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Impact of Typhoon Chan-hom on the marine environment and sediment dynamics on the inner shelf of the East China Sea: In-situ seafloor observations

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ABSTRACT

The suspended sediment transport in the inner shelf of the East China Sea (ECS) varies seasonally, and most of the suspended sediments are transported southward in winter. However, the influence of typhoons, which usually take place in summer, on the marine environments and sediment transport processes in the mud wedge area of the ECS inner shelf has not been elucidated. An in-situ monitoring platform moored approximately 440 km south of the Yangtze River mouth at a water depth of 40 m was resting on the seabed of the ECS inner shelf when Typhoon Chan-hom passed through the area. A 49-day data set of the temperature, suspended sediment concentration (SSC), chlorophyll *a* (chl *a*) concentration, and currents was recorded from this platform and analyzed in this study to characterize Typhoon Chan-hom and evaluate the associated sediment transport. The analysis of the data obtained shows that during the typhoon passage, the temperature decreased by approximately 0.8 °C, the maximum near-bottom current reached 152.0 cm/s, an average SSC of 919 mg/L was observed with peak hourly values exceeding 1785 mg/L, and the SSC and chl *a* concentrations reached approximately 50 and 10 times the corresponding values during the pre-typhoon period, respectively. During the typhoon passage, most of the suspended particles near the seabed were derived from the resuspension of bottom surface sediments. The chl *a* concentration near the seabed increased greatly because of surface sediment resuspension and the input of additional terrigenous nutrients transported by the typhoon passage. The net suspended sediment flux (SSF) associated with the passage of Typhoon Chan-hom was directed southwestward and landward. Sediment transport during Chan-hom accounted for approximately 89% of the total southwestward SSF and 44% of the total landward SSF during the whole observation period. Analysis of the wavelet power spectra reveals that in the upper water layers, the semidiurnal tidal currents prevailed before and after the typhoon passage; however, this dominant factor disappeared during the typhoon passage. Compared with winter storms in the ECS, summer typhoons such as Chan-hom mainly transport locally resuspended sediments, and sediment flux is landward in the across-shelf direction. Our study highlights the significant role of typhoons in the resuspension and redistribution of sediments and transport of suspended matter from north to south in the mud wedge area of the ECS.

1. Introduction

Short-term events, such as floods, storms, and typhoons, are expected to play important roles in sediment reworking and delivery on continental shelves. In some cases, such episodic events could contribute nearly half of the seasonal net sediment transport (Trowbridge et al., 1994) or even two orders of magnitude more than the sediment transport that occurs during fair weather conditions (Green et al., 1995). A typhoon may significantly alter the water column structures (Souza et al., 2001; Li et al., 2012, 2015a), modify the sediment transport and deposition (Wren and Leonard, 2005; Milliman et al., 2007; Bian et al., 2010; Li et al., 2015b), and change the nutrient distribution and biological production (Li et al., 2013b; Wang et al., 2015) in the affected seas over a short time.

Historically, the East China Sea (ECS) has received a large amount of terrigenous sediments from the Yangtze River (Changjiang), with an average annual sediment load of approximately 480×10^6 tons (Milliman and Meade, 1983). In the past 7000 yrs., after the postglacial

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sea level reached its mid-Holocene highstand, approximately 70% of the Yangtze River-derived sediment has been deposited in a deltaic system, with the remaining 30% resuspended and transported southward, accumulating in a distal mud wedge on the inner shelf along the coasts (Liu et al., 2006). The so-called "ECS inner shelf mud" is mainly derived from suspended sediments discharged by the Yangtze River, which are transported southward by the ECS Coastal Current (ECSCC) during winter (Liu et al., 2006; Xiao et al., 2006; Liu et al., 2007; Xu et al., 2009, 2012). The along-shelf mud wedge in the ECS is one of the best areas to study sediment diffusion, land-sea interactions, biogeochemical processes (e.g., carbon cycle), and processes from source to sink in continental margins. Because of the complexity and seasonal variability of the hydrodynamics in the ECS, the suspended sediment transport presents a unique characteristic; riverine suspended sediment is stored in the inner shelf in summer and transported to the middle or outer shelf in winter (Yang et al., 1992; Sun et al., 2000; Yuan et al., 2008; Pang et al., 2011; Bian et al., 2013; Pang et al., 2016). Until now, the importance of the role of episodic weather events such as typhoons in summer and their influence on suspended sediment transport and the effect of these events on sediment dispersal in the inner shelf mud wedge of the ECS has not been elucidated due to a lack of in-situ observations. The ECS is affected by an average of four typhoons annually (Su and Yuan, 2005), and approximately 35 typhoons passed through the ECS during 2002–2011 (Chen et al., 2017). Some studies of typhoon impacts on the sedimentary environment in the ECS were carried out based on shipboard measurements before and after the landfall of typhoons because of the difficulty in data collection under severe weather and sea conditions (Li et al., 2012, 2013b, 2015a). Due to the absence of hydrodynamic data in these studies, sediment transport processes during the typhoon passage were not revealed. Other topics, such as the importance of the role of summer typhoons on sediment transport and redistribution in the mud wedge of the ECS compared with those of winter storms, as well as the differences in the effects of these two types of events on sediment dispersal, have not been thoroughly studied. Typhoons can increase phytoplankton biomass, change its community structure (Chang et al., 1996) and enhance primary production in marginal seas (Fogel et al., 1999), which has an important impact on the carbon cycle in marine environments. Studies on the phytoplankton response to typhoons could be helpful to balance primary production budgets and estimate phytoplankton feedback to global warming (Zheng and Tang, 2007). For approximately half a century, near-bottom measurement systems, such as tripods, have provided important data and made great contributions to our understanding of sediment transport processes on continental shelves and in estuaries (Cacchione et al., 2006). Therefore, it is very necessary to perform in-situ observations at the along-shelf mud wedge to reveal marine environment changes and sediment transport processes during a typhoon, especially because the typhoons striking East Asia have recently intensified (Mei and Xie, 2016). However, long-term field observations from in-situ time-series monitoring are difficult to collect because of the intensive fishing activities, especially trawling, conducted in the ECS.

In this study, a 49-day field observation data set including temperature, suspended sediment concentration (SSC), chlorophyll *a* (chl *a*) concentration and currents was collected by an in-situ monitoring platform (bottom-mounted instrument system) located on the ECS inner shelf mud wedge. During the observation period, Typhoon Chan-hom passed through the ECS, and the related responses of the marine environment and sediment dynamics were recorded. The data were used (1) to characterize Typhoon Chan-hom, including analyzing the variations in temperature, SSC, and chl *a* concentration and the response of sediment dynamics due to the typhoon passage and (2) to elucidate the impact of Typhoon Chan-hom on the marine environment and sediment transport processes in the inner shelf mud wedge of the ECS.

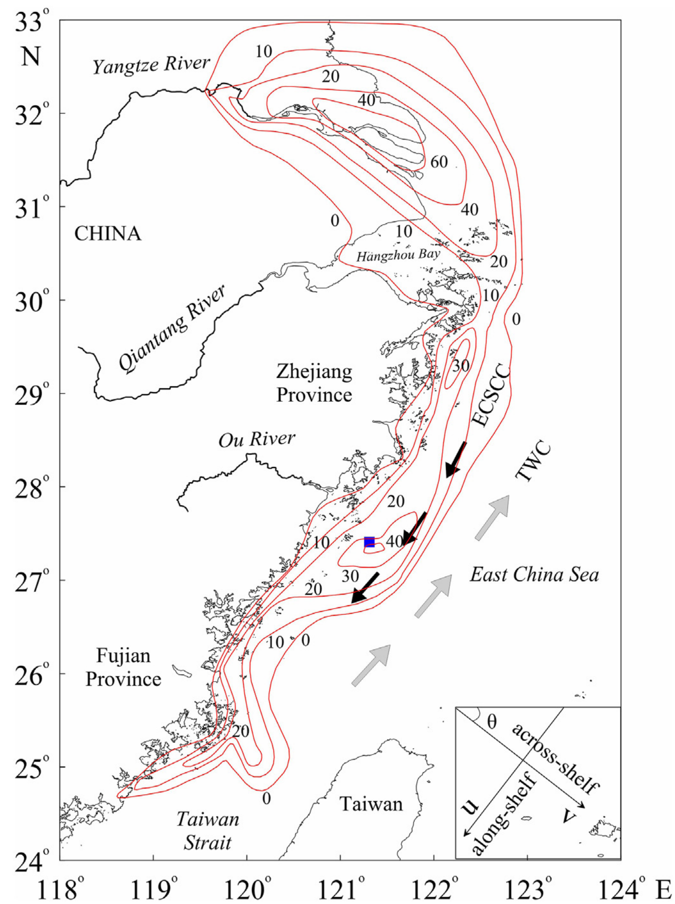

Fig. 1. Isopach map (in meters) of the Yangtze River-derived sediment deposited over the last 7000 yrs along the inner shelf in the ECS (after Liu et al., 2006). ECSCC, East China Sea Coastal Current; TWC, Taiwan Warm Current. The blue square represents in-situ monitoring platform. The lower part on the right shows the *u* (along-shelf) and *v* (across-shelf) coordinates (more details are shown in Methods and data). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

2. Study area and survey

The elongated mud wedge extends from the Yangtze River mouth southward along the Zhejiang-Fujian coast to the southwest of the Taiwan Strait, with northern and southern depocenters located in the modern Yangtze delta and at 27.5°N (Fig. 1), respectively (Liu et al., 2006; Xu et al., 2012). The sediment transport in the ECS is controlled by estuarine processes, waves, tidal currents, shelf circulation, and episodic events (storm, typhoon, etc., Pang et al., 2016). The circulation system in the southern depocenter of the mud wedge is mainly controlled by the ECSCC and the Taiwan Warm Current (TWC) (Fig. 1). Owing to the prevailing winds, the ECSCC flows southward in winter and northward in summer. The TWC, which has a high temperature and salinity and low turbidity, flows northward throughout the year and can be intensified in summer due to the southeast monsoon (Su and Yuan, 2005). Because of the obstruction effect of the TWC, suspended sediments from the Yangtze River estuary and the inner shelf mud wedge in the ECS cannot be transported to the outer shelf (Milliman et al., 1989; Guo et al., 2002; Liu et al., 2007; Yuan et al., 2008).

An in-situ monitoring platform was deployed on the seabed of the inner shelf in the ECS, positioned at 121°18.660′ E, 27°27.574′ N, approximately 440 km south of the Yangtze River mouth and near the southern depocenter of the mud wedge, at a water depth of 40 m (Fig. 1). All the instruments attached to the platform were powered up for operation on 19 June 2015, and the platform was retrieved on 3