Project title "Dynamics of Salinity Intrusion in Chao Phraya River Estuary (CPRE) – Thailand: Past, Present and Future Behaviors under Climate Change"

Project member

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Purposes

To examine and describe complicate three-dimensional interactions between the riverine and oceanographic physical circulation and saltwater intrusion processes of the CPRE, as an example of the narrow, meandering and low-lying estuaries in topic region.

Methods

This study utilized available resources from both the Faculty of Fisheries, Kasetsart University (FOF-KU) and the Center for Marine Environmental Studies, Ehime University (CMES-EU). The FOF-KU gathered field observation data and secondary data, e.g., river discharge data, water level, near-surface measurements at many monitoring stations (Figure1) and along the CPRE of full profiles CTD data at 28 stations from the river mouth to about +120 km from the rivermouth. At CMES-EU, a three-dimensional hydrodynamic model using curvilinear grid was developed based on the Delft3D-FLOW model. The model was calibrated and validated against measured data and the model was used to investigate responses of the CPRE system to the changing in river discharge, freshwater abstraction from the river, wind, water level at the seaside by tidal and non-tidal components.

Results

This study document first time that the CPE is a partially-mixed estuary regulated by tide, river discharge, local wind (controlled near-surface currents), remote wind and the South China Sea seasonal sea level cycle (controlled sub-tidal water levels).

Tidal ranges and currents are largest near the rivermouth and diminish toward the upstream region. Saltwater intrusion dynamics depend greatly on the river discharge, tidal mixing, near surface wind-driven current and sub-tidal sea level changes (Figure1). Low freshwater discharge, prevailing down-estuary wind and the highest sea level in December and January are the natural causes enhancing estuarine circulation and the highest salt intrusion distance annually. Salinity distribution in the dry year show that the saltwater can intrude deeper into the CPRE reaching +98 km from the rivermouth while the intrusion is limited during the wet year (Figure2). Being narrow and long, turbulences induced by river meandering and river side engineering structures and human activities near the river mouth significantly dissipate tidal waves energy and significantly reduce upstream water levels and flow velocities affecting the salt intrusion distance.

Modeling results also uncovered that because of rapid increasing freshwater abstraction for domestics, industrial and agriculture usages over the past decades, the saltwater intrusion problem elevated (Figure3). Therefore, freshwater allocation water management of the CPRE can be an important key to keep the quality of the tap water affecting health of more than 14 million people and related socio-economy in Bangkok and nearby cities.

Future Challenges

The CPRE is a low-lying area and will be significantly affected by the sea level rise and land subsidence which are ongoing problem in this area. Variation of the regional climate drivers (e.g. ENSO and IOD) will change pattern and intensity of the rain and river discharge of the CPRE. Together with increasing demand of freshwater, CPRE will soon face severe saltwater intrusion problems during the dry year. Apart of the saltwater intrusion problem which only occur during the dry year, CPRE water quality has been seriously deteriorated. Field measurements indicate large areas of hypoxia and anoxia. We need more number and accuracy of the measurements to be used as input data along with inclusion of more realistic boundary data, i.e., temporal variation of the freshwater demand, hydraulic interactions of the CPRE with the complex irrigation channels and dams. This is to be able to better model (= effectively manage) the CPRE system.

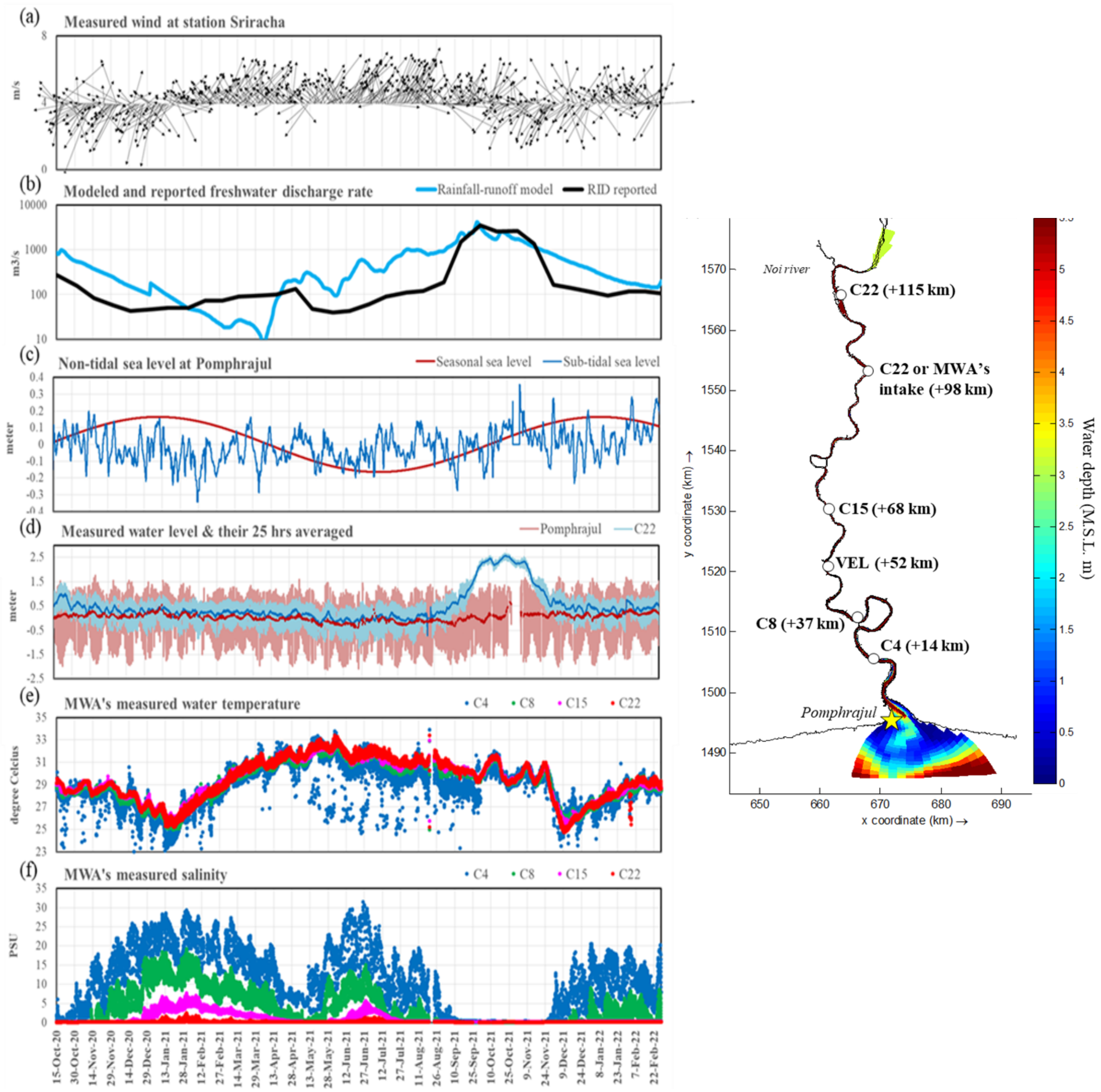

Figure 1 CPRE river channel and bathymetry. Time series of (a) measured wind at station Sriracha, (b) river discharge from global rainfall-runoff model (blue line) and that reported by the Royal Irrigation Department with some modifications (black line), (c) water levels measured at stations Pomprajul and C22, (d) sub-tidal water level and seasonal sea level variation data derived from measurements at station Pomprajul, (e) and (f) water temperature and salinity, respectively, measured at stations C4, C8, C15 and C22. Time spacing in horizontal axis is 15 days. Circle symbols show monitoring stations along the river; their distance from the river mouth is indicated in parentheses. *(modified from Pokavanich and Guo, submitted for publication)*

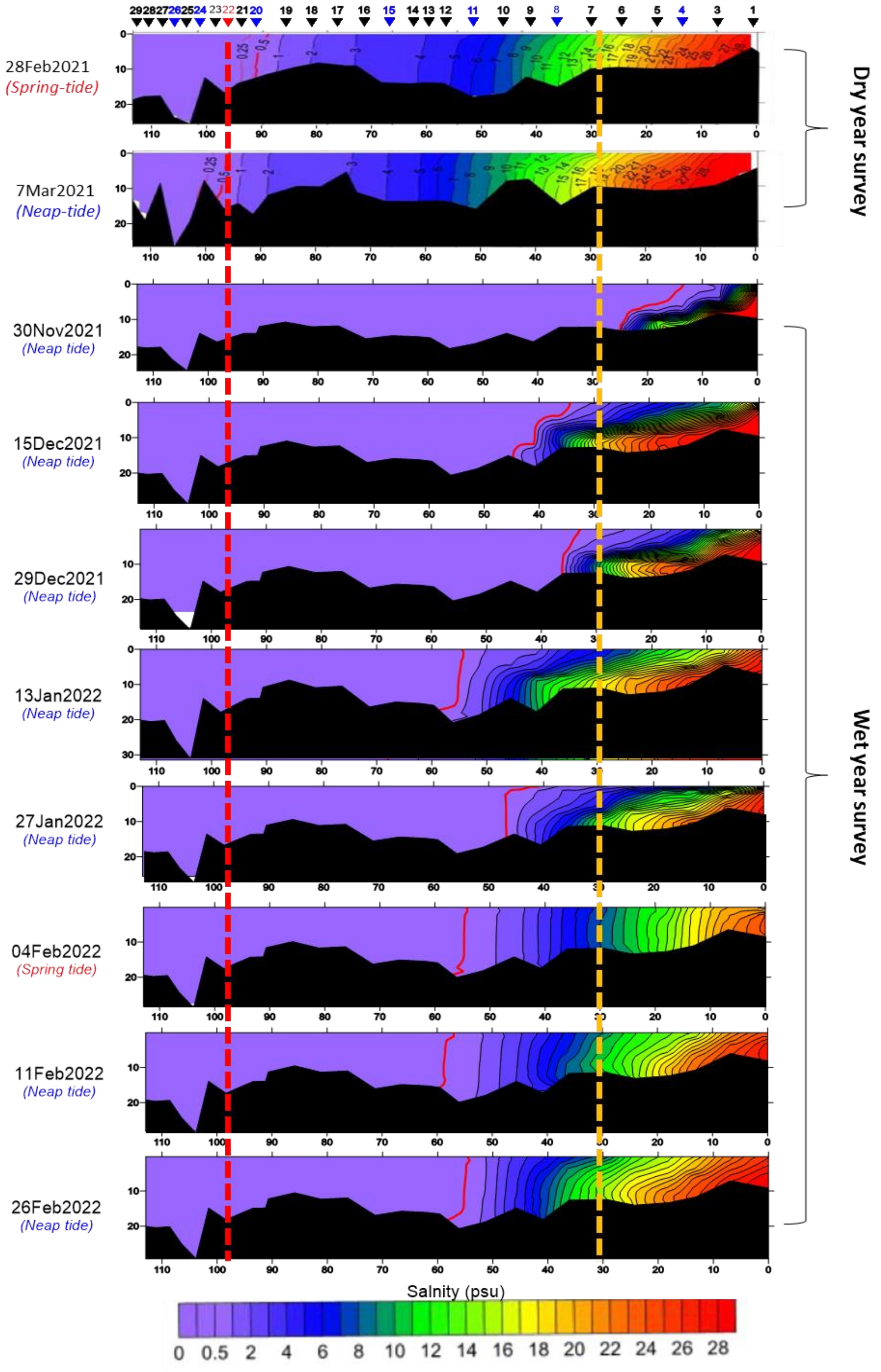

Figure 2 Observed salinity along longitudinal section in the dry year from February to March 2021, and in the wet year from November 2021 to February 2022. Dashed yellow and red lines represent location of + 30 km and the municipality raw water intake at + 98 km from the rivermouth, respectively.

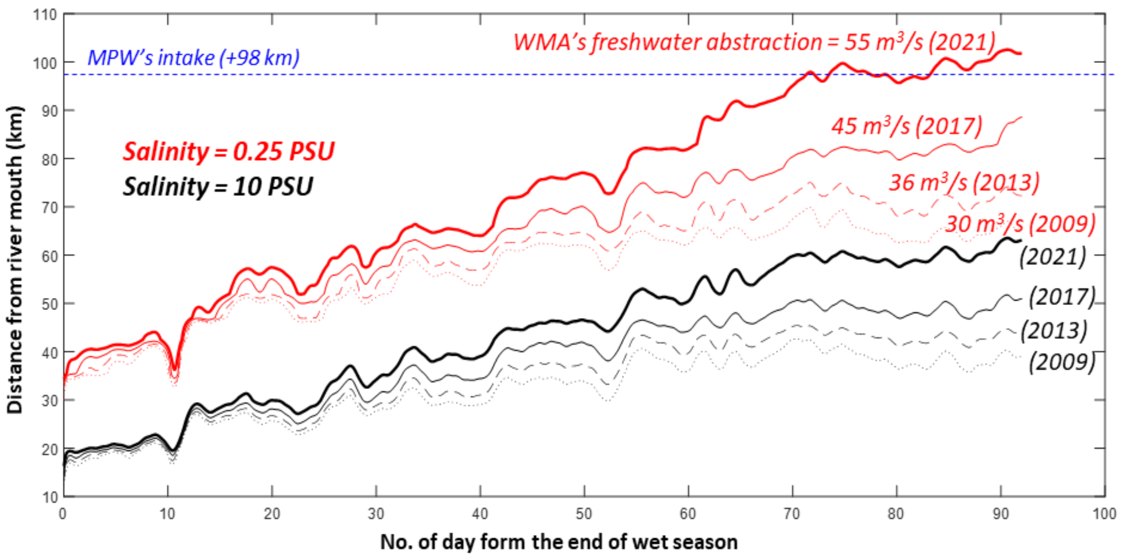

Figure 3 Temporal variation in the position of surface salinity with 0.25 PSU (red line) and 10 PSU (black line) after the end of the wet season in 2020 (dry year) between simulations with different freshwater abstraction rates by the WMA. The abstraction rates increase at an annual rate of 5% from 2009 to 2021. The WMA intake position is at +98 km from the estuary mouth. *(Pokavanich and Guo, submitted for publication)*
