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Arctic marine systems

CircA – Circadian rhythms of Arctic zooplankton from polar twilight to polar night – patterns, processes and ecosystem implications

Research carried out in the Svalbard archipelago in recent years has shown that ecosystems that were previously thought to lie dormant during the long polar night are actually still very much active during this period. Investigations are now taking place in order to try and characterise exactly what is happening and what the implications of this previously undiscovered activity might be for the Artic ecosystem

Mysteries of the polar night

Diel vertical migration (DVM) has been said to be the largest synchronised movement of biomass on the planet. It is a common feature of all the world's oceans (and most of the lakes) in which zooplankton migrate up to the surface layers of the water to feed under cover of darkness at night, and then return down into the deep to avoid being eaten during the day.

This process is, unsurprisingly, regulated by light. In most parts of the world, the rise and fall of the sun each day mediates DVM. However, a 2009 paper demonstrated that synchronised DVM was occurring in two fjords within the Arctic Circle during the polar night, a time when there is no direct light to control the behaviour. This discovery challenged the long-lasting paradigm of ecosystems at high altitudes becoming dormant during the polar night due to low food availability and lack of light, and prompted the creation of the CircA project by the paper's authors.

Professor Jørgen Berge of the University of Tromsø and leader of CircA explains the objectives of the project: "Our previous results provided strong evidence that zooplankton were carrying out DVM during the polar night," he says. "We set ourselves a few basic questions to build upon what we had found. We wanted to find which species are doing it, why they are doing it, and why it is important for the local ecosystem. We also set ourselves the goal of developing a new set of tools to set these questions into a Pan-Arctic perspective."

The first goal for the team was to confirm that their original observations were not anomalous. "We have deployed a number of acoustic instruments to try and monitor the potential migration of zooplankton," says Berge. "We are using ADCPs – acoustic Doppler current profilers – that detect not only the strength of echoes being emitted, but also the Doppler shift." Doppler shift is the phenomenon in which the frequency of a wave changes for an observer moving relative to the source (commonly experienced as the change in frequency of a siren as an ambulance or police car drives past), and so detecting the changing frequency of the echoes provides crucial information to Berge about the movement – or migration – of the zooplankton.

In order to find out which organisms actively migrate during the polar night, the team has carried out extensive field campaigns using an array of sampling devices. "When we are sampling the organisms from the fjords, we always note down the prevailing light climate," says Berge. "One of the most fascinating things we have noticed during this project is the importance of the moon. During the polar night, the zooplankton are no longer on a solar rhythm, and so during full moon –

when the moon is at its brightest – they start to synchronise with the lunar rhythm."

In very high latitudes in Arctic waters, the moon has a special cycle during the polar night. During new moon, it orbits below the horizon 24 hours a day, while during the full moon it stays above the horizon. In the phases in between, there is a daily moonset and moonrise. This, combined with the lack of sunlight, creates a unique climate of light during the polar night. "What we see happen is that the zooplankton switch from a 24 hour cycle to a 24.8 hour cycle," says Berge. "During full moon and on a clear night, the entire community will migrate deeper. It shatters the idea that the polar night is an environment entirely bereft of light and activity. The organisms in the water aren't going into some kind of hibernation as was imagined – they are actively responding to the prevailing light climate."

Although solar illumination is undetectable to the human eye during the polar night, the data indicates that the Arctic zooplankton are still responding to the variations in low light levels that exist. This means that there exists a whole suite of food-web interactions and ecosystem structural features that have simply been overlooked until now, and so the CircA project is now looking to establish the basic biological foundation behind the behaviours and their wider ecological impacts.

Having studied Arctic DVM throughout the seasons, Berge's team are now beginning to see that the idea of a huge mass of zooplankton moving up and down in absolute synchrony might be an oversimplification. "What we have noticed is that different species of zooplankton respond to the changing conditions throughout the year in different ways," he explains. "The group of species that are migrating extensively during the autumn are not the same as the ones migrating during the polar night.

> "What we see happen is that the zooplankton switch from a 24 hour cycle to a 24.8 hour cycle"

The team's findings have sparked interest in the field and more research is now being done. Berge believes that one of the most important outcomes of his findings could be the implications that they have in the field of environmental management. Increased levels of shipping as well as oil and gas prospecting pose a threat to all Arctic wildlife, but having solid evidence that organisms are actively migrating during the polar night and are present at the surface rather than hibernating in deeper waters shows that any potential oil spill or similar accident could be highly damaging to the local ecosystem.

AT A GLANCE

Project Information

Project Title:
Circadian rhythms of Arctic zooplankton from polar twilight to polar night – patterns, processes, and ecosystem implications (CircA)

Project Objective:
Determine the primary physical and biological factors that are responsible for the diel vertical migration patterns of zooplankton in the high Arctic during the polar night and twilight period, and to elucidate the resultant ecosystem effects.

Project Duration and Timing:
2012-2015

Project Funding:
Norwegian Research Council

Project Partners:
Norway: UNIS, UiT, APN, NTNU
International: SAMS (UK), IOPAS (Poland), Univ of Delaware (USA)

MAIN CONTACT

Jørgen Berge
Professor in marine biology at UiT The Arctic University of Norway and adjunct professor at UNIS. Finished PhD in 2000, and have since 2003 been working on Svalbard with marine ecosystems and ecosystem effects of climate change. Since 2012 leading two larger projects aimed at polar night processes

Contact:
Tel: +47 90169125
Email: Jorgen.berge@uit.no
Web: www.mare-incognitum.no

www.mare-incognitum.no

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