Observation of the Abyssal Current in the West Mariana Basin*

Noriya Yoshioka†, Masahiro Endoh† and Hiroshi Ishizaki†

Abstract: In order to investigate long-term variations of deep sea currents and temperature in the western North Pacific, a direct current measurement was made at 12.5°N, 137°E from July 1985 to July 1986. The current meter was moored at a depth of about 4,000 m (bottom depth 4,604 m) in the West Mariana Basin, very close to the deep water passage to the North Pacific Basin. Throughout the observed period, the current flows southward with an average speed of 0.8 cm sec⁻¹. There are significant variations of both currents and temperature within the period of 60 days. For the shorter time scales, in addition to the tidal oscillations with one day and half day periods, there is a notable spectral peak of the current with a clockwise rotation at a period of 2.2 days, which is slightly shorter than the local inertial period of 2.3 days.

The observed southward current seems to indicate that the deep sea water in the West Mariana Basin flows out through the sill which is deeper than 4,000 m and is located about 200 km southeast of the mooring point. A simple analysis of the linear plane wave indicates that the medium time-scale variation with a period of 60 days is associated with the barotropic Rossby wave whose wavelength is 390 km and whose trough direction is 30° clockwise from the north.

1. Introduction

In the western part of the North Pacific Ocean, south of the Japan Islands, the Izu-Ogasawara Ridge and the Mariana Ridge separate abyssal (deeper than 4,000 m) waters of the Sikoku Basin and the West Mariana Basin from the North Pacific waters, as shown in Fig. 1. At depths greater than 4,000 m, abyssal waters can be exchanged horizontally only through the passages at the southern end of the West Mariana Basin. Therefore, the direct measurement of current near the passage may aid in the understanding of abyssal water circulation in the western North Pacific region. Kaneko and Teramoto (1985) discussed the difference in chemical characteristics between the waters of the eastern and western sides of the ridges. Sudo (1986) showed, with the aid of a chemical tracer, that the abyssal water in the Shikoku...
Basin circulates clockwise and determined that the origin of anomalies of dissolved oxygen and temperature is traceable at least to 15°N in the West Mariana Basin.

For the upper layer (shallower than 1,000 m), routine oceanographic observation along the 137°E line in the western North Pacific has been carried out by Japan Meteorological Agency (JMA) since 1967. Along the 137°E line, it is known that long term variations of the North Equatorial Current (NEC) are related to other oceanographic variations such as the North Equatorial Counter Current, the Equatorial Subsurface Current, and the tropical heat content (Masuzawa and Nagasaka, 1975; Andow, 1987). The study of sea level by Wyrtki (1974) and the statistical study of long term hydrographic data by Yamagata et al. (1985) also indicate that inter-annual variations of the Kuroshio Extension, NEC and the El-Niño seem to be correlated. Moreover, White et al. (1985) clearly showed that the anomalous heat content of the upper subtropical ocean is connected to the El-Niño event in 1982. However, the variability of the tropical upper ocean in the western part of the North Pacific Ocean over time scales shorter than the seasonal is known very poorly.

In order to investigate long-term variability of the upper and deeper tropical ocean, we moored a current measurement system for one year at 12.5°N, 137°E, which is located in the middle of the averaged NEC. As we mentioned above, the site is considered to be a key place for monitoring long-term variation of the upper North Pacific Ocean and water exchange of the abyssal waters between the West Mariana Basin and the deep Pacific Ocean. In the following sections, analysis of the one-year record of the system is discussed.

2. Observation

Current measurement by a mooring system was made from 13 July 1985 to 13 July 1986 at the position of 12°31′N, 137°03′E. The depth of the bottom was sounded as 4,604 m. The mooring system consists of three current meters (Aanderaa model RCM 5/6), at nominal depths of 364 m, 2,586 m and 4,059 m, respectively (Fig. 2). The positions of the three current meters are designed to detect both the first baroclinic and barotropic motions, taking into consideration that the node of the first baroclinic mode is at about 1,000 m depth from the surface, given the density profile at the site (see section 6.12 of Pedlosky, 1979).

Unfortunately, only the bottom current meter which was moored at 4,059 m depth (545 m height above the bottom) provided us with available data. We deal with 8,751 sets of current and temperature data with a sampling interval of one hour. The magnetic deviation from the geographical direction at the site is about one degree, which is neglected in the following analysis.

3. Results

Figure 3 shows power spectra of zonal and meridional velocity components and temperature. A spectral peak at a period of 60 days is commonly seen for each component. Of the three spectra, the meridional velocity component is the most significant for the peak. The significant meridional velocity fluctuation with a period of 60 days is found in the benthic current in the eastern North Pacific near the origin of NEC (8°N-15°N, 151°W-125°W at 6-200 m height.