Results of direct current measurements in the La Perouse Strait (the Soya Strait), 1995-1998

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The La Perouse Strait (the Soya Strait) and its adjacent waters are good fishing grounds, but understanding of the physical, chemical, and biological environment has been very limited as the border between Japan and Russia runs along the center of the strait and a comprehensive survey has not been conducted. As an example, no direct estimates of the transport through the strait have been made.

The Hokkaido Central Fisheries Experimental Station (HCFES) and the Sakhalin Research Institute of Fisheries and Oceanography (SakNIRO) designed a cooperative observation project in the La Perouse Strait and its adjacent waters. This project is called the La Perouse Project, and it started in August 1995. Preliminary results of the project were presented by Yagi et al. (1996), Tanaka et al. (1996) and Nakata et al. (1996) at the 5th PICES Annual Meeting in Nanaimo.

Simultaneous direct current measurements in the La Perouse Strait were conducted by both institutions during the period from August 8 to 9, 1995. HCFES measured horizontal current structure by using a ship mounted ADCP (Acoustic Doppler Current Profiler), and SakNIRO applied two mooring systems along 142°E (Tanaka et al., 1996). Each of the mooring systems were set in the northern half of the strait, and were equipped with two current meters. The measurements were successful and the data series long enough to get residual currents by eliminating tidal current components. The observations of our joint project conducted in August 1995 were an historical first attempt to obtain the total volume transport passing through the whole section of the La Perouse Strait. However, the observation in August 1995 is the only direct current measurement in the northern half of the strait until now.

In this paper, we report the results of the ADCP observations conducted regularly in the southern half of the strait after 1995, by focusing on the long-term variability of the transport of the Soya Warm Current through the strait. Two kinds of ADCP were used on the R/V *Hokuyo Maru* (Wakkanai Fisheries Experimental Station): RD-VM150 (RD Instruments) was used in August 1995 and March 1997. The maximum number of levels measured was 20 and 5, respectively, and a FURUNO CI-30 (Furuno Electric. Co.) for the other observations (the maximum number of levels was 3).

As discussed by Odamaki and Iwamoto (1999), the magnitude of the tidal current may sometimes exceed that of the Soya Current. The ADCP observation in August 1995 were repeated eight times within the period of 25 hours (more exactly 24 hours and 50 minutes), in order to eliminate the diurnal- and semi-diurnal tidal components. After 1996, ADCP measurements were repeated four times within 25 hours. We used a method developed by Katoh (1988) to eliminate tidal components. The original version of his method was based on data repeated four times. The method was extended to accommodate data repeated eight times in the case of 1995. Katoh (1988) applied his method to the data repeatedly observed along a line but in 1995 many fishing boats were operating and many cargo ships navigating in the strait at the time of the observation. Our research vessel could not navigate along a straight line, and was often forced to change speed and direction. Thus, we selected three points, S101, S102 and S103 (Fig. 1) and the vessel came back to each of these stations exactly at the prescribed times so that Katoh's method could be applied. The vertical current shear in the Soya Warm Current is generally weak and the current is almost barotropic (Aota 1975, Kanari et al., 1984, Tanaka et al., 1996), although the magnitude tends to decrease a little with depth. Here, the vertically averaged velocity is used for the estimation of the transport.

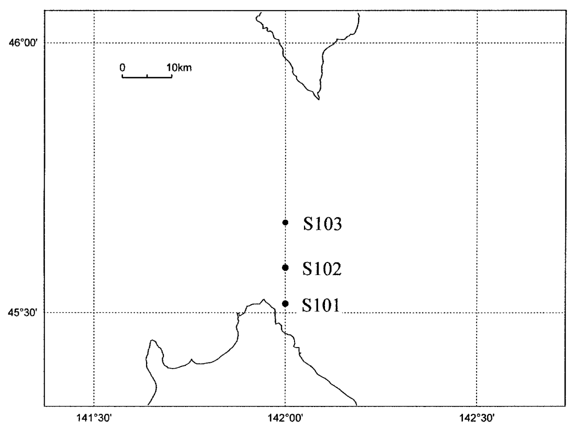

Fig. 1 Selected observation points, S101, S102 and S103, where the ADCP observations were repeated in each cruise, and where the residual current components (oceanic current velocities) were obtained.

HCFES oceanographic observations in the southern half of La Perouse Strait (the Soya Strait) were generally carried out four times per year: March (before 1998) or April (the observation was made both in March and April in 1998), June, August, and December. The ADCP observations repeated over 25 hours are similar to those taken in August 1995, and it was planned to continue these routine observations after 1996 until present. All of the repeated ADCP observations in December could not be conducted due to severe weather conditions so the measurements have been conducted 10 times until now.

The eastward component of the vertically averaged velocity at each station is multiplied by the water depth and by the representative horizontal scale, and integrated from the Hokkaido coast to the central part of the strait (S103). The resulting eastward transport of the Soya Warm Current crossing the southern half of the strait at each observation time is plotted in Figure 2 against the time. The transport of the Soya Warm Current is between 0.15 and 0.50 Sverdrup except in March 1997, when a negative (westward) transport was found.

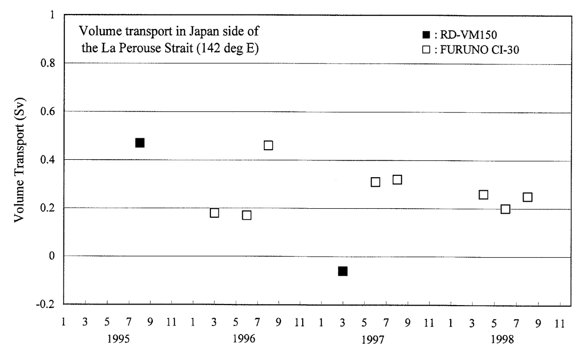

Fig. 2 Temporal variation of the volume transport (in Sverdrup) of the Soya Warm Current crossing the longitude of 142°E of the southern half of the La Perouse Strait (the Soya Strait). The black square indicates ADCP measurments by the RD-VM150 (RD Instruments) and the white square by the FURUNO CI-30 (Furuno Electric. Co.).

The transport of the Soya Warm Current tends to have a maximum in August in each year. The current velocity of the Soya Warm Current is well correlated with the sea level difference between Wakkanai and Abashiri tide gauge stations (Aota et al., 1988, Aota et al., 1985, Aota et al., 1990). By assuming that the Soya Warm Current is driven by the sea level difference between the Sea of Japan and the Sea of Okhotsk and by assuming barotropic flow (Aota 1975, Kanari et al., 1984, Tanaka et al., 1996), Aota (1975), Aota et al. (1985) and Ohshima (1994) were able to derive simple models to explain the basic characteristics of seasonal variation of the Soya Warm Current. Our result is generally consistent with the seasonal variations derived from sea level difference.

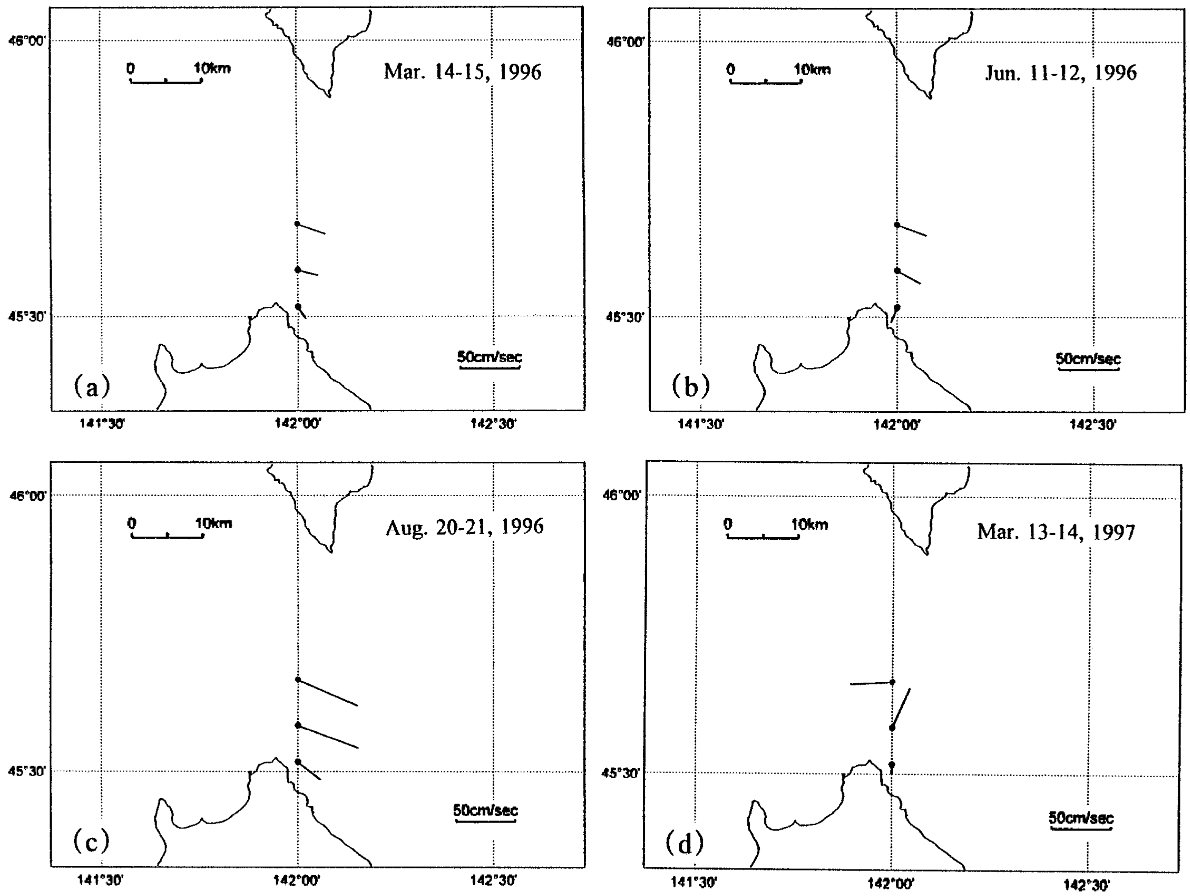

Fig. 3 Examples of the distribution of the vertically averaged residual current velocities: (a) March 14-15, 1996, (b) June 11-12, 1996, (c) August 20-21, 1996, and (d) March 13-14, 1997.

The transport of the Soya Warm Current in summer (the season of the maximum transport) appears to have decreased since 1996. However, the estimation of the transport might be influenced by shorter time scale variations, and further long time series of the observation would be needed to clarify this trend. Also, the detailed analysis of the sea level difference between Wakkanai and Abashiri should be carried out for this purpose.

It is necessary to discuss the negative transport found in March 1997, since the Soya Warm Current is usually found in March every year. Examples of the distribution of the vertically averaged current velocities are shown in Figure 3 for the four observations in the period from March 1996 to March 1997: (a) March 14-15, 1996, (b) June 11-12, 1996, (c) August 20-21, 1996, and (d) March 13-14, 1997. The current profile in March 1996 (Fig. 3a) shows the ordinary pattern of the Soya Warm Current although the magnitude of the currents are considerably smaller than those in summer (Fig. 3c: August 1996). On the other hand, the current distribution in March 1997 (Fig. 3d) is rather confused, and a strong westward flow was observed at Station S103. This westward flow found at Station S103 largely contributes to the negative transport in March 1997. A low density, less saline water with a negative temperature was observed in the surface layer in the northern half of the strait in March 1996 (Yagi et al., 1996; Nakata et al., 1999). Judging from the density structure and the horizontal temperature and salinity distributions, the less saline water seems to originate from the Okhotsk Sea and was carried westward. The current distribution in Figure 3d might be understood by the extension of the less saline water to the south. The associated westward flow region might cover the Station S103. The complexity of the current distribution in Figure 3d suggests that such a phenomenon occurs sporadically and that short-period disturbances like eddies may appear (Kanari et al., 1984). The model derived by Aota et al. (1990) predicts that the direction of the total volume transport through the La Perouse Strait (the Soya Strait) should be reversed when the mean sea level difference between Wakkanai and Abashiri is very small. Thus, it is plausible that the reversed flow occurs in winter when the sea level difference is relatively small. It might be emphasized that the observation in March 1997 is the first example of a reversal in total volume transport through La Perouse Strait (the Soya Strait) to be confirmed by direct current measurements.

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