

**The Abstracts of the Workshop on
Sediment Dynamics of Chinese Muddy
Coasts and Estuaries**

September 5-7, 2009

Guilin, China

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Keynote address

Advances in physics-biology links in fine sediment dynamics and its impact

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An increase in human activities in river catchments is resulting in increased muddiness of estuaries and coastal waters in most regions of the world (e.g. T. Healy, Y. Wang and J.-A. Healy (2002). *Muddy Coasts of the World: Processes, Deposits and Function*. Elsevier Science B.V., Amsterdam). Over the last few decades, much of the knowledge of mud dynamics, and its modelling, came from the engineering community. More recently significant advances in quantifying mud dynamics came from the scientific community because of coastal management implications, such as the role of mud in eutrophication processes, and the change of some coasts from sandy to muddy, which is an environmental degradation. Modelling mud dynamics by engineers seemed so 'simple', the belief was that mud was just a messy fluid and that its behaviour could be modelled by adding a few equations for erosion and deposition, with the parameters derived from laboratory experiments and the models could then easily be 'calibrated' against some field data for the collection of which ingenious probes were designed. And then, to everyone's surprise, these engineering models were seen to be largely unable to reproduce much of the field data once we get in the details. A reason for this failure is that these models largely neglect the biology, which, as I will demonstrate, has a major influence on controlling

- the settling of mud flocs
- the resuspension of settled mud
- the dewatering (consolidation)
- the patchiness
- the nutrient dynamics

In all these processes, the impact of the mud on the biology is dramatic. This leads now to view mud and muddy waters as a living body, not just a messy fluid as originally seen by engineers. This enables us to highlight research priorities to advance the knowledge of mud dynamics by quantifying the physics-biology links. While these are small-scale processes that affect the mud dynamics of estuaries and coastal waters at the local scale, a final suggestion for urgently needed research is to better understand the large-scale broadcast of mud in nepheloid layers, and its biological impact, because this can happen at very large scales in coastal and shelf waters surprisingly far away from the estuarine source of the mud.

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Session 1: Observations and instrument development

Suspended Sediment Transport in the Yellow Sea and East China Sea

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The suspended sediment transport in the Yellow Sea and East China Sea is investigated using a data set measured in 6 cruises from 2000 to 2006. The results show that highest concentrations of suspended sediments are always located in the Changjiang estuary and the coast of Jiangsu Province, because of the abundant sediment source and the active hydrodynamic condition. The coastal front along in the East China Sea and the continental shelf front between the Jiangsu coastal waters and the cold water mass in the Yellow Sea are important for the suspended sediment transport. The week tidal dynamics and the water mass stratification are the man factor for the fine grain sediment accumulation in the Yellow Sea.

Keywords: Yellow Sea, East China Sea, Suspended sediment, Front

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Ecological implications of heavy metal concentrations in the sediments of Burullus Lagoon of Nile Delta, Egypt

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This paper examines the spatial and temporal distribution of heavy metals (Fe, Al, Cu, Zn, Mn, Cd, Pb and Ni) from three short sediment cores collected from Burullus lagoon of the Nile delta, Egypt. ²¹⁰Pb and ¹³⁷Cs measurement is applied to understand sedimentation rate and related chronology. Remarkably lower isotopic activities and strong bioturbation in the lagoonal sediments rendered age determination difficult. Samples with detectable ¹³⁷Cs in the upper core sediments together with sediment lithology could help infer a sedimentation rate of about 2.0 mm/yr, thereby indicating post-dam (after 1964) sedimentation of the upper 10-cm core sediments. Our results demonstrate that most heavy metals in the surficial sediments after normalization to Al decrease seaward, showing a function of distance to the sewerage outlet on the inland lake coast. Also, there is an upwardly increasing trend of normalized heavy metals, especially in the upper 10-cm core sediments. Relevancy analysis has identified Mn, Pb and Cd as the diagnostic heavy metals in Burullus lagoon, most likely derived from Tanta and Kafrelsheikh, the major downtowns in the central Nile delta plain, from where wastewaters are directly discharging into the lake via canal networks. Although Burullus lagoon is presently least affected by pollution as compared to other major lagoons of the Nile delta, the increasing quantities of diagnostic metals, especially Mn, are extremely toxic, as they are potentially linked to the risks of digestive issues and pancreatic cancer reportedly. The situation calls for a rational planning for sewerage treatment in this Burullus protected coast.

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Observations and analysis of the bottom boundary layer characteristics in the Yangtze Estuary

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A bottom-mounted instrumental quadrapod was deployed in the navigation channel of the Yangtze Estuary from March 29 to April 5, 2009, in order to investigate the characteristics of the bottom boundary layer flows. A downward-looking Acoustic Doppler Current Profiler (ADCP) and an Acoustic Doppler Velocimeter (ADV) were fastened on the quadrapod, and the mean water depth at this mooring site is 9 m. Measurements from these bottom-mounted instruments were used to estimate shear velocity with such some techniques such as the logarithmic profile method, Turbulent kinetic energy (TKE) method and inertial dissipation method. The result from logarithmic profile method is sensitive to the bed height change during the survey, while the results from TKE method and inertial dissipation method are relatively steady. For the data obtained from March 29 to April 2, the logarithmic profile method is valid and the corresponding result is similar to the results of the TKE method and inertial dissipation method. However, the velocity profiles from April 2 to the end of survey deviate significantly from the logarithmic law, and it could be deduced that the occurrence of lutocline is responsible for this phenomenon.

Keywords: Yangtze Estuary, Bottom boundary layer, Shear velocity, Lutocline

长江口底部边界层特征的观测与分析

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2009年3月29日至4月5日期间, 通过布放四角架的方式对长江口深水航道潮流边界层的特征进行了观测。四角架主要搭载了下视的高分辨率的流速剖面仪 ADCP 和高频流速仪 ADV。通过对数剖面法、湍动能法和惯性耗散法等方法对四角架搭载仪器采集的数据进行了分析计算。对数剖面法对观察期间底床高度的变化比较敏感, 而湍动能法和惯性耗散法计算的结果相对稳定。自3月29日至4月2日流速剖面符合对数分布规律, 计算的结果与其他两个方法的结果接近; 而自4月2日至观察结束, 流速剖面偏离对数分布规律, 泥跃层的出现可能是导致这一现象的原因。

关键词: 长江口, 底边界层, 剪切速度, 泥跃层

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Mud deposition in Mai Po Nature Reserve

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Mai Po is an important nature reserve in Hong Kong which provides a habitat for migratory birds including some highly endangered species. Suspended solid has great impact on the ecology of the nature reserve. High suspended solid concentration (SSC) may damp light penetration, reduce thickness of the euphotic zone, limit primary productivity and also distribute contaminants. To predict SSC, deposition rate, which is defined as the amount of sediment that leaves the water column per unit area per time, is an important parameter. Sediment would deposit only when the bed shear stress is below a certain value, i.e. critical shear stress for deposition. To determine when deposition rate may take place, understanding and acquisition of the critical shear stress is essential. In this project, deposition of suspended solids of cohesive nature has been studied. Experimental investigations were performed with salinity of 0 and 30 ppt. The experiments with zero salinity were performed in the Hong Kong Polytechnic University while the experiments with 30 ppt salinity were performed in the Virginia Institute of Marine Science. Both of the experimental results show that there is a continuous deposition once the sediment undergoes a weaker shear stress. The decline of suspended sediment concentration increases while bed shear stress is below 0.05Pa.

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Session 2: Modelling for sedimentary processes

Observation and numerical simulation of suspended sediment concentration in the Changjiang Estuary

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The Deepwater Channel locates at the North Passage in Changjiang estuary. The back silting in the navigation channel focus on the region W3 from 2005 to 2008. Four tripods were mounted at the upstream and downstream of W3 area in the North Passage, and current, wave and sediment along the navigation channel was observed. These data were analyzed and the result shows that the hydrodynamic decrease from upstream to downstream. The dominant hydrodynamic spindles in the south of W3 area point to the navigation channel. The net sediment transport flux in the upstream and downstream points to W3 area. These dynamic factors are parts of reasons for heavy deposition in W3 area. Another four tripods were mounted in the section perpendicular to south dike. It was observed that the suspended sediment concentration (SSC) of the flow jumping over the south dike from Jiuduansha shoal increase during the northeast wind, which lead to more sediment transported into the North Passage and make contribute to siltation in the navigation channel. The three dimension hydrodynamic and sediment transport model in the Changjiang estuary was established, in which the TVD scheme was used to solve the advection term and sediment settling process. The model calculated water level, current and salinity were fairly well consistent with the observed ones. The impact of SSC on the density and turbulent coefficient were taken into account. The higher SSC will increase the density which could reduce the turbulence coefficient. Waves will lead to increase shear stress and turbulence, which led to increase SSC. The above measures make simulation of suspended sediment transportation more accurate. The numerical experiments verify that wave makes more sediment transported from the Jiuduansha shoal to the North Passage, which would make greater contribution to siltation in the navigation channel.

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A Numerical Study of the Sediment Transport Process from the Yellow River to the Bohai and the Yellow Seas

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Based on Ecomsed and Pomsed, a sediment numerical model was embedded into a three-dimensional baroclinic wave-tide-circulation model with 1/18 degree resolution covering the area of 24°~41°N and 117°~130.6°E, to simulate the transport, deposition and resuspension processes of the Yellow River-derived sediments. Effects of surface wave on sediments is discussed including wave-induced mixing and wave-enhanced bottom friction. The sediments from the Yellow River are vertically homogeneous in winter, while a high concentration appears at the upper level in spring and summer. The Yellow River-derived suspended sediment is transported first eastward along the northern coast of Shandong Peninsula, and then southward into the Yellow Sea. This transported direction remains the same all the year round. In addition to the river delta, the Yellow River-derived sediments deposit along the Shandong Peninsula on the Laizhou Gulf, the North Yellow Sea, and the South Yellow Sea. No sediment transport is found south of 33°N. The deposition center is between the 20~30m isobaths along Shandong Peninsula.

Wave plays a key role in the resuspension, when the water depth is lower than 20m, especially in a strong wind. The results in the Bohai Sea show that, when the wind speed is higher than 13m/s, the sediment resuspension due to wave-current interaction is 6 times of that without considering the waves. On the other hand, surface waves also play an important role in the vertical mixing of the upper layer.

Keywords: ECOMSED, POMSED, the Yellow River, the Bohai Sea, sediment transport, resuspension, deposition

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Distribution of suspended particles in the middle and northern Bohai Bay in summer and its relation with thermocline

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Based on the observed data at 312 stations in the middle and northern Bohai Bay in summer, the distribution of suspended particles concentration (SPC) in the Bohai Bay in summer was studied in this paper. In the horizontal distribution, it is higher concentration nearshore than offshore and at bottom than in surface. The distribution of SPC in the vertical direction can be divided into two types: increasing from surface to bottom and reaching a maximum value in the level of 10~15m. The vertical distribution of SPC is closely related to the thermocline.

Keywords: suspended particles, thermocline, Bohai Bay, summer

夏季渤海湾中北部悬浮体分布及其与温跃层的关系

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本文基于夏季渤海湾中北部 312 个站位的悬浮体观测资料, 细致刻画了夏季该海域的悬浮体浓度的分布特征, 并分析其形成原因。渤海湾中北部悬浮体水平分布表现出近岸高、远岸低, 底层高、表层低的分布趋势。悬浮体体积浓度的垂直分布表现为两种类型: 渤海湾的西部和中部的浅水海域, 由表至底悬浮体的体积浓度逐渐增大; 渤海湾湾口海域, 表、底层附近的悬浮体体积浓度随深度变化不大, 但在 10~15m 深度处出现极大值。悬浮体体积浓度这种垂直分布的差异性与温跃层的存在有关。

关键词: 悬浮体, 温跃层, 渤海湾, 夏季

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Simulation of the Yangtze River-derived sediment transport over the adjacent continental shelf

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The Yangtze River-derived sediment transport over the adjacent continental shelf is important for coastal structure design, fishing, environmental protection and pollution reduction. However, the transport process is really complex. In order to understand better about such a process, a three dimensional hydrodynamic model was set up first for the East China Sea (ECS) using the Regional Oceanic Modeling System (ROMS). The main circulations of ECS are successfully simulated such as the Kuroshio Current, Taiwan Warm Current and Zhejiang Fujian Coastal Current. The model results also show the intra-annual variation of the currents. After a series of verification, it is proved that the model is good enough for simulating the circulations of ECS. The Yangtze River-derived sediment is then added to study the sediment transport over the adjacent continental shelf. Initially, the number of the sediment bed layer is set to be zero on purpose of knowing better of the Yangtze River-derived sediment transport path. In the end, the intra-annual variations of the Yangtze River-derived sediment distribution over the adjacent continental shelf are achieved, and thus it is found that the model is a better tool to estimate the Yangtze River-derived sediment transport.

Keywords: Sediment transport, East China Sea, Continental shelf, Yangtze River, ROMS

长江携带的泥沙在毗邻陆架上输运的模拟

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长江携带的泥沙在毗邻陆架上的运移对沿海功能区划、海洋渔业、环境保护和降低污染都有着重要的影响。然而，泥沙入海后的输运过程却相当复杂。为了更好地了解这一复杂过程，本文首先利用 Regional Oceanic Modeling System (ROMS) 建立了东中国海的三维水动力模式。经过验证可以发现，本模式能够较好地模拟黑潮、台湾暖流和浙闽沿岸流等东中国海的主要环流及其年内变化。接着我们进一步利用 ROMS 泥沙输运模块模拟长江携带泥沙在陆架上的输运情况。为避免其他泥沙来源的影响，除长江外，其他区域泥沙含量均为零，且底层无泥沙分布。模拟结果显示出长江携带泥沙在毗邻陆架上的分布及其年内变化。研究表明模式是评估长江携带的泥沙在陆架上输运的一个较好的手段。

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Heavy metal pollution of Tambaraparni Estuary, Tamil Nadu, East coast of India

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Estuarine sediments in the fractions < 63 were collected from 13 stations with in Tambaraparni Estuary, located on the east coast of India. The distribution of heavy metals Cd, Co, Cr, Cu, Ni, Pb and Zn was recorded. The river and its tributaries posses its localized sedimentary traps where elevated concentrations were observed. Results were compared with the marine sediment quality standards (MSQS) as well as values reported in the literature to assess the pollution status of the estuarine sediments. The analysis distinguished two groups of elements. Firstly , Cd, Pb and Zn concentrations which occurred in higher than expected concentrations indicative of pollution . Secondly, Co, Cr, Cu and Ni which occurred at back ground levels. The study area recorded high concentrations (1200 µg/g) for Zn while the lowest concentrations (0.42 µg/g) for Cd. Results indicate that river runoff, industrial wastes, untreated domestic waters are major contributors to the heavy metal pollution of Tambaraparni estuary.

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Inter-comparison of sediment transport models: POM vs FVCOM

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This paper focuses on comparing the sediment transport model of The Finite-Volume Coastal Ocean Model (FVCOMSed) and the Princeton Ocean Model (POMSed), and modifying the models to produce consistent sediment distribution results. Running these two models with same conditions (for example open boundary, surface boundary, bottom boundary, external forcing). The objective of this study also involved the integration and application of the POM-Sed to FVCOM-Sed. In these two models the major difference is in the code used in calculating the vertical advection and vertical diffusion, among other smaller differences. A subroutine which calculates the net flux of bottom boundary was included in the FVCOM-STM, which calculates the net flux of the bottom boundary according to the magnitude of bottom shear stress; deposition would occur if the bottom shear stress is less than critical deposition stress otherwise erosion would will occur if bottom shear stress is more than critical erosion stress. In this study, we observed that code and parameter modifications to the FVCOM-Sed, produced consistent results to that by the POM-Sed in general.

Keywords: sediment, FVCOMsed, POMsed, comparison

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Numerical modeling of tidal current and sediment on the general planning scheme of Tonghai harbor at Nantong District

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2-D tidal and sediment numerical Model with triangular grids is set up to study the general planning scheme of Tonghai harbor at Nantong District based on the Yangtze estuary waterway maintenance management platform "SWEM2D / 3D". The model is fully validated and verified by the field observation data. The tidal current field is numerically simulated and studied on the general planning scheme of Tonghai harbor. According to the simulation results, the impacts of the general planning scheme on the nearby main waterways (main channel of Yangtze, Baimao channel, Beizhi channel xinkasha channel and fushan channel) are analyzed. The numerical simulation result shows: (1) The current on the Xuliujin section is further strengthened after the implementation of the general planning scheme . The impact scope of the general planning scheme is about 1.5km away from the harbor. (2) The affect of wharf engineering to Sutong Bridge is very small, its main navigable hole will keep stable (3) The general planning scheme of Tonghai Harbor has little influence on tidal force in the nearby main waterways, the general planning scheme is feasible.

Keywords: Yangtze estuary, Tonghai harbor at Nantong district, Tidal and sediment numerical Model

南通港通海港区总体规划潮流泥沙数学模型研究

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使用长江口航道维护管理核心计算平台《SWEM2D/3D》建立南通港通海港区所在区域的基于三角形网格的潮流泥沙数学模型, 在根据现场实测资料对模型进行了充分的验证的基础上, 对南通港通海港区总体规划方案进行了潮流场的数值模拟研究。对总体规划方案实施后对附近主要水道(长江主航道、白茆沙水道、北支水道、新开沙夹槽、福山倒套)的影响进行了分析, 研究表明:(1)港区工程实施后对于徐六泾河段而言, 是进一步加强了束流作用, 工程效应范围集中在束流段的上段及圈围线前沿约 1.5km 处;(2)码头工程对苏通大桥主通航孔影响较小, 主通航孔的情况基本不会改变。(3)总体规划方案对工程附近主要水道影响较小, 总体规划方案是可行的。

关键词: 长江口, 南通港通海港区, 潮流泥沙数学模型

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Session 3: Fluid mud transport and behavior

Resuspension and benthic boundary layer processes in high SSC environments

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According to the Ariathurai-Partheniades equation, the upward, vertical flux of fine-grained sediment due to resuspension is linearly related to near-bed shear stress, which causes increase of suspended sediment concentration (SSC) in the water column. Therefore, patterns of SSC changes may be used to derive the near-bed shear stress, under the conditions that there is a sufficient supply of fine-grained sediment on the bed (i.e., the bed always represents a material source) and the water mass is vertically well mixed (i.e., over the entire water column there is only weak density stratification). This provides an alternative approach to the evaluation of benthic boundary layer processes, in addition to the Von Kármán-Prandtl model of logarithmic velocity distribution. Analysis of the data sets of water level, tidal current velocity, suspended sediment concentration, water temperature and salinity, obtained from tidal cycle measurements carried out at 13 stations over the Jingtang Channel area, Hangzhou Bay, for spring, intermediate and neap tides in two different seasons, indicates that there are differences in the shear stress estimates between the two methods. In the Jingtang Channel, tidally induced resuspension is intense; generally, during spring tides the SSC is an order of magnitude higher than during the neaps. The use of the Von Kármán-Prandtl model overestimates the shear stress, as compared with the results derived on the basis of the Ariathurai-Partheniades equation. The presence of suspended sediment will reduce the near-bed shear stress, which does not require the condition of SSC induced density stratification. Furthermore, the erosion coefficient can be inferred from the time series of the SSC or its maximum during a spring-neap tidal cycle. The magnitude of this coefficient, together with the critical shear stress, controls the phase difference between the time series of the tidal current speed and the SSC. Different types of SSC patterns are possible and, therefore, the generalization that the highest SSC occurs in response to the largest tide range may not be accurate.

Keywords: Tidally-induced resuspension, fine-grained sediment, near-bed shear stress, erosion coefficient, Jingtang Channel

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高悬沙浓度环境的沉积物再悬浮与底部边界层过程

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根据 Ariathurai-Partheniades 公式, 再悬浮引起的细颗粒沉积物的垂向侵蚀通量与近底部切应力之间具有线性关系, 再悬浮作用导致水层中悬沙浓度的上升。因此, 悬沙浓度的时空变化可用来推算近底部切应力; 不过, 这种推算要满足两个条件, 一是海底有细颗粒沉积物的持续供给, 二是水层中的密度成层性要较弱 (否则会阻碍悬沙的垂向交换)。利用悬沙浓度来反演底部边界层过程, 这种方法是独立于 Von Kármán-Prandtl 模型的, 后者是根据水层的对数流速剖面来计算边界层参数的。在杭州湾东南部的金塘水道的 13 个站位进行了不同季节大、中、小潮期间的全潮水文观测, 所获水位、流速、流向、悬沙浓度、温盐度数据的分析表明, 用两种方法所得的近底部切应力是不同的。在金塘水道水域, 总体上潮致再悬浮过程是强烈的, 大潮期间的悬沙浓度比小潮期间高一个量级。相对于 Ariathurai-Partheniades 公式的推算结果, Von Kármán-Prandtl 模型高估了切应力, 说明悬沙浓度的提高会降低切应力, 而且这不需要悬沙浓度所导致的密度成层性的条件。此外, Ariathurai-Partheniades 公式中的侵蚀系数可以根据悬沙浓度的时间序列或大、小潮周期的最大悬沙浓度学来计算。侵蚀系数的大小与临界起动切应力共同决定了悬沙浓度时间序列与潮流流速时间序列之间的位相差, 通常所认为的最大潮差对应于最大悬沙浓度的说法实际上是不准确的。

关键词: 潮致再悬浮, 细颗粒沉积物, 近底部切应力, 侵蚀系数, 金塘水道

Hyperpycnal flows in estuaries: example of the Huanghe (Yellow River) Mouth

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Hyperpycnal flows in estuaries are unusually observed and thus not well understood; however, they are commonly believed to play critical role in sediment dispersal within estuarine systems. Due to extremely high sediment discharge, estuarine hyperpycnal flows had been a common feature of sediment dynamics off the Huanghe river mouth, as reported by Wright et al. in 1980s. During a cruise in the flood season of 1995 at the Huanghe River mouth 6 mooring stations were set for 25-hr simultaneous observations and the intra-tidal variations of estuarine hyperpycnal flows were recorded. Results of simultaneous observations at six mooring stations suggest that hyperpycnal flows off the Huanghe mouth are maintained by high concentration of river sediment and modulated by tides. The hyperpycnal flows start at the slack before high water and during the developing stage the bottom suspended sediment concentration increases rapidly while the salinity drastically decreases (an inverse salt wedge) and the median grain size of suspended particles within the hyperpycnal layer increases, creating a well sediment-stratified water column. Due to the energy dissipation from frictions at the bottom and top of the hyperpycnal flows, they begin attenuating at the slack before low water while the stratification of the water column becomes collapsed owing to the enhanced tidal mixing. As a result, both the sediment concentration and median grain size of suspended particles within bottom layer decreases. As coarser sediment particles are dumped on the seafloor, the hyperpycnal flows are no longer maintained. Such behaviors of hyperpycnal flows are closely associated with the variations of suspended sediment concentration and salinity, as well as the stratification or mixing of water column. Besides of the high-concentrated sediment input from the river, tidal straining has been regarded as controlling factor that governs the intra-tidal variation of sediment-induced stratification, as well as intra-tidal variations of hyperpycnal flows. The hyperpycnal flows contribute much to the sediment dispersal off the river mouth since nearly 90%

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of the river-laden sediment is delivered to the sea during the period when the hyperpycnal flows on the subaqueous slope are prominent.

Over the past 60 years human activities in the river basin have altered the nature of Huanghe system. Construction of large reservoirs within the river basin and soil-conservation practices have reduced the sediment flux to the sea by ~90% and altered the grain-size composition of suspended sediment delivered to the sea (30 μm now versus 18 μm before in median grain size), causing the lower channel to become another main sediment source in addition to the loess region in the middle reaches. Prior to the construction of the Xiaolangdi Reservoir which is located on the terminal of the middle reaches, the suspended sediment concentration at station Lijin, the last hydrographic station before the river enters the sea, was high enough ($>35 \text{ kg/m}^3$ in flood season) to offset the density contrast between freshwater and ambient seawater and thus to produce a hyperpycnal plume along the subaqueous bottom slope at the river mouth. A recent cruise in 2005 during the period of Water-Sediment Regulation by Xiaolangdi Reservoir suggested that the buoyant hypopycnal plume has been a common feature at the river mouth owing to the drastic decrease in concentration of suspended sediment discharged to the sea. The rapidly decreasing sediment discharge to the sea and the increasing grain size of suspended sediment not only changed the dispersal pattern of suspended sediment at the river mouth, but also modified the morphological features as indicated by the evident changes of shoreline and subaqueous slope.

Human perturbations from the river basin have been transferred along the hydrological pathway to the estuary and delta, and finally changed the process of estuarine sediment dynamics and delta morphology. The Huanghe presents an illustrative example to the river basin-coastal zone interactions in the context of global change and human activities.

Keywords: Hyperpycnal flow, Huanghe river mouth, Sediment dynamics, Human activities, Estuarine morphology

河口异重流：以黄河口为例

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河口异重流由于观测资料较少, 缺乏对其过程与机制的理解。河口异重流多发生在河流输沙量极高的河口, 因此在河口泥沙传输过程中扮演重要的角色。黄河入海泥沙量位居全球河流第二, 河口异重流成为过去黄河泥沙在河口和浅水陆架传输的基本动力特征, 上世纪八十年代的中美合作研究已对此进行了报道 (Wright et al., 1988, 1990)。在 1995 年的洪季进行的黄河口 6 站同步 25 小时连续观测完整地记录了河口异重流的潮周期内变化过程。观测结果表明, 河口异重流的产生和维持受控于河口高浓度泥沙输入, 并受河口潮汐混合的调制。河口异重流在涨潮初期开始发育, 伴随着底层泥沙浓度快速增加和盐度快速减小, 形成独特的倒盐水楔结构。在异重层内, 由于水体的湍动增强, 导致悬沙颗粒的粒径增大, 产生了明显的泥沙浓度主导的水体层化结构。异重流沿水下斜坡传输过程中, 由于底摩擦和上边界摩擦作用, 动能逐渐耗散, 异重流在落潮后期呈衰减趋势。异重层内粗颗粒泥沙在底床沉降, 大大降低了底层泥沙浓度和底层水体密度, 水体的垂向稳定结构崩塌, 导致河口底层异重流难以维持。观测到的泥沙浓度、悬浮颗粒的快速减少证实了这一变化过程。显然, 除河流高浓度泥沙输入外, 河口异重流的发育和稳定主要受控于河口的潮汐混合过程, 这一过程决定水体的层化与混合状态。而潮汐张力作用 (Tidal Straining) 控制潮周期内水体泥沙浓度层化结构变化, 与河口异重流的发育和衰减过程相吻合。泥沙传输通量的估算表明, 异重流是河口泥沙的重要传输通道。

然而, 最近 60 年来, 在人类活动和气候变化的驱动下, 黄河入海泥沙的通量、组成结构和季节性分配发生了重大变化, 黄河干流大型水利工程的修建和运行以及沿黄工农业耗水导致黄河入海泥沙减少 85%, 同时入海泥沙的粒径则快速增加, 由多年平均的 18 μm 增加至 30 μm 。入海泥沙浓度的快速减小和泥沙粒径的增加导致河口异重流的发生几率大大降低, 显著地改变了河口泥沙的传输路径和沉积范围, 引发河口地貌的快速响应。在空间上, 河口局地的快速淤积 (泥沙粒径粗化导致沉降速度加大) 和河口临近海岸的侵蚀 (泥沙传输范围缩小, 沿岸泥沙供应不足) 并存, 导致黄河三角洲呈现整体蚀退状态。

黄河流域内的人类活动引发了黄河河流物质通量、河口沉积动力过程和三角洲地貌演化产生一系列的快速反应和调整。如何认识其系列变化并预测未来所产生的环境效应是当前全球变化背景下流域—海岸带相互作用的重要科学命题。

A three-dimensional, wave-current coupled, sediment transport model for POM

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In the high-energy environment of coastal seas and estuaries, strong sediment resuspension/deposition events are driven by surface waves, tides, winds and buoyancy driven currents. In recent years, A POM based three-dimensional, wave-current coupled, sediment transport model has been developed by the University of New South Wales. This talk presents several examples of the model applications to study sediment dynamics in the environments where forcings such as waves, tides, and winds are equally important to affect sediment fluxes and distributions. Firstly, the sediment transport model coupled to the Adriatic Sea general circulation model and a third generation wave model SWAN was implemented in the Adriatic Sea to study the dynamics of the sediment transport and resuspension in the northern Adriatic Sea (Italy). The sediment distributions and fluxes under various forcing conditions such as the Po River plume, the Bora and Scirocco wind stress and the surface waves were studied by process oriented as well as realistic numerical simulations. Secondly, the sediment transport model was used to explore the effect of suspended sediment-induced stratification in the bottom boundary layer (BBL). The model uses a re-parameterized bottom drag coefficient C_d that incorporates a linear stability function of flux Richardson number R_f . The study has shown that the sediment induced stratification in the BBL reduces the vertical eddy viscosity and bottom shear stress in comparison with the model prediction in a neutrally stratified BBL. In response to these apparent reductions, the tidal current shear is increased and sediments are abnormally concentrated within a thin wall layer that is overlain by a thicker layer with much smaller concentration. The formation of this fluid-mud layer near the seabed has led to a significant reduction in the total sediment transport. This study contributes to the understanding of formations of tidal flats along the coasts of turbid seas and estuaries.

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Session 4: Sediment effect on biogeochemical processes

Dispersion of the Huanghe (Yellow River) sediment in the delta coast and adjacent Bohai Sea, and seasonal variability

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Most previous studies on the dispersion of the Huanghe sediment to the sea have focused on the river mouth area during the flood season of the Huanghe when sediment discharge is high and a unique sediment hyperpycnal flow from the river mouth to the sea is observed. Less attention has been paid to the sediment dispersion pattern in the other delta coastal area. No studies have yet demonstrated the sediment dispersion process or have quantitatively assessed the general pattern of dispersion and its seasonal variability.

Hydrographic and sediment data were collected during one synchronic multi-station hydrographic time-series survey along three transects in August, 2003 in low river water discharge and during two synchronic multi-station hydrographic time-series surveys along three transects in the delta coast and hydrographic surveys at 24 stations in the adjacent Bohai Sea in November, 2006, and in August, 2007. The sediment dispersion pattern and process of the Huanghe sediment in the delta coast and the Bohai Sea were studied. The seasonal variability was compared quantitatively.

Three tidal shear fronts were identified that in combination with the tidal currents were the dominant factors controlling the pattern of sediment dispersal based on the data in August 2003. Most of the river-laden suspended sediment from the river mouth was limited to the 5 m isobath of the mouth due to the barrier effect of the tidal shear front and the weak river flow. The sediment off the 5 m isobath transported northward or southward according to the direction of the alongshore ebb/flood tidal current. Shear fronts in the northern and southern shallow nearshore areas of the delta made the offshore sediment flux larger than the nearshore one, barring sediment transport and deposition close to the northern and southeastern coasts of the delta, and resulting in the formation of two erosion–accumulation transition zones with a drip-like subaqueous delta.. The summer survey in August 2007 show that the dispersal area of the Huanghe

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sediment to the sea was limited basically within the coastal zone to 20km from the coast in water depth of 13m even during the high water discharge period. However, the Huanghe diluted water dispersed widely, covering the north and middle part of the whole Laizhou Bay with its distal part in 70-80 km from the coast. The dispersal pattern of the diluted water is quite different from the sediment pattern. Two centers with high sediment concentrations were found in the river mouth area, and around the abandoned Diaokou river mouth area in corresponding to the sediment from the river mouth and the sediment from resuspension of the surface sediment in the abandoned river mouth, respectively. There was little sediment exchange between the two high sediment concentration centers. The barred and convergent effects of the tidal shear fronts near to the river mouth and off the delta coast were responsible for the limited dispersal of the Huanghe sediment within 13 m of the water depth. The wide dispersal of the Huanghe diluted water was controlled by the pattern of the surface residual currents. The residual currents and the sediment flux showed that the direction of the sediment dispersal was basically northeastward in summer season.

Under the winter regime in November 2006, the vertical mixing of the water column was quite strong due to the wave effect caused by the wind storm. The surface was resuspended intensively in the shallow coast area and the Bohai Sea forming the major sediment source in the study area. Three centers with high sediment concentrations were found in the river mouth area, old river mouth and around the abandoned Diaokou river mouth area. Strong southward coastal current was formed under the northern wind and southward wave induced current, and carried the sediment to be transported southward.

The sediment flux during winter regime was higher than that in summer by tens to hundred times, indicating that the most sediment in the study area is transporting in winter season. This conclusion is coincided with the basic pattern of the sediment dispersal as " summer accumulation, export in winter" in China seas.

黄河入海泥沙在黄河三角洲近岸及渤海的扩散和季节性对比

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前人对黄河入海泥沙扩散的研究, 主要集中在黄河口地区, 重点是洪季黄河高流量期间河口泥沙的扩散以及黄河口特有的泥沙异重流, 有关黄河入海泥沙在三角洲海岸的扩散很少关注, 黄河泥沙在三角洲海域及毗邻渤海的扩散的总体格局和定量评价及季节性变化尚未见报道。

本文以 2003 年 8 月黄河低流量期间沿岸海域 3 条断面多船同步连续站观测、2006 年 11 月冬季海况和 2007 年 8 月黄河调水调沙高流量期间 3 条断面多船同步连续站观测和 24 个大面站观测的水文泥沙资料为基础, 对黄河入海泥沙在黄河三角洲沿岸和相邻海域的扩散格局及其机制进行了研究, 并对冬夏两季不同海况下的泥沙扩散进行了定量性对比。

2003 年 8 月的观测表明, 在黄河三角洲沿岸由南而北存在 3 个潮流切变带, 在河口入海的泥沙受口门切变带的阻隔作用及低流量的影响, 大部分沉积在 5 米等深线以内。其余的泥沙在北向落潮流和南向涨潮流的搬运下在 5 米以外沿岸输送。受南北两侧潮流切变带的阻隔作用, 离岸站位的泥沙通量远大于近岸站, 沿岸泥沙无法在近岸区沉积, 从而在三角洲南北两侧形成两条侵蚀/沉积转换带, 形成了水滴状的水下三角洲冲淤形态。

2007 年 8 月夏季黄河调水调沙的大流量期间的观测表明, 入海泥沙扩散范围非常有限, 主要分布离岸约 20km 以内的带状沿岸区域; 但黄河冲淡水出现大面积扩散, 覆盖了整个莱州湾的北部和中部, 远端距岸约 70-80km, 显示泥沙扩散格局与冲淡水差异很大。在现行河口和钓口流路废弃河口存在两个独立的高浓度泥沙中心, 分别对应于现行河口和废弃河口两个不同成因的泥沙来源, 两个高浓度泥沙中心很少有泥沙交换。河口及三角洲近岸切变锋的阻隔及辐聚作用, 是大部分黄河入海泥沙沉积在河口及沿岸 13m 水深以内的主要动力因素。冲淡水的大面积扩散主要受表层余环流的影响。余流及悬浮泥沙通量计算显示, 夏季黄河入海水沙在近岸主要向东北方向扩散。

2006 年 11 月的冬季海况下, 由于风暴引起的波浪作用, 水体垂向混合均匀, 导致浅水的近岸区和毗邻渤海的底质沉积物方式强烈的再悬浮, 形成黄河口海域悬浮泥沙的主要来源。在钓口废弃河口区、现行河口及清水沟废弃河口形成三个高浓度悬浮泥沙中心。受北风和南向波浪的作用, 黄河三角洲海域产生较强的南向沿岸流, 携带再悬浮泥沙由三角洲北部海域向南输送。

冬季悬浮泥沙在输送通量是夏季的几倍甚至上百倍, 表明冬季是黄河三角洲毗邻海域悬浮泥沙输送的主要季节, 与中国东部陆架海悬浮泥沙“夏储冬输”的格局一致。

本文揭示了不同季节黄河入海泥沙沿岸的扩散格局和沉积动力机制, 定量地显示了泥沙输送的季节性差异, 解释了黄河入海泥沙扩散过程对黄河三角洲冲淤演化的影响。

Seasonal Variation of Particulate Phosphorus and its Potential Ecological Significance in the Changjiang Estuary and Adjacent East China Sea

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The Changjiang Estuary and the East China Sea is one of the largest shelf marginal seas in the world. Changjiang, the biggest river of China discharge 9×10^{11} m³ water and 4.86×10^8 t suspended particles per year into the East China Sea. On the basis of the two field investigations during the summer cruise in 2006, and winter cruise in 2007, nutrients and phosphorus species (DIP, dissolved inorganic phosphorus; DOP, dissolved organic phosphorus; POP, particulate organic phosphorus; PIP, particulate inorganic phosphorus) distributions in the Changjiang Estuary and adjacent East China Sea were discussed in order to understand the potential regeneration of particulate or organic phosphorus into phosphate. The DIP and TDP is higher along the coast, and gradually decline off the coast, the highest areas was observed in the mouth of the Changjiang and Hangzhou Bay. Both in summer and winter the distribution of PIP, POP and PP is very familiar with that of SPM. There is large spatial variation of phosphorus species in the study area. PIP is the main form of the surface water in the Hangzhou Bay, while DIP is the dominant form in the Changjiang Estuary and Subei coastal areas. The relative percentage of DOP and POP was increasing with the increasing of salinity along the section from the river to the open water, higher DOP and POP concentration was observed near the front area. These results suggests that organic phosphorus might provide potential nutrients for the phytoplankton when the nutrients was depleted at or out front areas.

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Dynamics on the intensified upwelling/downwelling over the shelf in the northeastern South China Sea

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Observational and modeling studies revealed that the intensifications of upwelling and nutrient enrichment in the northeastern South China Sea were formed as a result of intensified upslope advection of dense and nutrient-rich deep waters that crosses the mid shelf toward the inner shelf over a distinctly eastward widened shelf. Cross-shelf transport was amplified at the head of the widened shelf over the mid shelf and at the lee of the coastal cape over the inner shelf. The strong shoreward cross-isobath transport over the widened shelf was formed by a westward along-isobath pressure gradient force as a result of the net rate of the momentum influx over the diverging isobaths, and by an intensified bottom frictional transport at the head of the widened shelf. Enhanced stratification by the river plume enhanced the cross-shelf circulation in the upper water column such that the surface Ekman current and compensating flow beneath the plume were amplified. Yet, the plume over the shelf had little effect on the intensity of the shoaling of the deep dense water. The plume considerably speeded up the wind-driven current along the inshore edge of the plume, but retarded it along the offshore edge. The upwelling current was adjusted to a new dynamic balance invoked by the plume-induced changes of vertical viscosity and horizontal pressure gradient. High productivity upwelling waters inshore was co-existed with bloom from nutrient input from river plume which was initially confined in a bulge-shaped zone in the source and ensued with southeastward advection by the coastal jet. Under the similar dynamics of flow-shelf topography interaction, the widened shelf also serves as a cross-shelf conduit to transport cold and nutrient-rich shelf waters from East China Sea offshore during downwelling season.

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Organic Carbon Sources and Transportation Process in Changjiang Estuary and Adjacent East China Sea

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Seawater samples and surface sediments from the lower Yangtze River and adjacent East China Sea (ECS) shelf was characterized using elemental geochemical, stable carbon isotope, grain size and organic molecular biomarkers analysis. The results show that the grain size of suspended solid in seawater decreased from lower Yangtze River to estuary and along Zhejiang coast. There was a reverse trend between organic carbon, total nitrogen and grain size in sediment, reflecting organic carbon content was controlled by the fine-grained material which was controlled by hydrodynamic migration. By comparing organic carbon and grain size in sediment in 1981 and 2003, the correlation was closed between the reduction of grain size and the increase of organic carbon. Fine particles had specific surface area and can adsorb more organic carbon. The grain size in sediment core also showed the fine trend of deposition particulate matter in recent 20-30 years. This was beneficial to the accumulation of sedimentary organic carbon. soil organic carbon, marine organic carbon and relic organic carbon were the three main carbon sources in sediment. The trends in sedimentary TOC abundance indicated by high molecular weight n-alkane abundances and distributions, lignin-derived products, $\delta^{13}\text{C}$ values of total organic carbon ($\delta^{13}\text{C}$ TOC) and ratio of TOC to total nitrogen (C/N) suggest a southward (off-estuary) transport mode of TOC along the inner shelf transect while, counter intuitively, the opposite or no trend in TOM off-estuary transport occur along the cross-shelf transect. We therefore suggest that Yangtze-discharged OC was transported southwards along the Zhejiang coast and entered the Southern Okinawa Trough via near bottom currents, from where it was ultimately delivered back upslope to the middle shelf by the Kuroshio invading water, consistent with the hydro-chemical characteristics of the ECS.

Keywords: Changjiang Estuary, East China Sea, Organic Carbon, Sources, Transportation

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长江口及邻近东海有机碳的来源和运移过程

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对长江下游内河、长江河口及邻近东海的海水和沉积物样品, 进行了地球化学元素、稳定碳同位素、粒度和有机分子标志物的分析。结果表明: 沿长江下游到河口再到浙江沿岸, 海水中悬浮物的粒径逐渐降低。沉积物中有机碳、总氮和粒度的变化趋势相反, 反映了细颗粒物决定有机碳的含量, 而水动力过程控制细粒物质的运移从而控制有机碳的分布。通过对比 1981 年和 2003 年东海陆架有机碳和粒度的分布趋势, 表明沉积物中粒径的降低和有机碳的增加密切相关, 细颗粒比表面积大, 能吸附更多的有机碳。而柱样沉积物粒度分析结果也表明了该区域最近 20-30 年来的沉积变细的趋势, 这种趋势有利于沉积有机碳的积累。C/N 与有机碳 $\delta^{13}\text{C}$ 同位素线性关系表明长江输送有机碳的过程中, 其浓度分布在东海陆架海向递减, 与海源有机碳呈线形混合模式。通过有机分子标志物分析, 表明土壤有机碳, 海源有机碳, 残留有机碳是东海陆架三大主要碳库, 其比重随沉积环境的变化而变化。长江入海的陆源有机碳在浙闽沿岸流的夹带下南向运移, 大部分沿海岸线沉积下来, 呈带状堆积。另一部分在进一步南向传输中, 受台湾海峡高低隆升的阻隔和北上台湾暖流的夹带, 改变方向而向南冲绳海槽传输, 最终到达海槽深水区, 由于动力环境减弱而沉积下来。这部分沉积物又受入侵陆架的黑潮次表层水的夹带, 通过底流反向陆向传输, 可能存在着反循环模式。

关键词: 长江口, 东海, 有机碳, 来源, 运移

Session 5: Ecological and socio-economic Impacts

Effect of Reclamation between Islands in Complex Tidal Estuary on Hydrodynamic Sediment Environment

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The Oujiang Estuary is a very complex tidal estuary with many islands in Zhejiang province, China. Reclamation between islands will gain a great amount of land. In this paper, the feasibility of reclamation between Linkun Island and Niyu is studied from its impacts on hydrodynamic sediment environment. First, the natural hydrodynamic and sediment conditions and seabed evolution are analyzed according to in situ data. Second, numerical models of tidal current and sediment movement under the combined action of wave and current are set up with irregular triangular grid and used to carry out simulations. The study results show that (1) it is not a tidal passage between Linkun Island and Niyu. Wenzhou Shoal has been aggraded gradually, which is suited for reclamation; (2) the reclamation is feasible as far as its effect on surrounding hydrodynamic sediment environment is concerned; (3) the reclamation has great favorable socio-economic impacts.

Keywords: the Oujiang Estuary, tidal current, numerical model, Wenzhou Shoal, reclamation

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Variations of fluvial mass fluxes and their responses to natural and anthropogenic activities in the Liaodong Bay

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Data of flow, suspended sediment of four rivers, namely Daling river, Xiaoling river, Shuangtaizi river and Daliao river, entering into the north Liaodong bay, were collected to calculate the variations of water discharge and suspended sediment load in the past 50 years. With the method of Kendall rank correlation test and method of Mann-Kendall, the variations trend and mutation characteristics were analyzed. The results indicate that, generally, the water discharge demonstrated a decreased trend from 1960s to present. Meanwhile, the variations also showed obvious phasic features, that is, water discharge declined dramatically in the beginning of 1960s and in the end of 1970s, fluctuated drastically from 1980s to the middle of 1990s, and decreased sharply afterwards. Suspended sediment load exhibited the similar change to that of water discharge, but with greater variation.

Precipitation is natural background, and also the main reason for the change of water flow and suspended sediment loads. At the same time, human activities such as building of reservoirs, floodgates, and water and soil conservation also contribute a lot to the reduction of water and sediment loads.

Keywords: The Liaodong Bay, water discharge, sediment load, variation, anthropogenic activities

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Historical trends and sources of aliphatic and polycyclic aromatic hydrocarbons in the Bohai Sea, China elucidated from sediment cores

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The Bohai Sea located in North China is a shallow marginal sea enclosed by Liaodong and Shandong Peninsulas. Several large rivers, including Huanghe (Yellow River - the second largest sediment-load river in the world) drain into the Bohai Sea. The surrounding area of the Bohai Sea is a highly urbanized and industrialized region. The rapid industrialization and urbanization around the coastal regions has resulted in a severe environmental stress.

The marine sedimentary organic carbon (SOC) in the large-river dominated estuaries and their adjacent shelf seas plays a key role in the understanding of global carbon biogeochemical cycling. Hydrocarbons, the important constituents of the organic matter (OM), are ubiquitous in the sediments from the estuarine and coastal areas. Hydrocarbons in the sediments could originate from different sources: biogenic, diagenetic, petrogenic and pyrogenic. As the potential environmental contaminants, the aliphatic hydrocarbons (AH) and polycyclic aromatic hydrocarbons (PAHs) have also received much attention in recent years due to their prevalent occurrence and ecotoxicological concern in the marine environment especially in the coastal areas.

In this work, two sediment cores collected from the offshore (core B18) and central areas (core B178) of Bohai were analyzed to provide a better understanding of the temporal trends and sources of hydrocarbons in this area. The results indicated that concentration of total n-alkanes (C₁₃-C₃₅) in the core B18 ranged from 2.77 to 8.35 μg g⁻¹, with a mean of 4.97 μg g⁻¹, and from 1.22 to 5.91 μg g⁻¹ (averaged in 3.30 μg g⁻¹) in the core B178. The C/N ratios and n-alkanes profiles indicated that that the OM in the two cores was more characteristic of mixed origins, both from marine and terrestrial inputs. There seems no correlation between the ΣC₂₅₋₃₁ n-alkanes and TOC in the both two cores (R²<0. 1), which could be indicative of significant mix of input sources, including marine input and anthropogenic contamination. Total 16 US priority PAH concentrations in the core B18 ranged from 34.3 to 202.1 ng g⁻¹ with a mean value of 91.6 ng g⁻¹, while in the core B178 16 US priority PAHs ranged from 44.5

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to 186.3 ng g^{-1} , with a mean value of 101.1 ng g^{-1} . The historical trends of the 4 rings, and 5+6 rings PAHs (moderate to high molecular weight) could be more representative to evaluate the anthropogenic influence in the sediment cores for the past 100 years, and the temporal increasing trend of these 5+6 rings PAHs in both cores followed the economic development very well in the region from the beginning of 1980s. According to the ratios of PAHs with similar molecular weights, the pyrogenic PAHs in two cores were mainly from the incomplete combustion of coal or biomass burning.

Session 6: Posters

The grain size distribution of the suspended particulate matter in the Yellow River Estuary and its adjacent area in winter

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The grain size of suspended particulate matter in the Yellow River Estuary and its adjacent area was investigated with an in situ laser grain-size analyzer in November, 2006. The grain size parameters and distribution patterns vary strongly in the horizontal and vertical directions. The results show: 1) The mean grain-size of the suspended particulate matter ranges from 3.00~6.41 Φ , with an average value of 4.66 Φ . 2) The grain size distribution patterns of the suspended sediment included three types, e. g. mono-mode, dua-mode and tri-mode. 3) C-M patterns suggested that transportation forms of the suspended particulate matter not only included suspended transportation, but bed load transportation. The bed load transportation mainly appeared at bottom layer. The grain size pattern and distribution were basically controlled by the Yellow River discharge, hydrodynamics, surface sediment type, and chemical and biological conditions.

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Accumulation effect of shelf mud deposition on the distribution of Organochlorine pesticides (OCPs) in the Yellow and East China Seas

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Organochlorine pesticides (OCPs), as one of the groups of the persistent organic pollutants (POPs), are of environmental significance due to their widespread distribution in the environment and potential toxicity to organisms. China is ever the world's second largest producer of such pesticides and largely used them between 1950s and 1980s due to their low cost and high insecticidal efficacy.

Because of the low solubility and high affinity for organic matter, in the aquatic environment, OCPs are easily removed from the water column and adsorbed on the particulate matters, and finally accumulated in sediments, which were usually regarded as an important sink of organic contaminants. Particularly, these suspended particulate matters as an important medium, could significantly influence OCPs' transportation in aquatic environment as well as the further distribution in the sediments.

Recently, we have found that the effect of sedimentary hydrodynamics on the accumulation of sedimentary organic matter (Hu et al., 2009a), and the distribution of OCPs could also be influenced by the post-depositional sorption on the adjacent continental shelf (Hu et al., 2009b). In this work, about 60 surface sediment samples collected in 2007, mainly covering the continental mud areas of the Yellow and East China Sea were measure for OCPs to provide a better understanding of the influence factors controlling the accumulation and distribution of organic contaminants in these broader continental shelves. The results indicate that the levels of the OCPs in this work were relatively lower compared with those in other studies of the marine environment, due to the relatively far distance of these sampling sites from the coastline (>10 km for most sites). Higher levels of these OCPs in the coastal areas were obviously higher than those in other parts of this area, suggesting the possible direct contaminant loads from point and diffuse land-based sources. In addition, the high concentration levels of these pollutants was also found in the sediment situated within the patch mud areas with the finest sediment having the highest

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TOC there, suggesting the mechanism of shelf mud deposition controlled by the specific oceanographic hydrodynamic conditions in the typical semi-enclosed continental sea setting is an important factor for the distribution of OCPs in the surface sediments. The background values of DDTs (one species compound of OCPs) concentrations can be preliminarily established in the interval of 0.03 to 0.16 ng g⁻¹. This is consistent with the data from the bottom horizons sediment core samples collected using a gravity corer on the adjacent continental shelves in 2003, corresponding to the period of 1920s-1950s.

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