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Editorial: Eutrophication, algal bloom, hypoxia and ocean acidification in large river estuaries, volume II

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Editorial on the Research Topic
Eutrophication, algal bloom, hypoxia and ocean acidification in large river estuaries, volume II

Estuaries, which are the critical areas where freshwater from rivers mixes with saltwater from the sea, have undergone significant changes in recent decades. These transitional regions, serving as a connection between land and sea, are experiencing increasing anthropogenic and climate change pressures, including eutrophication, artificial construction, wetland degradation, and overfishing. Biogeochemical/ecological issues such as eutrophication, harmful algal blooms, hypoxia, and ocean acidification have become pressing concerns worldwide, drawing the attention of estuarine scientists and policy managers. Long-term observations have revealed the rising issues in large river estuaries.

In this Research Topic, papers covered key concerns of the Research Topic, including nutrients, phytoplankton, hypoxia and benthic organisms. The majority of the seven papers focused on the Chinese Estuaries, while one explored the Chesapeake Bay. Diverse methods were employed, include ship-based observation, physical-biogeochemical coupled model, and controlled incubation experiments. The findings showed that eutrophication, algal blooms, hypoxia in large river estuaries could be highly coupled, but occasionally de-coupled. The high riverine nutrient inputs exert strong impact on the phytoplankton growth and community structures. In addition, the upper layer algal growth and biological carbon production significantly influence bottom water chemistry and benthos. Natural factors such as wind patterns, ocean circulation, also influence biogeochemical cycles in large river estuaries.

Sun et al. investigated the effects of flooding on nutrient offshore transports in the Changjiang Estuary and adjacent East China Sea using data from the historical flooding year 2020, and comparing it with other years. Their results indicate that flooding leads to enormous riverine nutrient inputs and higher nutrient concentrations in the outer estuary. A detached low-salinity water patch with high dissolved inorganic nitrate was observed. A mixing model was used to identify nutrient contributions and biological processes, showing that offshore transport of the low-salinity, high-DIN water patch during flooding could probably have a significant influence on biogeochemical cycles in the broad shelf.

Three studies of this Research Topic focused on phytoplankton in the estuaries, while using different methods. In the Changjiang Estuary, Li et al. examined the photosynthetic characteristics and biomass accumulation of phytoplankton in the Changjiang Estuary and adjacent sea using active fluorescence measurements during cruises. The photosynthetic physiology of phytoplankton varied significantly among the different water bodies, with the highest activity near the front of Changjiang Diluted Water. Phytoplankton photosynthesis was relieved from light limitation downstream of the river mouth and benefited from phosphorus supply *via* tidal mixing and upwelling. However, nutrients further limited phytoplankton offshore in the East China Sea. As for Fu et al., incubation experiments were applied to investigate the impact of viral infection on the growth and photosynthetic performance of *Emiliania huxleyi* (BOF92) under different salinity and CO_2 levels. The results show that viral infection decreases the growth, photochemical efficiency, and photosynthetic carbon fixation of *E. huxleyi*. Lowered salinity exacerbates the impacts of viral infection, while elevated pCO_2 alleviates the impacts on photosynthetic performance but enhances virus burst size. Their study concludes that reduced salinity under elevated pCO_2 exacerbates the impact of the virus on *E. huxleyi*, leading to higher burst sizes and lower photosynthetic carbon fixation. In the Chesapeake Bay, Horemans et al. developed empirical habitat suitability models to forecast harmful algal bloom (HABs) occurrences using physical-biogeochemical environmental conditions. They identified water temperature, salinity, pH, solar irradiance, and total organic nitrogen as the most suitable set of variables by comparing goodness-of-fit of more than 16,000 combinations of variables. The resulting algorithm forecasted *Prorocentrum minimum* blooms with an overall accuracy of 78%, though with a significant variability depending on region and season. The study also found that the influence of predictors of these blooms change in time and space, and that model complexity impacts model performance and interpretation of driving factors.

Two studies explored the interaction of physical forcing and biogeochemical factors on hypoxia in the Changjiang Estuary. Miao et al. investigated the role of wind mixing in regulating dissolved oxygen variability off the Changjiang Estuary. Repeat transect observations were conducted throughout a fresh wind event in summer. Their results showed that wind-induced physical mixing transported dissolved oxygen downward but had a limited contribution to the water-column DO budget, while upwards nutrients induced by mixing fueled larger areas of algae bloom and subsequent substantial oxygen consumption. Wang et al. found both typical bottom hypoxia in the submarine canyon and subsurface oxygen minima (SOM) in the mid-layer of 10-15m off the Changjiang Estuary. The SOM phenomenon was located in the lower boundary of the pycnocline and above the Taiwan warm current and Kuroshio subsurface water. Their study revealed that the subsurface oxygen minima were predominantly controlled by remineralization and bottom-flushing effects. The flushing effects of offshore waters were found to reshape the hypoxia structure and alleviate the hypoxia severity in the south hypoxia area off the Changjiang Estuary.

Jia et al. analyzed the relationship between the environment and macrobenthic communities in the Hangzhou Bay, which is affected by the pollutions from the Yangtze River, Qiantang River. Macrobenthos were dominated by crustaceans in the Qiantang River Estuary and polychaetes elsewhere. Negative correlations were found between the abundances of certain polychaetes and salinity and pH, while positive correlations were found for other taxa. Their study provides baseline data for understanding the ecosystem health and conservation of macrobenthos in this highly polluted bay.

In all, these papers revealed new insights to the impacts of anthropogenic and natural forcing on biogeochemical processes in the large river estuaries. They provide a valuable contribution to the understanding of the complexities of estuarine systems and the impact of human activities on these ecosystems. The papers in this volume also demonstrate the need for a holistic approach to study estuaries and the urgent need for action to mitigate the impact of anthropogenic and climate change pressures on these vital ecosystems. The results and methodologies employed in these investigations should be relevant and valuable for estuarine researchers and managers around the globe.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication

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