Volume, Heat, and Salt Transport Connections Between the Taiwan, Cheju, and Korea Straits

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Abstract

The main currents flowing into the East China Sea and ultimately the Yellow and the Japan/East Sea are the Kuroshio, entering through the passage between Taiwan and the southwestern tip of the Ryuku Islands, and the Taiwan Warm Current, entering through the Taiwan Strait from the South China Sea. Insight into the circulation of the East China Sea and origin of the Tsushima current are investigated through direct, concurrent measurements of velocities through the Taiwan, Cheju, and Korea Straits. Current data are obtained from six bottom-mounted acoustic Doppler current profilers (ADCPs) arrayed along a section spanning the Korea Strait, a single bottom-moored ADCP in the Cheju Strait, and four bottom-moored ADCPs along a section spanning the Taiwan Strait. Mass transports are computed for the October to December, 1999 time period. In addition, heat and salt transports are examined in conjunction with climatological values of temperature and salinity. Average volume transport is 0.14 Sverdrups (Sv) through the Taiwan Strait, 0.59 Sv for the Cheju Strait, and 3.17 Sv for the Korea Strait. Salt and heat transport through the Korea Strait and into the Japan/East Sea are 110.48 x 10^6 kg/s and 0.24 x 10^{15} watts (w), respectively. The bulk of flow through the Korea Strait must come from the Kuroshio flowing onto the shelf since the flow through the Taiwan Strait (0.14 Sv) is quite small. Some heat loss occurs in the Korea Strait but most of the Kuroshio heat loss occurs in the East China Sea at a rate of about 200 w/m², and little heat is lost in the Yellow Sea. The total volume transport through the Korea Strait is formed from Taiwan Warm Current and Kuroshio waters which may have been modified by Yellow Sea, East China Sea, and South China Sea waters, and by river outflows. The main source for the Tsushima Current and its flow into the Japan/East Sea is clearly the Kuroshio for this time period.

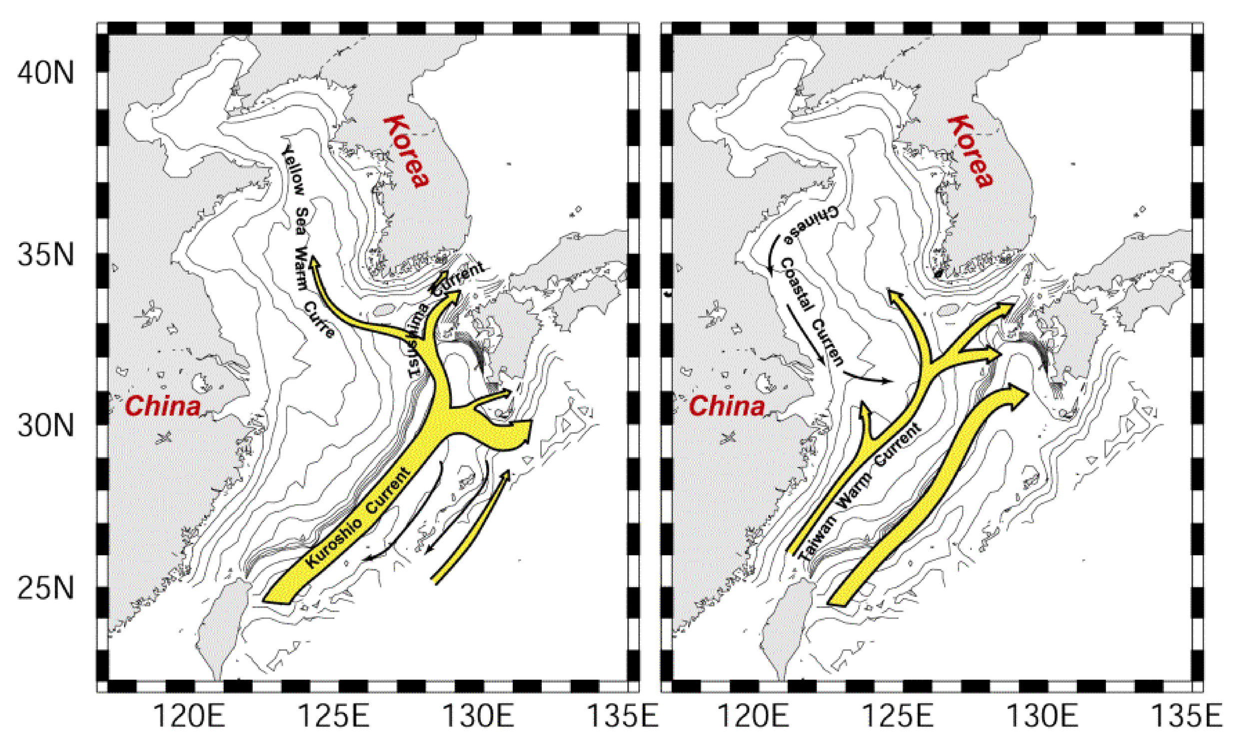

Figure 1 a) Results adapted from Nitani (1972) suggest that the Kuroshio Current is the main source of inflow for the Tsushima Current. The Yellow Sea Warm current is also hypothesized to form off the Tsushima Current.

b) Results adapted from Beardsley et al. (1985) suggest that the Taiwan Warm Current is the main source for the Tsushima Current and a Yellow Sea Warm Current.

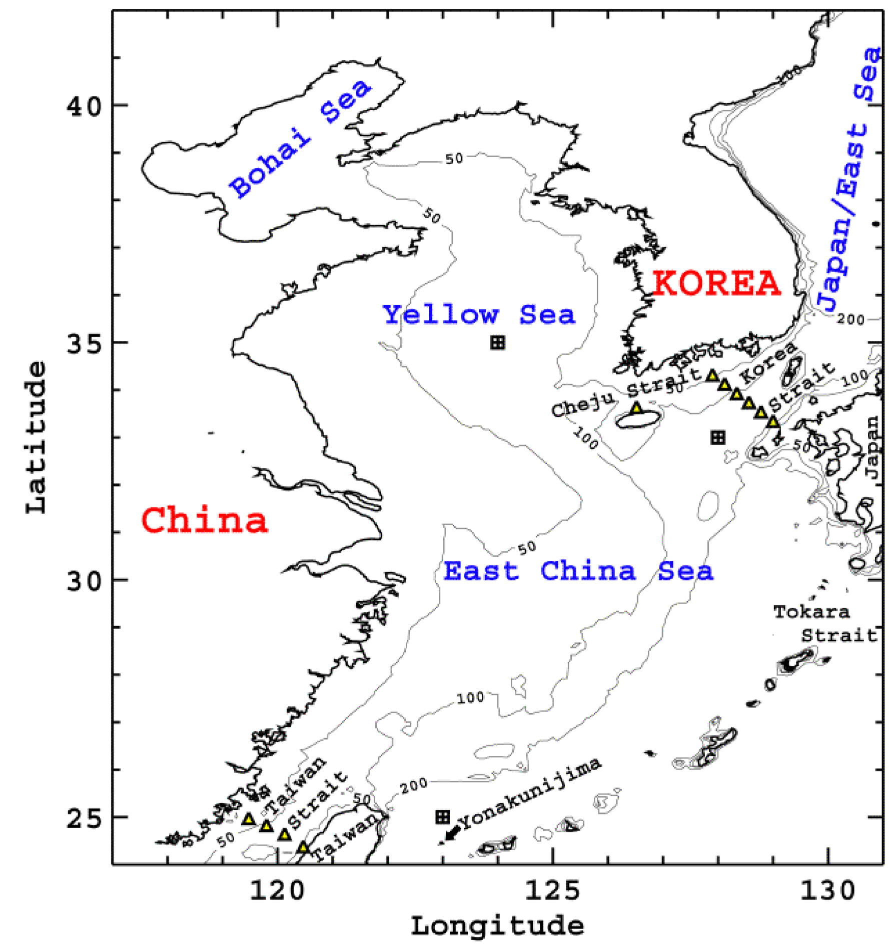

Figure 2. Mooring locations (triangles) are indicated in the Taiwan, Cheju, and Korea Straits. Wind observation positions (boxes with plus signs) are located near the Taiwan Strait, in the Yellow Sea, and in the Korea Strait. Bathymetry is in meters.

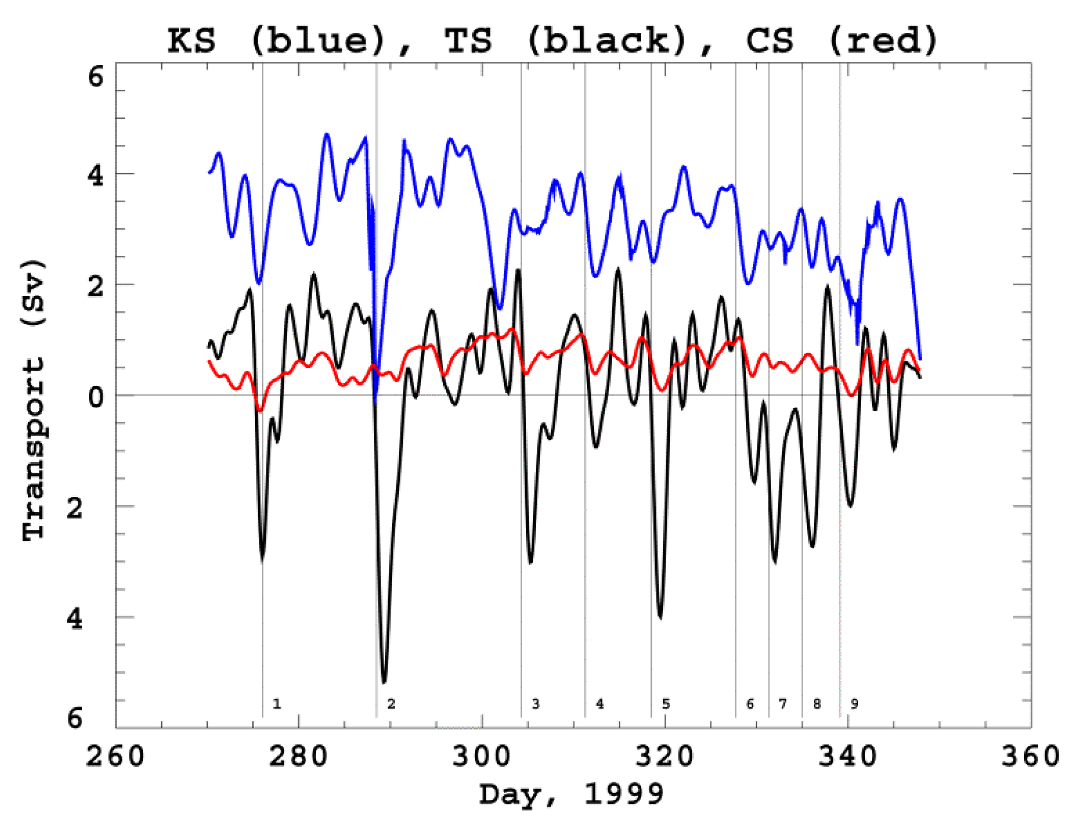

Figure 3. Transports as a function of time are shown for the Korea Strait (blue line), Cheju Strait (red line), and Taiwan Strait (black line). Major wind events are marked by the light vertical lines numbered 1 through 9.

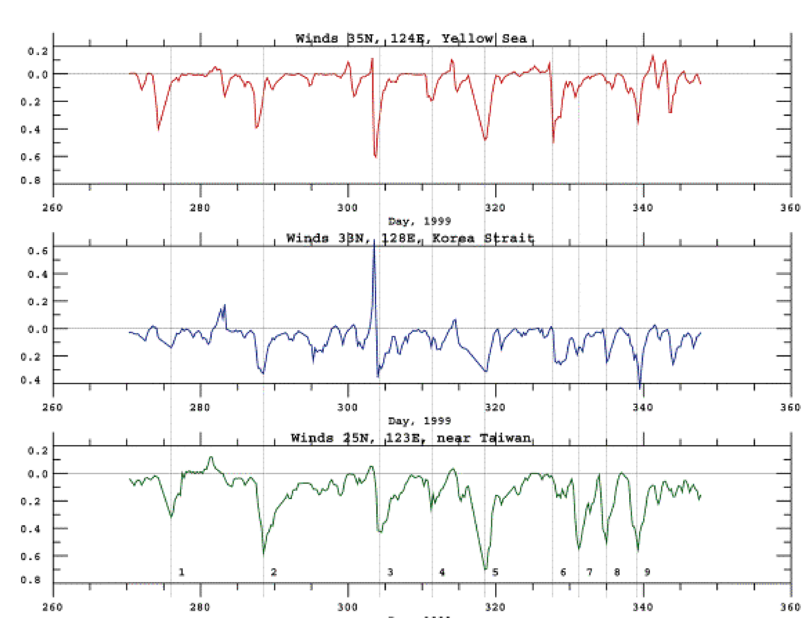

Figure 4. North-south wind stress component at the three locations indicated in Figure 2. Major wind stress events are marked by the light vertical lines numbered 1 through 9.

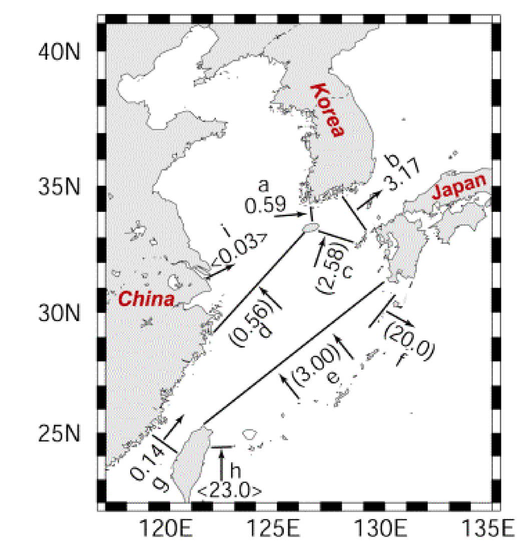

Figure 5. Calculated volume transports (a,b, and g), inferred (in parentheses) volume transports (c,d,e,and f), and climatological (in brackets) volume transports (h) and river outflows (i) are shown for October to December, 1999. Units are Sverdrups (10^6 m ^{3}/s).

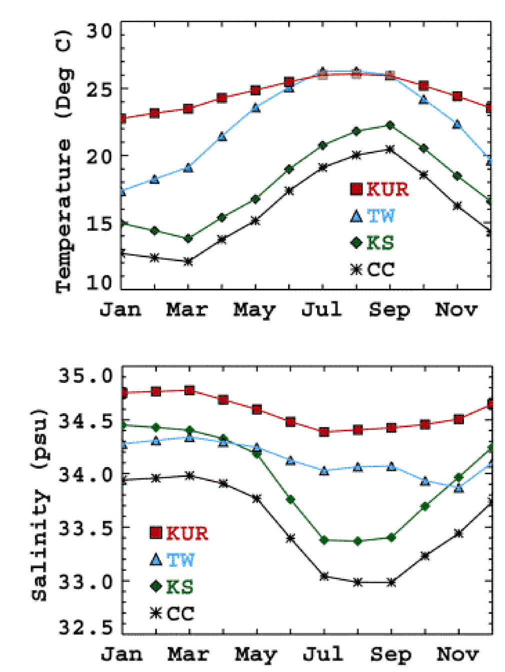

Figure 6a. Average monthly temperatures for the Cheju Strait (CC), Korea Strait (KS), Taiwan Strait (TW), and the Kuroshio (KUR) are shown.

6b. Average monthly salinities are shown. Salinities are computed from the MODAS static climatology (Fox et. al., 2001). http://www7320.nrlssc.navy.mil/modas

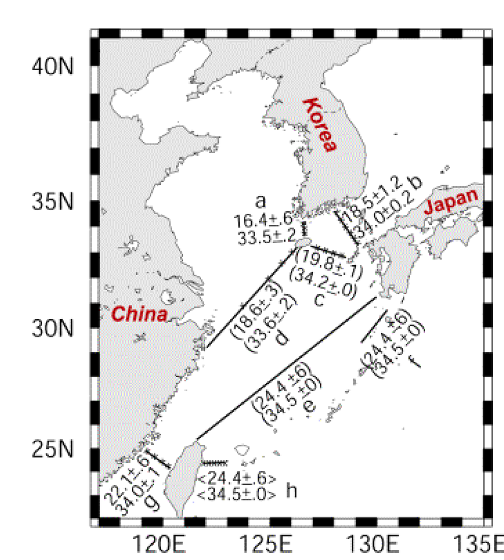

Figure 7. Average temperature (°C) and standard deviation (top number) and average salinity (ppt) and standard deviation (bottom number) for the climatological October to December time period. Values are obtained from the MODAS climatology (Fox et al., 2001). Averages are formed from depth-averaged quantities are the locations indicated by the crosses. Kuroshio average T&S values from MODAS at the entrance to the East China Sea are used for e, f, and h.

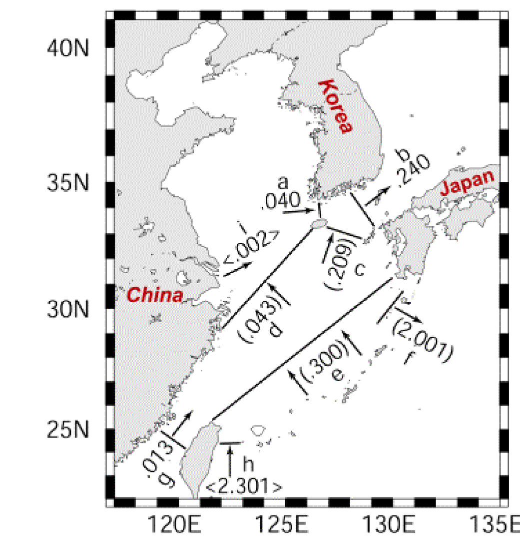

Figure 8. Temperature transports (x10^{15} w) are estimated from the values given in Figures 5 and 7. The river temperature transport (i) assumes an average temperature of 18°C for the river inflow.

Heat transport is given by:

$T_t = \rho C_p VT$,

where C_p is the specific heat, V is the volume transport, and T is the temperature.

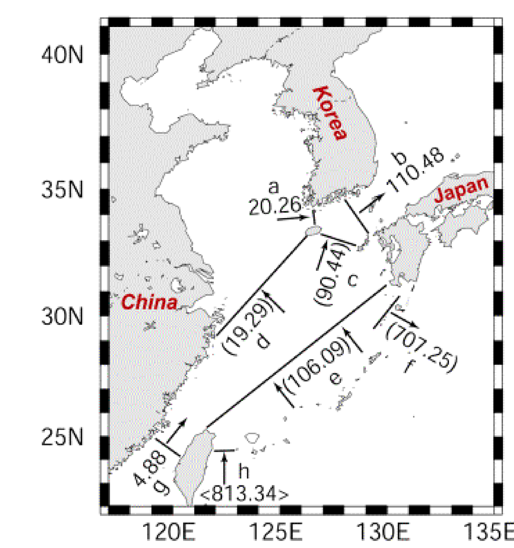

Figure 9. Salinity transports (x10^6 kg/s) are estimated from the values given in Figures 5 and 7.

Salt transport is given by:

$S_t = \rho VS$,

where ρ is the density of sea water, V is the volume transport, and S is the salinity.

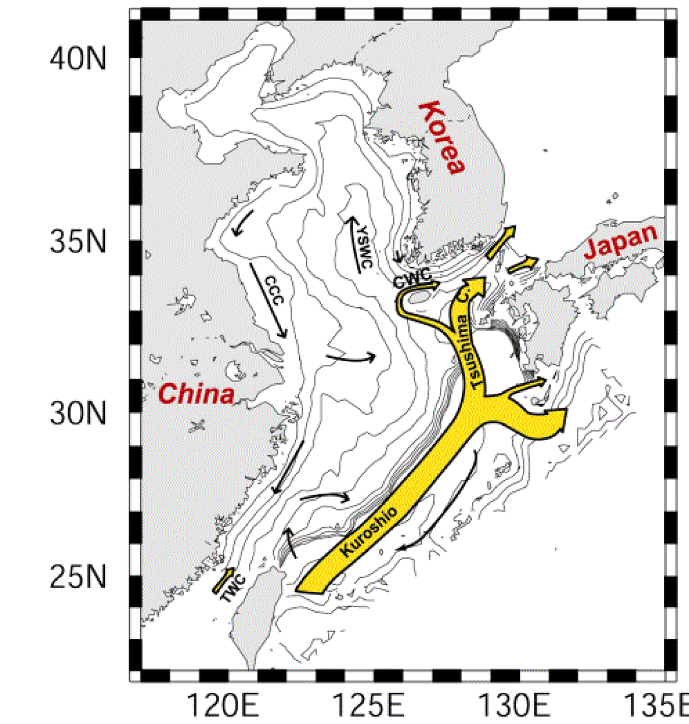

Figure 10. A new circulation pattern is proposed for the Yellow and East China Seas. The Kuroshio Current provides the main inflow into the Japan/East Sea via the Tsushima Current and Cheju Current. Tsushima Current transport is larger in the western channel than in the eastern channel (west and east of Tsushima, respectively). The Yellow Sea Warm Current does not form off the Tsushima Current. The Taiwan Warm Current can commingle with the Kuroshio Current.

CONCLUSIONS

For the October through December, 1999 time period, the following conclusions apply.

Volume transport through the Korea Strait is 3.17 Sv.
Heat transport through the Korea Strait is 0.24x10^{15} w.
Salt transport through the Korea Strait is 110.48 10^6 kg/s.

The bulk of flow through the Korea Strait must come from the Kuroshio flowing onto the shelf since the flow through the Taiwan Strait (0.14 Sv) is quite small. About 95% of the transport into the JES is of Kuroshio origin.

Some heat loss occurs in the Korea Strait but most of the Kuroshio heat loss occurs in the East China Sea at a rate of about 200 w/m², and little heat is lost in the Yellow Sea.

The largest percentage of the salt flux into the Japan/East Sea is attributed to the Kuroshio.

Transport fluctuations in the Korea Strait are highly coherent with fluctuations in the Taiwan Strait.

A new circulation pattern for the Yellow and East China Seas is shown in Figure 10.

References:

Beardsley, R.C., R. Limeburner, H. Yu, and G.A. Cannon, 1985. Discharge of the Changjiang (Yangtze River) into the East China Sea, *Cont Shelf Res.*, *4*, 57-76.

Nitani, H., 1972. Beginning of the Kuroshio, in *Kuroshio*, edited by H. Stommel and K. Yoshida, University of Tokyo Press, Tokyo, Japan, 353-369.

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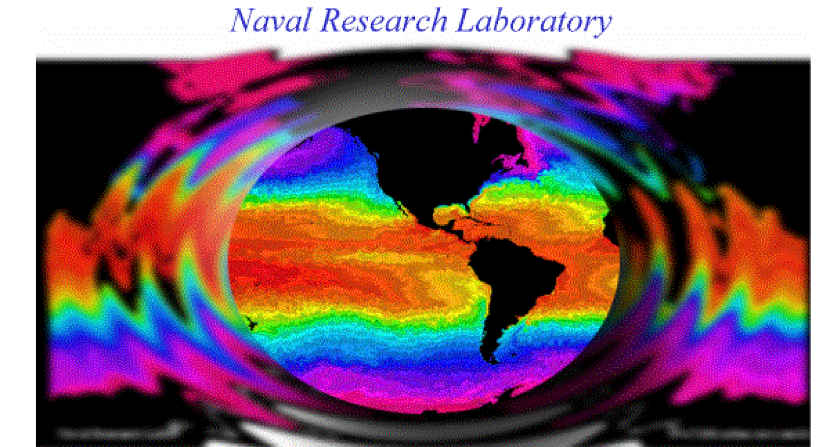

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