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# of an extremely shallow underwater explosion of the ROKS Cheonan sinking using seismic, hydroacoustic and infrasound waves including boundary element method

We estimated the detonation depth and net explosive weight for a very shallow underwater explosion using cutoff frequencies and spectral analysis of seismic and hydroacoustic waves. With detonation depth and a bubble pulse the net explosive weight for a shallow underwater explosion could simply be determined. The ray trace modeling confirms the detonation depth as a source of the hydroacoustic wave propagation in a shallow channel. We found cutoff frequencies of the reflection off the ocean bottom to be 8.5 Hz, 25 Hz, and 43 Hz while the cutoff frequency of the reflection off the free surface to be 45 Hz including 1.01 Hz for the bubble pulse, and also found the cutoff frequency of surface reflection to well fit the ray-trace modeling. We also attempted to corroborate our findings using a 3D bubble shape modeling and boundary element method (BEM) and infrasound signals. Our findings led us to the net explosive weight of the underwater explosion for the ROKS Cheonan sinking to be approximately 136 kg TNT at a depth of about 8 m within an ocean depth of around 44 m off the coast of Baengnyeong Island in the Yellow Sea on March 26, 2010.

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