Estimation of seismic wave velocity of seafloor surface and installation orientation at S-net station based on observed waveform of air gun: Toward sound source localization of large baleen whale

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The vocalization of fin whale, one of the large baleen whales, has been detected with hydrophones and ocean bottom seismometers (OBSs) which are equipped with submarine cabled observatories off Kushiro-Tokachi in Hokkaido, off Sanriku, and off Boso Peninsula (Iwase, 2015). In recent years, a large cabled observatory "S-net"(Seafloor observation network for earthquakes and tsunamis along the Japan Trench), consisting of 150 stations in the vast range from Hokkaido to Chiba in the Pacific Ocean off the east coast of Japan, was deployed by National Research Institute for Earth Science and Disaster Resilience (NIED). The waveform data of the observatory are open to public. Not only for the observation and early detection of earthquakes and tsunamis, “S-net" would expand the capability of the vocalization detection area that had been limited to local to the one in a vast ocean area, It is expected that it will contribute to the elucidation of migratory behaviors of the baleen whales in the West Pacific, which has been a mostly unknown area, especially in the waters of Japan.
Meanwhile, in order to elucidate these behaviors, it is desirable that not only to detect whale vocalization but also to know individual movement based on sound source localization becomes possible. However, unlike earthquakes, the source sound pressure level of the whale vocalization is usually not so large as to be detected at multiple stations constituting the cabled observatory. It is necessary to localize the sound source with waveform data at a single station. As a sound source localization method using a single three component seismometer, there is a method of using the incident angle of the underwater sound at seafloor based on particle motion for the horizontal distance estimation, in addition to the estimation of the azimuth, of sound source. However, the OBS can only observe the apparent emergence angle of the transmitted wave, which is a composite of a pressure wave (P-wave) and a vertical shear wave (SV wave), which are both converted at the seafloor provided that the incidence angle is less than the critical angle. Therefore, the relationship between the incidence angle and the apparent emergence angle depends not only on the difference in P-wave velocity between the water and the sediment of the seafloor surface but also on the S-wave velocity in the sediment. Thus, both the P-wave velocity and the S-wave velocity in the sediment are necessary. In Iwase (2016), the seismic wave velocities in sediment were estimated *in situ* based on the observation of the transmitted wave of an air gun signal, whose sound source location is known, using an OBS at the cabled observatory offshore of Kamaishi in Sanriku which was deployed by Earthquake Research Institute (ERI), the University of Tokyo. Specifically, the seismic velocities were estimated by comparing the apparent emergence angle of the transmitted wave, which was obtained from the observed particle motion, with the theoretical emergence angle based on the Zoeppritz equation assuming plane-wave incidence at fluid-solid boundary.
With regard to S-net, JAMSTEC's research vessel "Kaimei", whose track line data are published on the web, passed through in the vicinity of some stations while oscillating the air gun. The same method in Iwase (2016) is applicable.
This time, the estimated results of seismic wave velocities of seafloor surface and installation orientation at S-net station will be reported based on the open data of NIED and JAMSTEC.

References

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