Bund für Umwelt und Naturschutz Deutschland
BUND
FRIENDS OF THE EARTH GERMANY

MUD MATTERS! THE CLIMATE TREASURE AT THE SEAFLOOR

BUND „OCEAN & CLIMATE" FACT CHECK SERIES – PART 3

No other habitat on our planet permanently stores as much carbon as the seafloor. It is the final link in a chain of processes that removes CO_2 from the atmosphere, binds it in plants and animals and finally stores it in marine sediments. Coastal waters in particular are hotspots of this important natural carbon sink.

As large as these carbon reservoirs are, they are poorly protected. Especially widespread fishing with bottom-contacting gear threatens to turn this valuable climate treasure into a source of global CO_2 emissions. In addition, the climate crisis is affecting the complex processes of the marine carbon cycle, with largely unforeseeable consequences for the storage capacities of seafloor sediments, and, thus also for the climate itself.

Numbers & Facts

- ✓ The seafloor is the largest permanent sink for carbon on our planet. Around twice as much carbon is stored in the uppermost metre of its sediments compared to the soils on land.
- ✓ Coastal shelf seas such as the North and Baltic Sea account for less than 10 percent of the total ocean surface, but store almost 90 percent of the carbon sequestered annually in marine sediments.
- ✓ The disturbance of marine sedimentary carbon stores by human activities threatens to create a source of "underwater CO_2 emissions". Bottom trawling alone is estimated to release up to 1,470 million tonnes of the greenhouse gas per year, thus directly exacerbating climate change.
- ✓ Muddy marine sediments store particularly large amounts of carbon, yet there are no protective mechanisms for these habitats.

When CO_2 goes diving

Spectacular landscapes, an immense diversity of flora and fauna and at the same time a gigantic sink for atmospheric CO_2. We are not talking about tropical rainforests, but the seafloor. Beneath an inconspicuous water surface, besides glowing volcanoes, colourful corals and enormous shoals of fish, we find above all marine sediments. They form the largest single ecosystem on our planet – and are among its most important sinks and stores of carbon. Almost twice as much as in the soils on land is locked in the uppermost metre of this huge habitat of sand, clay and lime. Here, carbon can be stored for millions of years. As long as the sediments remain undisturbed.

But how does the carbon get there in the first place? The large amounts on the seabed mainly derive from land plants, coastal vegetation (e.g., seagrass or kelp) and marine plankton. They all capture CO_2 from the atmosphere through photosynthesis, convert it into biologically bound carbon and thus produce biomass. Via rivers, currents and the processes of the marine carbon pump, dead organisms, but also animal excrement, eventually reach the seabed. This stream of organic carbon is referred to as "marine snow". It constantly trickles from the water surface to the depths of the ocean. However, a large part of it is quickly converted back into CO_2 by the organisms living on and in the seafloor sediments. It is estimated that about one percent of the total carbon production at the sea surface finds its way into the sediment. What sounds like little at first is actually huge: in the uppermost 5 cm of marine sediment alone, there are an estimated 87 Gt (= billions of tonnes) of carbon globally. That is the equivalent of 322 Gt of CO_2 that have found their way from the atmosphere to the bottom of the ocean. More than eight times the global human emissions in 2021. A true treasure trove that helps to stabilise our climate.

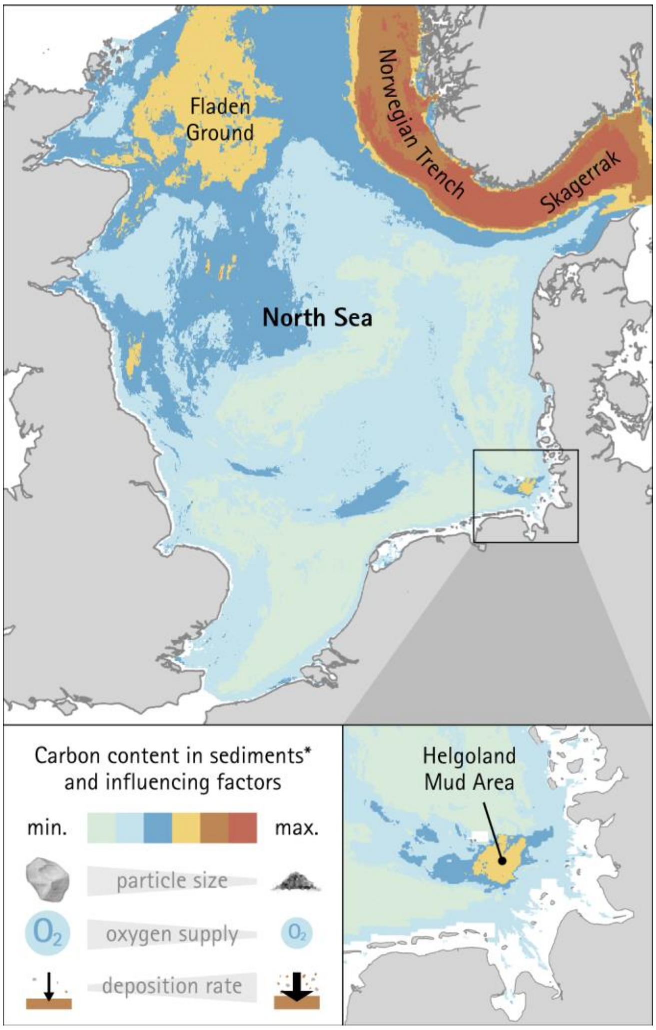
The coastal shelf seas in particular are hotspots for the deposition of carbon. These shallow marine areas extend to a water depth of 200 metres. Together with their steeply sloping margins down to a depth of 1,000 metres, they account for less than 10 percent of the global ocean area. Yet, 99 percent of the world's fishery yield comes from these biologically highly productive shelf seas, which include the North and Baltic Seas. Nowhere else is as much organic carbon stored in marine sediments every year as in these nearshore environments. But nowhere else are the ecosystems also exposed to such high pressures from human activities. This threatens the capacities of these unique but also sensitive sinks and stores.

Mud: the treasure trove of the marine carbon cycle

Carbon is very unevenly distributed on the seafloor. Where, how much and above all how long it is stored depends on a variety of factors. As a general rule, however, one might say: where there is mud, there is also a high content of organic carbon. But what are the characteristics of mud? Which factors favour the storage of carbon in muddy habitats? And what are the mechanisms that ensure its long-term conservation?

- Particle size | One important factor is the size of individual particles in the sediment. Mud consists of a large number of small particles with a relatively large surface area to which organic carbon can attach. This binding partially protects carbon from being converted back to CO_2 by microorganisms. Thus, fine-grained sediments generally store more carbon per area than habitats characterised by sand and coarser sediment with relatively small surfaces.
- Oxygen supply | How long organic matter can be stored in seafloor sediments depends largely on the oxygen content in the sediment. The less oxygen is present, the less carbon will be remineralized (=converted to CO_2) and the more carbon will remain locked in the sediment. Muddy sediments offer excellent conditions for carbon conservation, as oxygen can penetrate their surface only to a depth of a few millimetres.
- Deposition rate | Even more important, however, is the rate at which the sediment is deposited on the seafloor. If the deposition rate is high, i.e., large amounts of sediment reach the seafloor, the organic carbon is literally buried and thus preserved. Slow deposition rates, on the other hand, prolong the period in which microorganisms and oxygen can remineralize organic carbon to CO_2. This reduces the storage capacity of the sediment.

All these factors contribute to the fact that muddy habitats can accumulate large amounts of carbon and effectively conserve it over long periods – as long as they remain undisturbed from human-induced pressures that interfere with the natural environment and its dynamics.



RIGHT – Distribution of organic carbon in surface sediments of the North Sea, presented as carbon content in kg/m² (Diesing et al., 2021). *The colour classes from min. to max. correspond to the following values: <=2 | 2-4 | 4-6 | 6-8 | 8-10 | >10.

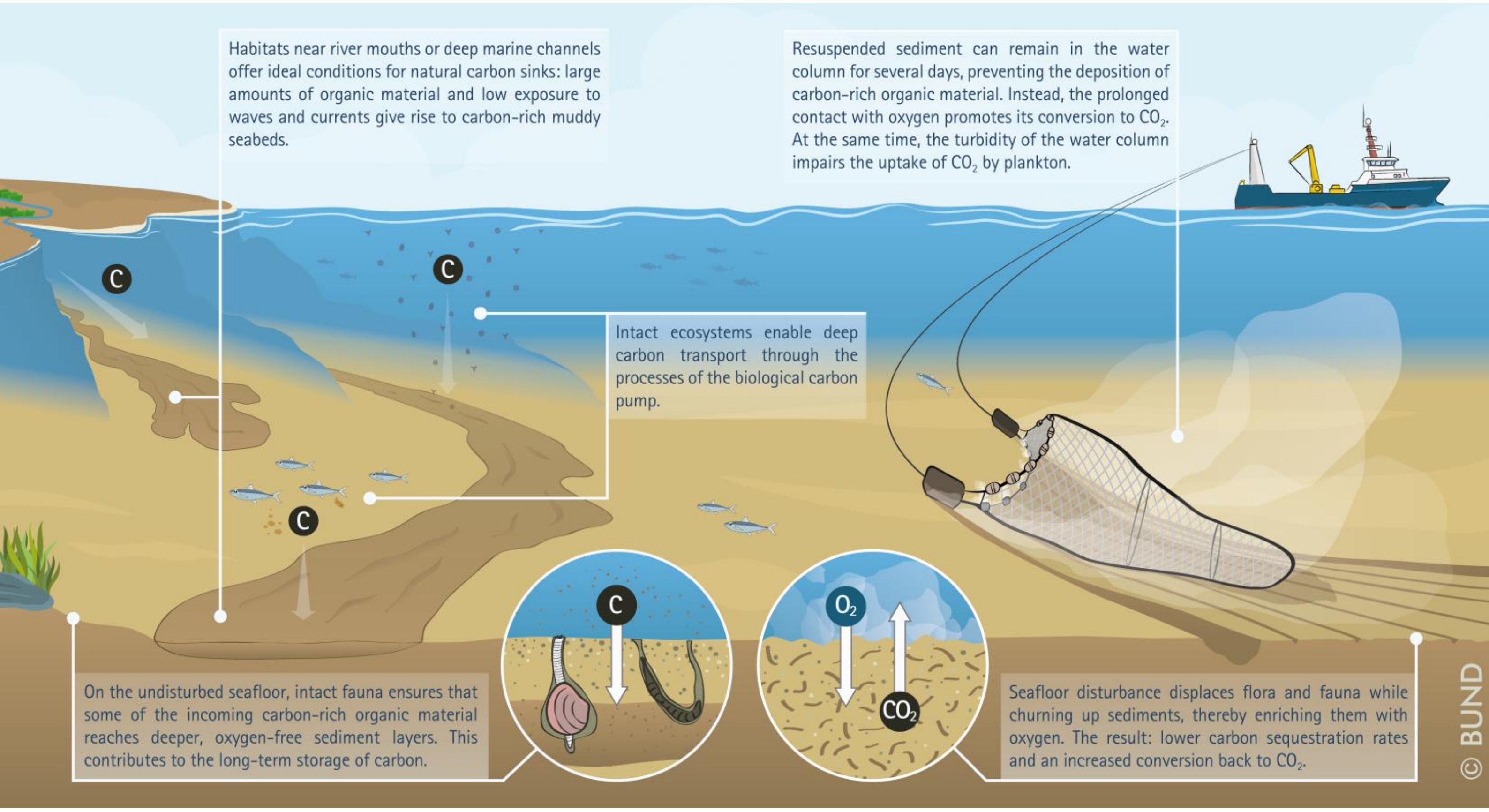
Habitats near river mouths or with low exposure to waves and currents are particularly rich in mud. On the one hand, they offer large quantities of organic carbon, and on the other hand, calm conditions ensure its rapid and permanent burial. Prominent examples in the North Sea are the Skagerrak at the border of the North Sea and the Baltic Sea, the deep Norwegian Trench or the Fladen Ground in Scottish territorial waters. But also the Helgoland mud area in the German part of the North Sea is a hotspot for the deposition of mud. All of these environments offer particularly favourable conditions for the storage and conservation of organic carbon. This makes them valuable marine carbon sinks.

Though shelf areas boast high carbon sequestration rates, muddy habitats are not restricted to these powerhouses of productivity. In fact, mud is one of the most common habitats at greater ocean depths. Although carbon accumulates two to three orders of magnitude more slowly in the deep sea than in the shelf areas, millions of years of undisturbed accumulation in many places have piled up layers of mud hundreds of metres thick. Due to the huge surface area covered by deep-sea environments, about 84 percent of the total carbon bound in marine sediments is thus stored at depths below 1,000 metres.

A mixed fate: how humans are affecting sedimentary carbon stores

Whether shipping, sediment extraction or fishing. Whether laying cables and pipelines, developing energy sources or dredging ports and shipping lanes. All these human activities have an impact on the marine carbon cycle and the natural carbon stores at the seafloor. They stir up large quantities of marine sediment, churn up its uppermost layers and can permanently change the faunal communities living on and in the sediment. The consequences? Carbon that has already been locked in seafloor sediments is re-exposed to oxygen and microorganisms, increasing the remineralization rate. In addition, short-lived and small species appear more frequently, which changes the amount of carbon in the food web. Taken together, human activities are significantly impacting the carbon sequestration potential and may even create a source of "underwater CO_2 emissions".

By far the greatest source of seafloor disturbance is linked to fishing with mobile bottom-contacting gear. Such bottom trawling is ubiquitous and can stir up the same piece of seabed



TOP – *Just like trees or seagrass meadows, seafloor sediments are important carbon sinks and stores. They ensure that CO_2 from the atmosphere is naturally stored in the long term. Muddy sediments in particular are true climate treasure troves that store a particularly large amount of carbon from of organic matter. At the same time, these valuable sinks and stores are vulnerable to disturbance by human activities, such as fishing with mobile bottom-contacting gear. These pressures threaten to turn existing carbon reservoirs into sources of CO_2 emissions.*

several times a year. It can disturb marine sediments to a depth of several decimetres and move huge masses of mud. Scientists have measured the impact in an experiment in the Baltic Sea: a 12-metre-long fishing boat with a mobile bottom-contacting gear (otter trawl) displaced about 500 tonnes of sediment, bringing more than 500 kilograms of already deposited carbon back into the seawater – per kilometre of track. In the North and Baltic Seas alone, bottom trawls in this way stir up more than a billion tonnes of marine sediment every year. The associated turbidity can subsequently also impair photosynthesis at the water surface – and thus reduce the uptake of CO_2 from the atmosphere. In oxygen-free marine areas, bottom trawling can even release methane, a potent greenhouse gas.

The extent of the impact of bottom-contacting activities on the sedimentary CO_2 sink is not yet fully understood. However, scientists assume that bottom trawling alone can lead to considerable greenhouse gas emissions and reduce the capacity of sedimentary carbon stores. Initial estimates suggest that up to 1,470 million tonnes of CO_2 could be released worldwide each year by bottom trawling activities. This is roughly twice the amount of annual greenhouse gas emissions of Germany.

Though scientists controversially discuss the scale of human-induced impacts on the sedimentary carbon sink, such estimates should be considered as a wake-up call. Despite these huge figures, there have been no protective mechanisms for muddy, carbon-rich sediments as yet. Scientists are therefore increasingly calling for the protection of mud as a measure to mitigate climate change.

The BUND demands

- Comprehensive mapping of the storage capacity of marine sediments for organic carbon and their sensitivity to disturbances.
- Establishment of marine protected areas in muddy and carbon-rich regions with consistent exclusion of any mobile bottom-contacting activities.
- Transition to more sustainable fishing methods and an ecosystem-based fisheries management.

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