Conjecture of sourcing wavelet conditions suitable for the simultaneous sourcing 3D seismic survey with the underwater speakers

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In Japan, active faults in coastal areas cause an earthquake such as the Noto Peninsula Earthquake (M6.9), and it has become increasingly important to understand geological information at that area. In recent years, a 3D seismic reflection survey (OGP & IACG, 2011) can recognize the structure under sea bottom spatially, and therefore provide more information than that of a 2D seismic reflection survey. However, a 3D seismic reflection survey requires high-cost and large-scale because of a large-capacity air gun and numerous cables. These problems make it for a 3D seismic reflection survey difficult to investigate in the coastal area. The simultaneous sourcing 3D seismic reflection survey system with multiple underwater speakers and one streamer cable (Tokyo University of Marine Science and Technology, 2018) was developed to resolve these problems and simplify a survey at coastal areas. An underwater speaker (200 ×65 mm, 4.5 kg) that is greatly smaller than airgun is able to survey with small-scale and therefore reduce a survey cost. Also, the maximum instantaneous sound pressure of an underwater speaker of 130 dB re 1 μPa at 1m (Tsuru et al., 2019) is very small compared to an airgun that is 210 dB re 1 μPa at 1m (IAGC, 2002). Additionally, an air gun with high sound pressure could cause environmental stress to marine life (Lokkeborg & Soldal, 1993; Cerchio et al., 2014) and it is necessary to reduce that stress (Mougenot et al., 2017). An underwater speaker with small-scale and small sound pressure contributes to resolving influences on marine life.
Our research group has been developing the sourcing wavelet of an underwater speaker to make a more accurate and stable observation (Ogawa et al., 2019). The underwater speaker system uses different non-pulse waves created by MATLAB (MathWorks) as sound source and makes a sound by signal generators. Adjustment of sourcing wavelets such as Marine Vibrator (Orji et al., 2020) is one of the advantages of an underwater speaker. In this research, we create two types of wavelets that are sweep waves and random waves to estimate the optimal wavelet conditions for the underwater speaker system. Sweep waves are generally used in ocean acoustic surveys and land seismic surveys, and random waves are generated by pseudo-random numbers (e.g. Dean, 2013). These two types of wavelets were created for each of the three frequency bands and a total of six wavelets were used for a test at sea. Our results show that the random wavelet is more suitable for the underwater speaker system than the sweep wavelet because the random wave has a higher signal to noise ratio after cross-correlation. Also, the penetration depth of the random wavelet was deeper though the sound pressure was smaller than that of the sweep wavelet. Finally, the seismic profile with more 100-200 Hz band was the most accurate in seismic profiles filtered at 50-100 Hz, 100-200 Hz, and 200-300 Hz.

Keywords: reflection survey, 3D seismic reflection survey, sourcing wavelet

