Responses of Salinity Front to Runoff in the South Passage of the Yangtze River Estuary

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ABSTRACT

A well-validated 2D hydrodynamic and salinity transport model is established in the Yangtze River Estuary (YRE). The numerical performances reveal that: (1) the highest salinity generally occurs after 1h of the flood current slack in the YRE. (2) The pattern of salinity front in the South Passage (SP) has a two-peak in the flood season and a one-peak in the dry season respectively. (3) The influence of the TGD on the salinity front position in the SP is not significant due to small runoff change. (4) The large seasonal runoff difference significantly impacts the salinity distribution and salinity front position.

KEY WORDS: salinity front, the South Passage, the Yangtze River Estuary, hydrodynamic and salinity transport model.

INTRODUCTION

The definition of the estuary front (Geyer and Ralston, 2015) is derived from the oceanic front. The oceanic front is a narrow transitional zone between two or more different hydrological features (Ping et al., 2013; Ren et al., 2015; Morales et al., 2018). The estuary fronts can be classified by water temperature, salinity, density, suspended sediment, flow velocity and chlorophyll (Zhan et al., 2017). The salinity front among estuary fronts, attracts more attention in recent years, which has obvious spatial and temporal distribution (Zhao et al., 2011; Liu and Zhang, 2015). The salinity gradient is a criterion for the intensity of salinity front (Mao et al., 1963). Runoff is the major dominant of the salinity front in estuary, however, the salinity front is mainly affected by storms, rainfall, current and climate change in open sea (Kao and Lagerloef, 2014). The salinity front intensity increases slowly in the South Pacific convergence zone over the last 210 years (Linsley et al., 2010). However, based on the monthly mean salinity data in 50 years from the SODA (Simple Ocean Data Assimilation), the salinity front intensity decreases in the South China Sea (Zhao et al., 2012; Carton and Giese, 2008). Salinity fronts can change sediment transport, so that affect the growth of delta (Mao et al., 1963). Abundant microorganisms gather near the salinity front, which is conducive to the development of fishery. The barrier effect of the salinity front hinders the pollutants transport and has a serious impact on the water environment (Ning et al., 2004; Huang et al., 2011). The investigation of salinity front can help us better understand the hydrodynamic conditions in estuary and enrich the estuary management theory. Estuary fronts have been studied since early 1960s in the Yangtze River Estuary (YRE). The fronts of YRE are divided into three levels: the inner front, the pinnate front and the outer front (ocean front), and the pinnate front is characterized by the salinity of 25 PSU (Hu et al., 1995). The density difference between two sides of the salinity front forms a barrier effect, which has influence on sediment transport and bed evolution. (Chen et al., 2001).

The Yangtze River Delta (YRD) is one of the most economically developed and densely populated regions in the world (Liu et al., 2018). It has vast coastal wetlands and various types of aquatic plants, and is an ideal habitat with rich species diversity for migratory birds and fishes. Therefore, the YRD has important socio-economic significance and ecological environmental value (Olliver and Edmonds, 2017). The YRE, with a mouth at approximately 90 km wide, is characterized by three-order bifurcations, numerous islands and shoals, and deep channels. The Chongming Island divides the YRE into the North Branch (NB) and the South Branch (SB), shown in Fig. 1. The Changxing Island and Hengsha Island divide the lower South Branch into the North Channel (NC) and the South Channel (SC). Finally, the lower SC is divided into the North Passage (NP) and the South Passage (SP) by Jiuduansha Shoal (Kuang et al., 2014a; Chen et al., 2016).

The Yangtze River, has a length of 6380 km and a catchment area of 1.8×106 km², making it the longest river in China. The tidal current limit and tidal limit of the YRE are located at Jiangyin and Datong (about 640 km upstream from the river mouth), respectively. The Three Gorges Dam (TGD), the largest hydropower dam in the world, is located in the upstream of the Yangtze River. The TGD controls the downstream extreme events by decreasing the maximum discharge and increasing the minimum discharge and was operated in 2003. It means 2003 can be chosen as a critical year to analyze and compare different river discharge characteristics pre- and post-TGD (Kuang et al., 2017). Figs. 2 shows the comparison of the monthly mean runoff at Datong gauge station in the scenario of pre-TGD from 1950 to 2002 and post-TGD from 2003 to 2011 (data source is from the Bulletin of China River Sediment in http: www.cjh.com.cn; Kuang et al., 2014b). The operation of the TGD caused redistribution of inter-annual runoff, i.e., the monthly mean runoff increases in the dry season (January-March) and decreases in other seasons. For example, the monthly mean runoff decreases by 6207m³/s in July and increases by 1440 m³/s in January respectively.