PML | Plymouth Marine Laboratory

Research brief | November 2023

Artificial Light At Night

impact on the marine environment

We need to talk about ALAN!

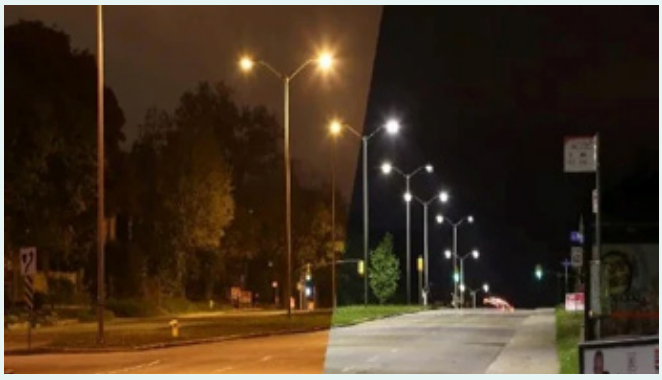
Artificial Light At Night (ALAN), produced by any human-made source, can propagate into the marine environment causing light pollution – *an excess of light that disrupts the natural patterns of wildlife, contributes to rising carbon dioxide levels, harms human health, and obscures the stars*. Light pollution threatens ocean ecosystems by disrupting natural light-driven cycles that regulate marine life.

Exposure to ALAN can:

- Mask lunar cycles disrupting the reproductive cycles of coral species.[1]
- Reduce the reproductive success[2], survival and growth of fish.[3]
- Decrease the effectiveness of camouflage at night across marine ecosystems, which may change patterns of predation, prey population sizes, and the frequency of genetic traits in a species.[4]
- Disrupt the behaviour and biological function of copepods, tiny crustaceans that are critical components in the marine food web.[5]
- Limit habitat availability and affect the abundance and distribution of sandy beach organisms.[5]
- Cause massive mortality events of severely threatened seabird fledglings.[5]
- Disorientate turtle hatchlings affecting their ability to reach the ocean.[6]

Lighting from coastal cities, oil platforms, boats and offshore structures scatters in the atmosphere to form artificial skyglow, expanding the reach of light pollution up to hundreds of kilometres into the surrounding marine habitats.

The proliferation of short-wavelength, blue-toned white lights since the advent of energy-efficient light-emitting diodes (LEDs) in the early 2000s has compounded this issue. The light is strong enough to penetrate deep into coastal waters, reaching more than 40 metres beneath the surface in areas with clear water and high intensity illumination.

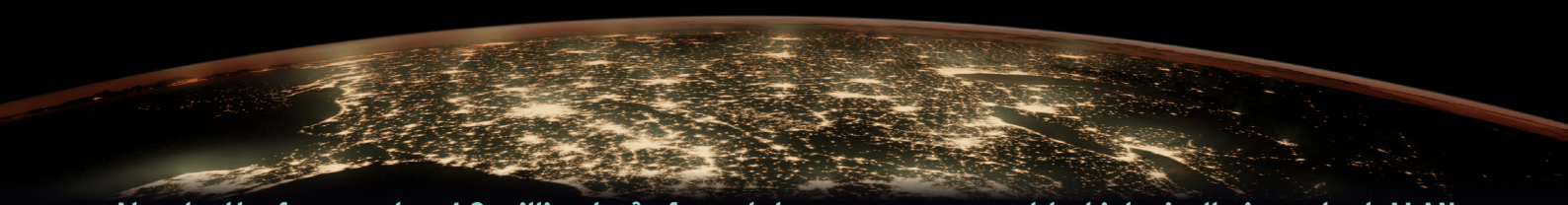


LEDs create a much brighter, whiter light than traditional sodium street lights.

Golden rules for dark night conservation*

- **Avoid short wavelength blue light, use longer-wavelength, redder bulbs or, at a minimum, lower colour temperature LEDs**
- **Only use lights at night where and when needed, not for decoration**
- **Designate marine 'Dark Sky' areas e.g. in Marine Protected Areas**
- **Dim some lights and/or use sensors so that they are only active when needed**
- **Direct lights toward the ground, keep them low and shielded**

*Adapted from *Ten golden rules for dark night conservation for marine habitats.*[5]



At a depth of one metre, 1.9 million km² of coastal ocean are exposed to biologically important ALAN

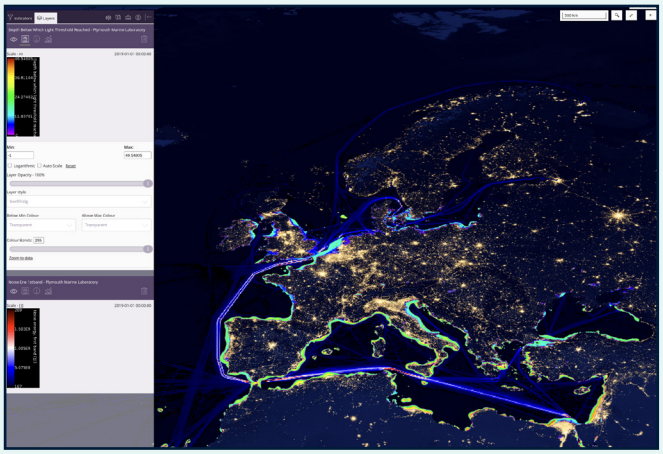
The ALAN atlas

Plymouth Marine Laboratory (PML) has led the development of the first global atlas of ALAN under the sea. Research, led by Prof Tim Smyth, has shown how far light pollution can reach the ocean's depths and which marine species are the most likely to exhibit a biological response. The research has been underpinned by PML's extensive expertise in ocean colour satellite Earth observation and Dr Tom Davies' (University of Plymouth) expertise in the ecological impacts of ALAN. The atlas brings together:

- Nightime light pollution data and satellite-derived ocean colour.
- Field measurements of atmospheric and in water optics.
- Global monthly datasets of in-water optical properties (1998 to 2017).
- Simulations modelling the transmission of light through the water[7].

The ALAN Atlas is openly available for all to use to aid understanding of the threat light pollution causes to marine life across the oceans. We are still developing the portal and welcome feedback on its use - impact@pml.ac.uk

scan or click to access the Atlas



Screenshot of the ALAN atlas, showing light pollution (upper layer) and shipping noise (lower layer) around the European coasts. The visualisation tool is under development and can be accessed using the QR code.

Applying the atlas...

PML's research can enable light pollution to be considered in a range of policies and management processes for the first time.

For example:

- Inform marine plans to ensure they minimise light emissions from new developments, activities and uses.
- Aid new maritime structures, such as windfarms, in choosing the least impactful lighting options.
- Influence a reduction in unnecessary coastal lighting.
- Inform street lighting plans around coastal areas so that they consider the impact of lighting alongside cost and carbon reduction in their decision making.
- Raise awareness of the need for policies and legislation to consider light pollution as another pressure on the marine environment that is reducing biodiversity.

A key example of one of these applications is below:

Working with local authorities in England

Plymouth City Council constantly look to reduce light pollution, primarily to reduce carbon emissions, be considerate to the natural habitat and reduce unnecessary expenditure, and have consulted with PML on the impacts of current lighting on the marine environment in Britain's Ocean City.

They are conducting pilot schemes in key areas to monitor the impact of profiling highway lighting and using dynamic systems to trim the time lights are active. They will consider lighting infrastructure around key coastal areas to reduce the amount of light shining out into the marine environment.

The impact of ALAN on society

The impacts of ALAN on the marine environment are becoming clearer but further research is needed to understand the subsequent implications for human uses of the oceans. These uses, such as fisheries and recreation, may be negatively or positively impacted by the biological and ecological impacts of ALAN. PML are developing a framework to link the environmental impacts of ALAN with human activities/uses of the marine environment to inform a balanced and holistic view of the situation, mitigation options and policy requirements.

PML researcher, Dr Olivia Rendon, is also leading a study of the perceived benefits and public perception of ALAN to help develop socially-acceptable mitigation measures that balance public safety with the reduction of light pollution. While a UK study found that there is no clear scientific evidence that increased outdoor lighting deters crime[8], PML research has demonstrated a link between ALAN and public safety in developing countries.

An extensive survey of residents in coastal cities of Chile revealed awareness of many benefits but little awareness of the negative impacts on the environment, especially on marine habitats and species. It is clear that further research and raising public awareness around the negative impacts of ALAN is important to help societies understand and accept the need for mitigation measures. This research is being prepared for publication and will be developed further in AquaPLAN (see opposite).

Related research

AquaPLAN: Aquatic Pollution from Light and Anthropogenic Noise

Starting in early 2024, the EU-funded project, AquaPLAN, aims to assess the combined effects of light and noise pollution on aquatic biodiversity in European waters. It will create the first ecological time series linking changes in freshwater, estuarine, and marine biodiversity to combined light and noise pollution and will establish a new long-term monitoring programme. The project will explore the social perceptions of current mitigation measures and review existing policy to provide applicable and efficient recommendations to reduce light pollution.

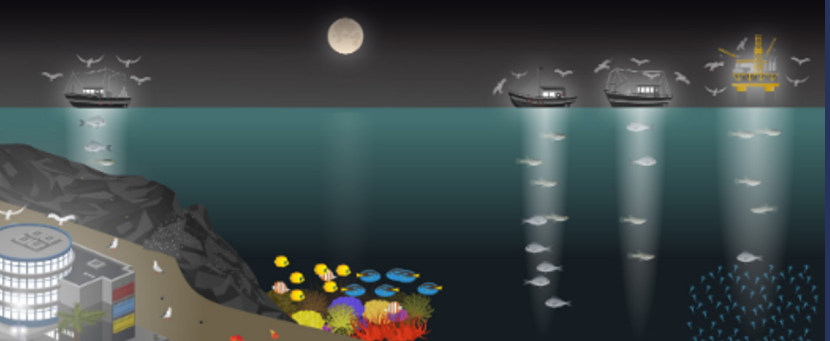
MSPACE: Marine Spatial Planning Addressing Climate Effects

The ALAN atlas is being used in a novel research project driving forward the capability of the four UK nations in designing and implementing climate-smart marine plans. The project is assessing modelled future marine conditions, aiming to enable planners and other decision makers to develop marine plans for the UK that take account of cumulative pressures on marine habitats, including projected future climate, as well as present pressures such as ALAN. The project has identified areas where the spatial management of human uses could be optimised to thus protect the natural resilience of habitats to climate change, where this is observed.

Further information: www.pml.ac.uk/mspace

Wider impacts

As well as impacting the marine environment, ALAN can harm human health (with links to cancer, diabetes and sleep disorders), interfere with bird migration and lead to the death of night flying birds, as well as being a key driver of insect decline. There is therefore an increasing urgency for better management and policies on ALAN.



Research into solutions

Further research is needed to better understand the problem and design solutions. PML is seeking funding to address the following priorities:

- Improve observations of ALAN to understand the wavelengths to which organisms are exposed using innovations in satellite technology and underwater sensors.
- Gain deeper insight into the effects of different parts of the light spectrum on organisms.
- Conduct social scientific research to understand people's lighting needs and preferences, key for successful interventions to mitigate ALAN impacts.

References

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Please share with us your thoughts and experiences of how the Atlas, and our related research, can inform adaptation and mitigation measures to reduce ALAN.

If you would like to talk to the researchers behind this innovative work please contact: impact@pml.ac.uk

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