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Hydromorphological mechanisms leading to hypoxia off the Changjiang estuary

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ABSTRACT

Based on the seasonal surveying data and long-term data, the annual changes in the geographical locations, occurrence frequency, affected areas and the minimum oxygen level as well as the formation mechanism of the summer hypoxia off the Changjiang estuary are summarized and discussed in this paper. The historical data indicates that there were episodes of hypoxia in the past 50 years but not every year, and the event of summer hypoxia could be traced back to as early as late 1950s off the Changjiang estuary. The minimum oxygen levels in the hypoxia zone did not show any decline in the past 50 years, but all the events with large size of affected area (>5000 km^2) were observed after the late 1990s, suggesting an enlarging trend. The author argues that the development of summer hypoxia off the Changjiang estuary was related not only to stratification and input of suspended particulate matter, but also to the inflow of Taiwan warm current water as well as the bottom topography.

1. Introduction

Because of their geomorphology and circulation patterns, some marine systems have a greater tendency to develop hypoxic conditions. The basic features of a system that make it prone to hypoxia are low physical energy (tidal, currents, or wind) and large freshwater input (Diaz, 2001). These features combine to form stratified or stable water masses near the bottom that become hypoxic when they are isolated from re-oxygenation with surface waters.

Hypoxia and anoxia have been widely observed in many estuarine and coastal regions over the last several decades, of which the most well-known areas for hypoxia/anoxia are the Gulf of Mexico, Chesapeake Bay, the North Sea, Tokyo Bay, the Black Sea, and the Baltic Sea (Diaz, 2001; Rabalais et al., 2001, 2002; Turner et al., 2005). Hypoxic zones also occur in coastal waters of China Seas, such as the summer hypoxia off the estuaries of Changjiang and Pearl River (e.g. Chen et al., 2007; Wei et al., 2007; Dai et al., 2006; Li et al., 2002; Yin et al., 2004). Previous studies have obtained some preliminary understanding about the formation mechanism of the summer hypoxia off the Changjiang estuary; however, these findings were based on the data of some single cruises (Chen et al., 2007; Li et al., 2002; Wei et al., 2007). The annual changes in the geographical locations, the frequency, the affected areas, the minimum oxygen levels, and the regional specific characteristics of summer hypoxia development in this area still remain unknown.

Based on the seasonal surveying data and the long-term data on summer hypoxia off the Changjiang estuary, the author attempted to answer the above questions and identify the regional specific hydromorphological mechanisms leading to the development of summer hypoxia off the Changjiang estuary.

2. Materials and methods

The source of field data used in this paper is the same as that of Wang et al. (2003). Since this paper focuses on the chemical hydrography in areas adjacent to the Changjiang estuary, ten cross-shelf transects covering the shelves of the Yellow Sea (YS) and East China Sea (ECS) were selected from the original database. The data collected from November 1997, May 1998, August 1998 to January 1999 cruises were designed to represent the autumn, spring, summer and winter conditions, respectively. The station locations, sampling resolution and analytical methods of temperature and salinity were described in detail elsewhere (Wang et al., 2003). Dissolved oxygen was measured using Winkler titration method. The precision in the measurements of temperature, salinity and dissolved oxygen were ±0.005 °C, ±0.005, ±0.06 mg L^{-1}, respectively.

Historical records of summer hypoxia were also compiled for comparison.

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3. Results

In the winter, circulation in areas adjacent to the Changjiang estuary is characterized by northward extension of the Taiwan warm current (TWC) and southward flow of coastal currents along the banks (Guan, 1994). Bottom temperature distribution showed that the saline warm water of TWC flowed northward along 123°E from the south of ECS and turned northwestward at 31°N into the trough off the Changjiang estuary, while the cold, less saline coastal water extended southeastward in a tongue-like shape from the west of YS to the northern ECS (Fig. 1a). The shapes of the isotherms were quite similar to isobaths (Fig. 1a). Similar distributions were also found for salinity (not shown) and dissolved oxygen (Fig. 1b). Water with DO <8 mg L^{-1} from the TWC occupied the trough off the Changjiang estuary, while >8 mg L^{-1} coastal water occupied the coastal areas as well as the middle shelf of the northern ECS (Fig. 1b). The vertical profiles of T, S and DO showed that the water column was homogeneous and the TWC water in the trough was very distinct with high temperature (>15 °C) and salinity (>34.2) and lower oxygen level (<7.8 mg L^{-1}) (Fig. 2a, b and c).

With the southerly monsoon predominant in spring, the coastal current in ECS moved northward along the coast with increasing width and velocity, while the coastal current in YS extended southeastward into the northern ECS with less intensity than that in winter (Guan, 1994). The TWC at all levels below the sea surface

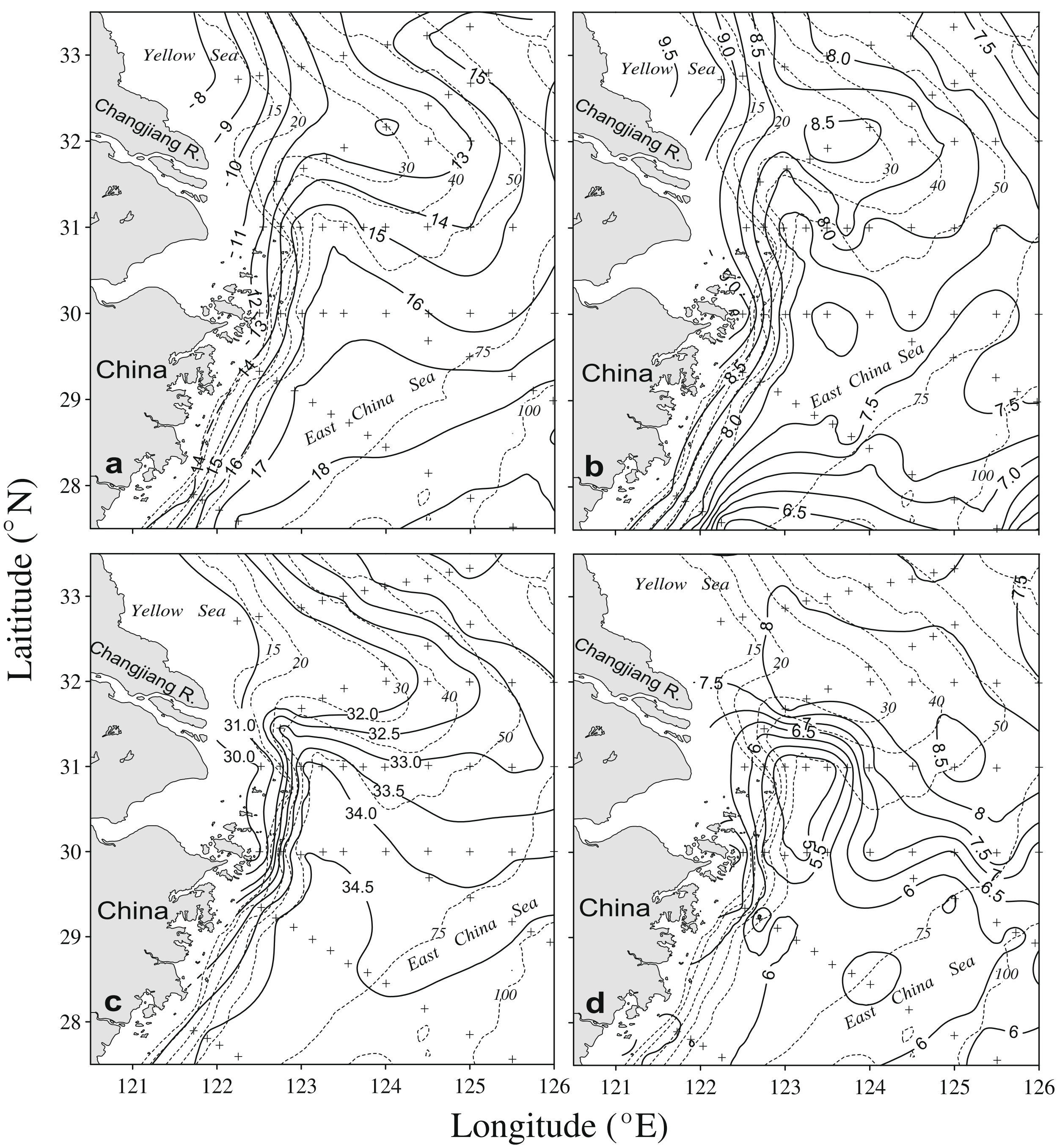

Fig. 1. Distributions of temperature (*T*, °C), salinity (*S*) and dissolved oxygen (DO, mg L^{-1}) in bottom water adjacent to the Changjiang estuary in the winter and spring (a: T, Jan. 1999; b: DO, Jan. 1999; c: *S*, May 1998; d: DO, May 1998).