Short to long term morphological changes and migration of sand waves in a semi-enclosed sea: a case study in Okinose area of Osaka Bay

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Sand waves are small-scaled topography of unconsolidated sand particles on seafloor or river bottom formed by water flow, and of wavelengths from a few meters to several hundreds of meters. Because of morphological changes and migration of sand waves by water flow, repeated surveys are required to observe short to long term behavior of sand waves. In the areas where oceanic current is dominant, sand waves migrate along the direction of oceanic current. In contrast, in the areas where tidal current is dominant, it is not easy to detect the relationship between morphological changes/migration of sand waves and the water flow near the seafloor, because velocity and direction of the water flow near the seafloor change gradually and complicatedly in the natural condition (Xu et al., 2008). In recent years, oceanic modeling system have been developed significantly and the water flow has been simulated with fine grid spacing for a long time and over a wide area especially in the case that the water flow into and out of the survey area is restricted such as bays (Uchiyama et al., 2018). Osaka Bay, where tidal current is dominant, has shallow eastern area (5-20 m in depth) and deep western area (20-70 m). A submarine dune is found in Okinose area apart from ~12 km southeast of the Akashi Strait, where the water depth is 25-45 m and shallower than the surrounding area (Yashima, 1992). On the sand dune of Okinose, sand waves with a wavelength of 20-100 m has been observed. In this study, focusing on the sand waves in Okinose as a model case where tidal current was dominant, we combined multiple topographic surveys with numerical simulations of the water flow near the seafloor to elucidate short to long term morphological changes and migration of the sand waves formed in a semi-enclosed sea and to discuss the mechanism.

Multiple surveys for submarine topography were conducted from September 2017 to October 2019 with the training ship Fukae Maru (Graduate School of Maritime Sciences, Kobe University) using MBES (Multi-Narrow Beam Echo Sounder), CTD (Conductivity Temperature Depth profiler) and a grab type mud sampler. The water flow near the sea floor in Osaka Bay was numerically simulated using the multi-nested high-resolution 3-D circulation-dispersal model developed by Uchiyama et al., (2018).

The distribution of the sand waves on the sand dune of Okinose shows that the crest lines of the sand waves extend from west-northwest (WNW) to east-southeast (ESE). Ikehara (1996) suggested that crest lines of sand waves were perpendicular to the water flow in the case that the current directions at the maximum flood tide and ebb tide are 180 degrees opposite. The numerical simulations of the water flow near the seafloor show that the current direction at the maximum flood tide is north-northwest (NNW) and the current direction at the maximum ebb tide is south-southeast (SSE) in the northwestern part of Okinose. It means that the crest line orientation of the sand waves was not perpendicular to the current directions at the maximum flood tide and ebb tide. Considering the average size (~0.65 mm) of the particles obtained from the sand sample and the water depth in the northwestern part of Okinose (25-45

m), water flow velocity to change sand waves morphologically is estimated to be at least 0.1 m/s (Rubin & McCulloch, 1980). By averaging the velocity through high pass filtering at 0.1 m/s, the direction of the mean velocity was south-southwest (SSW) and perpendicular to crest lines of the sand waves. Therefore, we conclude that in the area where the currents at the maximum flood and ebb tides are not 180 degrees opposite, short to long term morphological changes and migration of the sand waves reflect the temporally-averaged tidal currents over the critical velocity for sediment movement. In the presentation, we will discuss them together with observation of short-term morphological changes of the sand waves other than crest lines within two years.

Keywords: sand wave, Osaka Bay, morphological changes

