The sound of sediments: acoustic sensing in uncertain environments
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This dissertation examines methods that resolve uncertainties in shallow water environments in order to support acoustic sensing capabilities. Knowledge of the relevant acoustic characteristics of the water column and the seabed enable drastic improvements in predictions of sonar performance in the surveyed area.

Characteristics of the seabed and layers of sediment can be evaluated with geoacoustic inversion techniques. The conventional method relies on active sonar transmissions of low frequency that penetrate into the bottom. But the use of active sonar is not always an appropriate option. High power transmissions could harm marine mammals, give away the position or intentions of military units, or the required energy or equipment may simply not be available. Therefore, this dissertation examines geoacoustic inversion with passive sonar systems. A concept of environmental assessment is studied that includes the analysis of bottom reflected shipping sound. The analysis involves a global optimization problem that is solved with metaheuristic search strategies.

Experimental data have been collected during two sea trials. During a small scale campaign of rapid environmental assessment at the Saba bank in 2006, self noise of HNLMS Snellius was recorded on a sparse vertical array. The result of the geoacoustic inversion process is both an accurate description and an uncertainty assessment of a range-independent environmental model of a sandy sediment layer over a subbottom of calcareous rock. The Battlespace Preparation sea trials of
2007 took place in the Mediterranean Sea. Here the self noise of a relative quiet autonomous underwater vehicle was successfully used to locate the vehicle and at the same time classify the local sediment as silty clay.

For a swift solving of the global optimization problem, the performance of various metaheuristic optimization schemes has been studied. It is shown that Ant Colony Optimization is a capable optimizer to obtain an accurate geoacoustic model, and also that the method can provide an uncertainty assessment of the results. This dissertation challenges claims that certain metaheuristics are far more efficient than others. It has been shown for two inverse problems that tuning of a search strategy is just as important as selecting the most suitable method.

A swift geoacoustic inversion enables an optimal operational deployment of active and passive sonars in a given oceanic situation. The shown techniques have further potential in the design of advanced sonar systems: inversion with shipping sound is a passive method of source localisation in uncertain environments.