Transport Observations Across the Korea/Tsushima Strait

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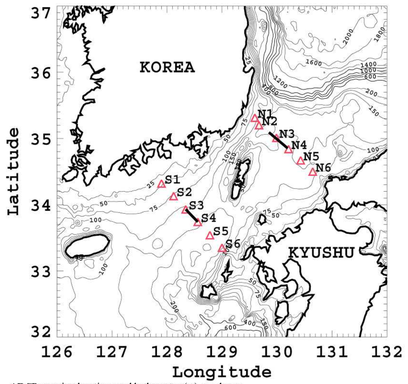
Abstract

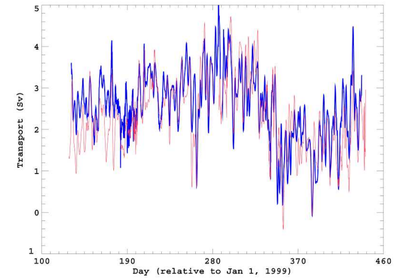
The Tsushima Current flows from the East China Sea to the Japan/East Sea via the Korea/Tsushima Strait. Volume transports and the variability across the strait are of high interest. Between May 1999 and March 2000, ADCP measurements were made in the strait to examine the transport. The Tsushima Current transport, averaging 2.65 Sverdrups, is split into two cores by Tsushima Island which divides the strait into eastern and western channels. Transport in the western channel is 23% higher than in the eastern channel over the measurement period. Some seasonality in transport variability is observed for both the western and eastern channels. Transports are largest in fall and smallest during winter. Transport variations across the strait are large, particularly in the lee of Tsushima Island where a countercurrent commonly exists. A wake zone that averages 40 km in width is observed downstream of Tsushima Island and appears to follow island wake zone dynamics. Reynolds numbers can range from 22 to 90 in the wake zone and eddy shedding can occur throughout the year. EOF analyses indicate total transport variations in summer are due mainly to transport variations near the Korea coast, while in winter, contributions to total transport variations are more uniformly distributed across the strait.



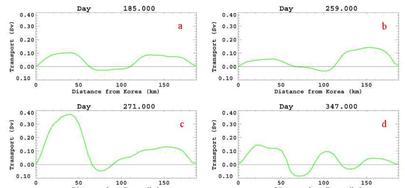
ADCP mooring locations and bathymetry (m) are shown.

The heavy bar on the south line (S1 -- S6) indicates the section where the Tsushima Current splits into the western and eastern channels. The heavy bar on the north line (N1 -- N6) indicates the highly variable, low transport,island wake section.

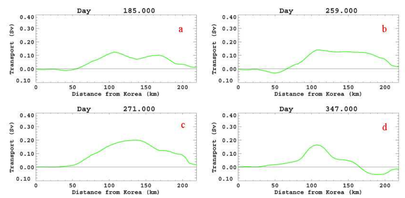
Bathymetry is from a 1-minute resolution data set available from the Laboratory for Coastal and Ocean Dynamics Studies, Sung Kyun Kwan University (Choi, 1999).



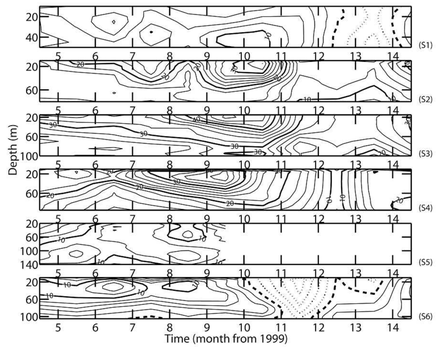
Total transport estimates for the south line (blue line) and north line (red line) are shown as a function of time.



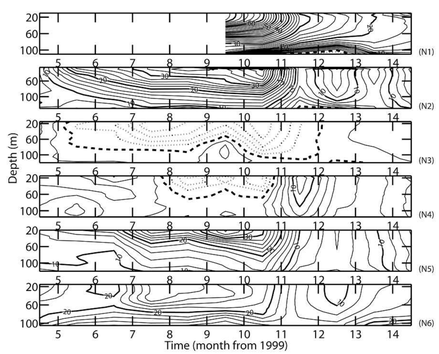
Representative transport cross sections for the north line: (a) transport similar in magnitude in the western and eastern channels (26% of the time), (b) transport stronger in the eastern channel than in the western channel (8% of the time), (c) transport stronger in the western channel than in the eastern channel (61% of the time), and (d) three outflows separated by weak inflow regions (5% of the time).



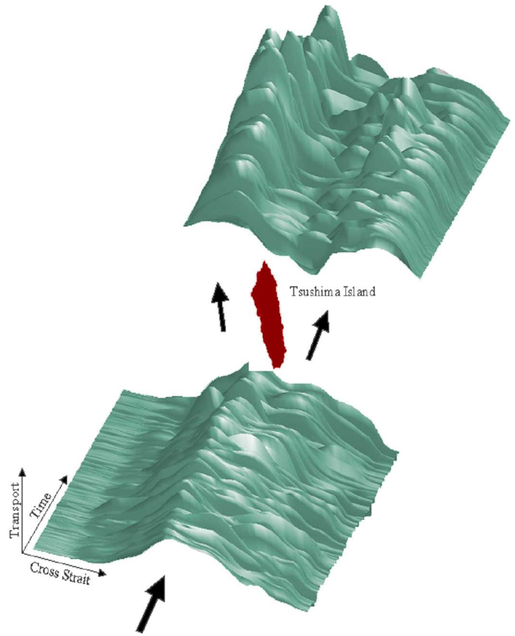
Transport cross sections for the south line, corresponding to north line times presented in figure above.



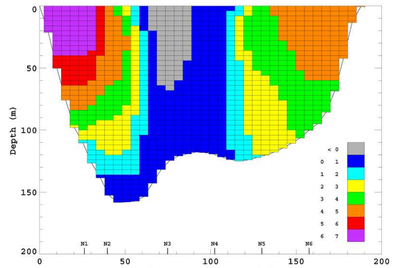
The temporal evolution of the vertical profiles of the daily mean velocity at the moorings upstream (south line) of Tsushima Island. Dotted contour lines are negative velocities, solid contour lines are positive velocities, and dashed contour lines are zero velocities.



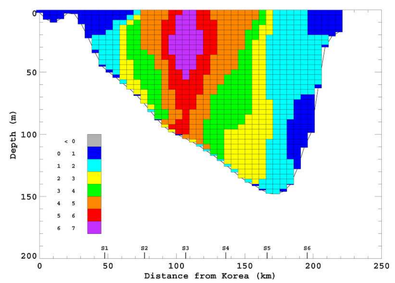
Same figures above but for the moorings downstream (north line) of Tsushima Island.



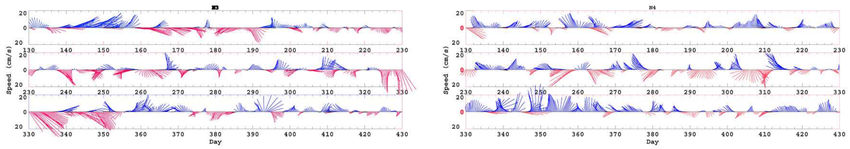
Three-dimensional depiction of the transport upstream (along the south line) and downstream (along the north line) of Tsushima Island.



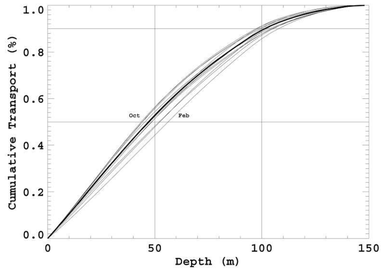
As in figure below but for the north line.



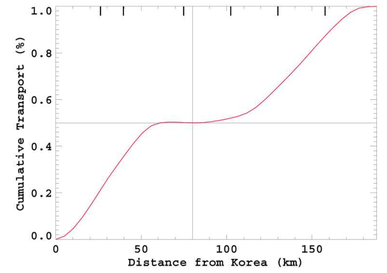
Transports averaged over May 1999 through March 2000 are shown for the south line. Units are $10^3 m^2 s^{-1}$ or $1x10^{-3}$ Sv. Each grid square is approximately 5 km across strait by 4 m in depth, except near the bottom where the depth dimension may be less. Positions of moorings, S1--S6, are indicated on the x axis.



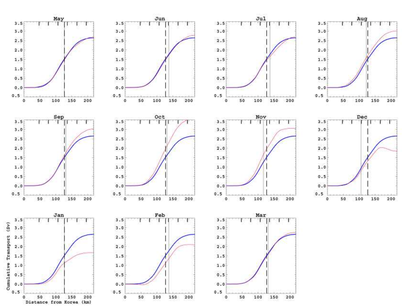
The temporal history of the velocity vectors at 20 m depth for the downstream stations of N3 and N4. The velocities have been rotated so that positive vectors normal to the x-axis are directed along strait towards the Japan/East Sea. The periodic rotation of the velocity vectors strongly suggests continuous eddy shedding or periodic wakes.



Normalized cumulative transports versus depth for the south line are shown for each month (thin lines, bounded by February and October) and for the eleven-month average (thick line).



Average cumulative transport distribution over the year as a function of distance from Korea for the north line. Positions of moorings, N1--N6, are indicated by the thick vertical bars on the top axis.



Cumulative transport distributions for the south line are shown for the annual mean (blue line) and for each month (red line). The dashed vertical line is the average location along the south line where the total transport for the 11 months splits into the west and east channels. The thin vertical line denotes the location where the monthly-averaged transport must split. Positions of moorings, S1--S6, are indicated by the thick vertical bars on the top axes.

	South Line	North Line	West Channel	East Channel
May-Mar	2.65	2.38	1.46	1.19
May	2.69	1.97	1.38	1.31
Jun	2.78	2.22	1.61	1.17
Jul	2.70	2.32	1.56	1.14
Aug	3.01	2.92	1.45	1.56
Sep	3.03	2.82	1.70	1.33
Oct	3.59	3.32	2.02	1.57
Nov	3.05	3.29	1.67	1.38
Dec	1.83	1.91	0.77	1.06
Jan	1.67	1.57	1.10	0.57
Feb	2.09	1.53	1.27	0.82
Mar	2.75	2.16	1.52	1.23

Transport summary for total transports through the south and north lines, and transports through the west and east channels.

$U(m/s)$	$K(m^2/s)$	R_e	S
0.30	100	90.0	0.145
0.30	200	45.0	0.145
0.15	100	45.0	0.289
0.15	200	22.5	0.289

Reynolds and Strouhal numbers representing the mean flow in the Korea/Tsushima Strait.

Conclusions

For May 1999 through March 2000 --

Total average transport through the strait: 2.65 Sv,

Average transport through the western channel: 1.46 Sv,

Average transport through the eastern channel: 1.19 Sv,

Transport range: 0.5 to 5.5 Sv.

Transport is higher in fall than in winter.

Transport is surface intensified.

Single high velocity core upstream of Tsushima Island.

Two high velocity cores downstream of Tsushima Island.

A 40-km wide wake zone forms downstream of Tsushima Island.

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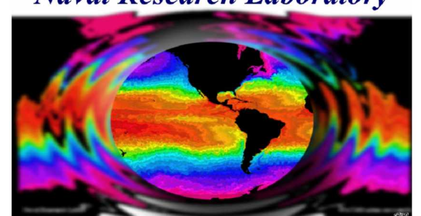

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