Hydroacoustic and tsunami waves originating from a series of submarine earthquakes near Torishima Island detected by a seafloor fiber optic strainmeter

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The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) is involved in development of multiple fiber optic sensing technologies to achieve broadband seismic observations in the Nankai Trough, Japan. We have started the Distributed Acoustic Sensing (DAS) observation using our abolished scientific submarine cable since 2019. A 120-km long measurement is performed by using an ultra-stable laser as an input light, which makes it possible to reduce the self-noise in the low frequency range less than 0.1 Hz particularly. In the meantime, a 200-m long fiber optic strainmeter was installed on the seafloor for the first time in 2019 (Araki et al., 2019). Two more fiber optic strainmeters were installed at the same location with different directions in 2022. Moreover, the same typed fiber optic strainmeter was installed in the deep borehole observatory in 2023 (Araki et al., 2023). Our seafloor/borehole fiber optic strainmeters are connected to the DONET seafloor network, and the *in-situ* dataset is available in real-time. In this study, we introduce the hydroacoustic and tsunami observations by a seafloor fiber optic strainmeter from the point of view of surveillance of submarine volcanic eruptions for natural hazards.

A series of submarine earthquakes near Torishima, a volcanic island of the Izu-Ogasawara (Izu-Bonin) Islands, Japan started early October 2023 (Figure 1). Numerous small earthquakes occurred from around 19:00 UTC to around 21:30 UTC on 08 October near the island. The Japan Meteorological Agency (JMA) issued a tsunami advisory for the Izu-Ogasawara Islands after observing a tsunami on one of the islands, although the magnitude of the seismic event remained unknown. Successively, the areas of the tsunami warning were gradually expanded. During this episodic event, three seafloor fiber optic strainmeters deployed in the Nankai Trough recorded 14 significant hydroacoustic signals, followed by a dispersive tsunami wave (Figure 2). The two micro-strain amplitudes were measured at 0.07~0.2 με and 0.003 με, respectively. On the other hand, the closer DONET pressure gauge, located approximately 3 km away, observed 1~5 hPa hydroacoustic signals and a 1.4 hPa tsunami wave. The spectrogram shows that the identified 14 hydroacoustic signals have short duration and broadband frequency contents, suggesting that the hydroacoustic signals may be associated with underwater explosive events. The main features of the frequency contents, i.e., short duration and broadband observed on the seafloor fiber optic strainmeters are comparable with the DONET sensors. Additionally, it has been confirmed that the tsunami signal is identified by the DAS of our JAMSTEC submarine cable (Tonegawa and Araki, 2024). Although discrimination between pressure contribution and seafloor deformation to the strain change should be addressed, what the present tsunami observation by the seafloor fiber optic strainmeters suggests that fiber optic sensing technologies can contribute to tsunami detection originating from non-seismogenic sources.

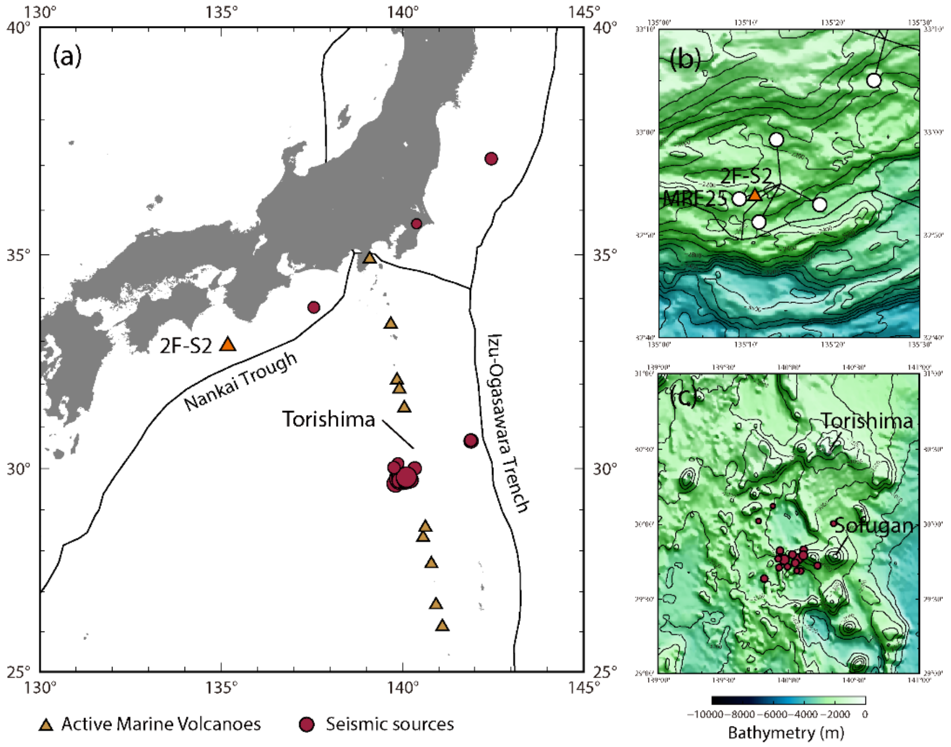

Figure 1. (a) Map showing the study area. (b) Detailed map showing 2F-S2 site denoted by the orange triangle, where three fiber optic strainmeters are installed. Open circles represent the DONET stations. (c) Detailed map around Torishima Island. Red circles represent the seismic sources determined by the USGS.

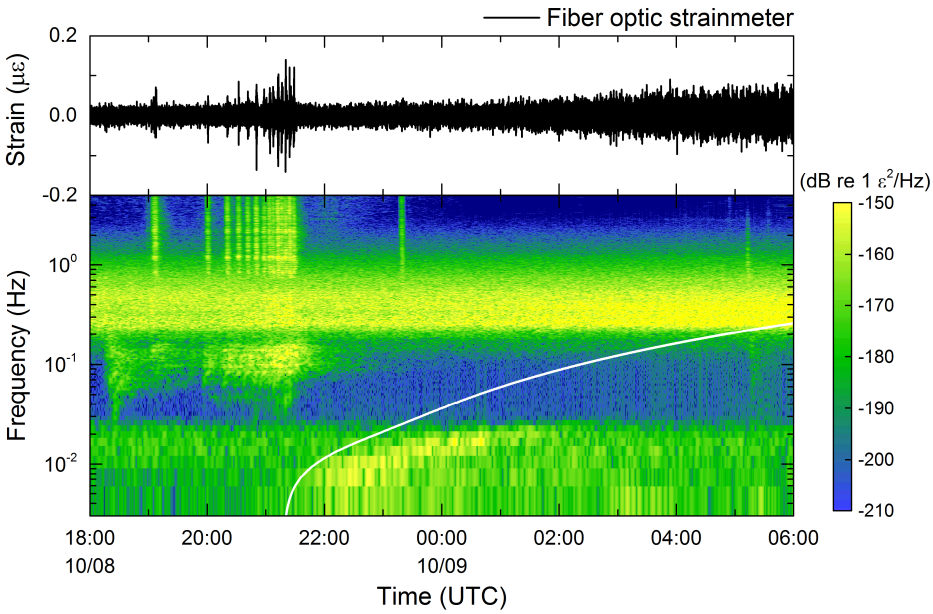

Figure 2. A recording of the fiber optic strainmeter and its spectrogram during a series of submarine earthquakes near Torishima Island. A chirp curve represents the theoretical tsunami arrival time by assuming the origin time is 20:25 UTC.