**////Title: Finding Reefs: Advances in Mapping Rare Marine Habitats**

**////Standfirst:**

The marine environment houses complex types of ecosystems that provide vital services and habitat to aquatic life. Areas of the seafloor where rocky outcrops are present, such as reefs and gravel beds, are some of the rarest marine habitats. Also known as ‘hard substrate habitats’ these ecosystems are under increasing pressure from fishing, eutrophication, climate change, and coastal management. Though hard substrates are protected in the European Union, we are unable to manage them effectively because maps describing their location and dimensions are inaccurate. In a review paper, Dr Svenja Papenmeier [Sven-yah Pah-pan-my-er] of Germany’s Leibniz Institute for Baltic Sea Research Warnemünde summarises existing rules for mapping substrate habitats, and describes new and potentially ground-breaking mapping techniques.

**////Main text:**

Any region of the seafloor that features rocky surfaces is considered to be a hard substrate habitat. Even human debris, such as shipwrecks, can constitute a hard substrate habitat. These zones provide nursery areas and feeding grounds for fish, as well as precious habitat for organisms that must anchor themselves to a solid surface. Along with their benefits to animal and plant communities, many of which are endangered, hard substrates also provide numerous ecological services including nutrient cycling and water purification.

Given their importance, the European Union has formally protected hard substrate zones. However, the EU specifies no common characteristics or dimension range that can be used to classify different types of hard substrate. As a result, each member state has developed their own set of criteria that can differ wildly from one another, complicating management of hard substrate habitats that cross jurisdictional lines.

Although the European Union mandates protection of hard substrate zones, inadequate data concerning the distribution, pattern and size of these habitats makes it nearly impossible to adequately protect them. In fact, these data are essential to answer present questions and accomplish directives, such as monitoring their environmental status and ensuring safe navigation for boats.Having access to these types of data is also critical when a company seeks to approve offshore constructures – a process that mandates no disturbance of hard substrate habitats.

Currently, maps of European hard substrate locations come from regional data and literature reviews. They are coarse, likely inaccurate, and do not allow for the mapping of different types of substrate habitat.

In a paper published in *Geosciences*, Dr Svenja Papenmeier and her colleagues review the existing guidelines for hard substrate mapping in German parts of the Baltic Sea. They also summarise current and new mapping and data processing techniques.

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The most common mapping technique involves the analysis of sidescan sonar or multibeam echosounder data. Researchers send sonar soundings from the ship to the surveyed area, and the resulting echo is used to estimate the ocean depth, bottom type, and dimensions of topographic features. However, the data processing involved in these methods is complex, and no international standardised protocol has been established to facilitate quick turnaround. It is not uncommon for experts to manually interpret sound signature data, which is a time-consuming process not appropriate for large areas.

In Germany, there are generalised habitat maps including hard substrates, created mostly with local hydroacoustic surveys. Based on the maps, large ridges of rock – termed reefs – were delineated. Officials selected reefs that seemed eligible for protection based on the European Union directive. The resulting area was 18 times smaller than the coarse European Union map, suggesting a significant mismatch of data.

The German Federal Agency for Nature Conservation has also issued reef mapping criteria for those hoping to receive offshore licensing privileges. However, although the criteria are based on expert knowledge, no scientists have performed the survey to confirm that it is appropriate.

In their paper, Dr Papenmeier and her colleagues summarise the history of Germany’s mapping campaigns, which range from fishermen noting where their nets became tangled in rocks, to a 2012 initiative coordinated by the Federal Maritime and Hydrographic Agency to map hard substrates and other sediment distributions. The team notes that, like in much of the rest of Europe, different entities within Germany are mapping and defining hard substrates in various ways.

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To get the type of data needed to delineate reefs and study how object distribution affects ecosystem function, we must be able to detect single objects, such as a single large boulder or cobble. Typically, single object detection is achieved using hydroacoustic surveys. This method, though, comes with several challenges.

Hydroacoustic surveys return backscattered images that reflect the strength of the acoustic return from the surveyed area. Objects elevated from the seafloor, such as reefs, will intercept the acoustic signal and produce a shadow corresponding to the object’s shape and size. However, this method requires high resolution, which is not always available.

The resolution of the imagery depends on sonar frequency, pulse length, sonar range, speed of the ship, and other factors. If any of these factors are off, the resolution – and accuracy – of the map will be decreased.

Some researchers have calculated a 42% underestimation of boulder size in low-resolution images. Along with low resolution, other issues can confound the accuracy of a map. For example, the presence of biomass, such as animals or plants, can absorb and scatter parts of the acoustic signal, potentially erasing some of the signal used to estimate size. These methods also have relatively small ranges and cannot detect very small items.

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Dr Papenmeier and her colleagues stress that inadequate technology is stifling efforts at creating a unified mapping protocol. Even with a thoughtful approach that uses both hydroacoustic methods – sidescan sonar and multibeam echosounding – delineating stony habitats and identifying single objects is time-consuming and subjective.

Potential new solutions posed by the authors include autonomous underwater vehicle data acquisition. Furthermore, using automated routines, such as machine learning, to analyse data would greatly speed up current methods. Though this is a promising line of research, it is still in early stages of development.

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Hard substrates are unique, important areas for marine life. However, owing to a combination of mediocre mapping technology and confusing international policy, we have no clear picture of the distribution of these habitats. This is the case in German parts of the Baltic Sea, which house a diversity of different types of reefs.

To protect these habitats and answer several important questions concerning their distribution and ecology, Dr Papenmeier and her colleagues argue that we must start a cohesive mapping campaign. However, this must be founded upon improved technologies that, unfortunately, are still not widely available.

With their review, the team identified needs and weaknesses in the field that must be addressed before effective conservation of hard substrates is feasible. They point out that demands from the international community cannot be met without first getting the right data. After all, if we don’t know the size and distribution of hard substrates, how can we possibly expect to protect them?

This SciPod is a summary of the paper ‘Hydroacoustic Mapping of Geogenic Hard Substrates: Challenges and Review of German Approaches’ from *Geosciences.* <https://doi.org/10.3390/geosciences10030100>

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