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Planetary Health Check 2026: Why a healthy seafloor matters for the Earth system

The seafloor is habitat, carbon sink and a hub for global matter cycles, yet human influence nowadays reaches from the coast all the way to the deep sea. Fishing, mining, shipping and infrastructure threaten ecosystems, stir up sediments and mobilise stored carbon. With a new chapter on seafloor integrity – compiled by researchers from the Leibniz Institute for Baltic Sea Research Warnemünde (IOW), Kiel University (CAU) and the Potsdam Institute for Climate Impact Research (PIK) – the Planetary Health Check 2026 for the first time focuses comprehensively on the threats to the seafloor and its significance for the Earth system.

The seafloor is more than just the ground beneath the sea

Two-thirds of the Earth's surface is covered by oceans, which have an average depth of almost four kilometres. For a long time, the seafloor's remoteness protected it from widespread human disturbance. But that is changing: Bottom trawling now reaches depths of around 4,000 metres and already disturbs up to 2 % of the global seafloor each year. A manganese nodule mining operation could directly affect more than 200 km² of the seafloor. Additionally, anchorage sites, shipping lanes, cables, pipelines and other infrastructure impact the global seafloor from the coast to depths of more than 6,000 metres.

The seafloor, however, is far more than just a passive substrate. Reefs, sponge beds, mussel beds, burrowing organisms and microbial communities form habitats and regulate the exchange of carbon and nutrients between sediment and water. "We need to understand the seafloor as an integral part of the Earth system," says Jacob Geersen, a marine geoscientist at the IOW and lead author of the chapter 'Seafloor Integrity: Why the Bottom of the Ocean Matters', which has newly been incorporated into the Planetary Health Check (PHC) this year. "When we plough up sediments or fundamentally alter marine ecosystems, it is not just a matter of a local seafloor disruption. Rather, we may be interfering with processes that store carbon, recycle nutrients and stabilise entire marine food webs," explains Geersen.

In a separate chapter dedicated to seafloor integrity, this year's PHC explicitly examines these functions from an Earth system perspective, thereby spotlighting a part of it that until now has received relatively little attention. Seafloor integrity, which describes the extent to which the physical structure, biotic communities and chemical functions of the seafloor are preserved, is, however, not yet recognised as an additional planetary boundary. The new chapter also examines the legal and political framework for the protection of the seafloor, which is primarily based on international maritime law and the importance of the precautionary principle. It further highlights the existing challenges in implementing this framework.

From the seafloor into the Earth system: How disturbances reverberate

How far-reaching the consequences of a disturbed seafloor can be, becomes obvious when looking at its role in the carbon cycle, for instance. Many hundreds of billions of tonnes of organic carbon are stored in the sedimentary layers of the continental shelves, accounting for the lion's share of long-term carbon sequestration in marine sediments. If these sediments are repeatedly disturbed, the stored carbon can be released as carbon dioxide (CO_2). Global modelling suggests that bottom trawling alone could free more than 100 million tonnes of carbon from sediments each year. However, there is still considerable uncertainty as to how much of this ultimately ends up in the atmosphere as additional CO_2.

Levke Caesar, climate researcher at PIK and co-head of the Planetary Boundaries Science Lab, comments: "The PHC 2026 urgently highlights, amongst other things, that natural carbon sinks are coming under increasing pressure. With regard to this, we must not limit our focus to forests and soils on land. The seafloor integrity chapter emphasises that the seafloor is also part of this system – and we are only just beginning to understand the consequences of compromising its long-term storage function."

However, the importance of the seafloor extends beyond its role as carbon sink. The many different organisms living on and in the seafloor influence food webs and, together with microorganisms and sediment chemistry, regulate the exchange of nitrogen, phosphorus and carbon between the seafloor and the water. If these systems are destroyed, matter cycles and ecosystem functions are also altered. Particularly in the deep sea, the consequences of such disruptions are still poorly understood, but, as deep-sea mining experiments have shown, they can persist for decades.

The Baltic Sea: A glimpse into the future of the oceans

How profound the loss of seafloor integrity can be, is illustrated in the new PHC chapter using the Baltic Sea as an example. Here, decades to centuries of human interference are compounded by global warming, acidification, eutrophication and oxygen depletion. Taking into account seafloor structure, biogeochemistry and benthic ecosystems, the authors conclude that not a single square metre of the Baltic seafloor is in a pristine state and free from anthropogenic alteration. Many of these changes are long-term and, in some cases, irreversible. "The Baltic Sea can therefore provide a window into the future of other marine regions if human pressure on the seafloor continues to increase," comments Jacob Geersen from the IOW.

From knowledge to the protection of the seafloor

To protect the seafloor, the researchers recommend that marine spatial planning and environmental assessments should take into account not only species and habitats, but also functions such as carbon sequestration and nutrient cycles. In particular, deep-sea ecosystems, which regenerate particularly slowly, and carbon-rich sediments should be protected from intensive human interference. At the same time, there is a need for a better understanding, which anthropogenic processes actually shape the seafloor in different regions, and how frequently and intensely this occurs.

This also poses a legal challenge: fisheries, shipping, mining, and biodiversity are often governed by separate regulatory frameworks, even though their impacts on the seafloor may overlap. The UN Agreement on the Conservation of Marine Biodiversity Beyond National Jurisdiction (BBNJ Agreement), which entered into force in January 2026, provides, among other things, the establishment of marine protected areas and strengthens requirements for environmental impact assessments. However, the International Seafloor Authority remains responsible for regulating the extraction of mineral resources in areas beyond national jurisdiction.

"The crucial step would be to stop considering the various uses and their cumulative impacts as isolated issues, especially given the lack of sufficient state of research of human activities in the deep sea," says Nele Matz-Lück, Co-Director of the Walther Schücking Institute for International Law at Kiel University. "International maritime law already provides important starting points for this. However, how effective these will be, depends on whether scientific findings are incorporated efficiently into marine protected areas, environmental assessments and concrete decisions regarding the use of the seafloor."

A key task for research now is to find better ways of measuring seafloor integrity and its role in the Earth system. Unlike for the already defined planetary boundaries, there exists neither an established global monitoring indicator nor a scientifically sound global threshold value for this – yet. Better observational data on stress, sensitivity and recovery are needed to help developing robust parameters and providing protection tailored to particularly important or sensitive marine areas.

The Planetary Health Check (PHC) is a scientific report on the state of the Earth system, published annually since 2024 and based on the concept of planetary boundaries. It is compiled by the Planetary Boundaries Science Lab at PIK in collaboration with an international network of subject matter experts and combines up-to-date Earth observation data with findings from Earth system research. The aim is to regularly monitor changes in key Earth system processes and to provide the scientific basis for maintaining the planet's stability and resilience. The **Planetary Health Check 2026** was published on September 21, 2026, and was created by about 70 researchers. **Download:** www.planetaryhealthcheck.org

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