論文の要旨

題目　Investigating hydrodynamics of an artificial estuarine channel that is affected by a flood control structure

（洪水制御構造物の影響を受けた人工感潮水路の流体力学に関する調査研究）

GILLANG NOOR NUGRAHANING GUSTI

Human activities have grown gradually over decades to become the major force that modify all aspects of nature, including the interaction of river and tides in estuaries. The understanding of basic knowledge about circulation and mixing in estuaries are necessary to optimize the management strategy and long-term vision on developing and managing these unique environments. This dissertation investigates the spatiotemporal variations in estuarine circulation and subtidal dynamics to present deeper understanding on how human intervention, particularly in an artificial estuarine channel, known as the Ota Diversion Channel, affects the estuarine hydrodynamics. This work is divided into three themes: (i) the influences of a flood control structure on lateral flow dynamics, (ii) the intrinsic mechanisms of estuarine circulation due to the longitudinal variation of channel geometry, and (iii) the effects of regulated freshwater discharge on subtidal dynamics.

The purpose of the first theme is to investigate the lateral circulation that is affected by a flood control structure in an estuarine channel. In this study, a numerical simulation was utilized to simulate secondary flow and salinity structure in the Ota Diversion Channel. The simulation is distinguished into two different scenarios based on the existence of a flood gate. The simulations' results yield that the existence of a flood gate indeed affects the secondary flow structure. The gate gives resistance to water flow, thus limiting the streamwise velocity. This limitation induces a smaller centrifugal force, which results in the dominance of the barotropic pressure gradient and baroclinic pressure gradient over other terms. The interaction between these two terms generates a strong secondary flow in the meandering section of the Ota Diversion Channel.

The second theme aims to offer a comprehensive understanding of the dynamics of a tidal river with longitudinally varying channel geometry. To accomplish the aforementioned aims, this work provides a spatiotemporal analysis of water current and density for a fortnight period of a mesotidal estuarine channel that encompasses both curved and straight channels in the streamwise direction. Moreover, a quantitative analysis of the governing mechanisms for estuarine dynamics is performed to determine the alteration of driving mechanisms due to channel geometry variation. The longitudinal velocity profile indicates the existence of tidal asymmetry where the ebb currents are dominant over flood currents. The asymmetry, which is induced by the interaction between the channel curvature and density gradient, is observed to be more enhanced in the curved channel than in the straight channel. Moreover, the across-channel bathymetry difference between the curved and straight channels leads to different patterns of lateral flow in those channels. Additionally, the longitudinal and lateral velocities averaged for the spring/neap tides reveal that the channel with a higher curvature degree has greater residual circulation. On the other hand, the

periodically varying density distribution denotes the existence of tidal straining, which is slightly modified by the variation in geometry. The notable findings of this study are as follows: (i) the variability in channel geometries introduces different responses of tidal straining and tidal stirring; (ii) the river effect (river-induced shear) in the curved channel substantially increases significantly compared to the straight channel over a certain threshold of river runoff. It is believed that the findings of this study deepen our understanding of tidal river dynamics in a longitudinally varying channel geometry.

The aim of the third work is to examine the spatial and temporal behaviors of subtidal friction and water flux in a tidal river channel with limited river runoff. This study utilized the frequency domain and theoretical decomposition analyses to determine the dominant tidal and subtidal mechanisms. Frequency domain analysis indicated the dominance of semidiurnal and diurnal tides in the observed tidal river channel. The rate of energy transfer owing to shallow water interaction is found to be stronger for the current velocity than for the water elevation. Decomposition analysis shows that subtidal friction and flux in a low-discharge tidal river channel are largely influenced by subtidal flow-induced subtidal friction and Eulerian return flux, respectively. The key findings of this study are as follows: (i) the limited amount of river runoff (4–20 m^3/s) leads to the vertical variability of subtidal friction contributions from subtidal flow and subtidal-tidal interaction, as well as Eulerian return flux, and (ii) the vertical variability of the aforementioned terms can be associated with the existence of influential longitudinal subtidal density gradients along the tidal river. This work advances the understanding of subtidal dynamics in tidal river systems, particularly those with limited discharge.