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Editorial

Dynamics of ecosystems and anthropogenic drivers in the Yellow Sea Large Marine Ecosystem

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In the developed world, governance of marine ecological environment is the important part of the national ecological and economic outcome. The Yellow Sea is one of large marine ecosystems in the seas of East Asia, which is an extension of one of the largest continental shelf areas, and forms a huge but shallow sediment body in its south area which is geographically unique in the world. As a region with the most fragile natural environment, unparalleled global ecological significance and the most urgent protection needs, the Yellow Sea ecological zone is becoming a common concern of countries around the Yellow Sea and beyond, such as tidal flats and the staging migratory birds (Murray et al., 2015).

The international research plans on the large marine ecosystems have been in full swing (Sherman, 2015). The Yellow Sea Large Marine Ecosystem (YSLME) is a water body bordered by China, R. O. Korea and D. P. R. Korea, with shallow and nutrient-enriched water, covering an area of 400 000 km^2. The YSLME experiences intensive human activities and global environmental changes, such as nutrients (nitrogen, phosphorus) overload, pollution, global warming, ocean acidification, etc. Rivers discharge about 1.6 billion ton per year of sediment and 1 500 billion ton per year of freshwater into the Yellow Sea. The low flushing rate between the Yellow Sea and East China Sea of one every seven years, combined with weak water circulation, makes this sea vulnerable to pollution and its coastal areas highly susceptible to localized pollution discharges. Qingdao, Dalian, Shanghai, Seoul/Incheon and Pyongyang/Nampo are the five cities with over tens of millions of inhabitants bordering the sea. This population relies on the YSLME's ecosystem carrying capacity to provide capture fisheries in excess of two million ton per year, mariculture over 14 million ton per year, support for wildlife, provision of bathing beaches and tourism, and its capacity to absorb nutrients and other pollutants (Kim et al., 2011; Liu and Su, 2017; Zhou et al., 2018). Yet fishing efforts increased threefold between the 1960s and early 1980s, during which time the proportion of demersal species, such as small and large yellow croakers, hairtail, flatfish and cod, declined by more than 40 percent in terms of biomass. The change of food resources (biomass yields, high-value dominant species, trophic level, and biodiversity) in the YSLME are in declining changing trends over the past half century as a response to multiple stressors (Tang, 2009). Other major transboundary problems include increasing discharge of pollutants (Mi et al., 2019; Wang et al., 2018; Zhang et al., 2013), changes to ecosystem structure leading to an increase in jellyfish and harmful algal blooms (Dong et al., 2010; Smetacek and Zingone, 2013), and 40 percent loss of coastal wetlands from reclamation and conversion projects. The ecosystem service values for the Yellow Sea tidal flats decreased from 21 billion USD per year in the 1980s to 14 billion USD per year in the 2010s, reflecting great loss of ecosystem services (Yim et al., 2018). The environmental foundation needed to sustain economic growth may be irreversibly altered, and the important human health implications of a deteriorating environment such as increased agriculture and food contamination and air and water pollution, have resulted in a series of efforts to improve the environment, in particular the implementation of the concept of ecological civilization in China and green growth in R. O. Korea which indicate readiness for environmental transformation.

The YSLME is well-known for rich variety of marine living resources, biodiversity and primary productivity. It encompasses a major part of world's fish catch and aquaculture. Totally, 113 families and 321 fish taxa have been recorded in the YSLME (Liu and Ning, 2011). Recently, the YSLME is experiencing severe ecological risks, such as frequent *Enteromorpha* green tide disaster, harmful algal blooms, plankton community structure changes, overfishing, and biodiversity loss. For example, large-scale green tides have bloomed successively in the Yellow Sea every summer since 2007, which pose a risk of bio-invasion (Cui et al., 2015; Zhao et al., 2018). As a product of anthropogenic activities, the occurrence of microplastics (<5 mm) has also become a nonnegligible issue. Fishing activities and atmospheric deposition are the major microplastic sources in the Yellow Sea (Wu et al., 2019; Zhang et al., 2022b). The sustainable development in goods and services of the YSLME is severely constrained. Many scientific research plans have been proposed to respond to concerns with the current changing status and attenuating but persistent threats in the YSLME (Tang, 2009, 2014; Tang et al., 2016; Wu et al., 2019). Through the application of integrated, science and ecosystem-based approaches, the YSLME region has demonstrated significant stress reduction and environmental quality improvements and socio-economic benefits deriving from the joint efforts of China and R. O. Korea. Tremendous efforts are needed to continuously diagnose and analyse the persistent environmental threats and resource stresses in the YSLME, understand the root causes of these transboundary issues and develop and implement concerted strategic actions to restore carrying capacity of the YSLME.

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The eight papers collected in this special topic represent the consistent efforts of the YSLME scientific community to support the application of science and ecosystem based management of the YSLME. Wang et al. (2022b) indicated that nutrient species in the southern Yellow Sea transferred from N to P limitation, which exhibited the phytoplankton dominant group from diatoms to dinoflagellates. Liu et al. (2022) assessed the nutrient fluxes in the Subei Shoal associated with eddy diffusion and submarine ground water discharge, demonstrated these nutrient fluxes could provide nutrients requirements for the primary productivity, and potentially affect the growth of phytoplankton in the marine ecosystem of the Yellow Sea. Park et al. (2022) showed that the diatom assemblages can serve as the bioindicators of Korean diatom-based ecoregions in the Yellow Sea, in both time and space. Zhang et al. (2022a) indicated that spring diatoms play a greater role in dimethylsulfide production in the southern Yellow Sea. Yuan et al. (2022) used the high-resolution satellite images to monitor the distribution, coverage and drifting of the pelagic *Sargassum* rafts in the Yellow Sea and East China Sea, providing insights to the future management of *Sargassum* blooms. Wang et al. (2022a) got a higher accuracy data by using a new method which is an implement of deep convolutional neural network, thus, the invasion mechanism of *Spartina alterniflora* was revealed in detail. Chen et al. (2022), using field survey data, investigated seasonal habitat suitability requirements for Tanaka’s snailfish (*Liparis tanakae*) in the Bohai Sea and Yellow Sea via a machine-learning, random forests method, provided a baseline for *L. tanakae* that can be further applied in ecosystem modelling and fishery management. Zhang et al. (2022c) classified the farming activities into fed culture types (include cage culture and pond culture) and extractive culture types (e.g., seaweed culture, filter-feeding shellfish culture), concluding with a new calculation of a net annual removal by mariculture industry of 50 794 t of nitrogen and 2 901 t of phosphorus in China. It is expected these papers will contribute to strengthening the scientific basis for sustainable exploitation and conservation strategies leading to adaptive ecosystem-based management and vision of the YSLME, which is to protect, conserve and restore the ecosystem health and natural resources of the Yellow Sea to secure a sustainable and reliable source of food, recreation and livelihoods, and also meet the aspirations of all generations into the future.

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