Introduction

During Pond Experiment 2010 (PondEx10), acoustic responses from four inert unexploded ordnances (UXO): solid cylinders, pipe, and replica of a UID, and two rocks were collected at the test pond facility of the Naval Surface Warfare Center, Panama City Division (NSWC PCDS). The IDOS were either placed on the water sediment interface, buried just beneath the sediment interface, or partially buried. Synthetic aperture sonar (SAS) data were taken for several orientations of the IDOS with respect to the path of the IDOS. The grazing angle was held at 20°. The IDOS were positioned on an acoustic field to promote to buried targets via ordinary reflection, while at a grazing angle of 20° only pure targets were interrogated. Two frequency bands were used to gain a 1 x 1000 range. SAS images for the targets at various orientations are displayed. The reduction of data sets to acoustic templates is shown. Acoustic templates provide a possible means to identify a detected object as a UXO-like target.

Objective

The overall objective is to investigate the use of broad-band sonar in the detection, classification, and identification of underwater munitions. A central hypothesis is that the environment alters the acoustic response of a target significantly, so the target-in-the-environment must be taken into account during the development of robust detection, classification, and identification strategies.

Experiment Site, Layout, and Materials

Fresh water pond at the NSWC PCDS and an engineered schematic of the pond with the experimental layout (right). The pond holds 9 million gallons of water, 150 ft by 60 ft in dimensions, and 14 ft deep. A 1-ft thick layer of sand covers the bottom. Biological growth and fouling of the targets and equipment are minimal. A detailed description can be found in [1] and [2].

Layout of the 10 m target field.

When multiple targets are in the target field and the separation distance between adjacent targets is on the order of a few meters or less, the scattered acoustic fields from neighboring targets interfere. SAS processing is unaffected by this interference due to the underlying coherent processing in SAS. However, to generate acoustic templates, a clear separation and isolation of the target’s acoustic response is required. The SAS filtering technique developed by Marston et al provides a means to achieve this goal. This pictorial description of the SAS filtering technique is shown below. The deconvolution and convolution steps are linear transformations, which do not add or remove information from the signals. Note the suppression of noise due to reverberation in the target’s acoustic response.

Target used during PondEx10 were a solid aluminum cylinder, an aluminum pipe, an inert 81 mm mortar, a solid steel pipe, and two rocks. The machined IDOS, based on a CAD drawing of the solid steel artillery shell, were constructed from materials with known properties. The aluminum cylinder is 2 ft long by 1 in in diameter, while the pipe is 2 ft long with an inner diameter of 11 in. and 3/8 inch wall thickness.

The acoustic template for a UXO-like target is obtained by filtering the IDOS data in three frequency bands with a replica in each frequency band. The IDOS data is normalized with respect to the target strength and normalized with respect to the target strength and the target’s acoustic response is obtained. The SAS filtering technique developed by Marston et al provides a means to achieve this goal. This pictorial description of the SAS filtering technique is shown below. The deconvolution and convolution steps are linear transformations, which do not add or remove information from the signals. Note the suppression of noise due to reverberation in the target’s acoustic response.

Data Sets, SAS Images, and Acoustic Templates

Raw acoustic data are pulse compressed and matched filtered the pings with a replica of the transmitted signal. During the matched filtering, a ballistic replica transforms the real-valued matched filtered pings to complex-valued signals, and the sum is removed to obtain band-limited signals. The figure (left) shows the magnitude of the baseline pulse-compressed pings for five targets from top to bottom: machine aluminum UXO, solid aluminum cylinder, machined steel IDOS, aluminum pipe, and solid artillery shell. For SAS processing the coherent addition of the complex signals is unaffected by the overlapping signals.

The image (right) shows the acoustic templates for the proud pipe and the model result is shown (below). The complex model captures the organ pipe structure and an elastic response of pipe. The model captures the organ pipe structure and an elastic response of pipe.

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