

The status of coastal oceanography in heavily impacted Yellow and East China Sea: Past trends, progress, and possible futures



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ARTICLE INFO

Article history:

Accepted 21 May 2015

Available online 30 May 2015

Keywords:

coastal oceanography
physical and biogeochemical processes
conservation
management
Yellow Sea and East China Sea
China
Korea
Japan
Taiwan

ABSTRACT

Coastal environments are a key location for transport, commercial, residential and defence infrastructure, and have provided conditions suitable for economic growth. They also fulfil important cultural, recreational and aesthetic needs; have intrinsic ecosystem service values; and provide essential biogeochemical functions such as primary productivity, nutrient cycling and water filtration. The rapid expansion in economic development and anticipated growth of the population in the coastal zones along the Yellow and East China Sea basin has placed this region under intense multiple stresses. Here we aim to: 1) synthesize the new knowledge/science in coastal oceanography since 2010 within the context of the scientific literature published in English; 2) report on a citation analysis that assesses whether new research topics have emerged and integrated over time, indicate the location of modelling and field-based studies; and 3) suggest where the new research should develop for heavily impacted estuaries and coastal seas of East Asia. The conclusions of the synthesis include: 1) China has emerged as a dominant force in the region in producing scientific literature in coastal oceanography, although the area of publications has shifted from its traditional fields such as physical oceanography; 2) there has been an increasing number of publications with cross-disciplinary themes between physical oceanography and other fields of the biological, chemical, and geological disciplines, but vigorous and systematic funding mechanisms are still lacking to ensure the viability of large scale multi-disciplinary teams and projects in order to support trans-disciplinary research and newly emerging fields; 3) coastal oceanography is responding to new challenges, with many papers studying the impacts of human activities on marine environment and ecology, but so far very few studying management and conservation strategies or offering policy solutions.

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1. Introduction

The environmental degradation of the waters of heavily populated coasts such as the Yellow and East China Sea (Fig. 1) is particularly serious because of the multiple environmental pressures facing these regions from rapid growth, coastal erosion, land reclamation, dredging, increased navigation, oil and gas infrastructure development, and sediment/nutrient run-off due to increased human activity in these catchment areas (Dong et al., 2010; Liu et al., 2010; Ding et al., 2011; Hu et al., 2011; Song et al.,

2013; Song and Wang, 2013; Zhou et al., 2014; Gao et al., 2014a, 2014b; Chen et al., 2014). Ineffectual coastal management including the lack of linkages between science and policy often escalate these environmental problems (Mee, 2012). Marine environmental conservation and integrated coastal zone management (ICZM) require research that integrates science with economic and social changes beyond the scope of current management regimes to assist in delivering more sustainable development outcomes (Wang et al., 2011b).

This synthesis follows the Special Issue (SI) with its theme: "Impact on coasts and their ecosystems in the Yellow and East China Sea by intensive anthropogenic activities". The contributors to this SI are from countries/region of the Yellow and East China Sea including mainland China (China hereafter), Korea,

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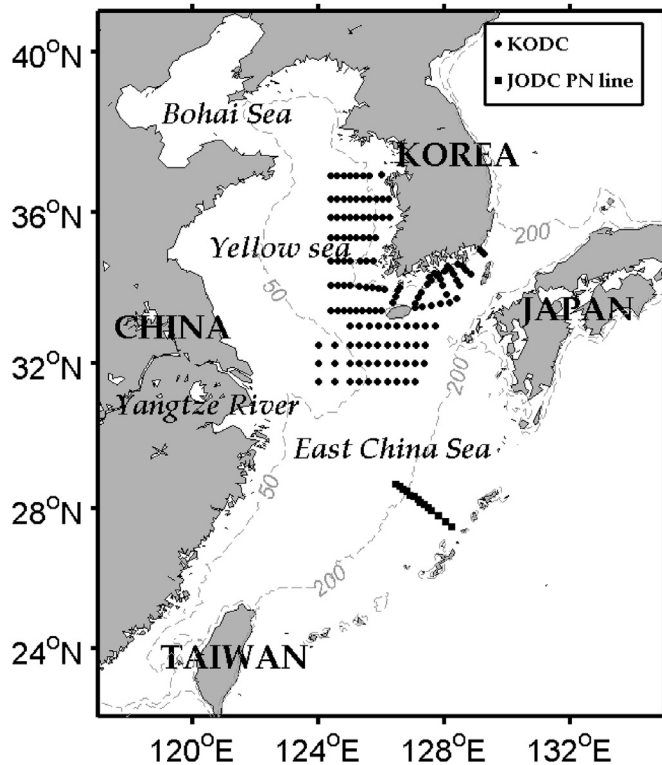


Fig. 1. Map of the Yellow and East China Sea with the long term hydrographic observation stations and PN line taken by National Fisheries Research and Development Institute, Korea, and the Japan Meteorological Agency, respectively. The observations are available from the Korea Oceanographic Data Center (KODC) and the Japan Oceanographic Data Center (JODC), respectively.

Japan and Taiwan. The SI aims to examine and document the physical and ecological impacts and the biogeochemical evolution and mechanisms of the coasts in the Yellow and East China Sea region due to intensive human activities and their resultant effects on the coastal ecosystem structures and functions. The SI assesses the influences of human activities on the environmental degradation and sustainable use of the marine resources in these environments; probes into the possible scientific approaches to manage and recover coastal ecological functions; reports whether the discipline has responded to on-going and new issues (such as climate change and eutrophication) and consequently has developed new directions of research. To this end, the paper aims to: 1) synthesize the new knowledge/science since 2010 within the context of the scientific literature published in English; 2) report on a citation analysis that assesses whether new research topics have emerged and integrated over time, indicate the location of modelling and field-based studies; and 3) make suggestions where the new research should develop for heavily impacted estuaries and coastal seas of East Asia.

The papers reviewed were indexed by the *Oceanic Abstracts*, which focuses on worldwide literature pertaining to the marine and brackish-water environment. We culled papers that were not in English even though they had English titles and abstracts listed within the database. We acknowledge the limitation of using one single database which may have led to a non-exhaustive search of entire literature available. However, a total of 670 papers from mainstream English journals reviewed here do represent a snapshot of the current status of coastal oceanography research for the heavily impacted Yellow and East China Sea region from 2010 to date.

2. A historical perspective

2.1. China

Studies of the Yellow and East China Sea during the 1980s and 1990s appear to be dominated by physical oceanography with a particular focus on hydrography and circulation dynamics using in-situ observations, and simple numerical models addressing specific mechanisms (e.g. Su, 1998). In this last decade, the Chinese scientific community has enjoyed a rapid rise in research and development funding. A conservative estimate suggests an investment in the order of CNY300 million (US\$50 million, Chen, D.K., personal communication) per year in oceanography/marine science research through major funding schemes such as '973' (Ministry of Science and Technology) and NSFC (National Natural Science Foundation of China). NSFC project management reports (e.g. Ren et al., 2014) suggest that NSFC alone has provided an annual funding of CNY138 million (US\$23 million) for marine and polar sciences averaged over a period from 2007 to 2014. This funding growth has been further coupled by an aggressive expansion of oceanography departments and schools among its universities and thus numbers of graduate students. As a result, among its regional neighbours in East Asia, China has published a total of 386 journal articles concerning the Yellow and East China Sea region, the largest number indexed by *Oceanic Abstracts* since 2010 (Table 1). Furthermore, it has boasted an averaged 8% per annum growth in the number of publications on the Yellow and East China Sea region between 2010 and 2014 (Fig. 2), again the fastest growth rate in the region.

Within this period, there are a limited number of review papers including 'Integrated management of nutrients from the watershed to coast in the subtropical region' by Chen and Hong (2012); 'Pollution status of the Bohai Sea: An overview of the environmental quality assessment related trace metals' by Gao et al. (2014b); and 'Marine renewable energy in China: Current status and perspectives' by Zhang et al. (2014b). A special issue on 'Dynamics of Chinese muddy coasts and estuaries' (Wang et al., 2011a) includes a collection of ten papers as case studies of the Changjiang (Yangtze River), Huanghe (Yellow River) and Zhujiang (Pearl River) estuaries, and the Chinese muddy coasts in the Bohai, Yellow, East China and South China Seas. These papers represent the recent advancement in Chinese estuarine and coastal research during the 2000s. A more geographically focused review can be found by Hong et al. (2011) who synthesized the physical, biogeochemical processes and ecosystem dynamics in the Taiwan Strait, and these processes' interconnectivity with El Niño–Southern Oscillation (ENSO) and interannual variability.

In biogeochemistry, extensive research has been conducted on nutrient dynamics (Guo et al., 2012; Hung et al., 2013; Chen et al., 2015), eutrophication and associated algal and jellyfish blooms (Dong et al., 2010; Cui et al., 2012; Huo et al., 2013; Dai et al., 2014), and molecular biology of bloom formation. Coastal pollution is a historical research area with a focus on heavy metals (Jiang et al., 2014), which has been enriched by the more recent efforts in organic pollution research, including pesticides, hydrocarbons (Deng et al., 2013; Hu et al., 2014), chlorinated compounds (Hu et al., 2011; Duan et al., 2013), polybrominated diphenyl ethers (Fan et al., 2014), and the emerging pharmaceuticals and personal care products (Yan et al., 2013; Zhang et al., 2013).

Table 1

The number of publications by countries/region between 2010 and 2015 focussing on the Yellow and East China Sea region.

China	Korea	Japan	Taiwan
393	119	39	117

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