A Measurement of Bottom Current on a Shoulder of a Sea Mount

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A measurement of bottom current was done by a Savonius meter together with a seismic observation near the top of the Suiko sea mount for about 102 hours from July 29 to August 2, 1968, during a cruise of RV Hakuho-maru.

Fig. 1 shows the station (44°26’N, 170°23’E) as well as the bottom configuration. The mooring system is sketched in Fig. 2. The current meter (Geodyne 102) was installed in a tripod of stainless steel of 4.5 m in height in order that the current meter was free from the motion of the mooring line. The mooring was launched current meter first and buoy last. The records of the inclination and the direction of the instrument tell that the instrument itself kept standing vertically without any rotating motion from landing till taking off, so that the Savonius rotor worked about 50 cm above the bottom in a depth of 1,293 m. The records of the current speed and direction on a photographic film were first illustrated on a strip chart by digital-to-analog transformation and then digitized again at a rate of one reading per minute for analysis.

Figs. 3 and 4 are the histograms of the current speed and direction. Current directions are given in degrees measured from the magnetic north. The boundary value between two segments is included in the left-hand side segment, for example, 963 is the number of readings of speeds which are faster than 11 cm/sec and equal to or slower than 12 cm/sec. The current is most frequently directed to about 200° and its speed ranges mainly from 9 to 17 cm/sec. The maximum speed reaches 29 cm/sec. It is a little

Fig. 1. Bathymetric chart in the vicinity of the station (X) with contours in meters.

Fig. 2. Mooring system.

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graph representation of velocity vector averaged over one hour. A systematic pattern is clearly seen. There are a southward general flow and clockwise motions on which are superimposed irregular motions.

After the current velocity is decomposed into eastward and northward components, spectral analysis is carried out for each component by means of Tukey's method (BLACKMAN and TUKEY, 1958).

Let \( V_i' \) be the readings of a component of the velocity at the time \( t_i \) \((i=1, 2, \ldots, N)\) with time interval \( \Delta t \). The quantity \( V_i \) is defined as \( V_i = V_i' - \sum_{i=1}^{N} V_i' / N \), so that the average of \( V_i \) becomes zero. The power spectrum \( P(k) \) is then calculated as follows,

\[
P(k) = \frac{1}{m} \sum_{i=0}^{m} \delta_i C(l) \left(1 + \cos \frac{\pi l}{m}\right) \cos \frac{k \pi l}{m}, \quad k=0, 1, 2, \ldots, m,
\]

where

\[
C(l) = \frac{1}{N-1} \sum_{i=1}^{N} V_i V_{i-l}, \quad l=0, 1, 2, \ldots, m,
\]

\[
\delta_i = \begin{cases} 
1/2 & \text{for } l=0, m, \\
1 & \text{for } l\neq0, m.
\end{cases}
\]

In Fig. 6 are shown the power spectra of the eastward and northward components of the velocity for the sampling time interval \( \Delta t = 16 \) min, the number of maximum lag \( m = 70 \) and the number of degrees of freedom \( v = 10.4 \). Most

Fig. 5. Hodograph representation of velocity vectors averaged over one hour. Numbers in hours.

Fig. 6. Power spectra of current velocity. The curves 1 (full line) and 2 (broken line) represent the eastward and northward components, respectively.
energy is concentrated in periods around 20 hours. The eastward component is stronger than the northward component, when energy is integrated over the whole range of frequencies. However, a good resolution is not obtained because of a short length of data used. Classical Fourier analysis reveals two peaks corresponding to diurnal and semi-diurnal tidal currents as is shown in Fig. 7. Computed with these tidal currents, of no importance is the inertial current which has a period of 17.15 hours at this latitude.

On the assumption that the current is expressed by a general flow and these three periodic currents alone, their amplitudes are determined by least square method. Then, we have the northward and eastward components in cm/sec,

\[
\begin{align*}
3.54 \sin \left( \frac{2\pi}{T_S} t - 2.42 \right) & \quad \text{for the semi-diurnal current} \ (T_S = 12.5 \text{ hours}), \\
5.96 \cos \left( \frac{2\pi}{T_D} t + 0.34 \right) & \quad \text{for the diurnal current} \ (T_D = 25 \text{ hours}), \\
5.17 \sin \left( \frac{2\pi}{T_P} t + 2.74 \right) & \quad \text{for the inertial current} \ (T_I = 17.15 \text{ hours}), \\
4.42 \cos \left( \frac{2\pi}{T_P} t - 0.46 \right) & \quad \text{for the general flow, respectively,}
\end{align*}
\]

and

\[
\begin{align*}
-9.06 & \\
-1.69 &
\end{align*}
\]

where \( t \) denotes the time.

All are clockwise motions. Fig. 8 represents their hodographs. Fourier coefficients in Fig. 7 of which the periods are slightly different from \( T_S, T_D \) or \( T_I \) but close to them agree fairly well with the amplitudes in (1). It follows that the current can be approximated well by the above four components.

Since the southward slope of the mount is about \( 2 \times 10^{-2} \) and the velocity of the southward general flow is about 9 cm/sec, the vertical component of the velocity is about 0.2 cm/sec. This strong downward velocity suggests that the bottom configuration can have an important effect on the hydrographic condition above and near the sea mount.

Neither measurements of other quantities such as temperature, pressure, salinity nor measurements of currents at other locations were done simultaneously because of a short time available, except only one GEK measurement carried out before the launching, which showed a flow of 0.8 knot in the direction of 160°. It is parenthetically remarked that the measurement was carried out from 3.8 to 8.1 in age of the moon and that the wind force varied between 1 and 7 in Beaufort scale during this period.

A part of data analysis was undertaken at the Computation Center of the University of Tokyo.

**Reference**