Analysis of sediment redistribution mechanisms due to flood generation by Tidal Power Plant

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1 Introduction

- The operation of the **Tidal Power Plant** (TPP) has a **major influence on coastal sediment dynamics** around the discharge channel
- Previous studies have provided limited analysis of sediment supply and redistribution patterns caused by the discharge from Lake Sihwa TPP
- This study evaluates the impact of **TPP discharge on sediment transport and sediment budget changes**

2 Methodology

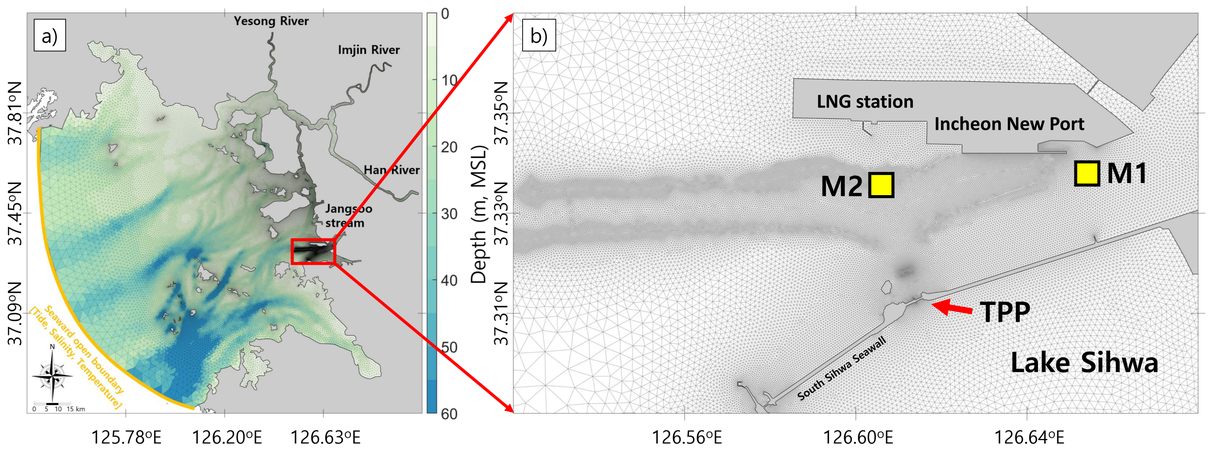


Figure 1. (a) Bathymetry and model domain of the Gyeonggi Bay. (b) High-resolution model applied to the Incheon New Port area, showing the locations of two mooring observation stations (M1 and M2). Station M1 data was collected for 2023.03.14–2023.04.19, and station M2 data was collected for 2023.08.01–2023.09.20.

- **Model setup**

Open boundary condition	Tidal components	M_2, S_2, K_1, O_1, N_2
	Salinity	32 psu
Atmospheric forcing	Wind	LDAPS, SWAN
	Heat flux	ERA5
River discharge		Han River, Imjin River, Yesong River

M : model data
O : observation data
$\bar{O}$ *: time averaged observation data*

- **Sediment transport**

$$F = \int u_n \cdot dA \cdot SSC$$

- **Skill score**

$$Skill = 1 - \frac{\sum (M_n - O_n)^2}{\sum (|M_n - \bar{O}| + |O_n - \bar{O}|)^2}$$

3 Model assessment

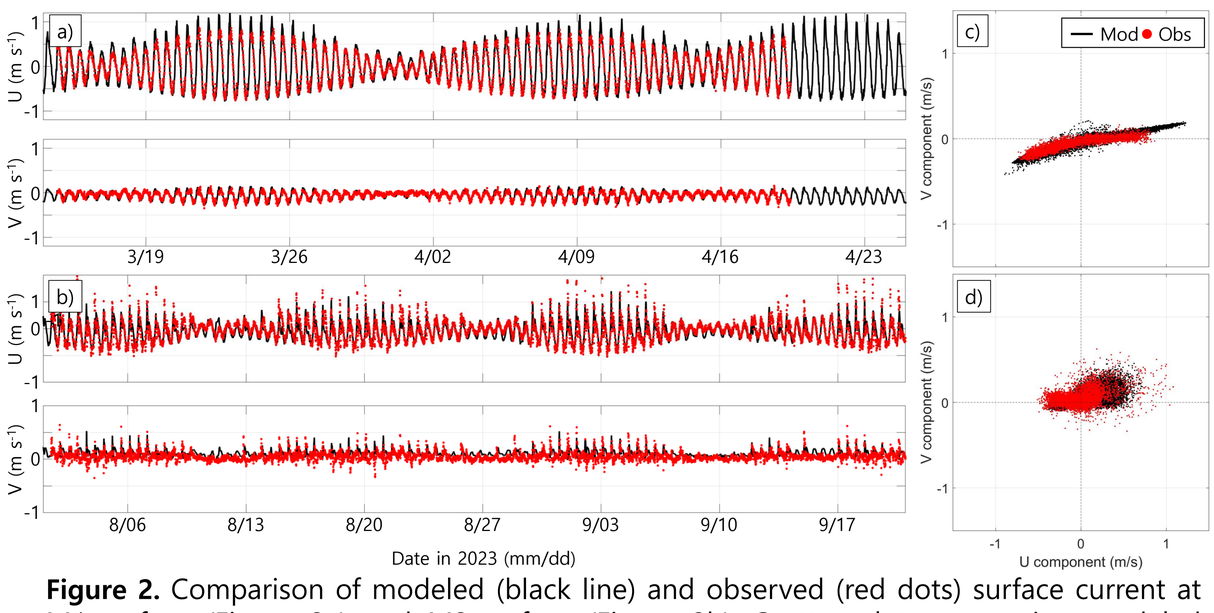


Figure 2. Comparison of modeled (black line) and observed (red dots) surface current at M1_surface (Figure 2a) and M2_surface (Figure 2b). Scatter plots comparing modeled and observed current velocities are shown in Figures 2c and d.

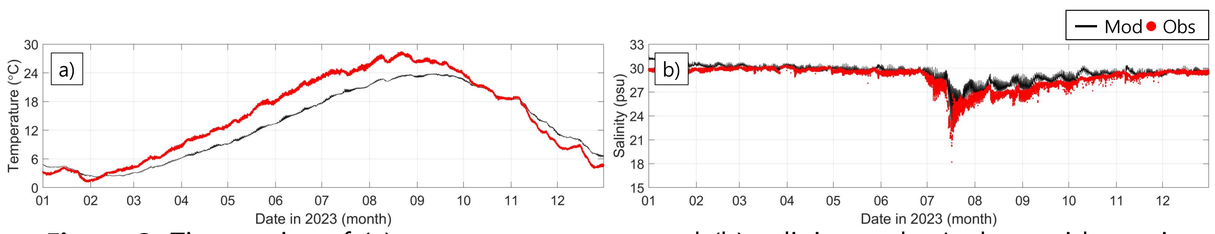


Figure 3. Time series of (a) water temperature and (b) salinity at the Incheon tide station in 2023, with model results (black lines) and observations (red dots).

Table 1. Model assessment

Variables	Station	Location	Validation periods	Skill
Along-channel velocity (m/s)	M1_surface	37° 20'26.02"N 126° 39'26.93"	2023.03.15 – 2023.04.19	0.97
	M2_surface	37° 20'15.99"N 126° 36'47.41"E	2023.08.01 – 2023.09.19	0.80
Temperature (°C)	Incheon tide station	37° 27'7.00"N 126° 35'32.00"E	2023.01.01 – 2023.12.31	0.96
Salinity				0.87

4 Results

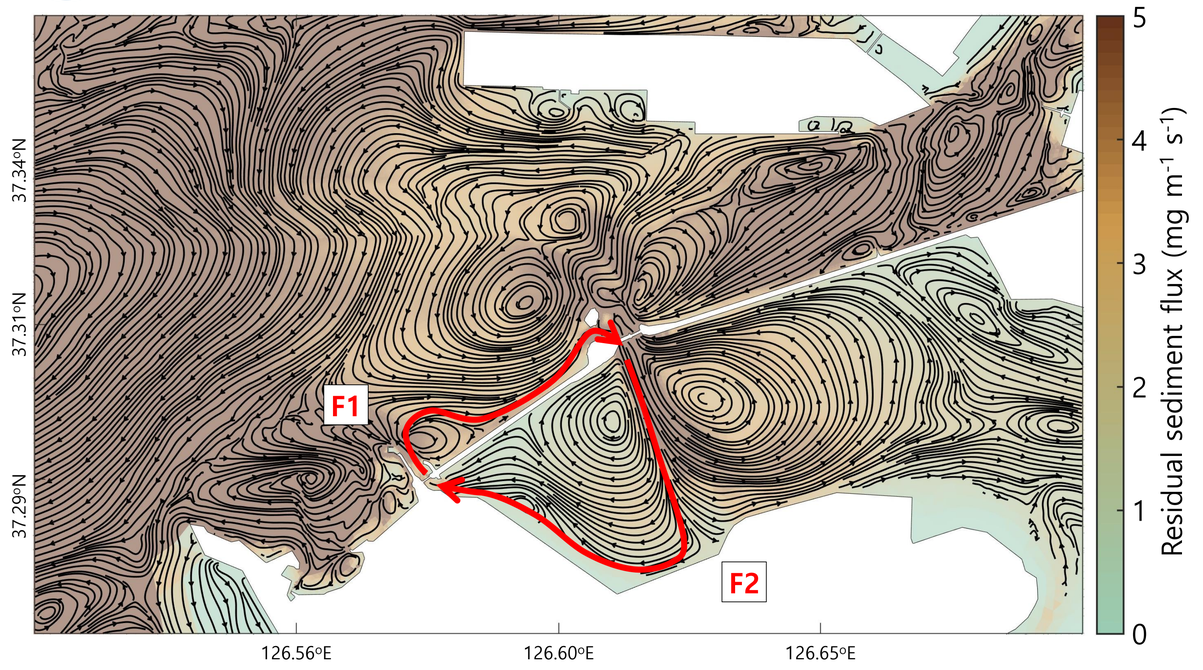


Figure 4. Depth-averaged and 7-month mean residual sediment transport near Lake Sihwa, starting from January 1, 2023. The seawater enters through the TPP due to power generation (F1). The seawater in Lake Sihwa is discharged through the sluice gates, establishing a circulation pattern.

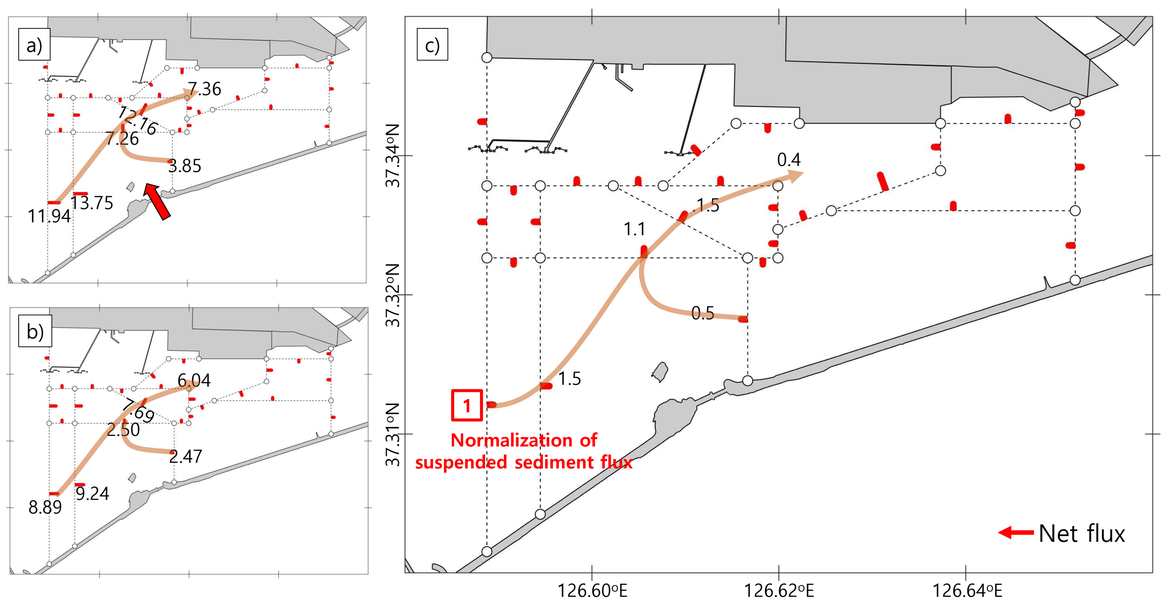


Figure 5. (a) Suspended sediment flux balance (kg/s) with TPP operation and (b) without TPP. (c) Difference of sediment fluxes between (a) and (b). Flux values are normalized at the lower-left cross-section.

5 Discussion

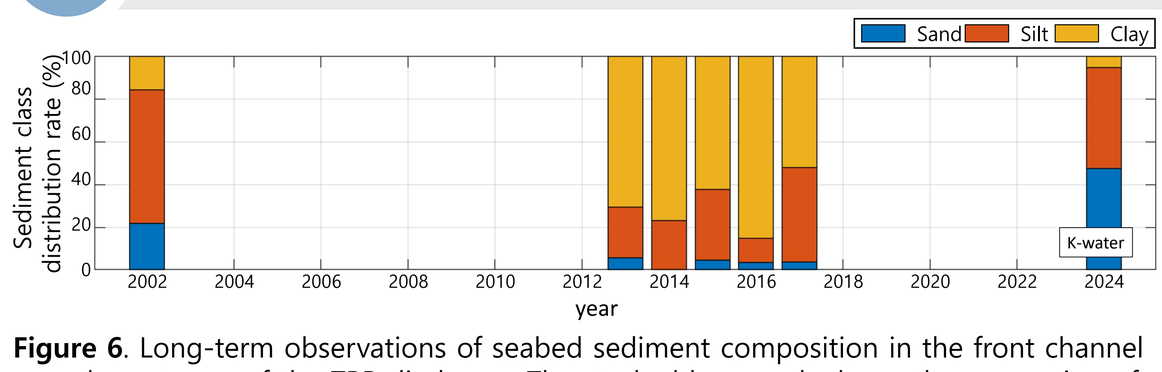


Figure 6. Long-term observations of seabed sediment composition in the front channel area downstream of the TPP discharge. The stacked bar graph shows the proportion of sand, silt, and clay fractions.

- Analysis of cross-sectional suspended sediment flux revealed that the sediment supply patterns were significantly altered by TPP discharge
- The residual sediment transport field was found to form distinct circulation mechanisms around the power plant discharge and the drainage sluice, altering sediment transport pathways
- The residual sediment transport field indicated a net sediment transport toward the northeast fairway, enhancing sediment deposition in the navigation channel

6 Conclusions

- The operation of the TPP enhanced bedload transport near the discharge outlet and increased fine sediment deposition within the navigation channel
- The operation of the TPP led to an increase in the inflow of externally sourced sediments
- Continuous monitoring and adaptive management are required to mitigate the long-term sedimentation impacts caused by TPP discharge

- 이 논문은 2024년도 해양수산부 재원으로 해양수산과학기술진흥원의 지원을 받아 수행된 연구임 (RS-2022-KS221548, 경기인천씨그랜트).
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