

Seafloor displacement in the northern Japan Trench examined by bathymetric surveys after the 2011 Tohoku-oki earthquake

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Maximum tsunami height caused by the 11 March 2011 Tohoku-oki earthquake (M_w 9.0) was observed at the coast of Sanriku, the northern Tohoku at ~39.5N [The 2011 Tohoku Earthquake Tsunami Joint Survey Group, 2011]. Therefore, in order to explain the tsunami source, some papers have introduced additional large fault slip of the megathrust up to ~40 m near the Japan Trench [e.g. Satake et al., BSSA 2013]. Alternatively, others preferred to put a large change in seafloor elevation, ~100 m uplift and down-drop, associated with a submarine landslide along the lower trench slope [e.g. Tappin et al., Marine Geology 2014].

After the earthquake, we have carried out multibeam bathymetric surveys in the rupture zone. Survey tracks were aligned along the tracks obtained before the earthquake across the Japan Trench, and we analyzed the difference in bathymetry before and after the earthquake in the area near the trench. For the analysis, apparent offsets of the absolute values of depth soundings and the uncertainty of ship position were examined on the seaward side because the seaward was thought to have suffered little change from the earthquake.

The extraordinary coseismic seafloor displacement caused by the 2011 earthquake was indeed detected by the bathymetric surveys. For the survey track crossing the trench axis at 38.1N, off the coast of Miyagi Tohoku, near the epicenter, there were large relative differences landward extended up to the trench axis, suggesting the earthquake fault rupture reached the trench axis [Fujiwara et al., Science 2011; JpGU 2015; Kodaira et al., Nature Geosci. 2012].

Eventually, we had an opportunity to survey the bathymetry near the Japan Trench off Sanriku between 39.2 and 39.5N by the German research vessel Sonne in 2012 and the last year 2016 (SO219A, SO251A cruises). We acquired two survey tracks. One survey track was on the track of the JAMSTEC R/V Kairei in 2010 (KR10-12 cruise) crossing the trench axis at 39.2N and extending to the landward trench middle slope (~143.5E, 39.3N), ~50 km from the trench axis (SO219A-KR10-12). And the other was on the track of the R/V Kairei KR07-08 cruise in 2007 crossing the trench axis at 39.5N and extending to the landward trench middle slope (~143.5E, 39.4N) (SO251A-KR07-08).

As the result of comparison of the bathymetry before and after the earthquake, horizontal and vertical seafloor displacements were within the error of the analysis because the results may incorporate errors of several meters in vertical displacement and about 20 m in horizontal displacement. Very large fault slip or very large submarine landslide is unlikely at least on the two survey tracks.

Keywords: 2011 Tohoku-oki earthquake, tsunami, Japan Trench, Sanriku, multibeam bathymetry, seafloor displacement