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Hydrography and nutrient dynamics in the *No*rthern *So*uth *C*hina Sea *S*helf-sea (NoSoCS)

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ABSTRACT

The hydrographic characteristics and the distributions of nitrate+nitrite, or (N+N), and soluble reactive phosphate, or SRP, in the *No*rthern *So*uth *C*hina Sea *S*helf-sea (NoSoCS) were determined in four transects across the shelf in the summer of 2010 and in two transects in the winter of 2011. The NoSoCS may be sub-divided into the inner shelf, the middle shelf and the outer shelf at water depths of <40 m, 40–90 m and 90–120 m, respectively. The water in the inner shelf is colder and its concentrations in the nutrients and chlorophyll-a (Chl_*a*) are higher in both seasons while the water in the outer shelf is warmer and its concentrations are lower. With depth, since the mixed layer depth in the NoSoCS in the winter (~70 m) and in the summer (~40 m) are both shallower than the shelf break depth (~120 m), the colder and relatively nutrient-rich upper thermocline-upper nutricline water in the open South China Sea (SCS) can freely extend into the NoSoCS to become its bottom water. This is a distinguishing characteristic of the NoSoCS as, unlike many of the more extensively studied temperate shelf-seas, vertical mixing within the NoSoCS, rather than shelf-edge processes such as upwelling, is the primary mechanism for bringing the nutrients from the sub-surface in the adjoining northern SCS to its mixed layer for supporting primary production. Four processes that may contribute to this vertical mixing in the NoSoCS include: shelf-wide winter surface cooling and convective mixing; the actions of internal waves which probably occur in both seasons along the entire outer shelf; wind and topographically induced coastal upwelling in the summer off Shantou at the northwestern corner of the NoSoCS; and winter formation of bottom water at the outer portion of the inner shelf and the inner portion of the middle shelf. The density of this bottom water formed in the winter of 2011 was equivalent to the density at ~120 m in the open SCS so that it could cascade across the shelf and contribute to not only vertical mixing but also in cross shelf mixing and the ventilation of the upper thermocline and nutricline of the open SCS. An enrichment in (N+N) over SRP, where (N+N)/SRP exceeded the Redfield ratio of 16 and $[N+N]_{ex} > 0$, was found when salinity dropped below about 33. In these fresher waters, which were found exclusively in the inner shelf during this study, SRP potentially could become the limiting nutrient.

1. Introduction

In the temperate shelf-seas, such as the more extensively studied East China Sea (Wong et al., 1991, 2004; Chen and Wang, 1999) and the South Atlantic Bight (Lee et al., 1991), the mixed layer depth in the adjoining ocean interior is often deeper than the shelf break depth. Horizontal exchange by frontal processes between the ocean interior and the shelf-sea would bring only the nutrient-poor mixed layer water from the former to the latter, and this would result in little net nutrient import into the shelf-sea. Upwelling over the shelf edge, induced by wind and/or topography, is necessary if the nutrient-laden sub-surface water below the mixed layer in the ocean interior is to be brought onto the shelf-sea to support biological activities. Since the maximum mixed layer depth in the ocean interior generally decreases with decreasing latitude (Montégut et al., 2004) while the shelf break depth, which on average is located at 130 m, is not latitude-dependent, the relationship between them and thus the availability of nutrients in the subsurface water in the ocean interior to the shelf-seas may become different in the tropical waters. Furthermore, at the lower latitudes, insolation is higher and more uniform throughout the year. The resulting water temperature in

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