Seismicity in shallow part of Hyuga-nada subduction zone by ocean bottom seismometer from 2015 to 2022

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The Nankai Trough extends from Suruga Bay off the coast of Shizuoka Prefecture in the north to the offshore area of Miyazaki Prefecture in Kyushu in the south. It lies at the plate boundary where the Philippine Sea Plate subducts beneath the landward plate in a northwestward direction. Due to this tectonic setting, this area is known for catastrophic earthquakes occurred repeatedly. Although Hyuga-nada is situated on the southwestern side of the Nankai Trough, there is no historical record of earthquakes with a magnitude of 8 or above. Additionally, the region frequently experiences slow earthquakes, such activities are believed to occur frequently at the plate boundary in the Nankai Trough region according to previous studies. Therefore, research on slow earthquakes in the study area is also beneficial for understanding the stress conditions of the plates. This research emphasizes the precise localization of regular seismic events and integrates it with an analysis of slow earthquake activities to provide a comprehensive discussion, aiming to deepen the understanding of seismic characteristics in the region. To monitor seismic activities consistently over approximately a year, marine seismic networks composed of pop-up-type Long-Term Ocean Bottom Seismometers (LT-OBS) were deployed in the Hyuga-nada segment. The LT-OBSs captured continuous waveform data, with event times sourced from the JMA catalog used for detecting seismic events. Waveforms were displayed based on these event times, followed by manual analysis to determine P-wave and S-wave arrival times, maximum amplitude, and first arrival polarity (Urabe and Tsukada, 1991). Additionally, P-waves converted from S-waves at velocity discontinuities between sediment layers and the igneous crust were used to adjust travel times considering structural heterogeneity.The initial event locations were determined using the Hirata and Matsuura method (1987) with one-dimensional velocity structure modified from Yamamoto et al. (2020). The difference in travel times between S-waves and converted P-waves from S-waves provided station corrections to refine event locations. Average differences between observed and calculated travel times were computed for each station and were applied to estimate station corrections. This process was repeated iteratively 10 times to achieve more accurate hypocenters. Subsequently, the events were relocated using the Double-Difference seismic tomography method (tomoDD-SE, Zhang and Thurber, 2003, 2006) with both absolute and relative arrival times. This method calculates travel times using a pseudo-bending ray tracing algorithm (Um and Thurber, 1987) and employed a three-dimensional velocity structure model based on Nakanishi et al. (2018). After relocation with tomoDD-SE, focal solutions were estimated using first-motion data of P-waves. Outputs of tomoDD-SE included calculated takeoff and azimuthal angles to each station, which were essential for determining fault plane solutions using the Hardebeck and Shearer method (2002). This program is based on a grid search method. Finally, the Frohlich method (1992, 2001) was applied to classify earthquake source mechanisms based on the dip angles of the pressure, tension and null axes. This classification divided the events into pure thrust-fault (vertical T-axis), normal-fault (vertical P-axis), and strike-slip (vertical B-axis) types based on their focal solutions.The results indicated that seismic events were uniformly distributed within the network in both spatial and temporal domains, except for earthquake swarms. The JMA catalog suggested earthquake swarms as numerous earthquakes occurring within a short time frame: from December 18th to 23rd in 2017 and January 10th to 18th in 2018. We identified many earthquakes occurred in narrow

region and most events had depths ranging between 10 and 20 km. While focal mechanism solutions revealed various source mechanisms in the study region, strike-slip fault and/or normal fault types were the most prevalent. The relocated events were notably deeper than the plate boundary, indicates that most earthquakes in the study region occurred within the subducting Philippine Sea plate.