Estuaries of the World

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Jing Zhang
Editor

Ecological Continuum from the Changjiang (Yangtze River) Watersheds to the East China Sea Continental Margin

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Preface

The idea of publishing a monograph on the Changjiang (Yangtze River) Estuary came to us about 5 years ago, when a research team of State Key Laboratory of Estuarine and Coastal Research, East China Normal University (Shanghai) was awarded by the Natural Sciences Foundation of China (NSFC) with the title "Creative Research Group". This award offered an opportunity for creating a network for cross-disciplinary study from watersheds of Changjiang to the continental margin of East China Sea through joint efforts of East China Normal University with collaborations of other research institutions in China.

Among the top five largest rivers on this planet, Changjiang is unique in several aspects. For instance, the population density of Changjiang watersheds is on average ca. 250/km^2, which is high relative to other river systems like the Amazon, Congo, Orinoco, and Brahmaputra. Hydraulic engineering is also very extensive in the watersheds of Changjiang, more than 50×10^3 reservoirs have been created through dam constructions over the past 60 years; agricultural activities are intensive with application of huge amount of chemical fertilizers that cause continuous increase in the concentration of plant nutrients (e.g. dissolved inorganic nitrogen) in river water over the past five decades. Therefore, if someone would like to know how human activities affect the river drainage basin with consequences of change in seaward fluxes, the lessons we have learned through cross-disciplinary studies in the Changjiang would be an example to refer to.

The East China Sea has 71 % of shelf area, which is among the top 10 largest continental margins of the world. The western boundary current of the Pacific Ocean at sub-tropical and temperate region, i.e. Kuroshio, flows through the East China Sea with a water flux of 25–30 Sv (1 Sv = 10^6 m^3/s), similar to the Gulf Stream of the North Atlantic Ocean. So if a colleague would like to examine how the interaction between boundary current and large rivers over a wide shelf area can affect the coastal ecosystems through biogeochemical dynamics, the results from the East China Sea can be an illustration. Indeed, when examining the complex aspects of land-ocean interactions, watersheds of the river and the recipient coastal environment have to be taken into consideration together, both for the merit of scientific research and for the purpose of adaptive management of ecosystems.

People may believe that rivers have an important effect on the coastal environment, indeed standing by the bank and/or on the bridge, one can be deeply impressed by the large quantity of water and sediments carried by the river flow to the ocean; for example, the Changjiang has a water flux of ca. 30×10^3 m^3/s and a river mouth 90 km wide. This impression is, however, not necessarily true. In the case of East China Sea, the exchange of Kuroshio with shelf amounts to 3–4 Sv of water, including the water flow through Taiwan Strait, which is almost two orders of magnitude higher than the collective fresh water influx in which Changjiang accounts for 90 %. Thus, the exchange of energy and materials across the shelf break can have a dramatic impact not only on the circulation and biogeochemical cycles of coastal environment that drives the function of ecosystem through bottom-up mechanism, but also the fate of terrestrial pollutants over the shelf, and the export flux into the open ocean, with strong feedback to the atmosphere as well (e.g. uptake and/or emission of CO_2). In this aspect, the multidisciplinary studies of East China Sea have provided the audience with knowledge and experience.

The systematic research activities of Changjiang started in the 1950s, and the Institute of Estuarine and Coastal Research at East China Normal University was established in 1957, among the first groups of research institutions focusing on the estuarine and coastal sciences. In the 1990s, the Institute of Estuarine and Coastal Research at East China Normal University was promoted to be the State Kay Laboratory of Estuarine and Coastal Research with three cross-linked foci: geomorphology and climate change, hydrography and sedimentary dynamics, biogeochemistry and ecology, with broad collaborations with other research institutions in China. Thus, the results presented in this book show the recent research progress that is based on the synthesis of existing knowledge and digestion of data generated by a multidisciplinary team. It should be kept in mind, however, that this monograph provides by no means a historical overview of scientific approaches on the "Ecological Continuum from the Changjiang (Yangtze River) Watersheds to the East China Sea Continental Margin" nor a summary of previous research results. Rather, in this book we tried to examine the very dynamic system in the continuum from the watersheds of Changjiang to the continental margin of East China Sea through the critical point of view of ecosystem function, which needs absolutely an approach of cross-disciplinary studies. As the reader can see from this work, the individual chapters of this monograph cover the research disciplines of hydrodynamics, sedimentary geology, geography and geo-morphology, ecology, fishery, as well as biogeochemistry and environmental sciences, etc.

We believe that knowledge generated from the watersheds of Changjiang across to the East China Sea is useful as reference to the scholar of land-ocean studies in the continuum of the river drainage basin to the continental margins. We hope that the lessons learned from the Changjiang watersheds and East China Sea will help colleagues to avoid having similar negative effects when promoting economic innovations in other places in the world.

Undertaking cross-disciplinary studies is a team work and needs continuous financial and logistic countenance. Although at the end of individual chapters my colleagues have expressed their gratitude to their colleagues, I would like to thank those people again, including our friends and students who have helped in the elaboration of field and sea-going observations as well as the generation of data in the laboratory. Also, I appreciate very much our funding agencies, particularly the Natural Sciences Foundation of China (NSFC), Ministry of Education (MOE), Ministry of Science and Technology (MOST) as well as the Municipality of Shanghai through its Commission of Science and Technology, for their continuous supports to the research efforts in this monograph.

Before ending this preface, we would like to take this opportunity to express our gratitude to Prof. Jean-Paul Ducrotoy who guided us in preparing for this monograph. Colleagues from Springer, including Alexandrine Cheronet, Judith Terpos, and Betty van Herk, etc., are acknowledged for their very kind support in publishing this work.

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Prologue

The importance of understanding the estuary, its watershed and the adjacent coastal habitats as a continuum.

Coastal ecosystems, estuaries in particular, are under strong influence of their watershed as they consist of semi-enclosed basins receiving water directly from a riverine basin. They are permanently connected to the sea whose waters are diluted by freshwater drainage and run-off. Estuaries maintain exceptionally high levels of biological productivity and play important ecological roles, including water purification, 'exporting' nutrients and organic materials to outside waters through tidal circulation; providing habitats for a number of commercially or recreationally valuable fish species; and serving the needs of migratory bird species which require areas for breeding and/or sanctuary for their young. In fact, influences come both from the adjacent land and the ocean, particularly when the tide exerts a significant effect on currents dynamics.

The importance of hydrology to understand the functioning of estuaries has been widely recognized by the scientific community. In this book "Ecological Continuum from the Changjiang (Yangtze River) Watersheds to the East China Sea Continental Margin", in the series Estuaries of the World, the aim is to understand the relationship between hydrology and function of estuarine wetlands and peripheral estuarine areas, stressing their importance and the need for preserving and restoring them when necessary. In mega-tidal estuaries, differential degrees of sediment mobility show crucial effects on the zonation of flora and fauna in the tidal flat. Spatial and temporal variations of tide as well as its harmonic constituents, form and distortion in the Changjiang Estuary were obtained in order to better understand hydrological processes that are responsible for the evolution of the variability within and across the various habitats and their functional value. They govern the movement of materials and organisms between the estuary and adjacent marshes, the watershed, groundwater and the atmosphere. Wind, especially, can push forward intruding saltwater in the Changjiang Estuary.

Similarly, the estuary connects marine and continental influences by sedimentary processes that combine fluvial and marine processes. The physical forces involved in shaping the morphology of an estuary and especially sediment distribution vary along a gradient from marine sands in the mouth to muddy sand and mud at the head of the estuary. In the Changjiang, seasonal variations in water and sediment discharge are monsoon-governed. Particle fluxes to mid-water depths in the adjacent sea are mainly controlled by fluvial discharge and primary production. It is of note that fluvial discharge could be responsible for the higher lithogenic fluxes during autumn and winter, while high primary production could play a key role in generating biogenic particles during spring and summer. Siltation is related to sedimentation rates associating themselves with the highest tidal amplitudes (in relation to the lunar cycle), resulting from the increased availability of sediments associated with high concentration of suspended matter in the turbidity maximum. The evolution of such systems results in maturity stages more or less advanced, shaped by human intervention. The accelerated filling of estuaries develops from the movement of sedimentary deposits by reducing the available space in the upper estuary due to anthropic land claim. In the Changjiang, estuarine and coastal responses to the decline of river sediment discharge have had a substantial impact on the geography of the mouth of the estuary. In the future, the combined effects of the tide and the increase in average sea level will contribute to change the position of the coastline, with varying degrees of potential consequences from erosion. Monitoring its position requires the implementation of hydro-sedimentary modelling that takes into account both climate change, astronomical and average sea level using tide models, wave and sediment transport quantification. In this book, monitoring data and question-orientated research activities cover a period of ca. 20 years, with the erosion of mudflats being taken into account in the models.

Nutrient material recycled in the mudflats adopts a seasonal behaviour, which is mainly influenced by changes in hydrodynamics. The release, including ammonium, is mainly related to the mineralization of organic matter, while phosphate release is delayed, probably because of the combination of phosphate with organic matter and/or his co-precipitation with calcium. In the Changjiang, changes in nutrient concentrations have been recorded in relation to the construction of dams upstream, but in the lower estuary nitrification is rapid and complete. This behaviour is related to the different sedimentary hydro conditions of the systems because of nitrifying bacteria associated with suspended particles that depend on the estuarine dynamics. Here, multiple biomarkers have been used to elucidate the complex relationship between a large river and the estuarine system. Particulate phosphorus in the turbidity maximum area is a possible source of dissolved inorganic phosphate, available for algae growth. Instead of playing a nutrient conservation role, the turbidity maximum of the estuary area can promote coastal eutrophication as the biogeochemistry of nutrients and trace elements over the East China Sea Shelf is linked to river input.

Benthic organisms respond to changes in particulate fluxes of mineral and organic matter in relation to the depth of the photic layer. The succession of plant communities on salt marshes in the Changjiang Estuary is described in the book and the patterns of spatial and temporal variation on salt marshes are analysed on the basis of remote sensing mapping combined with field data from the survey of sampling plots. In particular, the expansion of the exotic species *Spartina alterniflora* after its introduction to the salt marshes in the Changjiang Estuary is described and analysed. The future development, management and preservation of salt marsh vegetation and biodiversity is discussed.

It is essential to understand how coastal discharge has a bearing on marine environment quality. However, despite organic and chemical contamination from human activities, estuaries, even industrialized, remain essential relay ecosystems. Estuaries constitute main transition zones or ecotones between land, the ocean and the atmosphere. As ecotones, they need to be preserved in their complexity. In order to define strategies compatible with conservation and sustainable development at the local, national and regional levels, environmental aspects must be integrated in the management of estuaries, which must rely on thorough collaboration between and mutual understanding of all actors and stakeholders. In Eastern China, domestic sewage discharge per capita has increased significantly in the past few decades, especially in metropolitan cities such as Shanghai. Illegal reclamation and dumping have also had adverse effects on the marine environment. Increased use of fertilizers to promote higher agricultural crop yields has directly impacted water quality in the East China Sea, leading to widespread eutrophication, followed by frequent harmful algal blooms. Incidents such as oil spills have had serious impacts on the marine ecosystem. River inputs represent the largest source of water pollution in the East China Sea, but sewage outfalls, mariculture, engineering activities, agriculture and non-point source pollutants are other key contributors. Resting on a rigorous scientific approach, restoring ecological functionalities in an estuary is dependent on efficient procedures of socio-ecological. For making interdisciplinarity work, socio-economics needs to be considered in the early stages of the elaboration of any restoration programme. Taking into account the ecological continuum between the estuary, its watershed and the adjacent coastal habitats is essential in providing robust scientific information to decision-makers and managers. However, the concept of continuum should also be applied to decision-making processes through the integration of science into decision-making. The prioritisation of human "well-being" might be a good way to focus on pressures and impacts inflicted to ecosystems, emphasising the ensuing suboptimal health of 'natural systems', including human and animal life in existence within these systems. Therefore, the eco-systemic approach requires understanding of, first, social, political, economic and, secondly, ecological structures and functions fundamental to healthcare provision for growing populations. Ecology stands out as a key component considering such a continuum and to understanding the instrumental factors to decision-making bottlenecks and to identify weaknesses in socio-economic systems.

Jing Zhang

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Editor Biography

Jing Zhang is a full professor at the State Key Laboratory of Estuarine and Coastal Research, East China Normal University at Shanghai, China. While working as a mentor for postgraduate studies, he teaches chemical oceanography and biogeochemistry. He completed undergraduate studies in Nanjing University (China), received his M.Sc. from Ocean University of Qingdao (China) and Ph.D. from Universite Pierre et Marie Curie (Paris 6) in France.

The research experience of JZ has been in multidisciplinary studies from river watersheds to continental margins, where he and his colleagues worked on the transfer and transformation of chemical elements at land–ocean interfaces and the impacts on the food-web structure and ecosystem function.

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