LOCALIZATION OF RIGHT WHALES USING MATCHED CORRELATION PROCESSING

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1. INTRODUCTION

In August of 2005, researchers at DRDC Atlantic deployed a horizontal hydrophone array on the seafloor in the Bay of Fundy, Canada, in order to record and analyse the vocalizations and "gunshot" type sounds from North Atlantic right whales (*Eubalaena Glacialis*). The purpose of the experiment was to investigate various methods of marine mammal localization. The right whale gunshots are spectrally similar to the signature of an imploded light bulb. In this paper, we demonstrate the use of Matched Correlation Processing (MCP) to localize the position of a light-bulb signature [1]. We then apply the MCP technique to the right whale data.

2. MATCHED CORRELATION PROCESSING

For many years, model-based Matched Field Processing (MFP) techniques have been researched with the goal of improving the capability of passive sonar systems for localizing quiet underwater sources [2]. Recently, researchers at DRDC Atlantic have been investigating MCP as a faster alternative to MFP. In this method, the cross-correlations for a broadband source as measured with a pair of hydrophones in a horizontal array are matched with those generated with a correlation model for many candidate ranges and depths along a candidate bearing. These matches are carried out with a number of hydrophone pairs to form many range-depth ambiguity surfaces. The maximum on the average of these surfaces is assumed to yield the best estimate of the source position. By carrying out this procedure over a number of candidate bearings, a full 3D search for the source location is achieved.

3. THE EXPERIMENTS

Figure 1 shows the MCP setup for an experiment that was carried out in St. Margaret's Bay, Nova Scotia, during the fall of 2005. A three-sensor horizontal array (red curve) with an aperture of 125 m was deployed on the sea bottom in 68 m of water and the hydrophones were localized using an Array Element Localization (AEL) procedure [3]. A light bulb was imploded at a depth of 41.5 m, 232 m from hydrophone 1 along a bearing of 189°T (black dot) and the resulting signature was recorded on the array.

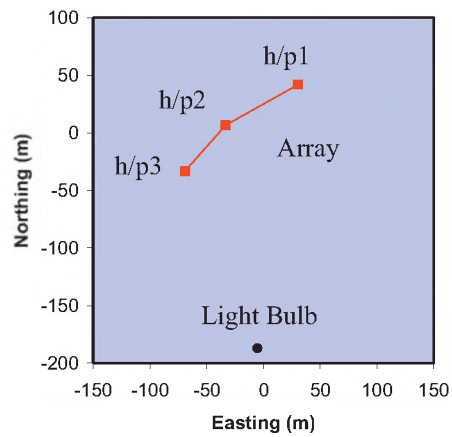

Fig. 1 The light bulb localization setup in St. Margaret's Bay.

The MCP algorithm was used to localize the position of the light bulb. The search was carried out over ranges from 0 to 600 m in steps of 5 m, over depths of 0 to 65 m in steps of 5 m, and over 360° of bearing in steps of 5°. That search resulted in a correlation peak of 0.6725 along a bearing of 190°T. The range-depth ambiguity surface corresponding to that bearing is shown in Fig. 2. The peak is very sharp and, as indicated by the white cross hairs, is located at a range of 235 m and a depth of 40 m. The errors in this MCP localization are smaller than the steps sizes used in the search. Thirteen other light bulbs with a variety of ranges and bearing were also successfully localized.

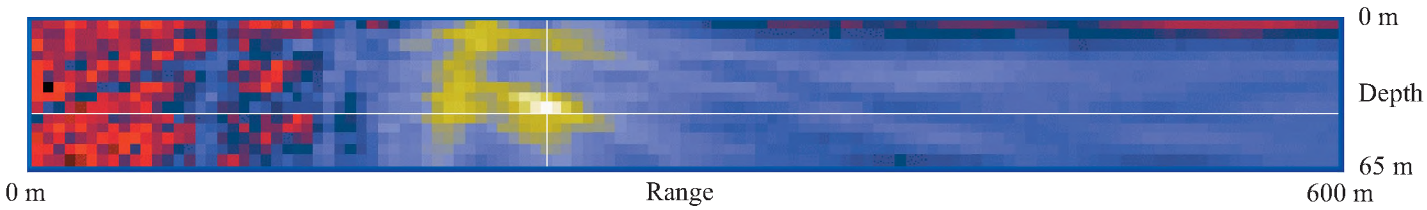

Fig. 2 The ambiguity surface at 190°T in St. Margaret's Bay. The white cross hairs show the estimated position of the light bulb.

As shown in Fig. 3, a similar experiment was carried out in the Bay of Fundy, Nova Scotia, during the right whale localization trials of 2005. In this case, the array aperture was shorter at 28.9 m, the bottom depth was deeper at 101 m and the light bulb was imploded at a depth of 40.2 m, 215 m from hydrophone 1 along a bearing of 222°T.

The ambiguity surface that contains the maximum correlation is shown in Fig. 4. Although the MCP algorithm accurately localized the light bulb at a bearing of 225°T, the localization of the range and depth is extremely poor. This was due to the low reflection coefficient of the bottom at this site. The MCP algorithm requires good bottom-bounce arrivals to find the range and depth. Similar results were found for the other nineteen light bulbs.

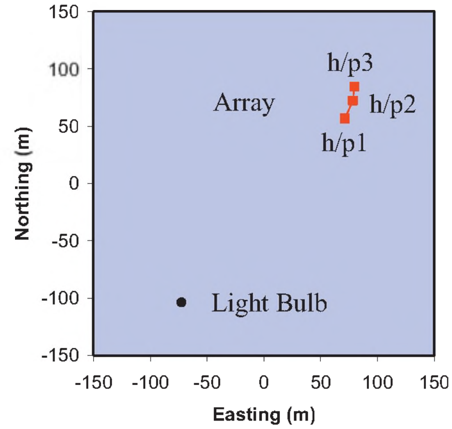

Fig. 3 The light bulb localization setup in the Bay of Fundy.

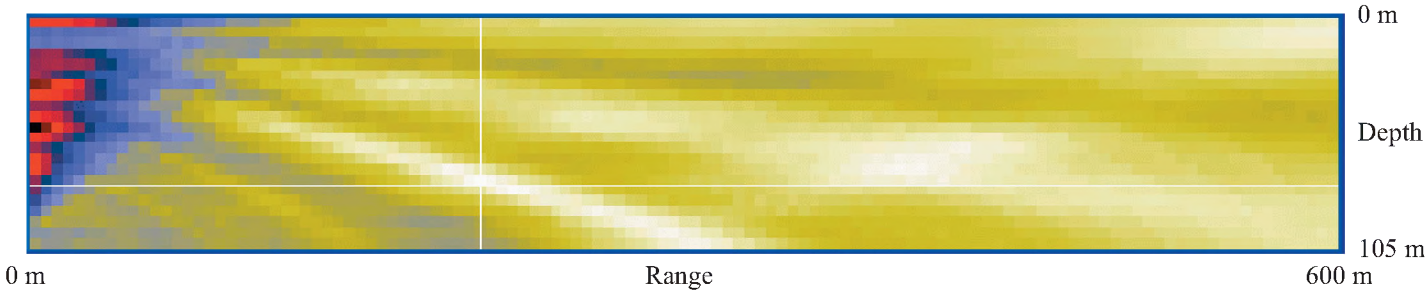

Fig. 4 The ambiguity surface at 225°T. The white cross hairs are at a range and depth of 205 m and 75 m, respectively.

Although it was clear that the range and depth of the right whales could not be estimated with the MCP algorithm in the Bay of Fundy environment, an attempt was made to track the whales in bearing. The results are shown in the bearing *vs.* time plot of Fig. 5. The algorithm successfully localized the right whales to bearings between 143 and 170°T over a one-hour time period. Because the variation of the bearing with time was small, it was concluded the whales were well outside the 600-m range of the MCP system. In fact, these localized bearings are in the general direction of an area some 10 to 15 km away that is known historically to have the highest concentration of right whales at this time of year.

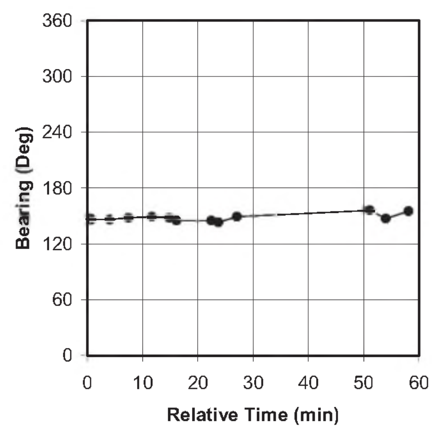

Fig. 5. Estimated whale bearings in the Bay of Fundy.

4. DISCUSSION

The concept of a MCP localization system for right whales was presented. Using light bulbs as simulated right whale gunshots, the technique was shown to work extremely well out to a range of about six water depths in an environment that has sufficient bottom reflections. Even over softer sea beds with little or no reflections, it was demonstrated that the right whales could still be tracked in bearing.

REFERENCES

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