The Effect of Vertical Towed Array Orientation on the 3D Acoustic Picture for Sound Sources and Ambient Noise Fields

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This research looks at towed-array data from an autonomous underwater vehicle (AUV) in a virtual environment to develop a 3-dimensional acoustic picture, which is the measured noise field in both the azimuthal and vertical direction. In this research a “yoyo” maneuver is used in which the vehicle moves up and down in the water column, as opposed to previous experiments where the AUV is kept at constant depth. The inspiration for this experiment is the upcoming ICEX planned for the Spring of 2016, in which the 3D acoustic picture produced by a Bluefin-21 with the DURIP towed array will be used in the array processing to gain insights into the Arctic environment for target tracking, seabed mapping using anthropomorphic ice cracking noise, passive target ranging, and the feasibility of using AUV's for persistent ice-edge surveillance. This thesis presents a method for quantifying and measuring the verticalness of an array for any maneuvers, conducts a number of virtual experiments to quantify the resolution of the picture, and draws general relationships between an array “vertical score" and the quality of a 3-dimensional acoustic noise pattern.

The verticalness of an array is measured by an inverse sine relationship, while the vertical score is calculated using an impulse response function, which tracks total verticalness over time. The vertical score is then tracked over a number of different experiments, and compared against the 3D noise field produced by an iterative algorithm that de-convolves the noise field from the beam response patterns for each run. The results conclude that within the vehicle maneuvering limits of the Bluefin-21, a fully pitched yoyo pattern vs. a constant depth pattern results in a relative increase in the maximum beam response of a source by approximately 8 dB, and also decreases the 3-dB down bandwidth in the vertical direction by approximately 16° without any significant losses for the bandwidth in the horizontal direction. This increase in vertical resolution allows measurements on range using simplified ray tracing calculations. When attempting to use a towed array to characterize a horizontally isotropic noise field, the results show that within the vehicle maneuvering limits of a towed array, the beam response patterns are not sufficient to produce an accurate acoustic picture, and that a vertical array is the most appropriate for measuring these types of noise fields.

Doctor of Philosophy in Mechanical Engineering