論 文 の 要 旨

題 目　　Investigating tidal evolution and tide–river runoff interactions in a two-inlet lagoon and multi-channel estuary

（2 つの入口を持つラグーンとマルチチャネル河口における潮汐進化および潮汐と河川流出の相互作用に関する調査研究）

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Understanding hydrodynamics induced by an interaction between tide and river flow is essential to continuously improve the management of delta and estuarine systems. The investigation of the interaction between tides and river flow could also enhance our understanding of the alteration process of the environment in tidal rivers. This research investigates the spatiotemporal tidal dynamics in various setting topography, aiming to understand the evolution of tidal waves in single-channel, multi-channel and multi-inlet lagoons. The work was divided into two main projects that worked in two site locations: the Segara Anakan Lagoon and the Ota River Estuary.

The first work aims to investigate the tidal dynamics in Segara Anakan Lagoon, which can be the main factor that leads to sedimentation patterns. The Segara Anakan Lagoon (SAL) is a two-inlet lagoon with a high sedimentation rate in the western part. The two-dimensional hydrodynamic model was used to investigate the tidal dynamics. Spatial computation of tidal duration asymmetry, peak discharge asymmetry, and slack water asymmetry are used to identify the tidal dynamics characteristics of the SAL. The model results show that tidal wave propagates to the lagoon from both inlets and amasses in the central part of the lagoon. Analysis of the tidal asymmetry shows that the tidal duration and slack water asymmetry are ebb dominance in both inlets, while the peak discharge is ebb dominance in the western lagoon and flood dominance in the eastern lagoon. However, the tidal duration, peak discharge, and slack water asymmetry show flood dominance in amassing areas. The convergence of tidal waves in the central part of the lagoon results in abrupt changes in the tidal range and near-zero discharge in the amassing area. Moreover, the tidal asymmetry pattern might have implications for the sedimentation pattern in SAL.

The second work aims to investigate the tidal evolution in a multi-channel estuary, in this case, the Ota River Estuary. The Ota River estuary has a straight channel, the Ota diversion channel (ODC), and a branching channel. This study examines tidal distortion, tidal asymmetry, and subtidal water elevation variations in two topographical settings, straight and branching channels, under low-flow conditions. The ratio of the amplitudes of the quarter-diurnal and semidiurnal tidal species shows that the tidal distortions in the straight and branching channels are similar. The skewness of the tidal duration shows a tendency to be flood-dominant in both topographical settings. However, the increase in tidal asymmetry on the branching channel is steeper than that on the straight channel. In addition, changes in bathymetry and channel width also contribute to

the steep increase in tidal asymmetry in branching channels. Moreover, the variation in the subtidal water elevation analysed using the decomposition of the subtidal friction term shows that the variation is more influenced by the interaction of the tides and tidal asymmetry in the junction area. In contrast, the variation is more affected by the subtidal flow in the straight channel. Moreover, the interaction between tides and river runoff in the straight ODC shows that the mixing was controlled by neap–spring tidal oscillation; high discharges significantly influence mixing during the neap tide. Furthermore, the results of the wavelet transform indicates that during the spring, tidal straining increases and induces intense mixing, while during the neap, river discharge has a more significant influence on circulation. The interactions between tides and river runoff influence the appearance of a convergence zone and estuarine turbidity maxima that are located approximately 4.8 km from the river mouth.

The tidal evolution mechanism in a branching channel is examined using a barotropic hydrodynamic model in an idealized junction domain, inspired by the Ota River Estuary junction. Even though the model was simplified, it successfully reproduced the increase in nonlinearity at the junction apex. A sensitivity analysis of tidal nonlinearity to the width of the upstream channel at the junction was performed by varying the upstream channel width from the same width as the branch channel width to three times the branch channel width. The relationship between the upstream channel width at the diversion point and tidal nonlinearity was not linear, whereas tidal nonlinearity was maximized when the width was twice the branch channel width. The convergence of the tides in the narrow junction induces an increase of M4 tidal constituent that raises the tidal nonlinearity, while in the case of a wider channel, which the wide of the upstream channel is more than twice of the branches channel, the river runoff dampens the M2 and M4 tidal constituents that lead to decrease tidal nonlinearity.