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A 12-hour-period variation of the ocean sound velocity possibly associated with the M2 internal tide

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Swarm of hydroacoustic waves (T-waves) associated with submarine volcanic activity has often been detected by ocean bottom seismometers (OBS). The Japanese submarine cabled OBS arrays are especially useful to monitor submarine volcanic activities in the Izu-Bonin-Mariana volcanic region. In three months from September to December, 1999, a series of large submarine volcanic events occurred in this region. We analyzed the waveform data recorded on the 3 submarine cabled OBS arrays (off-Boso (owned by JMA), off-Sanriku (owned by ERI, University of Tokyo and Tohoku University) and off-Kushiro (owned by JAMSTEC) which consists of 4OBSs, 3OBSs and 3OBSs, respectively) and the 9-month term broadband OBS array of the Ocean Hemisphere network Project with a few stations deployed near the hypocenters of the swarm.

We linearized the equation of observation to determine the hypocenters of the detected submarine volcanic T-wave events, assuming that the unknown ocean sound velocity is constant. Because the individual waveforms detected in a swarm are very similar to each other in a short time window, we stacked them to improve the signal-to-noise ratio. One of the off-Boso array stations was chosen as a reference, which locates at a depth near the SOFAR channel axis where the sound propagates most efficiently so that a higher signal-to-noise ratio can be anticipated for the record. At this reference station, we selected 40 waveforms with the largest amplitudes from the time series of every hour and stacked them to obtain a reference waveform at every hour. Assuming that the relative arrival time differences among the 40 events are common to all the other stations, the one-hour time window is shifted for each of these stations to obtain the best correlation in waveforms with the reference station. The time shift represents the delay or advance of the T-wave arrival relative to the reference station. We found that this time shift shows a 12-hour-period variation in a consistent way among the stations.

This result suggests that the ocean sound velocity structure has 12-hour-period variation in the channel from the source to the stations. With a special emphasis on the northwestern Pacific the spatial distribution of the global M2 internal tide was calculated using a three-dimensional primitive equation numerical model. The numerical result indicates that energetic M2 internal tides are generated at the depth near the SOFAR channel, a slowest zone in the vertical velocity structure. The excitation of the M2 internal tide is attributable to the amplitude of isopycnal vertical displacement. Since the ocean sound propagates as inner-refracted waves in the SOFAR channel, its speed is sensitive to the velocity structure in this channel, which should vary with the density structure variation associated with the internal tide. We consider that the observed 12-hour-period variation in differential travel time is due to the variation of the density structure in the SOFAR channel associated with the generation of the M2 internal tide.