Analysis of eddy fields for the vessel evacuation from the giant tsunami

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The Japanese government reported that Nankai Trough Earthquake will occur about 70 % of probability within 30 years in the future and drive the giant tsunami. The speed of the tsunami plus the tidal currents may exceed 2 knot (approximately 1 m/s) at many ports in the Japanese coasts facing to Pacific. Not only this speed but also eddies generated around the nearshore seas can make difficult to operate the marine vehicles and escape from the port that the tsunami attacks according to the evacuation scenarios for ships. The number of commercial vessels present in Osaka Bay was counted using the entry record of vessels and is approximately 100 vessels throughout the year. The ports of Sakai-Senboku, Osaka and Kobe located in the bay head are rank as international hub ports. Various vessels, oil tankers, LNG (liquefied natural gas) carriers, bulk carriers, and PCC (pure car carriers) enter the port of Sakai-Senboku to transport to petrochemical complexes. The influence of eddies should be considered when planning the vessel evacuation manual. This study clarified the characteristics of eddies in Osaka Bay generated by the giant tsunami caused by the Nankai Trough Earthquake, and the influence on vessel evacuation was discussed, especially for the port of Sakai-Senboku, which plays the role of an important lifeline.
We conducted the tsunami simulation with a horizontal resolution of 50 m by employing the nesting method to represent the complex coastal lines around the landfills along the bay coast in Osaka Bay. We used the shallow water equation model with the time step 0.5 seconds to predict the tsunami speed and height during the period from the earthquake occurrence to 600 minutes.
The simulated results showed that the spatial characteristics of eddies generated by the tsunamigenic earthquake around the Port of Sakai Senboku ranged in 900-2500 m during 600 minutes after the earthquake, indicating several times the length of a vessel. The location of eddies are largely fixed. The location of vessels recorded by AIS (Automatic Identification System) from September 1st to 8th, 2012 indicated the major fairways that most vessels enter at the hub ports. The strong eddies were generated in these fairways in the hub port. In particular, the eddies with the more than 2 knot were found in the entrance of the hub port. The vorticity generated in the entrance of the port of Sakai-Senboku can prevent stable navigation. The area-averaged vorticity around the ports increased from 80 minutes after the earthquake and gradually decreased from the approach of the second wave of tsunami, indicating the eddies remained in the port after the leading wave of the tsunami. This suggested that the vessels in the port must pass the entrance until 80 minutes to evacuate outside of the port.

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