THE EFFECT OF SANDBAR ON THE SALINITY INTRUSION IN A MICROTIDAL ESTUARY

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1. INTRODUCTION

Sandbars are valuable morphological features in estuaries. They are formed by the combined effect of tides, river flow and ocean waves. Sandbars are composed of sand, gravel, and fine sediment, and usually occur at the river mouth for bar-built and tide-dominated estuaries. The sandbar could also obstruct the river flow, navigation, and flood discharge while also being affected by human intervention activities such as dredging and land reclamation. Formation of sandbar is well documented, however, the effect of sandbar on the saltwater intrusion and ecosystem in small sized estuaries are rarely studied. Therefore, this study aims to understand how the sandbar formation will affect the salinity intrusion features in the shallow Shimoyama River estuary, Japan. Further, this study can fundamentally support the existing studies on fish habitats in the Shimoyama River estuary to identify the influencing factors on estuarine fish species.

2. RESEARCH METHODOLOGY

The study area is the Shimoyama River estuary located in Hayama, Kanagawa, a Class B river with a total length of 7.4 km and a catchment area of 10.4 km^2. **Fig.1** shows the points of observation along the river length. The vertical profile of salinity was collected from the river mouth to 800m upstream for three days (neap, intermediate, and spring tides) in October-November 2022 using AAQ Rinko water quality profiler. Water level and salinity were continuously monitored using HOBO U20 water level logger and DEFI2-CT conductivity and temperature recorder, respectively and placed at the bottom of 320m and 745m stations. Further, a topographic survey with 5m interval was conducted on the sandbar located at the river mouth. To understand the feature of salinity in the estuary, salinity intrusion length, SIL - distance from the river mouth to upstream where salinity is 1 at the bottom, and salinity interface gradient, SIG - slope of 10 isohaline, were calculated.

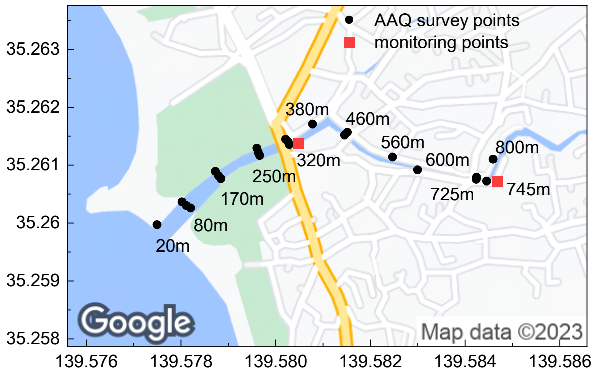

Fig. 1. Map of the study area - Shimoyama River estuary

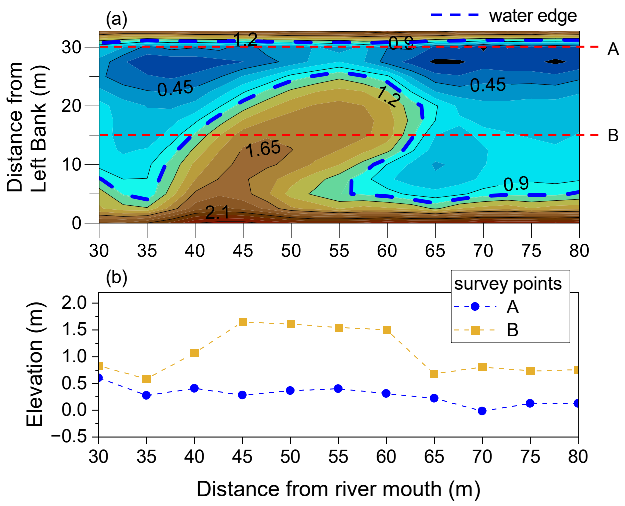

Fig. 2. (a) Sandbar topographic map and (b) Measured elevation of sandbar at 15m [A] and 30m [B] from left bank

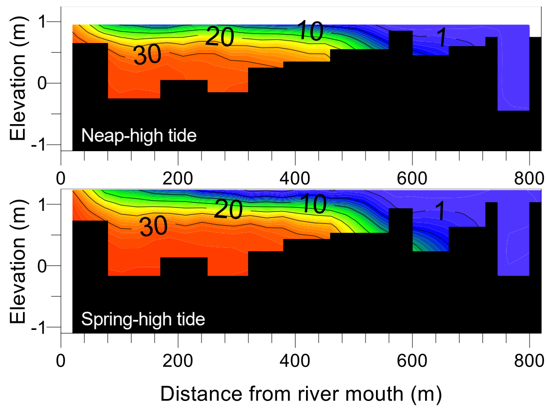

Fig. 3. Longitudinal distribution of salinity on neap-high (top) and spring-high (bottom) tides

Keywords: sandbar, salinity intrusion, mixing, neap-spring, microtidal estuary
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3. FIELD DATA ANALYSIS

When facing downstream, the left bank has a higher elevation due to the sandbar compared to the right bank (**Fig.2a**). At a distance of 15m from the left bank, the mound created by the sandbar was prominent (**Fig.2b**). The width of the channel is 32m but water can only pass through 7m . The longitudinal salinity distribution of the estuary (**Fig.3**) shows that salinity during high tide ranged from 0 to 34. During neap and spring tide, the river was in a partially mixed state where saltwater and freshwater mix at all depths with greater salinity around the river mouth and in the lower layers. Calculations of SIL (**Fig.4b**) and SIG showed that saltwater can reach up to 700m and the river was generally partially mixed (PM), developing definite salt wedge (SW) only on low tide of spring tide. It was during intermediate tide that it was close to being well-mixed (WM) (**Fig.4c**). Studies of other estuaries show the varying mixing conditions on the neap-spring transition (**Table.1**). The stability of the mixing condition of Shimoyama River can be attributed to its shorter length and lower tidal range.

4. EFFECT OF SANDBAR ON THE ESTUARY

No rainfall was recorded during the days of the observation. The water level 745m was constant (**Fig.5a**) and salinity was stable at 0.2 (**Fig.5b**). At 320m, salinity fluctuated from 0 to 31 then reached consistently high levels ranging from 23 to 32 from Nov 9 (**Fig.5d**). The water level was also fluctuating but the amplitude was limited for the daily lowest water level as it gradually increased from 0.38m on Oct 31 to 0.63m on Nov 12 (**Fig.5c**).

Saltwater and freshwater create two layers in the river channel with the denser saltwater at the bottom. When saltwater layer is thin, the sensor placed at the bottom detects freshwater only at low tide. However, it will indicate high salinity continuously if the thickness of the saltwater layer gradually increases due to the accumulation of saltwater. The increase of water level during low tide showed accumulation of saltwater which has been overlooked in fish ecology and sandbar studies caused by the sandbar at the river mouth as it blocks the saltwater that entered at the flood tide from escaping with the ebb tide. Accumulation continued in the subsequent intermediate and neap tide. Therefore, the sandbar at the mouth of Shimoyama River has significant influence on the behavior of saltwater and freshwater in addition to estuary length and tidal range.

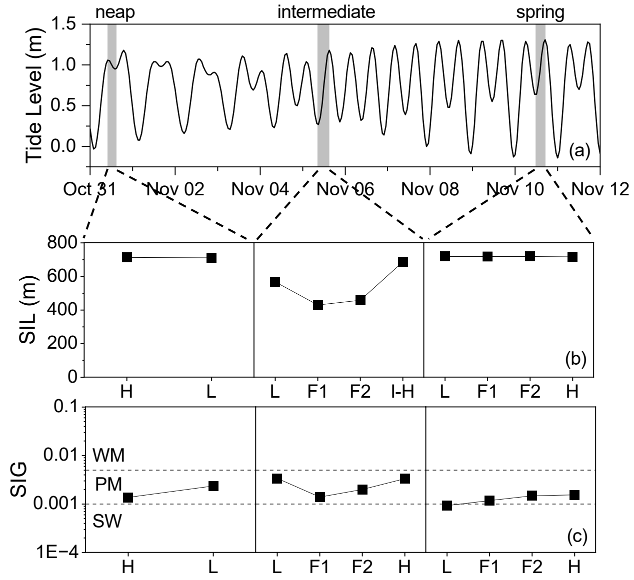

Fig. 4. (a) Tide level at time of observation and calculated (b) SIL and (c) SIG of the tidal events (L-low, F-flood, H-high)

Table. 1. Estuarine information

Name	Total Length (km) / Estuary Length (km)	Tidal Range (m)	Mixing Condition (neap to spring)
Shimoyama River, Japan	7.4 / 0.7	0.9 – 1.6	partially-mixed to partially-mixed
Chikugo River, Japan	143.0 / 23.0	1.5 – 5.0	stratified to well-mixed
Tanintharyi River, Myanmar	400.0 / 45.0	1.3 – 5.9	stratified to partially-mixed/well-mixed

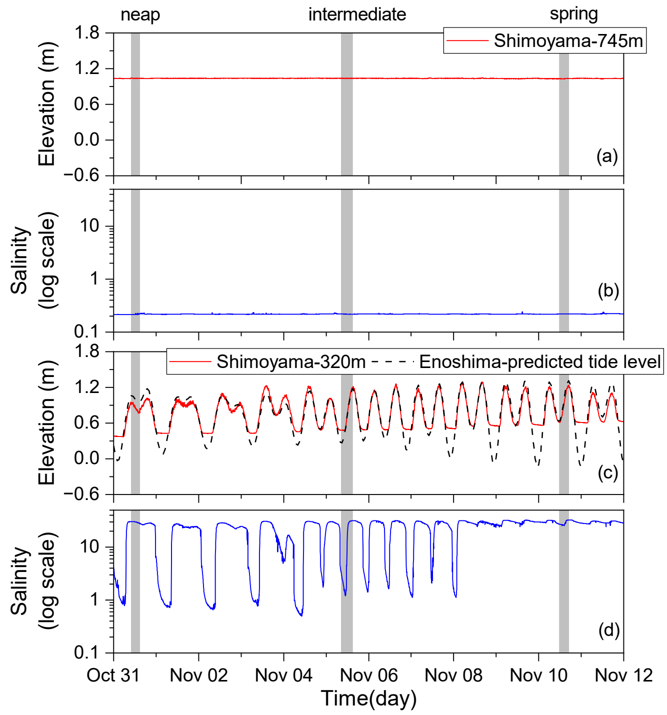

Fig. 5. Monitoring of water level and bottom salinity (a) 745m-water level, (b) 745m-salinity, (c) 320m-water level, (d) 320m-salinity