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Regression Analysis on the Relationship Between Elderly Ship Officers and Marine Accidents in Korea

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고령 해기사와 해양사고와의 회귀분석

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Abstract : *The Republic of Korea has a more rapidly aging society than any other country in the world. In order to prepare for the attendant challenges, this research provides basic data for policies related to aging ship officers, analyzing the relationship between elderly ship officers and marine accidents. The data used here spans 11 years, from 2006 to 2016, and the survey and regression analysis were conducted only on ship officers, excluding crew. As a result of this research, first, it was found that the number of employed ship officers older than 60 has increased 2.7 times over the past 11 years and the range of this increase was larger than for other age categories. Second, the number of elderly ship officers disciplined for marine accidents increased by around 2.6 times. Third, elderly ship officers had around 1.5 times the rate of marine accidents compared to non-elderly ship officers. Fourth, as a result of conducting regression analysis between the number of employed elderly ship officers and the number of officers disciplined, the degree of explanatory power of elderly ship officers for disciplined officials was 75.1%. Since our society will age quickly, policies such as license renewal education for elderly ship officers and regulation enforcing the quality of renewal will be needed.*

Key Words : *Aging society, Elderly ship officer, Marine accidents, Disciplined officials, Regression analysis*

요 약 : 우리나라는 세계에서 가장 빠르게 고령화 사회로 접어들고 있다. 본 연구는 급속한 고령화 사회를 대비하기 위하여 고령 해기사와 해양사고와의 관계를 분석하여 고령화되어 가는 해기사 정책에 기초 자료를 제공하고자 한다. 수집한 데이터는 2006년부터 2016년까지 11년간이며, 부원을 제외한 해기사만을 대상으로 현황 조사 및 회귀분석을 실시하였다. 연구결과 첫째, 60대 이상의 고령 해기사의 취업자 수는 지난 11년 동안 약 2.7배 증가하여 증가 추이 폭이 다른 연령대 보다 큰 것으로 조사되었다. 둘째, 해양사고로 징계를 받은 고령 해기사사는 약 2.6배 증가 추이를 보였다. 셋째, 고령 해기사는 비고령 해기사보다는 해양사고율이 약 1.5배 높은 것으로 나타났다. 넷째, 고령 해기사의 취업자 수와 징계자 수 간에 회귀분석을 실시한 결과, 고령 해기사 취업자 수가 고령 해기사 징계자 수를 설명하는 설명력의 정도가 75.1%로 나타났다. 고령화 사회가 신속히 진행될 수 있으므로 고령 해기사 면허 갱신 교육과 갱신 자격을 강화하는 규정 등의 정책이 필요할 것으로 판단된다.

핵심용어 : 고령화 사회, 고령 해기사, 해양사고, 징계자, 회귀분석

1. Introduction

Because of the drastic declination of birth rate and the expansion of life expectancy, the aging of South Korean population is proceeding noticeably fast in the world. South Korea is supposed to be such the fastest country in the aging of population and to become such the highest-ranked aging one in the world that population over 65 years accounts for 15 % of whole population by 2020 and 40 % by 2060 (Choi and Kim, 2015).

Due to the functional declination in the physical and contextual awareness and decision-making by aging, it has been a long time since the seriousness of rapidly-aging problem became a national

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and social issue. Specially, in the field of road traffic, there are a lot of analytic researches about the riskiness of the aged drivers' traffic accidents because of its highness in ratio (Park et al., 2009; Shin and Cho, 2010; Baek, 2015; Kim and Heo, 2015; Oh et al., 2015; Jang et al., 2016; Ko and Yoon, 2017).

The aging of South Korea is supposed to be no wonder, and so the rate of the elderly ship officers is supposed to drastically increase. Considering the researches related to the aging in the field of maritime traffic, there were the research developing educational contents for aged seafarers of towing vessels (Kim et al., 2011) and the study on the policy for seafarers according to the aging of seafarers in domestic merchant vessels and domestic passenger ships (Kim, 2012; Ju and Lee, 2016). However, in the studies so far, there has been no comparative analysis according to the age groups of ship officers excluding the crews, especially on elderly ship officers.

Therefore, in order to prepare for the rapidly-aging society, this research intends to provide basic data for the policy of ship officers who became aged, by conducting regression analysis of the relationship between the elderly ship officers and marine accidents.

2. Material and method

2.1 Method for research

This research examined the present condition according to the age groups by using the data about the number of employed ship officers and that of the disciplined related to accidents, and divided it into elderly and non-elderly ship officers. In addition, the ratio of marine accidents was indicated by comparing the number of the employed ship officers with that of the disciplined. The age groups were divided into 20s (20 ~ 29 years), 30s (30 ~ 39 years), 40s (40 ~ 49 years), 50s (50 ~ 59 years), and 60s (60 ~ 69 years).

Finally, the relationship between the number of employed elderly ship officers and that of the disciplined was analyzed, and regression analysis was conducted.

2.2 Research materials and criteria for the elderly

As for the data for this analysis, the current condition of employed crews with the age groups from Korea seafarers' welfare and employment center and the current data for the number of the disciplined for marine accidents with the age groups from Korea Maritime Safety Tribunal were used. The current condition of employed crews with the age groups was analyzed only for the ship officers excluding the crews. The data has been collected for 11 years from 2006 to 2016, and the data before 2006 was excluded in the analysis as missing data.

The age criteria for the elderly is divided differently according to the purposes and the contents of the researches. The population and housing census of Korea national statistical office defines people over 56 years as the elderly (KOSTAT, 2016), and the researches on the extension of retirement and the free fare system in urban railway classify ones over 60 as the elderly (Hong, 2016; Kim, 2016). Meanwhile, the age classifications of the data are different from each other because the current condition of the disciplined for marine accidents with the age groups collected in this research is the data totalized from 61 and the current condition of employed seafarers with the age groups is the data totalized from 60. Therefore, this research intends to classify and analyze people over 60 as the elderly, assuming that the data of the disciplined for marine accidents with the age groups is the one totalized from 60.

3. Current condition of employed ship officers

3.1 Number of employed ship officers with age groups

Fig. 1 indicates the number of employed ship officers with age groups. It was investigated that the total number of employed ship officers increased slightly by around 150 persons each year from 20,050 persons in 2006 to 21,696 persons in 2016 when 1,646 increased. Considered with age groups, 20s showed marginal growth in change, 30s little in change, and 40s indicated a decreasing change. While 50s has been continuously decreasing annually after reaching its pinnacle in 2013, it was found out that the increase range of over 60s was larger than other age groups. Especially, while the ratio of the number of elderly ship officers over 60s was smaller than those of other age groups in 2006, it became larger than that of 40s in 2010 and of 50s in 2016. This was analyzed as the ship officers of 40s and 50s got older into over 60s during the periods of investigation, naturally as time went by.

Table 1 indicates the differences in change according to the licenses and age groups of ship officers in 2006 and 2016. In order to be convenient in distinguishing the change of increase and decrease, the number increasing between 2006 and 2016 was indicated in blue, and the decreasing number was in red. It was found out that the increased age groups were 20s and the elderly over 60s. Specifically, it was analyzed that increase of 300 persons

respectively in the 3rd class deck officers and engineers of 20s was derived from the short term program of 3rd class ship officer training. The elderly over 60s increased by 4,508 persons, and, among them, the 1st class deck officers and engineers, and the 6th class deck officers and engineers increased relatively more than persons with other licenses. It was analyzed that the increase in the 1st class deck officers and engineers was because of the increase of the elderly working in merchant vessels, and that the increase of the 6th class deck officers and engineers was because of the increase of the elderly working in fishing vessels.

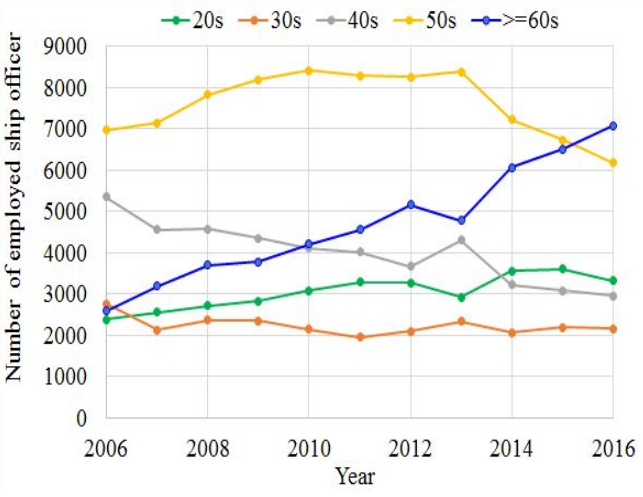

Fig. 1. Number of employed ship officer by age group.

Table 1. Difference of 2006 year and 2016 year by age group and the type of certificate

Type of certificate		20s	30s	40s	50s	>=60s
Deck officer	1st class	-6	-12	-141	-45	470
	2nd class	18	116	-87	-80	245
	3rd class	296	-35	-274	94	303
	4th class	134	-105	-107	-16	377
	5th class	34	-99	-85	-21	196
	6th class	-5	-212	-398	-105	484
	Subtotal	471	-347	-1,092	-173	2,075
Engine officer	1st class	-12	0	-155	-95	508
	2nd class	-1	93	-92	-56	248
	3rd class	333	68	-204	-65	313
	4th class	110	-107	-194	-21	374
	5th class	39	-105	-126	-19	252
	6th class	-6	-163	-386	-346	680
	Subtotal	463	-214	-1,157	-602	2,375
Total		933	-603	-2,393	-799	4,508

3.2 Number of employed elderly ship officers and non-elderly ship officers

The numbers of employed elderly ship officers over 60s and non-elderly ship officers under 60s were by years indicated in Fig. 2. While the number of employed elderly ship officers showed the increase, that of non-elderly ship officers showed the decrease. It was found out that the number of elderly ship officers in 2016 compared to 2006 showed 4,508 persons' increase representing the difference of around 2.7 %, but that of non-elderly ship officers between 20s and 50s decreased by 2,862 persons showing the difference of around 0.8 %.

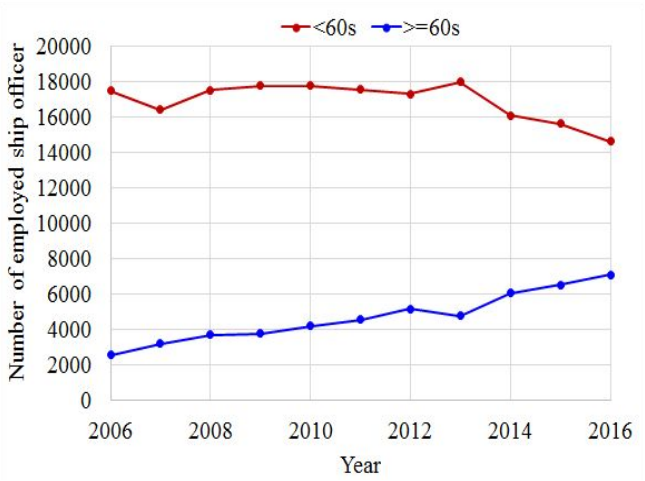

Fig. 2. Number of employed ship officer by elderly and non-elderly.

4. Current condition of ship officers disciplined for marine accidents

4.1 Number of ship officers disciplined for marine accidents with age groups

Fig. 3 indicates the number of ship officers disciplined for marine accidents with age groups. It was found out that an annual average of around 201 persons were subjected to disciplinary punishment such as suspension or revocation of their licenses. The number of the disciplined was highest in 2010 as 238 persons and lowest in 2013 as 154 persons. As for the data with age groups, it was found out that the annual average of the number of disciplined ship officers of 20s was 4.3 persons, 9.2 of 30s, 41.4 of 40s, 86.7 of 50s, and 59.7 of over 60s. Especially, it had an aspect that the number of disciplined elderly ship officers over 60s had become bigger than 50s since 2015.

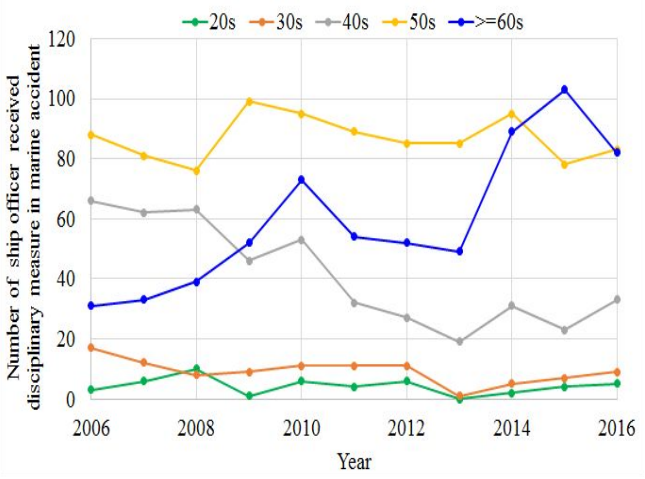

Fig. 3. Number of ship officer received disciplinary measure in marine accident by age group.

4.2 Number of elderly ship officers and non-elderly ship officers disciplined for marine accidents

Fig. 4 is the annual number of ship officers disciplined for marine accidents, indicated by being divided into that of the elderly and non-elderly. While the number of elderly ship officers disciplined for marine accidents showed an increase in change, that of non-elderly ship officers showed a decrease in change. It was found out that the number of disciplined elderly ship officers in 2016, compared to 2006, increased by 51 persons showing the difference of around 2.6 %, but that of non-elderly ship officers decreased by 44 persons, representing the difference of around 0.7 %.

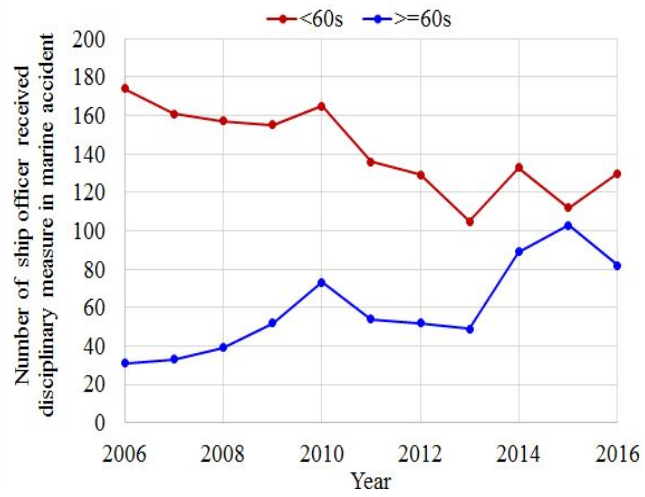

Fig. 4. Number of ship officer received disciplinary measure in marine accident by elderly and non-elderly

5. Analysis of marine accident rate

5.1 Marine accident rate with age groups

Fig. 5 is the marine accident rate with age groups indicated by comparing the number of employed ship officers with that of the disciplined. It was found out that the annual average of marine accident rate of 20s was 0.14 %, 30s 0.41 %, 40s 1.01 %, 50s 1.15 %, and that of elderly ship officers over 60s was 1.26 %. It was indicated that the marine accident rate of 20s and 30s, which was under 0.50 %, was relatively lower than other groups, but those of 40s, 50s, and the elderly over 60s were over 1.00 %.

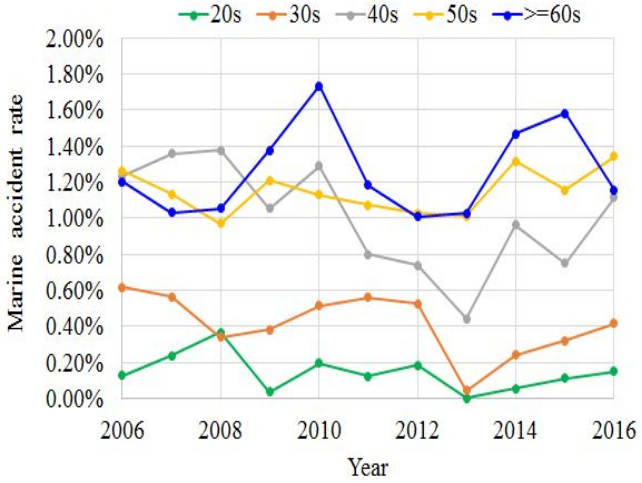

Fig. 5. Marine accident rate by age group.

5.2 Marine accident rate of elderly ship officers and non-elderly ship officers

Fig. 6 indicates the annual marine accident rate of the elderly and non-elderly by comparing the number of employed ship officers with that of the disciplined. It was found out that the marine accident rate of elderly ship officers was 1.5 times higher than that of non-elderly ship officers because the annual marine accident rate of elderly ship officers was 1.26 % and that of non-elderly was 0.84 %. Especially, the rate of elderly ship officers was highest in 2010 as 1.73 %, and lowest in 2012 as 1.01 %. The rate of non-elderly ship officers was highest in 2006 as 1.00 %, and lowest in 2013 as 0.59 %. As for the marine accident rate, it was found out that the rate of elderly ship officers had a relatively high annual deviation showing rather right-upward increasing tendency in change, but that of non-elderly ship officers showed rather right-downward declining tendency in change.

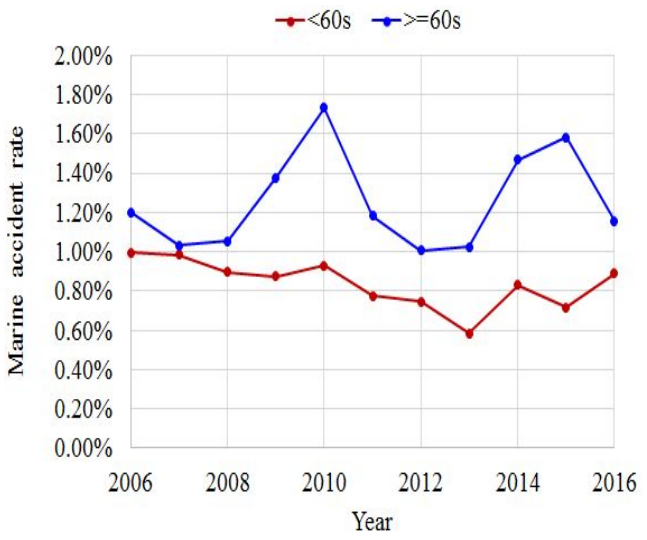

Fig. 6. Marine accident rate by elderly and non-elderly ship officer.

6. Regression analysis between the number of elderly ship officers and that of the disciplined

Table 2 indicates the relationship between the number of the employed ship officers and that of the disciplined for marine accidents. As a result of analysis, there was no distinguishable relationship between the number of employed non-elderly ship officers and that of the disciplined. However, it could be affirmed that the increasing number of employed elderly ship officers had a great effect on that of the disciplined elderly ship officers because the number of employed elderly ship officers and that of the disciplined elderly was indicated as 0.866 of a positive correlation coefficient ($p<.01$). Meanwhile, the number of employed non-elderly ship officers indicated a negative correlation coefficient ($p<.05$) with that of disciplined elderly ship officers. For this, it was analyzed that the number of disciplined elderly ship officers also increased because elderly ship officers relatively increased as non-elderly ship officers decreased. It was not analyzed that the number of employed elderly ship officers had a meaningful relationship with that of disciplined non-elderly ship officers.

Table 2. Analysis of correlation between number of employed ship officer and number of received disciplinary measure

Number of employed ship officer / Number of received disciplinary measure	elderly	non-elderly
elderly	.866**	-.622*
nonelderly	-.533	.306

* $p<.05$, ** $p<.01$

Regression analysis was conducted about the effect of the number of employed elderly ship officers on that of disciplined elderly ship officers. As a result of examining the autocorrelation of the independent variable, it was checked that this data was suitable for the regression analysis because it was independent without autocorrelation showing that Durbin-Watson value was indicated as 1.761 like Table 3.

As a result of regression analysis, it was indicated that the number of employed elderly ship officers gave a meaningful effect ($p<.05$) on that of disciplined elderly ship officers (Table 4), and it was shown that the larger the number of employed elderly ship officers was (B=0.015), the larger that of disciplined elderly ship officers was (Table 5). The explanatory power, in which the number of employed elderly ship officers explained that of disciplined elderly ship officers, was 75.1 % (Table 3) and it had a high effect (β=.866). The regression model is in equation (1) can be written as follows.

$$N_d = 0.015 N_e - 8.682 \quad (1)$$

where,

N_d : the number of disciplined elderly ship officers, N_e : the number of employed elderly ship officers

Table 3. Model summary

R	R^2	$adj\ R^2$	Std. Error of the Estimate	Durbin-Watson
.866	.751	.723	12.499	1.761

Table 4. Analysis of variance

	Sum of Squares	df	Mean Squares	F	p
Regression	4232.082	1	4232.082	27.088	.001
Residual	1406.099	9	156.233		
Total	5638.182	10			

Table 5. Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Std. Error	β		
Constant	-8.682	13.674		-.635	.541
Number of employed elderly ship officer	.015	.003	.866	5.205	.001

If the degree of scattering between expected cumulative probability and observed cumulative probability was drawn like Fig. 7 in order to verify the assumption of normality of residuals, it can be seen that normality was satisfied because two values of probability were mostly distributed near on a straight line. In order to verify the assumption of more exact normality of residuals, it was indicated that the assumption of normality of residuals was satisfied because Shapiro-wilk significance probability like Table 6 came out as 0.454.

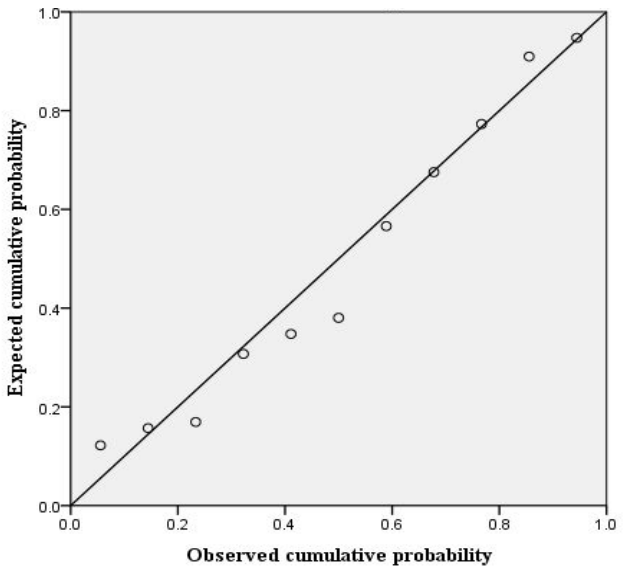

Fig. 7. Normal P-P plot of regression standardized residual.

Table 6. Test of normality

	Shapiro-wilk		
	Statistic	df	p
Standardized residual	.934	11	.454

Next, in order to examine homoscedasticity of residuals, it was analyzed by drawing the degree of scattering of predictive value and residuals like Fig. 8. In order to satisfy homoscedasticity, the relation between the two values should come out irregularly around '0' without a specific shape. As a result of analysis, it can be seen that homoscedasticity of residuals was satisfied because standardized value of residuals came out irregularly around '0'. Therefore, the regression model can be reliable because both normality and homoscedasticity of residuals were satisfied.

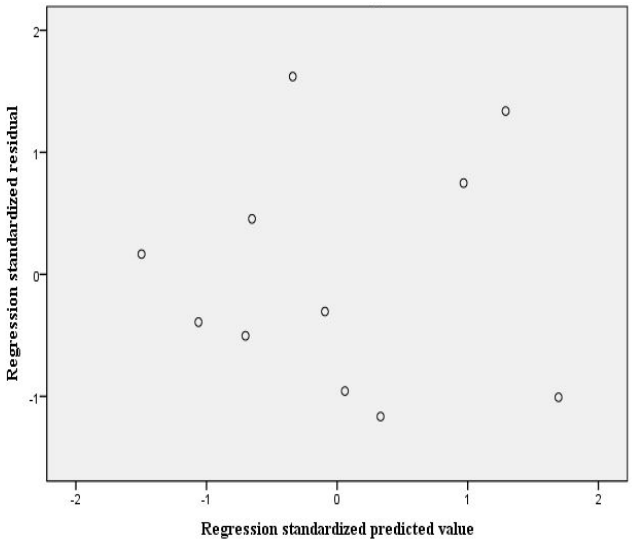

Fig. 8. Scatter plot of standardized predicted value and residual.

7. Conclusion

South Korea is more rapidly entering the aging-society than any other country in the world. Thus, this research compared and analyzed the number of elderly ship officers and that of the disciplined for marine accidents in South Korea.

The results of this analysis were as follows. First, it was found out that the number of employed ship officers over 60s had been increased around 2.7 times for the past 11 years and the range of increasing trend was larger than those of other ages, and that of non-elderly ship officers was decreased around 0.8 times. Second, it was represented that the number of elderly ship officers disciplined for marine accidents showed increase trend of around 2.6 times, but that of non-elderly ship officers showed decrease trend of around 0.7 times. It was analyzed that the number of the disciplined increased as that of employed elderly ship officers over 60s increased. Third, it was indicated that elderly ship officers had around 1.5 times of marine accident rate more than non-elderly

ship officers. Fourth, as the result of conducting regression analysis between the number of employed elderly ship officers and that of the disciplined, it was found out that the number of employed elderly ship officers had a significant effect on that of disciplined elderly ship officers, and explanatory power in which the number of employed elderly ship officers explained that of disciplined elderly ship officers was indicated as 75.1 %.

Because of the limitation of collected data, this research has a limitation that it wasn't analyzed according to the types of marine accidents such as collision, grounding, and so on. It also has a limitation of analysis in that the analysis couldn't be conducted for a long period of 20 ~ 30 years due to the missing of previous data. If the long-term statistic data can be secured, it is estimated that more accurate model can be developed. Afterward, it is necessary to analyze which causation and interrelation personal and circumstantial factors related directly to the elderly ship officers' marine accidents have, and to develop the model of elderly ship officers' marine accidents based on this analysis.

The elderly are lack of visual and auditory abilities in comparison with young and middle ages. Thus, their decisive and motional abilities are declined due to the blunting of reaction time in which they can perceive and respond to situations. In case of drastic increase of elderly ship officers, it is also supposed that marine accidents increase more. Nonetheless, the reality is not only that the researches on the risk of marine accidents due to elderly ship officers have not been active yet, but also that the efforts in policy to reduce marine accidents of elderly ship officers have not been active. Because the aging-society can proceed quickly, it is considered that the policy for ship officers who became elderly is also needed. It is suggested that license renewal education of elderly ship officers and the regulations enforcing the quality for renewal will be needed.

Acknowledgements

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