Photic Ecology in the Epipelagic High Arctic Polar Night: A Deep Sea Analogue?

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Light and vision play a large role in interactions among organisms in both the epipelagic and mesopelagic realms. Eye structure and function in these habitats is commonly adapted for photon capture in the underwater light field, with increasing specialization in the mesopelagic as light declines (Warrant & Locket 2004). While atmospheric light is typically considered to be the dominant source of photons to the underwater light field, chemically-generated light by organisms (bioluminescence) provides an additional source of light in the mesopelagic to supplement atmospheric light (Haddock et al. 2010). During Polar Night in the high Arctic, the sun remains 6° or more below the horizon throughout the diel cycle. During this time, the epipelagic is a dim photic environment over an extended period, which would seem to favor bioluminescence and organisms adapted to detect dim light, much like the mesopelagic.

In four years of sampling on the west coast of Svalbard during Polar Night (January 2014-2017), we have studied eyes and vision in micronekton (krill and amphipods), and the light field in which they function. We find these organisms to possess similar optical designs and visual function as comparable mesopelagic species (e.g., Warrant & Locket 2004). Bi-lobed compound eyes of amphipods *Themisto abyssorum* and *T. libellula* simultaneously perceive dim atmospheric light with the upper eye lobe and bright bioluminescence with the lower eye lobe. The superposition compound eye type of krill *Thysanoessa inermis* are common in mesopelagic species, and like other krill a trade-off is observed where these eyes have fast photoreceptor dynamics, presumably for detecting bioluminescent flashes, but which limit the sensitivity of the eye in dim light.

What light is available for these eyes to see? As in the mesopelagic, we observe biologically relevant levels of both atmospheric light (sun, moon, aurora) and bioluminescence in the epipelagic during Polar Night. Notably, by *in situ* bathyphotometer profiling coupled with an analysis of the timing of recorded light flashes we characterized a vertical gradient in structure of a generally low species diversity bioluminescent community in a representative high Arctic fjord (Kongsfjorden) (Cronin et al. 2016). Bioluminescence potential of the community increased with depth to a peak at 80 m. Community composition changed over this range, with an ecotone at 20–40 m where a dinoflagellate-dominated community transitioned to dominance by the copepod *Metridia longa*. Coincident at this depth was bioluminescence exceeding atmospheric light in the ambient pelagic photon budget, which we term the *bioluminescence compensation depth*. We posit these transition depths are important to understanding how bioluminescence structures planktonic communities in shallow waters of the high Arctic during Polar Night, and represent an analogue to the mesopelagic.

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References

Microplastic pollution identified in deep-sea water and ingested by benthic invertebrates in the Rockall Trough, North Atlantic Ocean

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Microplastics, small pieces of plastic < 5 mm in diameter, are found extensively in the natural environment and present numerous ecological threats. As a major source of marine pollution, plastic debris meets the ocean health index criteria and is recognized as a global threat (Halpern et al. 2012). While the ultimate fate of marine microplastics is not well known, it is hypothesized that the deep sea is the final sink for this anthropogenic contaminant.

This study provides a detailed quantification and characterisation of microplastics ingested by three benthic macroinvertebrates (Ophiomusium lymani, Hymenaster pellucidus and Colus jeffreysianus) with differing feeding modes and in adjacent water > 2200 m deep in the Rockall Trough, Northeast Atlantic Ocean.

Despite the relative remoteness of this location, microplastic fibres were identified in deep-sea water at a density of 70.8 particles m⁻³, comparable to that in surface waters. All the particles isolated from deep water were monofilament fibres, primarily of the polymer polyester. 48 % of the invertebrates examined (n = 66), ingested microplastics, with both monofilament fibres and fragments identified, again polyester was the dominant polymer type. While microplastic concentrations differed significantly between species, ingested quantities were comparable to coastal species.

Deep-sea microplastics were visually highly degraded; surface areas, calculated using photogrammetric methods found the surface areas of deep-sea microplastics to be more than double that of pristine particles.

The identification of synthetic polymers with inherent densities greater and less than seawater along with comparable quantities to the upper ocean indicates processes of vertical re-distribution which warrant further investigation. This study represents the first snapshot of deep ocean microplastics and the quantification of microplastic pollution in the Rockall Trough. Additional sampling throughout the deep-sea is required to assess levels of microplastic pollution and its sequestration in this still largely unstudied global ecosystem.

References

Environmental Assessment of Deep-Water Sponge Grounds in relation to Oil and Gas Activities: a Faroe-Shetland case study

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Deep-water sponge grounds constitute a major deep-sea habitat that support diverse benthic communities1. These habitats meet the criteria of Vulnerable Marine Ecosystems as recognized by the UN Food and Agriculture Organisation as well as Ecologically or Biologically Significant Areas as recognized by the UN Convention on Biological Diversity2. In July 2014, a new Nature Conservation Marine Protected Area (NCMPA) was designated in the Faroe-Shetland Channel (FSC) to protect the deep-sea sponge grounds present in the area where oil and gas exploration and production activities have taken place since the 1990s3. However, the current extent of the sponge grounds within the FSC and the impacts of oil extraction and production activities have on deep-sea sponges remain to be understood.

This talk will present results (i) from our analysis of FSC seabed still images and (ii) from short-term weathered crude oil and/or dispersant exposure experiments with shallow-water sponge Halichondria panicea as surrogate organisms.

First, over 1,500 still images of the FSC seabed acquired during successive Remotely Operated Vehicle surveys by BP were examined and presence of benthic organisms was scored. The resulting presence/absence dataset was combined with abiotic data from external sources (GEBCO, Atlantic Interactive…) and analysed by Redundancy Analysis and Partial Redundancy Analysis. Substrate type, depth and seawater temperature appeared to be the main factors impacting benthic community composition in the FSC. In addition, fish species, bryozoans and crinoids amongst others were found to be associated with the sponge grounds in the FSC.

Second, short-term experiments in which shallow-water sponges exposed to seawater or sediments contaminated with Foinaven crude oil and/or Slickgone NS dispersant were conducted to assess physiological and molecular effects in sponges. Respiration rate displayed a high inter-individual variability, consistent with scientific literature4. Only a decreasing trend in respiration rate when exposed to contaminated seawater or sediments could therefore be detected. Filtration rate significantly decreased in sponges exposed to contaminated seawater or sediments. It is therefore hypothesised that sponges can cope with short term exposure to crude oil and/or dispersants by halting their filtration behaviour. Tissue samples were also collected throughout the experiments and RNA extractions have been carried out. Transcriptomic sequencing of the samples are underway and will enable us to detect changes in gene expression patterns.

These initial results and our ongoing investigations will contribute to better understand the importance of deep-sea sponge grounds in the FSC and their sensitivity to oil production activities.

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References