Impacts of Outdoor Lighting: Considerations to Reduce Energy, Save Money and Minimize Light Pollution for People and the Environment

Thank You!

Hawai‘i Energy
YOUR CONSERVATION & EFFICIENCY PROGRAM

IES Honolulu Section

IDA

Housekeeping Announcements

- This presentation is being live-streamed AND recorded
- We will hold questions until the end
- Use the question pane for comments and questions
- Speakers will be provided comments and questions if we cannot get to all of them in the session
- Recording and slides will be available on the DLC website next week
- If you would like to receive AIA learning credits, be sure you have signed in. See Jordan with any questions.

Meet the Panel

Moderator:
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Executive Directors/CEO,
DesignLights Consortium

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Astronomer,
University of Hawaii

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Richard Wainscoat
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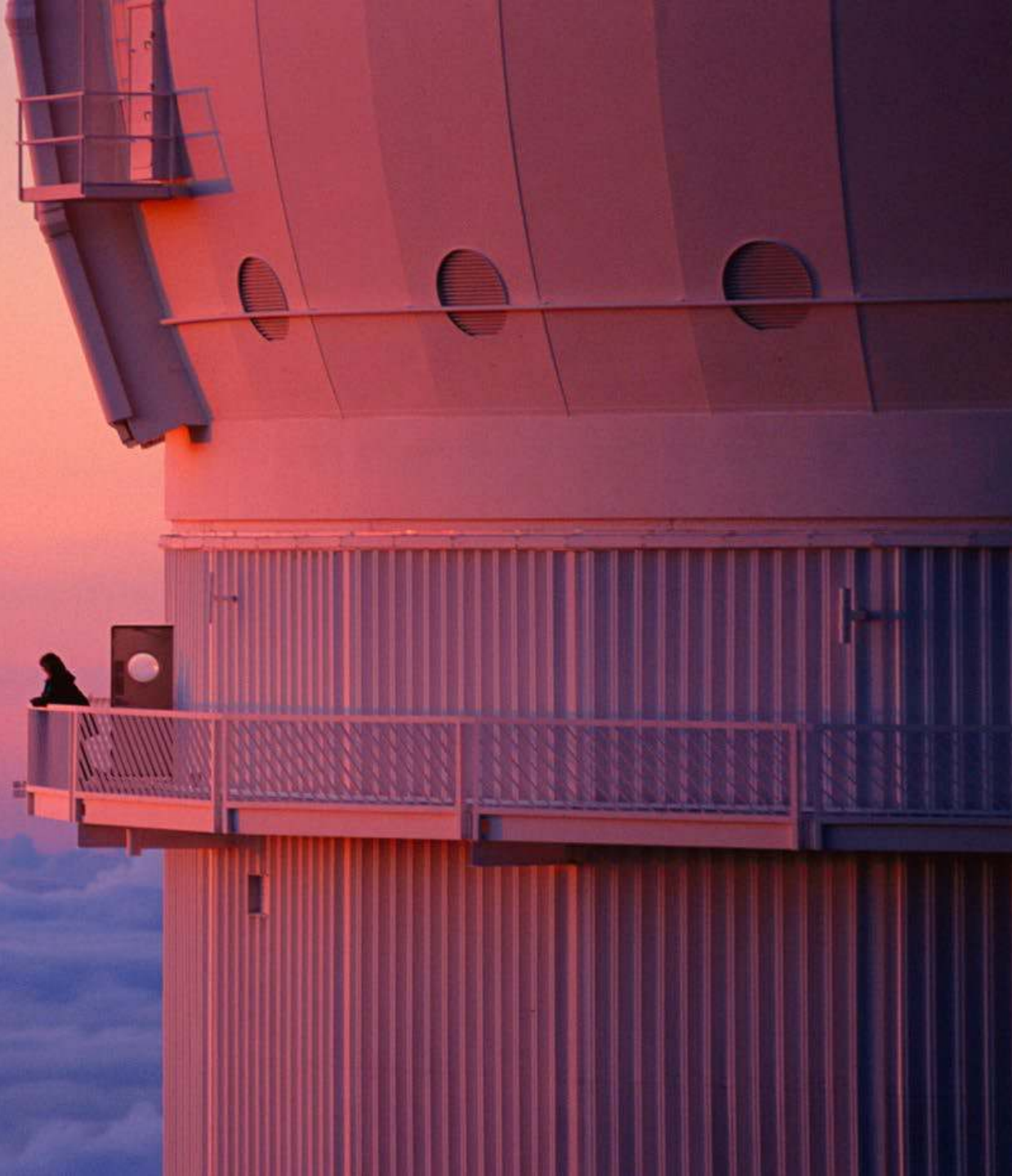
Impacts of Lighting on Astronomy

Astronomy and Lighting

- Nearly all modern astronomy involves study of faint objects requiring large telescopes
- Astronomers try to maximize contrast
  - We try to get as sharp an image as possible
  - We need as dark a sky as possible, because noise from the sky background limits our observations
  - If we allow the night sky to become 10% brighter (due to artificial light), then our telescopes effectively become 10% smaller



Astronomy in Hawaii

- Observatories need staff and need infrastructure such as airports, schools, harbors, roadways
- Strong lighting regulations are needed in order to preserve the dark night sky over the observatories

Skyglow

- The night sky is not completely dark
- The natural components of the dark night sky are:
  - Airglow coming from atoms in the upper atmosphere
  - Zodiacal light coming from dust in our solar system
  - Diffuse starlight
- Artificial light is scattered by the atmosphere, and makes the sky brighter
  - This makes it harder for astronomers to see faint sources, and if the sky becomes too bright, some astronomy becomes impossible

Skyglow

- Hawaii is located near Earth's magnetic equator
  - The airglow is less than at locations closer to Earth's magnetic poles
  - Hawaii's unpolluted night sky is darker than at any location on the US mainland
    - This is an amazing natural resource that we need to protect better
    - On the Island of Hawaii, the strong lighting ordinance has protected the dark night sky well
- On Oahu, the sky brightness ranges from a factor 2 brighter than natural on the North shore, to 40+ times brighter than natural in Honolulu
    - It is no longer possible to see the Milky Way from Honolulu

Light Travels Enormous Distances

- Honolulu is easy to see from Maunakea at a distance of almost 200 miles
- Honolulu is 110 miles from Haleakala and makes the northwestern half of the sky brighter on Haleakala
- Local light sources dominate over distant light sources

Key Factors for Protecting the Night Sky for Astronomy

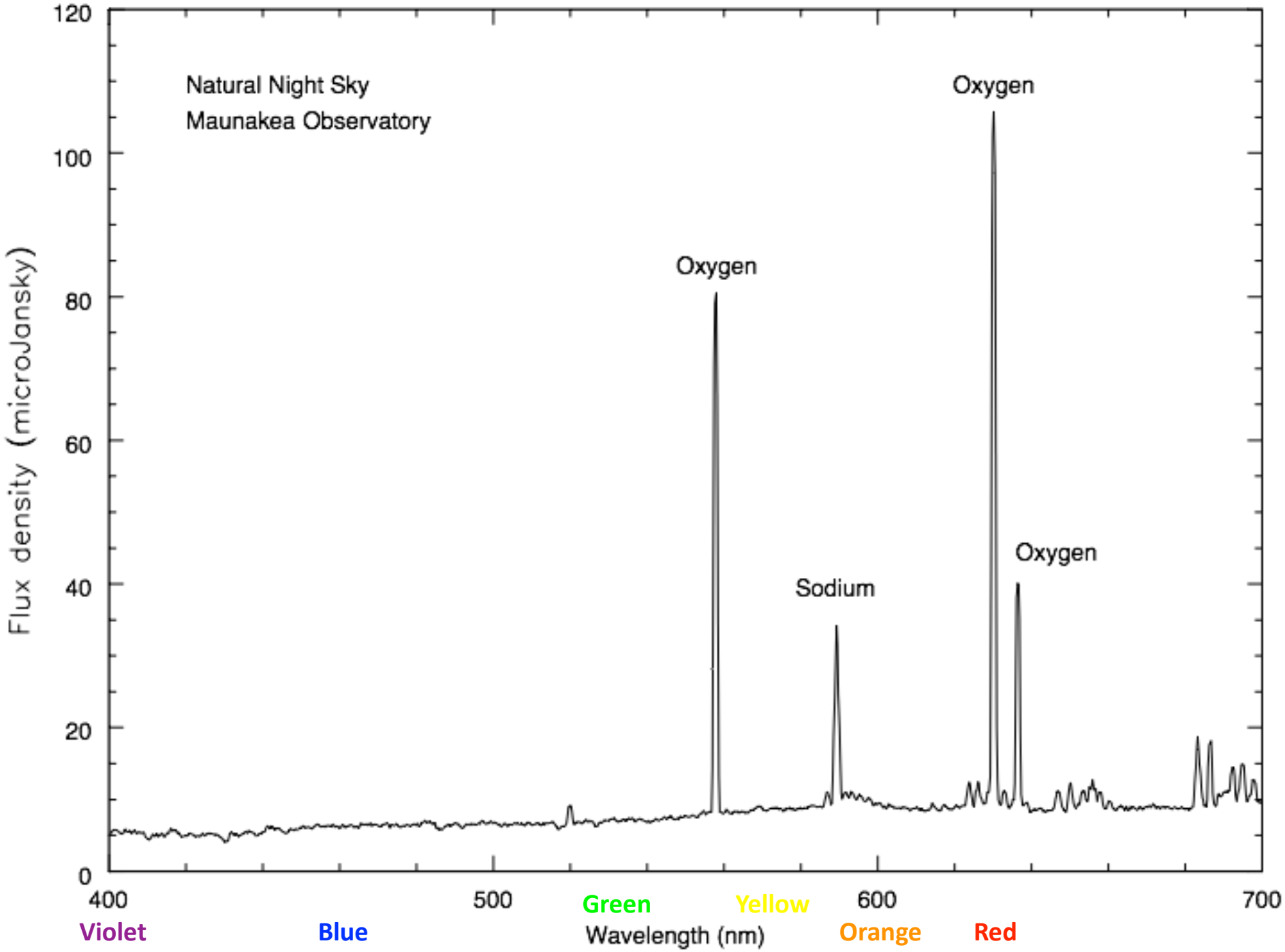
1. Color of the light
2. Direction of the light
3. Amount of the light

Scattering Makes the Color of Light Important

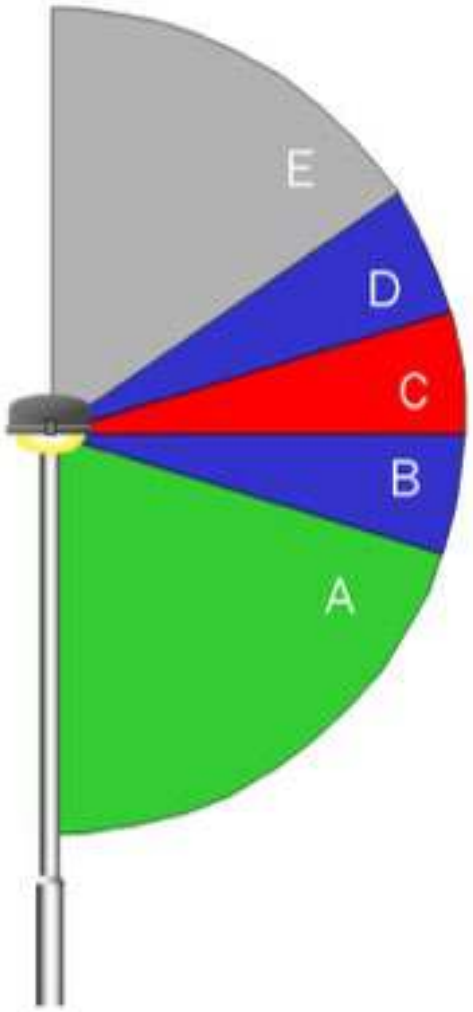
- At observatory sites, the air is very clean, and the main scattering process is Rayleigh scattering by air molecules
- Air molecules momentarily absorb artificial light then reemit it in a different direction producing skyglow
- Rayleigh scattering is strongly color dependent
  - Blue light scatters much more than red light
  - This is the reason that the daytime sky is blue, and why sunsets are red

Blue Light

- The human eye is quite insensitive to blue 450 nm light (the typical pump wavelength for phosphor converted LEDs)
  - Telescopes and astronomers instruments are very sensitive to blue light
- Compared to amber light, blue light is three times more likely to be scattered by air molecules
- This is why the lighting ordinances in Hawaii and Maui counties restrict blue light
  - Bluer wavelengths of light also tend to be more harmful to turtles and seabirds
- The natural night sky is very dark in the blue and green wavelengths, so this part of the spectrum is very precious


Natural Night Sky
Maunakea Observatory
Oxygen
Oxygen
Sodium
Oxygen
Flux density (microJansky)
120
100
80
60
40
20
0
400
500
600
700
Violet
Blue
Green
Yellow
Orange
Red
Wavelength (nm)

The Direction of Light is Very Important

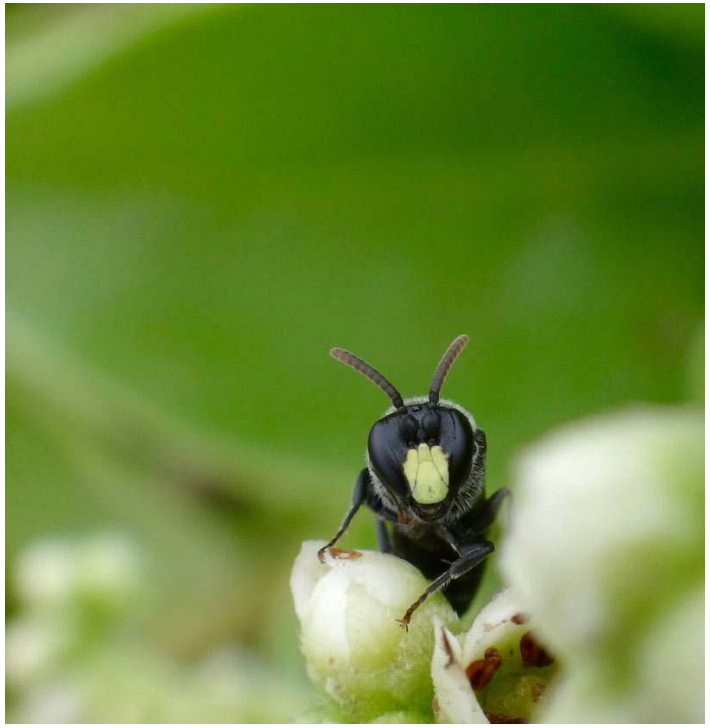


- **A**: 0°–70° ideal light distribution
- **B**: 70°–90° contributes to skyglow at a distance via reflections, but obstructions may mitigate
- **C**: 90°–100° critical emission zone that produces skyglow at large distance
- **D**: 100°–120° significant contributor to skyglow, and unlikely to be obstructed
- **E**: 120°–180° wasted energy that produces skyglow; more likely to leave the atmosphere without producing skyglow than C and D

Overlighting

- The amount of sky glow produced by artificial lights is directly related to the amount of light
  - Use the minimum amount of light needed for the task
  - Remember that the human eye has an iris, and it will open up if lighting levels are lower
  - We don’t need to light everything up to photopic levels
  - When possible, use motion sensors
  - Turn off lights with times when they are no longer needed
  - Use dimming to reduce the lighting level whenever appropriate
    - It is much easier to dim and use motion sensors with LED lighting
- All of these actions reduce energy usage and cost

Example of Excessive Light (Waikoloa)



Sheldon Plentovich, PhD

Pacific Islands Coastal Program

U.S. Fish and Wildlife Service

It’s Lights Out for Wildlife: How artificial night-time lighting attracts, disorients and harms animals

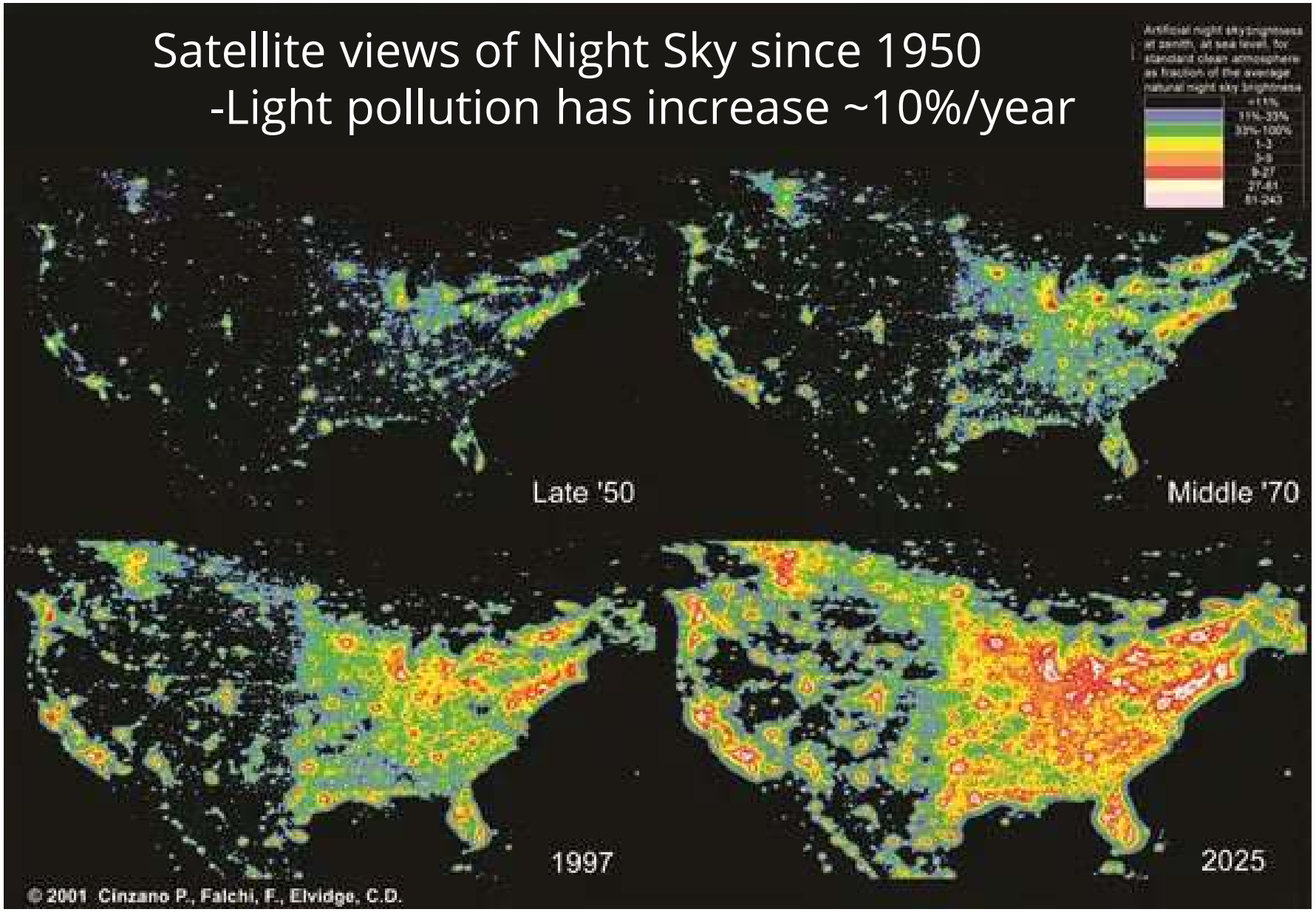
Outline

- General effects of light on wildlife
- Specific examples from Hawaii
  - Seabirds
  - Sea turtles
- Why it’s a problem
- What we can do to fix it

Animals use light cues from the moon and stars to navigate

- Late 1800s - 1st Electric bulbs
- By 1970 – light pollution reduced visibility of the night sky

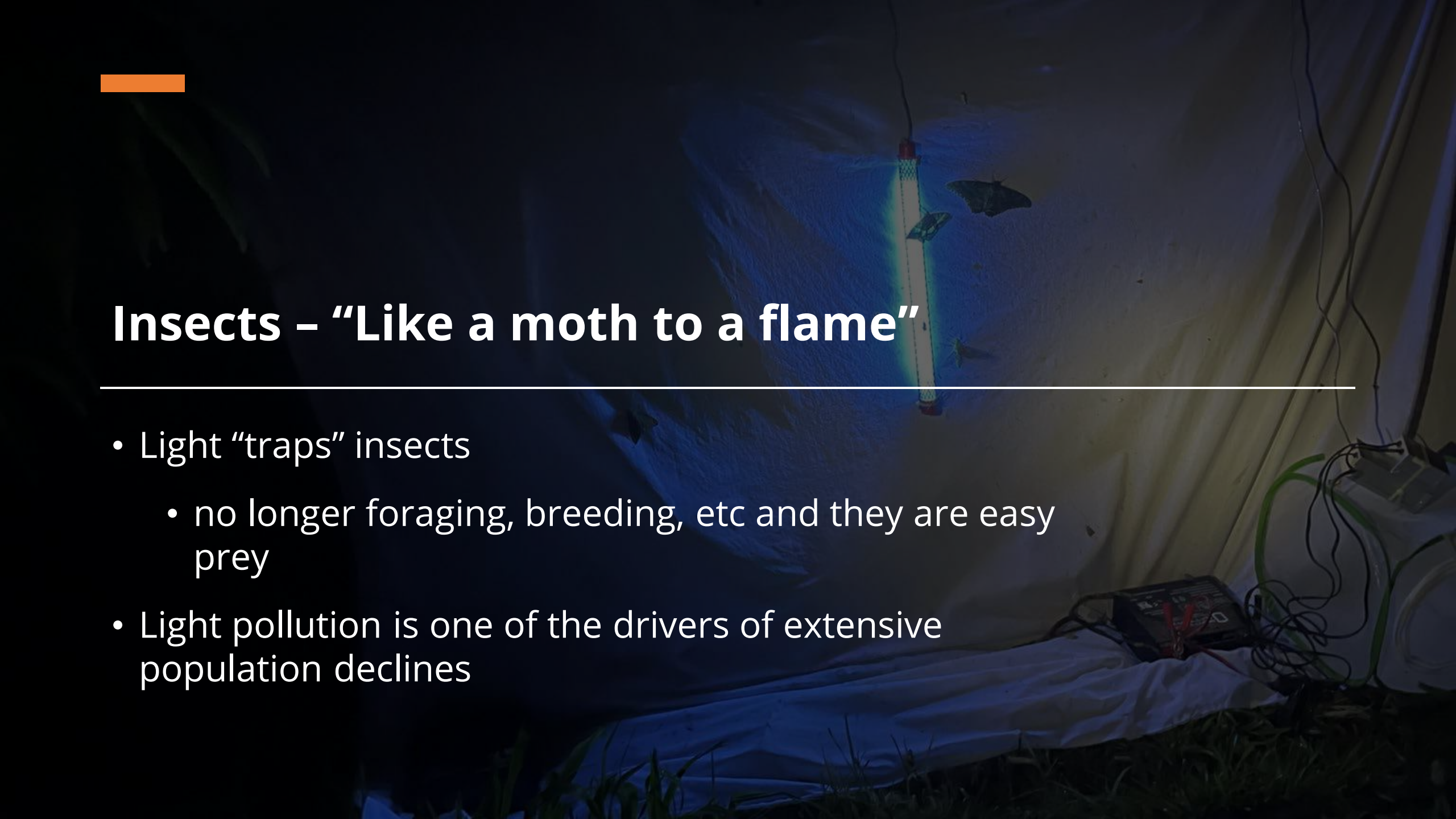
Satellite views of Night Sky since 1950
-Light pollution has increase ~10%/year



Harmful Effects of Artificial Light on Wildlife

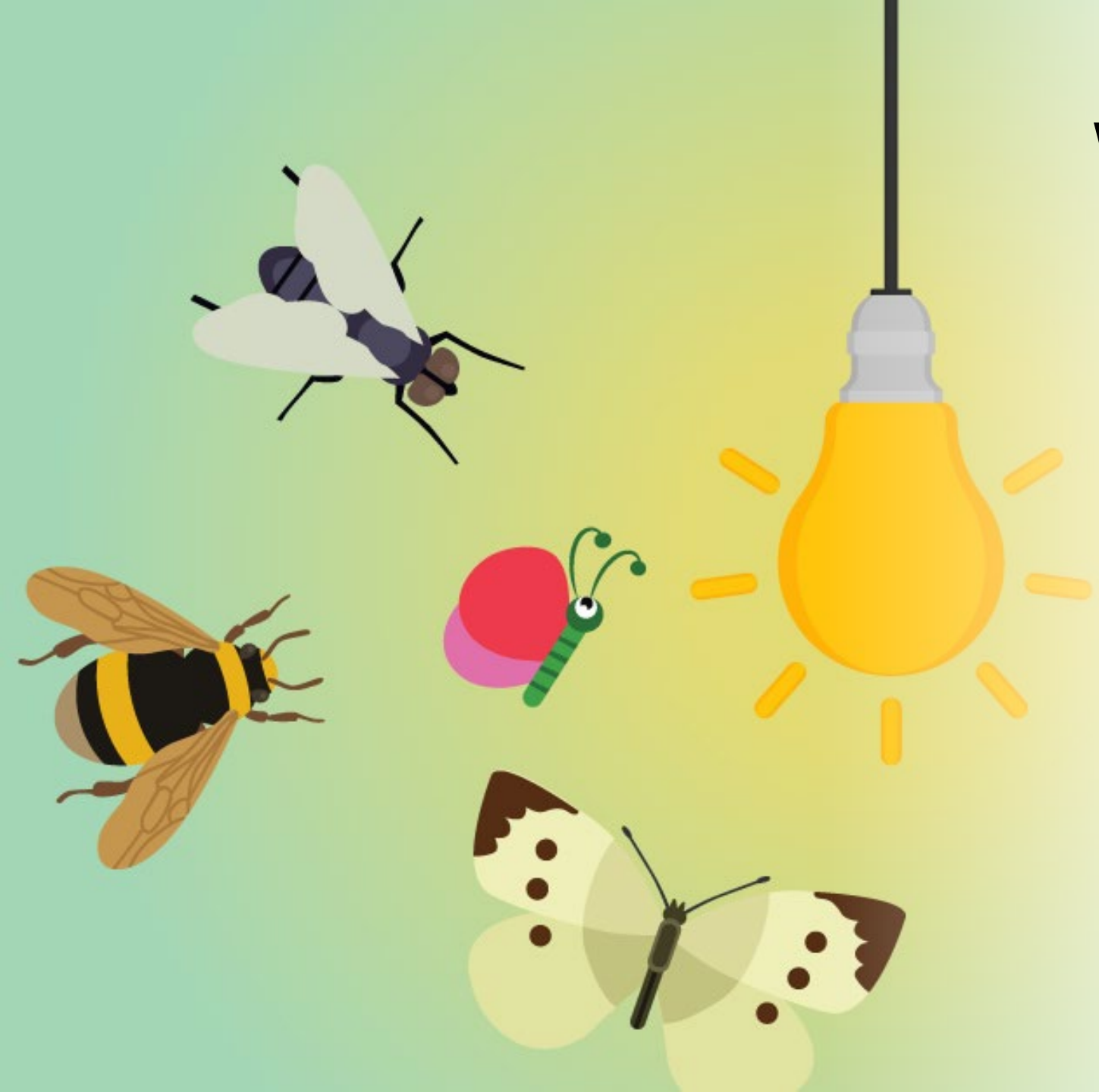
- **Attracts/disorients:** sea turtles, seabirds, insects. Attracted to the light which disorients, “traps” and concentrates them as a food source
- **Repels:** excludes spp from areas they would normally occupy. Form of habitat loss
- **Alters day/night patterns:** interrupting sleep & behavior patterns

Photo: Simone De Peak



Insects – “Like a moth to a flame”

- Light “traps” insects
  - no longer foraging, breeding, etc and they are easy prey
- Light pollution is one of the drivers of extensive population declines



Why is this problematic?

- Insects form the **base of terrestrial ecosystems**.
- **Pollinate** plants (~75% of plants grown for food)
- Are **food** for birds, amphibians, reptiles and mammals
- Are necessary for **decomposition and nutrient recycling.**

Illustration: Bugs.com

Harmful effects of artificial lighting: Examples from Hawaii

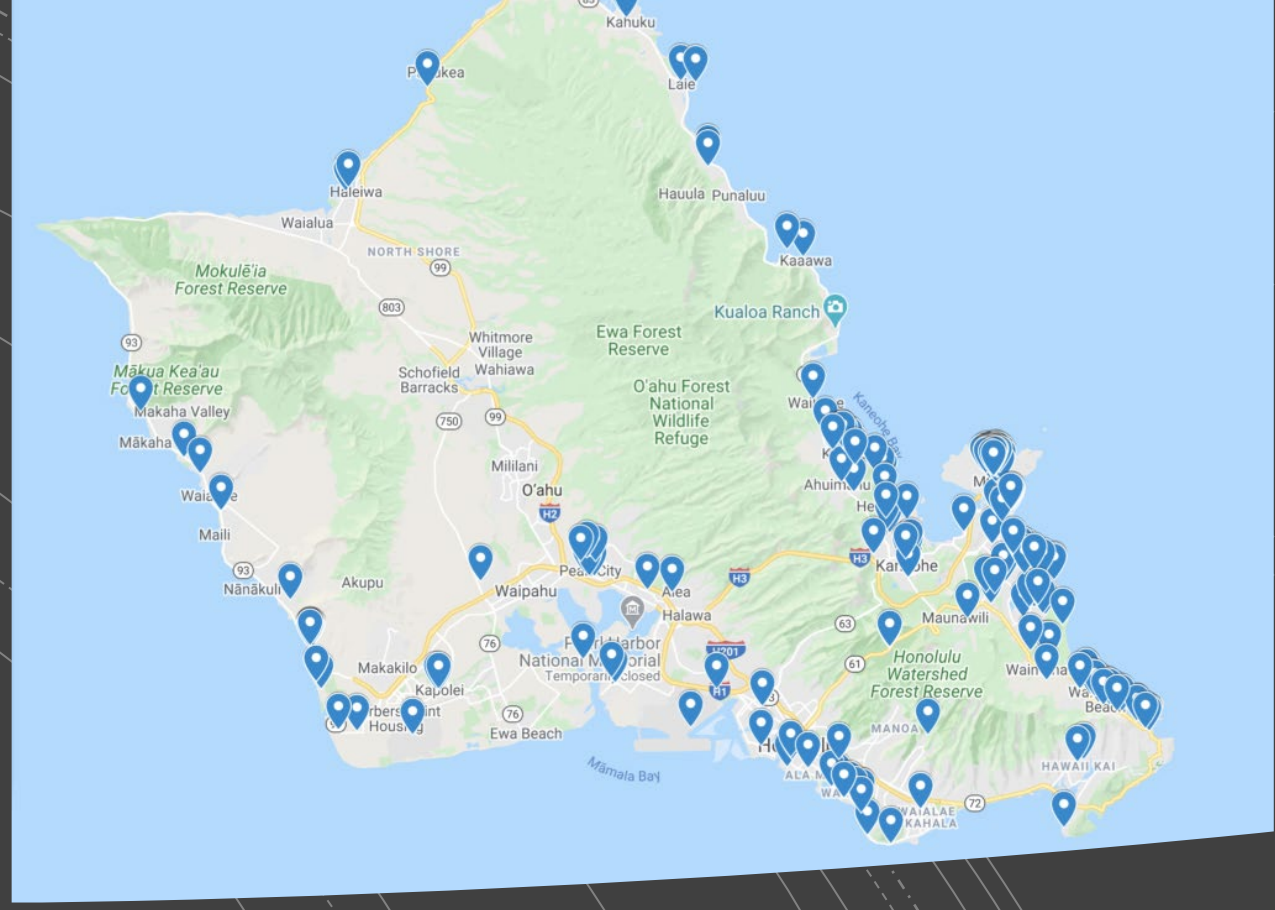
- Seabirds and sea turtles: Very vulnerable to night-time lighting
- Use the moon, stars and ocean to navigate
- Adults will avoid nesting in areas with artificial light
- Fledgling seabirds and hatchling turtles become disoriented when they are trying to reach the ocean

'ua'u kani or Wedge-tailed Shearwater

Negative effects of artificial lights on Seabirds

- Burrow-nesting seabirds are federally protected
- Fledglings leaving their burrow for the first time are most affected
- Birds will circle the cone of light until they collide with structures or are exhausted
- Once on the ground, they are easy prey for invasive mammals like cats and mongooses

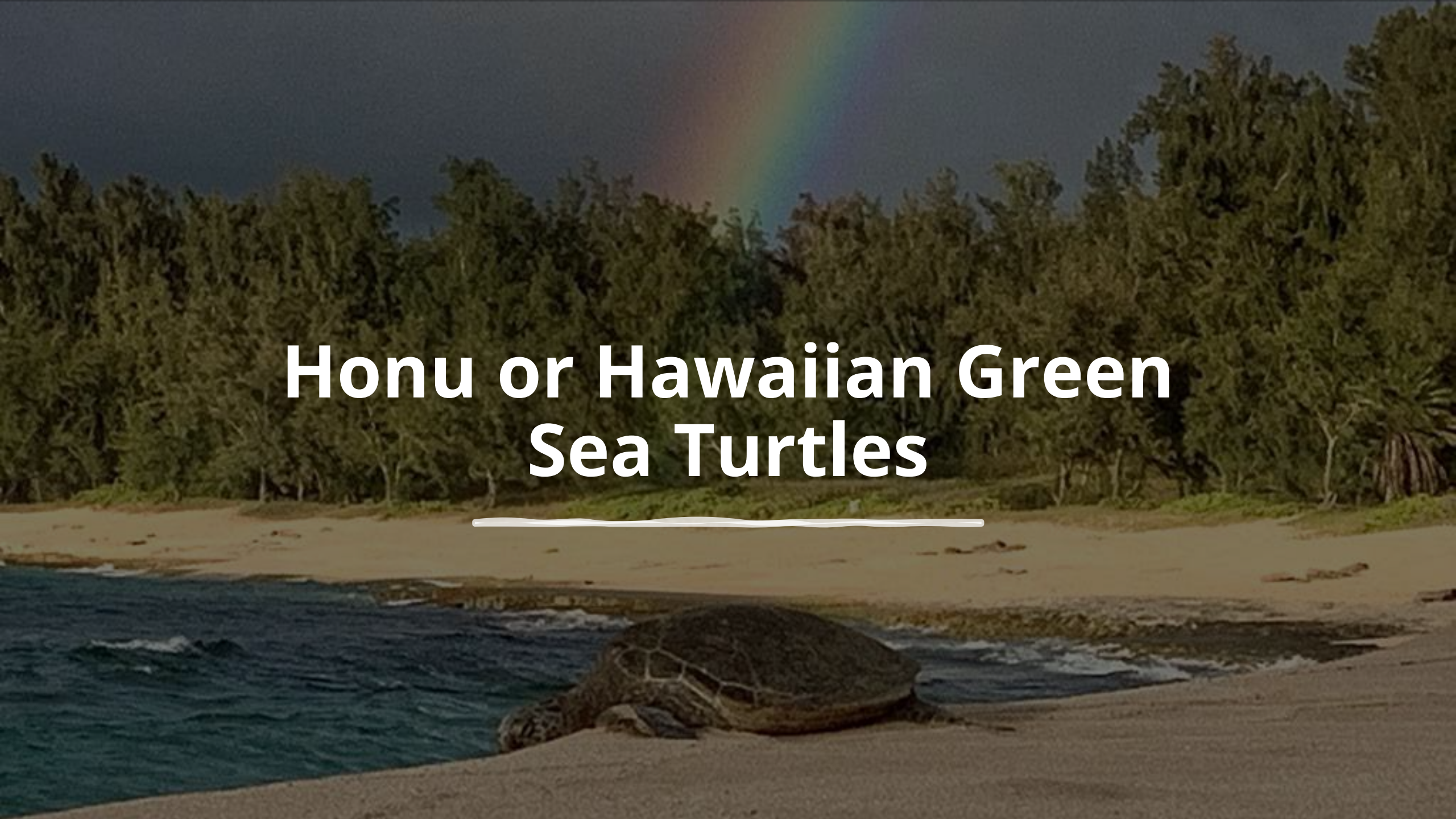
Endangered Newell's Shearwater



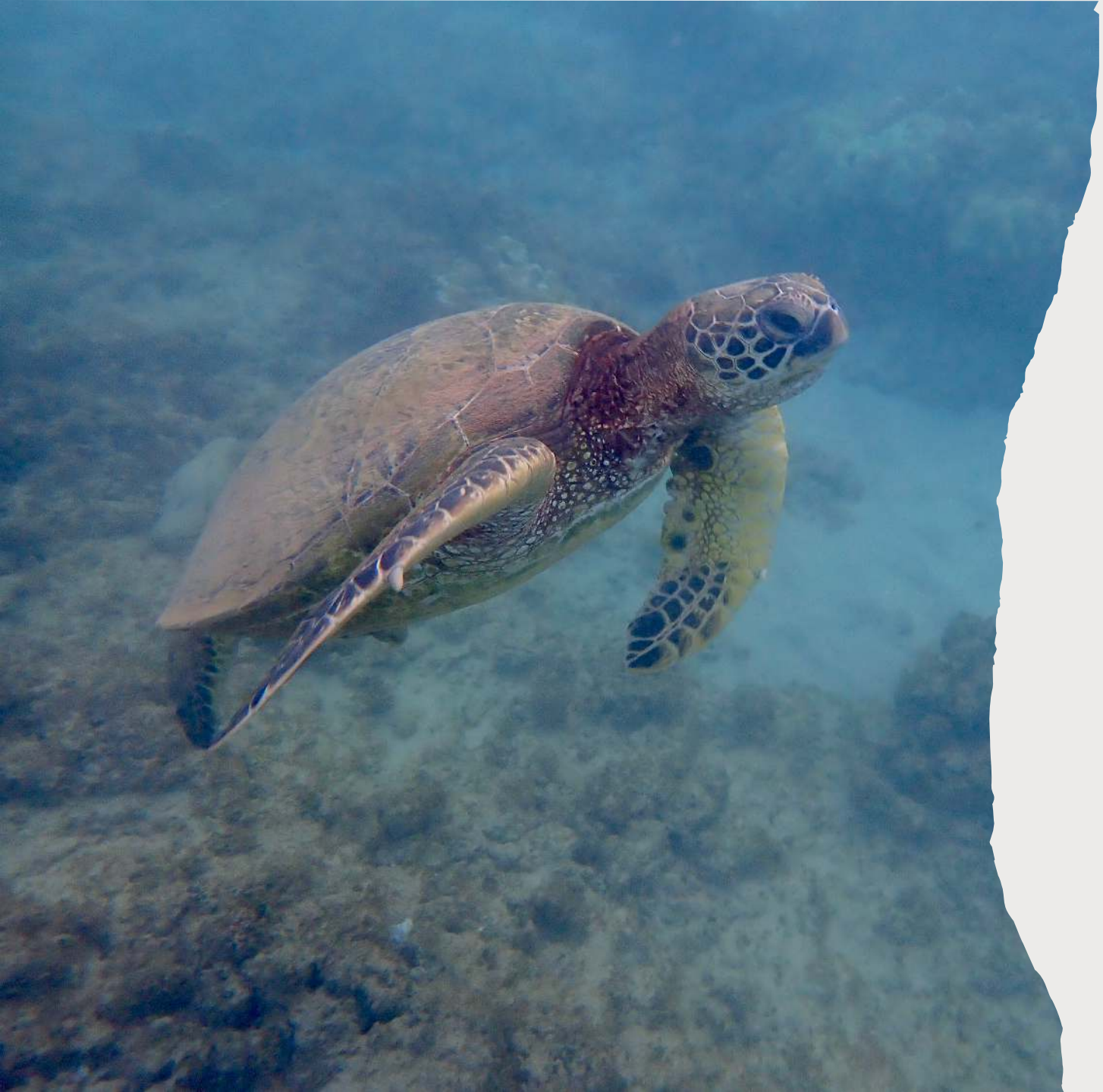
Seabird fallout on Oahu

Map & photo: Hawaii Wildlife Center

Downed seabirds are vulnerable to introduced predators like cats & mongooses



Honu or Hawaiian Green Sea Turtles

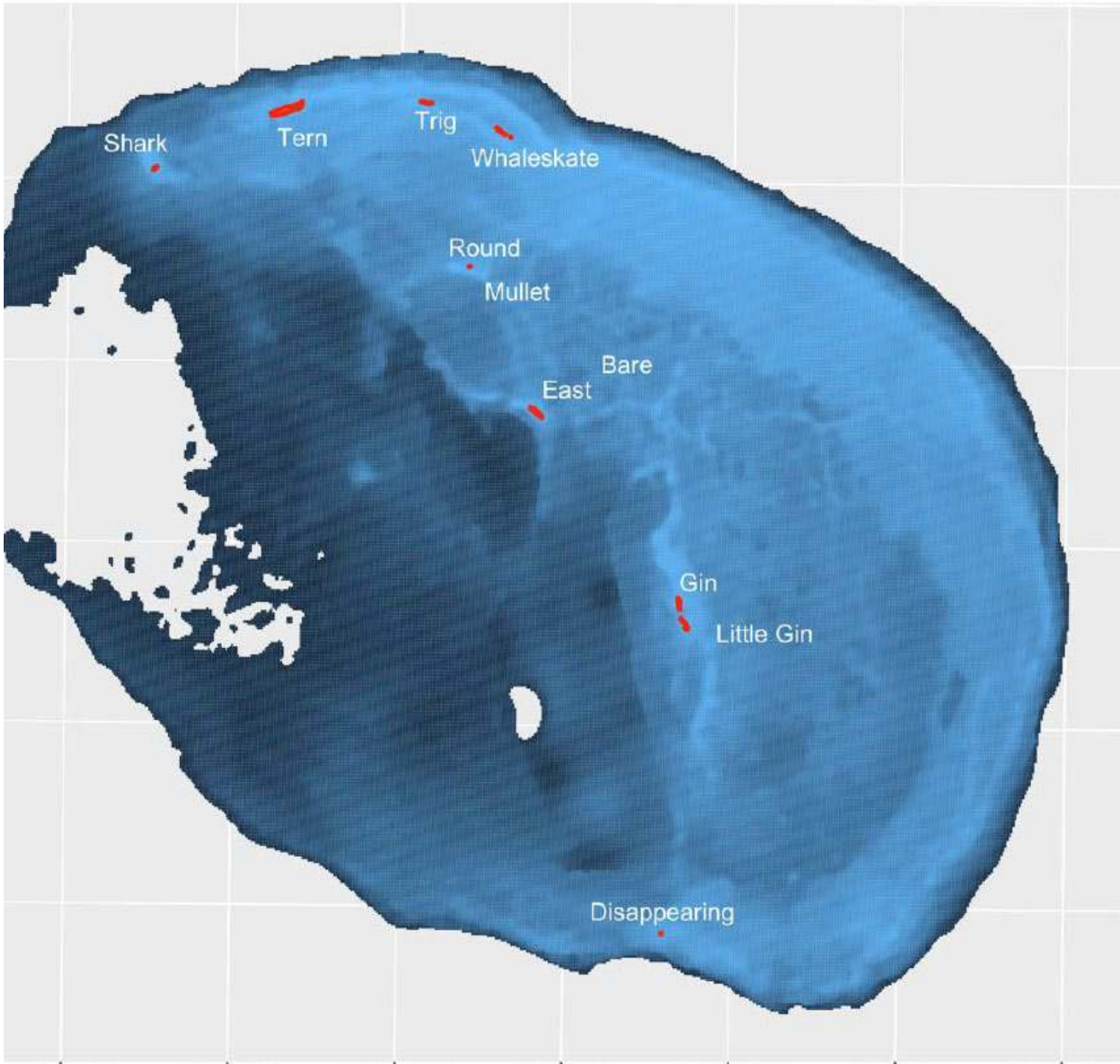


Honu

- Hawaiian Green Sea Turtles historically nested in significant numbers on all main Hawaiian Islands
- By 1950, overharvest, primarily for turtle soup, had decimated the population
- A single site in the Hawaiian Islands still had nesting honu

Lalo (French Frigate Shoals)

- >90% of honu nest at Lalo
- Made up of several tiny islets that come and go
- Mean elevation is 4 feet above sea level



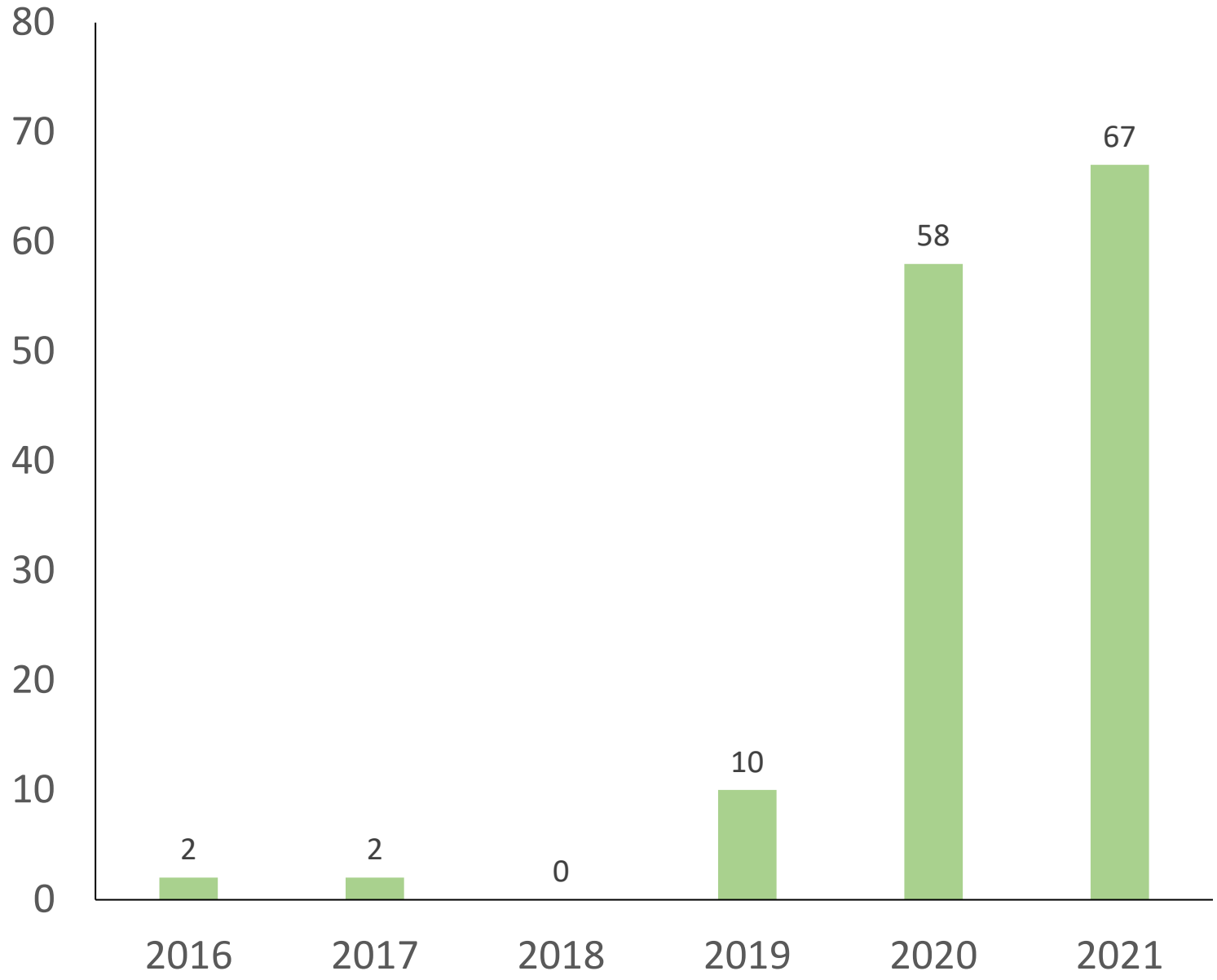
Hurricane Walaka destroys East Island

Photos NOAA

Why is this important?

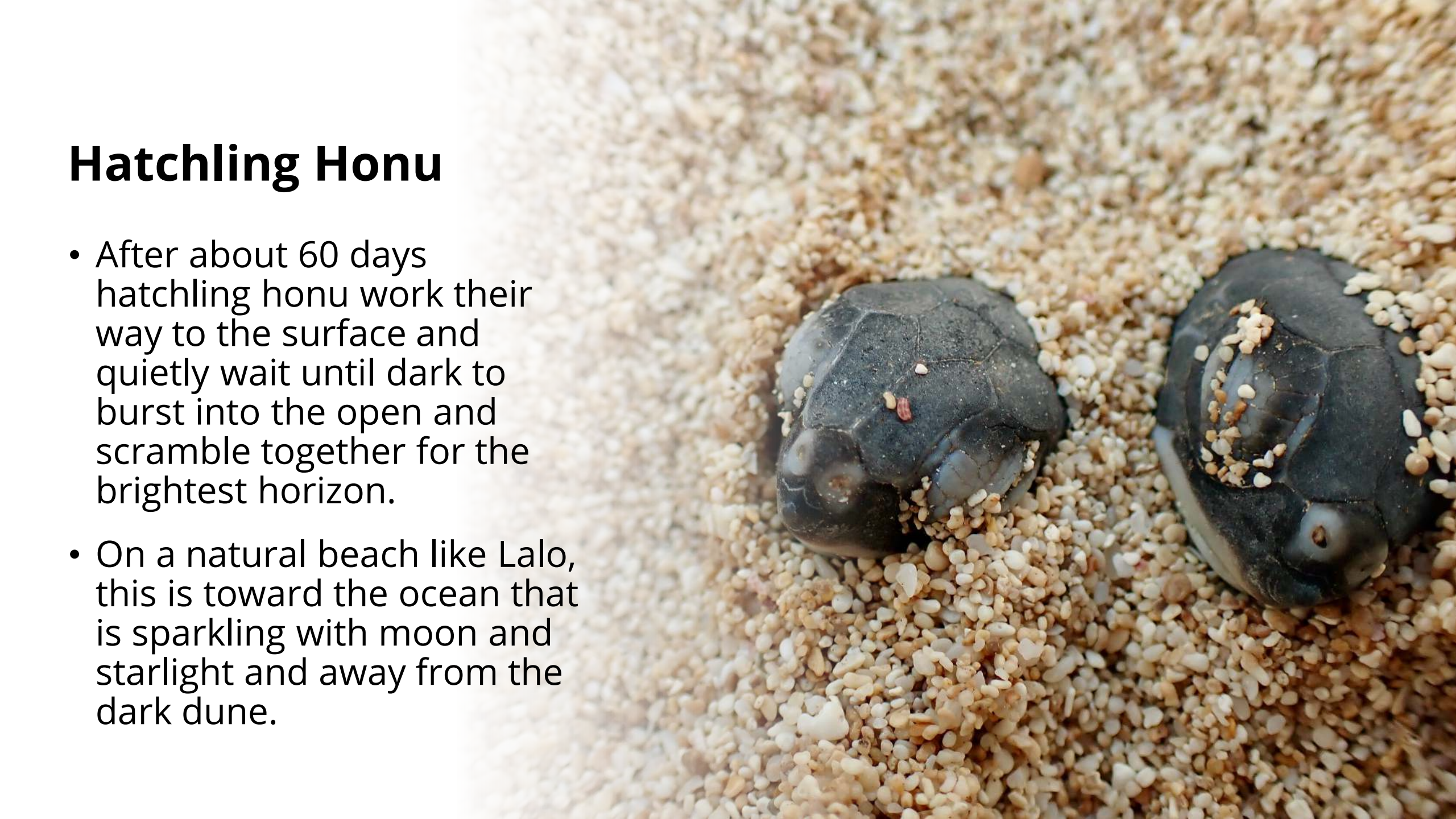
- Nesting habitat is disappearing at Lalo
- Need: safe nesting areas on the high elevation islands within the Main Hawaiian Islands

Total Number of nests on Oahu by year



Hatchling Honu

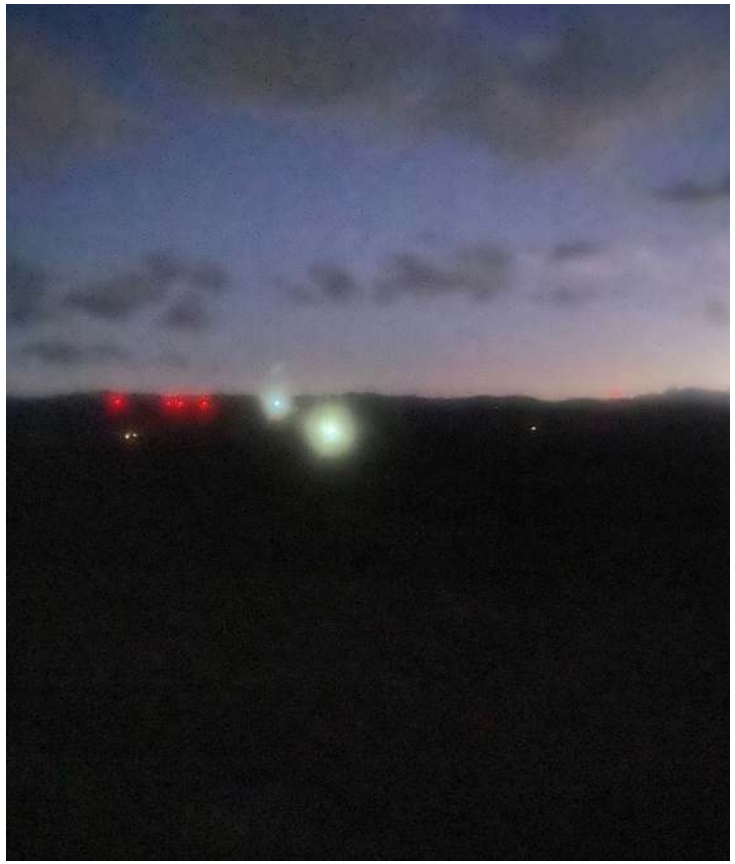
- After about 60 days hatchling honu work their way to the surface and quietly wait until dark to burst into the open and scramble together for the brightest horizon.
- On a natural beach like Lalo, this is toward the ocean that is sparkling with moon and starlight and away from the dark dune.



Honu or Hawaiian Green Sea Turtle

Artificial lights cause a problem because they lead hatchlings away from the ocean.

Artificial Lighting: The biggest threat to nesting honu



It's not just beachside lighting

Locations of nests w/ disoriented hatchlings

- Ke Iki to Ehukai
- James Campbell National Wildlife Refuge
- Bellows
- Ft Hase, MCBH
- Marconi Road
- Kailua Beach
- Sunset Beach

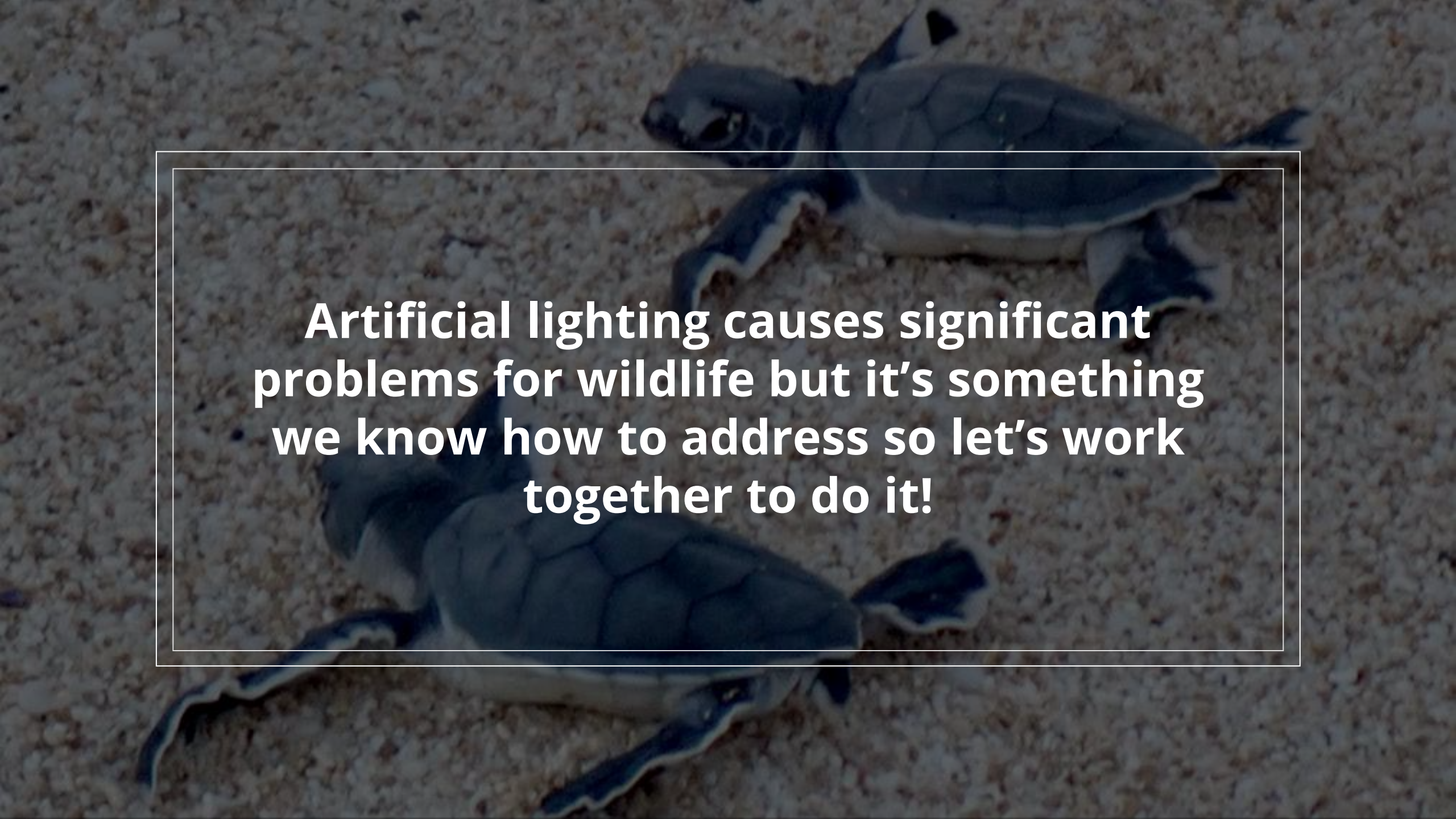
Once disoriented by artificial lights hatchlings are vulnerable

- Easy prey for invasive predators
- Can become exhausted and dehydrated
- Wastes vital energy sources for survival

Photo: K. Bryan

How to Use Artificial Light Responsibly

- Turn unnecessary lights off
- Use motions sensors & dimmers
- Keep lights low to the ground
- Shield lights so that light is only visible where it’s needed
- Use low wattage amber & red lighting.
    - Longer wavelengths are less harmful to wildlife

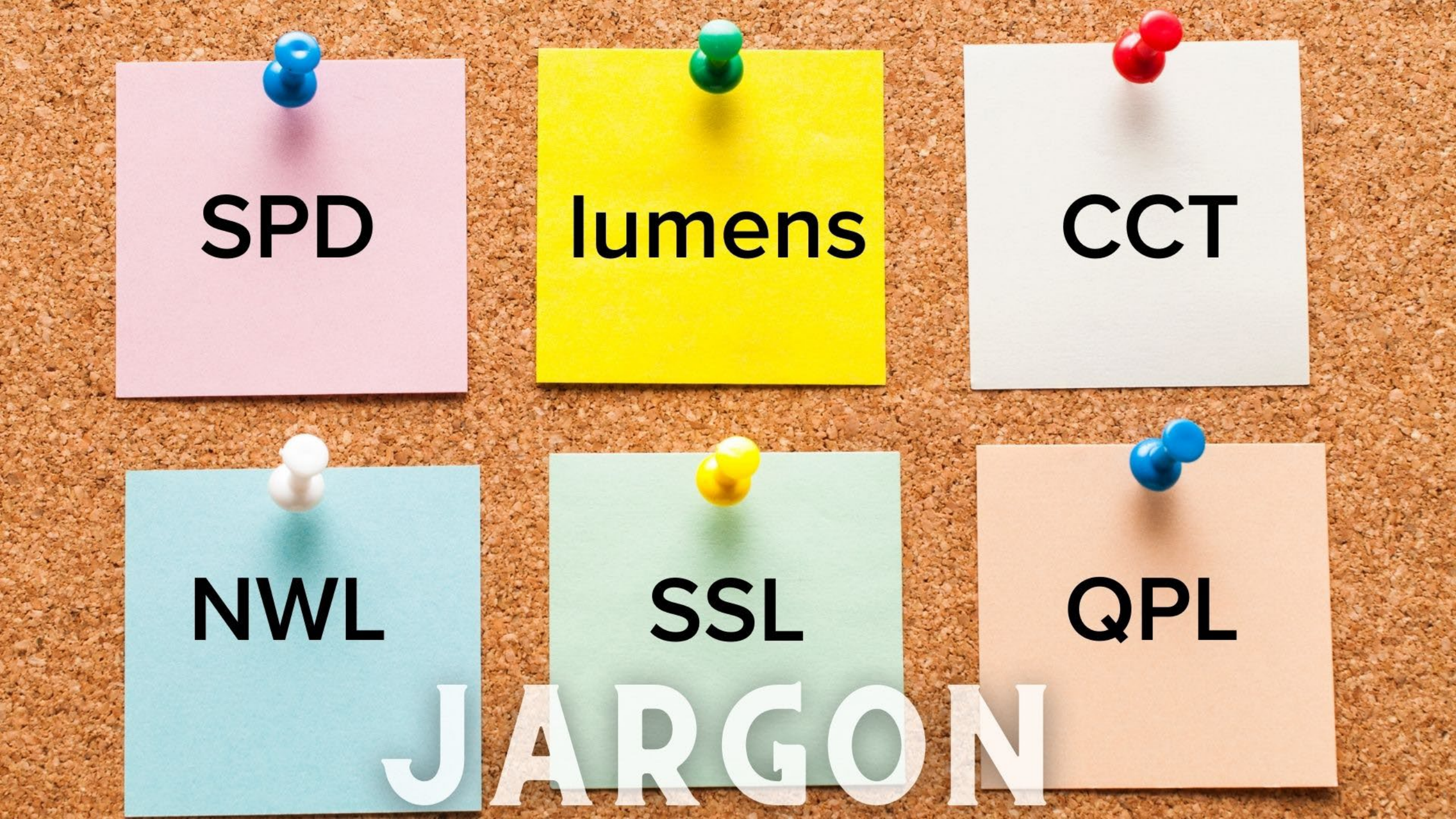


Artificial lighting causes significant problems for wildlife but it’s something we know how to address so let’s work together to do it!

Leora Radetsky
Sr. Lighting Scientist,
DesignLights Consortium

DLC Resources for Selecting Outdoor Lighting

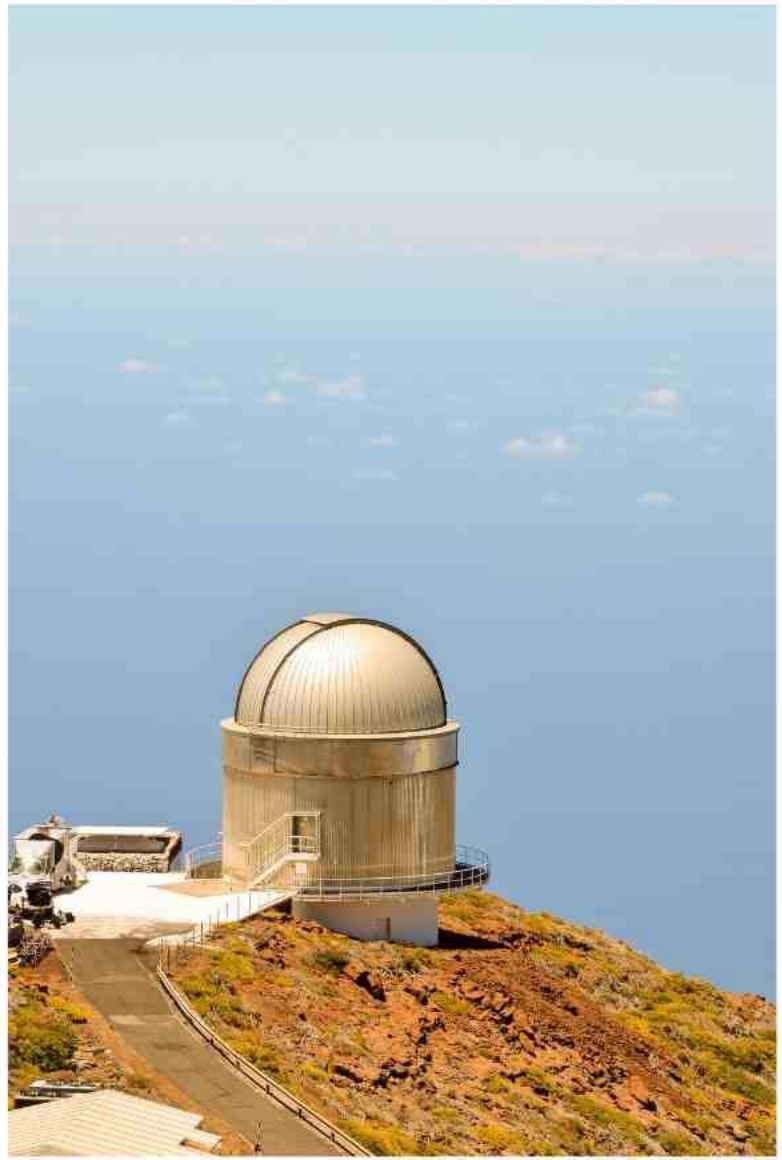
The DLC is a non-profit organization whose mission is to achieve energy optimization by enabling controllability with a focus on quality, people, and the environment.


SPD
lumens
CCT
NWL
SSL
QPL
JARGON

Seven Strategies to Minimize Negative Impacts of Outdoor Light at Night

SCAN ME

Use outdoor lighting that is dimmable and control ready.



Consult with local experts and community members.

Use the right amount of light.

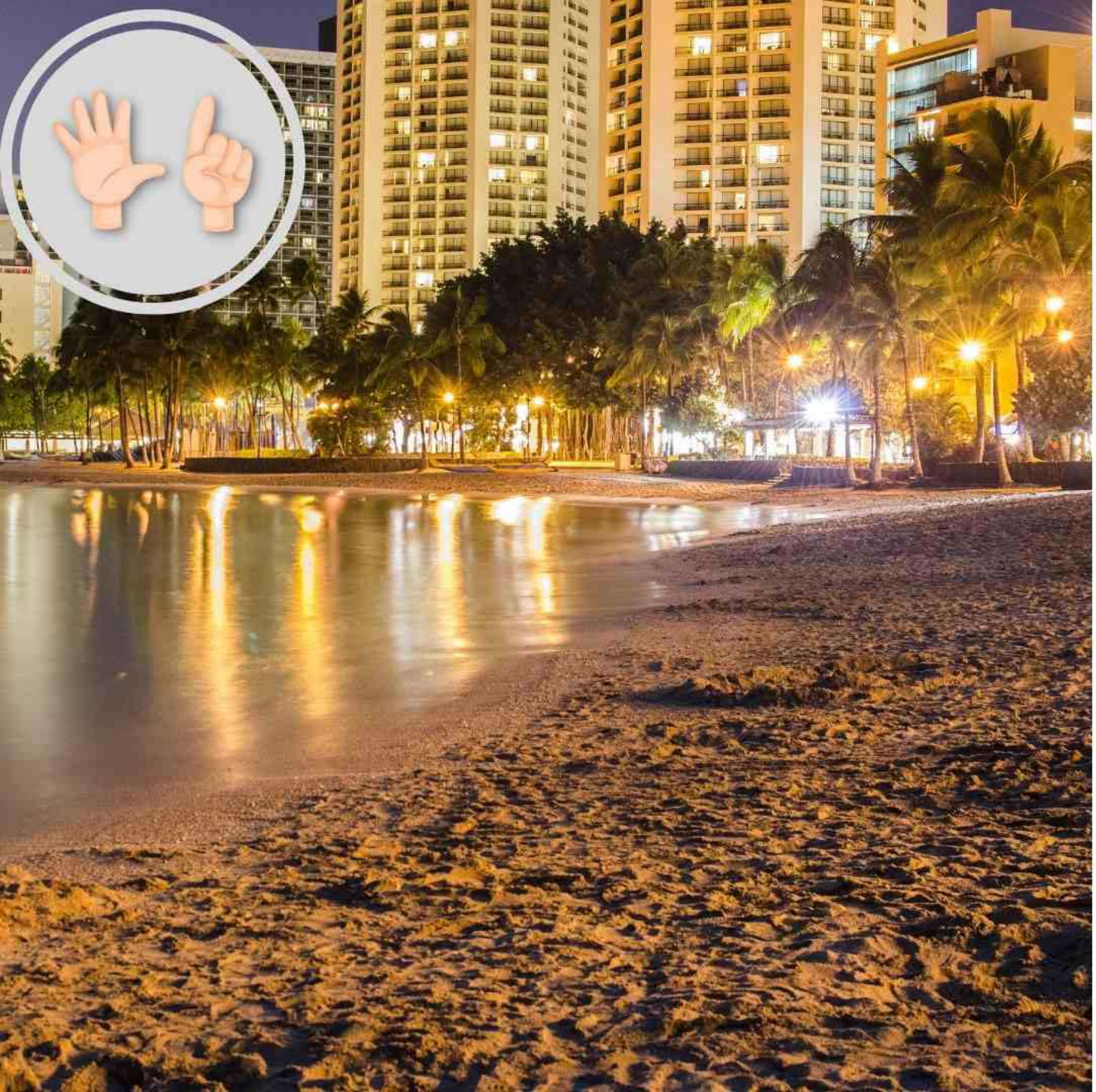
- Don't overlight
- Don't direct lights toward beach
- Don't use unshielded lights that put light on waterways

Control lighting to reduce energy use and light pollution

- Don't use light that isn't dimmed when beach is unoccupied.
- Don't light beach and water, light walkways.

Control lighting to respond to seasonal changes in the environment.

- Don't use non-essential lighting during migration (or dim)
- Don't use uplight during bird migration



Control the distribution of light.

- Don't point light towards beach and water
- Don't use unshielded lighting that is visible to turtle hatchlings
- Don't use white light around beaches

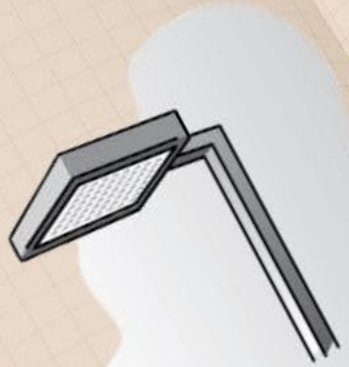
Minimize blue-violet light.

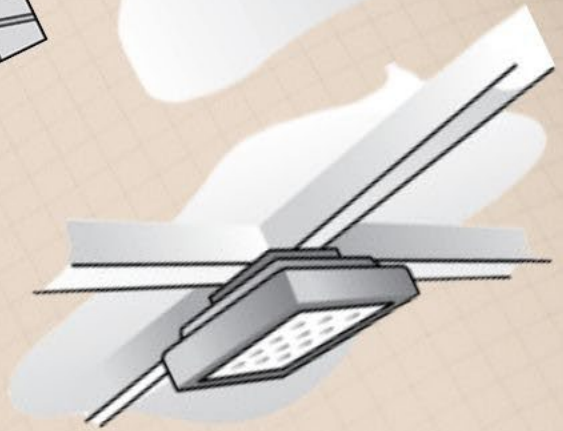
- Don't use bluish white light
- Don't use floodlights aimed towards beach
- Don't use lights at full power when unoccupied


LUNA V1.0
Technical
Requirements
DLC SSL V5.1
Technical
Requirements

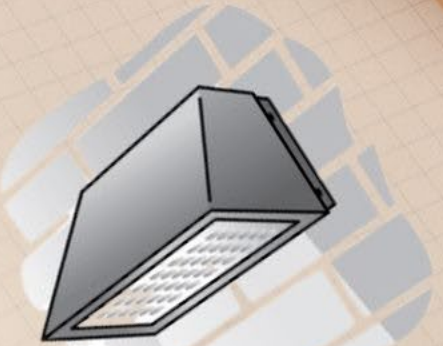

LUNA Version 1.0
Technical Requirements
SCAN ME

Eligible product types



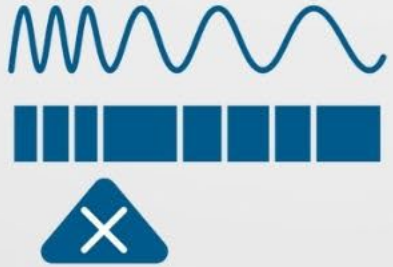


My Plan:



LUNA V1.0 Thresholds

Limited uplight
and aiming

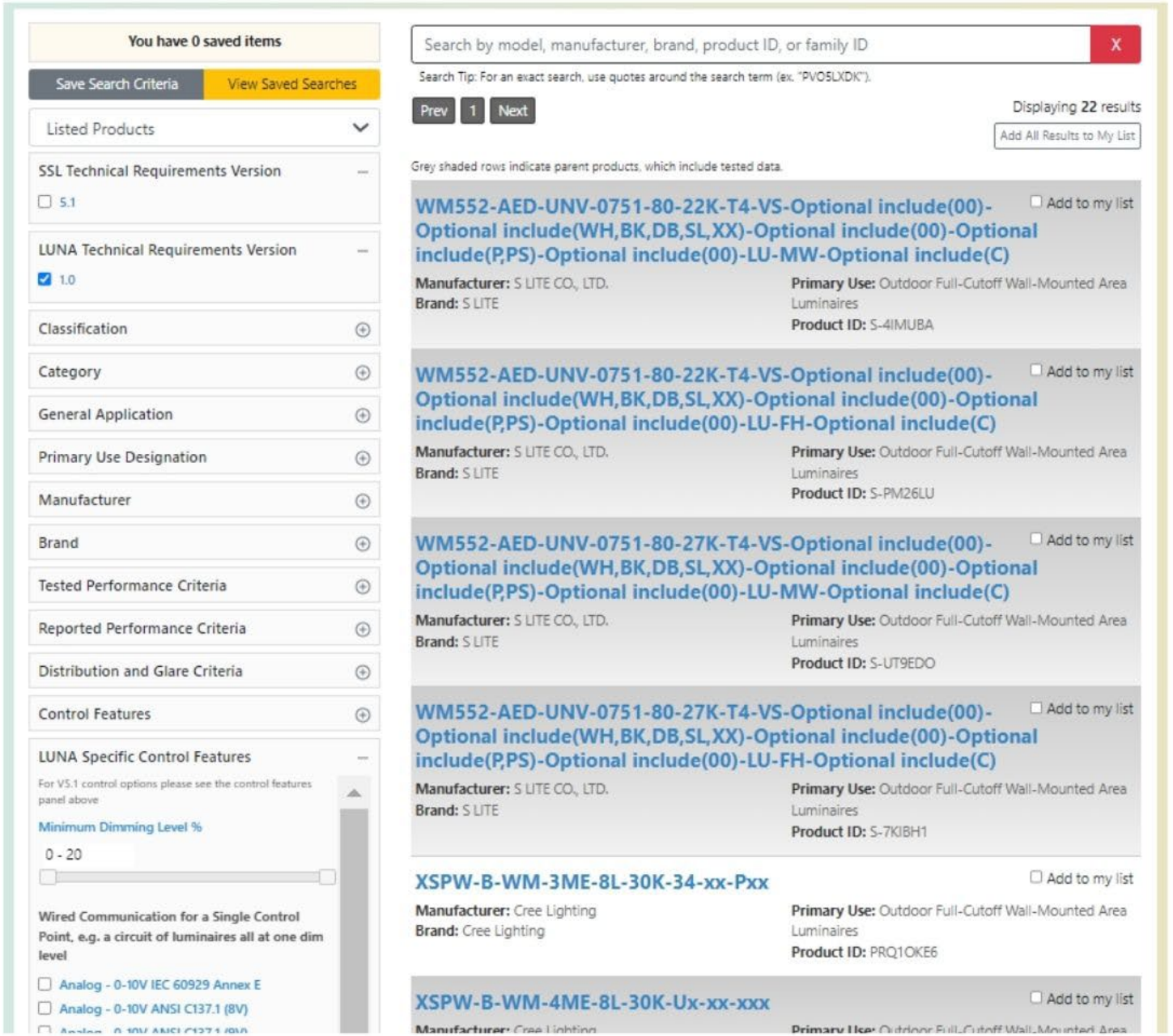


Warm color temperature
CCT: 2200 - 3000 K

Dimmable to
at least 20%

LUNA QPL

- Meet rebate program requirements
- 3rd-party evaluated
- Performance data
- Searchable and filterable




DLC LISTED
DLC LUNA
XSPW-B-WM-2ME-8L-30K-Ux-xx-xxx
Manufacturer: Cree Lighting
Brand: Cree Lighting
PHOTOMETRIC IMAGES AND FILES
Spectral Power Distribution Image
Spectral Power Distribution
VIEW DETAILS
VERSION HISTORY
PRODUCT OVERVIEW
Classification
Standard
Primary Use
Outdoor Full-Cutoff Wall-Mounted Area Luminaires
Reported Input Wattage
77 W
Reported Light Output
8475 lm
Reported CCT
3000 K
Reported CRI (Ra)
70
Manufacturer
Cree Lighting
Brand
Cree Lighting


Amber LEDs

STATUS QUO

DLC WHITEPAPER: NON-WHITE LIGHT SOURCES FOR NIGHTTIME ENVIRONMENTS

EFFICACY

TRADEOFFS

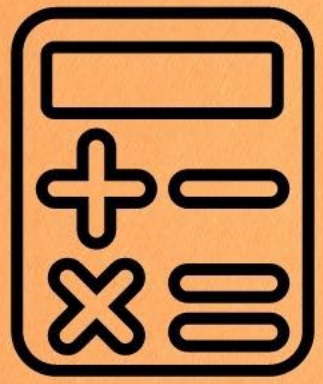
ANALYSES

SCAN ME

JOURNAL ARTICLE:
SPECIFYING NON-WHITE LIGHT SOURCES IN OUTDOOR APPLICATIONS TO REDUCE LIGHT POLLUTION

NEW BINS

TERMINOLOGY

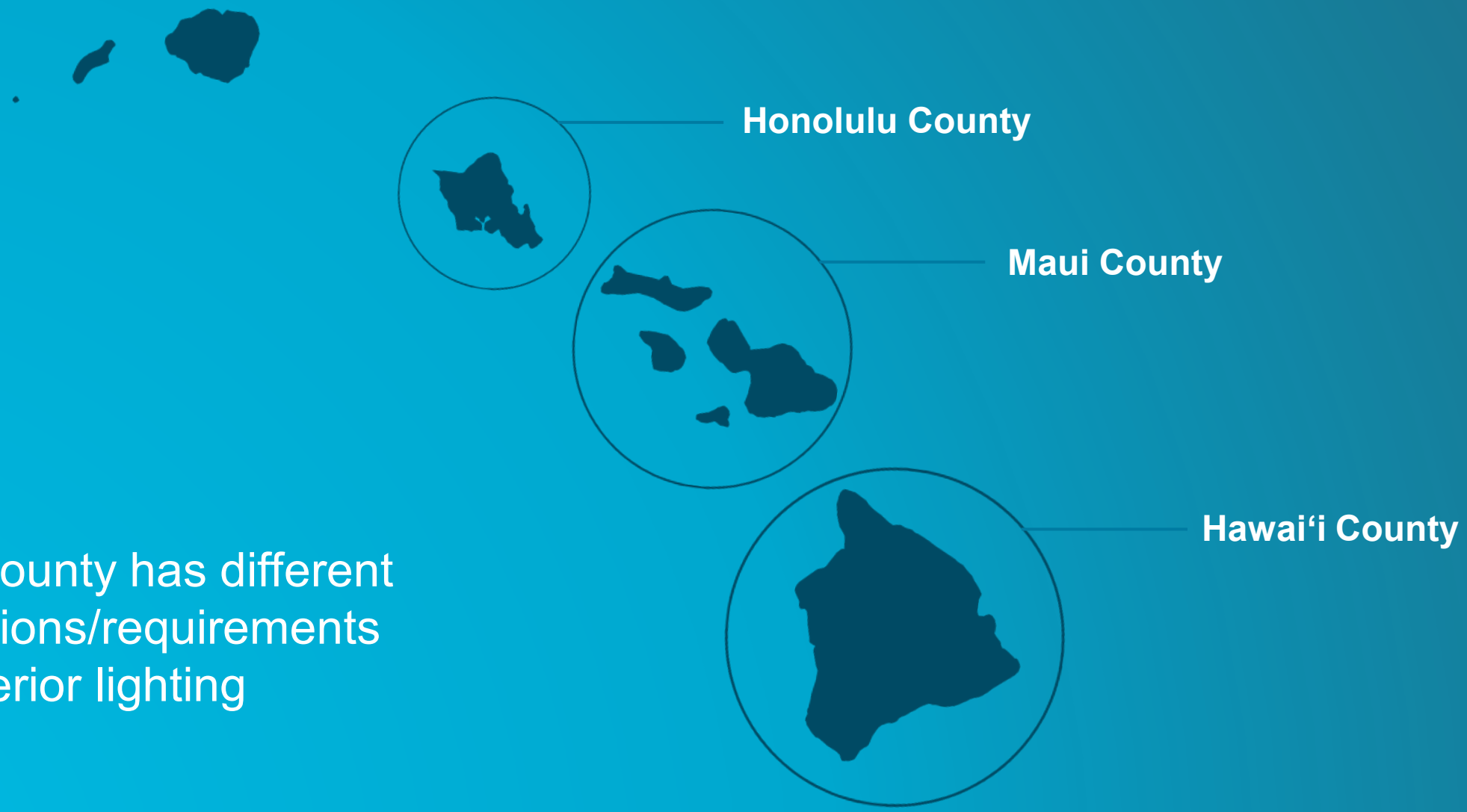


CALCULATOR

SCAN ME

Graceson Ghen
Hawaii County Manager,
Hawaii Energy Efficiency
Program

Hawai‘i Energy Service Territories



Each county has different regulations/requirements for exterior lighting

Hawai‘i Island

Hawai‘i County Code, Article 9

- Established in 1988 to protect Hawai‘i's dark skies.
- Low Pressure Sodium (LPS) was selected as preferred exterior lighting due to its narrow wavelength & filterability by astronomers. Fixtures required to be fully shielded.
- LPS was one of the most energy efficient sources of exterior lighting available.

LEDs Enter the Scene

New LPS fixtures & bulbs become harder to source

2006-'13 — County of Hawai'i Traffic Division, planning and testing period for conversion of ~10,500 LPS streetlights to LED. Article 9 revised.

2010 — 14 LEDs deployed for testing along Hilo's Bayfront area.

2013 — 1,000 LEDs deployed around the island as first pilot conversion.

2015-'17 — Full conversion of the remaining ~9,500 LPS fixtures, island wide.

Images source: Hawai'i County

Images source: Hawai'i County

Images source:
https://www.myoahustreetlight.com/gallery

Project Energy Numbers

- Existing LPS fixtures ranged from 55W-180W
- LED replacements ranged from 26W-108W
- After full conversion, first year savings were approx. 330 kW & 2,179,000 kWh!
- This also represents over 4,400,000 lbs of avoided CO_2 production.

Waikōloa Village

Images source: C&W Energy Solutions

Overview

- LEDs street light projects can cut energy use in half or more!
- Longer lifespans reduce maintenance costs.
- Plan your LED project with light pollution in mind.
    - Select products that are night sky & animal friendly, use bi-level dimming, & limit lumen output to only what is needed.
- Hawai'i Energy supports potential LED projects with very generous rebates.
    - ($0.08-$0.12/kWh for first year's savings, & $125-$400/kW reduced during peak hours!)

Contact the Presenters

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Q&A