Coastal seabed quantification based on digital scenarios using hydroacoustic data

Underwater hydroacoustic measurements are widely used in sonar applications not only for detecting target objects (such as vessels or fisheries) but also to characterize the nature of the seabed and monitor the coastal environment. In this present work, hydroacoustic measurements performed by a single beam narrowband echosounder are modelled using a Sommefeld integral representation. This mathematical modelling setting allows to mimic digitally the insonification of a specific location of the seabed, and the reflected signal received by the acoustic device is used to quantify not only the geophysical properties of the seabed but also the presence of biological and buried anthropogenic elements. Typically, the vibroacoustic behaviour of the coastal seabed is modelled by using homogeneous rigid-framed porous or poroelastic media. However, since granular materials with different pore sizes are also commonly found in coastal environments, consolidated and non-consolidated porous granular models, such as the Biot-Stoll model, have been considered, taking into account parameters such as porosity, tortuosity, flow resistivity and standard deviation of the pore size. Since the underwater fluid domain has a complex state law, its physical properties are considered strongly dependent on temperature and salinity in a specific coastal environment. From a numerical methodology point of view, the full physical model is written and solved using a displacement-based finite element method, which has to be combined with a perfectly matched layer technique to truncate the unbounded underwater domain. This algorithmic approach enables the numerical prediction of time-harmonic propagation of hydroacoustic signals through the seawater and the granular porous seabed domain. The quantification of the biological presence in those underwater environments, such as algae on the surface of the coastal seabed or the bivalve concentration buried in the upper layer of the sediment, will be quantified in terms of the frequency response function of the intensity of the reflected hydroacoustic signal recorded on the free surface of the sea, where the echosounder is placed in a variety of different digital seabed scenarios.

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