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A Study on the Observation Days of Maritime Traffic Investigation

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해상교통조사 관측일수에 관한 연구

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Abstract : *This study is to compare variation indexes by monthly, weekly and hourly using AIS data, which was collected for 365 days from January 1st to December 31st, 2013 at Mokpo Port and then, computed the maximum standard error by observation days. The comparison of monthly variation indexes showed that the monthly variation indexes for September and February were 1.11 and 0.84, respectively, in turn revealing that the maritime traffic in September was about 32.1 % larger than February. Also, the daily variation indexes for Tuesday and Sunday were 1.05 and 0.92, respectively, in turn revealing that the maritime traffic in Tuesday was about 14.1 % larger than Sunday. When the maritime traffic investigation is executed for at least 1 week in consideration of the daily variation index, it is possible to reduce the maximum standard error rate to be within 21 %. Therefore, if the maritime traffic investigation is made in the month and week with low maritime traffic, each variation index should be applied to reflect the actual maritime traffic.*

Key Words : *Maritime traffic investigation, Observation days, AIS, Variation index, Maximum standard error*

요 약 : 본 연구는 관측일수에 따른 교통량의 신뢰성을 검증하고자 한다. 목포항의 1년간 선박자동식별장치(AIS) 자료를 사용하여 월별, 요일별, 시간별 변화지수를 비교한 후, 각 관측일수에 따른 최대표준오차를 산출하였다. 월별변화지수를 비교한 결과 9월달 1.11, 2월달 0.84로 나타나 9월달이 2월달 교통량 보다 약 32.1 % 많은 것으로 나타났다. 요일변화지수는 화요일 1.05, 일요일 0.92로 나타나 화요일이 일요일 교통량보다 약 14.1 % 많았다. 해상교통조사는 요일변화지수를 고려하여 최소 1주일 이상 실시하면 최대표준오차를 21 % 이내로 산출할 수 있다. 따라서 해상교통조사 관측시기에 따라 각 변화지수를 적용하여 교통량의 흐름을 반영한 연구가 뒷받침 되어야 하겠다.

핵심용어 : 해상교통조사, 관측일수, 선박자동식별장치, 변화지수, 최대표준오차

1. Introduction

The maritime traffic investigation could be utilized as data for the maritime traffic congestion and flow evaluation, which is to evaluate whether a fairway could accommodate the maritime traffic volume, as well as setting of speed limits and improvement of fairways.

The previous studies on maritime traffic investigation include a study made on a 3-day maritime traffic investigation (Im et al., 2007; Kim et al., 2011; Lee et al., 2012) as well as studies on a 7-day maritime traffic investigation(Kim et al., 2006) and a 10-day maritime traffic investigation(Park et al., 2006). However, all of them have failed to suggest an error in the estimated maritime traffic upon the number of days investigating the maritime traffic. Also, they also did not suggest variation indexes including a month and a week and a hour of the maritime traffic investigation. In Japan, studies on the maritime traffic investigation have received a lot of interest(Kinzo and Kiyoshi, 1974), but there is no study on the maritime traffic investigation of Korea.

Therefore, this study aims to suggest variation indexes of the monthly and weekly maritime traffic, and validate the computation of the number of days of observation.

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2. Method of Study

2.1 Area of Study

This study was made with AIS(Automatic Identification System) data, which was collected for 365 days from January 1st to December 31st, 2013 at Mokpo Port and the analysis object region was Mokpogu where vessels navigating Mokpo Port pass through, as shown in the Fig. 1.

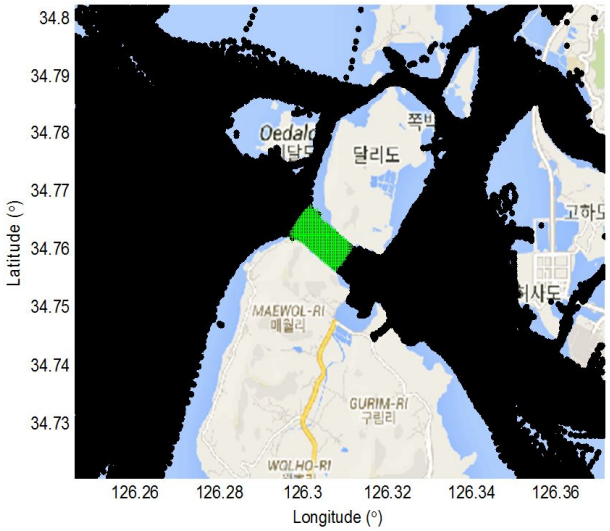

Fig. 1. Area of study.

2.2 Procedure of Study

Fig. 2 shows the study procedure, which is to compare the maritime traffic by maritime traffic investigation period such as a month, a week and a hour and then, apply it with the variation index and suggest the maximum standard error by observation days.

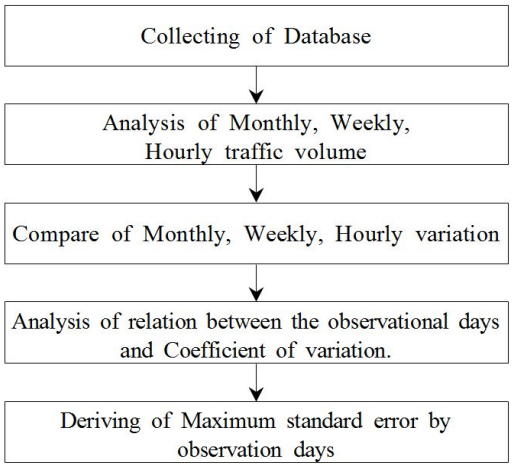

Fig. 2. Procedure of study.

3. Maritime Traffic Analysis

3.1 Daily maritime traffic

Fig. 3 shows the daily maritime traffic. Table 1, revealing the statistics data for 1 year, shows that 20,833 vessels navigated in one year and 76.8 vessels navigated in one day on average.

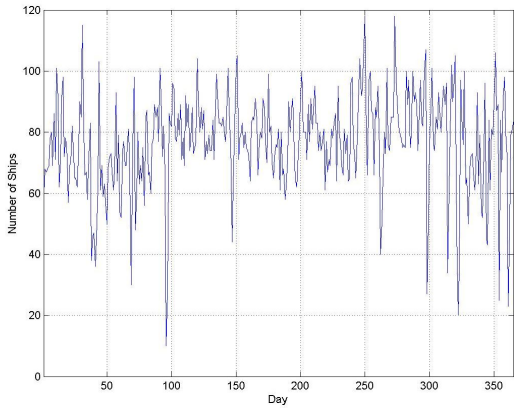

Fig. 3. Daily passing ship at Mokpogu.

Table 1. Statistics data of passing ship

Statistics data		
Total passing ship (ships/1year)		28,033
Average	(ships/1day)	76.8
	(ships/1hour)	3.2
Standard deviation (ships/1day)		15.9
Coefficient of variation (CV)		0.207

3.2 Monthly maritime traffic

Table 2, showing the investigation of vessels navigating Mokpogu by month, reveals that the average daily vessel traffic was the highest, of 84.9 vessels, in September and smallest, of 64.5 vessels, in February. Fig. 4 shows the monthly variation index (The monthly average daily maritime traffic for each month ÷ the annual average daily maritime traffic), which was shown to be 1.11 and 0.84 for September and February, respectively so the maritime traffic in September was about 32.1 % higher than the maritime traffic in February.

3.3 Weekly maritime traffic

Table 3 shows the maritime traffic by week. The average weekly maritime traffic by week reveals that it was highest, of 80.7 vessels, in Tuesday and smallest, of 70.8 vessels, in Sunday. Fig. 5

shows the weekly variation index (The average weekly maritime traffic by day ÷ the annual average daily maritime traffic) revealing that the daily variation indexes of Tuesday and Sunday were 1.05 and 0.92, respectively and the maritime traffic in Tuesday is about 14.1 % higher than of Sunday.

Table 2. Monthly passing ship and variation index

Month	Inbound ship	Outbound ship	Total	per day	Variation index
January	1189	1172	2361	76.2	0.99
February	914	893	1807	64.5	0.84
March	1117	1069	2186	70.5	0.92
April	1241	1111	2352	78.4	1.02
May	1311	1229	2540	81.9	1.07
June	1218	1132	2350	78.3	1.02
July	1266	1157	2423	78.1	1.02
August	1188	1174	2362	76.2	0.99
September	1283	1263	2546	84.9	1.11
October	1374	1213	2587	83.4	1.09
November	1201	1080	2281	76.0	0.99
December	1152	1086	2238	72.2	0.94

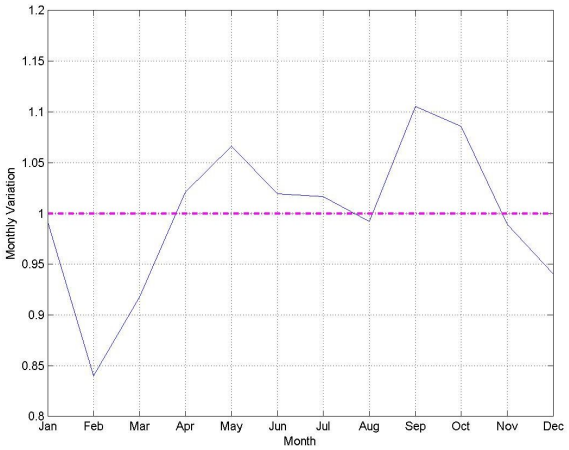

Fig. 4. Monthly variation index.

Table 3. Weekly passing ship and variation index

Day of Week	Inbound ship	Outbound ship	Total	per day	Variation index
Sunday	1897	1784	3681	70.8	0.92
Monday	1997	1936	3933	75.6	0.98
Tuesday	2257	2022	4279	80.7	1.05
Wednesday	2107	2053	4160	80.0	1.04
Thursday	2167	2021	4188	80.5	1.05
Friday	2068	1857	3925	75.5	0.98
Saturday	1961	1906	3867	74.4	0.97

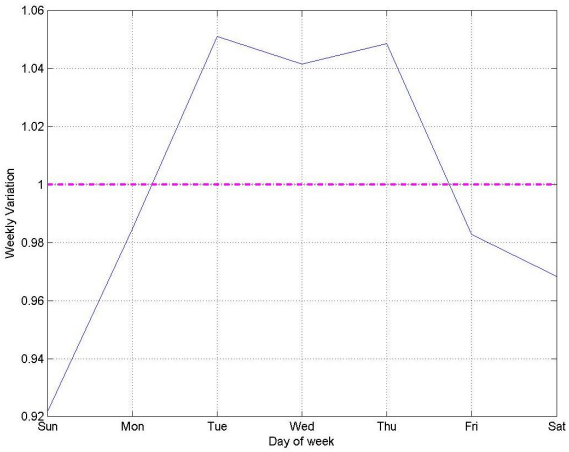

Fig. 5. Weekly variation index.

Table 4. Hourly passing ship and variation index

Hour	Inbound ship	Outbound ship	Total	per day	Variation index
00-01	381	147	528	1.45	0.46
01-02	312	139	451	1.24	0.39
02-03	282	184	466	1.28	0.40
03-04	209	241	450	1.23	0.39
04-05	207	288	495	1.36	0.43
05-06	258	419	677	1.85	0.59
06-07	595	1043	1638	4.49	1.42
07-08	529	963	1492	4.09	1.29
08-09	555	999	1554	4.26	1.35
09-10	1196	977	2173	5.95	1.88
10-11	936	903	1839	5.04	1.59
11-12	754	540	1294	3.55	1.12
12-13	824	625	1449	3.97	1.25
13-14	792	944	1736	4.76	1.50
14-15	883	1036	1919	5.26	1.66
15-16	638	792	1430	3.92	1.24
16-17	621	636	1257	3.44	1.09
17-18	1193	474	1667	4.57	1.44
18-19	1027	389	1416	3.88	1.23
19-20	414	470	884	2.42	0.77
20-21	379	355	734	2.01	0.64
21-22	604	295	899	2.46	0.78
22-23	370	343	713	1.95	0.62
23-24	331	229	560	1.53	0.48

3.4 Hourly maritime traffic

Table 4 shows the maritime traffic by hour. Fig. 6 shows the

hourly variation index (The average daily maritime traffic by hour ÷ the annual average daily maritime traffic) revealing that the maritime traffic from 09 to 10 was 1.88 which is about 382.1 % higher than 0.39 for the maritime traffic from 03 to 04. Also, from 20 to 03, the number of inbound vessels was found to be relatively higher than of outgoing vessels and from 03 to 09, the number of outgoing vessels was relatively larger than of incoming vessels.

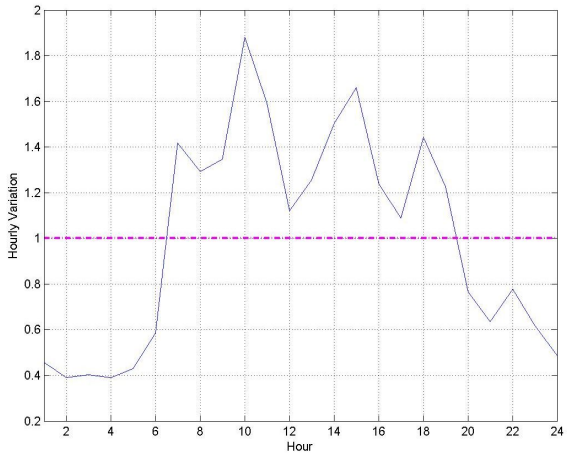

Fig. 6. Hourly variation index.

4. Reliability of Observation Days

4.1 Relationship between the Observation Days and Coefficient of Variation

When the coefficient of variation(CV) of the sample mean by the observation days is applied, it could be expressed as the equation (1)(Kinzo and Kiyoshi, 1974).

$$CV = \frac{\sigma}{\bar{x}} \cdot n^{-0.5} \quad (1)$$

Since the standard deviation(σ) of the maritime traffic in Mokpogu were 15.9 vessels, and the sample mean ($\bar{x}$) of the maritime traffic in Mokpogu was similar with the population mean (μ) of 76.8 vessels, it could be calculated as $\sigma/\bar{x}$ =0.207 and expressed as the analytical equation (2).

$$CV = 0.207 \cdot n^{-0.5} \quad (2)$$

On the other hand, from the population, it is possible to calculate the sample mean ($\bar{x}$) and standard deviation ($\sigma_{\bar{x}}$) for sample groups in the number of i={number of days in one year-(n-1)}, which was calculated by moving the number of populations by each observation days. The regression equation for CV for each of 50 sample groups could be computed as in the Fig. 7 and then, expressed as the equation (3).

$$CV_{mokpo} = 0.2033 \cdot n^{-0.3145} \quad (3)$$

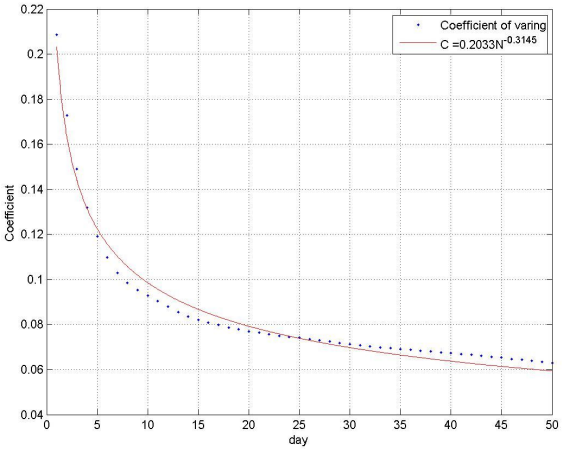

Fig. 7. Relation between the observational days and Coefficient of variation.

4.2 Estimation of Annual Average Daily maritime traffic

The annual average daily maritime traffic, in general, is estimated with continuous observation for days, as the equation (4).

$$(1-k \cdot CV)\bar{x} < \bar{\mu} < (1+k \cdot CV)\bar{x} \quad (4)$$

Where k : Reliability Coefficient

$\bar{\mu}$: Estimated Annual Average Daily maritime traffic

$\bar{x}$: Average maritime traffic, estimated with the observation made in the number of days.

For instance, during the 7-day maritime traffic investigation at Mokpogu, when the annual average maritime traffic was calculated at the 95 % confidence level (k=1.96), as the equation (5).

$$CV_{mokpo} = 0.2033 \cdot (7)^{-0.3145} \fallingdotseq 0.11 \quad (5)$$

$$(0.7839)\bar{x} < \bar{\mu} < (1.2161)\bar{x}$$

Table 5 shows the maximum standard error in the estimation of annual average daily maritime traffic by observation days. For

instance, when it is estimated at the 95 % confidence level, the 3-day maritime traffic investigation and 7-day maritime traffic investigation could have 28.2 % and 21.6 % of the maximum standard error, respectively.

Table 5. Maximum standard error by observation days (95 % confidence)

Observation days (n)	Maximum standard error (%)
1	39.85
2	32.04
3	28.21
4	25.77
5	24.02
6	22.68
7	21.61
8	20.72
9	19.97
10	19.31
14	17.38
30	13.67
50	11.64

4.3 Comparison with Previous Studies

Table 6 shows the comparison of the maximum standard errors between the previous study(Kinzo and Kiyoshi, 1974) on the maritime traffic at the Akashi Strait for 1 year and this study, and it reveals that a result of this study is similar with of the aforementioned study. When the observation days was 14, the maximum standard errors were found to be 17.6 and 17.3 for the Akashi Strait and Mokpogu, respectively. Also, when the observation days was 30, the maximum standard errors were found to be 13.1 and 13.6 for the Akashi Strait and Mokpogu, respectively. It could be reasonable to assume that the maximum standard error tends to be similar when the observation days is 14 or above.

Table 6. Comparison of Maximum standard error between Akashi kaikyo and Mokpogu

Observation days (n)	Maximum standard error (%)	
	Akashi kaikyo	Mokpogu
1	49.8	39.8
3	32.3	28.2
5	26.4	24.0
7	23.2	21.6
10	20.1	19.3
14	17.6	17.3
30	13.1	13.6
50	10.7	11.6

5. Conclusion

In this study, a difference in the monthly, weekly and hourly maritime traffic was compared after applying it with the variation index, and the maximum standard error, varied by observation days, is as the following.

The comparison of monthly variation indexes showed that the monthly variation indexes for September and February were 1.11 and 0.84, respectively, in turn revealing that the maritime traffic in September was about 32.1 % larger than February. Also, the daily variation indexes for Tuesday and Sunday were 1.05 and 0.92, respectively, in turn revealing that the maritime traffic in Tuesday was about 14.1 % larger than Sunday. Therefore, if the maritime traffic investigation is made in the month and week with low maritime traffic, each variation index should be applied to reflect the actual maritime traffic. Also, it is suggested that the maritime traffic investigation should be made on Tuesday, Wednesday and Thursday in either September or October when the maritime traffic is relatively large. When the maritime traffic investigation is executed for at least 1 week in consideration of the daily variation index, it is possible to reduce the maximum standard error rate to be within 21 %.

Since this study suggest an error rate of the maritime traffic investigation by variation index and observation days, it is possible to detect the maritime traffic flow by month, week, and hour. Thus, it could be utilized as data for the maritime traffic congestion and flow evaluation, which is to evaluate whether a fairway could accommodate the volume of maritime traffic, as well as setting of speed limits and improvement of fairways.

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