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The Comparision of the Volume Transport in the Korea Strait and in the Middle of the East Sea (Japan Sea)

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大韓海峽과 東海 中部에서의 容積 輸送量 比較研究

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Abstract: With the serial observation data of the Fisheries Research and Development Agency in Korea and Japan Meteorological Agency from 1969 to 1974, the geostrophic current and volume transport were calculated in the Korea Strait and in the middle of the East Sea (Japan Sea), in order to compare the total volume transport in summer and winter seasons.

The results are as follows. The annual mean of the net volume transport of the Korea Strait is $0.19\times10^6 m^3/sec$ in winter season and $1.33\times10^6 m^3/sec$ in summer season. The transport through the western and eastern channel of the Korea Srait is almost same in winter season, but the transport of the western channel is much larger than that of the eastern channel in summer season. The annual mean of the net volume transport of the middle section of the East Sea (Japan Sea) is $2.61\times10^6 m^3/sec$ in winter season and $2.41\times10^6 m^3/sec$ in summer season. Therefore the transorts are almost same in both seasons.

Comparing the transports of the two sections, the transport through the middle section of the East Sea is 13.7 times as large as that of the Korea Strait in winter season and 1.8 times in summer season.

要約：대한해협과 동해중부 단면에서 1969년부터 1974년까지, 국립수산진흥원 관측자료와 일본 기상청 관측자료를 이용하여, 동절기와 하절기로 구분하여 두 단면을 통과하는 지형류의 유속과 용적수송량을 비교분석했다.

대한해협을 통해서 동해로 유입되는 누년평균 순용적수송량은, 동절기에는 $0.19\times10^6 m^3/sec$이고, 하절기에는 $1.33\times10^6 m^3/sec$이다. 동절기에는 동수도와 서수도를 통해서 동해로 유입되는 수송량이 거의 같은 값을 보이나, 하절기에는 서수도를 통해서 동해로 유입되는 수송량이 동수도보다 훨씬크다.

동해중부단면을 통과하는 누년평균 순용적수송량은, 동절기에는 $2.61\times10^6 m^3/sec$이고, 하절기에는 $2.41\times10^6 m^3/sec$로서 본 단면에서는 동절기와 하절기에 거의 같은 수송량을 보인다.

두 단면에서 동절기와 하절기의 수송량 값을 비교하면, 동절기에는 대한해협보다 동해 중부단면을 통과하는 유량이 13.7배 정도 크고 하절기에는 1.8배 정도 크게 나타난다.

INTRODUCTION

The Korea Strait is located between Korea Peninsula and Japanese Islands, and has a breadth of about 200km and depth shallower than 200m. Because the water of the East Sea (Japan Sea) is supplied through this strait, the precise measure ment of the volume transport and physical characteristics of this section has a great meaning to decide a comprehensive oceanographical conditions of the East Sea

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(Fig. 1).

On the other hand, the volume transport and physical characteristics of the north-south section crossing the middle area of the East Sea can be regarded as a representative values of the East Sea and the Daema Warm Current (Tsushima Warm Current) goes through the southern part of this section. As shown in Fig. 1, we call hereafter the cross section of the Korea Strait as the section A and the north-south section in the middle of the East Sea as the section B.

On the current velocity of the Korea Strait, Miyazaki (1952) proposed that the maximum current velocity occurs in August and September. Yi (1966) suggested that the maximum current velocity occurs in August and September and the minimum in February and April, and he calculated that the total mean volume transport is $1.35\times10^6 m^3/sec$.

From the estimation of average current velocity in the western channel of the Korea Strait, Lee & Jung (1977) induced a linear formula which satisfies the relation of $V=4.016\ (H-98.3)$, where V is average current velocity and H is the sea surface slope across the channel, and this agrees fairly well with the results of Hidaka & Suzuki (1950) and Yi (1966).

In the section of Tateishizaki-Vladivostok which almost coincide with the section B, Naka-

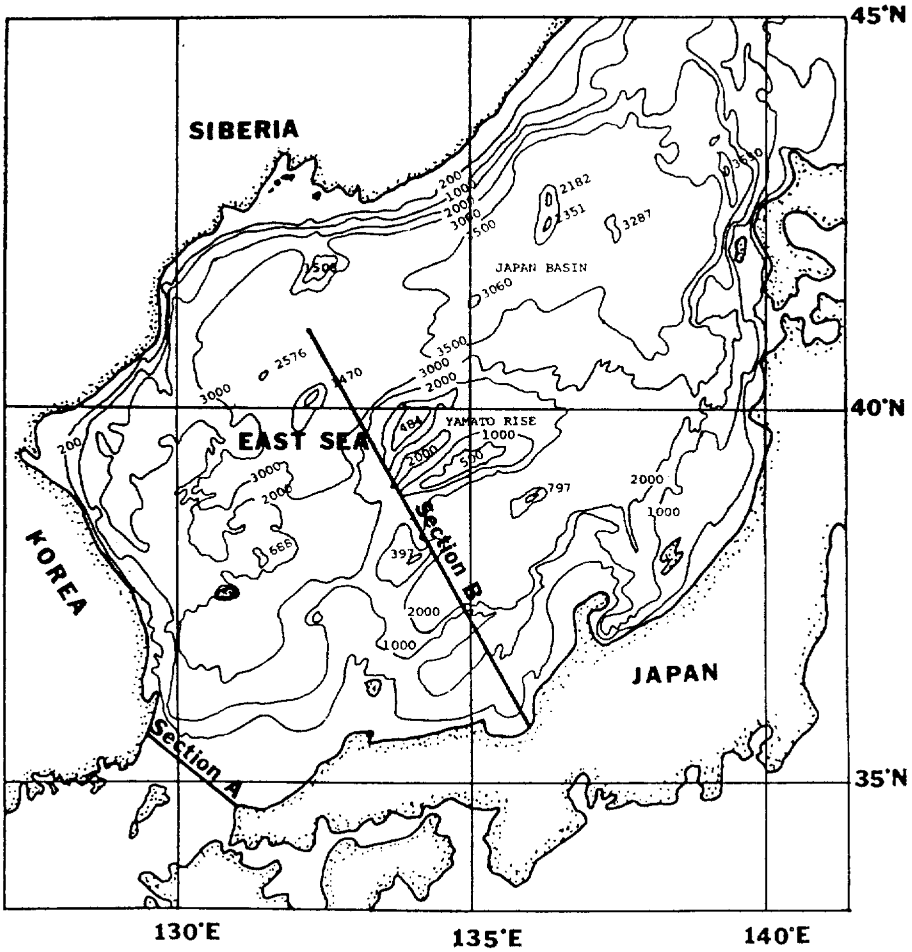

Fig. 1. Bottom topography of the East Sea (Japan sea). The solid straight lines indicate the sections A and B.

yama (1957) defined that the upper limit of the Japan Sea Proper Cold Water is 300m depth from the Japan coast to 250 miles, 150m depth from 250 to 300 miles, 100m depth beyond 300 miles. According to this result, the reference level below 400m is suitable for the dynamic calcuation in the middle of the East Sea.

In this study we will show how the geostrophic transport of the Korea Straits referring to 125m depth is unreasonable and especially how the seasonal variation is magnified by the formation of the seasonal thermocline, by comparing to the Daema Warm Current in the middle of the East Sea which is assumed reasonable.

DATA AND METHODS

The data used in this study were taken from the results of serial oceanographic observations of section A from 1969 to 1974 by the Fisheries Research and Development Agency in Korea, and the results of serial oceanographic observations of section B from 1969 to 1972 by the Marine Meteorological and Oceanographical Observations of the Japan Meteorological Agency (Fig. 1). In both sections, the winter and summer season physical properties are represented by the data in February and August.

The velocity of geostrophic current is calculated by using the Helland-Hansen and Sandström's formula.

In this calculation, the level of no motion is assumed at the 125m layer in section A and 400m layer in section B.

VOLUME TRANSPORT OF THE SECTION A

At first, We calculated the volume transport and velocity of the section A. According to this results, the geostrophic current velocities perpendicular to the section A have a inflow maximum surface velocity of 100cm/sec and outflow maximum surface velocity of 55cm/sec in summer season. The outflow maximum surface current velocity is irregularly located from station 4 to station 9.

Table 1. Annual total volume transport of the summer seasons across the section A.

Component \ Year	1969	1971	1972	1973	1974
NE Comp.	1.35	1.44	2.14	3.15	0.96
SW Comp.	0.49	0.77	0.52	0.80	0.39
NET TRANSPORT	0.86	0.67	1.62	2.35	0.57

$\times 10^6 m^3/sec$

The total volume transports in summer across the section A are shown in table 1. It shows that the inflow volume transport varies from $0.96\times10^6m^3/sec$ in 1974 to $3.15\times10^6m^3/sec$ in 1973, and outflow volume transport from $0.39\times10^6m^3/sec$ in 1974 to $0.80\times10^6m^3/sec$ in 1973, and net volume transport from $0.57\times10^6m^3/sec$ in 1974 to $2.35\times10^6m^3/sec$ in 1973.

Fig. 2 shows the annual means of the net volume transport between two neighbouring stations of the section A. The total net volume transports are $1.33\times10^6m^3/sec$ in inflow and $0.17\times10^6m^3/sec$ in outflow.

In the section A, in winter season the inflow maximum surface velocity is 12cm/sec and outflow 22cm/sec.

The total volume transports across the section

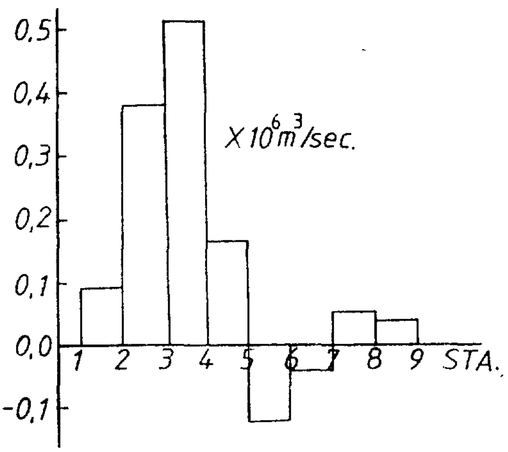

Fig. 2. Five years average in each subsections of the net volume transport in summer across the section A.

Table 2. Annual total volume transport of the winter seasons across the section A.

Component \ Year	1969	1970	1971	1972	1973
NE Comp.	0.19	0.13	0.30	0.40	0.26
SW Comp.	0.15	0.09	0.23	0.11	0.05
NET TRANSPORT	0.04	0.04	0.07	0.29	0.21

$\times 10^6 m^3/sec$

A in winter are shown in table 2. It shows that the inflow volume transport varies from $0.13\times10^6 m^3/sec$ in 1970 to $0.40\times10^6 m^3/sec$ in 1972, and the outflow volume transport from $0.05\times10^6 m^3/sec$ in 1973 to $0.23\times10^6 m^3/sec$ in 1971, and the net volume transport from $0.04\times10^6 m^3/sec$ in 1969 and 1970, to $0.29\times10^6 m^3/sec$ in 1972.

Fig. 3 shows the annual means of the net volume transport across the each sub-section of the section A in winter, the inflow and outflow net volume transports are $0.19\times10^6 m^3/sec$ and $0.10\times10^6 m^3/sec$. Particularly, inflow transport passing through the eastern and western channel is almost the same value in winter.

As a result, the net volume transports across the section A in winter and summer season are $0.19\times10^6 m^3/sec$ and $1.33\times10^6 m^3/sec$ respectively. In winter, the volume transport of Daema Warm Current through the both channels are almost same value, but in summer the volume transport through the western channel is come up to 93% of the total inflow volume transport.

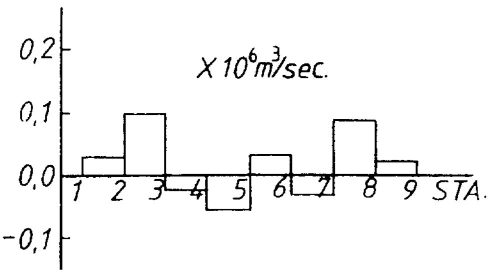

Fig. 3. Five years average in each subsections of the net volume transport in winter across the section A.

VOLUME TRANSPORT OF THE SECTION B

In summer season, the geostrophic current velocities perpendicular to the section B have a northeastward maximum surface velocity of 28 cm/sec and southwestward maximum surface velocity of 24cm/sec.

The total volume transports in summer across the section B are shown in table 3. It shows that the northeastward volume transport varies from $5.46\times10^6 m^3/sec$ in 1971 to $6.55\times10^6 m^3/sec$ in 1970, and southwestward volume transport from $3.12\times10^6 m^3/sec$ in 1971 to $3.78\times10^6 m^3/sec$ in 1972. Northeastward volume transport is 1.7 times larger than southwestward volume transport.

In winter season, the geostrophic current velocities perpendicular to the section B have a northeastward maximum surface velocity of 32 cm/sec and southwestward maximum surface velocity of 24cm/sec.

The total volume transports across the section B in winter are shown in table 4. It shows that the northeastward volume transport varies from $4.61\times10^6 m^3/sec$ in 1970 to $5.69\times10^6 m^3/sec$ in 1972 and southwestward volume transport from $0.97\times10^6 m^3/sec$ in 1969 to $3.97\times10^6 m^3/$

Table 3. Annual total volume transport of the summer seasons across the section B.

Conponent \ Year	1970	1971	1972
NE Comp.	6.55	5.46	5.79
SW Comp	3.67	3.12	3.78
Net Transport	2.88	2.34	2.01

$\times 10^6 m^3/sec$

Table 4. Annual total volume transport of the winter seasons across the section B.

Component \ Year	1969	1970	1971	1972
NE Comp.	5.17	4.61	5.60	5.69
SW Comp.	0.97	2.28	3.42	3.97
Net Transport	4.20	2.33	2.18	1.72

$\times 10^6 m^3/sec$

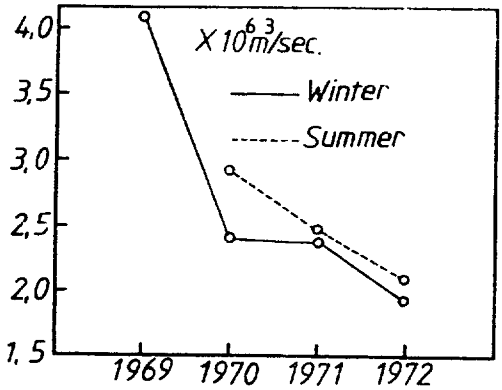

Fig. 4. Annual means of the net volumetransport across the section B.

sec in 1972.

Fig. 4 shows the annual means of the net volume transport across the section B. The transports of the summer and winter are $2.41\times 10^6 m^3/sec$, $2.61\times 10^6 m^3/sec$ and the difference between two seasons is not so large in contrast with section A.

THE COMPARISION OF THE VOLUME TRANSPORT BETWEEN SECTIONS A AND B

Table 5 shows the net volume transport of the two sections in winter (February) and summer (August). The volume transport of the section A is $0.19\times 10^6 m^3/sec$ in winter season and $1.33\times 10^6 m^3/sec$ in summer season, therefore summer season volume transport is 7 times as large as that of winter.

Comparing it with the result of Yi (1966),

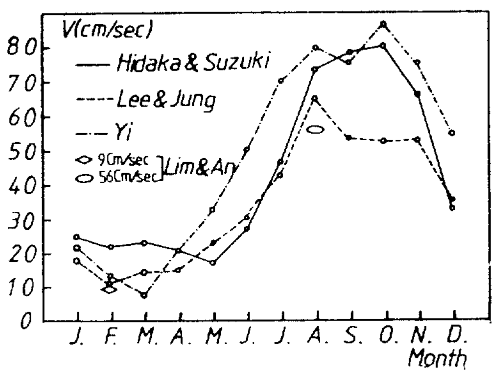

Fig. 5. Comparision with the previous works.

Table 5. Net volume transports of the section A and B in winter and summer season.

section / season	section A	section B
February	$0.19\times 10.^{6}m^3/sec$	$2.61\times 10^6 m^3/sec$
August	$1.33\times 10^6 m^3/sec$	$2.41\times 10^6 m^3/sec$

$0.20\times 10^6 m^3/sec$ and $2.0\times 10^6 m^3/sec$ in Febyuary and August for the ten years average from 1932 to 1941 in the Korea Strait, winter season transport is almost same value, but summer season transport is less than Yi's (1966).

In figure 5, we compare our results with others. The results of Hidaka & Suzuki's(1950) ranges from 20cm/sec in February to 80cm/sec in August, and the results of Lee & Jung (1977) are 11cm/sec in February and 65cm/sec in August. The average geostrophic current velocities by dynamic computation in this study are 9cm/sec in February and 56cm/sec in August. Therefore. the results of this study are more similar to Lee & Jung's (1977) than to Hidaka & Suzuki's (1950). This slight difference may be caused by the length of the section, and the determining method of current velocity.

But, if water volume transport be estimated from the results of current velocity gained by Hidaka & Suzuki (1950) and Lee & Jung (1977), it is clear that water volume transport in summer season is 7 times as large as in winter season, which is almost similar to the

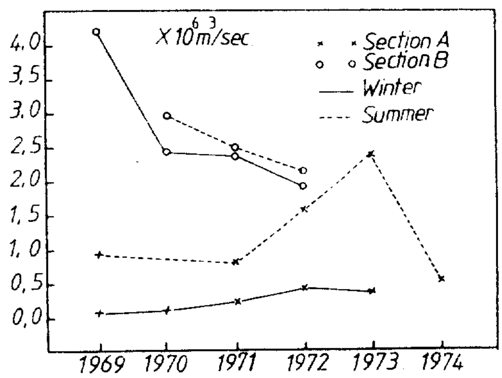

Fig. 6. The Comparision of net volume transport between sections A and B.

results of this study.

However, as seen in table 5, the volume transports in section B are not a large difference between summer and winter, it is easy to understand from the physical characteristics of temperature, salinity and density profile in the section B in winter and summer seasons.

Fig. 6 shows the volume transport in summer and winter across the section A and B. The transport of the section B is more than ten times of that of section A in winter, but no more than two times in summer season.

RESULTS AND DISCUSSION

The results in this study are as follows. The net volume transport of the section A is $0.19\times10^6m^3/sec$ in winter season and $1.33\times10^6m^3/sec$ in summer season, based on the dynamic computation.

In winter season, the volume transports which inflow into the East Sea (Japan Sea) through the eastern and western channel of the Korea Strait are almost same value. But in summer season, the volume transport which inflows into the East Sea through the western channel is corresponding to 93% of the total northeastward volume transport.

The volume transport of the section B is $2.61\times10^6m^3/sec$ in winter and $2.41\times10^6m^3/sec$ in summer. These values are almost same in summer and winter season. Comparing with section A and section B, the transport of the section B is 13.7 times in winter, and 1.8 times in summer as large as that of section A.

This discrepancy might be chiefly caused by the difference of the reference level between Korea Strait and middle section of the East Sea.

The place where the depth is shallow, such as Korea Strait, the dynamic computation have a some difficulty in estimating the current velocity and volume transport. Therefore direct measurement and another suitable correction are essential to estimate the current velocity and volume transport.

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