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Surface divergence in the Mediterranean Pelagic Accumulation as a Source of Variability

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ABSTRACT

Many studies have shown that habitat complexity or habitat diversity plays a major role in biodiversity at various spatial scales. As structural heterogeneity increases, so does the number of (micro) habitats available for potential species inventories. As habitat heterogeneity increases, the ability to accommodate species (including rare ones) increases rapidly. However, measuring the habitat complexity of marine subtidal sediments is not straightforward. In our study, we made a proposal to estimate the habitat complexity of subtidal benthic organisms using standard underwater video techniques. The tool was then used to study the impact of habitat complexity on species richness compared to other environmental parameters in the Fehmarnbelt Marine Protected Area, a narrow strait in the southwestern Baltic Sea our results show that heterogeneous substrate species richness is significantly higher for all sediment types considered. Therefore, the presence of rare species increases as the structure becomes more complex. Our results highlight the importance of microhabitat availability for benthic biodiversity and research areas of local ecosystem function.

Keywords: Macrozoobenthos; Baltic Sea; Species richness; Rare species

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INTRODUCTION

Environmental factors with respect to the considered spatial scale. For example, diversity and species richness of endobenthic macrofauna assemblages in the Baltic Sea are mainly influenced by salinity at regional scale of hundreds of kilometers. By contrast, on a sub-regional scale of tens of kilometers, substrate characteristics and other factors, often masked by water depth, become more important [1]. However, many terrestrial, limnic, and marine studies show that habitat complexity, or habitat diversity, plays a major role in biodiversity throughout different spatial scales as structural heterogeneity increases, so does the number of available (micro-) habitats for the potential species inventory, but also that highly specialized species might even be endemic in these areas [2]. As habitat heterogeneity increases, the ability to accommodate species (including rare ones) increases rapidly. On the other hand, common and rare species may play important roles in ecosystem functioning through new contributions to functional diversity or through functional redundancy. Furthermore, communities with rich functional features are more likely to survive during periods of natural or anthropogenic stress, which helps stabilize the system.

However, measuring the habitat complexity of marine subtidal sediments is not straightforward. At larger scales, seafloor morphology is often used as a proxy to capture habitat heterogeneity [3]. At smaller scales, the heterogeneity of sediment properties may be an important factor in determining species diversity. Nevertheless, sediment heterogeneity is often not recorded by standardized sampling with a small number of replicates at individual stations. Therefore, sediment composition in heterogeneous areas can be determined by significantly increasing the number of physical sampling iterations, requiring enormous additional effort. Another challenge relates to the amount of sediment used to analyze sediment properties. Taking small sub-samples for sediment analysis often does not cover the entire current grain size range. For this reason, sediment and animal samples are often taken separately to ensure that sufficient sample material is present for both analyses. However, taking separate samples to estimate substrate heterogeneity leads to potentially significant spatial discrepancies between biogenic and geological data, and the full range of available sedimentary structures is overwhelmed. Your ability to cover may be limited. In addition, potentially important geological and biogenic structures such as rocks, pebbles, macrophyte meadows and mussel shells are often overlooked. Another efficient way to estimate local habitat complexity is to use underwater video with physical sampling [4].

MATERIALS AND METHODS

Study area

The Natura 2000 area "Fehmarnbelt" (EU code DE 1332-301, hereafter referred to as the Marine Protected Area MPA) is located in the southwestern part of the Baltic Sea and includes most of the narrow strait between Denmark and the Danish island of Lolland. is included. Fehmarn Island, Germany [5]. It has an area of 280 km² and is characterized by a steep drop in depth. The Fehmarnbelt is part of the Baltic transition zone and is affected by saline inflow from the Atlantic Ocean and brackish outflow from the actual Baltic Sea. More than two-thirds of the water exchanged between the North Atlantic and the Baltic Sea flows through the Belt Sea, or Fehmarn Belt [6].

In fauna and sediment data

Samples were collected at various spatial locations from 2012 to 2018 as part of various projects. Sites (hereafter referred to as stations) were selected to reflect the expected distribution of all major surface sediment types within the study area, based on existing cartography, literature review, and authors' experience rice field. Stations sampled included both monitoring stations and randomly placed mapping stations, but the sampling method used was the same for his seven years [7]. At each station, at least one faunal sample and a sample for sediment characterization were collected with his Van Venn grab (0.1 square meter sampling area) and a short video recording was made on the same day within a radius of 50-100 meters. I was.

Animal samples were sieved through a 1 mm mesh screen and fixed in a 4% buffered formaldehyde seawater solution. In the laboratory, samples were classified using binoculars with 10x magnification to identify and count individuals at the lowest possible classification level (mainly the species level). The taxonomy followed the World Marine Registries (WoRMS) [8].

In contrast to the expected sediment types presented, the final assignment of stations to the four sediment types was based on particle size distribution measurements using particle size analysis. The sediment types considered were (i) muddy substrates (mean grain size d50 < 63 > 500 μm); The number of classes chosen was determined with the intention of ultimately having a sufficient number of stations within each class and complying with generally accepted (rough) sediment grain size classifications. Sandy and gravel sediments were automatically dry-sieved through a cascade of 10 sieves with different mesh sizes ranging from 63 μm to 2 mm. The particle size distribution of the muddy sediments was analyzed without chemical treatment using a CILAS 1180L laser diffraction particle size analyzer (3P Instruments GmbH & Co. KG, Odertshausen, Germany). The parameters describing the cumulative particle size distribution (that is, mean particle size, sorting, and skewness) were then fitted to the cumulative particle size data using the least-squares method using a special fitting algorithm, and the skewed calculated using the sigmoid function [9]. However, due to locally heterogeneous sediment conditions, additional information on the sediment composition of land samples was obtained from shipboard optical sediment descriptions. Samples were excluded from analysis if there were serious discrepancies between the sediment sample parameters and the onboard description of the faunal sample sediment [10].

Occurrence of rare species

Based on the number of records and number of samples, we calculated the rare species discovery rate per sample. This proportion increased continuously from homogeneous substrates (0.22 rare species per sample) to 0.83 rare species per sample for highly heterogeneous substrates when summed across all sediment types. The occurrence of rare species varied by sediment type fine sand had the lowest probability of finding a rare species (0.11 rare species per sample), while coarse substrates statistically allowed identification of one or more rare species per sample (1.17). Moreover, when heterogeneity and sediment classes were considered separately, the probability of finding rare species was highest in highly heterogeneous and coarse substrates.

DISCUSSION

In this study, we tested a newly proposed measure of substrate non-uniformity. This was inferred from the rich morphology of the seafloor recorded by underwater video and attributed to the heterogeneity of the seafloor at a spatial scale slightly larger than the standard sample. Our results suggest that the sediment information value of grab samples may be limited, especially if the sediments within the grab originate from homogeneous but globally heterogeneous environments.

The data used in this study are not experimental but based on various projects carried out in the study area over several years. Such an approach often carries the risk of the observation point distribution becoming unrepresentative with respect to the associated environmental gradient. We recognize that the results should be interpreted with caution due to the possibility of transient pseudoreplications. Moreover, in this study, the data points were not evenly distributed along the considered substrate slope and substrate non-uniformity classes. However, the fact that combinations of sediment types and heterogeneity classes are not evenly distributed within the data is mainly due to the origin and amount of added sediments. The coarse sediments are remnants of Ice Age sediments and were inherently poorly sorted by granulometry. Permanent hydrodynamic forces scattering microscopic fractions accumulated in low-energy regions (pits, rock shadows, etc.) enhanced the heterogeneity in regions dominated by lag sediments. The migratory sand cover of the southern abraded platform and thus the homogeneous sediment distribution was associated with the availability of large amounts of reprocessed offshore sediments. In this study, for each sampling event he included only one replicate in the analysis. This lack of reproducibility increases the uncertainty of results and can limit reliability. This is because of the presence of unexplained irregularities and fine-scale variability, and benthic distributions need to be kept in mind.

In addition, the relatively long time period of 7 years and the fact that the data were obtained from different seasons increases the natural variation considered in the biological data and increases the uncertainty associated with the results. Because the Fehmarnbelt is located at the mouth of the Baltic Sea, the communities living there are often affected by jutting saltwater from the Kattegat and Skagerrak rivers. These waters are home to pelagic larvae as well as adults, which may temporarily supplement native populations. However, both uniform and heterogeneous sediments were sampled over the entire period, so it is unlikely that this significantly affected the overall pattern of results.

CONCLUSION

In summary, uneven seafloor topography three-dimensionally structures habitats, increases species richness and buffers the functional diversity of ecosystems, thus allowing them to withstand fluctuating environmental factors. Regions with such high multidimensional diversity are likely to become of utmost importance in an era of global overfishing, climate change, and exploration for marine space and resources. The Fehmarnbelt is one of these regions in the Baltic Sea and its ecological development requires special attention to ensure the future provision of associated ecosystem services.

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