# The uncertain future of plankton

We talk to **Dr. Katarzyna Błachowiak-Samołyk**, professor at the Department of Marine Ecology at the PAS Institute of Oceanology in Sopot, about the impact of human activity on life in the oceans.

ACADEMIA: **Why are the oceans so important? It would seem that most of the problems faced by humankind today can be found on dry land.**

KATARZYNA BŁACHOWIAK-SAMOŁYK: Over two-thirds of our planet is covered by water. The oceans are constantly changing, from shore to shore, from their very depths to their surfaces, and generally they are not in the best of shape. Some changes are natural and driven by the seasons, but others – such as excessive exploitation of natural resources and pollution – are caused by human activity. If we don't continue improving our understanding of marine life and the significance of individual species in the structure and functioning of marine ecosystems, we won't be able to describe changes on a local level or forecast their impact on the global scale. For example, increasing carbon dioxide emissions driving climate change is a major problem, which is frequently belittled. Oceans are massive "storehouses" absorbing $CO_2$, and the rate of this process depends on temperature. As the atmosphere gets warmer, so do the oceans, which is most pronounced in the Arctic region where we conduct our research. Polar ecosystems are highly sensitive to increasing temperatures; their balance largely depends on the physical state of water, which is affected by tiny temperature changes. For example, melting icebergs reduce the salinity of seawater, which has a major impact on organisms adapted to life in certain conditions. Warmer temperatures also change species ranges; for the northern hemisphere, this means thermophilic species migrating further north.

In fact, increasing temperatures in polar regions are exerting an impact on the oceans on a global scale. This is due to thermohaline circulation and the system of ocean currents in the Northern Atlantic, which is key for Earth's heat management. Oceans are stratified with layers of specific water temperatures, which don't mix due to differences in their densities. However, thermohaline circulation acts similarly to a transmission belt, moving incredible volumes of salt, oxygen and carbon dioxide throughout the oceans. In the Atlantic, the process is driven by the Gulf Stream, moving warm waters from equatorial regions towards the north; when they reach polar seas of the Northern Atlantic, they cool down and sink since cold water is denser (and therefore heavier) than warm water. The sinking cold waters bring oxygen and nutrients down from the surface, and oxygenated cool waters return south as North Atlantic Deep Water (NADW). A warmer climate may disrupt this process. Since polar temperatures are increasing, it is becoming increasingly difficult for cold water to sink, and oxygen levels are decreasing throughout the oceans.

**Your research focuses on plankton. How does one go about studying it?**

The institute is fortunate to have the research vessel "Oceania," which we use each summer to conduct regular studies near Spitsbergen. Oceanographic research is expensive, especially when it's done in distant regions such as the European Arctic. Ecologists study the pelagic waters by using a range of plankton nets. They are made of gauze with a certain mesh size diameter, filtering organisms collected at different depths into a collector. The contents must be preserved as soon as they are pulled up, and then they are examined and identified in the lab. We also recently acquired a laser optical plankton counter (LOPC), which allows us to immediately take measurements of plankton size and density with a high spatial resolution. Using laser and optical methods enables us to collect the plankton data simultaneously with environmental parameters obtained using sensors measuring the salinity, temperature, fluorescence of chlorophyll and/or oxygen content. Such measurements are incredibly important since plankton is distributed unevenly. Additionally, different types prefer environments with different physicochemical parameters. Data recorded using the LOPC is analyzed more thoroughly when we are back at the Institute, but while still aboard we can determine whether measurements taken in a given region should be repeated or expanded.

**Why is plankton so important in studies of the impact of climate change?**

These kinds of organisms play a key role in the functioning of marine ecosystems due to their vast numbers. They are the main producers of organic matter (phytoplankton) and the main food source (zooplankton) for larger marine consumers, as well as land animals as part of the trophic foodweb. The volume and distribution of plankton is directly related to the numbers of fish, marine mammals and seabirds that feed on plankton and fish. Additionally, plankton is the best indicator of environmental changes due to its short lifespan and rapid response times to changes in water temperatures. And since it isn't exploited commercially, all long-term changes into its structure can be assumed to be due to climate changes. Plankton generates around half of all oxygen on Earth, which makes it a critical element in the functioning of the biosphere, and as such it has a major impact on human life. As temperatures continue to rise, the structure and composition of phytoplankton and zooplankton change. Studies of icebergs in the Antarctic show that the melting fresh water contains high volumes of biogenic compounds, which support the growth of phytoplankton. This can be seen on satellite maps showing the concentration of chlorophyll, indicating a higher biomass of photosynthesizing organisms as far as 100 km from a melting glacier. Phytoplankton is the main food source for zooplankton, which in the Arctic mainly includes large herbivorous copepods from the genus Calanus. If something changes at the phytoplankton level (e.g. a shift in its mass development known as blooming), it affects zooplankton and in turn other organisms, which feed on

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is a marine biologist. She earned her master's from the Faculty of Oceanography at the University of Gdańsk, where she also completed her PhD. She has been working at the PAS Institute of Oceanology since 1997. She studies the ecology of polar zooplankton, as well as the taxonomy, ecology and zoogeography of pelagic ostracods.

it. Increasing temperatures change the size structure of phytoplankton with higher numbers of smaller organisms, which are too small for invertebrates to feed on.

**It's difficult to grasp how fluctuations in the food source for certain some invertebrates in the distant Arctic could affect the average person.**
I don't think it's really that difficult. Cold-water species in the Arctic are increasingly being replaced by species typical of warmer waters. Thermophilic plankton is smaller, which means it could not be caught by the filtering apparatus of animals trying to feed on it; it's also less rich in fatty compounds, which makes it less attractive and nutritious to some fish, birds and sea mammals. This means that as temperatures rise and the boundaries of warm-water plankton (which is highly diverse but also extremely small) shift further north, that is bad news for the populations of species such as plankton-feeding fish.

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**Your team has studied a particular situation.**
Yes, together with the University of Gdańsk, our Institute carried out an important Polish-Norwegian project called ALKEKONGE, focusing on the relationships between water temperature, plankton and zooplankton and the reproductive success of a bird known as the little auk – the most numerous seabirds in the northern hemisphere. They mainly feed their young on the fifth copepodid stage (CV) of the cold water species *Calanus glacialis*. This copepod's life cycle has six copepodid life stages; the premature stage, just before the organisms reach their adult form, is extremely rich in fat, which comprises over 70% of its dry body mass. As such, the reproductive cycle of little auks – between late June until August – is closely linked with this copepod population. When warm waters reach further north, the numbers of species typical of arctic regions like *C. glacialis* decrease, and this has a negative impact on the reproductive success of birds. Another potential consequence of climate change on seabird populations may involve a seasonal mismatch between the peak number of their prey and the period of increased energy demand brought by the breeding season. This may have a negative impact on little auk populations, since the survival of their young depends on the availability of their preferred food.

Little auks play a key role in the functioning of arctic land ecosystems, including the fertilization of Spitsbergen's scant tundra. Their population numbers affect the growth of terrestrial plants, which provide feed for reindeer. This means that decreasing numbers of plankton specimens, which feed little auks, can disrupt the entire ecosystem; when there is an insufficient abundance of these copepods, the tundra isn't fertilized by the birds and becomes a cold, rocky desert and the numbers of herbivorous land animals such as reindeer and geese decline. And the latter provide food for the local human populations.

Unfortunately there are many more instances of the negative impact of human activity on marine ecosystems. During the 1970s, the Pacific population of sea otters was severely depleted after they had long been hunted for their pelts. Otters feed on sea urchins, which live in kelp stands, home to a rich fauna of fish, crabs and tunicates. Decreasing numbers of otters caused sea urchin populations to rise steeply, which led to a destruction of kelp stands since the shoals of fish, crabs and tunicates migrated elsewhere and the underwater jungles once teeming with life were replaced by monocultures inhabited only by algae and sea urchins. Preserving biodiversity, on the other hand, hugely improves the stability of ecosystems. Another example: the Barents Sea, a highly productive ecosystem and fishing area, is home to the capelin – a small fish in the smelt family. Due to overfishing of the capelin during the 1980s, the entire fishing industry in the region came under threat, since a key element in the food chain – a major food source for many commercial fish species and seabirds – had become severely depleted.

**Since we're talking about fishing, let's get closer to home. The Baltic is also heavily exploited.**
The Baltic is surrounded by highly industrialized countries, putting it under threat of oxygen depletion. The area of insufficiently oxygenated water has expanded almost tenfold over the last century. This is partly due to the fact that the Baltic is a relatively small, semi-enclosed basin with a low salinity. Large volumes of pollutants flow or are washed into it, with the sewage, effluent and residual fertilizers leading to serious blooms of cyanobacteria and algae.

We also have a problem with alien species, which have been introduced into the Baltic purposely or accidentally from regions where they occur naturally. Some of them become invasive species and have a negative impact on native populations and even entire ecosystems, which makes them a serious threat to biodiversity. One such species is the fishhook waterflea, first spotted in the Bay of Gdańsk in the late 1990s. It's a relatively large species of waterflea and a voracious predator, competing for food with small plankton-eating fish; it's a nuisance to fisheries as it clogs nets and fishing gear, and – most importantly – it replaces native species. Rising temperatures on the global scale result in conditions supporting the development of thermophilic species in previously cool climate zones.

**Was it the same story with the round goby, from the Black Sea?**

That's right – it was likely brought into the Baltic with ballast waters. The increasing average temperatures and the species' high tolerance of low oxygen levels in the Baltic waters mean the small predator has spread rapidly on a mass scale, successfully competing with many economically-valuable native species. This means that, unfortunately, almost all interference with natural ecosystems results in serious, unpredictable consequences.

12 hours in order to catch sufficiently high numbers of pelagic organisms.

Deep-water organisms look completely different to those living close to the surface. To experts, the differences are striking: for example, the fish have enormous mouths and tiny bodies. Each scientist was responsible for studying a particular group of organisms. I focused on pelagic ostracods – tiny planktonic crustaceans. Those found at greater depths had strange characters, highly ornamental and beautiful, dazzling shells – completely different to ostracods found in the upper layers of the ocean. Unfortunately the colors fade when the samples are preserved in formalin. Sorting the creatures "alive" in Polarstern's labs was a real journey into the unknown: almost half of the species collected from depths of between 4 and 5 km turned out to be new to science.

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"Live" planktonic ostracods *Conchoecissa plinthina* and *Chavturia abyssopelagica*

**Are the effects of human activity the same at all ocean depths?**

Naturally they are the easiest to observe in well-studied, shallow, coastal waters. In 2007 I took part in the research mission onboard the German research vessel "Polarstern" as part of the international Census of Marine Zooplankton programme. It was a major step towards estimating the diversity of species and zoogeography of oceans, in particular exploring waters at great depths. The ship travelled from Bremerhaven to Cape Town collecting plankton and fish from four stations located along the coast of south-eastern Africa. Commercial fishing and also plankton sampling is usually limited to depths between 50 and 100 meters, since these waters are the most productive. Deeper waters are far more interesting, but they are also far less rich in life. During the expedition, we collected plankton from depths of up to 5 km. Since the organisms are sparsely distributed at these depths, we used nets with an opening surface of 10 m2, which is significantly larger than standard nets used for sampling plankton in shallower regions (usually 0.25 m2). The sampling time was also different: the nets were hauled behind the vessel for over

**You worked with one of the greatest experts on ostracods.**

That's right – I collaborated closely with Dr. Martin Angel. Together we developed three online atlases (for example ocean.iopan.gda.pl/ostracoda) for easier identification of ostracod species for both beginner taxonomists and advanced zooplanktonologists. Unfortunately despite being almost 80 years old Martin hasn't managed to train a successor, so he jokes that his existing collection of new ostracod species would take around a hundred years to be described. And of course each deep-ocean plankton sampling is likely to deliver more new specimens.

**By destroying marine ecosystems, we risk losing something we didn't even know existed.**

Unfortunately that's right. Human activity isn't good for the oceans, and its impact must be monitored. Life in oceans undergoes constant changes, which we frequently don't understand, which means we can't control or even predict them.

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