Low bottom-water oxygen leads to more organic matter ending up on the seafloor

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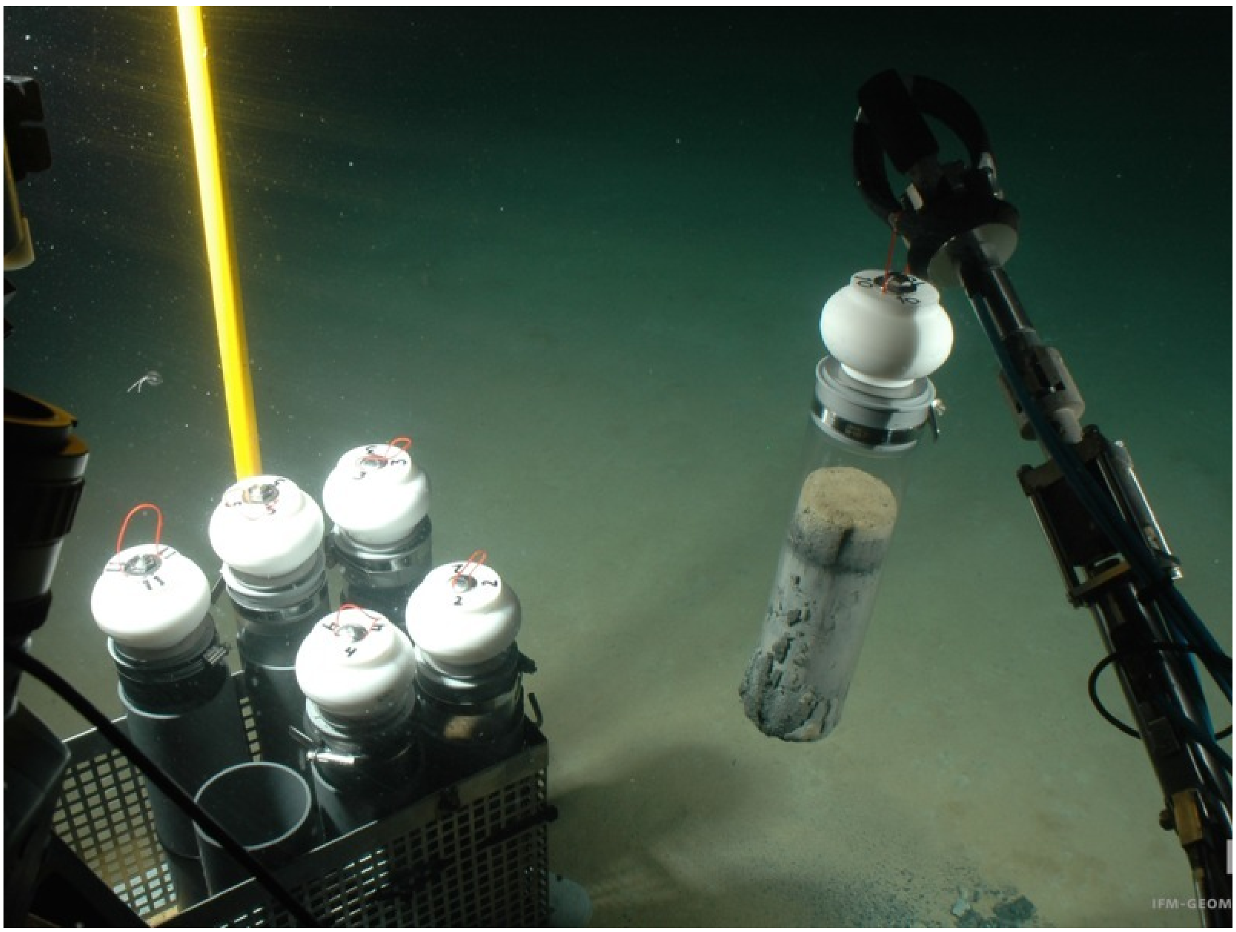


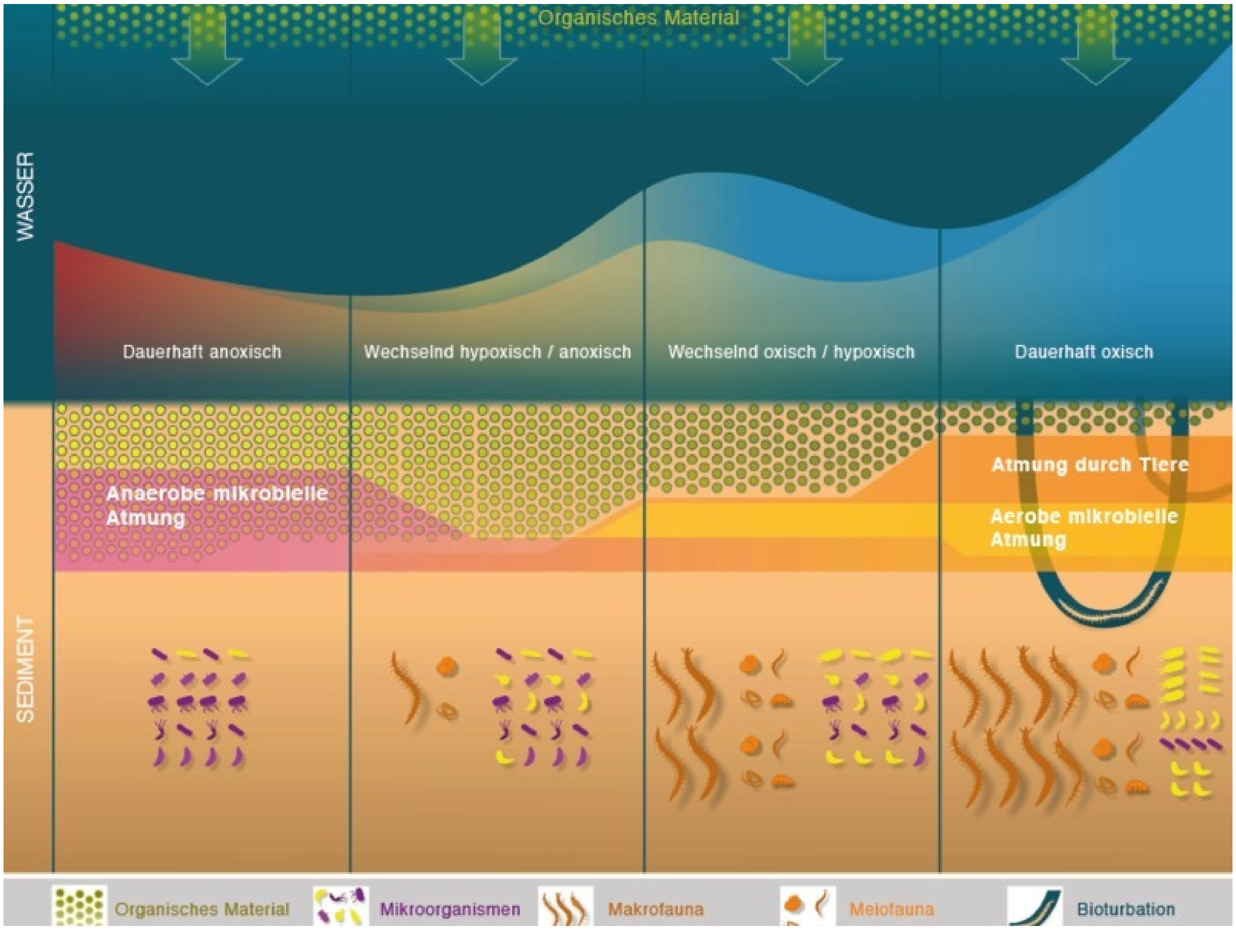
Retrieval of cores from the seafloor with the submersible Jago. Below the black layer that is visible close to the sediment surface the sediment is free of oxygen. Credit: Jago-Team, Geomar Kiel

Periodic oscillations of bottom-water oxygen concentrations can alter benthic communities and carbon storage for decades, reveals a new study published in *Science Advances*. This is particularly relevant as low oxygen conditions are on the rise in the world's oceans.

The seafloor plays a key role in the global elemental cycles. Its inhabitants consume and recycle organic matter sinking to the bottom. Usually, only a minor part of that material gets buried in the seafloor. The lion's share is remineralised by seafloor life – i.e. broken down and fed back to the ecosystem for the production of new biomass. Thus, the fate of this material at the seafloor crucially impacts global carbon and nutrient cycling and, as a consequence, marine productivity and our climate.

Temporary shortage, long-term storage

Animals need oxygen to breathe. Hence, declining bottom-water oxygen supply negatively impacts the community composition and activity of marine sediments. To which extent it also determines remineralisation and thus carbon burial rates remained controversial. Gerdhard Jessen from Max Planck Institute for Marine Microbiology in Bremen, Germany, and an international team of researchers reveal in Science Advances that declining bottom-water oxygen concentrations significantly influence carbon storage in the seafloor for decades. This effect happens earlier then previously thought and over larger areas of seafloor. When oxygen runs short, substantially less organic matter is remineralised and substantially more gets buried. And what gets buried stays buried for a long time. "The amount of organic matter ending up in the seafloor increases by half when the seafloor is periodically short of oxygen", says Jessen. "Even tasty and easily available bits, such as freshly deposited algal material, are not consumed."



Influence of bottom-water oxygen on the ecosystem on the northwestern Crimean shelf break. Stable oxic conditions (right) favour numerous animals, which aerate the seafloor. Respiration rates of fauna and aerobic microorganisms are high (yellow/orange area). At the onset of hypoxia (middle), respiration rates drop and lack of bioturbation favours anaerobic microbial communities and processes. Under anoxic conditions (left) only microorganisms remain. Credit: G. Jessen, in: Science Advances 2017

The Black Sea as a natural laboratory

Simulating such long-term and complex processes in the lab is hard to do. Therefore, Jessen and his colleagues took research vessel Maria S.

Merian to the Black Sea, the largest naturally anoxic water body in the world, within the framework of the EU FP7 project HYPOX. There, stable stratification results in a natural gradient of bottom-water oxygen concentrations at the outer shelf, ranging from well-oxygenated shallow waters over variable oxygen conditions to anoxic deeper waters below about 160 metres water depth. This provides for close-to-perfect experimental conditions. "We used the Black Sea seafloor as a natural laboratory. It allowed us to investigate what might be coming up to many party of the world's oceans," Jessen says.

"Low-oxygen areas in the oceans are on the rise, mainly as a consequence of anthropogenic nutrient inputs and climate change", explains Antje Boetius, senior author of the study and group leader of the HGF-MPG Research Group for Deep Sea Ecology and Technology. "Thus, it is particularly important to understand and measure what oxygen stress in the oceans means for their inhabitants as well as the global biogeochemical cycles."

Changing seafloor life

How come that the effects are so drastic if the seafloor runs periodically out of breath? "Oxygen deficiency changes the faunal community of the seafloor," Boetius elaborates. In particular larger animals, such as worms and mussels, cannot survive without it. These animals rummage through the sediment looking for food and shelter, intermixing oxygen and nutrients for smaller seafloor inhabitants in the process. "The large organisms disappear when oxygen is scarce. Sediment bacteria alone are then responsible for the remineralisation of the organic matter arriving at the seafloor, but they move slowly and take very long to break down complex materials without the help of animals." As a result, under hypoxic conditions more organic material is buried and thus removed from the system. Anaerobic microorganisms, gaining their energy without oxygen for example by fermentation or sulphate reduction, take the helm. These also produce toxic sulphide, further slowing down the breakdown of materials.

"The Black Sea can teach us many lessons", says Boetius, "as it clearly reveals the effects of fluctuating and low oxygen conditions on the ocean ecosystem, causing tremendous changes in the services of the ecosystem to us humans. Investigations as the current one are thus essential in the face of global change, to detect warning signals from the ocean in time."

More information: Gerdhard L. Jessen et al. Hypoxia causes preservation of labile organic matter and changes seafloor microbial community composition (Black Sea), *Science Advances* (2017). DOI: 10.1126/sciadv.1601897

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