Lithophilic organisms in polar coastal ecosystems

Life on a Pebble

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All living organisms face difficult conditions in the Arctic, but those which attempt to survive clutched to seafront stones, where they are lashed by water, wind, and ice, may face the toughest conditions of all

Stones can be found on the sea floor in all the climatic zones, from the tropics to the polar regions. They occur at all depths, from the waterfront zone to abyssal depths, although of course most of them are located near the coastline. They offer a habitat for many organisms, ranging from single-celled foraminifers, more complex sponges, ascidians, and polychaetes, to colonial organisms such as bryozoans or corals, whose colonies often encompass as many as a thousand specimens. The predominant organisms inhabiting the stones of the polar regions are polychaetes, barnacles, and bryozoans.

Sea-floor stones constitute ideal research material in view of their wide availability, ease of collection, and the abundance of organisms that inhabit them. In 2002, the Institute of Oceanology of the Polish Academy of Sciences, in cooperation with the British Antarctic Survey, launched an extensive research project to Arctic lithophiles (organisms that live on stones), concentrating above all on the coastal region. The aim of the research is to learn the species breakdown of the organisms occurring on such stones, and above all to identify the environmental factors that determine the occurrence of given species in certain locations.

At the mercy of the elements

Every sea-floor stone is like an island and has its own, frequently distinct life. There are two factors that exert a decisive influence on the set of organisms that inhabit a given stone: the stone's size and the depth at which it is immersed in water. The smaller the size and the more shallow the water, the more frequently a stone's position is changed by the dynamic processes at work in the environment, and this has a direct impact not only on the observed species breakdown, but also on the survival strategies which organisms employ.

Depth of immersion correlates with many environmental parameters, e.g. wave intensity, the presence of wind-induced currents, the availability of food and light,

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The Arctic waterfront zone is one of the Earth's most dynamic environments and the temperature. The deeper the immersion, the weaker wave and coastal currents become, and thus the environment becomes more stable. However, increased depth also usually entails a smaller food supply, caused by a lack of primary production - i.e. algae that need light for photosynthesis.

The polar intertidal zone, which can be considered one of the Earth's most dynamic environments, experiences not just diurnal changes in sea level but also seasonal changes in temperature, causing the repeated freezing and thawing of the water. This means that ice is almost always present here, and effectively thwarts all forms of life occurring on stones. Such environmental conditions mean that the colonization of stones in the intertidal zone is very haphazard, and the organisms that occur here rarely reach reproductive age.

Just below the tidal zone, at small depths, however, truly rich life and ecological processes start to appear. Nevertheless, the dynamic nature of the environment still exerts an overwhelming impact on the fauna. The species breakdown here differs from that of the tidal zone, and distinct morphological forms are likewise observed. Delicate, arborescent (tree-shaped), calcareous forms are only present in deeper sections of the ecosystem. Such shallower zones are dominated by low-lying forms, which allow organisms to better resist strong currents. There are also many organisms whose arborescent or bushy bodies are characterized by a certain flexibility. This enables them to survive strong storms without any damage to their skeletons, and it is moreover a kind of adaptation that makes them more competitive in an environment where space is frequently a limiting factor.

Building upwards

An organism that adopts the strategy of attaching itself to its base stone only along a small portion of its body stands to gain a lot. Firstly, it does not have to fight for surface area on the stone. Its mouth (or mouths in the case of colonial organisms) is then located somewhat above the sea bottom. Water currents are much stronger a certain distance above the bottom, and they bring a constant supply of food. Bushy or tree-like morphology also helps avoid attacks by certain predators, who cannot handle the stronger currents present higher above the bottom.

Frequently stones can be seen to exhibit multilevel colonization. Most organisms settle directly on the stones themselves, but there is also a group of organisms that prefer to build "upwards," settling on the arborescent forms of other organisms. This can especially be seen in deeper portions of the ecosystem, at a depth of more than 50m, where stones frequently rest on soft deposits. When such stones become buried under deposits lifted from the floor by a strong current, this can kill off most of the organisms living on them. The growth strategy of other organisms, which choose to place themselves higher above the stone surface, frequently enables them to survive such incidents, and moreover it frees them from having to fight for space on the stone itself.

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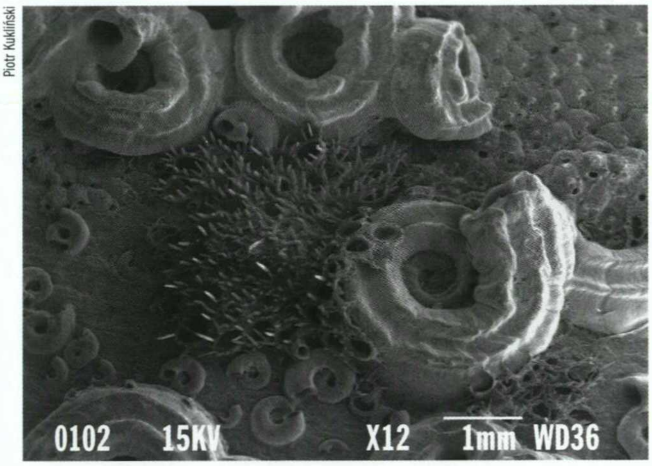

At a depth of several meters, where the water is calmer, there is fierce rivalry for space on stones. This scanning microscope image shows polychaetes and two generations of bryozoans

The fauna that inhabits small stones is in a state of constant transformation. Organisms that settle on such a foundation can develop only until the next apocalypse, meaning the next time the stone is turned over - something that happens more frequently the smaller the stone is. Not many organisms are able to survive under such unpredictable conditions; these are chiefly animals that procreate prolifically and exhibit very short life-cycles. The fauna hosted by small or shallowly-immersed stones are usually organisms that arise from larval forms currently present in the water column. Larger stones offer a much more stable environment, because they are harder to overturn, and they host a completely different set of species: animals that predominantly invest more energy in various defense mechanisms or mechanisms allowing them to secure living space on the stone, rather than in procreation.

Although we have already learned many of the secrets about life on stones in the arctic seas, there is still much to be researched. We do not know what impact a stone's mineral composition has on the organisms it hosts. We are not familiar with the life-cycles of all of these organisms; we do not know when and how they reproduce. Our current knowledge has been gained using samples taken in summer. What happens here during the long polar night? Many questions still remain unanswered. ■

Further reading:

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