

We wish to develop a new method of detecting submarines that does not require the generation of sound, as sonar does. Rather, it should employ changes in the water's ambient noise field to determine the location, size, and velocity of the submarine.

Our model suggests using transducer arrays suspended from boats on the surface of the sea to monitor the sound field in the water. Acoustic transducers are capable of determining the amplitude and direction of echoes from a submarine. From the amplitude of the echoes, we can determine how much the sound has been attenuated, or weakened, since it was generated. If we collect this information from two boats at different locations, we can use geometry to determine the location of the submarine. We can then extend this method to find both of the ends of the vessel, and then triangulate to determine its size.

We considered using the Doppler effect to compute the velocity of the submarine. To implement this idea, we would have had to monitor the shift of a wide range of frequencies, which proved impractical. Instead, we elected to determine velocity by making several position measurements and dividing change in position by change in time.

The first model was a success, but only in a limited range of conditions. The formula for the attenuation of the sound was only valid for ocean depths below the range of a submarine. So, we devised a second model which allowed for greater variation of conditions while maintaining accurate estimation of attenuation.

In both of our models, we made many simplifying assumptions which were probably detrimental to the quality of our results. We ignored the refraction of sound waves in water and we used a formula for planar attenuation on a spherical wave. In addition, we were unable to provide a numerical example for our second model due to technical difficulties.

Our models can successfully locate a submarine and find its size and velocity. Given figures for the accuracy of the equipment, we can estimate the error in our results. We have also provided a way to increase the accuracy of the method by using a refined attenuation formula.