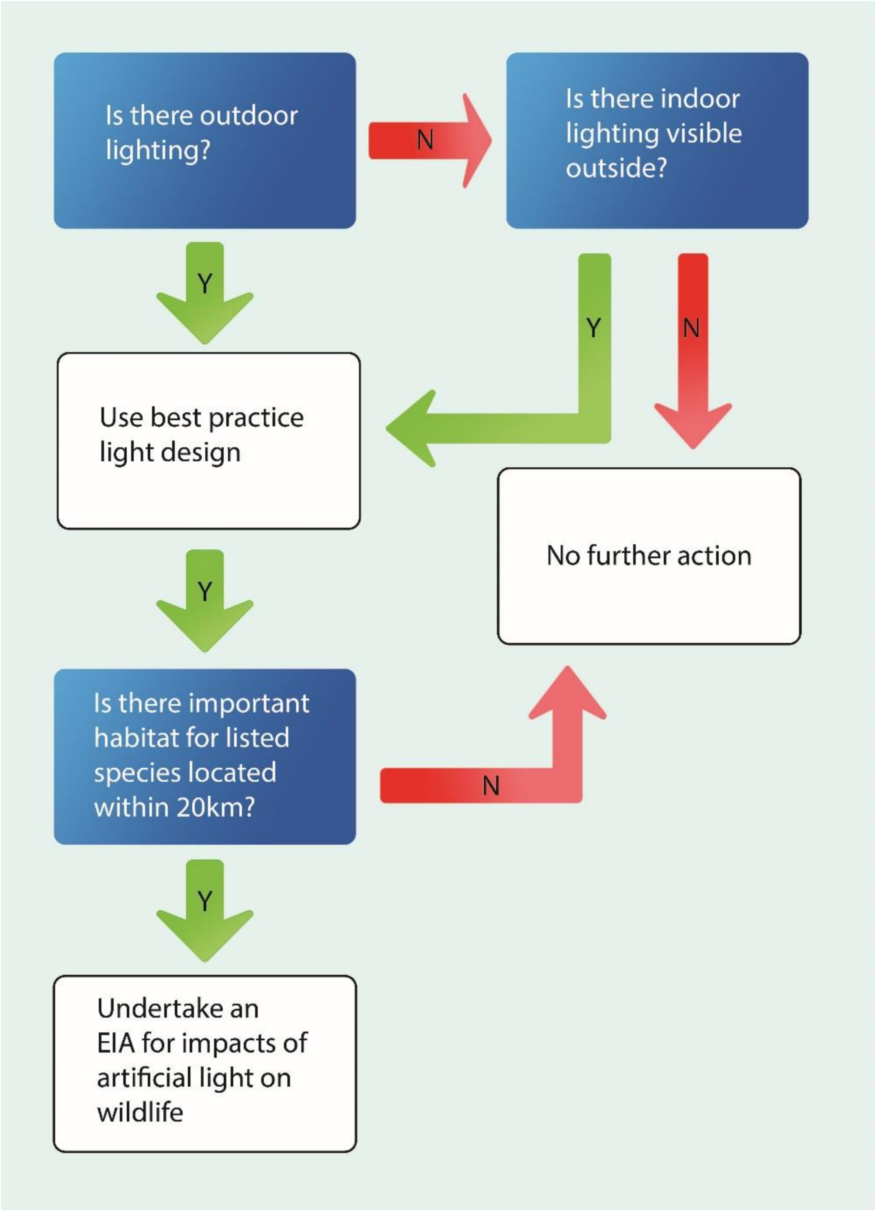

Figure 3 Decision tree to determine whether to undertake a light environmental impact assessment. © Pendoley Environmental.

Best practice lighting design

Natural darkness has a conservation value and should be protected through good quality lighting design and management for the benefit of all living things. To that end, all infrastructure that has outdoor artificial lighting or internal lighting that is externally visible should incorporate best practice lighting design.

Best practice lighting design incorporates the following design principles.

1. **Start with natural darkness and only add light for specific purposes.**
2. **Use adaptive light controls to manage light timing, intensity and colour.**
3. **Light only the object or area intended – keep lights close to the ground, directed and shielded to avoid light spill.**
4. **Use the lowest intensity lighting appropriate for the task.**
5. **Use non-reflective, dark-coloured surfaces.**
6. **Use lights with reduced or filtered blue, violet and ultra-violet wavelengths.**

Figure 4 provides an illustration of best practice light design principles. For a detailed explanation see Technical Appendix Best Practice Lighting Design.

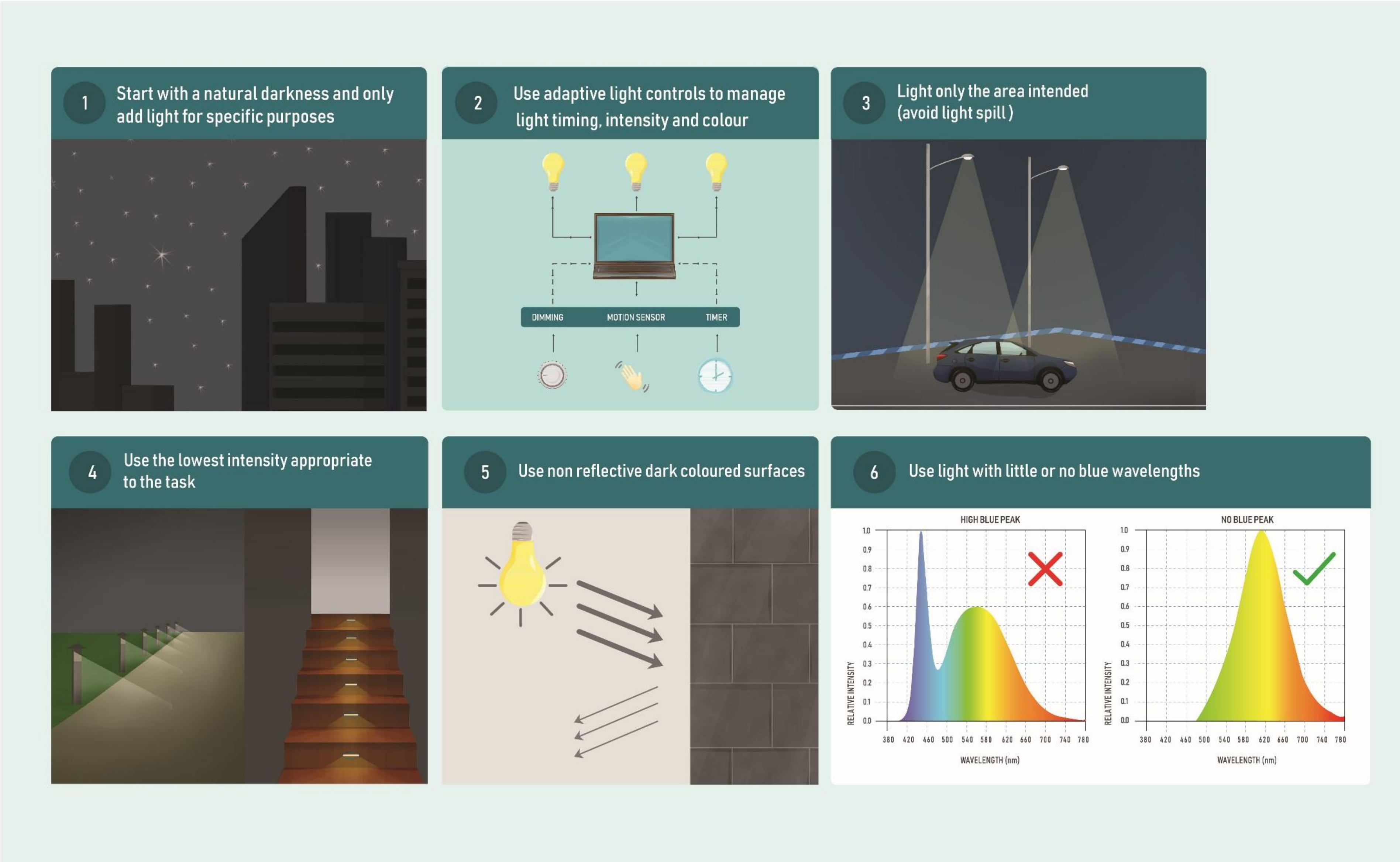

Figure 4 Principles for best practice lighting design. © Pendoley Environmental.

Is there Important Habitat for Listed Species Located within 20km?

Important habitats are those areas necessary for an ecologically significant proportion of a listed species to undertake important activities such as foraging, breeding, roosting or dispersal. This might include areas that are of critical importance for a particular life stage, are at the limit of a species range or habitat, or where the species is declining. They may also be a habitat where the presence of light pollution may cause a significant decline in a listed threatened or migratory species.

Important habitat will vary depending on the species. For some species, areas of importance have been designated through recovery plans, conservation advice, and under planning regulations (for example Queensland Sea Turtle Sensitive Areas). Important habitat would include those areas that are consistent with 'habitat critical to the survival' of a threatened species and 'important habitat' for listed migratory species as described in the EPBC Act Significant Impact Guidelines[22]. Important habitat may include areas designated as Biologically Important Areas (BIAs), or in the case of migratory shorebirds, Internationally Important or Nationally Important Habitat. Consideration should be given to the ecological characteristics of Ramsar sites and the biological and ecological values of National and World Heritage Areas.

Species specific descriptions of important habitat can be found in Technical Appendices relating to Marine Turtles, Seabirds and Migratory Shorebirds. For other listed species see relevant information available in Associated guidance and Desktop Study of Wildlife.

Where there is important habitat for listed species that are known to be affected by artificial light within 20 km of a project, species specific impacts should be considered through an Environmental Impact Assessment (EIA) process.

The 20 km threshold provides a precautionary limit based on observed effects of sky glow on marine turtle hatchlings demonstrated to occur at 15-18 km[23,24] and fledgling seabirds grounded in response to artificial light 15 km away[25]. The effect of light glow may occur at distances greater than 20 km for some species and under certain environmental conditions. The 20 km threshold provides a nominal distance at which artificial light impacts should be considered, not necessarily the distance at which mitigation will be necessary. For example, where a mountain range is present between the light source and an important turtle nesting beach, further light mitigation is unlikely to be needed. However, where island infrastructure is directly visible on an important turtle nesting beach across 25 km of ocean in a remote location, additional light mitigation may be required.

Managing existing light pollution

The impact of artificial light on wildlife will often be the result of the effect of all light sources in the region combined. As the number and intensity of artificial lights in an area increases there will be a visible, cumulative increase in sky glow. Sky glow is the brightness of the night sky caused by the reflected light scattered from particles in the atmosphere. Sky glow comprises both natural and artificial sky glow. As sky glow increases so does the potential for adverse impacts on wildlife.

Generally, there is no one source of sky glow and management should be undertaken on a regional, collaborative basis. Artificial light mitigation and minimisation will need to be addressed by the community, regulators, councils and industry to prevent the escalation of, and where necessary reduce, the effects of artificial light on wildlife.

The effect of existing artificial light on wildlife is likely to be identified by protected species managers or researchers that observe changes in behaviour or population demographic parameters that can be attributed to increased artificial sky glow. Where this occurs, the population/behavioural change should be monitored, documented and, where possible, the source(s) of light identified. An Artificial Light Management Plan should be developed in collaboration with all light owners and managers to mitigate impacts.

Environmental Impact Assessment for Effects of Artificial Light on Wildlife

There are five steps involved in assessing the potential effects of artificial light on wildlife, and the management of artificial light requires a continuing improvement process (Figure 5). The amount of detail included in each step depends on the scale of the proposed activity and the susceptibility of wildlife to artificial light. The first three steps of the EIA process should be undertaken as early as possible in the project's life cycle and the resulting information used to inform the project design phase.

Marine Turtle, Seabird and Migratory Shorebird Technical Appendices give specific consideration to each of these taxa. However, the process should be adopted for other protected species affected by artificial light.

Qualified personnel

Lighting design/management and the EIA process should be undertaken by appropriately qualified personnel. Management plans should be developed and reviewed by appropriately qualified lighting practitioners in consultation with appropriately qualified wildlife biologists or ecologists.

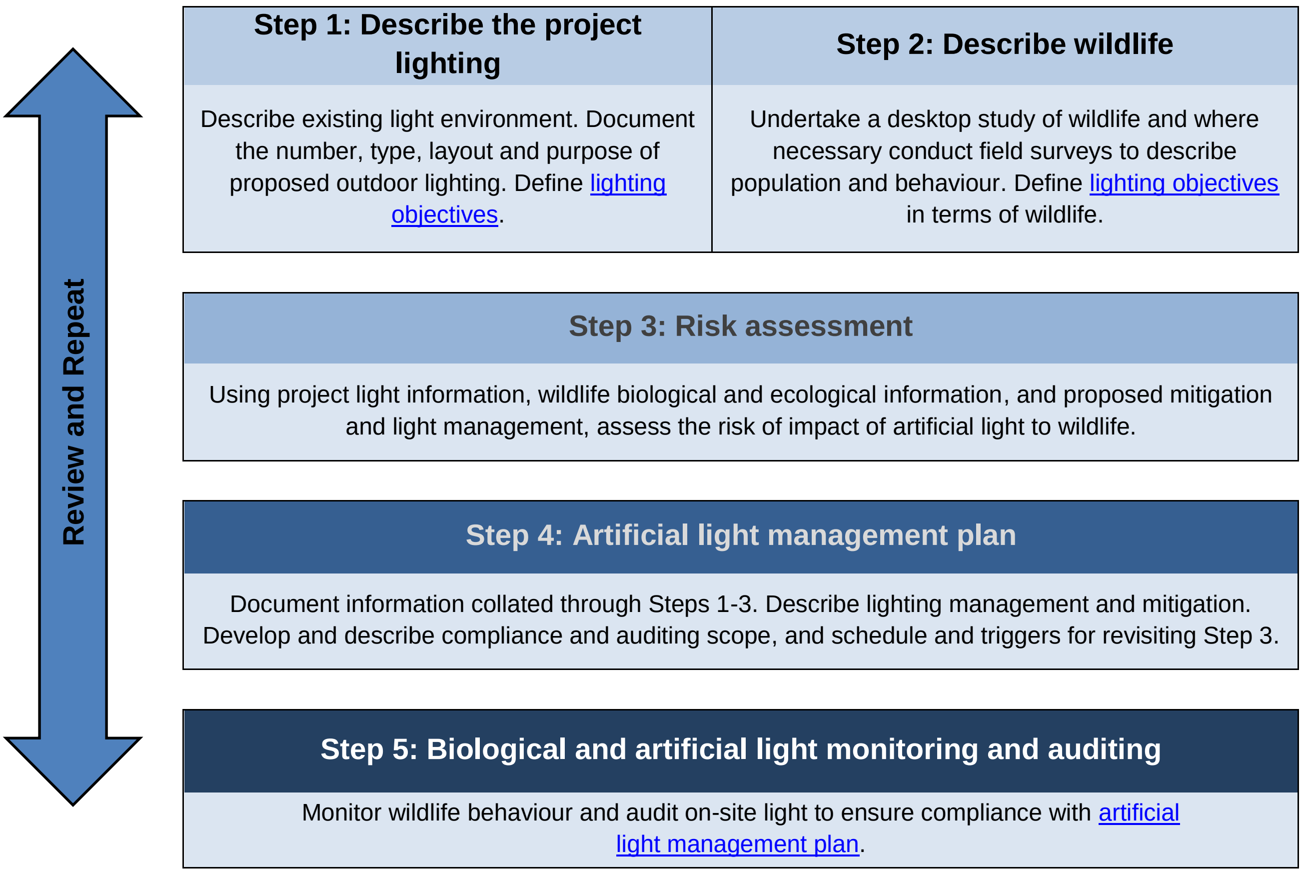

Figure 5 Flow chart describing the environmental impact assessment process.

Step 1: Describe the project lighting

Describe the existing light environment and characterise the light likely to be emitted from the site. Information should be collated, including (but not limited to): the location and size of the project footprint; the number and type of lights; their orientation and hours of operation; site topology and proximity to wildlife and/or wildlife habitat. This information should include whether lighting will be directly visible to wildlife or contribute to sky glow; the distance over which this artificial light is likely to be perceptible; shielding or light controls used to minimise lighting; and spectral characteristics (wavelength) and intensity of lights.

Project specific lighting should be considered in the context of the existing light environment and the potential for cumulative effects of multiple light sources. The information collected should be sufficient to assess the likely effects of artificial light on wildlife given the biology and ecology of species present (Step 2).

Where there will be a need to monitor the effectiveness of artificial light mitigation and management strategies (Step 5), baseline monitoring will be necessary. Measurements of the existing light environment should recognise and account for the biologically relevant short (red) and long (violet/blue) wavelengths of artificial lighting (see Measuring Biologically Relevant Light).

Lighting objectives

During the planning phase of a project the purpose of artificial lighting should be clearly articulated, and consideration should be given as to whether artificial light is required at all. Lighting objectives should be specific in terms of location and times for which artificial light is necessary, whether colour differentiation is required and whether some areas should remain dark. The objectives should include the wildlife requirements identified in Step 2 and be consistent with the aims of these Guidelines.

For more information about developing lighting objectives see Best Practice Lighting Design.

Step 2: Describe wildlife

Describe the biology and ecology of wildlife in the area that may be affected by artificial light (species identified during the screening process, Figure 3). The abundance, conservation status and regional significance of wildlife will be described, as will the location of important habitat. Recognise biological and ecological parameters relevant to the assessment, particularly how artificial light will be viewed by an animal. This includes an animal’s physiological sensitivity to wavelength and intensity, and its visual field.

Depending on the availability of information, scale of the activity and the susceptibility of wildlife to artificial light, this step may only require a desktop analysis. Where there is a paucity of information or the potential for effects is high, field surveys may be required. Where there will be a need to monitor the effectiveness of lighting mitigation and management strategies (Step 5), baseline monitoring will be necessary.

Desktop study of wildlife

A review of the available government databases, scientific literature and unpublished reports should be conducted to determine whether listed or protected wildlife that are susceptible to the effects of artificial light could be present. Tools to identify species or Important habitat that may occur within 20 km of the area of interest include (but are not limited to):

- Protected Matters Search Tool
- National Conservation Values Atlas
- State and territory protected species information
- Scientific literature
- Local and Indigenous knowledge

To assess the risks to a species, an understanding of the animal's susceptibility to the effects of light should be evaluated, as well as the potential for artificial light to affect the local population.

The species conservation status should be identified and relevant population demographic and behavioural characteristics that should be considered include population size, life stages present and normal behaviour in the absence of artificial light. This step should also identify biological and ecology characteristics of the species that will be relevant to the assessment. This may include understanding the seasonality of wildlife using the area; behaviour (i.e. reproduction, foraging, resting); migratory pathways; and life stages most susceptible to artificial light. Consideration should also be given to how artificial light may affect food sources, availability of habitat, competitors or predators.

Field surveys for wildlife

Where there are insufficient data available to understand the actual or potential importance of a population or habitat it may be necessary to conduct field surveys. The zone of influence for artificial lighting will be case and species specific. Surveys should describe habitat, species abundance and density on a local and regional scale at a biologically relevant time of year.

Baseline monitoring

Where it is considered likely that artificial lighting will impact on wildlife, it may be necessary to undertake baseline monitoring to enable assessment of mitigation and light management (Step 5).

Field survey techniques and baseline monitoring needs will be species specific and detailed parameters and approaches are described in the Marine Turtles, Seabirds and Migratory Shorebirds Technical Appendices. Guidance from species experts should be sought for other species.

Step 3: Risk assessment

Using information collated in steps one and two, the level of risk to wildlife should be assessed. Risk assessments should be undertaken on a case by case basis as they will be specific to the wildlife involved, the lighting objectives and design, and the prevailing environmental conditions. Assessments should be undertaken in accordance with the *Australian Standard Risk Management – Guidelines (AS ISO 31000:2018)* (or superseding equivalent), which provides for adaptive management and continuous improvement. The scale of the assessment is expected to be commensurate with the scale of the activity and the vulnerability of the wildlife present.

In general, the assessment should consider how important the habitat is to the species (e.g. is this the only place the animals are found), the biology and ecology of wildlife, the amount and type of artificial light and whether the lighting scenario is likely to cause an adverse response. The assessment should take into account the artificial light impact mitigation and management that will be implemented. It should also consider factors likely to affect an animal's perception of light; the distance to the lighting source; and whether light will be directly visible or viewed as sky glow. The process should assess whether wildlife will be disrupted or displaced from important habitat, and whether wildlife will be able to undertake critical behaviours such as foraging, reproduction, and dispersal.

Where a likely risk is identified, either the project design should be modified, or further mitigation put in place to reduce the risk.

If the risk is likely to be significant, consideration should be given as to whether the project should be referred for assessment under the EPBC Act and/or relevant state or territory legislation.

Step 4: Artificial light management plan

The management plan will document the EIA process. The plan should include all relevant information obtained in Steps 1-3. It should describe the lighting objectives; the existing light environment; susceptible wildlife present, including relevant biological characteristics and behaviour; and proposed mitigation. The plan should clearly document the risk assessment process, including the consequences that were considered, the likelihood of occurrence and any assumptions that underpin the assessment. It should document the scope of monitoring and auditing to test the efficacy of proposed mitigation and triggers to revisit the risk assessment. This should include a clear adaptive management framework to support continuous improvement in light management, including a hierarchy of contingency management options if biological and light monitoring or compliance audits indicated that mitigation is not meeting the objectives of the plan.

The detail and extent of the plan should be proportional to the scale of the development and potential impacts to wildlife.

A toolbox of species specific options are provided in the Marine Turtles, Seabirds and Migratory Shorebirds Technical Appendices. Guidance from species experts should be sought for other species.

Step 5: Biological and light monitoring and auditing

The success of the impact mitigation and artificial light management should be confirmed through monitoring and compliance auditing. Light audits should be regularly undertaken and biological and behavioural monitoring should be undertaken on a timescale relevant to the species present. Observations of wildlife interactions should be documented and accompanied by relevant information such as weather conditions and moon phase. The results of monitoring and auditing are critical to an adaptive management approach, with the results used to identify where improvements in lighting management may be required.

Light audits should be undertaken by appropriately qualified personnel and considered in consultation with an appropriately qualified biologist or ecologist.

Baseline, construction or post construction artificial light monitoring, wildlife biological monitoring and auditing are detailed in Measuring Biologically Relevant Light, Light Auditing and species specific Marine Turtles, Seabirds and Migratory Shorebirds Technical Appendices.

Review

Once light audits and biological monitoring have been completed, a review of whether the lighting objectives have been met should be conducted. The review should incorporate any changing circumstances and make recommendations for continual improvement. The recommendations should be incorporated through upgraded mitigations, changes to procedures and renewal of the light management plan.

Case Studies

Unlike many forms of pollution, artificial light can be removed from the environment. The following case studies show it is possible to balance the requirements of both human safety and wildlife conservation.

Gorgon Liquefied Natural Gas Plant on Barrow Island, Western Australia

The Chevron-Australia Gorgon Project is one of the world's largest natural gas projects. The liquefied natural gas (LNG) processing facility is on Barrow Island a Western Australian Class A nature reserve off the Pilbara Coast known for its diversity of fauna, including important nesting habitat for flatback turtles[26].

The LNG plant was built adjacent to important turtle nesting beaches. The effect of light on the turtles and emerging hatchlings was considered from early in the design phase of the project and species-specific mitigation was incorporated into project planning[26]. Light management is implemented, monitored and audited through a light management plan and turtle population demographics and behaviour through the *Long Term Marine Turtle Management Plan*[27].

Lighting is required to reduce safety risks to personnel and to maintain a safe place of work under workplace health and safety requirements. The lighting objectives considered these requirements while also aiming to minimise light glow and eliminate direct light spill on nesting beaches. This includes directional or shielded lighting, the mounting of light fittings as low as practicable, louvered lighting on low level bollards, automatic timers or photovoltaic switches and black-out blinds on windows. Accommodation buildings were oriented so that a minimal number of windows faced the beaches and parking areas were located to reduce vehicle headlight spill onto the dunes.

Lighting management along the LNG jetty and causeway adopted many of the design features used for the plant and accommodation areas. LNG loading activity is supported by a fleet of tugs that were custom built to minimise external light spill. LNG vessels are requested to minimise non-essential lighting while moored at the loading jetty.

To reduce sky glow, the flare for the LNG plant was designed as a ground box flare, rather than the more conventional stack flare. A louvered shielding wall further reduced the effects of the flare.

Lighting reviews are conducted prior to the nesting season to allow time to implement corrective actions if needed. Workforce awareness is conducted at the start of each turtle breeding season to further engage the workforce in the effort to reduce light wherever possible.

Figure 6 Liquefied natural gas plant on Barrow Island. Photo: Chevron Australia.

The *Long Term Marine Turtle Management Plan*[27] provides for the ongoing risk assessment of the impact of artificial light on the flatback turtles nesting on beaches adjacent to the LNG plant, including mitigation measures to minimise the risk from light to turtles. The plan also provides for an ongoing turtle research and monitoring program. The plan is publicly available.

Phillip Island

Victoria's Phillip Island is home to one of the world's largest colonies of listed migratory Short-tailed Shearwaters (*Ardenna tenuirostris*). It supports more than six per cent of the global population of this species[25]. Shearwaters nest in burrows and are nocturnally active at their breeding colonies. Fledglings leave their nests at night. When exposed to artificial light fledglings can be disoriented and grounded. Some fledglings may reach the ocean, but then be attracted back toward coastal lighting. Fledglings are also vulnerable to collision with infrastructure when disoriented and once grounded become vulnerable to predation or road kill[4] (Figure 7).

Phillip Island also attracts over a million visitors a year during peak holiday seasons to visit the Little Penguin (*Eudyptula minor*) ecotourism centre, the Penguin Parade®. Most visitors drive from Melbourne across a bridge to access the island. The increase in road traffic at sunset during the Easter break coincides with the maiden flight of fledgling shearwaters from their burrows[25].

In response to the deaths of fledglings, Phillip Island Nature Parks has an annual shearwater rescue program to remove and safely release grounded birds[25]. In collaboration with SP Ausnet and Regional Roads Victoria, road lights on the bridge to the island are turned off during the fledgling period[28]. To address human safety concerns, speed limits are reduced and warning signals put in place during fledgling season[28,29]. The reduced road lighting and associated traffic controls and warning signals, combined with a strong rescue program, have reduced the mortality rate of shearwaters.[25].

Figure 7 Short-Tailed Shearwater (*Ardenna tenuirostris*) fledgling grounded by artificial light, Phillip Island. Photo: Airam Rodriguez.

Raine Island research vessel light controls

The Queensland Marine Parks primary vessel *Reef Ranger* is a 24 m catamaran jointly funded by the Great Barrier Reef Marine Park Authority and the Queensland Parks and Wildlife Service under the Field Management Program (FMP). The *Reef Ranger* is often anchored at offshore islands that are known marine turtle nesting sites and is regularly at Raine Island, one of the world's largest green turtle nesting sites[30] and a significant seabird rookery.

Vessels often emit a lot of artificial light when at anchor and the FMP took measures to minimise direct lighting spillage from the vessel. A lights-off policy around turtle nesting beaches was implemented, where the use of outdoor vessel lights was limited, except for safety reasons.

The original fit out of the vessel did not include internal block-out blinds (Figure 8a). These were installed before the 2018-19 Queensland turtle nesting season. The blinds stop light being emitted from inside the vessel, therefore limiting light spill around the vessel (Figure 8b). This can make an important difference at remote (naturally dark) sites such as Raine Island.

Anecdotal evidence suggests hatchlings previously attracted to, and captured in, light pools around the vessel are no longer drawn to the *Reef Ranger*.

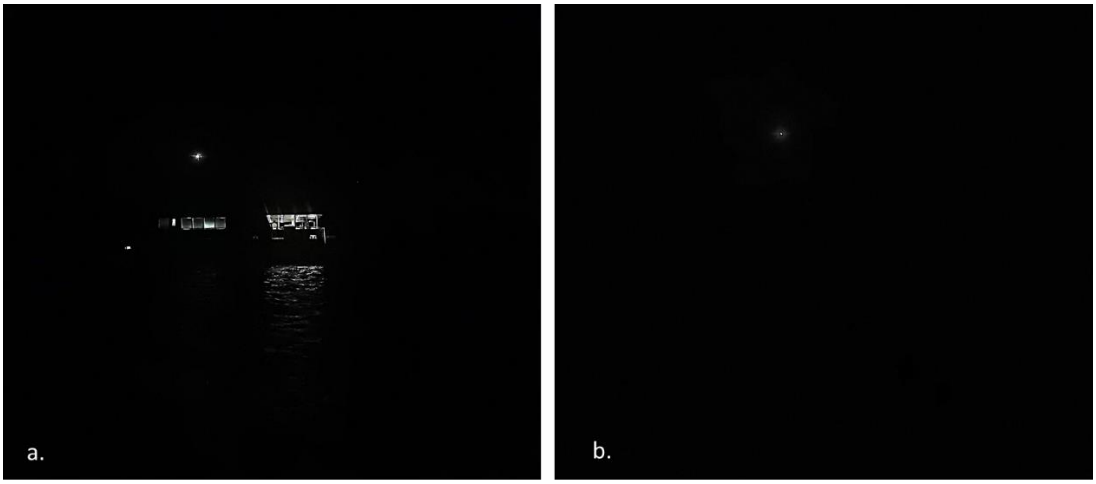

Figure 8 Vessel lighting management at Raine Island a. Vessel with decking lights, venetian blinds down and anchor light on; and b. Vessel with outside lights off, and blackout blinds installed (note the white anchor light is a maritime safety requirement). Photo: Queensland Parks and Wildlife Service.

Appendix A – Best Practice Lighting Design

Natural darkness has conservation value in the same way as clean water, air and soil and should be protected through good quality lighting design.

Simple management principles can be used to reduce light pollution, including:

1. **Start with natural darkness and only add light for specific purposes.**
2. **Use adaptive light controls to manage light timing, intensity and colour.**
3. **Light only the object or area intended – keep lights close to the ground, directed and shielded to avoid light spill.**
4. **Use the lowest intensity lighting appropriate for the task.**
5. **Use non-reflective, dark-coloured surfaces.**
6. **Use lights with reduced or filtered blue, violet and ultra-violet wavelengths.**

Lighting Objectives

At the outset of a lighting design process, the purpose of artificial lighting should be clearly stated and consideration should be given as to whether it is required at all.

Exterior lighting for public, commercial or industrial applications is typically designed to provide a safe working environment. It may also be required to provide for human amenity or commerce. Conversely, areas of darkness, seasonal management of artificial light, or minimised sky glow may be necessary for wildlife protection, astronomy or dark sky tourism.

Lighting objectives will need to consider the regulatory requirements and Australian standards relevant to the activity, location and wildlife present.

Objectives should be described in terms of specific locations and times for which artificial light is necessary. Consideration should be given to whether colour differentiation is required and if some areas should remain dark – either to contrast with lit areas or to avoid light spill. Where relevant, wildlife requirements should form part of the lighting objectives.

A lighting installation will be deemed a success if it meets the lighting objectives and areas of interest can be seen clearly, easily, safely and without discomfort.

Principles of Best Practice Lighting Design

Good lighting design incorporates the following design principles. They are applicable everywhere, especially in the vicinity of wildlife.

1. Start with natural darkness

The starting point for all lighting designs should be natural darkness (Figure 9). Artificial light should only be added for specific and defined purposes, and only in the required location and for the specified duration of human use. Designers should consider an upper limit on the amount of artificial light and only install the amount needed to meet the lighting objectives.

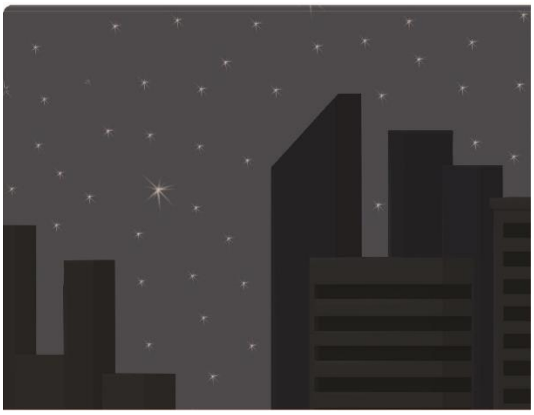

Figure 9 Start with natural darkness. © Pendoley Environmental.

2. Use adaptive controls

Recent advances in smart control technology provide a range of options for better controlled and targeted artificial light management (Figure 10). For example, traditional industrial lighting should remain illuminated all night because the High-Pressure Sodium, metal halide, and fluorescent lights have a long warm up and cool down period. This could jeopardise operator safety in the event of an emergency. With the introduction of smart controlled LED lights, plant lighting can be switched on and off instantly and activated only when needed, for example, when an operator is physically present within the site.

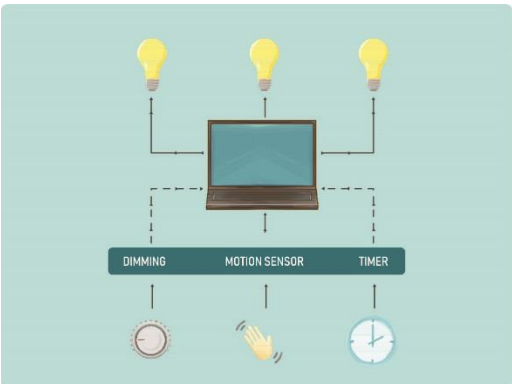

Figure 10 Use adaptive controls to manage light timing, intensity and colour. © Pendoley Environmental.

Smart controls and LED technology allow for:

- remotely managing lights (computer controls)
- instant on and off switching of lights
- control of light colour
- dimming, timers, flashing rate, motion sensors
- well defined directivity of light.

Adaptive controls should maximise the use of latest lighting technology to minimise unnecessary light output and energy consumption.

3. Light only the intended object or area - keep lights close to the ground, directed and shielded

Light spill is light that falls outside the area intended to be lit. Light that spills above the horizontal plane contributes directly to artificial sky glow while light that spills into adjacent areas on the ground (also known as light trespass) can be disruptive to wildlife in adjacent areas. All light fittings should be located, directed or shielded to avoid lighting anything but the target object or area (Figure 11). Existing lights can be modified by installing a shield.

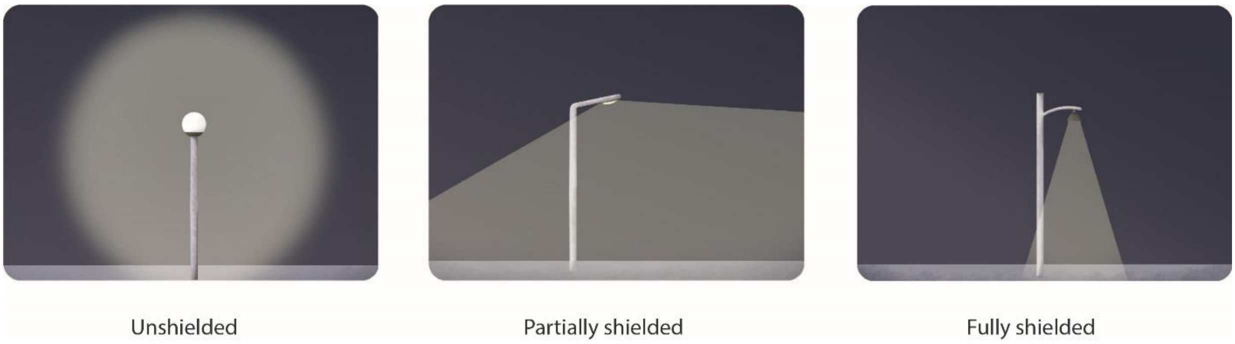

Figure 11 Lights should be shielded to avoid lighting anything but the target area or object. © Pendoley Environmental, adapted from Witherington and Martin (2003)[3].

Lower height lighting that is directional and shielded can be extremely effective. Light fixtures should be located as close to the ground as possible (Figure 12).

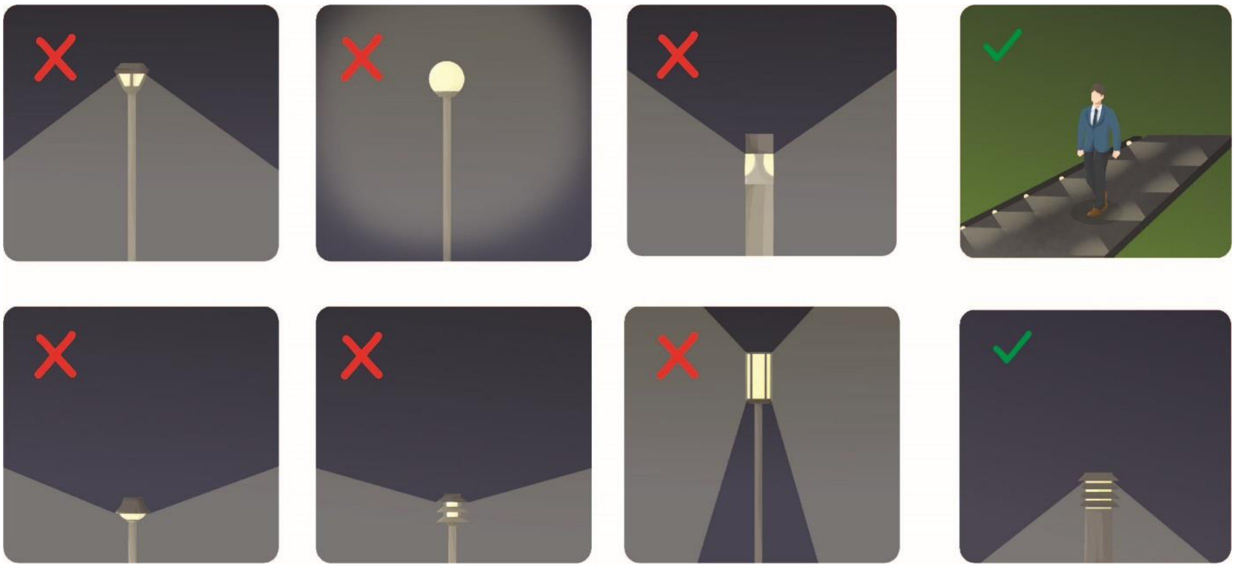

Figure 12 Walkway lighting should be mounted as low as possible. © Pendoley Environmental, adapted from Witherington and Martin (2003)[3].

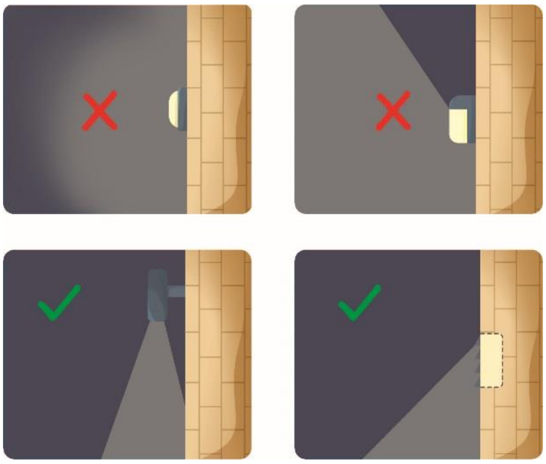

**Figure 13 Lighting should be directed to ensure only the intended area is lit.
© Pendoley Environmental, adapted from Witherington and Martin (2003)[3].**

Artificial light can be prevented from shining above the horizontal plane by ensuring the luminaire is mounted horizontally relative to the ground and not at an angle or mounted on a building so that the structure prevents the light shining above the horizontal plane. When determining angle of the mounting, consideration should be given to the reflective properties of the receiving environment.

If an unshielded fitting is to be used, consideration should be given to the direction of the light and the need for some form of permanent physical opaque barrier that will provide the shielding requirement. This can be a cover or part of a building (Figure 13). Care should be taken to also shield adjacent surfaces, if they are lightly coloured, to prevent excessive reflected light from adding to sky glow.

Consideration should also be given to blocking light spill from internal light sources. This should include block-out blinds for transparent portions of a building, including sky lights.

4. Use appropriate lighting

Lighting intensity should be appropriate for the activity. Starting from a base of no lights, use only the minimum number and intensity of lights needed to provide safe and secure illumination for the area at the time required to meet the lighting objectives. The minimum amount of light needed to illuminate an object or area should be assessed during the early design stages and only that amount of light installed. For example, Figure 14 provides examples lighting for a parking lot.

**Figure 14 Lighting options for a parking area.
© Pendoley Environmental, adapted from Witherington and Martin (2003)[3].**

Off-the-shelf lighting design models

Use of computer design engineering packages that recommend a standard lighting design for general application should be avoided or modified to suit the specific project objectives, location and risk factors.

Lumens mean more than Watts

Improvements in technology mean that new bulb types produce significantly greater amount of light per unit of energy. For example, LED lights produce between two and five times the amount of light as incandescent bulbs. The amount of light produced (lumen), rather than the amount of energy used (watt) is the most important consideration in ensuring that an area is not over lit.

Consider re-evaluating security systems and using motion sensor lighting

Technological advances mean that techniques such as computer managed infra-red tracking of intruders in security zones is likely to result in better detection rates than a human observer monitoring an illuminated zone.

High quality, low glare lighting should always be a strong consideration regardless of how the project is to be designed. Low glare lighting enhances visibility for the user at night and places light where it is needed.

5. Use non-reflective, dark coloured surfaces

Light reflected from highly polished, shiny or light-coloured surfaces such as white painted infrastructure, polished marble or white sand can contribute to sky glow. For example, alternatives to painting storage tanks with white paint to reduce internal heating should be explored during front-end engineering design. If a darker colour paint or material is selected, this should be included in the Artificial Light Management Plan.

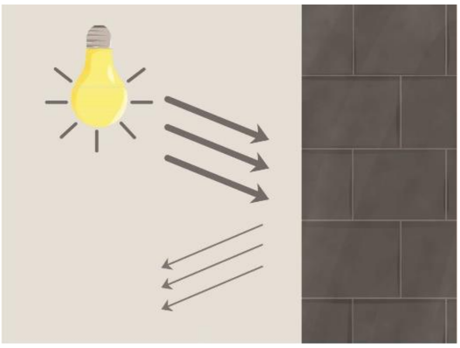

Figure 15 Use non-reflective dark coloured surfaces. © Pendoley Environmental.

6. Use lights with reduced or filtered out blue, violet and ultraviolet wavelengths

Humans and wildlife are sensitive to short wavelength (blue/violet) light (for detailed discussion see What is Light and how do Wildlife Perceive it?). Only lights with little or no short wavelength violet or blue light should be used to avoid unintended effects.

It is not possible to tell how much blue light is emitted from an artificial light source by the colour of light it produces (see Light Emitting Diodes). LEDs of all colours, particularly white, can emit a high amount of blue light and the Colour Correlated Temperature (CCT) only provides a proxy for the blue light content of a light source. Consideration should be given to the spectral characteristics (spectral power distribution curve) of the lighting to ensure short wavelength light is minimised.

Appendix B – What is Light and how does Wildlife Perceive it?

A basic understanding of how light is defined, described and measured is critical to designing the best artificial light management for the protection of wildlife.

Humans and animals perceive light differently. However, defining and measuring light has traditionally been focused exclusively on human vision. Commercial light monitoring equipment is calibrated to the sensitivity of the human eye and has poor sensitivity to the short wavelength light that is most visible to wildlife. These issues should be considered when describing, monitoring and designing lighting near important wildlife habitat.

What is Light?

Light is a form of energy and is a subset of the electromagnetic spectrum that includes visible light, microwaves, radio waves and gamma rays (Figure 16). In humans, visible light ranges from 380 nm to 780 nm - between the violet and red regions of the electromagnetic spectrum. In animals, visible light ranges from 300 nm to greater than 700 nm, depending on the species. White light is a mixture of all wavelengths of light ranging from short wavelength blue to long wavelength red light.

The perception of different wavelengths as 'colour' is subjective and is described and characterised by how the human eye perceives light, ranging from red (700 nm), orange (630 nm), yellow (600 nm), green (550 nm), blue (470 nm), indigo (425 nm) and violet (400 nm) (Figure 16). Generally, this is not how animals see light (Figure 2).

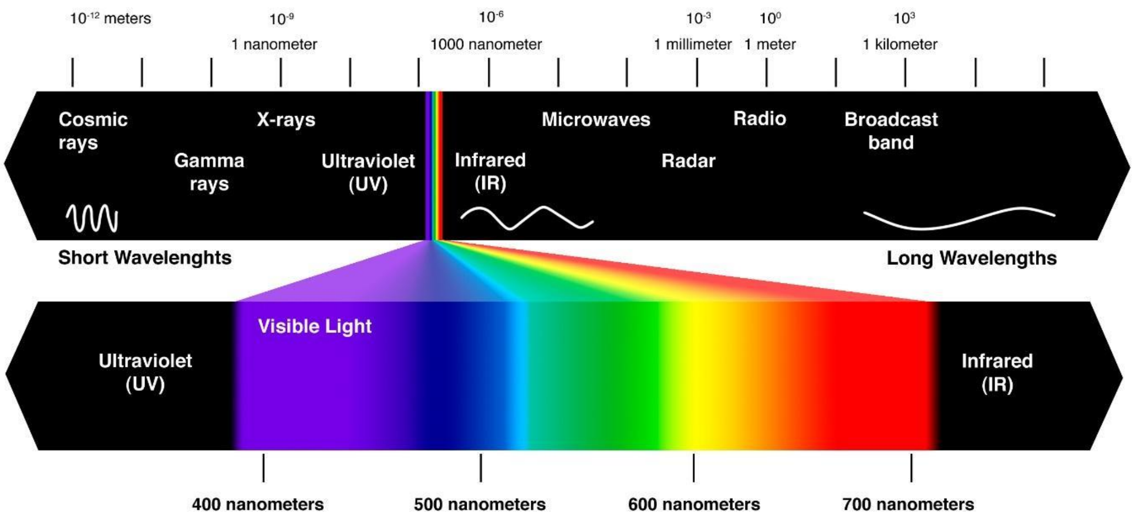

Figure 16 The electromagnetic spectrum. The 'visible light spectrum' occurs between 380-780 nm and is the part of the spectrum that the human eye can see. Credit: Mihail Pernichev[31].

Artificial light

Artificial light at night has many positive attributes. It can enhance human safety and provide for longer periods of work or recreation. However, it can also have a negative effect. For example, it can cause:

- physiological damage to retinal cells in human and animal eyes[32]
- disruption of the circadian cycles in vegetation, animals and humans[2,13,33]
- changes in animal orientation, feeding or migratory behaviour[16,34-36].

The biological mechanisms that cause these effects vary. It is necessary to understand some basic light theory and language in order to assess and manage the effect of light on wildlife. Some basic principles are briefly described in this section.

Vision in Animals

Vision is a critical cue for animals to orient themselves in their environment, find food, avoid predation and communicate[7]. Humans and wildlife perceive light differently. Some animals do not see long wavelength red light at all, while others see light beyond the blue-violet end of the spectrum and into the ultraviolet (Figure 17).

Both humans and animals detect light using photoreceptor cells in the eye called cones and rods. Colour differentiation occurs under bright light conditions (daylight). This is because bright light activates the cones and it is the cones that allow the eye to see colour. This is known as photopic vision.

Under low light conditions (dark adapted vision), light is detected by cells in the eye called rods. Rods only perceive light in shades of grey (no colour). This is known as scotopic vision and it is more sensitive to shorter wavelengths of light (blue/violet) than photopic vision.

The variation in the number and types of cells in the retina means animals and humans do not perceive the same range of colours. In animals, being 'sensitive' to light within a specific range of wavelengths means they can perceive light at that wavelength, and it is likely they will respond to that light source.

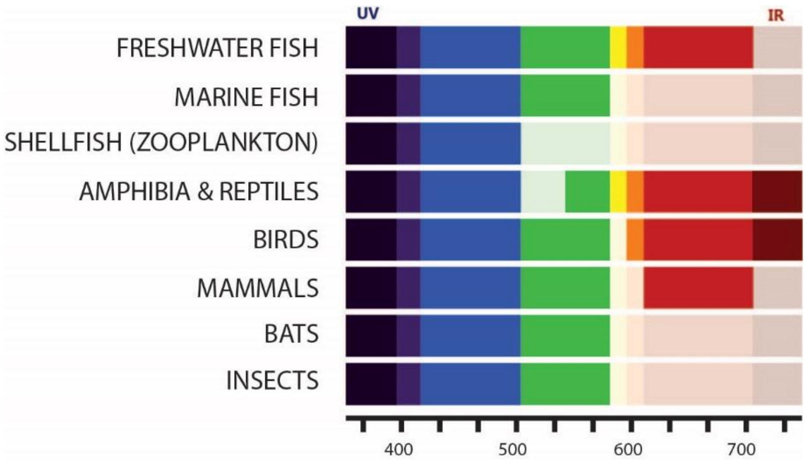

Figure 17 Ability to perceive light in different groups of wildlife. Note the common sensitivity to ultraviolet, violet and blue light. © Pendoley Environmental.

Sensitivity to blue light

Sensitivity to high energy, short wavelength UV/violet/blue light is common in wildlife (Figure 17). This light is strongly detected under scotopic (dark adapted) vision, particularly in nocturnal species. Short wavelength light at the blue end of the spectrum has higher energy than longer wavelength light at the red end of the spectrum. This is important to understanding the physical impact that the short wavelength, high energy UV/blue light has on damaging photoreceptor cells in the eye[37].

In addition to the potential for physical damage to the eye from exposure to blue light (400 - 490 nm), there is mounting evidence that exposure to these wavelengths at night may affect human and wildlife physiological functions. This is because a third type of photoreceptor cell has recently been identified in the retina of the mammalian eye – the photosensitive retinal ganglion cells (pRGCs). The pRGCs are not involved in image-forming vision (this occurs in the rods and cones), but instead regulate the production of melatonin and are involved in synchronising circadian rhythms to the 24-hour light/dark cycle[38]. These cells are particularly sensitive to blue light[39].

Factors Effecting Perception of Light

Factors affecting how humans and wildlife perceive light include the type of cells being employed to detect light (photopic vs scotopic vision); whether the light is viewed directly from the source or as reflected light; how the light interacts with the environment; and the distance from the light source. These influences are discussed below.

Perspective

Understanding an animal's perception of light will include consideration of the animal's visual field. For instance, when flying, birds will generally be looking down on artificial light sources, whereas turtles on a nesting beach will be looking up. Further, some birds' field of view will stretch around to almost behind their head.

Bright vs dim light

Understanding photopic and scotopic vision is important when selecting the colour (wavelength) and intensity of a light because scotopic (dark adapted) vision allows for the detection of light at very low intensities and the sensitivity in the blue/UV region (Figure 18) may explain why nocturnal wildlife are extremely sensitive to white and blue light even at low intensities.

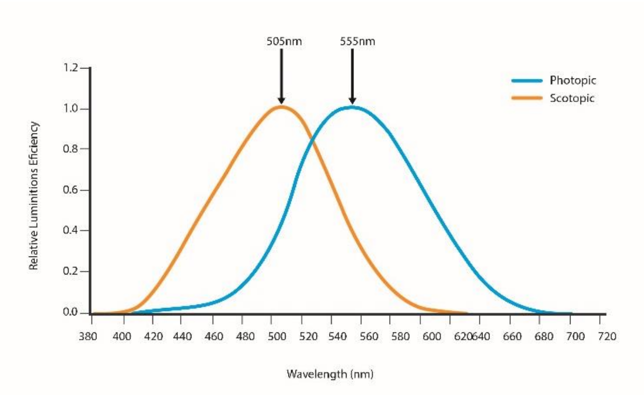

Figure 18 Scotopic and photopic luminosity functions. © Pendoley Environmental.

Direct vs reflected light

Understanding the difference between light direct from the source (luminance) and reflected or refracted light (illuminance) is important when selecting methods for measuring and monitoring light. Equipment used to measure illuminance and luminance is not interchangeable and will lead to incorrect conclusions if used incorrectly.

Luminance describes the light that is emitted, passing through or reflected from a surface. This light is detected by the human eye. The total amount of light emitted from a light is called luminous flux and represents the light emitted in all directions (Figure 19). Luminance is quantified using a Spectroradiometer or luminance meter.

Illuminance describes the measurement of light waves falling onto (illuminating) and spreading over a surface. An instrument to measure this light will be aimed directly at the light source to collect the light waves leaving the source. Illuminance is quantified using an Illuminance spectrophotometer or Lux meter.

The total amount of light emitted by a bulb is measured in lumens and is different to watts, which are a measure of the amount of power consumed by the bulb. Lumens, not watts, provide information about the brightness of a bulb.

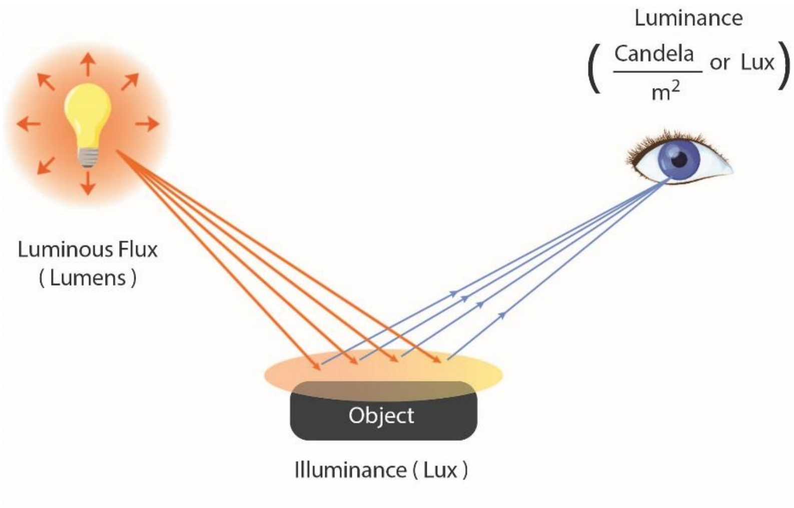

Figure 19 Luminous flux, luminance and illuminance. © Pendoley Environmental

Visibility of light in the environment

The physical properties of light include reflection, refraction, dispersion, diffraction and scattering. These properties are affected by the atmosphere through which light travels. Short wavelength violet and blue light scatters in the atmosphere more than longer wavelength light such as green and red, due to an effect known as Rayleigh scattering[40].

Scattering of light by dust, salt and other atmospheric aerosols increases the visibility of light as sky glow while the presence of clouds reflecting light back to earth can substantially illuminate the landscape[41]. Hence the degree of overhead sky glow is a function of aerosol concentration and cloud height and thickness.

Direct light vs sky glow

Light may appear as a direct light source from an unshielded lamp with direct line of sight to the observer or through sky glow (Figure 20). Sky glow is the diffuse glow caused by light that is screened from view but through reflection and refraction creates a glow in the atmosphere. Sky glow is affected by cloud cover and other particles in the air. White/blue light scatters more easily and further in the atmosphere compared with yellow-orange light. Clouds reflect light well.

Figure 20 Point source of light directly visible (circled left) and sky glow created by lights shielded by a vegetation screen (circled right). © Pendoley Environmental.

Distance from light source

The physical properties of light follow the inverse square law which means that the visibility of the light, as a function of its intensity and spatial extent, decreases with distance (Figure 21). This is an important factor to consider when modelling light or assessing the impact of light across different spatial scales.

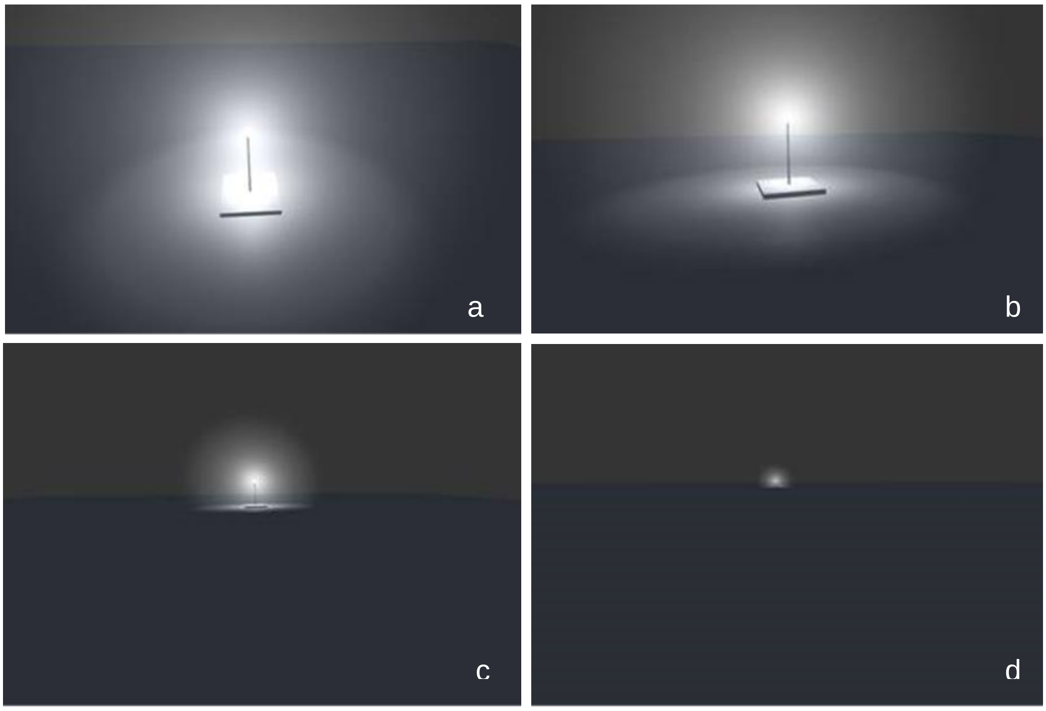

Figure 21 Modelled changes in the visibility of an unshielded 1000 W white LED viewed from a. 10 m; b. 100 m; c. 1 km and d. 3 km. © Pendoley Environmental.

Measurement of Light

Light has traditionally been measured photometrically or using measurements that are weighted to the sensitivity of the human eye (peak 555 nm). Photometric light is represented by the area under the Commission International de l'Eclairage (CIE) curve, but this does not capture all light visible to wildlife (Figure 22).

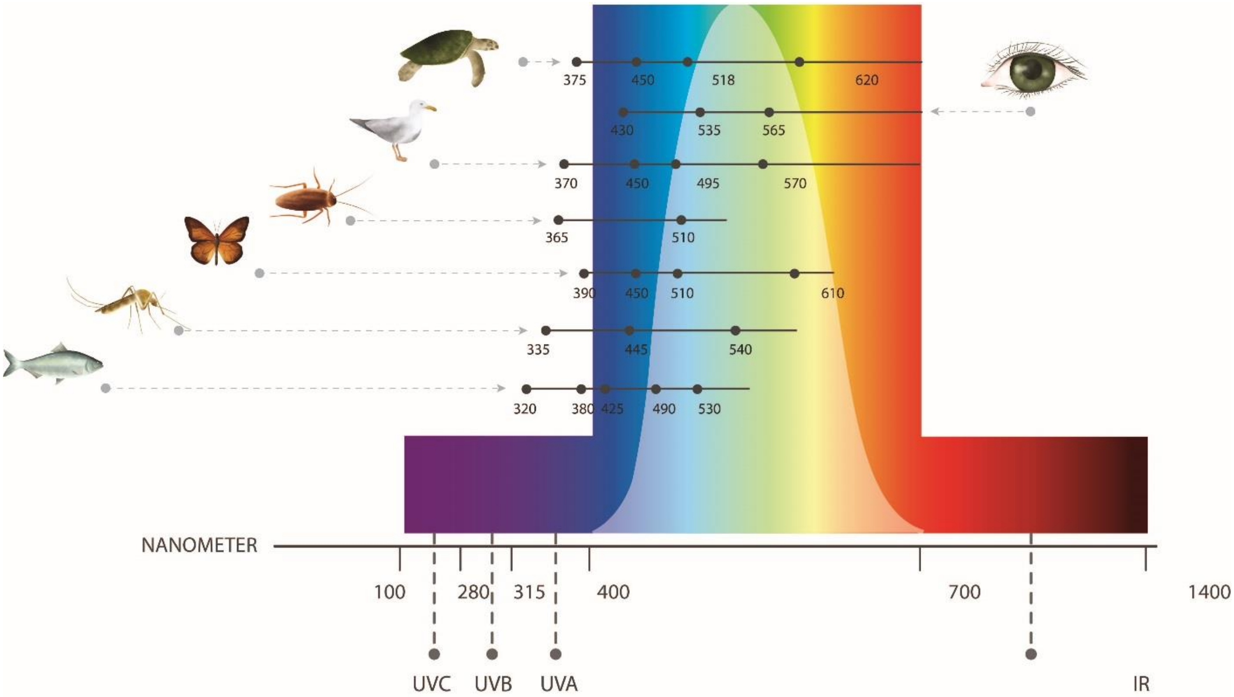

Figure 22 Photometric light represented by the area under the CIE curve (white area). Note that this measurement of light does not include much of the violet and ultra-violet light visible to many animals. © Pendoley Environmental adapted with permission from Campos (2017)[10].

Light can also be measured radiometrically. Radiometric measurements detect and quantify all wavelengths from the ultra-violet (UV) to infrared (IR). The total energy at every wavelength is measured. This is a biologically relevant measure for understanding wildlife perception of light. Terminology, such as radiant flux, radiant intensity, irradiance or radiance all refer to the science and measurement of light across all wavelengths of the electromagnetic spectrum.

Understanding the difference between photometry (weighted to the sensitivity of the human eye) and radiometry (measures all wavelengths) is important when measuring light since many animals see light in the blue and the red regions of the spectrum and, unlike photometry, the study of radiometry includes these wavelengths.

Photometric measures (such as luminous, luminous flux, luminous intensity, illuminance and luminance) can be used to discuss the potential impact of artificial light on wildlife, but their limitations should be taken into account as these measures do not include blue and red wavelengths to which animals can be sensitive.

Spectral curve

White light is made up of wavelengths of light from across the visible spectrum. A spectral power curve (Figure 23) provides a representation of the relative presence of each wavelength emitted from a light source. This is an important tool for understanding the amount of blue light emitted by a lighting design.

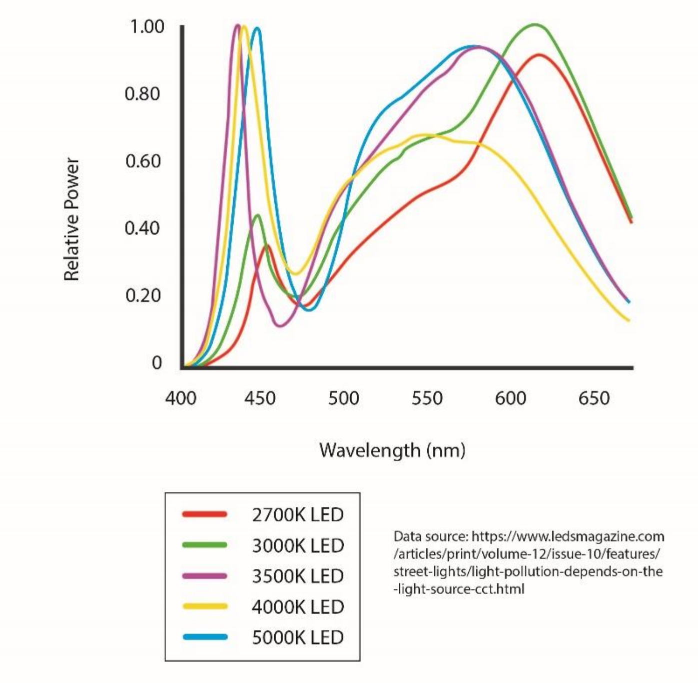

Figure 23 Spectral curves showing the blue content of 2700-5000 K LED lights. © Pendoley Environmental.

Light Emitting Diodes (LEDs)

Light emitting diodes are rapidly becoming the most common light type globally as they are more energy efficient than previous lighting technology. They can be smart controlled and are highly adaptable in terms of wavelength, intensity and can be instantly turned on and off.

Characteristics of LED lights that are not found in older types of lamps, but which should be considered when assessing the impacts of LEDs on wildlife, include:

- With few exceptions, all LED lights contain blue wavelengths (Figure 24).
- The wattage of an LED is a measure of the electrical energy needed to produce light and is not a measure of the amount or intensity of light that will be produced by the lamp.
- The output, or intensity of light produced by all lamps, including LEDs, is measured in lumens (lm).
- LED lamps require less watts (energy) to produce the equivalent amount of light output. For example, 600 lm output of light requires 40 watts of energy for an incandescent light bulb and only 10 watts of energy for a LED lamp. It is important to

not replace an old-style lamp with the equivalent wattage LED. For example, a 100 W incandescent bulb will produce the same amount of light as a 20 W LED.

- Different LED lights with the same correlated colour temperature (CCT) can have very different blue content (Figure 24) yet can appear, to the human eye, to be a similar colour. As the colour temperature of a white LED increases so can the blue content (Figure 23). Little or none of this increase in blue wavelength light is measured by photometric equipment (i.e. lux meter, luminance, illuminance meter, Sky Quality Meter – see Measuring Biologically Relevant Light).
- All animals studied to date (including humans) are affected by blue wavelength light, regardless of the wavelength to which they are most sensitive. It is the single common vision characteristic in all species independent of eye physiology and irrespective of adaptive nocturnal behaviours.

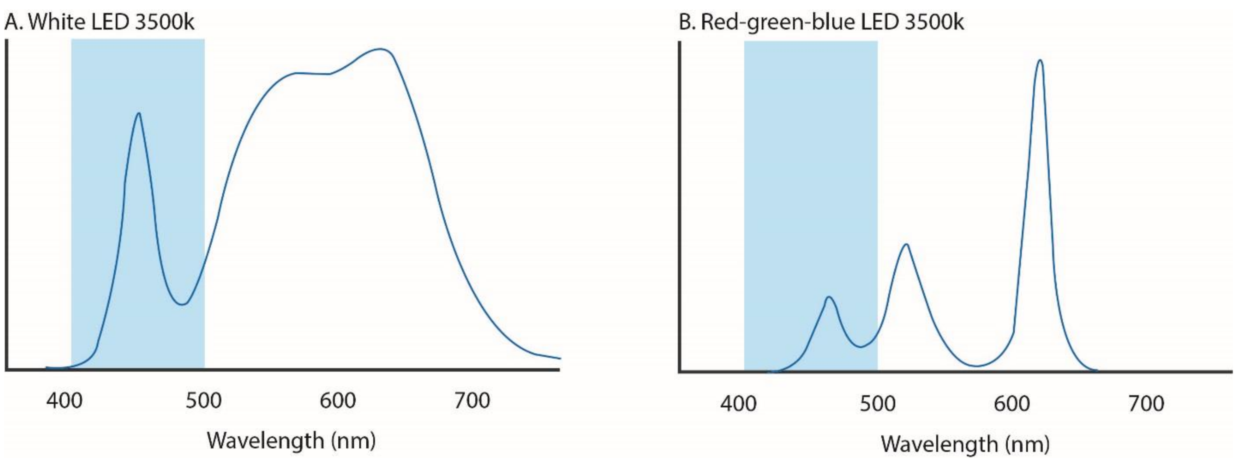

Figure 24 A comparison of the blue wavelength spectral content of two LED lights with the same CCT (3500k). The blue wash shows the blue region of the visible spectrum (400–500 nm). The light in A. has a much greater blue light content than B. yet the two appear to the human eye as the same colour. © Pendoley Environmental.

Correlated colour temperature (CCT)

This is a simplified way to characterise the spectral properties of a light source and is correlated to the response of the human eye. Colour temperature is expressed in degrees Kelvin, using the symbol K, which is a unit of measure for absolute temperature. Practically, colour temperature is used to describe light colour and perceived “warmth”; lamps that have a warm yellowish colour have low colour temperatures between 1000K and 3000K while lamps characterised by a cool bluish colour have a colour temperature, or CCT, over 5000K (Figure 25).

Correlated colour temperature does not provide information about the blue content of a lamp. All LEDs contain blue light (Figure 23) and the blue content generally increases with increased CCT. The only way to determine whether the spectral content of a light source is appropriate for use near sensitive wildlife is to consider the spectral curve.

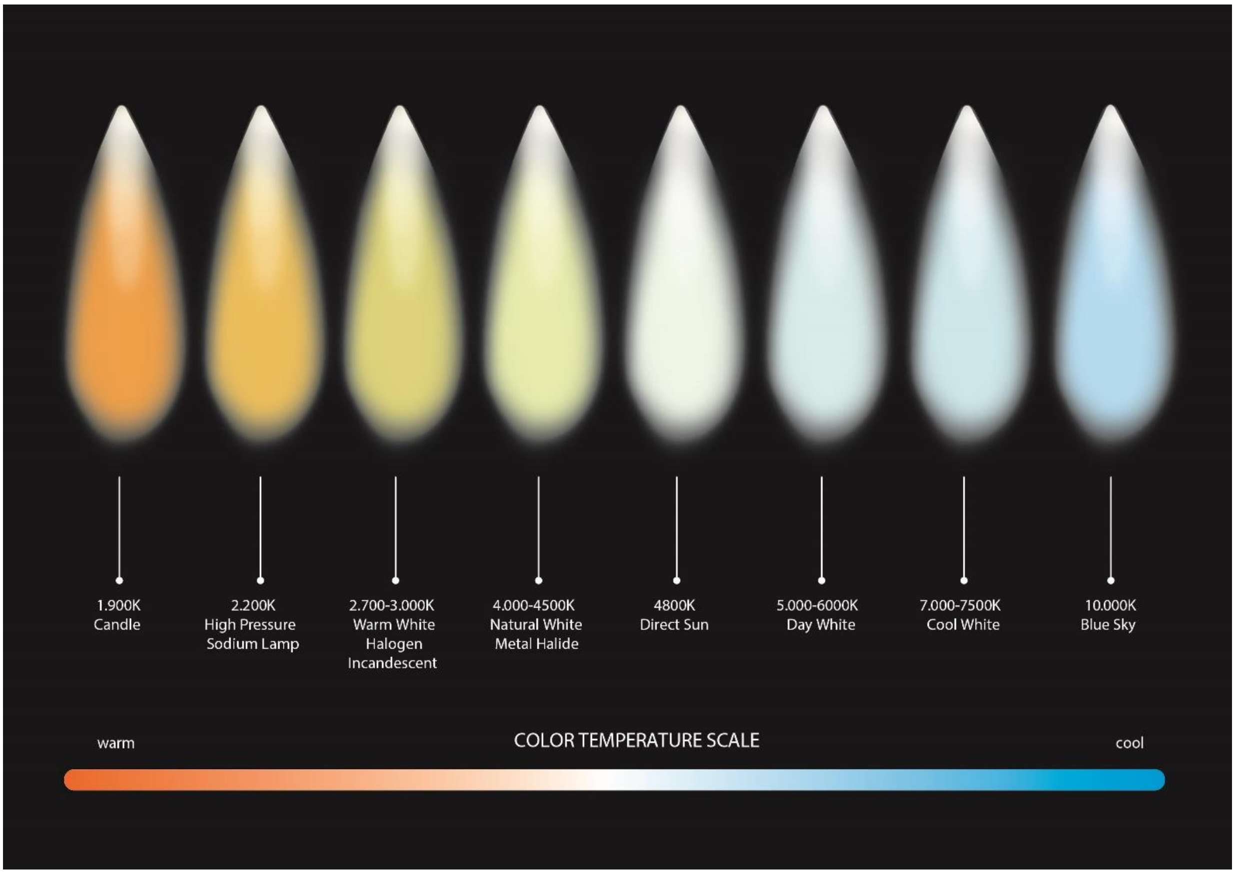

Figure 25 Correlated colour temperature (CCT) range from warm 1000K to cool 10,000K. © Pendoley Environmental.

Appendix C - Measuring Biologically Relevant Light

Animals and humans perceive light differently. Commercial light monitoring instruments focus on measuring the region of the spectrum most visible to humans. It is important to recognise and account for this fact when monitoring light for wildlife impact assessment purposes.

Commercial light modelling programs focus on light most visible to humans and this should also be recognised and accounted for in the impact assessment on wildlife.

Information critical to monitoring light for wildlife includes:

- **Sky glow**
- **Bearings to lights on horizon**
- **Spatial extent of sky glow**
- **Visibility of light (direct and sky glow) from wildlife habitat**
- **Spectral curves of source lights.**

Measuring light to assess its effect on wildlife is challenging. Most instruments used to measure sky glow are still in the research phase of development, with only a few in early operational trials. The wide range of measurement systems and units in use globally makes it difficult to choose an appropriate measurement method and results cannot be compared between techniques due to variations in how light is measured and different units of measurement. There is no globally recognised standard method for monitoring light pollution.

Radiometric vs Photometric Measurement Techniques

Radiometric instruments detect and quantify light equally across the spectrum (see Measurement of Light) and are the only instruments appropriate for monitoring and measuring light for wildlife management. However, the techniques to measure radiometric light are not well developed beyond classical astronomy applications. The instruments being trialled globally are largely experimental or in early stages of academic and/or commercial research and development, are expensive, and require specialised technical skills for operation, data analysis and interpretation and equipment maintenance.

The majority of both commercial and research instruments quantify photometric light, which is weighted to the sensitivity of the human eye, as per the CIE luminosity function curve described in Measurement of Light. Consequently, they have little or no sensitivity to light in the blue (400 – 500 nm) (or the red (650 –700 nm), regions of the spectrum – wavelengths to which wildlife may be sensitive (Figure 22).

When using photometric instruments for monitoring light this insensitivity to the short and long wavelength region of the spectrum should be recognised and accounted for in the assessment of impact. Information on the spectral power distribution of commercial lights is readily available from manufacturers and suppliers and should be used to inform any artificial light impact assessment or monitoring program. An example of the spectral power distribution curves for various light sources is shown in Figure 26, along with an overlay of the CIE curve that represents the light that is measured by all commercial photometric instruments.

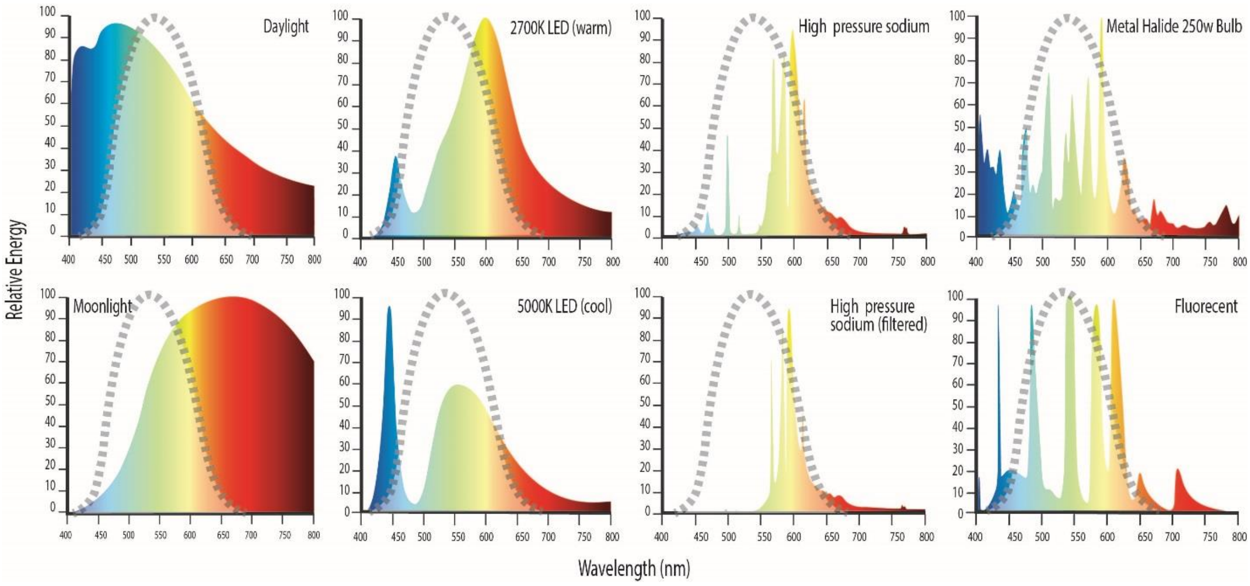

Figure 26 Photometric instruments only quantify light that is within the CIE curve (shaded area under grey dashed line). This is shown in comparison with the spectral curves of a range of different light sources. © Pendoley Environmental.

It is possible and acceptable to use photometric instruments under conditions where the light sources are consistent. Monitoring results can be compared for measurements taken of the same light types (i.e. comparing two High Pressure Sodium, HPS, lights spatially or temporally), but cannot be used to compare light from an HPS and an LED since they have different wavelength distribution. It is not acceptable therefore to use photometric instrument to measure cumulative sky glow, which is often the result of cumulative light from multiple sources and there is more than one light type being assessed. An assessment of the various instrumental techniques for monitoring light is provided in the following sections.

In selecting the most appropriate measuring equipment to monitor the biological impacts of light on wildlife, it is important to decide what part of the sky is being measured; horizon, zenith or whole of sky. For example, marine turtles view light on the horizon between 0° and 30° vertically and integrate across 180° horizontally[42], so it is important to include measurement of light in this part of the sky when monitoring for the effects on hatchling orientation during sea-finding. In contrast, juvenile shearwaters on their first flight view light in three dimensions (vertically, from below and above) as they ascend into the sky. Overhead sky glow (zenith) measurements are important when the observer is trying to avoid glare contamination by point sources of light low on the horizon. Quantifying the whole of sky glow is important when measuring the effects of cloud cover which can reflect light back to illuminate an entire beach or wetland.

The effect of light on wildlife is a function of the animal's sensitivity and response to light and the cues it uses during sea finding, foraging, migrating etc. The effect of light on marine turtle hatchling sea finding behaviour is relatively well understood, but the effects are less well described for seabirds and migratory shorebirds. However, the literature suggests that all three taxa appear to respond to high intensity short wavelength light, point sources of light, sky glow and directional light.

Consequently, the information/techniques likely to be needed to monitor light for marine turtles, shearwaters and migratory shorebirds includes:

- The brightness of the entire sky from horizon to horizon;
- The bearing to light (point sources and sky glow) on the horizon. This will dictate the direction in which wildlife can be disoriented;
- The spatial extent of glow on the horizon. A large area of glow on the horizon is likely to be more visible and attractive to turtle hatchlings, or more disruptive to shearwater fledglings than a small area of glow;
- Presence or absence of clouds. Clouds reflect light from distant sources very well, making an inland source highly visible on the coast. Sky glow is a function of cloud height and thickness;
- Qualitative information on the light visible to wildlife. An image of light pollution visible from wildlife habitat can show the spatial extent of light in the sky and direction (see Figure 20) and in some cases provide information on the light source type (i.e. orange sky glow will be caused by high pressure sodium or amber LEDs);
- Emission spectra (colour) of the light. It is particularly important to identify light in the UV-blue region of the visible spectrum since this is the light most visible and disruptive to wildlife; and
- The ability to measure radiometric and photometric light, recognising that photometric light measurements underestimate the short wavelength blue light most visible to wildlife.

Instrumental Techniques

The science of measuring and monitoring sky brightness or sky glow is complex and poorly understood by most biologists and ecologists. A recent study reviewed the various commercial and experimental instrumental techniques used around the world for quantifying sky glow[43]. The review assessed the benefits and limitations of the various techniques and made recommendations for biologists interested in characterisation of field sites.

Light can be measured in different ways, depending on the objective, landscape scale and point of view and include:

- satellite imagery
- spectrometers
- one dimensional (numerical) instruments
- two dimensional (numerical and imaging) instruments.

Satellite imagery

Satellite photography has been used to map artificial light at night. Examples are:

- [The New World Atlas of Artificial Night Sky Brightness]()
- [Light pollution map]()

<u>Benefits</u>: The maps are useful as broad scale indicators of light pollution and for designing biological and light monitoring programs.

<u>Limitations</u>: Maps have limited value in quantifying light. The images are a measure of light after it has passed though the atmosphere and been subject to scattering and absorption. They do not give an accurate representation of the light visible to wildlife at ground level. The annual composite images are made from images collected under different atmospheric conditions and therefore they cannot be used to confidently quantify light within or between years.

This tool is not appropriate for the measurement of light in wildlife monitoring programs.

Spectroradiometry

A telescope with a spectrometer collects light data as a spectral power distribution curve which deconstructs light into characteristic wavelengths for a specific light type. Different light types produce a specific spectral signature that can be identified within the visible spectrum.

<u>Benefits</u>: This approach can quantify light at specific wavelengths across the entire spectrum (radiometric) so it can measure light visible to wildlife.

<u>Limitations</u>: Collection and interpretation of these data requires specialist knowledge and equipment and is expensive. It requires calibration by a specialist knowledgeable in astronomical calibration techniques. It cannot resolve individual light sources, so is a measure of all cumulative light energy in the sky.

Spectroradiometry can be used with an imaging instrument to measure light visible to wildlife on a local and a landscape scale.

One dimensional (numerical) Instruments

These instruments measure sky glow using a single channel, producing a single numerical value to represent sky glow, typically at zenith. Commonly used instruments, their benefits and limitations are discussed below and summarised in Table 1**.**

Sky quality meter (SQM)

This is a small handheld unit that quantifies the light in an area of sky directly overhead within a 20° field of view. It is simple to use, relatively cheap and portable. It measures photometric light in units of magSQM/arcsec^2 at relatively low detection limits (i.e. it can measure sky glow). Instrument accuracy is reported at ±10 per cent though a calibration study on a group of SQM instruments in 2011 found errors ranging from -16 per cent to +20 per cent[44]. Long term stability of SQMs has not been established.

Reviewers suggest that the first 3-4 measurements from a handheld SQM should be discarded, then the average of four observations should be collected by rotating the SQM 90° after each observation to obtain a value from four different compass directions so that the effects of stray light can be minimised or identified[43]. If the measurements vary by more than 0.2 magSQM/arcsec^2 the data should not be recorded and a new location for measurements selected. Data should not be collected on moonlit nights to avoid stray light influencing the results.

Benefits: The SQM is cheap, easy to use and portable.

Limitations: SQM cannot be used to resolve individual lights, identify light direction nor can it measure light visible to wildlife on the horizon. The precision and accuracy of the instrument can vary substantially and an intercalibration study is recommended to quantify the error of each instrument.

A sky quality meter can be used to measure sky glow overhead at the wildlife habitat, however, it is important to recognise its limitations and follow the methods recommended by Hänel et al (2017).

Dark sky meter

This is an iPhone app developed in the Netherlands.

Benefits: It's cheap and easy to use.

Limitations: It's restricted to Apple iPhones. It will not work on older models and cannot be used to resolve individual lights or identify light direction. It is relatively imprecise and inaccurate and cannot reliably measure light on the horizon.

A dark sky meter is not appropriate for the measurement of light in wildlife monitoring programs.

Solar cell-based Lightmeter and Digilum

These are experimental photometric instruments that are built, calibrated and operated by research groups in Europe.

Benefits: Both instruments report data in lux and have good precision and accuracy.

Limitations: They require specialised knowledge to operate and interpret data. They are expensive (Digilum) or unavailable (Lightmeter) and cannot be used to resolve individual lights or identify light direction nor can they reliably measure light on the horizon.

A solar cell-based Lightmeter and Digilum is not appropriate for the measurement of light in wildlife monitoring programs.

Lux meters and luminance meters

These meters measure photometric light.

Benefits: Both are cheap and easy to use.

Limitations: Their detection limits are not low enough to measure typical night sky brightness and therefore cannot measure sky glow for wildlife monitoring purposes.

Lux and luminance meters are not appropriate for the measurement of light in wildlife monitoring programs.

Two dimensional (Imaging) instruments

These instruments map and measure the sky brightness by analysing photographic images of the whole sky. The images are processed to derive a luminance value for all or parts of the sky. Commonly used, their benefits and limitations are discussed below and summarised in Table 1**.**

All-Sky Transmission Monitor (ASTMON)

This charge-coupled device (CCD) astronomical camera has been modified by the addition of a filter wheel to allow collection across the visible spectrum.

Benefits: The Lite version of the instrument is portable with a weather-proof enclosure and can remain outdoors operating robotically for weeks. It reports data in magnitudes V/arcsec^2 and has good precision and accuracy.

Limitations: The ASTMON is expensive and requires specialised knowledge to operate and interpret data. The software provided is not open source and so cannot be modified to suit individual requirements.

The ASTMON is not appropriate for the measurement of light in wildlife monitoring programs.

All Sky Mosaics

This technique collects whole of sky images by mosaicking 45 images collected using a wide-angle lens. The system comprises a CCD detector, a standard 50 mm lens, an astronomical photometric Bessel V filter with IR blocker and a computer controlled robotic telescope mount. Data collection is managed using a portable computer, commercial software and custom scripts.

Benefits: The precision and accuracy of the system is good, and it is calibrated and standardised for research purposes. The system is best suited for long range monitoring from mountain tops and high-quality dark sites.

Limitations: It is expensive and requires specialised knowledge to operate the system, analyse and interpret data.

All sky mosaics are not appropriate for the measurement of light in wildlife monitoring programs.

Digital Camera Equipped with Wide Angle and Fisheye Lenses

Provides quantitative data on the luminance of the sky in a single image.

Benefits: The cameras are easily accessible and portable. When precision is not critical, the directional distribution of night sky brightness can be obtained. As a minimum, the use of a digital camera with a fisheye lens allows for qualitative imagery data to be collected and stored for future reference and data analysis. If standard camera settings are used consistently in all surveys, it is possible to compare images to monitor spatial and temporal changes in sky brightness.

Limitations: Cameras must be calibrated before use and this, together with the specific camera model, will dictate the precision of the measurements. Calibration for data processing requires lens vignetting (also known as flat fielding), geometric distortion, colour sensitivity of the camera, and sensitivity function of the camera. Specialised knowledge is required to process and interpret these images.

Calibrating the camera is difficult and standard methods have not been developed. Laboratory or classical astronomy techniques are used and both require specialist knowledge and expertise to complete. A precision of ~10 per cent can be achieved using this technique.

A digital camera equipped with wide angle and fisheye lenses is the most appropriate method for measuring light in wildlife monitoring programs.

Most appropriate instrument for measuring biologically relevant light

At the time of writing, the digital camera and fisheye lens technique was recommended by Hänel et al (2017) as the best compromise between cost, ease-of-use and amount of information obtained when measuring and monitoring sky glow. Hänel et al (2017) did, however, recognise the urgent need for the development of standard software for calibration and displaying results from light monitoring instruments[43].

Table 1 Instrumental light measurement techniques (modified from Hänel et al, 2017[43]).

Instrument	Measurement Units	Detect Sky Glow	Data Type	Ease of Use	Commercially Available	Data Quality	Price (as at 2018)	Appropriate for wildlife
SAND[¥]	$W/(m^2 nm\ sr)$	Yes	Spectral power curve	Spec Knowl	Yes	Mod-high	$7000	Landscape scale
Sky Quality Meter - SQM	$mag_{SQM}/arcsec^2$	Yes	Num. Val.	Easy	Yes	Mod	<$300	Limited
Dark Sky Meter – iPhone app	$\sim mag_{SQM}/arcsec^2$	Yes	Num. Val.	Easy	Yes	Low	$0, iPhone only	No
Digilum	Cd/m^2	Yes	Num. Val.	Spec Knowl	?	High	~$16,000	No
Luxmeter	Lux	No	Num. Val.	Easy	Yes	Low	<$300	No
ASTMON	$mag_v/arcsec^2$	Yes	Image + Num. Val.	Spec Knowl	Yes	High	>$15,000	No
USNPS, All sky mosaic	cd/m^2, $mag_v/arcsec^2$	Yes	Image + Num. Val.	Spec Knowl	No	High	~ $20,000	No
*DSLR + fisheye	$\sim cd/m^2$, $\sim mag_v/arcsec^2$	Yes	Image + Num. Val.	Spec Knowl	Yes	Mod-high	>$2,500	Yes

[¥] Spectrometer for Aerosol Night Detection (SAND)

*1D photometric = 1 dimensional photometric numerical values only, 2D photometric = 2 dimensional photometric numerical values and imagery. Num. Val. = Numerical Value: Spec Knowl = Specialist Knowledge required, USNPS = United States National Park Service * System recommended by Hänel et al, 2017 as the best compromise between cost, ease of use and data.

Modelling Predicted Light

Available commercial light models

Most modelling software that is currently available is problematic as the models are weighted towards a human perception of light as represented by the CIE/photometric curve and do not account for the light that is most visible to wildlife. For example, most wildlife is sensitive to short wavelength violet and blue light (Figure 17), but little or none of this light is measured by commercial instruments and consequently it is not accounted for in commercial light models.

A second limitation of many commercial light models is the inability to accurately account for environmental factors, such as: atmospheric conditions (moisture, cloud, rain, dust); site topography (hills, sand dunes, beach orientation, vegetation, buildings); other natural sources of light (moon and stars); other artificial sources of light; the spectral output of luminaires; and the distance, elevation, and viewing angle of the observing animal (which will differ between turtle hatchlings and birds, for example). Such a model would involve a level of complexity that science and technology cannot deliver commercially at this time.

A final major limitation is the lack of biological data with which to confidently interpret a model outcome, therefore it is not possible to put a numerical value on how much artificial light is going to cause an impact on a particular species, or age class, over a given distance and under variable environmental conditions.

Recognising these limitations, it can still be valuable to model light during the design phase to test assumptions about the light environment. For example, models could test for the potential for light spill. These assumptions should be confirmed after construction.

Appendix D – Artificial Light Auditing

Industry best practice requires onsite inspection of a build to ensure it meets design specifications. An artificial light audit should be undertaken after construction to confirm compliance with the artificial light management plan.

An artificial light audit cannot be done by modelling of the as-built design alone and should include a site visit to:

- **Confirm compliance with the artificial light management plan**
- **Check as-built compliance with engineering design**
- **Gather details on each luminaire in place**
- **Conduct a visual inspection of the facility lighting from the wildlife habitat**
- **Review the artificial light monitoring at the project site**
- **Review artificial light monitoring at the wildlife habitat.**

Following completion of a new project or modification/upgrade of the lighting system of an existing project, the project should be audited to confirm compliance with the artificial light management plan.

Step-by-Step Guide

The steps required to carry out an artificial light audit include:

- Review of the artificial light management plan
- Review of best practice light management or approval conditions
- Review of as-built drawings for the lighting design
- Check for compliance with the approved pre-construction (front end) lighting design;
- Conduct a site inspection and visually check the placement, number, intensity, spectral power output, orientation, and management of each lamp and lamp type
- Report on the findings and include any non-conformances
- Make recommendations for any improvements or modifications to the lighting design that will decrease the impact on wildlife.

The audit should be conducted by a qualified environmental practitioner/technical specialist during a site visit. The audit should also include:

- A visual inspection of the facility lighting from the location of the wildlife habitat and where feasible the perspective of the wildlife (i.e. sand level for a marine turtle)
- Artificial light monitoring at the project site
- Artificial light monitoring at the wildlife habitat.

A post-construction site visit is critical to ensure no previously unidentified lighting issues are overlooked.

Appendix E – Artificial Light Management Check List

Table 2 provides a check list of issues to be considered during the environmental assessment of new infrastructure involving artificial light, or upgrades to existing artificial lighting for both proponents and assessors. Table 3 provides a check list of issues to be considered for existing infrastructure with external lighting where listed species are observed to be impacted by artificial light. Relevant sections of the Guidelines are provided for each issue.

Table 2 Checklist for new developments or lighting upgrades.

Issue to be considered	Light owner or manager	Regulator	Further information
Pre-development			
What are the regulatory requirements for artificial light for this project?	Is an environmental impact assessment required? What other requirements need to be addressed?	What information should be sought from the proponent as part of the assessment process?	Regulatory considerations for the management of artificial light
Does the lighting design follow principles of best practice?	What is the purpose of the artificial light for this project?	Does the project use the principles of best practice light design?	Best practice light design
What wildlife is likely to be affected by artificial light?	Review species information within 20 km of the proposed development.	Assess species information.	Wildlife and artificial light
What light management and impact mitigation will be implemented?	What light mitigation and management will be most effective for the affected species?	Is the proposed management and mitigation likely to reduce the effect on listed species?	Species specific technical appendices and species expert guidance
How will light be modelled?	Is light modelling appropriate? How will the model be used to inform light management for wildlife?	Are the limitation of light modelling for wildlife appropriately acknowledged?	Modelling predicted light
Have all lighting-relevant considerations been included in the light management plan?	Have all steps in the EIA process been undertaken and documented in the light management plan?	Does the light management plan comprehensively describe all steps in the EIA process?	Environmental impact assessment for effects of artificial light on wildlife Light Management Plan
How will continuous improvement be achieved?	How will light management be evaluated and adapted?	Is a continuous review and improvement process described?	Light Management Plan

Issue to be considered	Light owner or manager	Regulator	Further information
Post development			
How will lighting be measured?	What is the appropriate technique for measuring biologically relevant light?	Ensure appropriate light measurement techniques are used or limitations of methods recognised.	Measuring biologically relevant light
How will lighting be audited?	What is the frequency and framework for in-house light auditing?	How will the results of light audits feedback into a continuous improvement process?	Artificial light auditing
Is artificial light affecting wildlife?	Does the biological monitoring indicate an effect of artificial light on fauna?	How will the results of light audits feedback into a continuous improvement process?	Wildlife and artificial light Light Management Plan Managing existing light pollution
What adaptive management can be introduced?	How will the results of light audits and biological monitoring be used in an adaptive management framework, and how will technological developments be incorporated into artificial light management?	What regulatory mechanisms can be put in place to ensure that approval conditions can adjust to new information? Conditions put in place in 2020 may not be suitable in 2050 for the same project.	Light Management Plan

Table 3 Checklist for existing infrastructure

Consideration	Light owner or manager	Regulator	Further information
Are wildlife exhibiting a change in survivorship, behaviour or reproduction that can be attributed to artificial light?	What listed species are found within 20 km of light source? Are there dead animals or are animals displaying behaviour consistent with the effects of artificial light?	Is there evidence to implicate artificial light as the cause of the change in wildlife survivorship, behaviour or reproductive output? Review existing environmental approvals.	Describe wildlife Wildlife and artificial light Regulatory considerations for the management of light Species expert advice
Is lighting in the area best practice?	Are there improvements or technological upgrades that could be made to improve artificial light management?	Are there individual light owners or managers who can be approached to modify current lighting?	Principles of best practice light management
Is the light affecting wildlife from a single source or multiple sources?	Are there multiple stakeholders that need to come together to address the cumulative light pollution?	Is there a role for government to facilitate collaboration between light owners and managers to address light pollution?	Managing existing light pollution Light Management Plan
Can appropriate monitoring be undertaken to confirm the role of artificial light in wildlife survivorship, behavioural or reproductive output changes?	How much light is emitted from my property?	Facilitate wildlife monitoring.	Field surveys for wildlife Measuring biologically relevant light Species expert advice
How will artificial light be audited?	What is the frequency and framework for in-house light auditing?	Can a light audit be undertaken on a regional scale?	Artificial light auditing
What adaptive light management can be introduced?	Are there improvements in lighting technology that can be incorporated into existing lighting?	What changes can be implemented in response to biological monitoring and light audits?	Specialist lighting engineer advice

Appendix F - Marine Turtles

Marine turtles nest on sandy beaches in northern Australia. There is a robust body of evidence demonstrating the effect of light on turtle behaviour and survivorship. Light is likely to affect the turtles if it can be seen from the nesting beach.

Adult females may be deterred from nesting where artificial light is visible on a nesting beach. Hatchlings may become misoriented or disoriented and be unable to find the sea or successfully disperse to the open ocean. The effect of light on turtle behaviour has been observed in lights up to 18 km away.

The physical aspects of light that have the greatest effect on turtles include intensity, colour (wavelength), and elevation above beach. Management of these aspects will help reduce the threat from artificial light.

Six species of marine turtles are found in Australia: the green (*Chelonia mydas*), loggerhead (*Caretta caretta*), hawksbill (*Eretmochelys imbricata*), olive ridley (*Lepidochelys olivacea*), flatback (*Natator depressus*) and leatherback (*Dermochelys coriacea*) turtles.

Light pollution was identified as a high-risk threat in the *Recovery Plan for Marine Turtles in Australia (2017)* because artificial light can disrupt critical behaviours such adult nesting and hatchling orientation, sea finding and dispersal, and can reduce the reproductive viability of turtle stocks[45]. A key action identified in the Recovery Plan was the development of guidelines for the management of light pollution in areas adjacent to biologically sensitive turtle habitat.

Figure 27 Loggerhead turtle. Photo: David Harasti.

Conservation Status

Marine turtles in Australia are protected under international treaties and agreements including the Convention on the Conservation of Migratory Species of Wild Animals (CMS, Bonn 1979), the Convention on International Trade in Endangered Species of Flora and Fauna (CITES, Washington 1973), and the CMS Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-east Asia (IOSEA, 2005). In Australia, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) gives effect to these international obligations.

All six species are listed under the EPBC Act as threatened, migratory and marine species. They are also protected under state and territory legislation.

The *Recovery Plan for Marine Turtles in Australia* (2017) identifies threats to marine turtles and actions required to recover these species[45]. To ensure the maintenance of biodiversity, the Plan considers marine turtles on a genetic stock basis rather than the species level. The Plan found light pollution to be a high-risk threat to five of 22 genetic stocks of marine turtles. The development and implementation of best practice light management guidelines was identified as a key action for promoting the recovery of marine turtles[45].

Distribution

Turtle nesting habitats include sub-tropical and tropical mainland and offshore island beaches extending from northern New South Wales on the east coast around northern Australia to Shark Bay in Western Australia. The extent of the known nesting range for each genetic stock can be found on the Department of the Environment and Energy's Species Profile and Threats Database and in the Recovery Plan[45].

Timing of nesting and hatching

Marine turtles nesting in the far north, between the Kimberley and Cape York, typically nest year round, but have a peak during the cooler winter months, while summer nesting is favoured by turtles nesting from the Central Kimberley south in Western Australia and along the Pacific coast of Queensland and Northern New South Wales. Specific timing of nesting and hatching seasons for each stock can be found in the Recovery Plan[45].

Important habitat for marine turtles

The effect of artificial lights on turtles is most pronounced at nesting beaches and in the internesting area through which hatchlings travel to reach the ocean. For the purposes of these Guidelines, Important Habitat for turtles includes all areas that have been designated as **Habitat Critical to Survival of Marine Turtles** and **Biologically Important Areas (BIAs)**, or in Queensland areas identified under local planning schemes as **Sea Turtle Sensitive Areas**.

- **Habitat Critical to the Survival of Marine Turtles** was identified for each stock as part of the development of the *Recovery Plan for Marine Turtles in Australia (2017)*. Nesting and internesting areas designated as Habitat Critical to the Survival of Marine Turtles can be found in the Recovery Plan or through the Department of the Environment and Energy's National Conservation Values Atlas.

- **Biologically Important Areas** (BIAs) are areas where listed threatened and migratory species display biologically important behaviour such as breeding, foraging, resting and migration. BIAs of highest relevance for the consideration of light impacts are nesting and internesting BIAs for each species. Marine turtle BIAs can be explored through the Department of the Environment and Energy's National Conservation Values Atlas.
    - The presence of a BIA recognises that biologically important behaviours are known to occur, but the absence of such a designation does not preclude the area from being a BIA. Where field surveys identify biologically important behaviour occurring, the habitat should be managed accordingly.
- **Sea Turtle Sensitive Areas** have been defined in local government planning schemes in accordance with the Queensland Government Sea Turtle Sensitive Area Code. These may be shown in local government biodiversity of coastal protection overlay maps in the planning scheme.

Effects of Artificial Light on Marine Turtles

The effect of artificial light on turtle behaviour has been recognised since 1911[46] and since then a substantial body of research has focused on how light affects turtles and its effect on turtle populations - for review see Witherington and Martin (2003)[3]; Lohmann et al (1997)[42]; and Salmon (2003)[47]. The global increase in light pollution from urbanisation and coastal development[48] is of particular concern for turtles in Australia since their important nesting habitat frequently overlaps with areas of large-scale urban and industrial development[49], which have the potential to emit a large amount of light, including direct light, reflected light, sky glow and gas flares[50,51]. Nesting areas on the North West Shelf of Western Australia and along the south-eastern coast of Queensland were found to be at the greatest risk from artificial light[49].

Effect of artificial light on nesting turtles

Although they spend most of their lives in the ocean, females nest on sandy tropical and subtropical beaches, predominantly at night. They rely on visual cues to select nesting beaches and orient on land. Artificial night lighting on or near beaches has been shown to disrupt nesting behaviour[3]. Beaches with artificial light, such as urban developments, roadways, and piers typically have lower densities of nesting females than dark beaches[47,52].

Some light types do not appear to affect nesting densities (Low Pressure Sodium, LPS, and filtered High Pressure Sodium, HPS), which excluded wavelengths below 540 nm)[53]. On beaches exposed to light, females will nest in higher numbers in areas that are shadowed[54]. Moving sources of artificial light may also deter nesting or cause disturbance to nesting females (e.g. flash photography)[36].

Effect of artificial light on hatchlings emerging from the nest

Most hatchling turtles emerge at night[55] and must rapidly reach the ocean to avoid predation[36]. Hatchlings locate the ocean using a combination of topographic and brightness cues, orienting towards the lower, brighter oceanic horizon and away from elevated darkened silhouettes of dunes and/or vegetation behind the beach[34,42,56]. Sound and beach slope are secondary cues that are overruled by light[42].

Sea finding behaviour may be disrupted by artificial lights, including flares[50], which interfere with natural lighting and silhouettes[3,23,34]. Artificial lighting may adversely affect hatchling sea finding behaviour in two ways: disorientation - where hatchlings crawl on circuitous paths; or misorientation - where they move in the wrong direction, possibly attracted to artificial lights[3,36]. On land, movement of hatchlings in a direction other than the sea often leads to death from predation, exhaustion, dehydration, or being crushed by vehicles on roads[57].

Wavelength, intensity and direction

Brightness is recognised as an important cue for hatchlings as they attempt to orient toward the ocean. Brightness refers to the intensity and wavelength of light relative to the spectral sensitivity of the receiving eye[3]. Both field and laboratory-based studies indicate that hatchlings have a strong tendency to orient towards the brightest direction. The brightest direction on a naturally dark beaches is typically towards the ocean where the horizon is open and unhindered by dune or vegetation shadows.

The attractiveness of hatchlings to light differs by species[51,58,59], but in general, artificial lights most disruptive to hatchlings are those rich in short wavelength blue and green light (e.g. metal halide, mercury vapour, fluorescent and LED)[51,60] and lights least disruptive are those emitting long wavelength pure yellow-orange light (e.g. high or low pressure sodium vapour). Loggerhead turtles are particularly attracted to light at 580 nm[61], green and flatback turtles are attracted to light <600 nm with a preference to blue light (400 – 450 nm) over longer wavelength light[51,60], while flatback turtles are also attracted to light in the ultra violet range (365 – 400 nm[60]). Metal halide lighting has been found to be particularly disruptive to flatback turtle hatchlings on land, even at low intensities, as it is enriched in short wavelength light[34].

Although longer wavelengths of light are less attractive than shorter wavelengths, they can still disrupt sea finding[34,51,62], and if bright enough can elicit a similar response to shorter wavelength light[63,64]. Hence, the disruptive effect of light on hatchlings is also strongly correlated with intensity. Red light must be almost 600 times more intense than blue light before green turtle hatchlings show an equal preference for the two colours[64]. It is therefore important to consider both the wavelength and the intensity of the light.

Since the sun or moon may rise behind the dunes on some nesting beaches, hatchlings attracted to these point sources of light would fail to reach the ocean. Hatchlings orientate themselves by integrating light across a horizontally broad (180° for green, olive ridley and loggerhead turtles) and vertically narrow ("few degrees" for green and olive ridleys, and 10° - 30° for loggerheads) "cone of acceptance" or "range of vision". This integration ensures that light closest to the horizon plays the greatest role in determining orientation direction, so it is important to consider the type and direction of light that reaches the hatchling[42].

As a result of these sensitivities, hatchlings have been observed to respond to artificial light up to 18 km away during sea finding[23].

Shape and form

Horizon brightness and elevation are also important cues for hatchling orientation. In laboratory and field studies hatchlings move away from elevated horizons and towards the lowest bright horizon[56,65]. However, in situations where both cues are present, hatchlings are more responsive to the effects of silhouettes and darkened horizon elevation than to differences in brightness. On a natural beach this behaviour would direct the hatchlings away from dunes and vegetation and towards the more open horizon over the ocean.

This hypothesis has been supported by field experiments where hatchling sea finding was significantly less ocean oriented when exposed to light at 2° elevation compared with 16° elevation, emphasising the importance of horizon elevation cues in hatchling sea-finding[34].

Effect of artificial light on hatchlings in nearshore waters

Artificial lights on land can also interfere with the dispersal of hatchlings swimming through nearshore waters. Lights can slow their in-water dispersal[59,66], increase their dispersion path[59] or even attract hatchlings back to shore[67]. In addition to interfering with swimming it can influence predation rates, where hatchlings were predated more in areas with significant sky glow[68,69]. Since the nearshore area tends to be predator-rich, hatchling survival may depend on them rapidly leaving this area[68].

At sea, hatchlings have been reported swimming around lights on boats[30,70] and in laboratory studies lights have attracted swimming hatchlings[71]. Recent advances in acoustic technology has allowed hatchlings to be tracked at sea, demonstrating that hatchlings are attracted to lights at sea and spend longer in the nearshore environment when lights are present[66,72]. In one study, approximately 80 per cent of hatchlings oriented towards a metal halide light and became trapped in the light spill, while 60 per cent of hatchlings were attracted to longer wavelength high pressure sodium light[66]. This can become a more serious problem when light sources are associated with structures that also attract fish (such as jetties), as there will be increased predation[21].

Hatchling's attraction to white LEDs increases with increasing intensity. Recent studies on the effects of light intensity on hatchlings in the water found olive ridley hatchlings were attracted to low intensity green and yellow lights, and to high intensity red lights while swimming[73]. And a field study investigating five different intensities of white LEDs located on a boat found an increase in hatchling attraction with increasing LED intensity during their nearshore transit (Wilson et al. unpublished data). This study also provided evidence that the presence of artificial light (white LEDs) contributed to an increase in predator encounter rates, with the highest rates in the brightest (120 watt) treatment.

Environmental Impact Assessment of Artificial Light on Marine Turtles

Infrastructure with artificial lighting that is externally visible should implement Best Practice Lighting Design as a minimum. Where there is important habitat for turtles within 20 km of a project, an EIA should be undertaken. The following sections step through the EIA process with specific consideration for turtles.

The 20 km buffer required for considering important habitat is based on sky glow approximately 13 km from the nesting beach affecting flatback hatchling behaviour[23] and light from an aluminium refinery disrupting turtle orientation 18 km away[24].

Where artificial light is likely to affect marine turtles, consideration should be given to employing mitigation measures as early as possible in a project's life cycle and used to inform the design phase.

Associated guidance

- *Recovery Plan for Marine Turtles in Australia* (2017)
- *Single Species Action Plan for the Loggerhead Turtle (*Caretta caretta*) in the South Pacific Ocean*
- Queensland Government *Sea Turtle Sensitive Area Code*

Qualified personnel

Lighting design/management and the EIA process should be undertaken by appropriately qualified personnel. Light management plans should be developed and reviewed by appropriately qualified lighting practitioners who should consult with an appropriately qualified marine biologist or ecologist. Methods that lower the impact of artificial light on turtles should be incorporated into the lighting design process and reduce the need to refer the activity for environmental approval.

People advising on the development of a lighting management plan, or the preparation of reports assessing the impact of artificial light on marine turtles should have qualifications equivalent to:

- a tertiary qualified marine turtle biologist; or
- publication on a relevant topic in peer reviewed literature within the past five years; or
- a member of the IUCN Marine Turtle Specialist Group.

Step 1: Describe the project lighting

Information collated during this step should consider the Effects of Light on Marine Turtles. Turtles are susceptible to the effect of light on beaches and in the water, so the location and light source (both direct and sky glow) should be considered. Turtles are most sensitive to short wavelength (blue/green) light and high intensity light of all wavelengths. Hatchlings are most susceptible to light low on the horizon. They orient away from tall dark horizons so the presence of dunes and/or a vegetation buffer behind the beach should be considered at the design phase.

Step 2: Describe marine turtle population and behaviour

The species and the genetic stock nesting in the area of interest should be described. This should include the conservation status of the species; stock trends (where known); how widespread/localised nesting for that stock is; the abundance of turtles nesting at the location; the regional importance of this nesting beach; and the seasonality of nesting/hatching.

Relevant species and stock specific information can be found in the *Recovery Plan for Marine Turtles in Australia* (2017), Protected Matters Search Tool, National Conservation Values Atlas state and territory protected species information; scientific literature and local/Indigenous knowledge.

Where there is insufficient data to understand the population importance or demographics, or where it is necessary to document existing turtle behaviour, field surveys and biological monitoring may be necessary.

Biological monitoring of marine turtles

Any monitoring associated with a project should be carried out by appropriately qualified personnel to ensure reliability of the data.

The objectives of turtle monitoring in an area likely to be affected by artificial light are to:

- understand the size and importance of the population;
- describe turtle behaviour before the introduction/upgrade of light; and
- assess nesting and hatchling orientation behaviour to determine the cause of apparent misorientation or disorientation.

The data will be used to inform the EIA and assess whether mitigation measures are successful. Suggested minimum monitoring parameters (what is measured) and techniques (how to measure them) are summarised in Table 4.

As a minimum, qualitative descriptive data on visible light types, location and directivity should also be collected at the same time as the biological data. Handheld-camera images can help describe the light. Quantitative data on existing sky glow should be collected, if possible, in a biologically meaningful way, recognising the technical difficulties in obtaining these data. See Measuring Biologically Relevant Light for a review.

Table 4 Recommended minimum biological information required to assess the importance of a marine turtle population and existing behaviour, noting that the risk assessment will guide the extent of monitoring required (e.g. a large source of light visible over a broad spatial scale will require monitoring of multiple beaches whereas a smaller localised source of light may require fewer beaches to be monitored).

Target Age Class	Survey Effort	Duration	Reference
Adult Nesting	Daily track census over 1–1.5 internesting cycles at peak of the nesting season (14–21 days). If the peak nesting period for this population/at this location has not been defined, then a study should be designed in consultation with a qualified turtle biologist to determine the temporal extent of activity (i.e. systematic monthly surveys over a 12-month period).	Minimum two breeding seasons	Eckert et al (1999)[74] Pendoley et al (2016)[75] Queensland Marine Turtle Field Guide NWSFTCP Turtle Monitoring Field Guide Ningaloo Turtle Monitoring Field Guide
Hatchling Orientation	Hatchling fan monitoring. Minimum of 14 days over a new moon phase about 50 days* after the peak of adult nesting.	Minimum two breeding seasons	Pendoley (2005)[51] Kamrowski et al (2014)[23] Witherington (1997)[76]

*Incubation time will be stock specific. Consult the Recovery Plan for Marine Turtles in Australia for stock specific information.

To understand existing hatchling behaviour, it will be necessary to undertake hatchling fan monitoring (or similar approach) to determine hatchling ability to locate the ocean prior to construction/lighting upgrades.

A well-designed monitoring program will capture:

- hatchling behaviour[23,51,76] at the light exposed beach and a control beach
- hatchling behaviour before project construction begins to establish a benchmark to measure against possible changes during construction and operations
- hatchling behaviour on a new moon to reduce the influence of moonlight and capture any worst case scenario effects of artificial light on hatching orientation
- hatchling behaviour on full moon nights to assess the relative contribution of the artificial light to the existing illuminated night sky.

Ideally, survey design will ensure that hatchling orientation and artificial light data sets can be integrated for meaningful analysis and interpretation of findings.

Step 3: Risk assessment

The Recovery Plan states that management of light should ensure turtles are not displaced from habitat critical to their survival and that anthropogenic activities in biologically important areas are managed so that the biologically important behaviour can continue. These consequences should be considered in the assessment process. The aim is to ensure that at important nesting beaches females continue to nest on the beach, post nesting females return to the ocean successfully and hatchlings orient in a seaward direction.

Consideration should be given to the relative importance of the site for nesting. For example, if this is the only site at which a stock nests, a higher consequence rating should result from the effects of light

In considering the likely effect of light on turtles, the risk assessment should consider the existing light environment, the proposed lighting design and mitigation/management, and the behaviour of turtles at the location. Consideration should be given to how the turtles will perceive light. This should include wavelength and intensity information as well as perspective. To assess how/whether turtles are likely to see light, a site visit should be made at night and the area viewed from the beach (approximately 10 cm above the sand) as this will be the perspective of the nesting turtles and emerging hatchlings. Similarly, consideration should be given to how turtles (both adults and hatchlings) will see light when in nearshore water.

Using this perspective, the type and number of lights should be considered/modelled to determine whether turtles are likely to be able to perceive light and what the consequence of the light on their behaviour is likely to be.

Step 4: Light management plan

A light management plan for marine turtles should include all relevant project information (Step 1) and biological information (Step 2). It should outline proposed mitigation. For a range of specific mitigation measures see the Mitigation Toolbox below. The plan should also outline the type and schedule for biological and light monitoring to ensure mitigation is meeting the objectives of the plan and triggers for revisiting the risk assessment phase of the EIA. The plan should outline contingency options if biological and light monitoring or compliance audits indicate that mitigation is not meeting the objectives of the plan (e.g. light is visible on the nesting beach or changes in nesting/hatchling behaviour are observed).

Step 5: Biological and light monitoring and auditing

The success of risk mitigation and light management should be confirmed through monitoring and compliance auditing. The results should be used to inform continuous improvement.

Relevant biological monitoring is described in Step 2: Describe marine turtle population and behaviour above. Concurrent light monitoring should be undertaken and interpreted in the context of how turtles perceive light and within the limitations of monitoring techniques described in Measuring Biologically Relevant Light. Auditing as described in the light management plan should be undertaken.

Marine Turtle Light Mitigation Toolbox

Appropriate lighting design/lighting controls and light impact mitigation will be site/project and species specific. Table 5 provides a toolbox of options for use around important habitat. These options would be implemented in addition to the six Best Practice Light Design principles. Not all mitigation options will be required for every project. Table 6 provides a suggested list of light types appropriate for use near turtle nesting beaches and those to avoid.

One of the most effective approaches for management of light near important nesting beaches is to ensure there is a tall dark horizon behind the beach such as dunes and/or a natural vegetation screen.

Table 5 Light management options specific to marine turtle nesting beaches.

Management Action	Detail
Implement light management actions during the nesting and hatching season.	Peak nesting season for each stock can be found in the Recovery Plan for Marine Turtles in Australia[45].
Avoid direct light shining onto a nesting beach or out into the ocean adjacent to a nesting beach.	Adult turtles nest in lower numbers at lit beaches[14].
Maintain a dune and/or vegetation screen between the nesting habitat and inland sources of light.	Hatchlings orient towards the ocean by crawling away from the tall, dark horizon provided by a dune line and/or tree screen.
Maintain a dark zone between turtle nesting beach and industrial infrastructure	Avoid installing artificial light within 1.5 km of an industrial development[63].
Install light fixtures as close to the ground as practicable.	Any new lighting should be installed close to the ground and reduce the height of existing lights to the extent practicable to minimise light spill and light glow.
Use curfews to manage lighting.	Extinguish lights around nesting beaches by 10 pm.
Aim lights downwards and direct them away from nesting beaches.	Aim light onto the exact surface area requiring illumination. Use shielding on lights to prevent light spill into the air and outside the footprint of the target area.
Use flashing/intermittent lights instead of fixed beam.	For example, small red flashing lights can be used to identify an entrance or delineate a pathway.
Use motion sensors to turn on lights only when needed.	For example, motion sensors could be used for pedestrian or street lighting near a nesting beach.
Prevent indoor lighting reaching beach.	Use fixed window screens or window tinting on fixed windows and skylights to contain light inside buildings.
Limit the number of beach access areas or construct beach access such that artificial light is not visible through the access point.	Beach access points often provide a break in dune or vegetation that protects the beach from artificial light. By limiting the number of access points or making the access path wind through the vegetation, screen light spill can be mitigated.
Work collectively with surrounding industry/private land holders to address the cumulative effect of artificial lights.	Problematic sky glow may not be caused by any one light owner/manager; by working with other industry/stakeholders to address light pollution, the effect of artificial light may be reduced more effectively.
Manage artificial light at sea, including on vessels, jetties and marinas.	Hatchlings are attracted to, and trapped by, light spill in the water.

Management Action	Detail
Reduce unnecessary lighting at sea.	Extinguish vessel deck lights to minimum required for human safety and when not necessary. Restrict lighting at night to navigation lights only.
Avoid shining light directly onto longlines and/or illuminating baits in the water.	Light on the water can trap hatchlings, delaying their transit through nearshore waters, consuming their energy reserves and exposing them to predators.
Avoid lights containing short wavelength violet/blue light.	Lights rich in blue light include; metal halides, fluorescent, halogens, mercury vapour and most LEDs.
Avoid white LEDs.	Ask supplier for an LED light with little or no blue in it or only use LEDs filtered to block the blue light. This can be checked by examining the spectral power curve for the globe.
Avoid high intensity light of any colour.	Keep light intensity as low as possible in the vicinity of nesting beaches. Hatchlings can see all wavelengths of light and will be attracted to long wavelength amber and red light as well as the highly visible white and blue light, especially if there is a large difference between the light intensity and the ambient dark beach environment.
Shield gas flares and locate inland and away from nesting beach.	Manage gas flare light emissions by: reducing gas flow rates to minimise light emissions; shielding the flame behind a containment structure; elevating glow from the shielded flare more than 30^{o} above hatchling field of view; containing pilot flame for flare within shielding; and scheduling maintenance activity requiring flaring outside of turtle hatchling season.
Industrial/port or other facilities requiring intermittent night-time light for inspections should keep the site dark and only light specific areas when required.	Use amber/orange explosion proof LEDs with Smart lighting controls and/or motions sensors. LEDs have no warmup or cool down limitations so can remain off until needed and provide instant light when required for routine nightly inspections or in the event of an emergency.
Industrial site/plant operators to use head torches.	Consider providing plant operators with white head torches (explosion proof torches are available) for situations where white light is needed to detect colour correctly or when there is an emergency evacuation.
Supplement facility perimeter security lighting with computer monitored infra-red detection systems.	Perimeter lighting can be operated if night-time illumination is necessary, but remain off at other times.
No light source should be directly visible from the beach.	Any light that is directly visible to a person standing on a nesting beach will be visible to a hatchling and should be modified to prevent it being seen.
Manage light from remote regional sources (up to 20km away).	Consider light sources up to 20 km away from the nesting beach, assess the relative visibility and scale of the night sky illuminated by the light e.g. is a regional city illuminating large area of the horizon and what management actions can be taken locally to reduce the effect i.e. protect or improve dune systems or plant vegetation screening in the direction of the light.

Table 6 Where all other mitigation options have been exhausted and there is a human safety need for artificial light, this table provides commercial luminaire types that are considered appropriate for use near important marine turtles nesting habitat and those to avoid.

Light type	Suitability for use near marine turtle habitat
Low Pressure Sodium Vapour	✓
High Pressure Sodium Vapour	✓
Filtered* LED	✓
Filtered* metal halide	✓
Filtered* white LED	✓
White LED	✗
Metal halide	✗
White fluorescent	✗
Halogen	✗
Mercury vapour	✗

* 'Filtered' means LEDs can be used *only* if a filter is applied to remove the short wavelength light.

Appendix G - Seabirds

Seabirds spend most of their lives at sea, only coming ashore to nest. All species are vulnerable to the effects of lighting. Seabirds active at night while migrating, foraging or returning to colonies are most at risk.

Fledglings are more affected by artificial lighting than adults due to the synchronised mass exodus of fledglings from their nesting sites. They can be affected by lights up to 15 km away.

The physical aspects of light that have the greatest impact on seabirds include intensity and colour (wavelength). Consequently, management of these aspects of artificial light will have the most effective result.

Seabirds are birds that are adapted to life in the marine environment (Figure 28). They can be highly pelagic, coastal, or in some cases spend a part of the year away from the sea entirely. They feed from the ocean either at or near the sea surface. In general, seabirds live longer, breed later and have fewer young than other birds and invest a great deal of energy in their young. Most species nest in colonies, which can vary in size from a few dozen birds to millions. Many species undertake long annual migrations, crossing the equator or circumnavigating the Earth in some cases[77].

Artificial light can disorient seabirds and potentially cause injury and/or death through collision with infrastructure. Birds may starve as a result of disruption to foraging, hampering their ability to prepare for breeding or migration. High mortality of seabirds occurs through grounding of fledglings as a result of attraction to lights[4] and through interaction with vessels at sea.

Figure 28 Flesh-footed Shearwater at sunset. Photo: Richard Freeman.

Conservation Status

Migratory seabird species in Australia are protected under international treaties and agreements including the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS, Bonn Convention), the *Ramsar Convention on Wetlands*, the *Agreement on the Conservation of Albatrosses and Petrels* (ACAP), and through the East Asian - Australasian Flyway Partnership (the Flyway Partnership). The Australian Government has bilateral migratory bird agreements with Japan (Japan-Australia Migratory Bird Agreement, JAMBA), China (China-Australia Migratory Bird Agreement, CAMBA), and the Republic of Korea (Republic of Korea-Australia Migratory Bird Agreement, ROKAMBA). In Australia the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) gives effect to these international obligations. Many seabirds are also protected under state and territory environmental legislation.

An estimated 15.5 million pairs of seabirds, from 43 species, breed at mainland and island rookeries[4]. Of the 43 species, 35 are listed as threatened and/or migratory under the EPBC Act. Of the 35 EPBC Act listed species, 90 per cent are Procellariiformes (petrels, shearwaters, storm petrels, gadfly petrels and diving petrels) that breed in burrows, only attend breeding colonies at night[78], and are consequently most at risk from the effects of artificial light. Short-tailed Shearwaters comprise 77 per cent (11.9 million pairs) of the total breeding seabird pairs.

Distribution

Seabirds in Australia belong to both migratory and residential breeding species. Most breeding species include both temperate and tropical shearwaters and terns that undergo extensive migrations to wintering areas outside Australia's Exclusive Economic Zone (EEZ). However, there are significant numbers of residential species that remain within the EEZ throughout the year and undergo shorter migrations to non-breeding foraging grounds within the EEZ.

Timing of habitat use

Most seabird breeding occurs during the austral spring/summer (September-January), but may extend in some species to April/May. The exceptions are the austral winter breeders, a handful of species largely comprised of petrels that may commence nesting in June. Breeding occurs almost exclusively on many of the offshore continental islands that surround Australia. Seabirds spend most of their time flying, at sea, and so are usually found on breeding islands only during the breeding season, or along mainland coastal sand bars and spits or island shorelines when roosting during their non-breeding period.

Important habitat for seabirds

Seabirds may be affected by artificial light at breeding areas, while foraging and migrating. For the purposes of these Guidelines, Important Habitat for seabirds includes all areas that have been designated as Habitat Critical to the Survival of Seabirds and Biologically Important Areas (BIAs) and those areas designated as important habitat in wildlife conservation plans and in species specific conservation advice.

- The *National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016*[*] provides designated Habitat Critical to the Survival of affected species. Where a recovery plan is not in force for a listed threatened species, please see relevant approved conservation advice.
- Actions in Antarctica should consider Important Bird Areas in Antarctica[79].
- Biologically Important Areas (BIAs) are areas where listed threatened and migratory species display biologically important behaviour, such as breeding, foraging, resting and migration. Seabird BIAs can be explored through the Department of the Environment and Energy's National Conservation Values Atlas.
    - The presence of a BIA recognises that biologically important behaviours are known to occur, but the absence of such a designation does not preclude the area from being a BIA. Where field surveys identify biologically important behaviour occurring, the habitat should be managed accordingly.

Effects of Artificial Light on Seabirds

Seabirds have been affected by artificial light sources for centuries. Humans used fire to attract seabirds to hunt them for food[80] and reports of collisions with lighthouses date back to 1880[81]. More recently artificial light associated with the rapid urbanisation of coastal areas has been linked to increased seabird mortality[82] and today, 56 petrel species worldwide are known to be affected by artificial lighting[4,28]. Artificial light can disorient seabirds causing collision, entrapment, stranding, grounding, and interference with navigation (being drawn off course from usual migration route). These behavioural responses may cause injury and/or death.

All species active at night are vulnerable as artificial light can disrupt their ability to orient towards the sea. Problematic sources of artificial light include coastal residential and hotel developments, street lighting, vehicle lights, sporting facility floodlights, vessel deck and search lights, cruise ships, fishing vessels, gas flares, commercial squid vessels, security lighting, navigation aids and lighthouses[28,82-88]. Seabirds, particularly petrel species in the Southern Ocean, can be disoriented by vessel lighting and may land on the deck, from which they are unable to take off. The effect of artificial light may be exacerbated by moon phase[85], wind direction and strength[25,89], precipitation, cloud cover and the proximity of nesting sites or migrating sites to artificial light sources[90-92]. The degree of disruption is determined by a combination of physical, biological and environmental factors including the location, visibility, colour and intensity of the light, its proximity to other infrastructure, landscape topography, moon phase, atmospheric and weather conditions and the of the bird.

[*] This legislative instrument is in force until 2021.

Seabirds that are active at night while migrating, foraging or returning to colonies and are directly affected include petrels, shearwaters, albatross, noddies, terns and some penguin species. Less studied are the effects of light on the colony attendance of nocturnal Procellariiformes, which could lead to higher predation risks by gulls, skuas or other diurnal predators, and the effects on species that are active during the day, including extending their activities into the night as artificial light increases perceived daylight hours.

High rates of fallout, or the collision of birds with structures, has been reported in seabirds nesting adjacent to urban or developed areas[4,93,94] and at sea where seabirds interact with offshore oil and gas platforms[95,96]. A report on interactions with oil and gas platforms in the North Sea identified light as the likely cause of hundreds of thousands of bird deaths annually. It noted that this could be a site specific impact[97].

Gas flares also affect seabirds. One anecdote describes 24 burnt carcasses of seabirds (wedge-tailed shearwaters) in and around an open pit gas flare. The birds were likely to have been attracted to the light and noise of the flare and as they circled the source, became engulfed, combusting in the super-heated air above the flame (pers. obs. K Pendoley, 1992).

Mechanisms by which light affects seabirds

Most seabirds are diurnal. They rest during dark hours and have less exposure to artificial light. Among species with a nocturnal component to their life cycle, artificial light affects the adult and fledgling differently.

Adults are less affected by artificial light. Many Procellariiformes species (i.e. shearwaters, storm petrels, gadfly petrels) are vulnerable during nocturnal activities, which make up part of the annual breeding cycle. Adult Procellariiformes species are vulnerable when returning to and leaving the nesting colony. They may leave or enter to re-establish their pair bonds with breeding partners, repair nesting burrows, defend nesting sites or to forage. Adults feed their chick by regurgitating partially digested food[98]. A recent study shows artificial light disrupts adult nest attendance and thus affects weight gain in chicks[99].

Fledglings are more vulnerable due to the naivety of their first flight, the immature development of ganglions in the eye at fledging and the potential connection between light and food[93,100]. Burrow-nesting seabirds are typically exposed to light streaming in from the burrow entrance during the day. The young are fed by parents who enter the burrow from the entrance and this creates an association between light and food in newly fledged birds[28]. Much of the literature concerning the effect of lighting upon seabirds relates to the synchronised mass exodus of fledglings from their nesting sites[85,87,90,91,101,102]. Fledging Procellariiformes leave the nesting colony for the sea at night[78], returning to breed several years later. In Australia, the main fledgling period of shearwaters occurs in April/May[103].

Emergence during darkness is believed to be a predator-avoidance strategy[104] and artificial lighting may make the fledglings more vulnerable to predation[102]. Artificial lights are thought to override the sea-finding cues provided by the moon and star light at the horizon[105] and fledglings can be attracted back to onshore lights after reaching the sea[25,94]. It is possible that fledglings that survive their offshore migration cannot imprint their natal colony, preventing them from returning to nest when they mature[87]. The consequences of exposure to artificial light on the viability of a breeding population of seabirds is unknown[106].

Eye structure and sensitivities

Seabirds, like most vertebrates, have an eye that is well adapted to see colour. Typically, diurnal birds have six photoreceptor cells which are sensitive to different regions of the visible spectrum[107]. All seabirds are sensitive to the violet – blue region of the visible spectrum (380 - 440 nm)[108]. The eyes of the Black Noddy (*Anous minutus*) and Wedge-tailed Shearwaters (*Puffinus pacificus*) are characterised by a high proportion of cones sensitive to shorter wavelengths[109]. This adaptation is likely due to the need to see underwater, and the optimum wavelength for vision in clear blue oceanic water is between 425 and 500 nm. There is no ecological advantage to having many long-wavelength-sensitive photoreceptors in species foraging in this habitat[109].

Many diurnal birds can see in the UV range (less than 380 nm[110]), however, of the 300 seabird species, only 17 have UV sensitive vision[108]. In all seabirds, their photopic vision (daylight adapted) is most sensitive in the long wavelength range of the visible spectrum (590 – 740 nm, orange to red) while their scotopic (dark adapted) vision is more sensitive to short wavelengths of light (380 – 485 nm, violet to blue).

Petrel vision is most sensitive to light in the short wavelength blue (400 – 500 nm), region of the visible spectrum. Relative to diurnal seabirds, such as gulls and terns, petrels have a higher number of short wavelength sensitive cones. This is thought to be an adaptation that increases prey visibility against a blue-water foraging field favoured by petrels[109].

Little has been published on vision in penguins. Penguins are visual foragers with the success of fish capture linked directly to the amount of light present[111]. The eyes of the Humbolt Penguin (*Spheniscus humboldti)* are adapted to the aquatic environment, seeing well in the violet to blue to green region of the spectrum, but poorly in the long wavelengths (red)[112].

Wavelength, intensity and direction

The intensity of light may be a more important cue than colour for seabirds. Very bright light will attract them, regardless of colour[87]. There are numerous, although sometimes conflicting, reports of the attractiveness of different wavelengths of artificial light to seabirds. White light has the greatest effect on seabirds as it contains all wavelengths of light[7,85,113]. Seabirds have reportedly been attracted to the yellow/orange colour of fire[80], while white Mercury Vapour and broad-spectrum LED is more attractive to Barau's Petrel (*Pterodroma baraui*) and Hutton's Shearwater (*Puffinus huttoni*) than either Low or High-Pressure Sodium Vapour lights[85]. Bright white deck lights and spot lights on fishing vessels attract seabirds at night, particularly on nights with little moon light or low visibility[84,86,93].

A controlled field experiment on Short-tailed Shearwaters at Phillip Island tested the effect of metal halide, LED and HPS lights on fledging groundings[29]. The results suggested the shearwaters were more sensitive to the wider emission spectrum and higher blue content of metal halide and LED lights relative than to HPS light. The authors strongly recommended using HPS, or filtered LED and metal halide lights with purpose designed LED filters to remove short wavelength light for use in the vicinity of shearwater colonies[29].

The first studies of penguins exposed to artificial light at a naturally dark site found they preferred lit paths over dark paths to reach their nests[114]. While artificial light might enhance penguin vision at night, reducing predation risk and making it easier for them to find their way, the proven attraction to light could attract them to undesirable lit areas. This study concluded that the penguins were habituated to artificial lights and were unaffected by a 15 lux increase in artificial illumination[114]. However, the authors were unable to rule out an effect of artificial light on penguin behaviour due natural differences between the sites; potential complexity of penguin response to the interaction between artificial light and moonlight; and probable habituation of penguins to artificial lights.

Environmental Impact Assessment of Artificial Light on Seabirds

As a minimum, infrastructure with artificial lighting that is externally visible should have Best Practice Lighting Design implemented. Where there is important habitat for seabirds within 20 km of a project, an EIA should be undertaken. The following sections step through the EIA process with specific consideration for seabirds.

The 20 km buffer required for considering important seabird habitat is based on the observed grounding of seabirds in response to a light source at least 15 km away[25].

The spatial and temporal characteristics of migratory corridors are important for some seabird species. Species typically use established migratory pathways at predictable times and artificial light intersecting with an overhead migratory pathway should be assessed in the same way as ground-based populations.

Where artificial light is likely to affect seabirds, consideration should be given to mitigation measures at the earliest point in a project development and used to inform the design phase.

Associated guidance

- National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016†
- EPBC Act Policy Statement 3.21—Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species

Qualified personnel

Lighting design/management and the EIA process should be undertaken by appropriately qualified personnel. Light management plans should be developed and reviewed by appropriately qualified lighting practitioners who should consult with appropriately trained marine ornithologists and/or ecologists. People advising on the development of a lighting plan, or the preparation of reports assessing the effect of artificial light on seabirds, should have qualifications equivalent to:

- a tertiary qualified ornithologist; or
- publication on a relevant subject in ornithology peer reviewed literature in the past five years.

† Please note that this legislative instrument is in force until 2021.

Step 1: Describe the project lighting

The type of information collated during this step should consider the biological Impact of Light on Seabirds. Seabirds are susceptible when active at night while migrating, foraging or returning to colonies. The location and light source (both direct and sky glow) in relation to breeding and feeding areas should be considered. Seabirds are sensitive to short wavelength (blue/violet) light with some species able to detect UV light. However, the intensity of lights may be more important than colour.

Step 2: Describe seabird population and behaviour

The species, life stage and behaviour of seabirds in the area of interest should be described. This should include the conservation status of the species; abundance of birds; how widespread/localised is the population; regional importance of the population; and seasonality of seabirds utilising the area.

Relevant seabird information can be found in the, *National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016*; Protected Matters Search Tool; National Conservation Values Atlas; relevant conservation advice; relevant wildlife conservation plans; state and territory protected species information; scientific literature; and local/Indigenous knowledge.

Where there are insufficient data available to understand the population importance or demographics, or where it is necessary to document existing seabird behaviour, field surveys and biological monitoring may be necessary.

Biological monitoring of seabirds

Any biological monitoring associated with a project should be carried out by an appropriately qualified biologist or ornithologist to ensure reliability of the data.

The objectives of monitoring in an area likely to be affected by light are to:

- understand the habitat use and behaviour of the population (e.g. migrating, foraging, breeding)
- understand the size and importance of the population
- describe seabird behaviour prior to the introduction/upgrade of light.

The data will be used to inform the EIA process and assess whether mitigation measures are successful. Suggested minimum monitoring parameters (what is measured) and techniques (how to measure them) are summarised in Table 7.

Table 7 Recommended minimum biological information required to assess the importance of a seabird population. Note: the information in this table is not prescriptive and should assessed on a case-by-case basis.

Target Age Class	Survey Effort	Duration	Reference
Adult Nesting	• In colonial nesting burrow or surface nesting species with fixed or transient nesting sites, a single survey timed to coincide with predicted peak laying period. • A minimum of three sampling areas (transects/quadrats) appropriate for nest density to capture ~100 nests per transect. Status of nests recorded (used/unused- chick stage). • Transient surface nesting species - estimate of chicks in crèches using aerial or drone footage. • A minimum of three sampling areas (transects/quadrats) appropriate for nest density to capture ~100 nests per transect. Status of nests recorded (used/unused- egg or chick).	Minimum of two breeding seasons	Henderson and Southwood (2016)[115] Surman and Nicholson (2014)[116] Survey Guidelines for Australia's Threatened Birds [117]
Fledging	In colonial nesting burrow or surface nesting species with fixed nesting sites, a single survey timed to coincide with predicted max fledging period.	Minimum of two breeding seasons	Henderson and Southwood (2016)[115] Surman and Nicholson (2014)[118]

Additional seabird monitoring

- Monitor fledging behaviour before project begins to establish a benchmark for assessing changes in fledging behaviour during construction and operations.
- Monitor fallout by assessing breeding colonies prior to fledging to assess annual breeding output/effort and measure against fallout (expecting greater fallout in years with higher reproductive output).
- Install camera traps at key locations to monitor fallout.
- Conduct nightly assessments of target lighting/areas to identify and collect grounded birds.
- Conduct observations post-dusk and pre-dawn with night vision goggles to assess activity/interactions.
- Track movement using land-based radar to determine existing flightpaths[87].

As a minimum, qualitative descriptive data on visible light types, location and directivity should also be collected at the same time as the biological data. Handheld camera images can help to describe the light. Quantitative data on existing sky glow should be collected, if possible, in a biologically meaningful way, recognising the technical difficulties in obtaining these data. See Measuring Biologically Relevant Light for a review.

Step 3: Risk assessment

The objective is that light should be managed in a way that seabirds are not disrupted within, or displaced from, important habitat, and they are able to undertake critical behaviours, such as foraging, reproduction and dispersal. These consequences should be considered in the risk assessment process. The aim of the process is to ensure that at important seabird rookeries, burrow usage remains constant, adults and fledglings are not grounded, and fledglings launch successfully from the rookery.

In considering the likely effect of light on seabirds, the assessment should consider the existing light environment, the proposed lighting design and mitigation/management, and behaviour of seabirds at the location. Consideration should be given to how the birds perceive light. This should include both wavelength and intensity information and perspective (i.e. when in flight likely to be looking down on lights). To discern how/whether seabirds are likely to see light, a site visit should be made at night and the area viewed from the seabird rookery. Similarly, consideration should be given to how seabirds will see light when in flight.

Using this perspective, the type and number of lights should be considered/modelled to determine whether seabirds are likely to perceive light and what the consequence of the light on their behaviour is likely to be.

Step 4: Light management plan

This should include all relevant project information (Step 1) and biological information (Step 2). It should outline proposed mitigation. For a range of seabird specific mitigation measures please see the Seabird Mitigation Toolbox below. The plan should also outline the type and schedule for biological and light monitoring to ensure mitigation is meeting the objectives of the plan and triggers for revisiting the risk assessment phase of the EIA. The plan should outline contingency options if biological and light monitoring or compliance audits indicate that mitigation is not meeting objectives (e.g. light is visible in seabird rookeries or fallout rates increase).

Step 5: Biological and light monitoring and auditing

The success of the impact mitigation and light management should be confirmed through monitoring and compliance auditing and the results used to facilitate an adaptive management approach for continuous improvement.

Relevant biological monitoring is described in Step 2: Describe the Seabird Population above. Concurrent light monitoring should be undertaken and interpreted in the context of how seabirds perceive light and within the limitations of monitoring techniques described in Measuring Biologically Relevant Light. Auditing, as described in the light management plan, should be undertaken.

Seabird Light Mitigation Toolbox

Appropriate lighting design/lighting controls and mitigating the effect of light will be site/project and species specific. Table 8 provides a toolbox of management options relevant to seabirds. These options should be implemented in addition to the six Best Practice Light Design principles. Not all mitigation options will be practicable for every project. Table 9 provides a suggested list of light types appropriate for use near seabird rookeries and those to avoid.

A comprehensive review of the effect of land based artificial lights on seabirds and mitigation techniques found the most effective measures were:

- turning lights off during the fledgling periods
- modification of light wavelengths
- banning external lights and closing window blinds to shield internal lights
- shielding the light source and preventing upward light spill
- reducing traffic speed limits and display of warning signs
- implementing a rescue program for grounded birds[4].

Additional mitigation measures listed, but not assessed for effectiveness were:

- using rotating or flashing lights because research suggests that seabirds are less attracted to flashing lights than constant light
- keeping light intensity as low as possible. Most bird groundings are observed in very brightly lit areas[4].

Table 8 Light management options

Management Action	Detail
Implement management actions during the breeding season.	Most seabird species nest during the Austral spring and summer. Light management should be implemented during the nesting and fledgling periods.
Maintain a dark zone between the rookery and the light sources.	Avoid installing lights or manage all outdoor lighting within three kilometres of a seabird rookery[91]. This is the median distance between nest locations and grounding locations. Avoiding the installation of lights in this zone would reduce the number of grounding birds by 50 per cent.
Turn off lights during fledgling season.	If not possible to extinguish lights, consider curfews, dimming options, or changes on light spectra (preferably towards lights with low blue emissions). Fledglings can be attracted back towards lights on land as they fly out to sea.
Use curfews to manage lighting.	Extinguish lights around the rookery during the fledgling period by 7 pm as fledglings leave their nest early in the evening.
Aim lights downwards and direct them away from nesting areas.	Aim light onto only the surface area requiring illumination. Use shielding to prevent light spill into the air and outside the footprint of the target area. This action can reduce fallout by 40 per cent[4].
Use flashing/intermittent lights instead of fixed beam.	For example, small red flashing lights can be used to identify an entrance or delineate a pathway.
Use motion sensors to turn lights on only when needed.	Pedestrian or street lighting within three kilometres of a seabird rookery.
Prevent indoor lighting reaching outdoor environment.	Use fixed window screens or window tinting on fixed windows and skylights to contain light inside buildings.
Manage artificial light on jetties, wharves, marinas, etc.	Fledglings and adults may be attracted to lights on marine facilities and become grounded or collide with infrastructure.
Reduce unnecessary outdoor, deck lighting on all vessels and permanent and floating oil and gas installations in known seabird foraging areas at sea.	Extinguishing outdoor/deck lights when not necessary for human safety and restrict lighting at night to navigation lights. Use block-out blinds on all portholes and windows.

Management Action	Detail
Fishing vessels at high risk of interaction with seabirds should not set lines at night except in accordance with approved management arrangements, but should also keep deck lighting to the minimum where possible so as to not breach minimum standards for safety and navigation, and to allow for appropriate use of electronic monitoring equipment.	Night setting is between nautical dusk and nautical dawn (as defined in the Nautical Almanac tables for relevant latitude, local time and date). Record bird strike or incidental catch and report these data to regulatory authorities.
Avoid shining light directly onto longlines and/or illuminating baits in the water.	Light on the water can attract birds and facilitate the detection and consumption of baits, increasing bycatch in fisheries (i.e. killing or injuring birds). Record bird strike or incidental catch and report these data to regulatory authorities.
Vessels working in seabird foraging areas during breeding season should implement a seabird management plan to prevent seabird landings on the ship, manage birds appropriately and report the interaction.	For example, see the International Association of Antarctica Tour Operators (IAATO) Seabirds Landing on Ships information page.
Avoid lights containing short wavelength violet/blue light.	Do not use lights rich in blue light, i.e. metal halides, fluorescent, halogens, mercury vapour and white LEDs in or near seabird rookeries. Sodium vapour and amber LEDs are preferable options.
Avoid white LEDs.	Ask your supplier for an LED light with little or no blue in it, or only use LEDs filtered to block blue light. Relative wavelength content can be visualised through a spectral power curve.
Avoid high intensity light of any colour.	Keep light intensity as low as possible in the vicinity of seabird rookeries and known foraging areas.
Shield gas flares and locate inland and away from seabird rookeries.	Manage gas flare light emissions by: reducing gas flow rates to minimise light emissions; shielding the flame behind a containment structure; containing the pilot flame for flare within shielding; and scheduling maintenance activity requiring flaring outside of shearwater breeding season or during the day.
Minimise flaring on offshore oil and gas production facilities.	Consider reinjecting excess/test gas instead of flaring.

Management Action	Detail
In facilities requiring intermittent night-time inspections, turn on lights only during the time operators are moving around the facility.	Use amber/orange explosion proof LEDs with smart lighting controls and/or motion sensors. LEDs have no warmup or cool down limitations so can remain off until needed and provide instant light when required for routine nightly inspections or in the event of an emergency.
Ensure industrial site/plant operators use head torches.	Consider providing plant operators with white head torches (explosion proof torches are available) for situations where white light is needed to detect colour correctly or in an emergency.
Supplement facility perimeter security lighting with computer monitored infrared detection systems.	Perimeter lighting can be operated when night-time illumination is necessary but otherwise remain off.
Tourism operations around seabird colonies should manage head-torch use so birds are not disturbed.	Consideration should be given to educational signage around seabird colonies where tourism visitation is generally unsupervised.
Design and implement a rescue program for grounded birds.	This will not prevent birds grounding, but it is an important management action in the absence of appropriate light design. Rescue programs have proven useful to reducing mortality of seabirds. The program should include documentation and reporting of data about the number and location of rescued birds to regulatory authorities.

Table 9 Where all other mitigation options have been exhausted and there is a human safety need for artificial light, this table provides commercial luminaires recommended for use near seabird habitat and those to avoid.

Light type	Suitability for use near seabird habitat
Low Pressure Sodium Vapour	✓
High Pressure Sodium Vapour	✓
Filtered* LED	✓
Filtered* metal halide	✓
Filtered* white LED	✓
White LED	✗
Metal halide	✗
White fluorescent	✗
Halogen	✗
Mercury vapour	✗

* ‘Filtered’ means this type of luminaire can be used *only* if a filter is applied to remove the short wavelength light.

Appendix H - Migratory Shorebirds

There is evidence that night-time lighting of migratory shorebird foraging areas may benefit the birds by allowing greater visual foraging opportunities. However, where nocturnal roosts are artificially illuminated, shorebirds may be displaced, potentially reducing their local abundance if the energetic cost to travel between suitable nocturnal roosts and foraging sites is too great.

Artificial lighting could also act as an ecological trap by drawing migratory shorebirds to foraging areas with increased predation risk. Overall the effect of artificial light on migratory shorebirds remains understudied and consequently any assessment should adopt the precautionary principle and manage potential effects from light unless demonstrated otherwise.

Shorebirds, also known as waders, inhabit the shorelines of coasts and inland water bodies for most of their lives. Most are from two taxonomic families, the Sandpipers (*Scolopacidae*) and the Plovers (*Charadriidae*). They are generally distinguished by their relatively long legs, often long bills, and most importantly, their associations with wetlands at some stages of their annual cycles[119].

At least 215 shorebird species have been described[120] and their characteristics include long life-spans, but low reproductive output, and they are highly migratory[121]. Many species have special bills for feeding on different prey in wetlands. Their bills contain sensory organs to detect the vibrations of prey inside the substrate. Shorebirds are often gregarious during the non-breeding season, which is perhaps a mechanism to reduce individual predation risk[122] and increase the chance of locating profitable feeding patches[121]. About 62 per cent of shorebird species migrate. Some are transoceanic and transcontinental long-distance migrants capable of flying up to eight days non-stop, with examples of individuals covering distances up to 11,500 km[123].

Figure 29 Curlew Sandpipers. Photo: Brian Furby.

Conservation Status

Migratory shorebird species in Australia are protected under international treaties and agreements including the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS, Bonn Convention), the Ramsar Convention on Wetlands, and through the East Asian - Australasian Flyway Partnership (the Flyway Partnership). The Australian Government has bilateral migratory bird agreements with Japan (Japan-Australia Migratory Bird Agreement, JAMBA), China (China-Australia Migratory Bird Agreement, CAMBA), and the Republic of Korea (Republic of Korea-Australia Migratory Bird Agreement, ROKAMBA). In Australia, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) gives effect to these international obligations. Many species are also protected under state and territory environmental legislation.

There are 37 species listed as threatened and/or migratory species under the EPBC Act and are hence Matters of National Environmental Significance (MNES) in Australia. At least 56 trans-equatorial species belonging to three families: Pratincoles (*Glareolidae*), Plovers (*Charadriidae*) and Sandpipers (*Scolopacidae*) have been recorded in Australia[124]. Of these, 36 species and one non-trans-equatorial species are listed under the EPBC Act. Three species (and one subspecies) of migratory shorebird are listed as “Critically Endangered”, two species as “Endangered” and one species (and one subspecies) as “Vulnerable” under the EPBC Act.

These Guidelines should be read in conjunction with EPBC Act *Policy Statement 3.21 Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species*[125].

Distribution

Migratory shorebirds are found in all states and territories, and are found in Australia throughout the year. Peak abundance occurs between August and April, however, sexually immature birds defer their northward migration for several years and can be found in Australia during the Austral winter months.

They are predominantly associated with wetland habitats including estuaries and intertidal wetlands, coastal beaches, saltmarsh, mangrove fringes, wet grasslands, and ephemeral freshwater and salt lakes in inland Australia. Shorebirds are also opportunists and exploit artificial habitats such as pastures, tilled land, sewage treatment plants, irrigation canals, sports fields and golf courses. Of 397 internationally recognised sites considered important for migratory shorebirds along the East Asian–Australasian Flyway, 118 are found in Australia[126].

Important habitat for migratory shorebirds

For the purposes of these Guidelines, Important Habitat for migratory shorebirds includes all areas that are recognised, or eligible for recognition as nationally or internationally important habitat. These habitats are defined in *EPBC Act* *Policy Statement 3.21 Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species*[125] and the *Wildlife Conservation Plan for Migratory Shorebirds (2015)*[127].

- **Internationally important** habitat are those wetlands that support one per cent of the individuals in a population of one species or subspecies; or a total abundance of at least 20 000 waterbirds.
- **Nationally important** habitat are those wetlands that support 0.1 per cent of the flyway population of a single species; 2000 migratory shorebirds; or 15 migratory shorebird species.

Effects of Artificial Light on Migratory Shorebirds

Artificial light can disorient flying birds and subsequently cause their death through collision with infrastructure. Birds may starve as a result of disruption to foraging, hampering their ability to prepare for breeding or migration. However, artificial light may help some species, particularly nocturnally foraging shorebirds as they may have greater access to food[128,129].

Annual cycle and habitat use in migratory shorebirds

Migratory shorebird species listed on the EPBC Act breed in the northern hemisphere, except the Double-banded Plover (*Charadrius bicinctus*), which breeds in New Zealand. Many of the northern hemisphere breeders nest in the arctic or sub-arctic tundra during the boreal summer (May – July) and spend the non-breeding season (August – April) in Australia or New Zealand. They usually spend five to six months on the non-breeding grounds, where they complete their basic (non-breeding plumage) moult, and later commence a pre-alternate (breeding plumage) moult prior to their northward migration. While undergoing their pre-alternate moult, shorebirds also consume an increased amount of prey to increase their fat storages, permitting them to travel greater distances between refuelling sites. Shorebirds refuel in East Asia during their northward migration, but during southward migration, some individuals travel across the Pacific, briefly stopping on islands to refuel. Shorebirds migrating across the Pacific typically have non-breeding grounds in Eastern Australia and New Zealand. Shorebirds returning to non-breeding grounds in Western and Northern Australia, once again pass through East Asia on their southward journey.

A common feature for many birds is their reliance on inland or coastal wetland habitats at some stages in their annual life-histories. In many migratory shorebirds, despite the vast distances they cover every year, they spend most of their time on coastal wetlands except for the two months of nesting when they use the tundra or taiga habitats. However, productive coastal wetland is localised, which means large proportions, or even entire populations, gather at a single site during stopover or non-breeding season. The Great Knot and Greater Sand Plover, is an example, with 40 per cent and 57 per cent respectively of their entire flyway population spends their non-breeding season at Eighty-Mile Beach in Western Australia[126]. Wetlands commonly used include coastal mudflats and sandflats, sandy beaches, saltmarsh and mangrove fringes, ephemeral freshwater wetlands and damp grasslands.

The coastal intertidal wetlands favoured by many migratory shorebirds are a dynamic ecosystem strongly influenced by the tidal cycle. This is part of the critical transition zones between land, freshwater habitats, and the sea. Throughout the East Asian-Australasian Flyway, intertidal wetlands have been susceptible to heavy modification for the development of farmlands, aquaculture, salt mining, ports and industry.

Daily activity pattern and habitat use of migratory shorebirds

The daily activity pattern of shorebirds at coastal wetlands is not only determined by daylight, but also tidal cycle[120]. They feed on the exposed tidal wetland during low tide and roost during high tide as their feeding areas are inundated. The birds feed during both the day and night, especially in the lead-up to migration[130,131].

Roost site selection can vary between day and night. Shorebirds often use diurnal roosts nearest to the intertidal feeding area and may travel further to use safer nocturnal roosts – but at greater energetic cost[132,133]. Roosting habitat can also vary between day and night. For example, the Dunlin (*Calidris alpina*), in California, had a greater use of pasture at night (which tended to be less affected by artificial light and disturbances) and relied less on their diurnal roosts of islands and artificial structures such as riprap and water pipes[134].

Foraging behaviours differ between day and night, and between seasons[131,135]. Shorebirds typically show a preference for daytime foraging, which occurs over a greater area, and at a faster rate, than nocturnal foraging[131]. Increased prey availability, avoidance of daytime predation and disturbance are some reasons for nocturnal foraging[135]. Two basic types of foraging strategies have been described: visual and tactile (touch-based) foraging, with some species switching between these strategies. Tactile feeders such as sandpipers can use sensory organs in their bills to detect prey inside the substrate in the dark and can switch to visual foraging strategy during moonlit nights to take advantage of the moonlight[135]. Visual feeders such as plovers, have high densities of photo receptors, especially the dark adapted rods, which allow foraging under low light conditions[135,136]. Plovers have been shown to employ a visual foraging strategy during both the day and night, whereas sandpipers can shift from visual foraging during the day, to tactile foraging at night, likely due to less efficient night vision[131].

Vision in migratory shorebirds

There is a dearth of literature on light perception in migratory shorebirds with most studies confined to the role of vision in foraging and nothing on the physiology of shorebirds' eyes or their response to different wavelengths of light.

Birds in general are known to be attracted to and disoriented by artificial lights. This could be a result of being blinded by the intensity of light that bleaches visual pigments and therefore failing to see visual details[137] or interference with the magnetic compass used by the birds during migration[138]. An attraction to conventional artificial night lightings may lead to other adverse consequences such as reducing fuel stores, delaying migration, increasing the chance of collision and thereby, injury and death[139].

Gulls and terns (*Anous minutus, Anous tenuirostris* and *Gygis alba*) have been shown to share visual pigments that give them vision in the short wavelength ultraviolet region of the spectrum in addition to the violet (blue) region of the spectrum. However, this sensitivity to very short wavelength light is rare in seabirds, which are characterised by photopic vision (daylight adapted) sensitivity in the long wavelength range of the visible spectrum (590 – 740 nm, orange to red) while their scotopic (low light, dark adapted) vision is more sensitive to short wavelengths of light (380 – 485 nm, violet – blue)[108].

Biological impacts on migratory shorebirds

The exponential increase in the use of artificial light over the past decade means ecological light pollution has become a global issue[48]. Although the extent to which intertidal ecosystems are being affected is unclear[140], several studies have assessed both the positive and negative aspects of light pollution on migratory shorebirds.

Artificial lighting has been shown to influence the nocturnal foraging behaviour in shorebirds[129,141]. Santos et al (2010) demonstrated three species of plover (Common Ringed Plover *Charadrius hiaticula*, Kentish Plover *Charadrius alexandrina* and Grey Plover *Pluvialis squatarola*) and two species of sandpiper (Dunlin *Calidris alpina* and Common Redshank *Tringa totantus*) improved foraging success by exploiting sites where streetlights provided extra illumination[141].

Similarly, Dwyer et al (2013) showed artificial light generated from a large industrial site significantly altered the foraging strategy of Common Redshanks within an estuary. The greater nocturnal illumination of the estuary from the industrial site allowed the birds to forage for extended periods using a visual foraging strategy, which was deemed a more effective foraging behaviour when compared to tactile foraging[129].

Although shorebirds may be attracted to foraging areas with greater nocturnal illumination, artificial light near nocturnal roosting sites may displace the birds. Rogers et al (2006) studied the nocturnal roosting habits of shorebirds in north-western Australia, and suggested nocturnal roost sites with low exposure to artificial lighting were selected (e.g. streetlights and traffic), and where the risk of predation was perceived to be low[128]. The study also found nocturnal roosts spatially differed from diurnal roosts and required increased energetic cost to access as the distance between nocturnal roosts and foraging areas was greater than the distance between diurnal roost sites and the same foraging areas[133]. The overall density of shorebirds in suitable foraging areas is expected to decline with increased distance to the nearest roost, due to the greater energetic cost travelling between areas[132,133]. The artificial illumination (or lack thereof) of nocturnal roost sites is therefore likely to significantly influence the abundance of shorebirds in nearby foraging areas.

Intermittent or flashing lights could flush out the shorebirds and force them to leave the area, especially if the light is persistent (Choi pers. obs. 2018, Straw pers. comm. 2018).

There is no information that specifically addresses the impact of light on migrating shorebirds while in flight. However, Roncini et al (2015) reported on interactions between offshore oil and gas platforms and birds in the North Sea and found these were likely to include migratory shorebirds. The review estimated that hundreds of thousands of birds were killed each year in these interactions and light was the likely cause. The review recognised the gaps in monitoring and concluded that impacts are likely to be region, species and platform specific[97].

Environmental Impact Assessment of Artificial Light on Migratory Shorebirds

As a minimum, Best Practice Lighting Design should be implemented on infrastructure with externally visible artificial lighting. Where there is important habitat for migratory shorebirds within 20 km of a project, consideration should be given as to whether that light is likely to have an effect on those birds. The following sections step through the framework for managing artificial light, with specific consideration for migratory shorebirds.

The 20 km buffer is based on a precautionary approach that sky glow can cause a change in behaviour in other species up to 15 km away[25].

Where artificial light is likely to affect migratory shorebirds, consideration should be given to mitigation measures at the earliest point in a project and used to inform the design phase.

It is important to recognise the spatial and temporal characteristics of migratory corridors for some migratory shorebird species. Species typically use established migratory pathways at predictable times and artificial light intersecting with an overhead migratory pathway should be assessed in the same way as for ground-based populations.

Associated guidance

- *Wildlife Conservation Plan for Migratory Shorebirds* (2015)

Qualified personnel

Lighting design/management and the EIA process should be undertaken by appropriately qualified personnel. Plans should be developed and reviewed by appropriately qualified lighting practitioners who should consult with an appropriately trained marine ornithologist or ecologist. People advising on the development of a lighting plan, or the preparation of reports assessing the effect of artificial light on migratory shorebirds, should have qualifications equivalent to:

- a tertiary qualified ornithologist; or
- publication on a relevant subject in ornithology peer reviewed literature in the previous five years.

Step 1: Describe the project lighting

The information collated during this step should consider the biological impact of light on migratory shorebirds. They can be affected by light when foraging or migrating at night. Artificial light at night may also affect their selection of roost site. The location and light source (both direct and sky glow) in relation to feeding and resting areas should be considered, depending on whether the birds are active or resting at night. Shorebirds are sensitive to short wavelength (blue/violet) light with some species able to detect UV light. However, the intensity of lights may be more important than colour.

Step 2: Describe the migratory shorebird population and behaviour

The species, and behaviour of shorebirds in the area of interest should be described. This should include the conservation status of the species; abundance of birds; how widespread/localised is the population; the regional importance of the population; the number of birds in the area in different seasons; and their night-time behaviour (resting or foraging).

Relevant shorebird information can be found in the *EPBC Act Policy Statement 3.21 Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species*[125], *Wildlife Conservation Plan for Migratory Shorebirds (2015)*[127], the Protected Matters Search Tool, the National Conservation Values Atlas, state and territory protected species information, scientific literature, and local/Indigenous knowledge.

Where there is insufficient data to understand the population importance or demographics, or where it is necessary to document existing shorebird behaviour, field surveys and biological monitoring may be necessary.

Biological monitoring of migratory shorebirds

Monitoring associated with a project should be carried out by appropriately qualified biologists to ensure reliability of the data.

The objective is to collect data on the abundance of birds and their normal behaviour. Please see Survey guidelines for Australia's threatened birds[117].

The data will be used to inform the EIA and assess whether mitigation measures are successful. Suggested minimum monitoring parameters (what is measured) and techniques (how to measure them) are summarised in Table 10.

Table 10 Recommended minimum biological information required to assess the importance of a migratory shorebird population. Note: the information in this table is not prescriptive and should be assessed on a case-by-case basis.

Target Age Class	Survey Effort	Duration	Reference
Adult	Four surveys of roosting birds (one in December, two in January and one in February), with an additional three to four surveys within the same neap-spring tide cycle is recommended.	Two hours before and after predicted high tide.	*Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species*[125]
Immature	One to two surveys on roosting birds between mid-May and mid-July.	Two hours before and after predicted high tide.	

Monitoring migratory shorebird populations

- Monitor the population (during different seasons) to establish a benchmark for assessing abundance before, during and after construction, and during operations to detect project-related change.
- Quantify the diurnal and nocturnal habitat use and movement in relation to tidal cycle (both high and low tides during the neap and spring tide cycles) in the area under baseline conditions to compare with light-affected conditions during construction and operations.
- Measure nocturnal light levels at foraging sites and nocturnal roost sites before and after the construction period of a project.
- Monitor nocturnal roost sites using acoustic recording devices and/or infrared cameras to determine nocturnal roost site use following the introduction of artificial light.

As a minimum, qualitative descriptive data on visible light types, location and directivity should also be collected at the same time as the biological data. Handheld camera images can help to describe the light. Quantitative data on existing sky glow should be collected, if possible, in a biologically meaningful way, recognising the technical difficulties in obtaining these data. See Measuring Biologically Relevant Light for a review.

Step 3: Risk assessment

The objective of these Guidelines is that light should be managed so that shorebirds are not disrupted within or displaced from important habitat and are able to undertake critical behaviours such as foraging, roosting and dispersal. These consequences should be considered in the risk assessment process. At important shorebird habitats, roosting and foraging numbers should remain constant and foraging birds should not be startled or at increased risk from predators as a result of increased illumination.

The assessment should consider the existing light environment, the proposed lighting design and mitigation/management, the behaviour of shorebirds at the location, and how the birds perceive light. This should include wavelength and intensity information and perspective. To understand how/whether shorebirds are likely to see light, a site visit should be made at night and the area viewed from the intertidal flats and roosting areas. Similarly, consideration should be given to how shorebirds will see light when in flight.

The type and number of artificial lights should then be considered to assess whether the birds are likely to perceive the light, and the possible consequences of light on their behaviour.

Step 4: Light management plan

This plan should include all relevant project information (Step 1) and biological information (Step 2). It should outline proposed mitigation. For a range of shorebird specific mitigation measures see the Migratory Shorebird Light Mitigation Toolbox below. The plan should also outline the type and schedule for biological and light monitoring to ensure mitigation is meeting the objectives of the plan and triggers for revisiting the risk assessment phase of the EIA. The plan should outline contingency options if biological and light monitoring or compliance audits indicate that mitigation is not meeting the objectives of the plan (e.g. light is visible on intertidal flats or shorebirds cease using resting areas).

Step 5: Biological and light monitoring and auditing

The success of the plan should be confirmed through monitoring and compliance auditing. The results should be used to facilitate an adaptive management approach for continuous improvement.

Biological monitoring is described in Step 2: Describe the Migratory Shorebird Population. Concurrent light monitoring should be undertaken and interpreted in the context of how the birds perceive light and within the limitations of monitoring techniques described in Measuring Biologically Relevant Light. Auditing, as described in the plan, should be undertaken.

Migratory Shorebird Light Mitigation Toolbox

All projects should incorporate the Best Practice Light Design Principles. Appropriate lighting controls and light impact mitigation will be site/project and species specific. Table 11 provides a toolbox of options that would be implemented in addition to the six Best Practice Light Design principles. Not all mitigation options will be required for every project. Table 12 provides a suggested list of light types appropriate for use near rookeries or roosting sites and those to avoid.

Table 11 Light management actions specific to migratory shorebirds.

Management Action	Detail
Implement actions when birds are likely to be present. This includes peak migration periods (flyway locations).	Birds are found in Australia year-round. Major movements along coastlines take place between March and April, and August and November. Between August and April, shorebird abundance peaks. Smaller numbers are found from April to August.
No light source should be directly visible from foraging or nocturnal roost habitats.	Any light that is directly visible to a person standing in foraging or nocturnal roost habitats will potentially be visible to a shorebird and should be modified to prevent it being seen.
Do not install fixed light sources in nocturnal foraging or roost areas.	Installing light sources (e.g. light poles) within shorebird habitat may permanently reduce the available area for foraging or roosting and provide vantage points for predators (e.g. raptors) during the day.
Prevent mobile light sources shining into nocturnal foraging and roost habitat.	The light from mobile sources such as mobile lighting towers, head torches or vehicle headlights should be prevented from aiming into nocturnal foraging or roost areas, as this can cause immediate disturbance.
Maintain a natural barrier (e.g. dune and/or vegetation screen) between nocturnal foraging and roost areas, and sources of artificial light.	Reducing the exposure of shorebirds to artificial light will reduce the risk of predation and disturbance.
Maintain a dark zone between nocturnal foraging and roost habitats and sources of artificial lights.	Creating a dark zone between artificial lights and shorebird habitat will reduce disturbances to shorebirds.

Management Action	Detail
Use curfews to manage lighting near nocturnal foraging and roosting areas in coastal habitats.	Curfews must consider the tidal cycle if the artificial lighting is located coastally, e.g. extinguish lighting from two hours before high tide, until two hours after high tide, while shorebirds are potentially roosting.
Use of flashing/intermittent lights instead of fixed beam.	For example, small red flashing lights can be used to identify an entrance or delineate a pathway. The timing of when lights flash must follow a predictable, well-spaced pattern.
Use motion sensors to turn lights on only when needed.	For example, installing motion-activated pedestrian lighting within 500 m of nocturnal foraging or roost areas may reduce the amount of time the habitat is exposed to artificial light.
Manage artificial light on jetties and marinas.	Shorebirds will often roost on breakwaters and jetties, so allowing dark areas in such places may provide a safe area for shorebirds to roost.
Reduce deck lighting to minimum required for human safety on vessels moored near nocturnal foraging and roost areas, and those operating offshore.	Extinguish deck lights when not necessary and restrict lighting at night to navigation lights only. Offshore vessels should direct light inwards, particularly during the migration periods when shorebirds are potentially overhead.
Minimise night-time flaring on offshore oil and gas production facilities.	Consider reinjecting excess/test gas instead of flaring. Schedule maintenance flaring during daylight hours.
Avoid lights containing short wavelength violet/blue light.	Lights rich in blue light include: metal halides, fluorescent, halogens, mercury vapour and most LEDs.
Avoid high intensity light of any colour.	Keeping light intensity as low as possible in the vicinity of nocturnal foraging and roost areas will minimise impact.
Prevent indoor lighting reaching migratory shorebird habitat.	Use fixed window screens or window tinting on fixed windows and skylights to contain light inside buildings.

Management Action	Detail
In facilities requiring intermittent night inspections, turn lights on only during the time operators are moving around the facility.	Use amber/orange explosion proof LEDs with smart lighting controls and/or motions sensors. LEDs have no warmup or cool down limitations so can remain off until needed and provide instant light when required for routine nightly inspections or in the event of an emergency.
Industrial site/plant operators to use personal head torches.	Consider providing plant operators with white head torches (explosion proof torches are available) for situations where white light is needed to detect colour correctly, or in the event of an emergency. Operators should avoid shining light across nocturnal foraging or roost areas as this can cause disturbance.
Supplement facility perimeter security lighting with computer monitored infrared detection systems.	Perimeter lighting can be operated when night-time illumination is necessary but remain off at other times.

Table 12 Where all other mitigation options have been exhausted and there is a human safety need for artificial light, the following table provides commercial luminaires recommended for use near migratory shorebird habitat and those to avoid.

Light type	Suitability for use near migratory shorebird habitat
Low Pressure Sodium Vapour	✓
High Pressure Sodium Vapour	✓
Filtered* LED	✓
Filtered* metal halide	✓
Filtered* white LED	✓
White LED	✗
Metal halide	✗
White fluorescent	✗
Halogen	✗
Mercury vapour	✗

* ‘Filtered’ means this type of luminaire can be used *only* if a filter is applied to remove the short wavelength light.

Glossary

ACAP is the *Agreement on the Conservation of Albatrosses and Petrels*.

Adaptive controls are devices to vary the intensity or duration of operation of lighting, such as motion sensors, timers and dimmers used in concert with outdoor lighting equipment.

ALAN is Artificial Light At Night and refers to artificial light outside that is visible at night.

Artificial light is composed of visible light as well as some ultraviolet (UV) and infrared (IR) radiation that is derived from an anthropogenic source.

Artificial sky glow is the part of the sky glow that is attributable to human-made sources of light (see also **sky glow**).

Baffle is an opaque or translucent element to shield a light source from direct view, or to prevent light reflecting from a surface like a wall.

Biologically Important Area (BIA) is a spatially defined area where aggregations of individuals of a species are known to display biologically important behaviour, such as breeding, feeding, resting or migration.

Biologically relevant is an approach, interpretation or outcome that considers either the species to which it refers, or factors in biological considerations in its approach.

Brightness is the strength of the visual sensation on the naked eye when lit surfaces are viewed.

Bulb is the source of electric light and is a component of a light fitting, not a light fitting on its own.

CAMBA is the *China-Australia Migratory Bird Agreement*.

Candela (cd) (**photometric term**) is a unit of luminous intensity of a light source in a specific direction. Technically, the radiation intensity in a perpendicular direction of a surface of 1/600 000 m^2 of a black body at the temperature of solidification of platinum under a pressure of 101,325 N/m^2. A candle emits light with a luminous intensity of approximately one candela.

Charge Coupled Device (CCD) is the sensor technology used in digital cameras. It converts captured light into digital data (images) which can be processed to produce quantifiable data.

CIE is the Commission Internationale de l'Eclairage (International Light Commission), which sets most international lighting standards.

CMS is the *Convention on the Conservation of Migratory Species of Wild Animals* or the Bonn Convention.

Colour temperature is the perceived colour of a light source ranging from cool (blue) to warm (yellow), measured in degrees Kelvin (K). A low correlated colour temperature such as 2500K will have a warm appearance while 6500K will appear cold.

Correlated Colour Temperature (CCT) is a simplified way to characterize the spectral properties of a light source and is correlated to the response of the human eye. Colour temperature is expressed in degrees Kelvin (K).

Cumulative light refers to increased sky brightness due to light emissions contributions from multiple light producers. Measured as **sky glow**.

Disorientation refers to any species moving in a confused manner e.g. a turtle hatchling circling and unable to find the ocean.

EEZ is the Australian Exclusive Economic Zone.

EIA is an environmental impact assessment process.

Electromagnetic radiation is a kind of radiation including visible light, radio waves, gamma rays, and X-rays, in which electric and magnetic fields vary simultaneously.

EPBC Act is the Commonwealth *Environment Protection and Biodiversity Act 1999*.

Fallout refers to birds that collide with structures when disoriented.

Footcandle (fc or ftc) (photometric term) is a unit of light intensity based on the brightness of one candle at a distance of one foot. Measured in lumens per square foot, one ftc is equal to approximately 10.7639 lux.

FMP refers to the Field Management Program.

Genetic stock is a discrete grouping of a species by genetic relatedness. Management of the species may be undertaken on a genetic stock basis because each genetic stock represents a unique evolutionary history, which if lost cannot be replaced.

Grounding refers to events where birds fail to take their first flight from the nest or collide with a structure (adults and juveniles) and are unable to launch back into the air.

Habitat critical to the survival of the species is an area defined in a Recovery Plan for a listed threatened species that provides for the recovery of the species.

Horizontal plane, in relation to the light fitting, means the horizontal plane passing through the centre of the light source (for example the bulb) of the light fitting.

HPS is a high-pressure sodium lamp that produces a characteristic wavelength near 589 nm.

IAATO is the International Association of Antarctica Tour Operators.

Illuminance is the amount of light reflected from a surface.

Important habitats are those areas that are necessary for an ecologically significant proportion of a listed species to undertake important activities such as foraging, breeding, roosting or dispersal. Important habitats will be species specific and will depend on their listing status. It will include areas that have been designated as **Habitat Critical to Survival** of a threatened species.

Incandescent bulb is a bulb that provides light by a filament heated to a high temperature by electric current.

Intensity is the amount of energy or light in a given direction.

Internationally important refers to wetland habitat for migratory shorebirds that support one per cent of the individuals in a population of one species or subspecies; or a total abundance of at least 20 000 waterbirds.

IR is infrared radiation and represents a band of the electromagnetic spectrum with wavelength from 700 nm to 1 mm.

Irradiance (**radiometric term**) is a measurement of radiant flux on a known surface area, W/m^2. This measure is appropriate for understanding animal perception of light.

IUCN is the International Union for the Conservation of Nature.

JAMBA is the *Japan-Australia Migratory Bird Agreement*.

Kelvin (K) is the absolute unit for temperature and is equal in magnitude to one degree Celsius. Kelvin is typically used to describe **Correlated Colour Temperature (CCT)**.

Lamp is a generic term for a source of optical radiation (light), often called a “bulb” or “tube”. Examples include incandescent, fluorescent, high-intensity discharge (HID) lamps, and low-pressure sodium (LPS) lamps, as well as light-emitting diode (LED) modules and arrays.

LED is a light-emitting diode, or a semiconductor light source that emits light when current flows through it.

Light fitting is the complete lighting unit. It includes the bulb, reflector (mirror) or refractor (lens), the ballast, housing and the attached parts.

Light is the radiant energy that is visible to humans and animals. Light stimulates sight and makes things visible.

Light pollution is the brightening of the night sky caused by **artificial light**.

Light spill is the light that falls outside the boundaries of the object or area intended to be lit. Spill light serves no purpose and if directed above the horizontal plane, contributes directly to **artificial sky glow**. Also called spill light, obtrusive light or light trespass.

Lighting controls are devices used for either turning lights on and off, or for dimming.

LNG is liquefied natural gas.

LPS is a low pressure sodium lamp that produces a characteristic wavelength near 589 nm.

Luminaire refers to the complete lighting unit (fixture), consisting of a lamp, or lamps and ballast(s) (when applicable), together with the parts designed to distribute the light (reflector, lens, diffuser), to position and protect the lamps, and to connect the lamps to the power supply.

Luminous flux is the light emitted by a bulb which is measured in **lumen**.

Lumen (lm) (photometric term) is the measure of light output from a bulb. The output of artificial lights can be measured in lumens and is the most common measurement of light output (luminous flux). This is a **photometric** unit, weighted to the sensitivity of the human eye (as distinct from a watt which is a measure of power consumption). The quantity of lumens produced by a bulb is independent of the wattage (the energy required to illuminate the lamp.

Some types of bulb (e.g. **LED**) are more energy efficient than others and produce more lumens per watt. This is not an appropriate measure for understanding how animals perceive light.

Luminance (cd/m^2) is the amount of light emitted in a given direction by the light source or illuminated surface and is measured in candelas per square metre.

Lux (lx) (photometric term) is a unit of illumination equal to one lumen per square metre. This is the metric equivalent of foot-candles (one lux equals 0.0929 foot candles). Also called metre-candle. This is not an appropriate measure for understanding how animals perceive light.

Magnitudes per square arc second (**magnitudes/arcsec^2)** (**radiometric term**) is a term used in astronomy to measure sky brightness within an area of the sky that has an angular area of one second by one second. The term magnitudes per square arc second means that the brightness in magnitudes is spread out over a square arcsecond of the sky. Each magnitude lower (numerically) means just over 2.5 times more light is coming from a given patch of sky. A change of 5 magnitudes/arcsec^2 means the sky is 100x brighter.

Misorientation occurs when a species moves in the wrong direction, e.g. when a turtle hatchling moves toward a light and away from the ocean.

MNES are Matters of National Environmental Significance as defined by the EPBC Act and include listed threatened and listed migratory species.

Mounting height is the height of the fitting or bulb above the ground.

Nationally important habitat are those wetlands that support 0.1 per cent of the flyway population of a single species of migratory shorebird; or 2 000 migratory shorebirds; or 15 migratory shorebird species.

Natural sky glow is that part of the **sky glow** that is attributable to radiation from celestial sources and luminescent processes in the Earth's upper atmosphere.

Outdoor lighting is the night-time illumination of an area by any form of outside light fitting.

Outside light fitting means a light fitting that is attached or fixed outside or on the exterior of a building or structure, whether temporary or permanent.

Photocells are sensors that turn lights on and off in response to natural light levels. Some advanced mode can slowly dim or increase the lighting (see also **adaptive controls**).

Photometric terms refer to those measurements of light that are weighted to the sensitivity of the human eye. They are not appropriate for understanding how animals perceive light.

Photometry is a subset of radiometry that is the measurement of light as it is weighted to the sensitivity of the human eye.

Point source is light from an unshielded lamp (i.e. directly visible).

Radiance (**radiometric term**) is a measure of radiant intensity emitted from a unit area of a source, measured in W/m^2.

Radiant flux/power (**radiometric term**) is expressed in watts (W). It is the total optical power of a light source. It is the radiant energy emitted, reflected, transmitted or received, per unit time. Sometimes called radiant power, and it can also be defined as the rate of flow of radiant energy.

Radiant intensity (**radiometric term**) is the amount of flux emitted through a known solid angle, W/steradian, and has a directional quantity.

Radiometric terms refer to light measured across the entire visible spectrum (not weighted to the human eye). These are appropriate for understanding how animals perceive light.

Radiometry is the measurement of all wavelengths across the entire visible spectrum (not weighted to the human eye).

Reflected light is light that bounces off a surface. Light coloured surfaces reflect more light than darker coloured surfaces.

ROKAMBA is the *Republic of Korea-Australia Migratory Bird Agreement*.

Sensitive receptor is any living organism that has increased sensitivity or exposure to environmental contaminants that may have adverse effects.

Shielded light fitting means a light fitting that does not permit light to shine above the horizontal plane.

Sky glow is the brightness of the night sky caused by the cumulative impact of reflected radiation (usually visible light), scattered from the constituents of the atmosphere in the direction of observation. Sky glow comprises two separate components: natural sky glow and artificial sky glow (see also **natural sky glow** and **artificial sky glow**).

Spectral power curve provides a representation of the relative presence of each wavelength emitted from a light source.

Task lighting is used to provide direct light for specific activities without illuminating the entire area or object.

Upward Light Ratio (ULR) is the proportion of the light (flux) emitted from a **luminaire** or installation that is emitted at and above the horizontal, excluding reflected light when the luminaire is mounted in its parallel position. ULR is the upward flux/total flux from the luminaire.

UV is ultraviolet light and represents a band of the electromagnetic spectrum with wavelength from 10 nm to 400 nm.

W/m^2 is a measure of radiance, the radiant intensity emitted from a unit area of a source (see **radiance**). This is an appropriate measure for understanding how animals perceive light.

Wattage is the amount of electricity needed to light a bulb. Generally, the higher the wattage, the more **lumens** are produced. Higher wattage and more lumens give a brighter light.

Wavelength as light travels through space it turns a wave with evenly spaces peaks and troughs. The distance between the peaks (or the troughs) is called the wavelength of the light. Ultraviolet and blue light are examples of short wavelength light while red and Infrared light is long wavelength light. The energy of light is linked to the wavelength; short wavelength light has much higher energy than long wavelength light.

Zenith is an imaginary point directly above a location, on the imaginary celestial sphere.

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