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Monitoring of seismic activity around the source region of the Tohoku-oki earthquake by ocean bottom seismometers

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The 2011 off the Pacific coast of Tohoku earthquake occurred at the plate boundary between the Pacific plate and the landward plate on March 11, 2011, and many aftershocks followed the mainshock. To obtain a precise aftershock distribution is important for understanding of mechanism of the earthquake generation. In order to study the aftershock activity of this event, we carried out extensive sea floor aftershock observation using more than 100 ocean bottom seismometers (OBSs) just after the mainshock. Four days after the mainshock, we started to deploy seventy-two OBSs in the source region. Consequently, we observed the aftershocks at 121 sites including the pre-installed OBS sites in total (1st term). The observation area covered the source region of the mainshock with OBS interval of 25 km. Some OBSs were recovered in late April and deployment of OBSs to the same position were carried out (2nd term). In June, almost of the deployed OBS were recovered and we concentrated observations with OBSs in off-Miyagi and off-Boso regions (3rd term). Observations in both areas were terminated in September 2011. There is a possibility that spatial and temporal changes of seismic activity occur due to the recovery process of plate coupling. To detect spatiotemporal changes of the seismic activity, we deployed 40 long-term OBSs (LT-OBSs), which have observation duration of one year, in the whole source region, and started monitoring of seismic activities in the source region (4th term). In April 2012, other 40 LT-OBSs were deployed in the southernmost source region to increase spatial density of the network. In October and November 2012, all the LT-OBSs on seafloor were recovered, and spatial high dense network by using 40 LT-OBSs was deployed with OBS interval of approximately 20 km in the off-Fukushima region (5th term) in November 2012. After one-year seafloor observation, the network off Fukushima was retrieved. In September 2013, we deployed 30 LT-OBSs in off-Miyagi and off-Iwate regions to monitor seismic activity (6th term). These LT-OBSs were successfully recovered in October in 2014, and we continue seafloor seismic observation in the off-Miyagi region with 18 sites from October 2014.

We selected events whose epicenter is located below the OBS network from the JMA earthquake catalog, and P and S-wave arrival times were picked from the OBS data. Hypocenters were estimated by a maximum-likelihood estimation technique with one dimensional velocity structures. Thickness of sedimentary layer, which changes at each OBS site was evaluated and the estimated travel times by the location program were adjusted. From the observations in the 1st and 2nd terms, a precise aftershock distribution for approximately three months were obtained. The aftershocks form a plane dipping landward in the whole area. Comparing our results to velocity structures by marine seismic surveys, there is no aftershock along the plate boundary in the region off Miyagi, where a large slip during the mainshock is estimated. A plate coupling in this region may change due to occurrence of the mainshock. Activity of aftershocks within the landward plate above the source region is high and many aftershocks within the landward plate have normal fault type or strike-slip type mechanism. Within the subducting oceanic plate, most of earthquakes has normal fault type or strike-slip type mechanism. Using hypocenter distribution by long-term observation from the autumn 2011, we compare locations of the hypocenters with those of the aftershock just after the mainshock. In the aftershock distribution, the low-seismicity region is recognized at the plate boundary in the off-Fukushima region. The long-term observations show the seismicity is not low in the identical region. On the other hand, seismic activity along the plate boundary in off-Miyagi region was still low until the end of the long-term observation carried out from 2011 to 2012.