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GPS/Acoustic seafloor positioning off Kamaishi on the landward slope of the Japan Trench

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The Pacific plate is subducted at the Japan Trench at a fast rate of about 9 cm/y, and interplate earthquakes caused by the plate motion occur episodically at an interval of tens of years. Considering the important results obtained from the GEONET, seafloor geodesy is indispensable. We have started GPS/Acoustic seafloor positioning for direct observation of the seafloor crustal movement in the subduction zone. We developed precision acoustic transponder (PXP) systems under the Ocean Hemisphere Program for precise positioning both at 3 km and 6 km water depths. The deep water system was developed jointly with the Scripps Institution of Oceanography and has been deployed seaward the Japan Trench (280 km from the coast, depth around 5450 m) (Fujimoto et al., 2001, 2002). We deployed 3 PXPs for the medium water depth in 2001 on the landward slope of the Japan Trench off Kamaishi (130km from the coast, depth around 2850m) near the end of the submarine cable for the monitoring of earthquakes and tsunamis.

We developed the acoustic system for the medium water depth on the base of a PXP for horizontal ranging on the seafloor. The system was an analogue system for the reception of a coded acoustic signal. The signal of 10 kHz acoustic waves was coded with the phases of 0 and 180 degrees. We revised the system with digital processing. The signal sent from the surface is recorded with each PXP at a sampling rate of 500 kHz, and is sent back to the sea surface with a fixed delay time. The surface acoustic unit digitized the received signal at 500 kHz, and fixed the reception time based on cross-correlation with the original signal sent to the bottom.

We carried out GPS/A observations twice on board the Iwate-maru (40m, 150 ton) of the Iwate Fishery Technology Center of Iwate Prefecture. We deployed 3 PXPs and roughly located their positions during the first cruise in November 2001. We used a small buoy equipped with 3 GPS antennas, an acoustic transducer, and a motion sensor. The acoustic system worked well with sufficient S/N ratio of signal reception. The distance among the GPS antennas was 1 meter. We used compact marine antennas for kinematic GPS positioning. We realized after the cruise that we could not get precise positions with the marine antennas.

We added extra floatation to the buoy to use GPS antennas for land geodesy. The distance among the antennas remain to be 1 m, because the horizontal dimension of the buoy was limited due to the operation on the Iwate-maru. We carried out the second observation for about 12 hours during a cruise in late June 2002. Although the acoustic system worked well, we found a problem on the kinematic GPS again. The GPS positioning was unstable. The estimated error was 2-3 cm in good conditions, but it was over tens of centimeters occasionally. We estimate that the distance of 1 m among the GPS antennas may be too short, because another buoy with 3 GPS antennas at distance of 2 m has got an excellent result of 2-3 cm accuracy (Miura et al., 2002).