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Ocean acidification

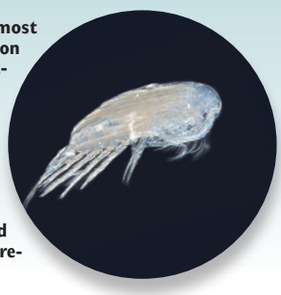
The seas and oceans have absorbed more than a quarter of the CO_2 released by industry. Ocean acidification occurs when such amounts of CO_2 dissolve in the water and are converted into acid (carbonic acid).

BY MARIE HAUGE

As the amount of carbonic acid increases, the pH of the water falls. At a lower pH, the limestone (calcium carbonate) in sea water dissolves more easily. Since the start of the industrial revolution, the pH of the oceans' surface layer has fallen by 0.1. This may sound very little, but a 0.1 reduction in pH is equivalent to a 30 per cent increase in acidity. This is a significant change, which may have serious consequences for sea life, and particularly for organisms that form their shells and skeletons out of calcium carbonate.

Fishing and aquaculture are important to the Norwegian economy. It is therefore of serious concern if commercially important fish species are being harmed by acidification.

Calanus finmarchicus is the most abundant species of zooplankton in Norwegian waters, representing an important link in the food chain between phytoplankton and fish. The shell contains chitin and calcium. During its life cycle, *Calanus finmarchicus* changes shell several times. Scientists are performing experiments to find out whether, and if so, how it reacts to ocean acidification.

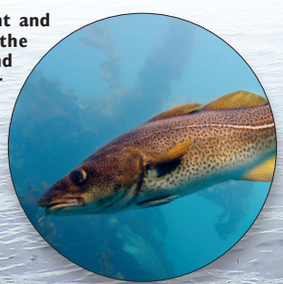


Lobsters have a hard external skeleton (exoskeleton) made of chitin and enforced with magnesium calcite. As juveniles, lobsters change shell roughly every month (at 15 °C); later they change shell less frequently. Researchers are studying the impact of ocean acidification on their shells, and are investigating whether they are modifying their behaviour as a result of having weaker shells. They are also looking at how the oxygen consumption and egg production of adult lobsters is affected by ocean acidification.

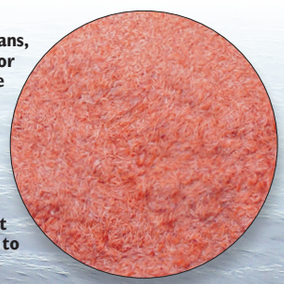
Mackerel is a fast-swimming species, which means that the CO_2-concentration in itself can act as a limiting factor on its activity level. Consequently we are doing aquarium experiments to see how mackerel will cope with the marine environment of the future, particularly in terms of their energy requirements for physical activity when the CO_2-content of the water increases.

Scallops have a wide distribution range. The shell of a scallop contains large amounts of calcium, and it only takes a day or two for it to form its first one. The process of calcification (hardening with the help of calcium carbonate) starts after approximately two days. Researchers are studying the effect of ocean acidification on shell development and mortality rates.

Cod may become less efficient and competitive as a result of the stress caused by falling pH and higher CO_2-concentrations. Our scientists are studying in detail how the general body functions of cod react in aquarium experiments involving different CO_2-concentrations. The experiments cover most of the life cycle of the fish.



Krill are small, shrimp-like crustaceans, and an important source of food for fish, birds and sea mammals. The Northern krill is the largest species found in Norwegian waters, reaching lengths of up to 40 mm. Krill shells contain chitin and calcium. During their life cycle, krill change their shells several times. Scientists are doing experiments to find out whether, and if so, how krill react to ocean acidification.



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Ocean acidification

Steel cones used for adding CO_2 to acidification experiments at the Matre Research Station. The pipes to the right distribute water to the research halls.

MONITORING AND RESEARCH

The Institute of Marine Research has in recent years increased its research into ocean acidification. We are monitoring the carbon cycle in Norwegian waters and investigating how ocean acidification affects marine organisms.

THE MATRE RESEARCH STATION

At the Institute of Marine Research, simulation experiments with changing parameters (temperature, salinity, oxygen etc.) are performed on a regular basis.

Thanks to new advanced experiment facilities and 158 tanks of different size and capacity, the Matre Research Station holds a world leading position for large scale investigations of fish physiology. The station is equipped with highly sophisticated environmental control systems where fine scale CO_2-studies can be carried out. Matre is especially well suited for experiments involving fish (salmon) and other larger marine species like lobster.

THE AUSTEVOLL RESEARCH STATION

At Austevoll, a new research hall with 36 tanks has been built. Water of four different qualities can be added to the tanks. The facilities are being used for experiments on planktonic organisms, such as *Calanus finmarchicus* and krill at all life stages, and the early life stages of larger animals.

Control systems have been designed to ensure long-term stability, so that experiments can continue throughout the life cycle of the relevant organisms.

MONITORING AND ARCTIC RESEARCH

At the request of the Climate and Pollution Agency (Klif), the Institute of Marine Research has started systematically monitoring the acidification of Norwegian coastal waters and seas. Our research vessels are equipped with instruments to measure the CO_2-content of the sea water.

FLAGSHIP IN TROMSØ

The Institute of Marine Research is leading the flagship research programme on *Ocean acidification and ecosystems effects* in Nordic waters at the High North Research Centre for Climate and the Environment (Fram Centre) in Tromsø. We are particularly focusing on processes linked to the Arctic and sea ice, and on how ocean acidification affects individual species and entire ecosystems.

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