Spatially varying seismicity distribution in the Tonankai-Nankai regions revealed by repeating long-term ocean bottom observations

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Large earthquakes with magnitudes greater than 8 repeatedly occur at a constant recurrence interval of ˜100 years along the Nankai Trough. Distribution of seismicity and its dependency on structural variations in the crust are key factors for long-term evaluation on probabilities of large earthquakes. However, it is difficult to monitor offshore microearthquake activity and to precisely locate hypocenters by the on-land seismic network. In order to overcome such difficulties, we conducted repeating seismic observations over expected focal regions of forthcoming large earthquakes along the Nankai Trough using long-term ocean bottom seismometers (LTOBS).

We started a series of long-term observations by deploying 9 LTOBSs in 2003 off Cape Shionomisaki around the fault boundary between the Tonankai and Nankai earthquakes. Spatial intervals between LTOBS stations were ˜20 km. We expanded the network by adding 14 stations in 2004 to cover a region from the west of Kumanonada to the southeast of the Shikoku Island. The observation continued until mid June of 2006 with the same network configuration, while we once made replacements of the instruments in 2005. The seismicity off southeast of the Kii Peninsula was found very low. Therefore, we shifted the network to southwest to cover the eastern half of the source region of the Nankai earthquake with additional 2 stations near the trough axis, thus totaling 25 stations. As we found the seismicity near the trough axis off Cape Shionomisak fairly active, we expanded the network further offshore by adding 2 new stations over the trough axis in 2006. We completed the series of observations by recovering 27 LTOBSs in December, 2007.

Seismic events were extracted either by referring to the JMA catalogue, or by visually identifying smaller events. Waveform data from the land stations of the catalogued large events were merged to the OBS data. P and S arrival times were manually picked for all events using the WIN system. The number of observed earthquakes from the JMA catalogue is 7116, and that of small earthquakes is 20756.

The crustal structure along the Nankai Trough has been known to be largely heterogeneous. We grouped the earthquakes by their initial epicenters into spatial subsets defined by a circle of a diameter of 30 km centered at each station, while earthquakes were allowed to belong to multiple subsets. We then iteratively applied a hypocenter determination method, a modified version of HYPOMH, that allows varying 1D structures at different stations. At each iteration, the amount of a station correction at each station for each subset of earthquakes was statistically revised to minimize the travel-time residuals, so that such a correction represents both structural deviation from the 1D structure and a correction for the sedimentary layer at each station for the subset of earthquakes. The number of earthquakes within the entire range becomes 2328 as to the catalogued and 4690 as to the small earthquakes. We chose earthquakes with a well determined hypocenter whose spatial determination error is less than 5 km. The final numbers of the catalogued events and the small earthquakes are 1876 and 2849, respectively.

Resulted earthquake distribution shows large heterogeneity. Seismicity in the Tonankai region appears very low, whereas seismicity to the west of the Cape Shinomisaki in the Nankai region is high. The clear seismicity boundary between these regions appears coincident with the fault boundary between the Tonankai and Nankai earthquakes. The seismicity off the Cape Shinonomisaki continues offshore toward the trough axis within a band of a ˜30 km width, and is concentrated near the plate interface. Seismic activity to the west of the band off the Kii Channel occurs in the upper mantle of the subducting oceanic plate. Its activity is low within a ˜60 km range landward from the trough axis. The boundaries between these regions appear sharp and normal to the trough axis.