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EDITORIAL
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Editorial: Physics and Biogeochemistry of the East Asian Marginal Seas

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Editorial on the Research Topic

Physics and Biogeochemistry of the East Asian Marginal Seas

INTRODUCTION

The oceans are experiencing unprecedented rates of change associated with climate change and human activities. Amongst the many marginal seas of the global ocean, the East Asian marginal seas, including the East/Japan Sea (EJS), Yellow Sea (YS), East China Sea (ECS), and South China Sea (SCS), are likely to be the most heavily influenced by anthropogenic activities. These marginal seas receive massive amounts of allochthonous materials *via* submarine groundwater discharge as well as large rivers, including the Changjiang and the Yellow River, and are subject to substantial atmospheric forcing by their location beneath the westerlies (i.e., Nakamura et al., 2005; Lee and Kim, 2007; Müller et al., 2008; Jiang et al., 2014; Park et al., 2019). The human footprint in these seas is amplified because the residence times of the YS (about 5 years, water volume: 9.96×10^{12} m^3, average water depth: 44 m) and the EJS (about 100 years, water volume: 1.68×10^{15} m^3, average water depth: 1680 m) are relatively shorter than the major oceans (Nozaki et al., 1991; Tsunogai et al., 1993) (**Figure 1**). This means that the external inputs have a significant impact on the marginal seas. Vigorous biogeochemical alterations occur in the YS and the ECS, which compose one of the largest continental shelves in the world (Kim et al., 2018; Cho et al., 2019; Han et al., 2022). These shelf waters eventually influence the euphotic zone of the EJS and the adjacent Pacific Ocean. On the other hand, the EJS has its own deep water ventilation system and various oceanographic features that are similar to those of the global ocean, such as numerous eddies, subpolar thermal fronts, brine rejection, and deep convection (Kim et al., 2001; Senjyu et al., 2002; Talley et al., 2003; Lee et al., 2019). Since these marginal seas are at the forefront of our human interaction with the marine environment, there is a pressing need to explore the responses of physics and biogeochemistry in these seas to climate change and human impacts.

This Research Topic gathered 28 articles on physics (14 articles) and biogeochemistry (14 articles) of the East Asian marginal seas. The articles on physics highlight the recent observational and modelling efforts to understand the physics of the EJS, YS, ECS, and SCS. The articles on biogeochemistry deal with

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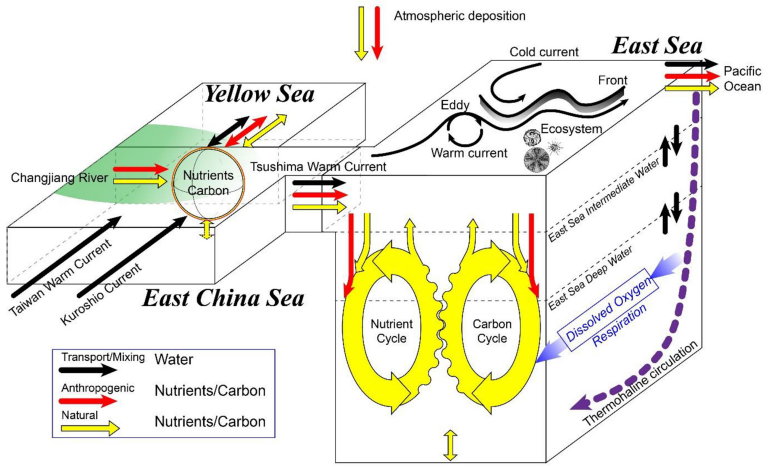

FIGURE 1 | A diagram showing the transport patterns of water, nutrients, and carbon in the East Asian marginal seas, including deep water formation and the cycling of nutrients and carbon in the deep East Sea (Japan Sea).

various biogeochemical components both in the water column and in sediments through various approaches such as *in-situ* measurements, laboratory analysis, satellite observations, and models.

PHYSICS

A wide range of physical processes occurring in the EJS was examined by several works. Jeong et al. investigated the physical processes underlying a distinct contrast in decade-long trends of surface and subsurface (100–300 m) temperature change in the EJS. An important role of northwesterly/northerly wind in the central part was suggested as a main driver of the contrasting decade-long trends in warming and cooling rates. Using the nonstationary extreme value analysis methods, Lee and Park examined the sea's abnormal sea surface temperatures over the past decades and potential change in future decades. Trusenkova and Kapluenko presented intra-annual sea level fluctuations and variability of mesoscale processes in the northern EJS based on eddy kinetic energy. Senjyu investigated the sea's mid-depth water mass ventilation and its sensitivity to global warming using long-term hydrographic observations. Kim et al. numerically examined the deep convection process and dense water formed by strong wintertime cooling in the northern shelf and slope in the EJS. Turnover times of the sea's meridional overturning circulation were estimated at several to tens of years by Han et al. based on reanalysis products.

Both numerical and observational studies advanced our understanding of physical processes in the East Asian marginal seas, particularly the YS, ECS, and SCS. Lee et al. found alongshore propagation of subtidal (3–20 days) coastal sea level fluctuations around the Korean Peninsula, from the EJS to the YS. The propagation speeds of a few to tens of m/s were comparable to phase speeds of wind-forced, coastally trapped waves. Using ocean tide-corrected, multi-mission satellite altimetry data, Lee et al. revealed a spatial pattern of the long-term (1993–2019) linear trends in sea level around the Korean peninsula and highlighted two regions of rapid sea level rise (one in the EJS and the other in the YS). Kim et al. identified unprecedented retardation of increasing spring water temperatures in 2020 in the northeastern YS. The conditions favorable for fog generation and the underlying processes associated with these conditions were evaluated by Yun and Ha using the turbulent heat flux data collected in the same region. Fei et al. examined a sandwich-shaped temperature structure that was formed in the middle of the southern YS from spring to autumn. Kang and Na investigated long-term (1993–2018) variability of the Kuroshio intrusion onto the ECS shelf northeast of Taiwan and its relationship to the current and temperature variability within the ECS. Features of the strong intraseasonal variability of the upper-layer current in the northern SCS were presented by Xu et al.

BIOGEOCHEMISTRY

A few studies investigated dissolved gaseous components and atmospheric input. Liu et al. (Jing Liu) measured pH and total alkalinity in the outer Changjiang Estuary and estimated the air-sea exchange of CO_2. Yu et al. reported that acidification and decreases in aragonite saturation in the south YS cold water mass in the warm seasons were mainly derived from organic matter degradation based on the correlation with apparent oxygen utilization (AOU), with little effect of water column mixing and currents. Gu et al. examined N_2O and hydroxylamine in the south YS and the ECS to reveal their controlling factors. In the EJS, Na et al. measured dissolved inorganic carbon (DIC) and total alkalinity in 2019 and showed a large increase in DIC and acidification of the deep water compared with those measured

in 1999. Seo et al. measured Pb and ^{210}Pb in the water column and estimated atmospheric input of ^{210}Pb in the EJS.

East Asian margin is the hotspot of organic carbon cycle research. Cao et al. showed that production and sedimentation of POC are spatially decoupled based on stable carbon isotope and lipid biomarkers, which improved the understanding of sources and burial processes of marine organic carbon in marginal seas. Seo et al. examined suspended particles and revealed sources of POC based on dual carbon isotopes, determined POC flux to the sediment based on ^{234}Th-^{238}U disequilibrium, and stressed the importance of sediment resuspension in POC cycling in this region. Liu et al. examined the effect of the relocation of the Yellow River outlet in 1855 from the examination of a sediment core retrieved from the south YS. In the EJS, Choi et al. examined trophic dynamics of sinking particles using nitrogen isotopes of amino acids. Hyun et al. reported how bacterial processes were related to dissolved organic matter (DOM) supply from sediments, such as bacterial consumption of bioavailable components of DOM and bacterial production of refractory components in the water column.

Physical-biogeochemical interactions were studied using satellite observations and models. Ding et al. examined the influence of a subsurface anticyclonic eddy on chlorophyll concentrations in the northwestern Pacific based on a 3D biogeochemical model. Park et al. examined chlorophyll concentration from 2003 to 2020 using MODIS satellite data and found that chlorophyll-a concentration was increasing and that chlorophyll-a variability was related with tropical-subtropical, arctic-subarctic interactions between the atmosphere and ocean. Tak et al. used a 3D physical-biogeochemical coupled model to reveal nitrate budgets in the YS and showed the importance of a lateral supply of nitrate by currents in addition to biological processes. To seek the cause of the collapse of walleye pollock catch in south Korea, Kim et al. examined a temporal variation of data-assimilated reanalysis results in the northern EJS and showed how the late 1980s regime shift changed the intensity of the East Korean Warm Current with direct effects on the water temperature of the spawning area of the walleye pollock. Xu et al. utilized an *in-situ* multiple excitation fluorometer for phytoplankton composition and related it to nutrient and chlorophyll concentrations and to hydrological properties.

CONCLUSIONS

The East Asian marginal seas display very dynamic features of hydrographic circulation, deep water formation, wave propagations, and biogeochemical cycles. The articles in this special issue looked at important aspects of the oceanographic processes that affect hydrography, carbon cycles, human footprints, and ecosystem changes in these marginal seas. Current knowledge, however, is still far from a holistic understanding of changes in physics and biogeochemistry that is necessary to resolve how these systems will respond to continuing climate and ecosystem changes and to human activities. Thus, we recommend devoting increased attention to the dynamics of this region with future studies that apply interdisciplinary approaches, incorporate socioeconomic perspectives, and better leverage international collaborations and coordination.

AUTHOR CONTRIBUTIONS

All authors contributed to the manuscript writing and revisions and approved it for publication.

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