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Leibniz Institute for Baltic Sea Research Warnemünde (IOW)
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Underestimated wake:
Shipping traffic causes more turmoil in the Baltic Sea than expected

Commercial shipping not only affects the Baltic Sea on the surface, but also has a significant impact on the water column and the seabed. A study by the Leibniz Institute for Baltic Sea Research Warnemünde (IOW) and Kiel University (CAU) now shows for the first time that wake turbulence from large ships in heavily trafficked areas of the western Baltic Sea significantly alters water stratification and leads to marked sea floor erosion. The research team has therefore documented a previously underestimated human impact on shallow marine areas. The results are published in the journal Nature Communications.

Ships as physical disturbance factors in shallow seas

The Baltic Sea is one of the most intensively utilised sea areas in the world. Around 85 million people live in its catchment area, and a significant share of the goods and passenger traffic between its coastal states is handled by sea. Particularly in the western Baltic Sea, heavily trafficked shipping routes cross areas with comparatively shallow waters, often less than 20 metres deep.

"So far, the impact of shipping traffic has mainly been discussed in terms of emissions, noise or the risk of accidents. Our study, however, aimed at investigating, whether and how ships also act as a mechanical disturbance factor that reaches as far down as the seabed," says Jacob Geersen, lead author of the new study that has now been published in the journal Nature Communications. He is an expert on geological and anthropogenic processes in the Baltic Sea region, which he investigates as part of the IOW research focus 'Shallow Water Processes and Transitions to the Baltic Scale'.

Research cruises to Kiel Bay were of central importance to the investigations, particularly the AL619 expedition in 2024 with the research vessel Alkor, led by Kiel University. During this expedition, the surface structure of the seabed was mapped with centimetre precision. These bathymetric data allowed a direct comparison with earlier such surveys conducted in 2014 by the Germany's Federal Maritime and Hydrographic Agency in the same area. In addition, acoustic, temperature and salinity measurements were taken in the water column, specifically targeting the passage of individual ships. The researchers thereby gained an understanding of how and to what extent the turbulence generated by the ship propellers affected the water column. Sediment samples provided information on grain size distribution and the mobility of the marine sediments. Furthermore, the research team analysed ship position data to record traffic intensity, ship types and draughts in the study area. Hydrodynamic calculations made it possible to estimate the shear stresses generated by the ships and correlate them with the observed erosion patterns.

Seabed erosion: small but frequent

In particular, the shipping traffic effects on the seabed were apparent. The researchers recorded thousands of mostly small-scale depressions in the study area, especially around larger rocks. These elliptical structures occurred predominantly along the main shipping routes and were systematically aligned there. Typically, they have a diameter of around 10 metres and are up to one metre deep. A comparison of the bathymetric data sets from 2014 and 2024 showed that these structures form and, in some cases, disappear again within a few years or decades – which rules out a purely geological origin. The most significant changes occurred in areas with particularly heavy traffic from ships with deep draughts. In the most intensively used areas, an average of around 50 ships per day passed through during the study period.

Sediment analyses revealed that especially fine-grained sand was mobilised. The shear stresses generated by ship propellers regularly exceeded the thresholds, at which sediment begins to move – in some cases over stretches of up to 60 metres in width along the direction of travel. In the approximately 7.2 square kilometre study area, the volume of sediment eroded from the depressions totalled around 450,000 cubic metres. This corresponds to an average material loss of around 6 centimetres across the affected area.

Water column mixing right down to the bottom

In addition to the seabed changes, the study also shows how strongly the turbulence in the wake of large ships can affect the water column. Acoustic measurements showed that the wake, including the air bubbles, can spread to depths of 12 to 16 metres, destroying the natural stratification of the water column. In the majority of documented ship passages, this effect extended almost right down to the Baltic Sea floor with the propeller wake overcoming a distance of three to ten metres to the seabed. Outside the wake, the water column remained clearly stratified.

“We are observing several physical processes here that can be excellently quantified and monitored by modern underwater acoustic methods,” emphasises Jens Schneider von Deimling from the Marine Geophysics and Hydroacoustics working group at Kiel University. “Especially in shallow sea areas, this kind of repeated disturbance can have a significant impact, but so far such effects have not been systematically taken into account, neither in regional matter balances nor in large-scale modelling,” says the Kiel-based researcher, who led the sonar measurements on board the Alkor expedition.

Ecological significance and prospects for research and management

“The results clearly show that shipping must be considered an active shaper of marine habitats. Extrapolated to the entire Baltic Sea, we estimate that around 7.5 percent of the sea area could be affected by ship-induced sediment changes,” explains IOW researcher Jacob Geersen. The results only refer to shallow, heavily trafficked marine areas and cannot be readily transferred to deeper or less intensively used regions. “But even if only a part of these areas is affected, this still represents a significant contribution to sediment and matter fluxes,” says Geersen.

The observed processes have potentially far-reaching consequences for marine ecosystems. The mixing of the water column influences the fluxes of oxygen, nutrients and dissolved trace elements between surface and bottom waters. At the same time, the erosion of the seabed leads to the mobilisation of sediments that may contain organic matter as well as bound pollutants and nutrients. Marine life is also likely to be severely affected. “We therefore see a particular need for long-term observation programmes that jointly record physical, chemical and biological processes. Furthermore, numerical models could help to better assess the effects of different ship types, speeds or routes,” says CAU researcher Jens Schneider von Deimling.

Both scientists agree, that the findings raise questions for maritime management. “Adjustments to shipping lanes, speed regulations, or alternative routes could help to relieve the pressure on particularly sensitive seabed areas in the long term. Whether such measures are effective, should be accompanied by further research,” they conclude.

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