Influence of Kuroshio Flow on the Horizontal Distribution of North Pacific Intermediate Water in the Shikoku Basin

YOSHIHIKO SEKINE* and SHINGO MIYAMOTO

Institute of Oceanography and Climate, Faculty of Bioresources, Mie University, Kamihama-cho, Tsu, Mie 514-8507, Japan

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The influence of the Kuroshio flow on the horizontal distribution of North Pacific Intermediate Water (NPIW) in the Shikoku Basin is examined based upon observational data collected by the training vessel "Seisui-marun" of Mie University together with oceanographic data compiled by the Japan Oceanographic Data Center (JODC). Although it has been stated that the NPIW with salinity less than 34.2 psu had been confined to the south of the Kuroshio main axis along the PT (KJ) Line on the eastern side of the Izu Ridge, a similar tendency can be detected on the western side of the Izu Ridge. Namely, the NPIW on the southern side of the Kuroshio main axis in the Shikoku Basin does not indicate a tendency to go northward across the Kuroshio main axis without an increase in salinity of more than 34.2 psu. However, the JODC data show that less saline water (<34.2 psu) was present on the northern side of the Kuroshio main axis south of the Kii Peninsula in May 1992. Satellite observed sea surface temperature (SST) data suggested that the Kuroshio approaches the Kii Peninsula after forming a small meander off Kyushu and some intrusions of the NPIW into the northern coastal side of the Kuroshio main axis occurred in this period. It is concluded that intrusion of the NPIW with salinity less than 34.2 psu to the northern coastal side through the Kuroshio main axis occurred during the decay period of the small meander path in May 1992. Based on these observational results, the source of the salinity minimum water on the northern coastal side of the Kuroshio main axis is discussed.

Keywords:
- Intermediate Oyashio Water (IOW),
- salinity minimum layer,
- North Pacific Intermediate Water (NPIW).

1. Introduction

In the Shikoku Basin, there are two dominant salinity minima on both sides of the main flow of the Kuroshio (e.g., Sekine et al., 1991b; Yang et al., 1993a, b; Senju et al., 1998), while salinity in its minimum layer is relatively high in the Kuroshio main axis. One dominant salinity minimum layer on the northern coastal side of the Kuroshio main axis exists in the relatively shallow layer at depths of 300–500 m. The other dominant salinity minimum layer on the southern offshore side of the Kuroshio main axis is located at greater depths of 500–900 m. Both dominant salinity minimum waters have a potential density (σθ) of 26.7–26.9.

Yasuda et al. (1996) have pointed out that on the eastern side of the Izu Ridge, the North Pacific Intermediate Water (NPIW) of salinity less than 34.1 psu is formed by mixing of the Kuroshio Water (KW) and the Oyashio Water (OW) to the east of 150°E and this spreads southwestward up to 25°N to form a salinity minimum layer in the subtropical circulation. They also pointed out that less saline water on the northern side of the Kuroshio Extension west of 150°E is the OW and some part of NPIW flows into the confluent region of KW and OW. Sekine et al. (2000) indicated that the southwestward flowing of NPIW is influenced by the topographic effect of the Izu Ridge and a westward shift of NPIW over the Izu Ridge into the Shikoku Basin is confined to the south of 30°N at a depth deeper than 2000 m. The schematic view of these results is shown in Fig. 1.

The Intermediate Oyashio Water (IOW) originated from OW flows southward along the east coast of Honshu and then reaches Sagami Bay (Yang et al., 1993a, b; Senju et al., 1998). Sekine and Uchiyama (2002) detected the outflow of IOW from Sagami Bay to the Shikoku Basin through a southeastern channel off the Izu Peninsula. They also detected that a part of IOW to the

* Corresponding author. E-mail: sekine@bio.mie-u.ac.jp

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south of the Boso Peninsula flows southward along the eastern side of the Izu Ridge, then into the Shikoku Basin through the gate channel of the main Kuroshio path over the Izu Ridge between the Miyake-jima and Hachijo-jima islands.

Together with this observational evidence, it is inferred from Fig. 1 that two salinity minimum layer waters on both sides of the Kuroshio main axis are mainly separated by the main Kuroshio flow. The NPIW is confined to the south of the Kuroshio main axis (Reid, 1965; Talley, 1993; Yasuda et al., 1996), while IOW is mainly confined to its northern coastal side. However, because there is a possibility that the NPIW and IOW may intrude to the other side of the main Kuroshio path, more clear discussion is needed to draw firm conclusions.

In the present study, we use observational data to examine whether or not the NPIW could flow northward under the main flow of the Kuroshio. Sources of salinity minimum water on the northern coastal side of the main Kuroshio axis are discussed on the basis of this result. The characteristics of the observational data used in this study are described in the following section. The results of the data analysis are described in Section 3. Summary and discussion are given in Section 4.

2. Data

CTD (Mark III System of Neil Brown Instrument Systems, Inc.) observations to the south of Japan during the period May 1983 to August 1999 were carried out by the training vessel "Seisui-maru" of Mie University. All CTD observation stations of CTD, of which salinity data are used for the NPIW analyses, are shown in Fig. 2. Field data on temperature and salinity and geostrophic volume transport before 1988 were reported by Sekine et al. (1991a, b). Observed CTD data in comparison with standard salinity water were checked at 10 levels of three observation stations for every course. Accuracy of the observed CTD data was found to be within 0.03 psu even in the worst-case. The salinity data observed by the "Seisui-maru" of Mie University are hereafter referred to as Mie Univ. data.

Observational salinity data from September 1976 to September 1994 compiled by the Japan Oceanographic Data Center (JODC) of the Hydrographic Department of the Japan Coast Guard (formerly the Maritime Safety Agency of Japan; hereafter referred to as JODC data) are also used in the present study. Additionally, satellite observed sea surface temperature (SST) data by NOAA 11 AVHRR and ADCP velocity observed by "Seisui-maru" are used to examine the main Kuroshio flow during observations.

3. Results

In order to investigate whether or not the NPIW in the Shikoku Basin could flow northward across the main current axis of the Kuroshio, all the salinity data in the salinity minimum layer of Mie Univ. data (Fig. 2) are examined. In the Shikoku Basin, almost all the data indicate that the NPIW of less than 34.2 psu is confined to the south of Kuroshio main axis. As an example, the salinity distribution of Mie Univ. data along 137°E and 139°E observed in July 7-13, 1992 are shown in Fig. 3. As the Kuroshio main axis is located at Stns. 7 to 11 along 137°E and Stns. 27 to 30 along 139°E (Fig. 3(b)), the