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# Seismo-acoustic imaging of marine hard substrate habitats: a case study from the German Bight (SE North Sea)

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The detection of hard substrate habitats in sublittoral environments is a considerable challenge in spite of modern high resolution hydroacoustic techniques. In offshore areas those habitats are mainly represented by either cobbles and boulders (stones) often located in wide areas of soft sediments or by glacial relict sediments (heterogeneous mixture of medium sand to gravel size with cobbles and boulders). Sediment classification and object detection is commonly done on the basis of hydroacoustic backscatter intensities recorded with e.g. sidescan sonar (SSS) and multibeam echo sounder (MBES). Single objects lying on the sediment such as stones can generally be recognized by the acoustic shadow behind the object. However, objects close to the sonar's nadir may remain undetected because their shadows are below the data resolution. Further limitation in the detection of objects is caused by sessile communities that thrive on the objects. The bio-cover tends to absorb most of the acoustic signal. Automated identification based on the backscatter signal is often not satisfactory, especially when stones are present in a setting with glacial deposits. Areas characterized by glacial relict sediments are hardly differentiable in their backscatter characteristics from rippled coarse sand and fine gravel (rippled coarse sediments) without an intensive ground-truthing program. From the ecological point of view the relict and rippled coarse sediments are completely different habitats and need to be distinguished.
The case study represents a seismo-acoustic approach in which SSS and nonlinear sediment echo sounder (SES) data are combined to enable a reliable and reproducible differentiation between relict sediments (with stones and coarse gravels) and rippled coarse sediments. Elevated objects produce hyperbola signatures at the sediment surface in the echo data which can be used to complement the SSS data. The nonlinear acoustic propagation of the SES sound pulses produces a comparably small foot print which results in high spatial resolution (decimeter in the xyz directions) and hence allows a more precise demarcation of hard substrate areas. Data for this study were recorded in the "Sylt Outer Reef" (German Bight, North Sea) in May 2013 and March 2015. The investigated area is characterized by heterogeneously distributed moraine deposits and rippled coarse sediments partly draped with Holocene fine sands. The relict sediments and the rippled coarse sediments indicate both high backscatter intensities but can be distinguished by means of the hyperbola locations. The northeast of the study area is dominated by rippled coarse sediments (without hyperbolas) and the southwestern part by relict sediments with a high amount of stones represented by hyperbolas which is also proven by extensive ground-truthing (grab sampling and high quality underwater videos). An automated procedure to identify and export the hyperbola positions makes the demarcation of hard substrate grounds (here: relict sediments) reproducible, faster and less complex in comparison to the visual-manual identification on the basis of sidescan sonar data.