

Sedimentary signals of the upwelling along the Zhejiang coast, China

Xin Zhang^{a,b}, Jian Liu^{b,c} and Yoshiki Saito^{d,e}

a School of Earth Sciences, China University of Geosciences, Wuhan, China

b Qingdao Institute of Marine Geology, Qingdao, China

c Laboratory for Marine Geology, Qingdao National Laboratory for Marine Science and Technology, Qingdao, China

d Geological Survey of Japan, AIST, Tsukuba, Japan

e Estuary Research Center, Shimane University, Matsue, Japan

Contents

1

Introduction

2

Materials

3

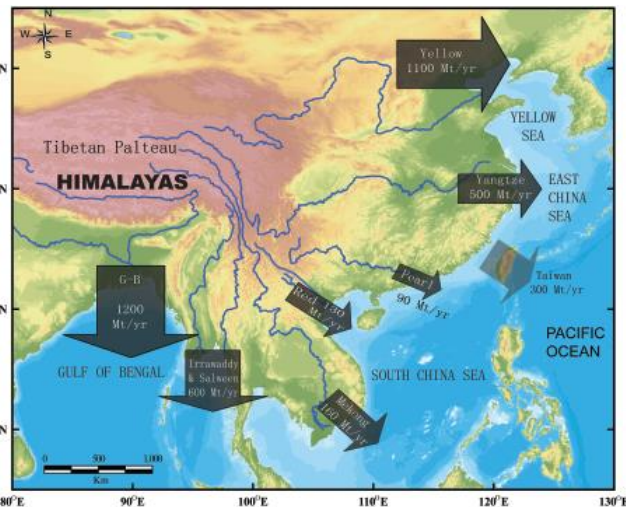
Results and Discussion

4

Conclusions

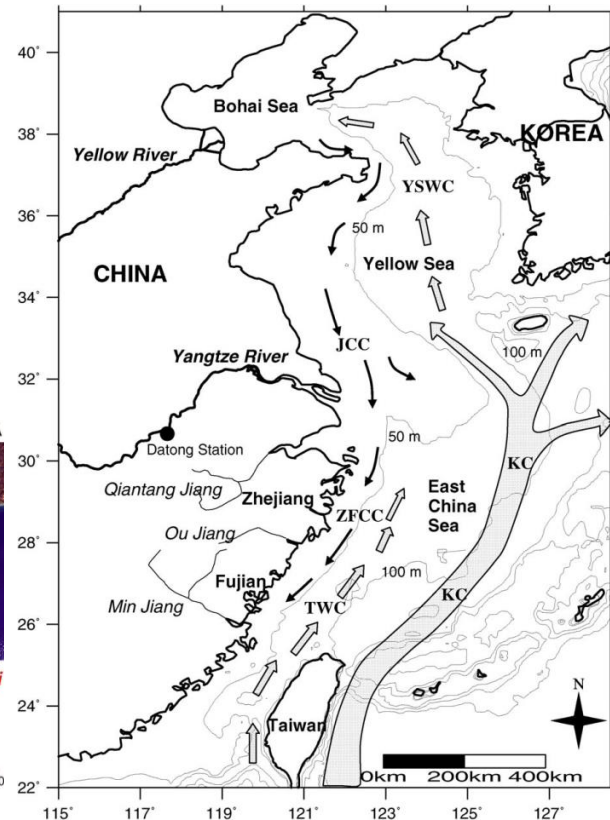
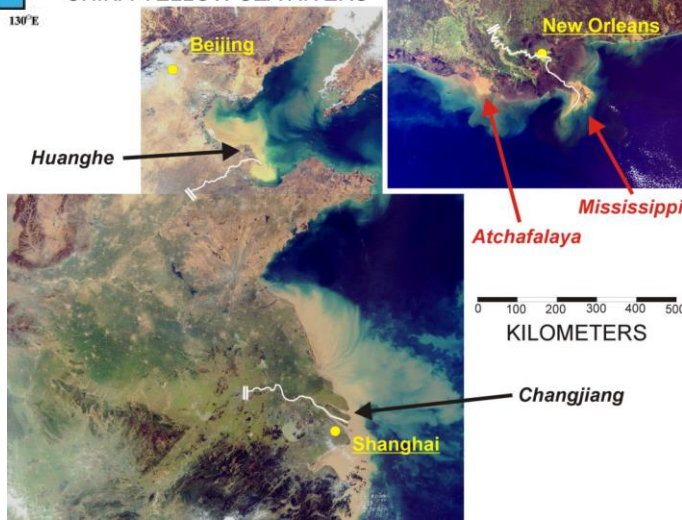
Source to Sink

The East China continental shelf receives a large amount of sediments from the Yellow River, Yangtze River, and other smaller rivers.

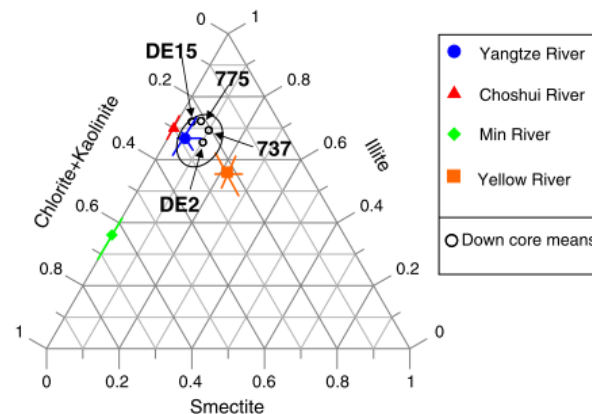
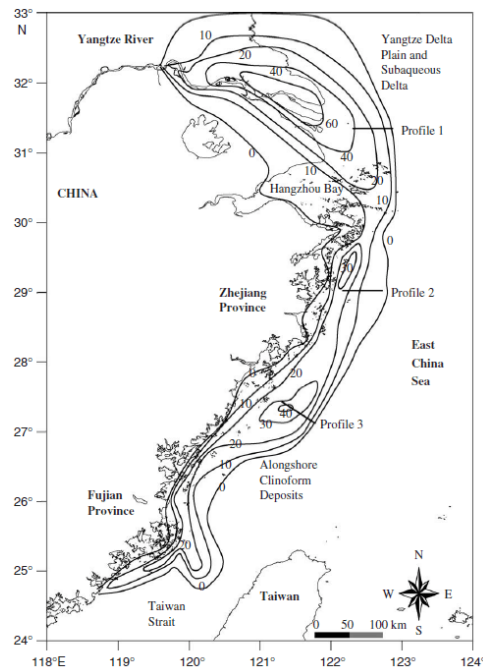


Terrigenous materials are transported by rivers into the oceans and deposited in the estuaries and on the adjacent continental shelves. Consequently, these areas are of great importance to understand “source to sink” processes.

CHINA-YELLOW SEA RIVERS

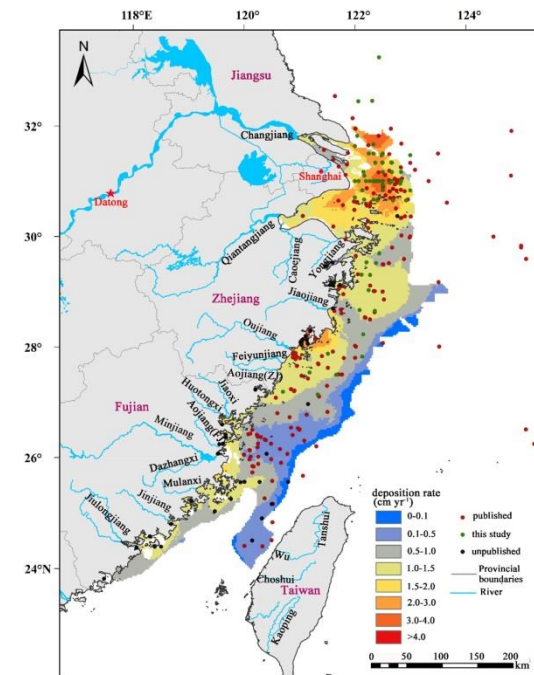


Zhe-Min Muddy Area

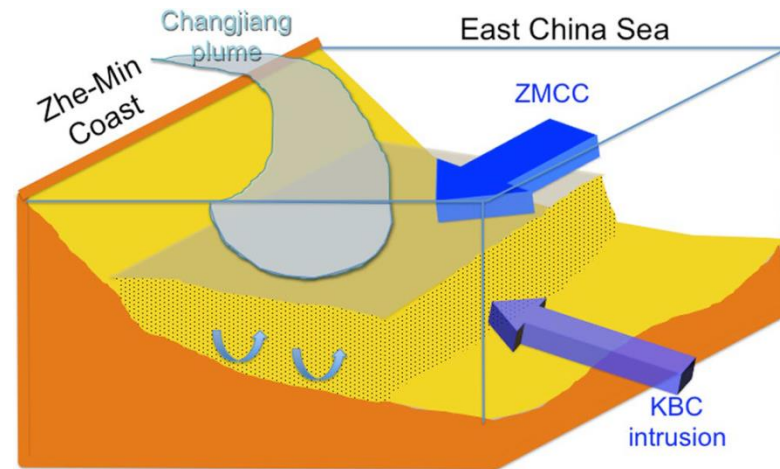
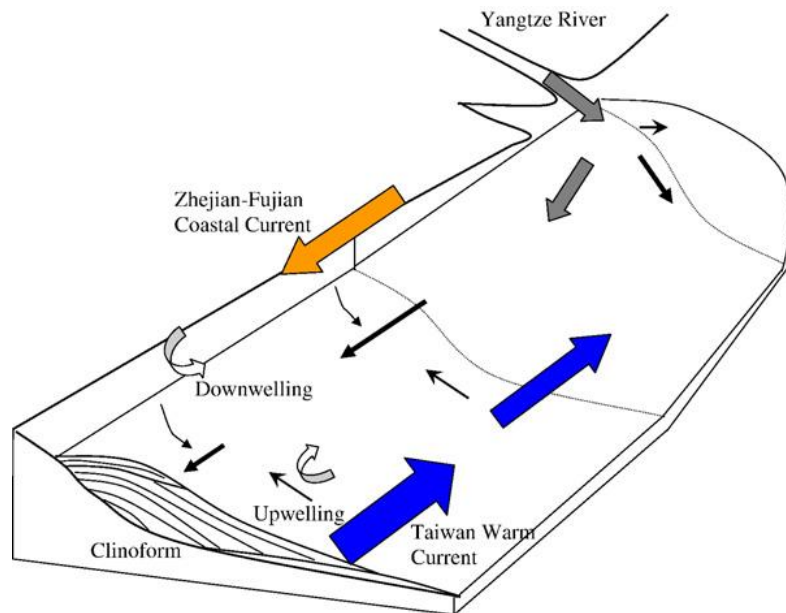


High-resolution seismic profiles and cores have revealed a mud wedge extending southwards from the Yangtze River mouth to the Taiwan Strait along the Chinese coast.

Considerable efforts have been devoted to studying the muddy deposits in terms of their provenance, paleoenvironment and the relationship with paleoclimate and monsoon.



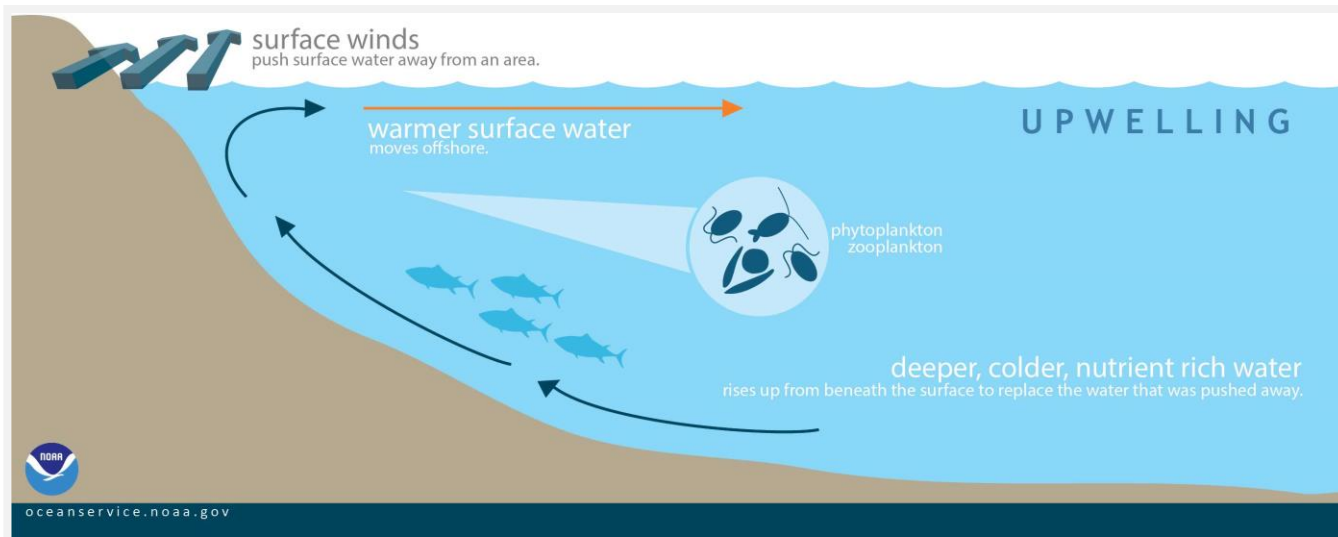
Formation of mud deposits



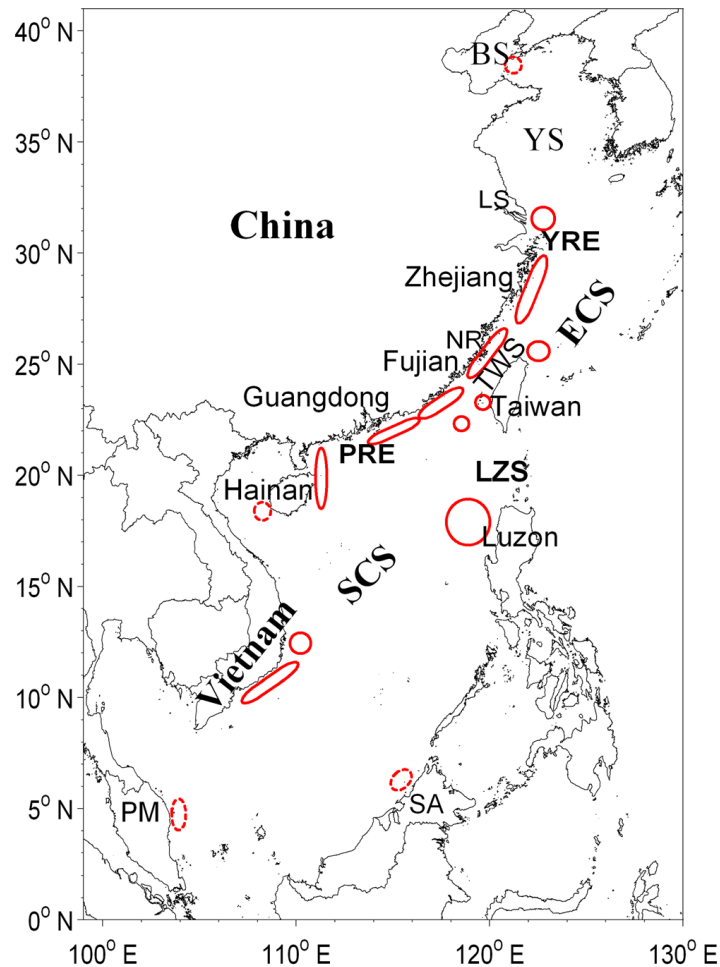
The formation of the mud deposits on the shelf are mainly associated with coastal river input, tidal currents, alongshore currents and upwelling.

What is Upwelling?

Upwelling is a process in **which deep, cold water rises** toward the surface.



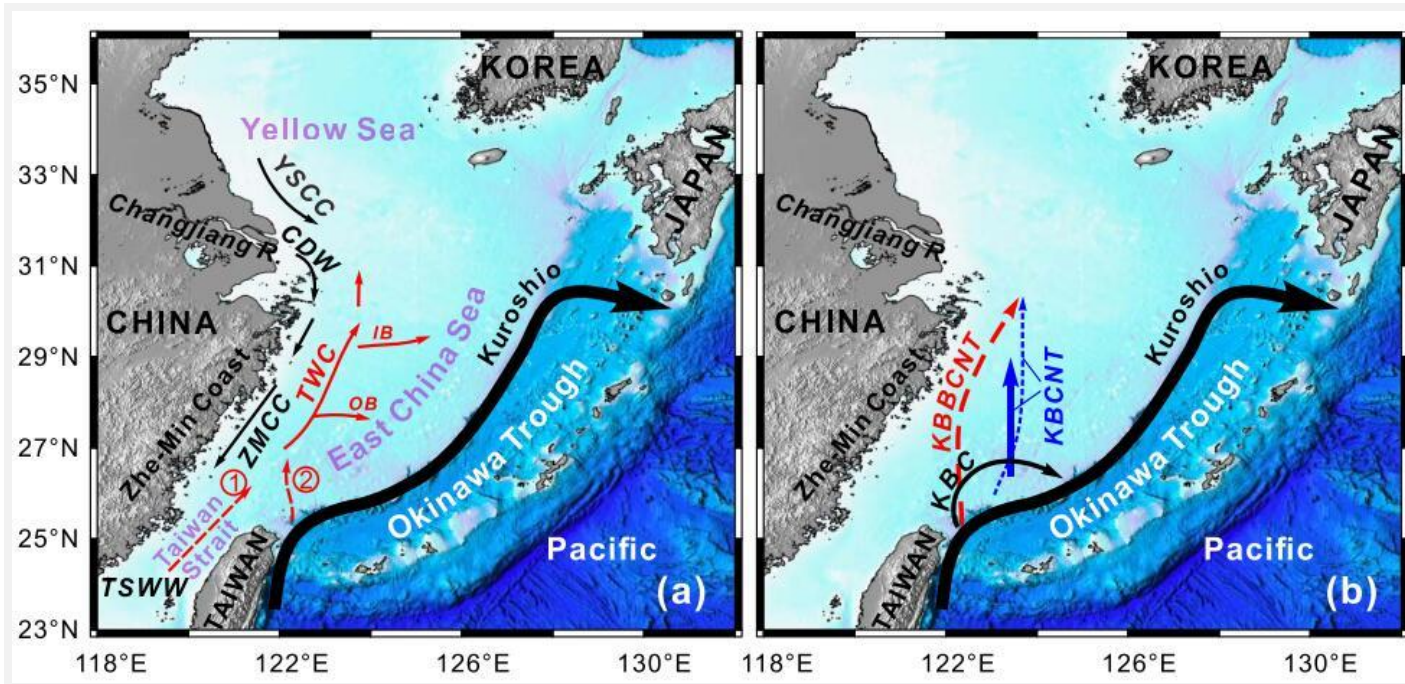
Upwelling is defined as an upward movement of seawater, with relatively high concentration of chlorophyll and relatively low sea surface temperature. The upwelling signals are always identified by temperature, salinity, nutrients and concentration of chlorophyll in studies of physical oceanography.



The coastal upwelling phenomenon has been observed along the Zhejiang coast, and has attracted scientific interest in recent years because of its ecological and economic impacts. However, the mechanism of the upwelling along the Zhejiang coast is complex, presumably controlled by the interaction of the alongshore current, Taiwan Warm Current, the Kuroshio Current intrusion into the coast, tidal currents and waves.

Upwelling

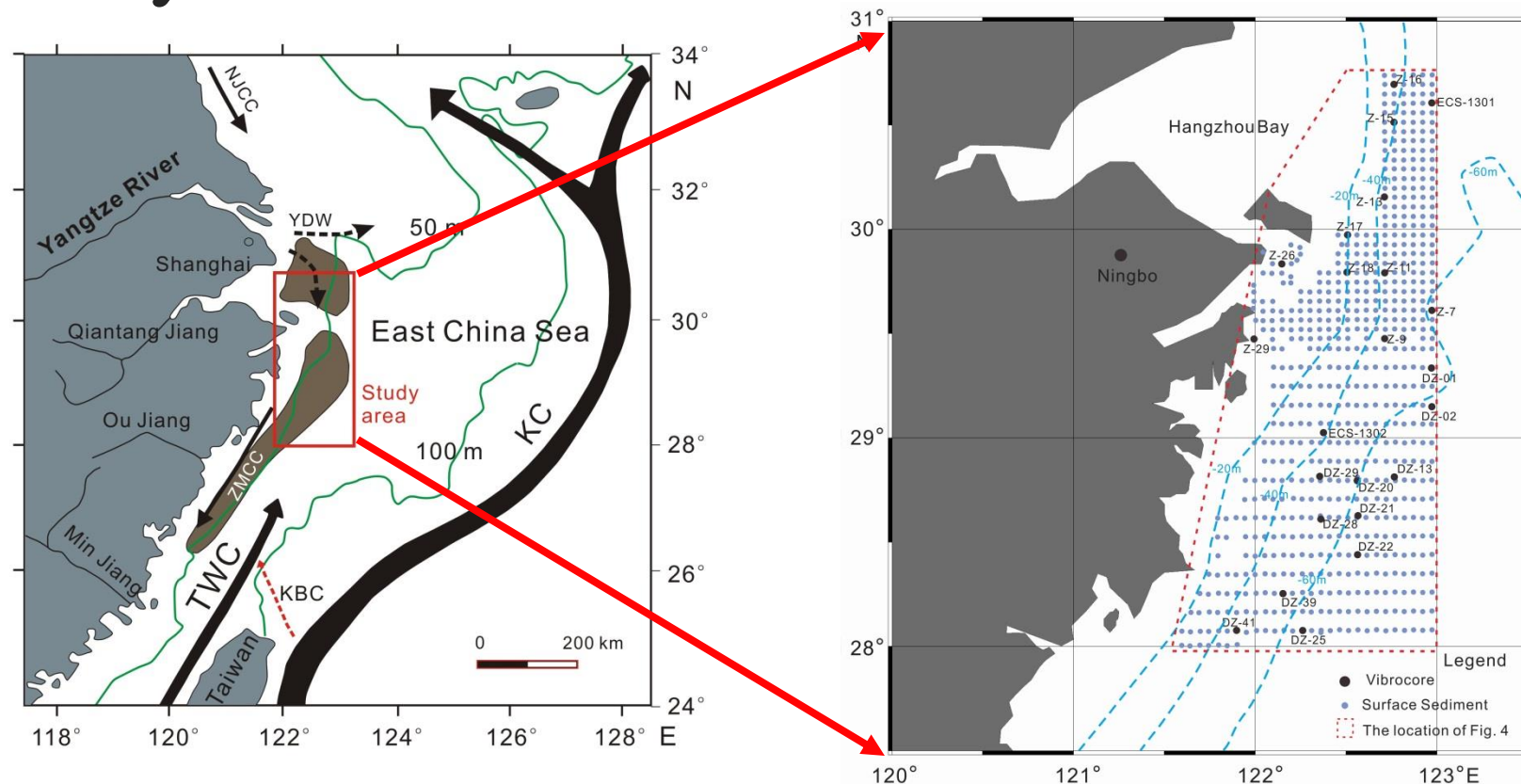
Kuroshio-branched water

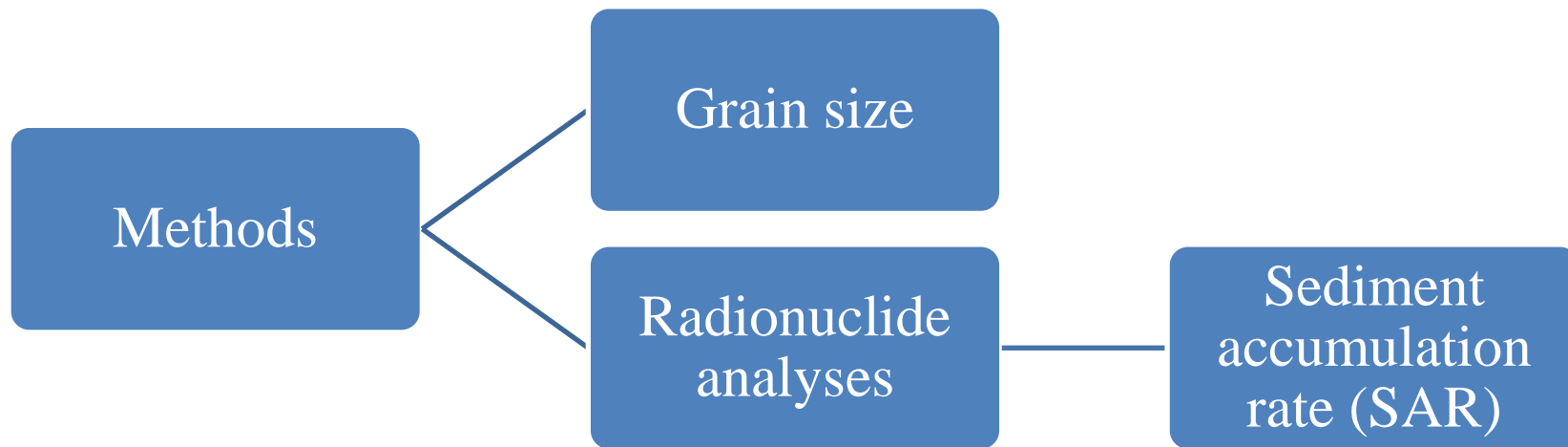


Recently, physical oceanographic evidences have shown that the Kuroshio-branched water can intrude into the inner shelf near the Zhejiang coast via the upwelling. The geological evidences in response to the upwelling and/or Kuroshio Current intrusion are still lacking!

Study area

643 surface samples
23 vibrocores



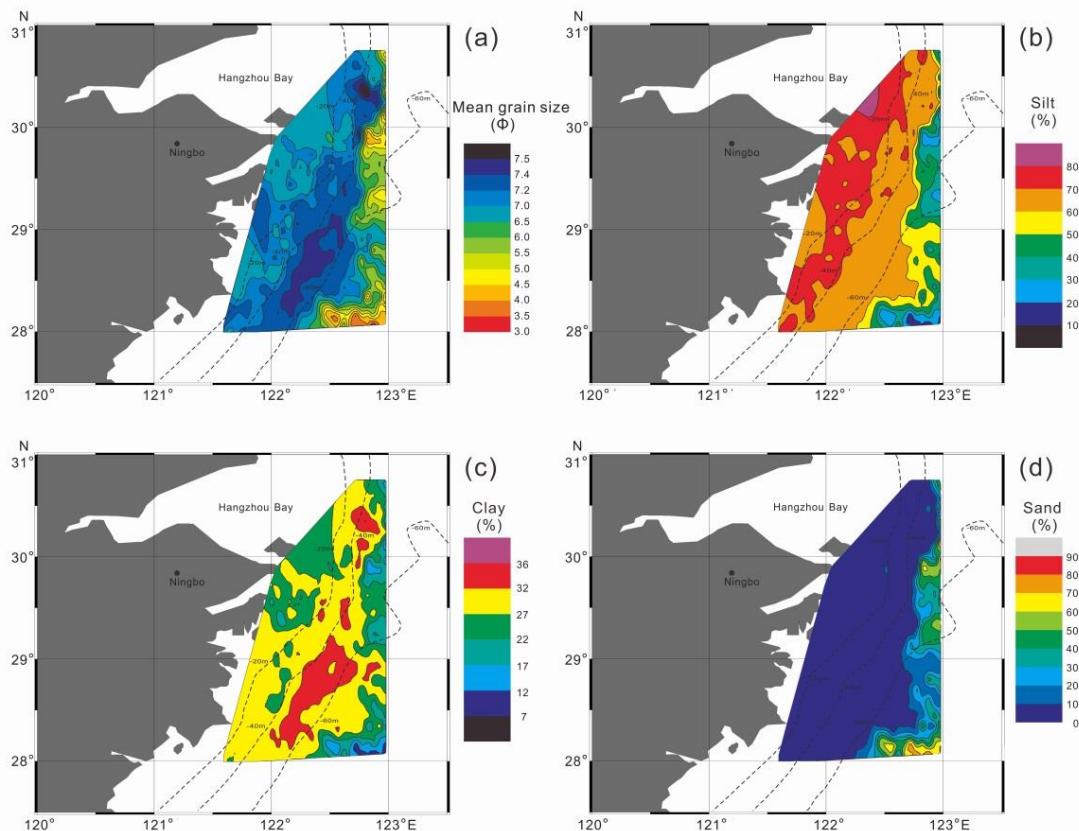


The 643 surface samples and 23 vibrocores were spaced with much higher density than in the previous studies.

Determining SAR is an important element of our understanding of sedimentary processes and deposition patterns.

Spatial distribution

The value of mean grain size ranged from 3.0Φ to 7.5Φ and the average value was 6.7Φ

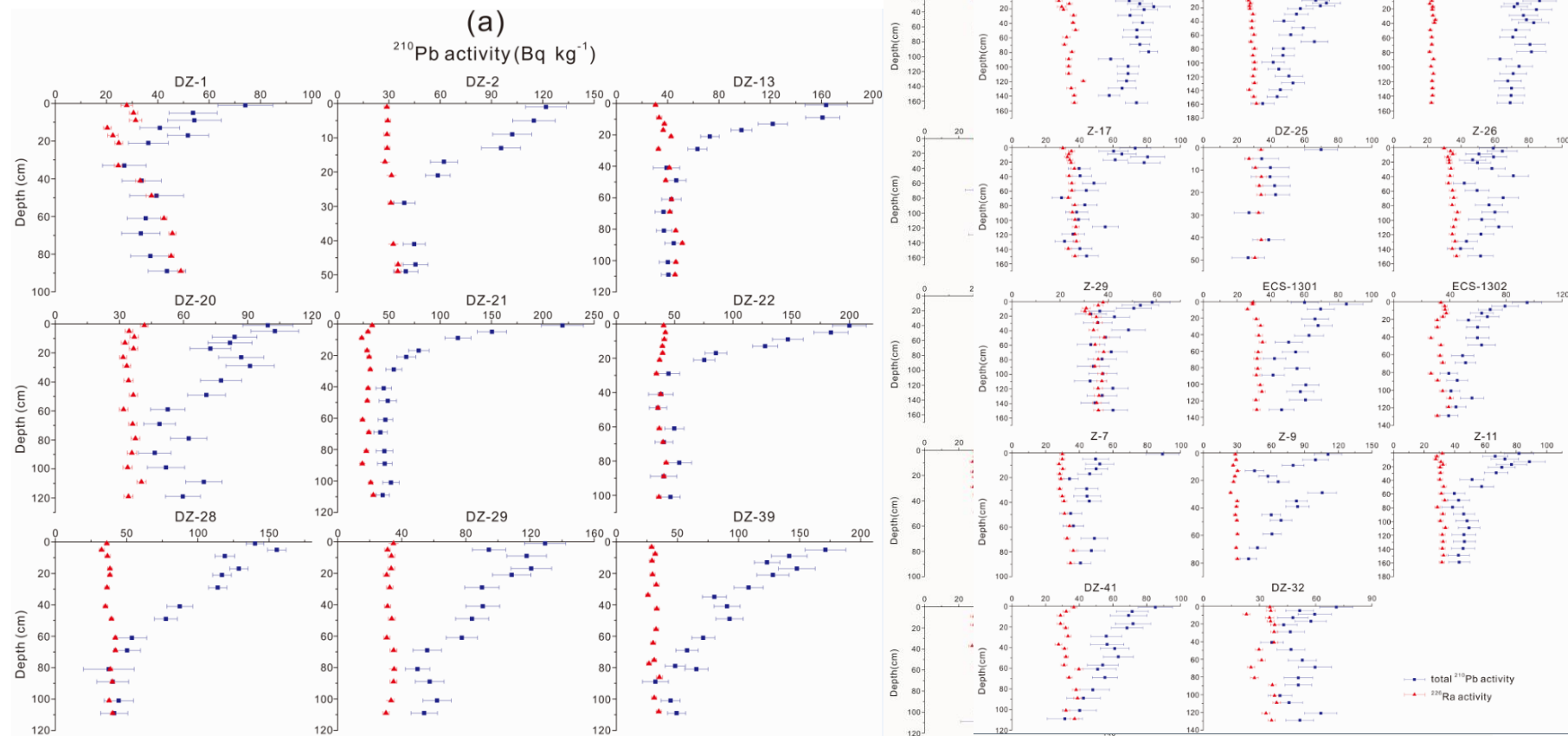


The clay-sized component was concentrated in the middle of the study area and gradually decreased from the middle to both sides.

The silt-sized component was the dominant grain size, and the spatial distribution of the silt-sized component was located mainly in the nearshore area and generally parallel to the coastline.

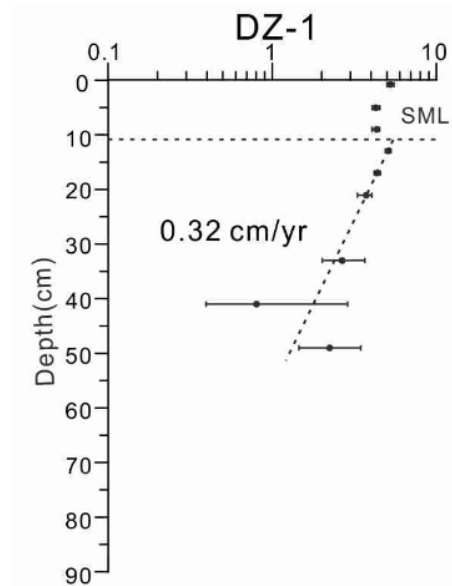
The sand-sized component was similar to that of silt-sized and the sandy sediments were found mainly in the southeast of the study area.

Total ^{210}Pb and ^{226}Ra activities

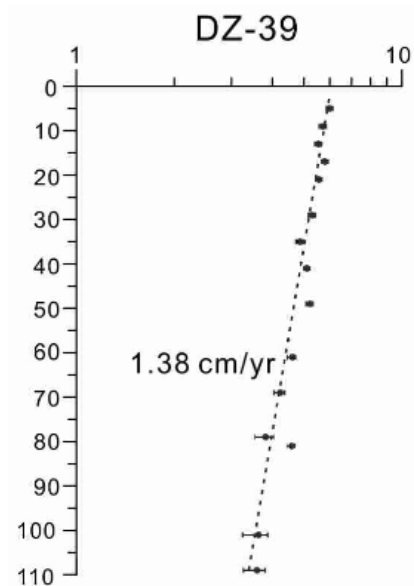


Downcore excess ^{210}Pb profiles

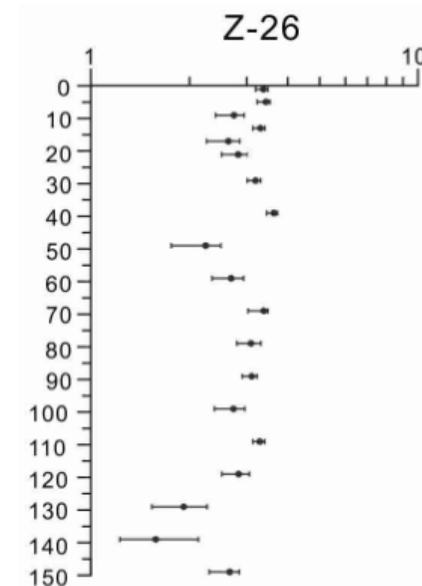
Excess ^{210}Pb activity (Bq/kg)



Surface mixed layers

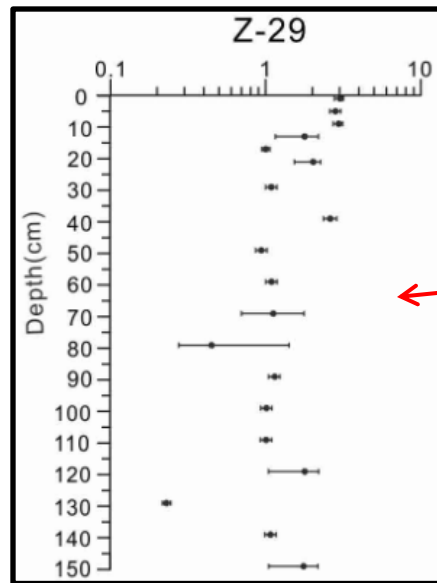


Non-reworked setting



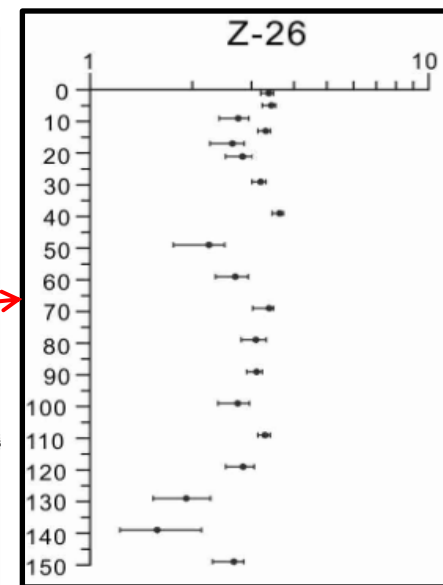
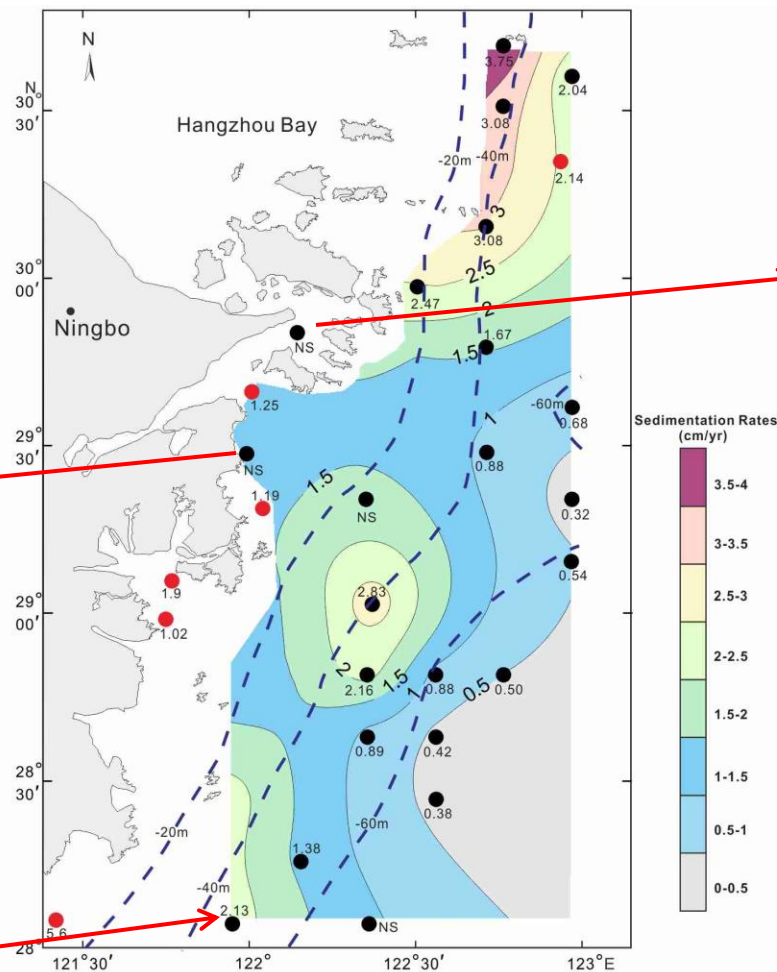
Intense reworking setting

Spatial distribution of SARs



some vibrocores collected near the coastline reveal excess ^{210}Pb activities with fluctuations throughout the vibrocores, indicating erosion or intense reworking of the sediments.

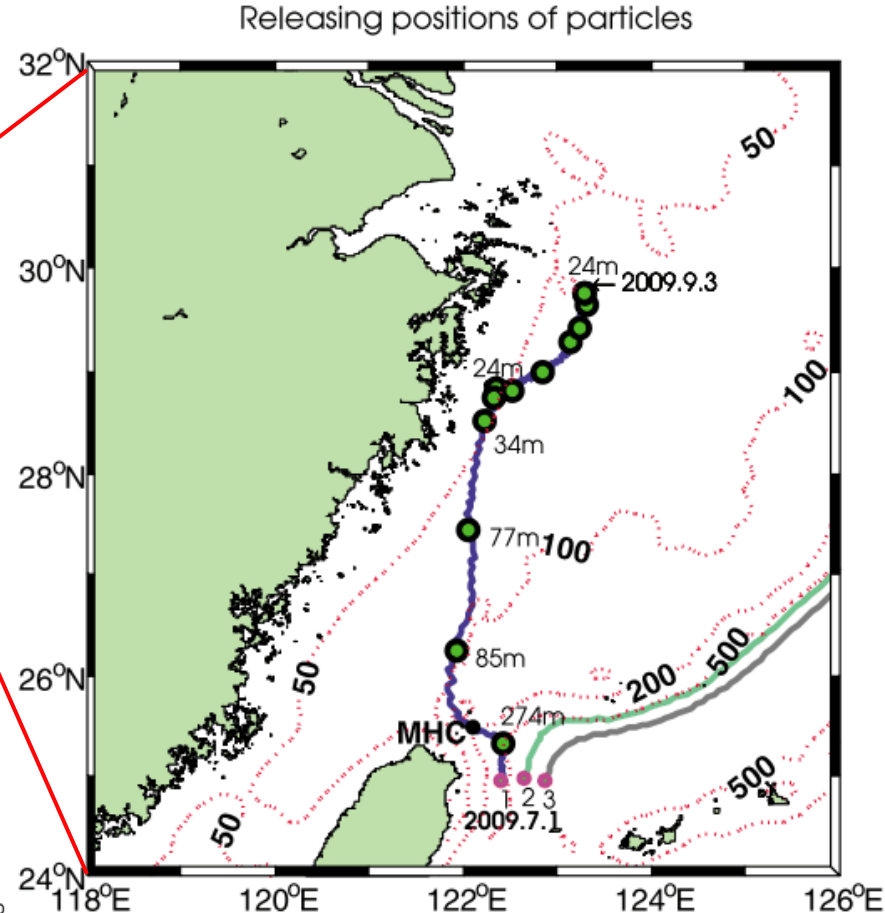
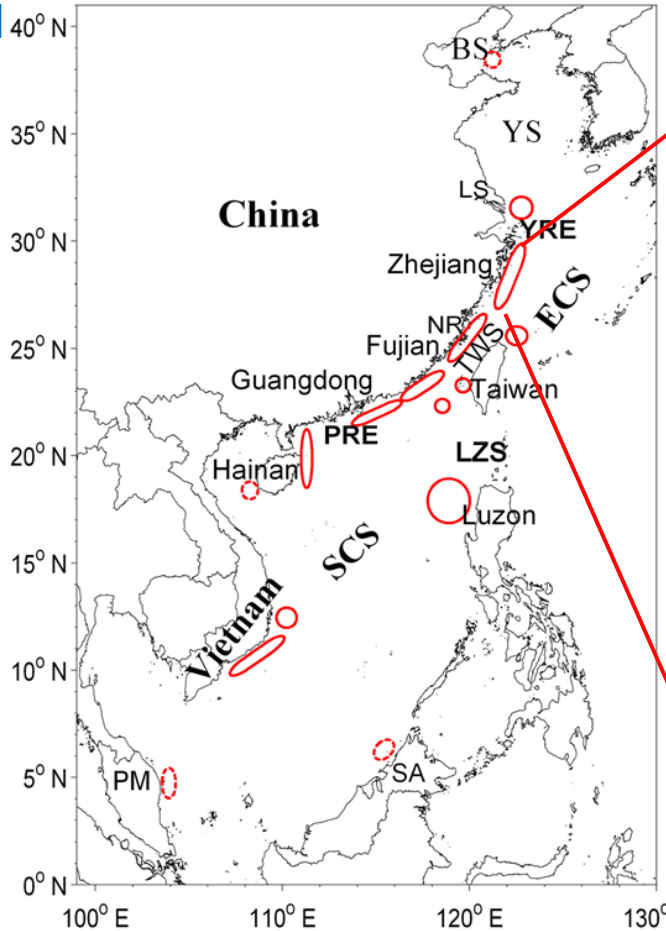
**Vibrocore
DZ-41**



The sedimentation rates calculated in the muddy area along the Zhejiang coast ranged from 0.32 to 3.75 cm/yr, with an average of 1.67 cm/yr over a period of ~100–150 yr.

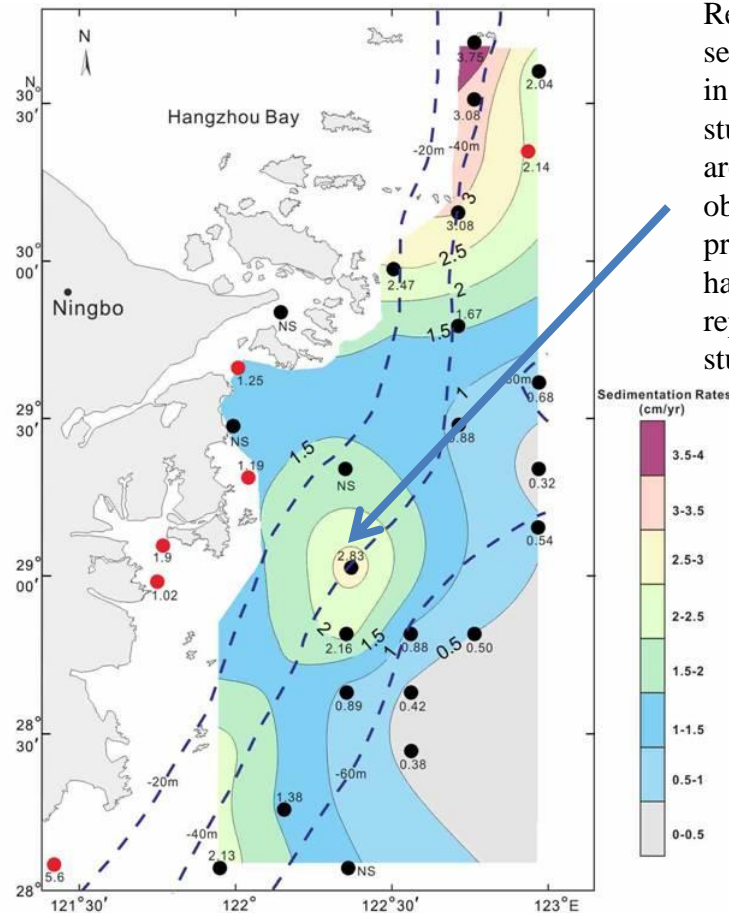
It should be noted that there is an area of high sedimentation rate near 29°N.

Kuroshio-branched water and the upwelling



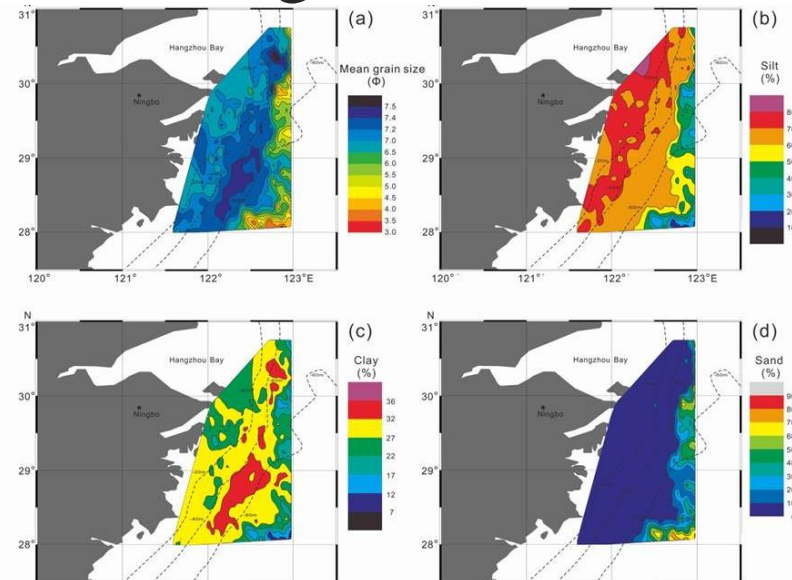
Physical oceanographic evidences have shown that the Kuroshio-branched water can intrude into the inner shelf near the Zhejiang coast via the upwelling.

The particle tracking experiment showed that fine sediments were trapped at 29°N and transported to the east when the branch of Kuroshio intruded into Zhejiang coast.



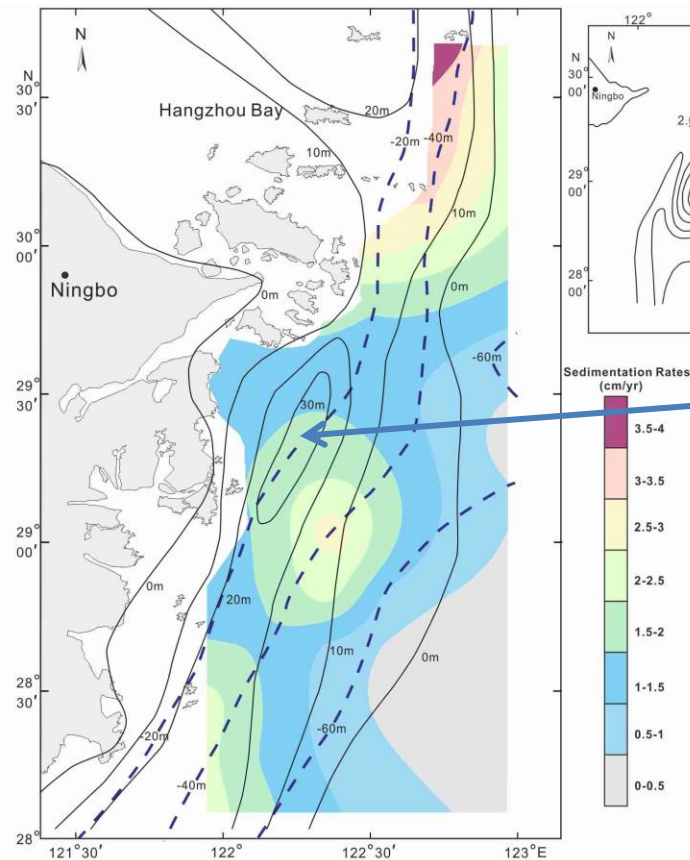
Relatively high sedimentation rates in the middle of the study area around 29°N are observed in the present study, which has never been reported in previous studies

Geological evidences



The numerical mode showed that the grain sizes of sediments near the center part of the upwelling became smaller and the SARs were higher. A qualitative analysis also showed that the presence of upwelling in the overlying water column could increase the SAR.

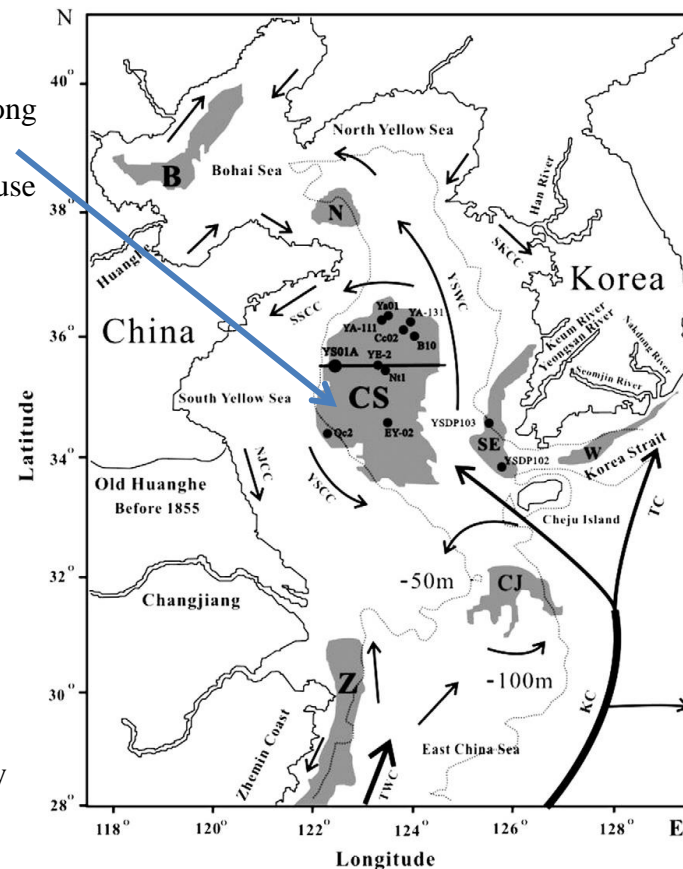
In this study, the central part of this upwelling is in accord with the extent of the finest sediments and highest sedimentation rate. This spatial distribution of SARs, as well as the grain size of surface sediments, indicate the presence of upwelling along the Zhejiang coast.



Very thick sediment deposits were found along 50 m bathymetry in the South Yellow Sea because of upwelling

There is a mud depocenter (>30 m thick) located between 29°N and 30°N.

The locations of high SAR around 29°N and Holocene maximum thickness deposition are slightly different. We surmise that this difference may be caused by the variation of the upwelling intensity along the Zhejiang coast.



Conclusions

- We present a new ^{210}Pb geochronology for the muddy area along Zhejiang coast, revealing the spatial variation of the accumulation rate in detail.
- We illustrate the geologic evidence for the existence of upwelling along the Zhejiang coast.
- Our new data are helpful to better understand the formation mechanism of the muddy deposits.



Thanks for your attention