Influence of Kuroshio Meandering on the Nutrient Transport to Osaka Bay

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ABSTRACT

Recent research discussed the possibility that not only terragenic but also oceanic nutrient loads had a considerable influence on the water quality of an enclosed bay such as Osaka Bay in Japan. In this study, numerical simulations are conducted to clarify the influence of Kuroshio meandering on the nutrient transport to Osaka Bay. As a result, nutrient transport process from the Pacific Ocean to the bay was clarified and nutrient transport amounts in the bay mouths were calculated. Moreover, the simulation results showed that Kuroshio meandering had a significant influence on the nutrient balance in the bay.

KEY WORDS: Osaka Bay; Nutrient transport; Kuroshio meandering; Oceanic nutrient; 3-D numerical simulation; Field survey.

INTRODUCTION

Policies to improve water quality in enclosed bays such as Tokyo Bay and the Seto Inland Sea including Osaka Bay have been long implemented according to the plans outlined for reducing total pollution loads in Japan. However, we currently do not meet water quality standards. Moreover, water pollution phenomena such as red and blue tides still occur frequently in these waters.

Water quality in an enclosed bay is strongly related to the following: (1) pollutant loads inflowing from land areas; (2) interaction between pelagic and benthic systems such as the nutrient release process caused by decomposition of organic polluted sediment; (3) groundwater seepage to the bottom in coastal region; and (4) atmospheric loads. Tidal exchange with the outer ocean as a nutrient supply source to an enclosed bay is another factor that has recently received considerable attention. For example, Ishii and Yanagi (2006) estimated that approximately 30 to 40% of nutrients in Osaka Bay originate in the Pacific Ocean, using variations in terragenic nutrient load and nutrient concentration in the sea. In addition, Fujiwara et al. (1997) showed in their field survey that large amount of nutrients comparable to pollutant load amounts from land inflowed into the Kii Channel from the Pacific Ocean in the summer. In light of these researches, it may be necessary to reconsider existing measures that emphasize reducing pollutant loads from land to appropriately control water quality in Osaka Bay.

Takeuchi et al. (1997) reported the following from observation data collected over 33 years: When the southward distance to the Kuroshio current axis from Cape Shionomisaki (defined as the Kuroshio distance in this study) is less than 20 NM (nautical miles: =37.0 km), warmer water with a lower nutrient load intrudes into the Kii Channel from the Pacific Ocean. On the other hand, when the Kuroshio current axis is farther than 30 NM (=55.6 km), colder water with a higher nutrient load intrudes into the bottom layer of the Kii Channel from the Pacific Ocean. Our research team also conducted field surveys for long periods at the bay mouth to quantify the oceanic nutrient fluxes to Osaka Bay. We determined an interesting fact: There was an apparent variation in the nutrient transport process in the bay mouth in the summer varied obviously depending on Kuroshio meandering (e.g., Kim et al. (2005) and Nishida et al. (2006)). However, it is difficult to continuously evaluate mass transport in the Kitan Strait through field surveys because of a strong tidal current and depth of more than 150 m. The present study aims to clarify the current and water quality structure in the Kii Channel and Osaka Bay using 3-D numerical models, considering the influence of Kuroshio meandering.

Fig. 1 Location and topography of study area.