Preliminary numerical study of offshore sediment transport by the tsunami

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Numerous studies of tsunami deposits have been conducted on the plains and lakes along the Pacific coast of Japan, and the tsunami histories during the past several thousand years have been reconstructed in various places (e.g., Sawai et al., 2008, 2009). Although these studies were mainly conducted on land, most of the tsunami deposits at the geological era are reported in the marine deposits (Fujino et al., 2006). However, there are few researches on offshore tsunami deposits so that little has been understood on characteristics, identification criteria and sedimentation process of offshore tsunami deposits. It is thus important to study recent offshore tsunami deposits as modern analogue.
Regarding to the 2011 Tohoku-oki tsunami, Tamura et al. (2015) and Yoshikawa et al. (2015) reported offshore tsunami deposits shallower than 30 m in depth in the Sendai Bay. According to them, offshore tsunami deposits were transported from the beach by backwash and the thickness became thinner toward the offshore. On the other hand, deposition of turbidites triggered by the earthquake and tsunami are reported on the sea floor deeper than 100 m in depth (Arai et al., 2013; Ikehara et al., 2014; Usami et al., 2016).In this way, erosion and deposition by the 2011 Tohoku-oki tsunami have been reported in a wide area ranging from the shallow to deep sea along the Japan Trench. However, conventional studies quantitatively evaluating the sediment transport process have focused on only in the shallow sea (Yamashita et al., 2016), not whole the shallow to deep sea.
Herein, we examine offshore sedimentation and erosion based on the numerical modeling for sediment transport by the tsunami in the Sendai Bay. The calculation was carried out with TUNAMI-STM model (Yamashita et al., 2016) which combines a sediment transport model with a numerical model by the finite-difference method of nonlinear long-wave theory. In this time, the behavior of sediment of 4 sizes (very fine, fine, medium, and coarse sands) was simulated in consideration of tsunami deposit and bottom sediment reported in Sendai bay.
As a result of calculation of very fine sand condition, bottom sediments in the wide area were suspended by the first run-up wave. However, the suspended sediments continued to have been moved landward and seaward both by run-up waves and backwashes. Consequently, sediments were not moved significantly from the original areas. In case of fine and medium sand conditions, coastal sediments were transported toward the shallow sea by backwash. Namely, sediments can be transported seaward by backwash up to 30 m under the fine sand condition. In case of coarse sand condition, sediment were not moved at the depth where coarse sand is actually distributed in the Sendai Bay.

Keywords: tsunami deposit, Tohoku-oki tsunami, numerical simulation, sediment transport

