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Introduction

The oceanography of the *No*rthern *so*uth *C*hina Sea *S*helf-Sea (NoSoCS) and its adjacent Waters—overview and Highlights[1]

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ABSTRACT

Tropical shelf-Seas constitute a sub-set of shelf-seas that has not been studied extensively. The *No*rthern *So*uth *C*hina Sea *S*helf-sea (NoSoCS) study is a continuation of the longstanding interest in Taiwan on the oceanography of the East Asian shelf-seas, and is an attempt to provide systematic and synoptic observations on a tropical shelf-sea. The two basic hypotheses in the study are: (1) as in the Ocean interior, the behaviors of the shelf-seas vary with latitude; and (2) the behaviors of the NoSoCS are representative of those of the shelf-seas in the tropical zone. The NoSoCS has been sampled bi-annually in alternating seasons since 2009. The results obtained primarily in 2009 to 2012 are presented here. As in the tropical Ocean interior, a distinguishing characteristic of the NoSoCS is its shallow mixed layer, with depths of about 40 m in the summer and 70 m in the winter. As similar mixed layer depths are found in the adjoining Northern South China Sea (SCS) and they are shallower than the shelf break depth of 120 m, the upper nutricline Water in the Northern SCS extends freely into the NoSoCS and forms a layer of Water with significant concentrations of the nutrients immediately below its mixed layer. Any process that can induce vertical mixing on the shelf may make the nutrients in this subsurface Water available for supporting biological activities in the mixed layer in the NoSoCS. Such processes include winter convective overturn over the entire NoSoCS as a result of surface cooling and the strong northeast monsoonal wind, winter formation of bottom Water in parts of the inner and middle shelf, the action of internal waves at the outer shelf and the continental slope, and upwelling maintained by wind and/or topography. The upwelling takes place in the summer off the coasts of Dongshan–Shantou and the northeast coasts of the Hainan Island, but year-round at the Taiwan Bank. Upwelling over the shelf break is not required for bringing the nutrients in the sub-surface Waters in the open SCS to the NoSoCS, and it was not observed. In addition to vertical mixing, terrestrial inputs, especially through the outflow of the Pearl River, which reaches its peak in the summer, also contribute to the spatial and temporal variations in the composition of the NoSoCS. The combined effects of all these processes lead to a unique seasonal pattern in the variations of the surface concentrations of chlorophyll-a in the NoSoCS, with two distinct yearly maxima in the winter and summer.

1. Introduction—shelf-seas and the Northern south China Sea *S*helf-Sea (NoSoCS) study

Continental shelves of various widths rim the Oceans (Postma and Zijlstra, 1988; Walsh, 1988). The Waters that extend from the coasts to the shelf-break on those shelves with sufficient widths form the shelf-seas. These Seas are the part of the Ocean that is at the closest proximity to land, and are thus most sensitive to the effects of the ever-increasing human activities. They also constitute an integral component of the continental margin, which plays a disproportionately important role, relative to their areal coverage, in regulating the biogeochemical behaviors of the Oceans (Liu et al., 2010). Thus, ecologically, while shelf-seas constitute only about 7% of the area of the global Ocean, they support about one-fifth of marine primary production and half of global fish production (Ryther, 1969). Geochemically, their high biological activities, high particulate and organic loads, and high sediment-surface to Water-volume ratio favor the occurrence of many of the principal types of biogeochemical reactions, such as acid–base, oxidation–reduction, complexation, photochemical and adsorption–desorption reactions. For example, the shelf-seas' lower concentrations of iodate and higher concentrations of iodide relative to the open Ocean have been explained by the biologically mediated reduction of iodate to iodide in the shelf (Wong, 1995; Wong et al., 2004). The higher concentrations of hydrogen peroxide have been attributed to the facilitation of its photochemical production by the ready availability of organic chromophores in the shelf Waters (Moore et al., 1993). The elevated concentrations of manganese (Wei et al., 2001) and methane (Brooks et al., 1981) have been linked to a sedimentary source, while the depletion of ^{210}Pb (Nozaki et al., 1976) may have resulted from a sedimentary

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0967-0645/

Wong, G.T.F., Li, Y.-H., Chao, S.-Y., Chung, Y.-C. (guest editors) 2000. Kuroshio Edge Exchange Processes (KEEP)—Interactions between the East China Sea and the Kuroshio. Continental Shelf Research 20, pp. 331–635.
Wong, G.T.F., Hung, C.-C., Gong, G.-C., 2004. Dissolved iodine species in the East China Sea—a complementary tracer for upwelling Water on the shelf. Cont. Shelf Res. 24, 1465–1484.
Wong, G.T.F., Ku, T.-L., Mulholland, M., Tseng, C.-M., Wang, D.-P., 2007a. The SouthEast Asian Time-series Study (SEATS) and the biogeochemistry of the South China Sea—an overview. Deep-Sea Res. II 54, 1434–1447. http://dx.doi.org/10.1016/j.dsr2.2007.05.012.
Wong, G.T.F., Tseng, C.-M., Wen, L.-S., Chung, S.-W., 2007b. Nutrient dynamics and N-anomaly at the SEATS station. Deep-Sea Res. II 54, 1528–1545. http://dx.doi.org/10.1016/j.dsr2.2007.05.011.
Wong, G.T.F., Hong, H., Lin, S., Liu, H., Xue, H., 2011. Upwelling Ecosystem in the Southern Taiwan Strait. Cont. Shelf Res. 31, S1–S76.
Wong, G.T.F., Pan, X., Li, K.-Y., Shiah, F.K., Ho, T.-Y., Guo, X., 2015. Hydrography and nutrient dynamics in the Northern South China Sea Shelf-sea (NoSoCS). Deep-Sea Res. II. 117, 23–40.
Wu, M., Wong, G.T.F., Wu, Y.-C., Dao, M., 2015. Hydrogen peroxide in a sub-tropical shelf-sea: the northern South China Sea Shelf-sea (NoSoCS). Deep-Sea Res. II. 117, 143–154.
Xia, X., Yan, C.S., Liu, H., 2015. Dynamics of the bacterioplankton and diazotroph communities in the northern South China Sea by 454 pyrosequencing of the 16S RNA gene and *nifH* gene. Deep-Sea Research II. 117, 97–107.
Xu, J., Yin, K., He, L., Yuan, X., Ho, A.Y.T., Harrison, P.J., 2008. Phosphorus limitation in the northern South China Sea during late summer: Influence of the Pearl River. Deep-Sea Res. I 55, 1330–1342.
Xu, J., Yin, K., Ho, A.Y.T., Lee, J.H.W., Anderson, D.M., Harrison, P.J., 2009. Nutrient limitation in Hong Kong Waters inferred from comparison of nutrient ratios, bioassays and ^{33}P turnover times. Mar. Ecol. Prog. Ser. 388, 81–97.
Yin, K., Harrison, P.J., 2008. Nitrogen over enrichment in subtropical Pearl River estuarine coastal Waters: possible causes and consequences. Cont. Shelf Res. 28, 1435–1442.
Yin, K., Lin, Z., Ke, Z., 2004. Temporal and spatial distribution of dissolved oxygen in the Pearl River Estuary and adjacent coastal Waters. Cont. Shelf Res. 24, 1935–1948.
Zhang, J., 1995. Geochemistry of trace metals from Chinese River/estuary systems: an overview. Estuar. Coast. Shelf Sci. 41, 631–658.
Zhang, J., 1996. Nutrient elements in large Chinese estuaries. Cont. Shelf Res. 16, 1023–1045.
Zu, T., Gan, J., 2015. A numerical study of coupled estuary-shelf circulation around the Pearl River Estuary during summer: responses to variable winds, tides and River discharge. Deep-Sea Res. II. 117, 53–64.

George T.F. Wong*
Research Center for Environmental Changes, Academia Sinica, 128 Academia Road Section 2, Nankang, 115 Taipei, Taiwan
Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur, Malaysia
E-mail address: gtfwong@gate.sinica.edu.tw

Teh-Lung Ku
Department of Earth Sciences, University of Southern California, CA 90089, Los Angeles, United States

Hongbin Liu
Hong Kong University of Science and Technology, Hong Kong

Margaret Mulholland
Department of Ocean, Earth and Atmospheric Sciences, Old Dominion University, Norfolk, VA 23508United States

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* Corresponding author.