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EDITED AND REVIEWED BY
Eric 'Pieter Achterberg,
Helmholtz Association of German Research Centres (HZ), Germany

*CORRESPONDENCE
Wenyan Zhang
wenyan.zhang@hereon.de

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Editorial: Multi-scale variability of ecosystem functioning in European and Chinese shelf seas

Wenyan Zhang[1]*, Xueen Chen[2], Jun Sun[3], Qicheng Meng[4], Jie Nie[2] and Ute Daewel[1]

[1]Institute of Coastal Systems, Helmholtz-Zentrum Hereon, Geesthacht, Germany, [2]College of Oceanic and Atmospheric Sciences, Ocean University of China, Qingdao, China, [3]State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences (Wuhan), Wuhan, China, [4]State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou, China

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Editorial on the Research Topic
Multi-scale variability of ecosystem functioning in European and Chinese shelf seas

Coastal and shelf seas constitute the most dynamic part of the Earth surface where intense interactions between geosphere, ecosphere and anthroposphere take place. They process and accumulate continent-derived material (sediments, nutrients, contaminants, etc.), serve as cradles for life and contain the highest biodiversity in the Earth system. Coastal ecosystems are among the world's most productive ecosystems that provide important functioning to sustain natural resources and carbon cycle (von Storch et al., 2021). On the other hand, these transitional ecosystems are highly vulnerable to multiple stressors including climate change, nutrient loading, pollution and fishing. Systematic changes in ecosystem functioning have been observed in coastal areas that are heavily affected by proliferation of industries, agriculture, and aquaculture (Halpern et al., 2019). Biogeochemical responses of the systems to external drivers are often nonlinear, involving feedback that may amplify or dampen a perturbation imposed to the system (Martiny et al., 2022). A profound understanding of the sensitivity of coastal ecosystem functioning to physical and biogeochemical perturbations necessitates a comparative assessment between different coastal shelf seas.

This topical collection serves as a platform for more efficient knowledge share and distribution through a comparative assessment between distinct coastal shelf systems in China and Europe to further our understanding of complicated ecosystem dynamics in response to a changing climate and increasing anthropogenic pressure. The studies aim to derive a deepened understanding of the sensitivity of coastal shelf ecosystem functioning to physical and biogeochemical perturbations, the role of shelf seas in global carbon cycling,

and the resilience of Chinese and European shelf seas to ongoing and future changes in climate and anthropogenic activities. Fifteen research articles have been collected on this Research Topic, as summarized below.

Most articles in the Research Topic focus on the variability of driving forces and ecosystem response. Tidal forcing, as one of the regionally dominant physical forcing mechanisms, regulates the mixing-stratification status of the water column that acts as a major control for biological productivity on many shelf seas. In the study by Kossak et al., a coupled hydrodynamic–biogeochemical modeling system was used to quantify the tidal impacts on primary production on the northwest European shelf. Their results suggest that tidal forcing increases biological productivity and that around 16% of annual mean primary production on the shelf is related to tidal forcing. The tidally enhanced turbulent mixing of nutrients fuels new production in the seasonally stratified parts of the shelf seas, which may impact the air–sea CO_2 exchange at a regional scale. Wind forcing has also been identified as a pivotal factor driving the climate variability of shelf primary production. Lin et al. found a significantly positive correlation between anomalies of the monthly mean of the summer sea surface Chl-a and wind speed at the continental slope region in the southwestern Yellow Sea where strong wind-driven upwelling occurs. The dissolved inorganic nitrogen (DIN), phosphorus, and silicate fluxes contributed by wind-driven upwelling were estimated to account for 30%-40% of total nutrient supply. In addition, in this region, the interannual variability of the summer mean Chl-a was negatively correlated to both the Pacific Decadal Oscillation (PDO) and El Niño-Southern Oscillation (ENSO) indexes, due to the opposite phase of the summer wind anomaly and the PDO/ENSO. Wang et al. investigated the environmental variables controlling the seasonal dynamics of phytoplankton in the coastal Yellow Sea and found that the water temperature and dissolved inorganic nitrogen (DIN) act as the key drivers controlling the seasonal variability of phytoplankton community in the region. This confirms the role of wind forcing in controlling primary production in shelf seas. In addition, they found significant correlations between phytoplankton abundance and heavy metals Zn, As, and Hg, suggesting that these metals also had potential influences on the seasonal dynamics of phytoplankton community in the coastal Yellow Sea.

At a longer time scale, sea level variability also impacts the socio- cultural and natural ecosystems of the coastal regions in shelf seas. Li et al. analyzed satellite altimetry data from 1993 to 2020 for the Bohai, Yellow Sea, and East China Sea, and identified monsoons, atmospheric forcing, ocean circulation, wind-driven Ekman transport, and the Kuroshio as the primary factors influencing the sea level variability in these regions at a seasonal scale. Furthermore, the sea level variations exhibit a sensitive response to strong El Niño years, with a clear regionalization of the response, which is related to the intricate atmospheric circulation and local wind pressures, as well as the influence of ocean circulation. Large-scale climate modes such as the El Niño-Southern Oscillation and Dipole Mode Index strongly modulate not only sea level variability, and wind forcing but also the co-occurrence of compound extreme events that impact ecosystem functioning in shelf seas. In the investigation by Chen et al., the southwest sections of the South China Sea (WSCS) and Indonesian Seas were identified the hotspots for compound events of marine heat waves (MHW) and low-chlorophyll (LChl) events, with total MHW-LChl days that are more than 2.5 times higher than in the other sub-regions. Notably, there is a trend toward more frequent d/decade), stronger, and longer-lasting MHW-LChl occurrences in the WSCS. The occurrence of compound MHW-LChl extremes exhibits remarkable seasonal differences, with most of these events transpiring during winter. Moreover, there are generally statistically significant increasing trends in MHW-LChl events for all properties on both seasonal and inter-annual timescales that are driven by large-scale climate modes.

In addition to natural forces, human activities present another important driver for development of coastal and marine ecosystems. Morphological change induced by human activities (navigation channel dredging, sand mining, land reclamation) and sea level rise could significantly enhance stratification which consequently affect particulate transport and development of hypoxia (Ma et al.). Stratification caused by temperature gradient has also been identified as a main physical factor for promoting seasonal hypoxia in the Bohai Bay by (Zhang et al.). This also significantly affects the distribution of Dimethyl sulfide (DMS) and dimethylsulfoniopropionate (DMSP) in summer in the Bohai Sea and North Yellow Sea (Guo et al.) as well as production and sedimentation of marine planktonic Ciliophora in the region (Yu et al.). Human-induced nutrient loading from land has also led to rising nitrogen (N) to phosphorus (P) ratios and decreasing silicon (Si) to N and P ratios according to the study by (Shi et al.). Such changes in the stoichiometric relationship of nutrient species also alter the community structure of the primary producers.

Management becomes indispensable to mitigate the deterioration of shelf sea ecosystems in response to climate change and human impact. Yan et al. proposed a theoretical framework for the sustainable development of coastal regions, integrating land-sea management with so-called coupling coordination theory. Using a coupling coordination theoretical model, the study examines the sustainable development of the coastal provinces and cities around the Bohai Sea, from 2006 to 2020. The findings highlight an S-shaped spiral trend in the region's sustainable development trajectory, with the economic subsystem playing a crucial role. The study underscores the importance of eco-environmental governance for promoting positive interactions among systems. Additionally, it notes differences in sustainable development between coastal cities and their respective provinces, suggesting that adaptive policies in economic, social, and environmental domains are essential for fostering sustainable development.

In summary, these articles provide new insights to further our understanding of complicated shelf sea ecosystem dynamics in response to a changing climate and increasing anthropogenic pressure. The findings of this Research Topic should be of interest to a broad community of researchers and stakeholders worldwide.

Author contributions

WZ: Conceptualization, Funding acquisition, Writing – original draft, Writing – review & editing. XC: Funding acquisition, Writing – original draft, Writing – review & editing. JS: Writing – original draft, Writing – review & editing. QM: Writing – original draft, Writing – review & editing. JN: Writing – original draft, Writing – review & editing. UD: Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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