ARTIFICIAL LIGHT AT NIGHT (ALAN) – ASSESSMENT, MEASUREMENT AND MANAGEMENT

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Outline

- Cues used by sea turtles
- Impact of light on turtles
- Sources and types of Artificial Light
- What light is the most disruptive?
- Measuring and quantification light, how?
- Monitoring the impact of light on hatchlings
- Guidelines, regulations, education
- Assessing and Managing light

Cues used for orientation - adults

- Migrations
  - Visual bathymetric landmark cues
  - Chemosensory
  - Earths magnetic map
- Nesting beach selection
  - Beach orientation,
  - subtidal bathymetry,
  - sand type, temperature and depth
  - **Light** (neophytes vs experienced)

Cues used for orientation - Hatchling

- Sea-finding after leaving the nest
  - **Light is the primary cue**
  - Geotaxis
  - Vibration?? Possible but not proven
- Migration from natal beach
  - Surface water currents
  - Tides
  - Orient into the wavefront in coastal waters
  - Earth magnetic map in deep water

How adults use light cues

- Nesting adult females nest in the region of their natal rookery.
- Females cruise the offshore waters inspecting the beach before they come ashore to nest.
- Experienced nesting females are unlikely to be disturbed by light.
- Neophytes (first time nesting females) are likely to be disturbed by light when they are selecting their first nesting beach.
- Neophytes may be forced to select a poorer quality nesting beach in order to avoid light.

How hatchlings use light cues

- Light used in sea finding after emerging from nest
- Hatchlings Integrate light over a 180° x 30° area
- Orient towards the lowest, lightest horizon
- Orient away from the tallest darkest horizon (regardless of light behind or above the dark horizon)

Threats to hatchlings from light

- Light disorients hatchlings and reduces their ability to find the ocean
- Makes them more visible to predators – birds, lizards, foxes etc.
- Increases their time on the beach, increasing the risk of dehydration, predation and reduced energy reserves

Sources of Artificial Light at Night (ALAN)

- Urban lighting - Cities, towns and villages
- Tourism – beach front hotels
- Marinas
- Ports
- Industrial developments – onshore and offshore
- Nearshore dredging
- Nearshore vessels

ALAN - High Pressure Sodium

ALAN – Metal halide

ALAN - Halogen

ALAN - Fluorescent

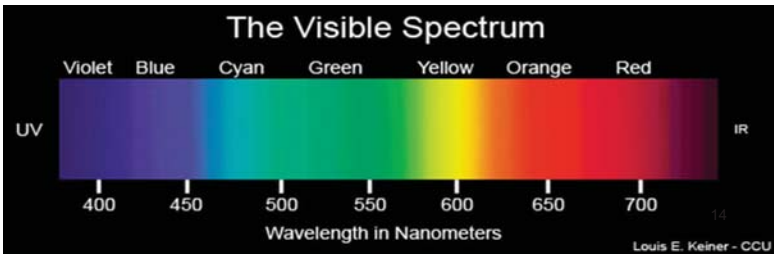
ALAN – Light Emitting Diode (LED)

How do hatchlings see light?

Marine turtle hatchlings;

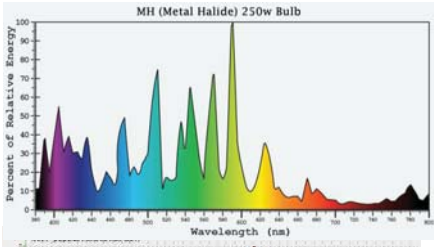
- Can see all visible light between 400 – 700 nm
- Favour short wavelengths (400nm – 500nm) over long wavelengths (600nm – 700nm),
- Respond to high intensity light

So which lights are rich in short wavelength light ?

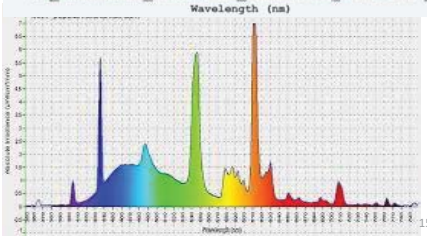


Light rich in short wavelengths

Metal halide

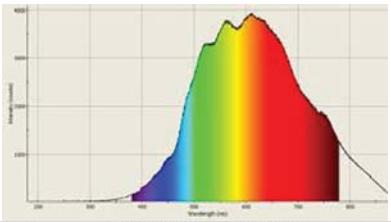


Fluorescent

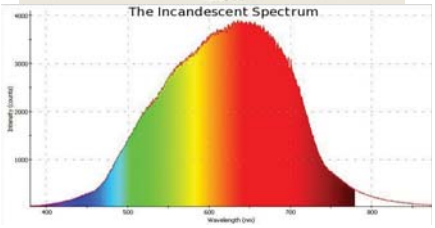


Light rich in short wavelengths

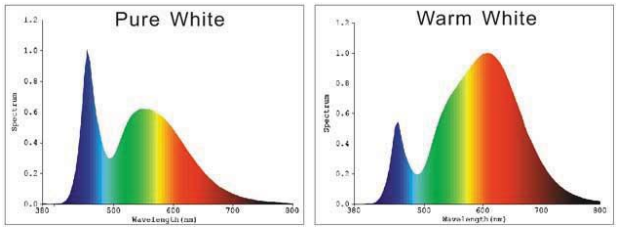
Halogens



Incandescent



Light rich in short wavelengths

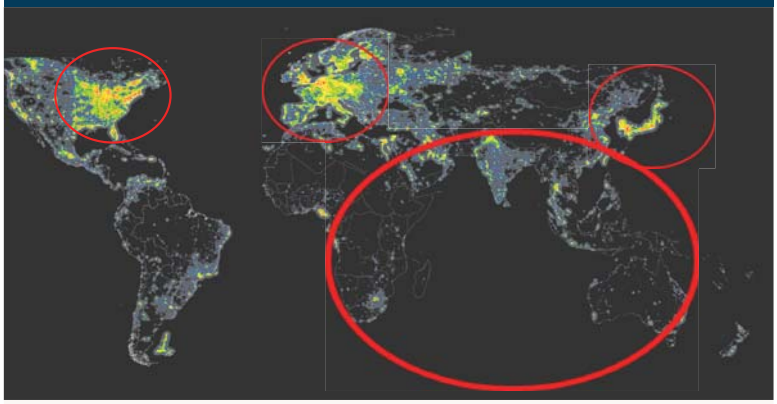


White LED

and

Blue or green LED

where is the light ?



Why do we need to quantify light?

- Identify lights that are causing problems for wildlife,
- Track the change in light pollution over time,
- Compare different light types,
- Compare lights in different locations,
- Track the actions taken to manage lights,
- Provide evidence to regulators that approval conditions are being met,
- Use light results to interpret biological data (all fauna).

Measuring ALAN

- Physical light measurements
  - SQM
  - CCD
  - Commercial instruments inappropriate (Lux)
- Biological
  - Nest fans
- Integration of physical and biological data

Sky Quality Meter (SQM)

- Small, hand held device
- Measures light directly overhead (zenith)
- Measures low levels of light, i.e. dark sky through to polluted urban sky
- Measures in units of magnitudes/arcsec^2
- Good for broad scale light mapping
- Not good for point sources or horizon lights

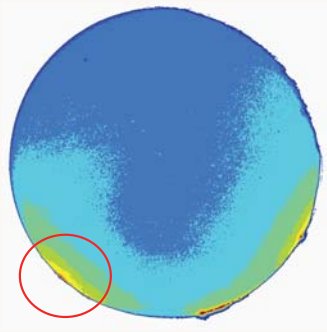
Charged Coupled Device

- Digital camera technology,
- Units – Magnitudes/arecsec^2
- Camera and fish eye lens
- Operate off rechargeable batteries
- Data capture - SD card
- Isolate the blue, green and red regions of the spectrum digitally.
- Captures 100% of the sky and 100% of the horizon
- Rugged and weatherproof
- Small and portable
- Suitable for remote sites
- Quickly and easily deployed
- Packs into hand luggage
- Operational within seconds - flip the ON switch
- No special training required

Results - Isophote

Raw image of a coastal industrial site

Processed isophote image



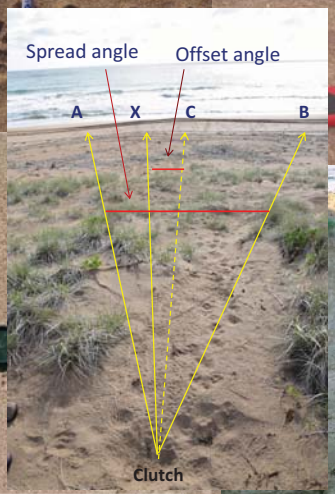
Biological monitoring - Hatchling Orientation

- Biological data, collect data on the dispersal pattern of hatchlings as they emerge from the nest and begin crawling towards the ocean.
- Light causes hatchlings to spread out and take a less direct route to the ocean.

Data collected*:

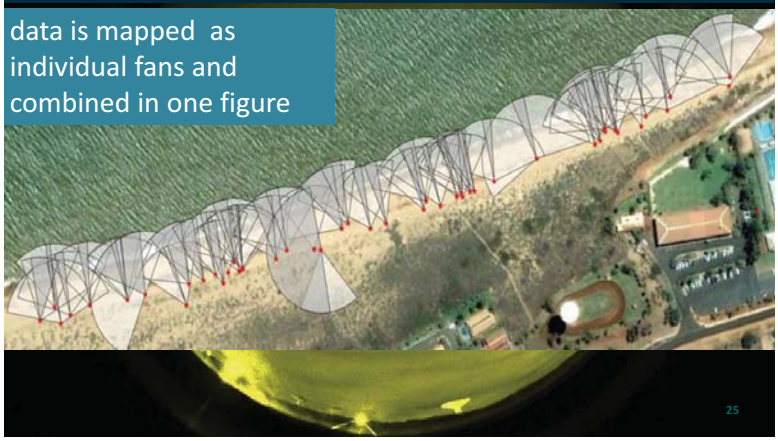
- **Spread** = angle between A and B
- **Offset** = angle between X and C

*Pendoley, 2005.



Hatchling Orientation: Hatchling fans on Cemetery Beach, Port Hedland, Western Australia

data is mapped as individual fans and combined in one figure



Light Management Guidance Documents

- Florida
  - Witherington and Martin (2000), Understanding, Assessing and Resolving Light Pollution Problems on Sea Turtle Nesting Beaches.
- Australia
  - EPA Guidance Document #5; Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts

Regulatory requirements – Chevron Gorgon LNG example

The West Australian State Government and the Federal Government require all lights be managed to protect turtles.

Chevron must;

- Establish a Marine Turtle Expert Panel to oversee all aspects of turtle management
- Long-term Marine Turtle Management Plan which describes how the turtles will be protected and managed, ***with specific reference to removing, reducing and managing light , including gas flares***

Generating awareness and understanding of ALAN

- Education of the public, regulators and the local industries producing light
- Artificial Light at Night Conference (ALAN 2015), May 30, 2015 - June 1, 2015, Sherbrooke, Quebec, Canada
- **International Year of Light and Light-based Technologies (IYL 2015)**. proclaimed by The United Nations (UN) General Assembly (68th session)

"The International Year of Light is a global initiative which will highlight to the citizens of the world the importance of light and optical technologies in their lives, for their futures, and for the development of society."

Assessment of existing lights

- Light pollution assessment
  - Identify all existing light sources and fixtures
  - Assess what management actions can be taken to manage the lights (see next slide)
  - Conduct light monitoring to quantify light emissions before and after remedial actions (SQM, CCD technology)
  - Collect biological data on hatchling behaviour to confirm light management has been successful

Light Management Options

Planned or existing light management options might include:

- Turn unnecessary lights off
- Chose long wavelength light over short wavelength light (High Pressure Sodium, amber LEDs instead of any white light)
- Reduce the intensity of light fixtures
- Prevent escape of light above the fixture
- Use timers and motion sensors
- Implement a light curfew

Light Management Options

Planned or existing light management options continued…

- Target light onto work area
- Shield light fixtures from above and around the sides
- Mount lights on low poles
- Shield lights behind structures or barriers
- Aim lights away from the beach
- Reduce refection from hard surfaces by using matt paint on structures
- Enclose sports facilities