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Effects of Reduced Yangtze River Discharge on the Circulation of Surrounding Seas

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ABSTRACT

A regional model of the western Pacific Ocean with 1/6° resolution is used to investigate possible effects of reduced Yangtze River discharge on the circulation of surrounding seas. To the extent of data availability, the model is mostly driven by monthly climatological winds and inflows/outflows through open-ocean boundaries. With climatological discharge rate, the Yangtze River plume disperses to the northeast in summer but follows the China Coastal Current (CCC) to the south in winter. While a substantial amount of the summer plume is retained in the southern Yellow Sea and northern East China Sea until the arrival of winter northerly monsoon, the winter Yangtze River discharge is able to escape freely to the south through advection by the CCC. The source water of the CCC is mainly comprised of winter discharge from Yangtze River, remnants of Yangtze River plume water retained in areas northeast of the river mouth from the preceding summer, Yellow Sea water and even some of the Bohai water. The effect of reduced Yangtze River discharge is highly asymmetric between summer and winter. Summer reduction produces an expansive, positive salinity anomaly northeast of the Yangtze River mouth. The response is rather swift and directly proportional to the reduction of freshwater supply. Winter reduction of freshwater discharge from the Yangtze River leads to higher salinity in the CCC south of the river mouth. The winter insensitivity of the CCC to reduced Yangtze outflow arises because the CCC is fed by multiple sources, some of which are not related to winter discharge

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from Yangtze River. In the highly unlikely event that the Yangtze River discharge is terminated for multiple years, the source water of the CCC will be dominated by the Yellow Sea and even Bohai waters.

(Key words: Yangtze River Plume, Satellite image, Tracer concentration)

1. INTRODUCTION

The Yangtze River (Fig. 1), or Changjiang, discharges over 928 km^3 of water annually (Zhang et al. 1990). The discharge also carries more than 4.68 x 10^8 tons yr^{-1} of sediments (Huang et al. 2001) and a large amount of nutrients into the East China Sea (ECS) (Zhang 1996). The river plume as indicated by the Changjiang Diluted Water (S < 32 psu) may extend more than hundreds of kilometers away from the river mouth (Beardsley et al., 1985; Gong et al. 1996; Lee and Chao 2003). The rich supply of nutrients and sediments supports high primary productivity and active biogeochemical processes in and around the East China Sea. The largest dam in the world, Three Gorges Dam, is currently under construction in the middle reach of the river and is expected to be operational in 2009. Possible impacts of the dam to the coastal environment are becoming a major concern of the oceanic community.

Damming generally reduces the strength and alters the seasonality of river runoff. Further, the biogeochemistry of surrounding seas is also likely altered. Drawing experiences from the past, the Farakka Dam on the Ganges River in India has led to 75 percent reduction of water flowing to Bangladesh (Chen 2000). The Aswan Dam on the Nile River reduced freshwater and sediment flux entering the Mediterranean, decreasing fish catches in the offshore region (Chen 2000). Constructions and dams on the Yellow River in China, combined with low rainfall due to El Nino effects, have led to about 50 percent drop of water discharge to the Bohai Sea in recent years (Milliman 1997). At the present time, it is difficult to predict the percentage reduction and seasonality of the Yangtze River discharge after damming. If damming is solely for the generation of hydroelectric power, the regulated discharge will likely have a reduced seasonal variation, but the net discharge per year will change little. If some of the water is retained for other usage, then the net annual discharge will be reduced as well.

Despite uncertainties regarding future net discharge and seasonal variation, possible consequences of the altered Yangtze outflow are beginning to attract attention. For example, a steady-state box model of Chen (2000) suggested that a 10 percent reduction in Yangtze outflow would reduce the cross-shelf water exchange between shelf waters and the western Pacific by about 9 percent along the continental margin of the East China Sea. Even more recently, a numerical model simulation (Delcroix and Murtugudde 2002) suggested that reduced Yangtze outflow leads to higher salinity, colder sea surface temperature and weakened anticyclonic circulation in the catchment area. Delcroix and Murtugudde (2002) used a rather coarse (1/4° ~ 1/2°) resolution model and truncated areas shallower than the open ocean mixed-layer depth, including nearshore areas off the China coast, Bohai and the northern portion of the Yellow Sea. Further, the Yangtze River discharge was treated as a surface freshwater flux.