# Study shows how vertebrates shape the North Sea seafloor

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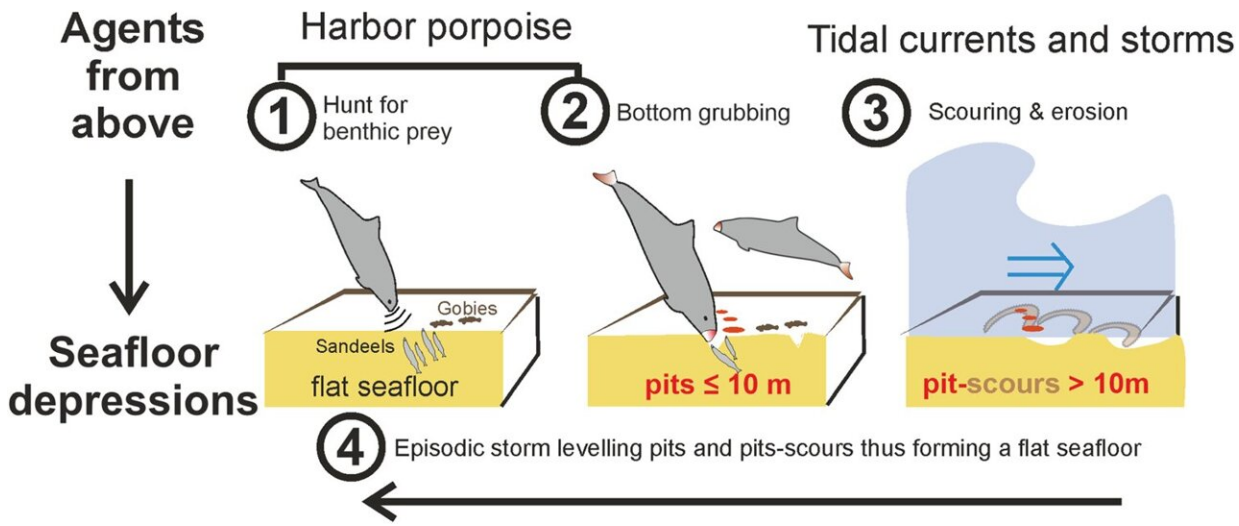


The harbor porpoise pits model. We suggest the following model for the formation of the pits and pit-scours. Phase 1: Harbor porpoise acoustically search for buried fish (sand eel) using their sonar on a flat seafloor. Phase 2: Bottom grubbing similar to the one observed for dolphins and gray whales, resulting in decimeter to meter large pits with a distinct morphology. Phase 3: The pits act as nucleation points for bottom currents to initiate scouring and formation of pit-scours, erosion and sediment transport, which subsequently leads to the commingling of individual pit-scours, resulting in larger structures on the seafloor. Phase 4: Episodic but severe storms predominantly in winter completely level out the structures over time and eventually form a flat seafloor, setting the start point for phase 1, thus closing the evolution cycle. Credit: *Communications Earth & Environment* (2023). DOI: 10.1038/s43247-023-01102-y

The world's oceans are a vast habitat for countless creatures that settle, spawn, dig or feed on the seafloor. They also influence the shape of the ocean floor. How exactly this takes place has scarcely been investigated.

In an interdisciplinary study, geoscientists from Kiel University, together with colleagues from biology and oceanography, have examined crater-like depressions on the floor of the North Sea. They were able to show that these directly relate to the habitats of porpoises and sand eels, and for the first time provide a conclusive explanation for the importance of vertebrates in shaping the seafloor. The results were published today (December 19) in the journal *Communications Earth & Environment*.

The North Sea seafloor is dotted with thousands of crater-like depressions in the sediment known as pockmarks. There are probably millions of them around the world ocean. They are formed by fluid discharge such as the greenhouse gas methane or groundwater, according to common scientific understanding. The majority of these pockmarks still puzzle researchers today, as many cannot be explained by fluid seepage.

"Our results show for the first time that these depressions occur in direct connection with the habitat and behavior of porpoises and sand eels and are not formed by rising fluids," says Dr. Jens Schneider von Deimling, lead author of the current study and geoscientist at Kiel University. "Our high-resolution data provide a new interpretation for the formation of tens of thousands of pits on the North Sea seafloor, and we predict that the underlying mechanisms occur globally, but have been overseen until now."

For the study, Schneider von Deimling and researchers from the Alfred Wegener Institute, the Helmholtz Center for Polar and Marine Research (AWI), the University of Veterinary Medicine Hannover, Foundation (TiHo) as well as the Leibniz Institute for Baltic Sea Research

Warnemünde (IOW) examined the seafloor in the North Sea off Heligoland down to centimeters. They also included the behavior of vertebrates such as porpoises in their analyses.

## Vertebrates leave pits in the seabed of the North Sea

Most of the depressions in the seafloor in the German Bight, the team suspects, are created by porpoises and other animals in search of food, and then scoured out by bottom currents. The sand eel, a small eel-like fish that spends most of the year buried in shallow sediments, plays a key role in this process. Sand eels are not only popular with the fishing industry, but are also consumed in large quantities by porpoises.

"From analyses of the stomach contents of stranded porpoises, we know that sand eels are an important food source for the North Sea population," says Dr. Anita Gilles of the TiHo-Institute for Terrestrial and Aquatic Wildlife Research (ITAW), who has long studied the biology of marine mammals. In their study, the researchers showed that the marine mammals leave pits in the seafloor when they hunt for buried sand eels. Although these pits resemble the familiar pockmarks, they are much shallower.

## Advanced multibeam echosounder technology provides information on pit condition

The detection of the pits has only become possible in recent years with the help of modern multibeam echosounder technology, which is taught and practiced intensively at Kiel University. "The formation mechanism of these pits, as we call them, probably also explains the existence of numerous crater-like depressions on the seafloor worldwide, which have been misinterpreted as the result of methane gas leaks," says Schneider von Deimling.

In the North Sea, the researchers identified 42,458 of these enigmatically shaped, shallow pits with an average depth of just 11 centimeters, which differ in their morphology from the more conical craters of the pockmarks.

Schneider von Deimling works in the Kiel Marine Geophysics and Hydroacoustics working group at the Institute of Geosciences and the Kiel Marine Science (KMS) priority research area at Kiel University, and is vice chairman of the German Hydrographic Society (DHyG). As an expert in seafloor mapping, methane gas seepage and seafloor pockmarks, he never believed that the depressions in the German Bight were caused by rising fluids.

"We had to come up with an alternative hypothesis for the formation. This allowed us to predict where potential porpoise feeding sites are, and that is exactly where we found the pits—always close to sand eel habitats. Our extensive and multidisciplinary data analysis now provides a conclusive explanation for our harbor porpoise pits hypothesis."

## An interdisciplinary approach leads to the harbor porpoise pits hypothesis

The key to the new findings was an interdisciplinary approach that brought together geological studies, geophysical sonar measurements, vertebrate behavior and feeding biology, satellite evaluation, and oceanographic analysis. By precisely analyzing millions of echosoundings collected by German research vessels, the researchers were able to locate the unusual pits.

"Using special echosounding methods, we can now measure the seafloor with centimeter precision and thus find the shallow pits. We can also look into the seafloor and see, for example, whether there is free

methane gas," explains AWI researcher Dr. Jasper Hoffmann.

Analyzing the data, collected by research vessels over thousands of nautical miles, was a mammoth task. "With modern methods, such structures can be automatically detected and characterized in acoustic data sets and automatically analyzed in large data sets," says Dr. Jacob Geersen, co-author of the study.

## From the North Sea into the world: Results with far-reaching effects

The research team currently believes that the initial feeding pits serve as a nucleus for scouring and eventually develop into larger pits. This finding also has global implications. The scouring of sediments by vertebrates in the ocean could modulate the seafloor on a global scale and influence benthic ecosystems.

In the study area alone, pits cover 9% of the seafloor. Initial volume estimates indicate that 773,369 tons of sediment have been deposited over an area of 1581 $km^2$. This is roughly equivalent to the weight of half a million cars.

"Our results have far-reaching implications from a geological and biological perspective. They can help to assess the ecological risks associated with the expansion of renewable energies in the offshore sector and thus improve marine environmental protection," concludes Schneider von Deimling.

**More information:** Jens Schneider von Deimling et al, Millions of seafloor pits, not pockmarks, induced by vertebrates in the North Sea, *Communications Earth & Environment* (2023). DOI: 10.1038/s43247-023-01102-y

Provided by Kiel University

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