MARINE TRAFFIC ENGINEERING IN KOREAN COASTAL WATERS

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MARINE TRAFFIC ENGINEERING IN KOREAN COASTAL WATERS

by

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ABSTRACT

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This study describes and discusses the marine casualties, the effectiveness of existing traffic services, and marine safety and Vessel Traffic Service(VTS) in Korean coastal waters.

Marine traffic is comprehensively assessed in Korean waters, an analysis of casualties is undertaken by block scheme. Marine environmental parameters are identified relating to marine casualties as appropriate. Various statistical techniques are employed to evaluate the inter-relationships between individual causal factors, and for the first time effect level is instituted to quantify the relative importance of the causal factors in Korean waters.

A further innovation is the examination of the adequacy of existing Korean traffic services by casualty and traffic analysis, and an accident danger index is introduced to compare accident danger over different time periods.

A mixed population of contributors to marine safety is sought by questionnaire. The design of this is both innovative and original in content in order to evaluate the perceived importance of the various risk factors, the marginal effectiveness of various options in reducing risks, and their weight with regard to VTS services and activities.

The main part of the study uses an original multiple coefficient to estimate casualty reduction rate and a new method to quantify the effectiveness of VTS. The Korean waters traffic study is conducted as an intermediate level and provides the data base for the main body of work.

The conclusions include recommendations with respect to the stricter enforcement of the routeing scheme(TSS) and the adoption of further traffic observation/surveillance over the areas concerned.

Finally it is noted in particular that additional Vessel Traffic Service and Traffic Separation Schemes are now required if any substantial improvement is to be achieved in marine traffic safety in Korean coastal waters.

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ABBREVIATIONS

ANOVA	Analysis of Variance
Av	Average
B/B	Bridge-to-Bridge
BIMCO	Baltic and International Maritime Council
CCG	Canadian Coast Guard
CCTV	Closed Circuit Television
CNIS	Channel Navigation Information Service
COST	Cooperation in the field of Sciences and Technologies
C/R/G	Collision/Ramming/Grounding
DnV	Det norske Veritas
E	East
Ed(s)	Editor(s)
E/L	Effect Level
ETA	Estimated Time of Arrival
et al	*et alibi* (and elsewhere)
Fig	Figure
FRP	Fibreglass Reinforced Plastics
FY	Fiscal Year
GCG	Government Consulting Group
GRT	Gross Register Tonnage
HAR	Harbour Advisory Radar
HHW	Highest High Water
HMSO	Her Majesty's Stationery Office
HP	Horse Power
HUT	Helsinki University of Technology
IALA	International Association of Lighthouse Authorities
ibid	*ibid*em
IMCO	Intergovernmental Maritime Consultative Organization
IMO	International Maritime Organization
JAMRI	Japan Maritime Research Institute
KMPA	Korea Maritime and Port Administration

KMU	Korea Maritime University
LPG	Liquified Petroleum Gas
m, M	Metre(s)
MAIA	Marine Accident Inquiry Agency
MAREP	Ship Movement Reporting Scheme
M/E	Main Engine
MF	Medium Frequency
MRR	Movement Restriction Regulations
MSA	Maritime Safety Agency
MSL	Mean Sea Level
MTSL	Maritime Traffic Safety Law
M/V	Motor Vessel
N	North
NMI	National Maritime Institute
PAI	Problem Area Identifier
p or pp	Page or Pages
P+I	Protection and Indemnity
SAR	Search and Rescue
SPSS	Statistical Package for Social Science
SSB	Single Side Band
TR	Tidal Range
TSS	Traffic Separation Scheme
USCG	United States Coast Guard
VHF	Very High Frequency
VMRS	Vessel Movement Reporting Scheme
VTS	Vessel Traffic Service

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AUTHOR'S DECLARATION

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award.

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3. The Impact of New Technology on the Marine Industries. Southampton Institute. September 13-15 1993. Southampton
4. Ship Emergency Response Forum. The Nautical Institute Southwest Branch. October 8 1993, Plymouth
5. Marine Safety in Coastal Waters. The Nautical Institute Southwest Branch. January 18 1994, Plymouth

External Contacts:

1. Thames Navigation Service - Port of London Authority (visited)
2. VTS Project & Development - Canadian Coast Guard, Ottawa
3. The Basic Maritime Science Institute, Korea Maritime University, Pusan
4. Korea Maritime and Port Administration, Seoul
5. The Marine Accident Inquiry Agency, Seoul

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Chapter 1

INTRODUCTION

1.1 BACKGROUND

Traffic density has increased recently in Korean waters due to an expansion in sea trade and development of coastal fisheries. The enlargement of coastal industrial belts and the development of coastal islands is further increasing marine traffic.

The rapid increase of marine traffic has often resulted in marine casualties with attendant loss of life, damage to property, and marine pollution. Risk to shipping may be reduced by navigational aids, route planning and, by shore-based aids to navigation.

Unfortunately, relatively little research has been done so far in this field in Korea. Although statistics relating to accidents, environment and traffic exist, and traffic separation schemes and vessel traffic service(VTS) systems have been introduced[1-1]. There are neither general rules to identify problem areas nor any evaluation of the effectiveness of existing and proposed systems. Further research has investigated navigational aids in Korean waters and suggested extension of aids and improvement in the management of such devices[1-2].

This research involves the analysis and processing of traffic statistics, a statistical and causal analysis of marine casualties, an evaluation of effectiveness of existing traffic systems, an estimation of the VTS effectiveness, and provides some guidelines for the formulation of solutions to the problems identified in Korean waters.

1.2 OBJECTIVES AND METHODOLOGY OF RESEARCH

This study assesses the level of safety achieved in Korean waters, discusses the effectiveness of existing traffic measures, and estimates the effectiveness of proposed VTS systems. In order to establish the basic needs of a VTS system, it is necessary to examine the existing level of safety through casualty and traffic analysis.

This thesis examines marine traffic and focuses on an analysis of casualties leading to recommendations for a vessel traffic service in Korean waters with improvements in navigational practices identifying the nature and needs. Further emphasis is placed on the development of an unique model to quantify VTS effectiveness.

As a secondary objective the adequacy of the existing traffic measures (Traffic Separation Scheme & Vessel Movement Reporting System) in Korean waters are assessed with recommendations, as appropriate, for improvements in navigation safety.

The risk to shipping in a particular area may be expressed in terms of the probability of a casualty and the consequences of such a casualty. This leads to an initial requirement for estimating the expected frequencies of casualties in the water. The estimation of casualty rates presents a number of problems.

A first necessary step is to divide Korean Waters into several sea-areas. The sea-areas have to be such that local conditions (such as environmental conditions and traffic density) within each would be sufficiently uniform. Accordingly the Korean coastal waters are divided into ten sub-areas taking into account the jurisdiction of each district port authority and marine police. Figure 1.1 illustrates the study areas with the sub-area division.

Within a relatively small area, such as one of the selected sea-areas, casualties to ships are quite rare events, so that to obtain a statistically significant number of recorded casualties on which to base the predictions for a particular sea area, many years of data would be required. However, over a long period, many factors which affect the occurrence of casualties may change. Traffic patterns may change, navigation aids may improve, mixes of ship type and nationalities may vary and even hydrographic features may alter due to dredging, reclamation or to natural sea-bed movement. Consequently, long-term historical records are unlikely to be representative of present or future risk, and short-term records generally contain too few casualties to give reliable guidance as to future trends[1-3].

In order to meet the problem of estimating risk in the absence of reliable experience, a number of techniques[1-4]-[1-11] have been devised for deducing a measure of risk from observation of marine traffic interactions in a given sea-area.

1.2.1 SURVEY OF EXISTING METHODS OF ASSESSING RISK

Risk assessment methods used in earlier research include:

(a) <u>HUT (Helsinki University of Technology) report</u>[1-4][1-5]. A detailed data base of ship casualties has been collected for the Baltic Sea for 1979-81. The analysis of this data base leads to an estimation of the consequences and costs of casualties in the area and these can be used to indicate both problem areas and the potential benefits of measures to reduce casualty rates.

(b) CCG (Canadian Coast Guard) report[1-6][1-7]. This report describes the methods used for ranking vessel traffic management sites for marine risk by means of traffic forecasts, a navigational risk index, and estimation of the impact of marine casualties. The risk index was determined by using a panel of experts to rate a number of factors which affected the safety of navigation in the areas of interest and then to weight the factors according to their importance. The weighted ratings were then added to obtain an overall index for each area.

(c) COST 301. PAI (Problem Area Identifier) is based on simple mathematical techniques for estimating the frequency of encounters and the mean casualty rate in an area, modified by the assessment of navigational risk made by a panel of experienced navigators. The PAI comprises the two components of annual expected collision rate and expected stranding rate, and these are kept as separate entities. This is necessary if recommendations concerning shore-based aids are to be formulated[1-8]. This method relates directly to the cost-benefit analysis[1-9].

(d) WENNINK C.J. [1-10]. In this paper, the risk analysis methods for the evaluation of collision and grounding risks have been reviewed with emphasis on a causal approach (fundamental) method in preference to the frequently used statistical (historical) method based on records of previous port accidents.

Wennink suggests a Causal Approach Method (Risk prediction on the basis of contributory elements) instead of statistical method. Since such contributory elements directly relate to the size of a transiting vessel and its navigational and environmental constraints, the transit risk related to such a vessel can be measured against these contributory or "causal risk parameters". Eventually, this established relationship between causal conditions and ship-related risk levels can, in turn, be used for port safety prediction purposes in general.

(e) SHIP DOMAIN STUDY. The ship domain concept has been developed in recent years by the Japanese[1-11][1-12]. In the United Kingdom Goodwin[1-13] and Coldwell[1-14] have been involved in further work with the general aim of increasing the safety and efficiency of marine traffic.

Toyoda and Fujii[1-11], in 1971, gave a brief history of how the domain developed as far back as 1966. They defined the effective domain as "a two-dimensional area surrounding a ship which other ship must avoid." Later in the same year(1971) Fujii and Tanaka[1-12] gave a much more detailed description of the effective domain.

The further primary domain study is that made by Goodwin[1-13] in 1975. Goodwin's main concern was an attempt to establish the water areas required by any one ship for safe navigation, and this led to the concept of the ship domain. Goodwin defined the ship domain as "the effective area a ship which a navigator would like to keep free with respect to other ships and stationary objects."

The study of ship domains carried out by Coldwell[1-14] in 1982 was an effort to develop a ship domain for use in a relatively narrow channels. The ship domain for use in restricted waters was established and dimensions were given to a limited extent for independent variables such as vessel type and length. Certain dimensions for a ship domain with navigation marks were also established.

Fig 1.1 Study areas with the subarea division

1.2.2 ANALYSIS OF FACTORS AFFECTING MARINE TRAFFIC SAFETY

A comprehensive literature survey has been carried out to determine the factors which influence marine traffic safety. A good background of the factors that may lead to a casualty is given by MOON & HIGGINS[1-15], KARLSEN & KRISTIANSEN[1-16], QUINN & SCOTT[1-17] and KEMP[1-18], identifying the statistics that should be collected. Other studies on ship casualties also gave detailed analysis and classifications of similar factors.[1-19][1-20][1-21]

For the purpose of this study, the factors undermentioned are reviewed in detail:

(1) Technological factors

- Ship factors (type, length, beam, age, speed, flag, etc)
- Waterway (type, channel width & depth, etc)
- Traffic condition (density, flow, etc)

(2) Environmental factors

- Weather (visibility, wave, wind, etc)
- Current & Tide
- Social situations (rules & regulations, commercial pressure, etc)

(3) Human factors

- Manning and watch system (health, organization, training, watchkeeping, etc.)
- Ship control tasks (appreciation of information, manoeuvring, etc.)

A statistical analysis is undertaken of a casualty data base for the years 1986-1990. Additional information on the causal factors of the casualties has been compiled by block scheme. The effect level of VTS addressable risk is quantified.

1.3 MARINE TRAFFIC ENGINEERING

Definitions of marine traffic engineering include:

(a) Part of engineering which, for any transport system, deals with the form and lay-out of the track and its controls and with the operation of traffic, so as to provide safe, convenient and economic means for the movement of vehicles, people and goods[1-22].

(b) The study of marine traffic and the application of the results of such studies to improvements in navigation facilities and traffic regulations[1-23].

A very wide range of studies has been published to date, especially in the publications of the Navigation Institutes. These studies have investigated, broadly speaking, the following aspects of the maritime traffic phenomena: traffic features, casualties and economies. All these aspects are inter-related but the classification made serves as an outline[1-24].

(a) Traffic features. The basic traffic features of a given sea area are the nationality and the number of ships, their sizes, speeds, types, tracks and cargo. There have been many traffic observation projects to obtain the distributions of these fundamental variables. The first systematic traffic survey was carried out by Yamaguchi *et al* in 1963 in Japan, where the marine traffic had become heavily congested. Nowadays more than 30 surveys a year are being carried out with the cooperation of the Maritime Safety Agency in Japan alone [1-25]. In Europe the Dover Strait is under continuous surveillance. In the Baltic Sea the Polish traffic measurements in the southern Baltic, which started in 1979, are worth mentioning [1-26]. There are currently two supplementary methods of observation of the traffic in use: visually and by radar.

(b) Casualties. Maritime casualties may be divided into two discrete groups according to their elementary causes: traffic accidents and technical accidents.

Collisions, groundings and rammings are traffic accidents; fires and explosions, founderings, capsizings, floodings and weather damages are the latter type. The explanation of such grouping is evident: the remedies against traffic accidents can be found in the development of the traffic situations and environment, but the technical accidents are addressed by the technical development of ships[1-27]. Marine traffic engineering has mainly concentrated on accidents of the traffic type. The complex nature of marine accidents and the difficulties in conducting direct experiments explain why the collection and analysis of various accident data files or databases has been the predominant methods of safety study. The best known worldwide casualty statistics are contained in the data bank of Lloyd's Register of Shipping. One of the difficulties of the statistical method of study has been the lack of a uniform international code of investigation and recording[1-28]. Another problem is the quality of the information collected. The statistical analysis shows only information of a general nature and detailed conclusions are generally not possible. The usefulness of the statistics lies in their diagnostic ability: they show what and where the main problems are.

(c) Economic aspects. Proper assessment of the costs and benefits of each proposed new traffic or safety measure is beneficial to society as a whole. In practice these are difficult to estimate. Total losses resulting from marine accidents should take into account both direct and indirect costs. The former (repair, lost cargo, lay-days...) is in theory possible to estimate, but the latter (price of human life lost, damaged environment, ...) are difficult to express in monetary terms. On the benefits side, a U.S. Coast Guard study [1-29] came to the conclusion that, except in rare cases, no quantitative assessment is possible of the extent to which any specific safety action is effective in reducing the risks of marine accidents.

1.4 THESIS ORGANIZATION

This thesis comprises eight chapters.

Chapter 2 discusses some meteorological and topographical factors which are considered to impinge on marine casualties. These factors include fog & visibility, wind, precipitation, sea & swell, current & tide and coast & ports.

Chapter 3 details the nature of marine traffic including vessel statistics, vessel movements and cargo traffic.

Chapter 4 summarizes the general trend of marine casualties in Korean waters, and describes the casualty data base, from which the causes and consequences of the casualties are derived. Various statistical tools are used to evaluate the inter-relationships between individual causal factors including marine environmental and marine traffic parameters identified in Chapter 2 and Chapter 3. Emphasis is given to determining the causal relationships connected with ship casualties, and for the first time the quantification of the effect level of causal factors is made for Korean waters.

Chapter 5, contains the first evaluation of the effectiveness of existing traffic services in Korean waters, and recommends possible measures to improve navigation safety. An accident danger index is used to compare the level of safety in various time periods.

Chapter 6 analyzes a questionnaire derived to evaluate marine safety and Vessel Traffic Services in Korean coastal waters. Various factors increasing marine risk are discussed, a number of options for improving safety are examined, and the median addressing VTS assistance is considered. Multiple range test is proposed as a means of testing differences between occupational groupings.

Chapter 7 describes the effectiveness of proposed Vessel Traffic Services. A wide range of literature related to the effectiveness is reviewed, a novel method of estimating VTS effectiveness(benefits) is proposed and sensitivity analysis is discussed. The unique approach quantifying the VTS effectiveness is the combination of the casualty rate reduction factors with the effect level of causal factors. The development of casualty rate reduction factors is based on the questionnaire survey in Chapter 6, and the development of effect level of causal factors is based on the casualty analysis in Chapter 4. This new approach produces a more valid index of VTS effectiveness by the another filtering process.

Chapter 8 summarizes the findings, summaries and recommendations of the research. Annexes of causal factors, statistical tables of casualty analysis, list of traffic accidents and questionnaire survey are included at the end of the thesis.

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Chapter 2

MARITIME ENVIRONMENT

2.1 METEOROLOGICAL FEATURES

2.1.1 GENERAL

Korea is a middle latitude peninsular country affected by both maritime and continental air masses. Many frontal systems pass through the region, and the weather generally changes from west to east. The most influential air masses are the Siberian air mass and the North Pacific Ocean air mass. That is why Korea has the following notable features;

(a) a wide range of temperature between the hottest and coldest periods of the year
(b) rainfalls that are concentrated during summer season
(c) sea and swell directions and heights are determined almost entirely by the circulation of the north-east monsoon in winter and the south-west monsoon in summer.

A discussion and survey on some meteorological factors, which may have an important influence on marine casualties, is given in this chapter.

2.1.2 FOG AND VISIBILITY

Fog is formed by water droplets held in suspension at or near the surface so as to reduce an observer's visibility to less than 1,000 metres (1,100 yards). When dust, smoke, or sand particles obscure vision in the surface layers, the reduction in visibility is known as haze.

Visibility is defined as the greatest distance at which an object of specified characteristics can be seen and identified with the unaided eye in any particular circumstances, or, in the case of night observations, could be seen and identified if the general illumination were raised to the normal daylight level.[2-1]

Table 2.1 Visibility scale used at sea

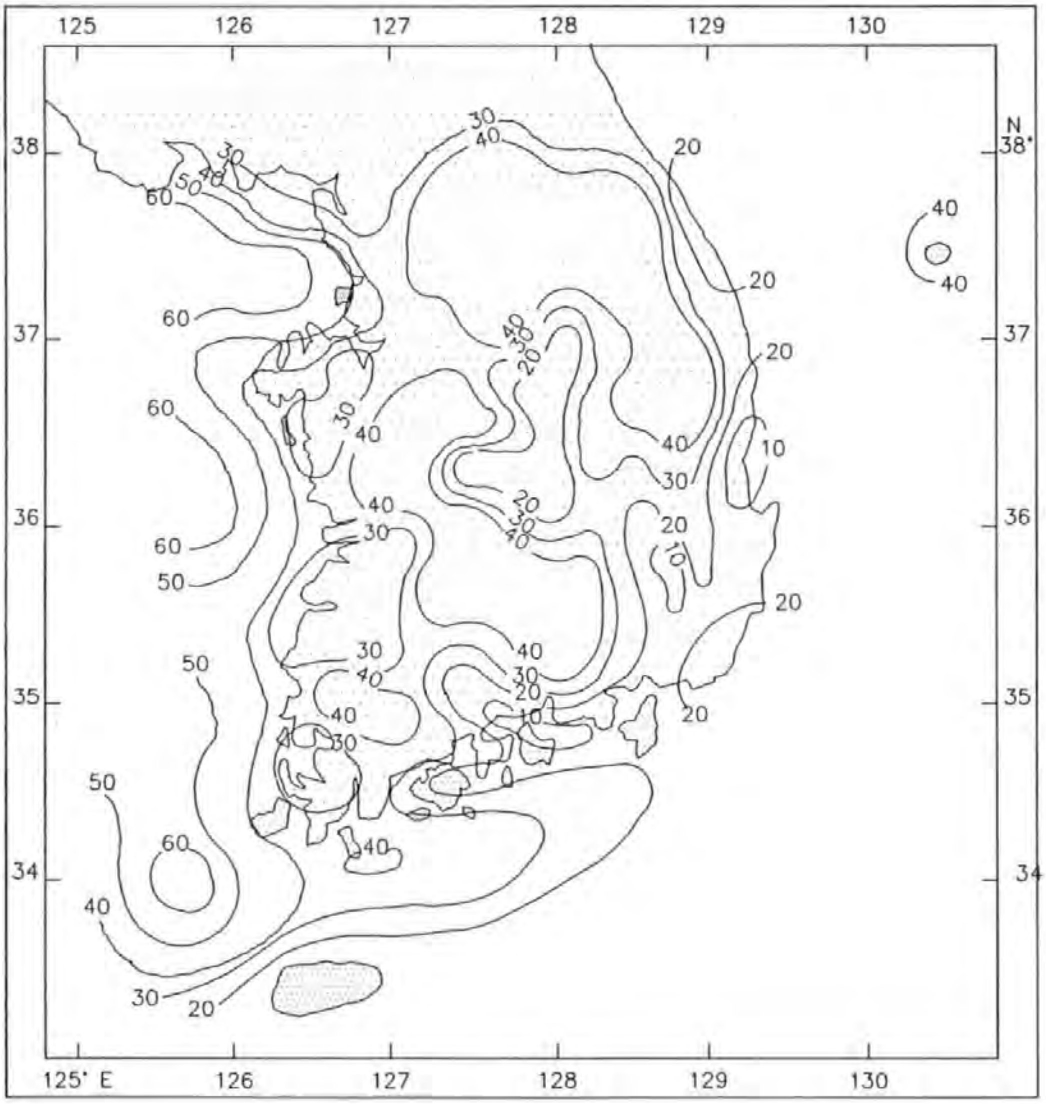
Range Recorded in Steps			
Km	*N. Mile*	*Km*	*N. Mile*
< 0.05	< 0.03	2.0 - 4.0	1.1 - 2.2
0.05 - 0.2	0.03 - 0.1	4.0 - 10.0	2.2 - 5.4
0.2 - 0.5	0.1 - 0.3	10.0 - 20.0	5.4 - 11.0
0.5 - 1.0	0.3 - 0.5	20.0 - 50.0	11.0 - 27.0
1.0 - 2.0	0.5 - 1.1	≥ 50.0	≥ 27.0

Source: BURGESS C.R. Meteorology for seafarers p.35

Visibility is assessed by viewing the horizon through 360 degrees and recording the shortest distance. Land observing stations use objects at known distances in daytime and a visibility meter at night, thus making it possible to provide accurate visibility ranges. At sea, however, the limited availability of objects often makes the estimation of visibility difficult and a coarser scale is used.[2-2]

Visibility is an important factor in relation to collisions, contacts and strandings. Collisions will occur more frequently in areas where there is a high incidence of low visibility.[2-3] Motte[2-4] stated that fog still remains the ship-master's greatest enemy, and

Fig 2.1 Foggy days per annum
(1980–1984)



Source: The Ministry of Science & Technology (1986) the fog hazard becomes extreme in closed waters. Bearing in mind the importance of visibility as a factor for navigation safety, it is suggested that detailed investigation should be carried out separately for each area.

Figure 2.1 illustrates the average number of foggy days per annum, showing the frequency is 40-50 days over coastal waters in west and south-west areas, and more than 20 days in east and south-east waters.

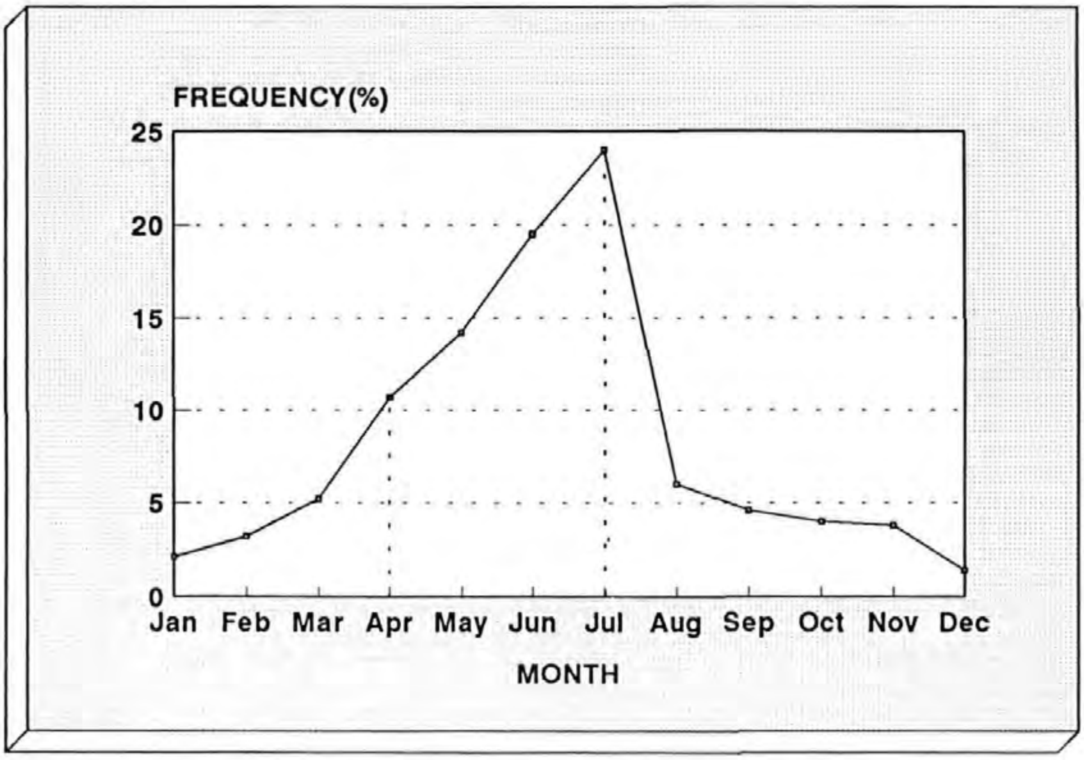
Sea fog is rare during the months from August to March the frequency being less than three percent. Most of the fog at sea occurs in the months of April to July during the SW monsoon period; fog being most frequent in July[2-5][2-6]. It can be seen from Figure 2.2 that 69 percent of sea fog is formed during the four months from April to July, 24 percent occurring during July.

Table 2.2 Average foggy days per month in major ports (visibility ≤ 1 Km)

Port	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Av.
Inchon	2.0	2.0	3.4	4.6	5.3	7.1	9.0	2.5	1.3	2.8	1.6	2.4	3.7
Kunsan	1.8	1.9	2.5	4.0	3.4	4.4	4.0	2.1	3.7	5.2	3.1	1.9	3.2
Mokpo	0.7	1.2	1.2	1.7	1.7	2.9	4.7	1.3	1.8	1.6	1.5	0.9	1.8
Yosu	0.4	0.5	1.4	2.4	3.5	3.6	7.9	0.7	0.4	0.6	0.6	1.4	2.0
Cheju	0.1	0.3	1.0	2.0	3.5	6.1	3.3	0.1	0.1	0.1	0.1	0.0	1.4
Soguipo	0.0	0.0	0.2	1.4	3.5	5.3	4.9	0.0	0.3	0.0	0.0	0.0	1.3
Chungmu	0.1	0.3	0.4	0.9	2.1	3.3	5.3	0.5	0.1	0.2	0.2	0.8	1.2
Pusan	0.3	0.5	1.0	2.5	3.7	6.5	5.6	0.2	0.4	0.3	0.1	0.5	1.8
Ulsan	0.1	0.0	0.6	1.4	1.4	3.9	2.0	0.4	0.1	0.6	0.5	0.3	0.9
Pohang	0.0	0.1	0.7	1.0	0.8	2.3	2.1	0.7	0.6	0.3	0.7	0.0	0.8
Ulnungdo	0.0	1.3	2.2	6.2	7.2	10.5	12.9	6.8	3.6	0.8	0.5	0.6	4.4
Gangnung	0.2	0.3	0.1	1.4	1.9	2.2	3.2	1.6	0.6	0.5	0.1	0.0	1.0
Average	0.5	0.7	1.2	2.5	3.2	4.8	5.4	1.4	1.1	1.1	0.8	0.7	

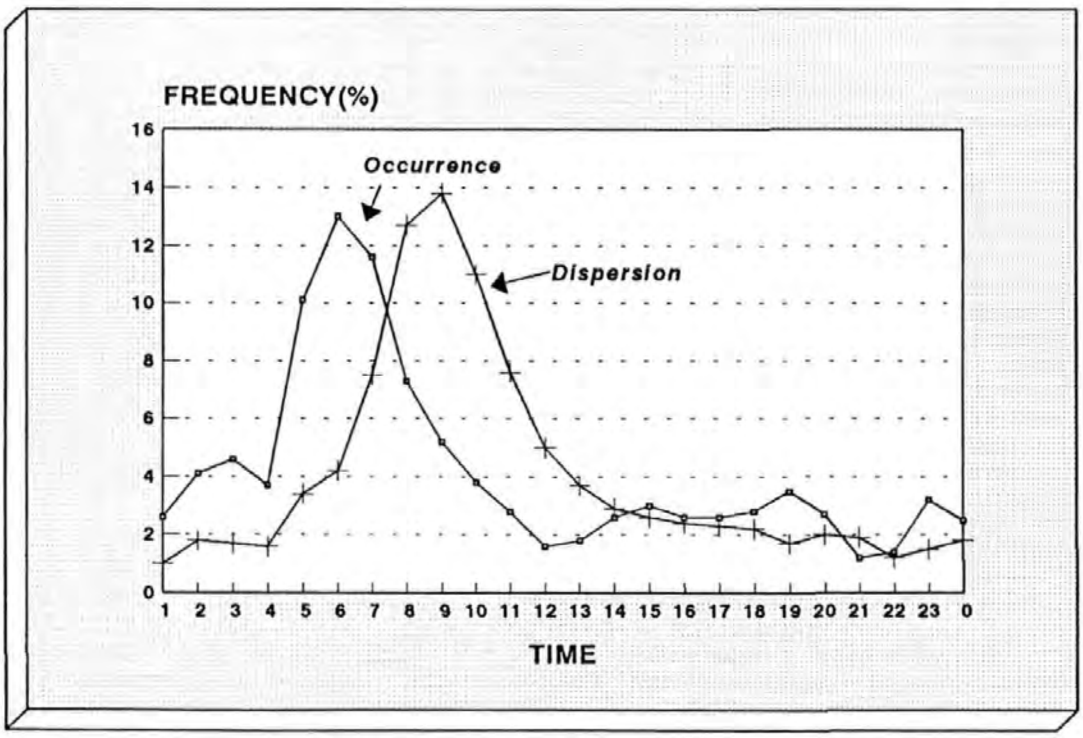
Source: A Comprehensive developing plan of navigational aids (1987). KMU, Pusan

Fig 2.2 Monthly frequency of sea fog (1980-1984)



Source: The Ministry of Science and Technology (1986), Seoul

Fig 2.3 Frequency of sea fog occurrence (1980-1984)



Source: The Ministry of Science and Technology (1986), Seoul

As can be seen in Figure 2.3, sea fog commonly occurred between 0500-0800 hours and dispersed between 0700-1100 hours. Average duration time of sea fog is 4.5 hours, the longest being 5.6 hours in January and the shortest 3.3 hours in October.

Table 2.2 indicates the average foggy days per month in the major port areas of Korea. The "Ulnung-do" area suffers most from fog with Inchon/Kunsan following next in terms of severity.

Dust and sand storms are experienced at times. In the western part of the region, dust haze being carried along by strong winds from the dust deserts of Mongolia can be fairly extensive in late winter and spring. In the worst cases visibility is reduced to a few yards by the thick haze, which also causes irritation to eyes, throat and chest[2-7]. Most of the sea areas has good visibility in winter. Exceptions occur during precipitation.

2.1.3 WIND

Wind force is a factor which may have an important influence on casualty rates, particularly in the case of strandings. The wind speed at which the navigation of a ship is a significantly affected clearly depends on the size, shape and speed of the vessel. Detailed data on the effect of wind force on different vessels are relatively scarce[2-8].

The winter monsoon starts in September and continues through February to March; winds are north, or at times north-west, with average force five in January and gales on about five to ten percent of occasions in December and January, and one to five percent in the other winter months. The winds in summer are east and south during June, and between south-east and south-west during July and August, with average force three to four.[2-9]

Table 2.3 Average wind speed in major ports (metre/second)

Port	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Av.
Inchon	4.1	4.2	4.2	4.2	3.6	3.0	2.8	2.8	2.8	3.0	3.8	4.0	3.9
Kunsan	4.0	4.6	4.7	4.5	4.1	3.8	3.6	3.8	3.7	3.8	3.7	3.9	4.1
Mokpo	4.9	5.0	4.9	4.3	3.7	3.6	3.6	3.7	3.8	3.6	4.3	4.4	4.2
Yosu	4.8	4.9	4.6	4.0	3.1	3.0	2.8	3.4	4.0	4.0	4.3	4.3	4.0
Cheju	5.3	5.0	4.2	3.9	3.2	3.2	3.1	3.3	3.3	3.7	4.3	4.9	4.2
Pusan	4.2	4.3	4.4	4.3	3.8	3.7	3.8	4.1	3.7	3.5	3.9	4.0	4.4
Ulsan	2.8	2.7	2.6	2.4	2.2	1.8	1.9	2.1	2.0	1.8	2.1	2.5	2.7
Pohang	3.1	3.2	3.1	3.3	3.1	2.0	2.9	3.1	3.2	2.9	2.9	2.9	3.5
Ulnungdo	4.5	4.4	4.4	5.4	5.3	3.9	3.9	4.1	3.8	4.0	4.3	4.3	4.3
Gangnung	3.8	3.3	2.9	2.9	2.6	1.7	1.6	1.6	1.8	2.5	3.0	3.3	2.6
Average	4.2	4.2	4.0	3.9	3.5	3.1	3.0	3.2	3.2	3.3	3.7	3.9	

Source: A Comprehensive developing plan of navigational aids (1987). KMU, Pusan

Table 2.3 indicates the monthly average wind force in major port areas, in which Pusan has the strongest recorded wind speed. West and south-western areas have stronger winds than the east. Generally, wind directions are constant during the summer months of June to September. North-west is the most dominant direction on western coasts but the wind direction tends to vary on the eastern side of the peninsula.

2.1.4 PRECIPITATION

The main effect of precipitation in the form of rain or snow is a decrease in visibility. It is also possible that heavy rain, with large drop sizes, may interfere with the operation of radar preventing the detection of target ships. The effect of precipitation on radar performance depends on the radio wavelength used.

Annual rainfall varies from 800 to 1,200 mm, but at Cheju-do(Soguipo Hang) exceeds 1,500 mm (Table 2.4). The number of wet days is an indication that the higher amounts of rainfall in summer are due to the greater intensity rather than the duration, especially over the south-east region. Very large amounts in a short period have been recorded in this area; 250 mm fell in eight hours during one August and falls of 200 mm in one day are rather common along the Korean coast. Large seasonal and annual deviations from the normal occur in all parts of the area. The July total at Pusan has varied from between 60 mm to 650 mm.[2-10] Rainfall in general, becomes more frequent and widespread in south than north, and more frequent in west than east. As can be seen in Figure 2.4, the amount of rainfalls are concentrated during summer months over the coasts.

Table 2.4 Average rainfalls in major ports (mm)

Port	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Av.
Inchon	14	12	38	79	74	92	222	180	109	51	45	29	79
Kunsan	18	31	46	91	75	148	228	220	106	47	57	37	92
Mokpo	21	54	50	105	83	192	170	153	162	58	48	24	93
Yosu	13	40	66	136	139	252	240	261	259	60	47	25	128
Cheju	46	79	76	97	72	214	188	258	198	107	83	48	122
Soguipo	34	87	128	175	191	315	263	247	183	80	85	42	153
Chungmu	17	45	96	156	139	225	215	209	131	77	59	24	116
Pusan	22	42	80	153	134	243	218	219	212	80	62	26	124
Ulsan	21	42	62	128	75	187	162	226	213	72	49	17	105
Pohang	27	38	60	92	53	145	133	203	175	62	52	16	88
Ulnungdo	140	102	76	89	63	103	112	124	180	107	114	121	111
Gangnung	41	39	64	99	71	119	165	309	184	114	71	44	110
Average	35	51	70	117	97	186	193	217	176	76	64	38	

Source: A Comprehensive developing plan of navigational aids (1987). KMU, Pusan

Snow occurs on one or two days per month as far south as Pusan from December to March and snowfall becomes more frequent and widespread further north. Days with snowfall are included for some stations in the climatic table. Visibility is seriously reduced with moderate snowfall in strong winds and when drifting of fallen snow occurs with high winds. These conditions may cause problems in northern parts of the area.[2-11]

Table 2.5 Climatic table

Ports	Temperature (°C)			Number of days				
	Highest	Lowest	Average	Rain	Snow	Fog	Gale	Thunder
Inchon	32.8	-16.2	12.3	119	25	58	5	23
Kunsan	34.0	-13.9	13.5	128	24	72	24	14
Mokpo	35.7	-11.1	14.7	117	26	39	33	11
Yosu	33.9	-9.9	14.8	107	12	24	9	8
Masan	37.1	-10.0	15.3	101	5	11	0	12
Pusan	34.3	-10.4	15.5	103	5	19	5	7
Ulsan	36.5	-11.8	14.9	96	3	10	0	12
Pohang	35.7	-11.1	15.0	105	6	3	1	12
Samcheog	33.8	-13.5	13.2	113	10	6	0	10
Sokcho	33.2	-13.8	12.4	141	14	20	10	17
Cheju	37.0	-4.5	16.4	130	15	7	23	12
Soguipo	34.7	-4.2	17.1	126	6	18	2	5

Source: Statistical Yearbook 1991, KMPA, Seoul

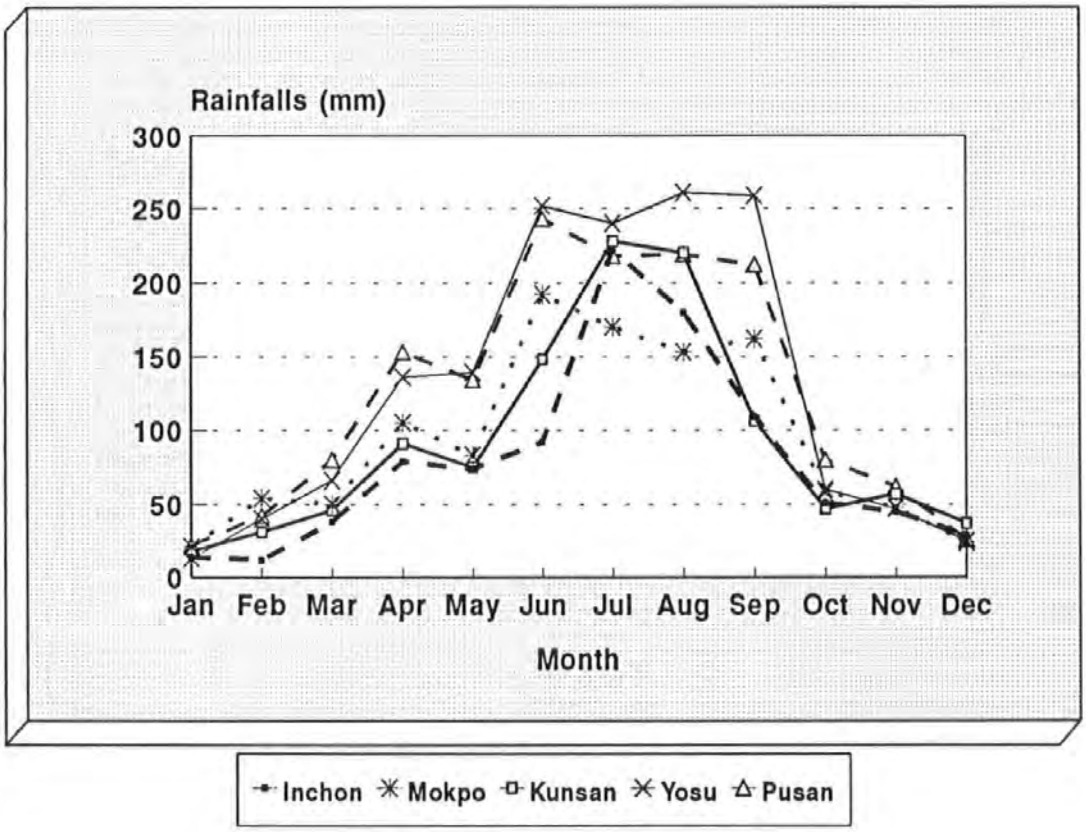
2.2 MARITIME TOPOGRAPHY

2.2.1 GENERAL

Korea lies approximately between the parallels of 33° north and 43° north, and the meridians of 124° east and 131° east. The major part of Korea consists of a peninsula extending nearly 350 miles south from the east seaboard of the Asian continent to from the east side of Yellow Sea; it is separated from Japan by the Korea Strait. A mountainous ridge extends the length of the peninsula sloping towards the heavily indented west coast which is intersected by the principal rivers; the east coast has only narrow coastal plain separating it from the spinal ridge; there are few harbours on that side and the rivers are small.

Fig 2.4 Average rainfalls in major ports

(West & South coast)



Source: Compiled by Author from Table 2.4

The west coast of Korea is fringed by a multitude of islands which provide sheltered harbours and anchorages, but their value is somewhat impaired by the large rise and fall of tide and hence the strength of tidal streams.[2-12]

2.2.2 SEA AND SWELL

Waves can, under certain circumstances, constrain the way in which ships navigate and this might have an influence on both stranding and collision rates.

The relationships are complex and, unfortunately, little is known concerning any correlation between wave characteristics and casualty rates, because it is not only wave height but also wave length which needs to be considered. Further a given sea state will have a quite different effect on different classes of ships.

Another consideration is that observed sea state may include a swell component which is unrelated to local wind.[2-13]

Sea and swell directions and heights are determined predominantly by the circulation of the north-east monsoon in winter and the south-west monsoon in summer in Korean waters. North-east to south-east wave/swells are diffused to the east coast in Korea as the coast faces the open sea. A period of strong north winds causes moderate to heavy swell from between north and north-east over the southern part of the Japan Sea in winter. Persistent heavy swells occur in the Korean Strait when the summer monsoon is well established. Sea disturbance through the Strait is also complicated by the north-moving Kuro Shio(Japan) Current. Heavy swell is infrequent, but may develop over the east and south-east sector when vigorous depressions cross the central area. The south coast, however, is sheltered by coastline and is therefore not much affected by the north-west and north-east wind.

Table 2.6 Frequency of wave height

Season	Height	Mid-west (%)	Mid-south (%)	Mid-east (%)
Winter	≥1.5m	35	30	35
	>2.4m	10	10	11
	>3.6m	4	4	4
Spring	≥1.5m	5	5	5
	>2.4m	2	2	2
Summer	≥1.5m	10	12	10
	>2.4m	5	4	4
	>3.6m	2	2	2
Autumn	≥1.5m	20	20	20
	>2.4m	15	15	15
	>3.6m	5	5	7

Source: A Comprehensive developing plan of navigational aids(1987), KMU, Pusan

In some coastal areas heavy swell is encountered on the rare occasions of strong to gale force southern winds, and when typhoons occur. There are about two typhoons yearly, on average, and these give confused seas with mountainous waves and heavy swell.

As can be seen in Table 2.6, wave/swell is predominant by the continuous north-east monsoon in winter months, and the frequency of sea and swell reaching a height of 3.6 metre or more is four to seven percent in autumn and winter, and less in spring and summer.

2.2.3 CURRENT AND TIDE

It is believed that currents or tidal streams have an important influence on strandings, collisions and contacts between ships and fixed objects, but little influence on the incidence of collisions between ships.[2-14]

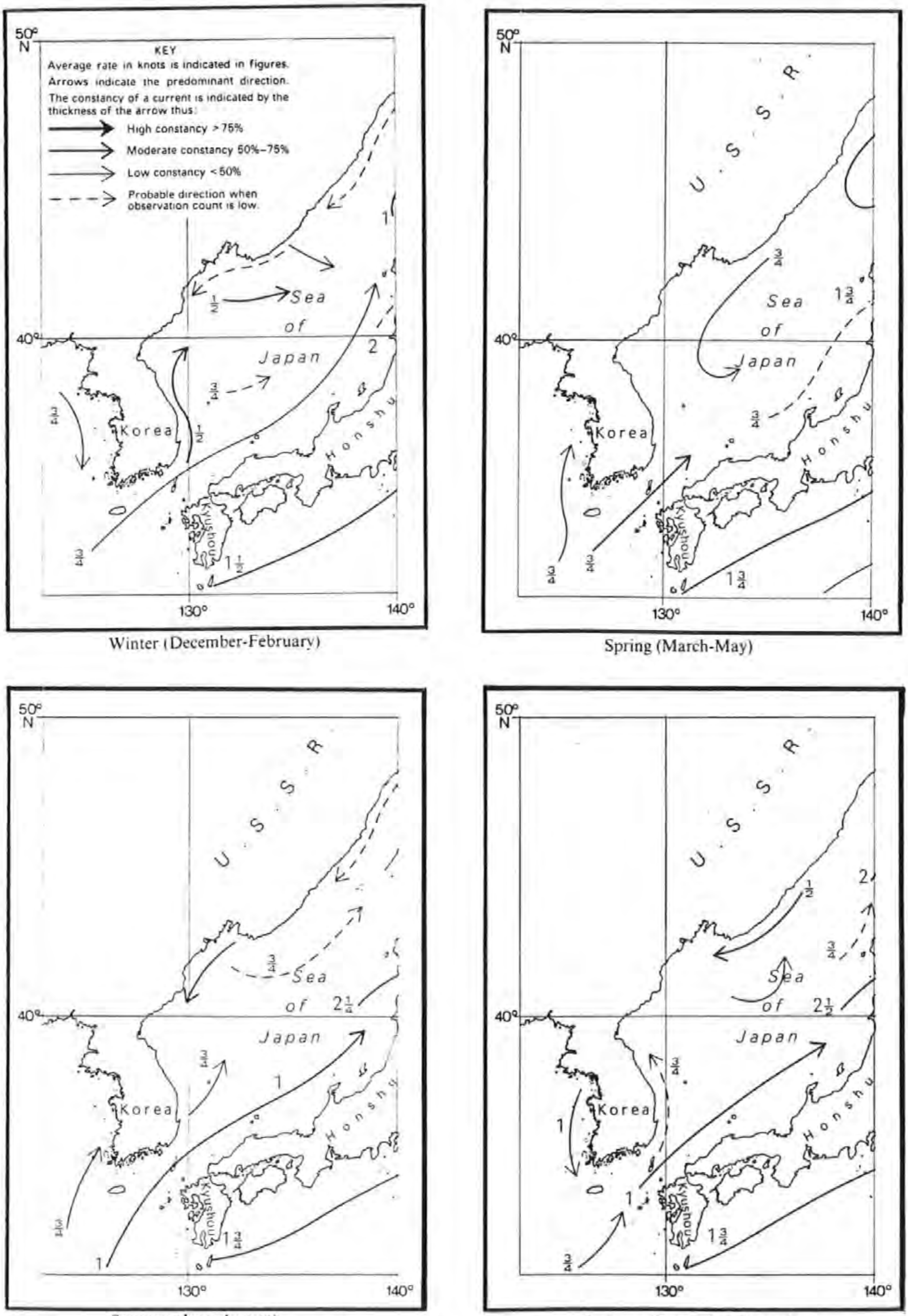
(a) Currents. Although the area in general, is subject to monsoon winds it is only near the west coast of Korea that the currents reverse their direction in accordance with the prevailing monsoon.

Seasonal changes are evident as illustrated in Figure 2.5. In this figure, arrows indicate the predominant direction and average rate but there is some variability in current, so that sets different from those indicated on the figures may be experienced at times and, exceptionally, the current may flow in the opposite direction.

Kuro Shio Current (Japan Current or Tsushima Current): A warm current of Pacific origin flows north-east towards Kyushu and Tsushima. To the south of Cheju-do it subdivides with the weaker stream flowing to the Yellow Sea and the stronger flow turning north-east to pass either side of Tsushima into the Japan Sea. During the summer months, the flow through the Korea Strait is at a maximum, with average rates of one knot. Water passing on the north and north-west sides of Tsushima bifurcates at the north-east end of the Korea Strait, one part of the flow moves north along the east coast of Korea to become the East Korean Current. During the winter months this current sometimes reverses its flow as the Liman Current extends south and also because the flow through the Korea Strait is at a minimum at that time of year.[2-15]

Liman Current: The Liman Current has its origin in the neighbourhood of Proliv Nevelskogo, at the north end of the Gulf of Tartary. It is a cold current which sets south along the Siberian coast eventually branching east into the Japan Sea. The extent to which this current penetrates south is dependent on season. For much of the year it is limited to about 40° north. In winter, however, it continues on, to pass down the east coast of Korea, before branching east.

Fig 2.5 Predominant current in Korea



Source: Admiralty Coast Pilot No. 43 (1983)

Currents within the central part of the Japan Sea are somewhat variable as the result of branching from both the Tsushima and Liman Currents. Southerly sets are most likely in the winter and northerly sets in the summer, but constancy cannot be relied upon.[2-15]

(b) Tides and Tidal Streams. The rising tide sets north from the Pacific Ocean into Yellow Sea, and thence north-west into Bo Hai, by following the west coast of Korea and south coast of Liaodong Bando.

In general the streams have a maximum rate of one to three knots, except where local topography causes an increase. The range of tide varies from three metres to eight metres in west coast, about six metres at the port of Kunsan and eight metres at the port of Inchon. Also the approach to Inchon is a particularly interesting area where streams of five knots or more are found between the islands in the vicinity.

Table 2.7 Tidal features in major ports

Port	Water Level (Cm)			Tidal Speed (m/s)	
	H.H.W.	M.S.L.	Av. T.R.	Flood	Ebb
Inchon	927.0	463.5	527.4	3.30	2.10
Kunsan	682.0	341.0	419.2	1.90	1.70
Mokpo	467.6	233.8	269.0	5.10	8.00
Yosu	361.6	180.8	202.4	0.60	0.60
Masan	214.8	107.4	129.8	0.50	0.50
Pusan	128.2	64.1	78.8	0.60	0.80
Ulsan	60.8	30.4	32.6	0.75	1.18
Pohang	24.6	12.3	6.2	0.00	0.00
Samcheog	35.0	17.5	11.6	0.35	0.23
Cheju	283.4	141.7	142.6	1.40	1.60
Soguipo	303.2	151.6	151.4	0.50	0.70

Source: Statistical Yearbook (1991), KMPA, Seoul

Table 2.7 presents the tidal characteristics in major ports in Korea. Along the south coast of Korea, among the islands offshore and in the north half of the Korea Strait the flood stream sets west at one to two knots, increasing to five knots among the islands. In general, the rates diminish east; off Pusan Hang the flood stream sets south-west at one knot. Along the east coast of Korea the flood stream sets southward but diminishes rapidly in strength as one goes north and becomes negligible northward of Ulsan Man. The tidal streams are generally negligible along the south-east and east coasts of Korea. The range of tide is only 0.3 metre in the east and 1.2 metre in the south-east, but south-west area has 3 metres tidal range. It should be noted that the set due to the tidal streams is additional to that caused by the current; in general, the tidal streams are more important close inshore and the currents offshore, but this is not always so.

2.2.4 COAST AND PORTS

The length of South Korea's coastline is 5,560 Km in peninsula and 7,229 Km in islands, which is 12,789 Km in total.[2-16]

Most ports on the west and south coasts have relatively difficult navigational approaches with a large number of offshore islands.

Another feature of the ports in the west coast is the tidal range of approximately three to eight metres, which results in a large area of mud banks being exposed when the tide is out.

The depth of water off the west coast is less than 20 metres out to approximately 20 miles from the shore line and approximately 12 miles from the shore line on the south coast. There are no islands off the east coast, where deeper water exists.

2.3 SUMMARY

(1) Most (69%) of fog at sea occurs in the months of April to July during the south-west monsoon period; fog being most frequent in July.

(2) Pusan experiences the strongest wind and the west and south-western areas have stronger winds than the east.

(3) Rainfall is more frequent in the west than the east, being heaviest during the summer months.

(4) Tidal ranges vary from three metres to eight metres on the west coast and tidal streams have a maximum rate of one to three knots.

(5) Most ports on the west and south coasts of Korea have relatively difficult navigational approaches with many offshore islands.

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Chapter 3

VESSEL TRAFFIC DATA

In general, vessel tonnage and cargo volume are measures used to describe marine traffic, but the following factors are particularly fundamental[3-1]

- vessel tonnage and nature (size, type, age, etc.)
- number of ships and their tonnage entering & leaving ports

Therefore a discussion and survey on vessel tonnage, movement of ships and cargo traffic is given in this chapter.

3.1 VESSEL STATISTICS

(1) Vessels registered: Table 3.1 shows the number of ships of Korean register and their tonnage, and Figure 3.1 shows a growth trend. The register of vessels other than fishing vessels has grown slowly but continuously with an average rate of 2 percent per annum in numbers and 4.3 percent in terms of tonnage.

(2) Vessels registered by tonnage group: Table 3.2 shows the number of ships and their gross tonnage by tonnage group. The number of ships less than 100 gross tons accounts

for 78 percent of all registrations, but only one percent in terms of total tonnage.

Table 3.1 Vessels registered - December 1990 (grt: 1,000 tons)

	Passenger		Cargo ship		Tanker		Tugs		Others		Total	
Year	No	grt	No	grt	No	grt	No	grt	No	grt	No	grt
1981	163	29	1256	3477	491	1379	640	36	1365	38	3915	4959
1982	156	33	1211	4388	491	1143	653	38	1489	47	4000	5650
1983	162	45	1236	4922	508	1072	684	42	1565	58	4155	6139
1984	160	45	1248	5174	522	1146	677	44	1647	93	4254	6501
1985	156	45	1163	5414	517	1065	682	39	1656	100	4174	6662
1986	156	55	1075	5312	521	1144	699	41	1785	104	4236	6655
1987	166	55	1039	5281	518	1031	745	44	1868	104	4336	6514
1988	160	54	1045	5850	527	1189	795	49	2022	98	4549	7239
1989	151	56	1049	6369	529	733	805	50	2076	99	4610	7306
1990	152	57	1049	6308	532	596	838	53	2140	101	4711	7115

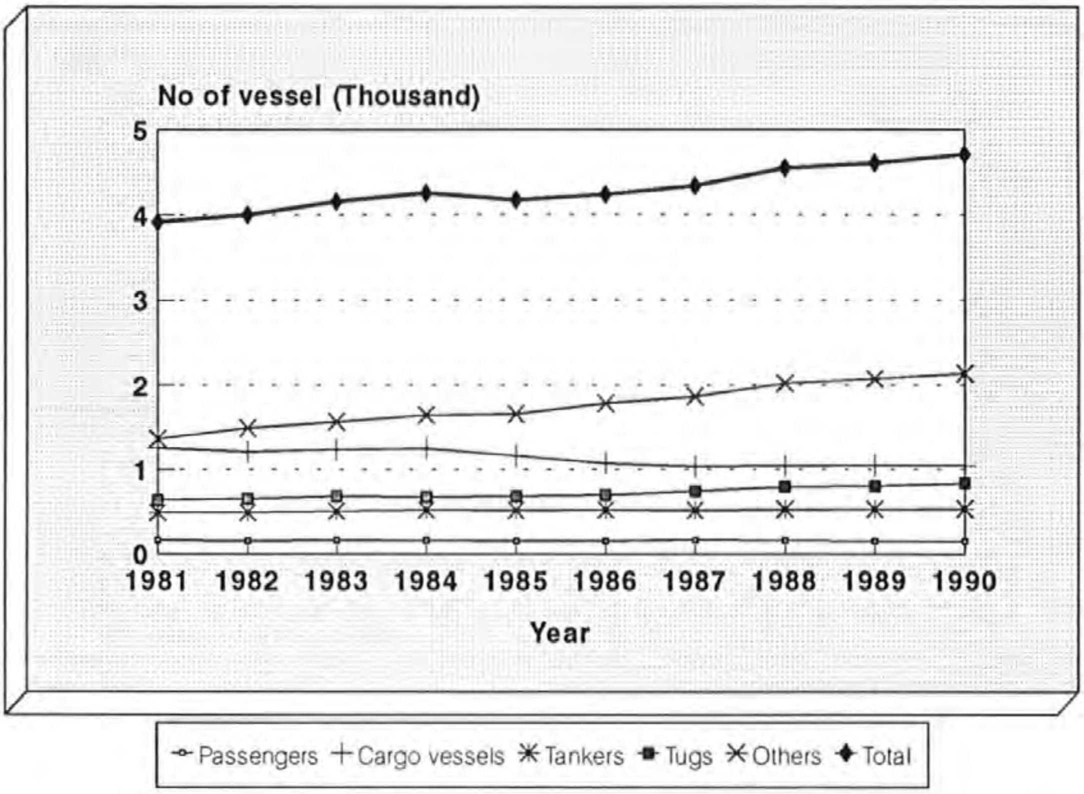
Source: Statistical yearbook (1991). KMPA, Seoul

Table 3.2 Vessels registered by Tonnage - December 1990 (grt: 1,000 tons)

Group	Passenger		Cargo ship		Tanker		Tugs		Others		Total	
	No.	grt	No.	grt	No.	grt	No.	grt	No.	grt	No.	grt
-99	78	5	485	12	338	9	705	23	2074	30	3680	80
100-499	60	11	137	37	83	20	130	24	55	11	465	104
500-999	3	2	75	59	54	43	2	1	2	1	136	106
1000-1999	2	2	67	112	25	36	0	0	3	5	97	155
2000-4999	7	21	105	379	19	60	1	5	3	11	135	475
5000-9999	2	16	14	98	5	45	0	0	1	8	22	166
10000-19999	0	0	76	1136	4	62	0	0	1	10	81	1208
20000-49999	0	0	60	1873	2	87	0	0	1	25	63	1984
50000-	0	0	30	2603	2	234	0	0	0	0	32	2837
Total	152	57	1049	6308	532	596	838	53	2140	101	4711	7115

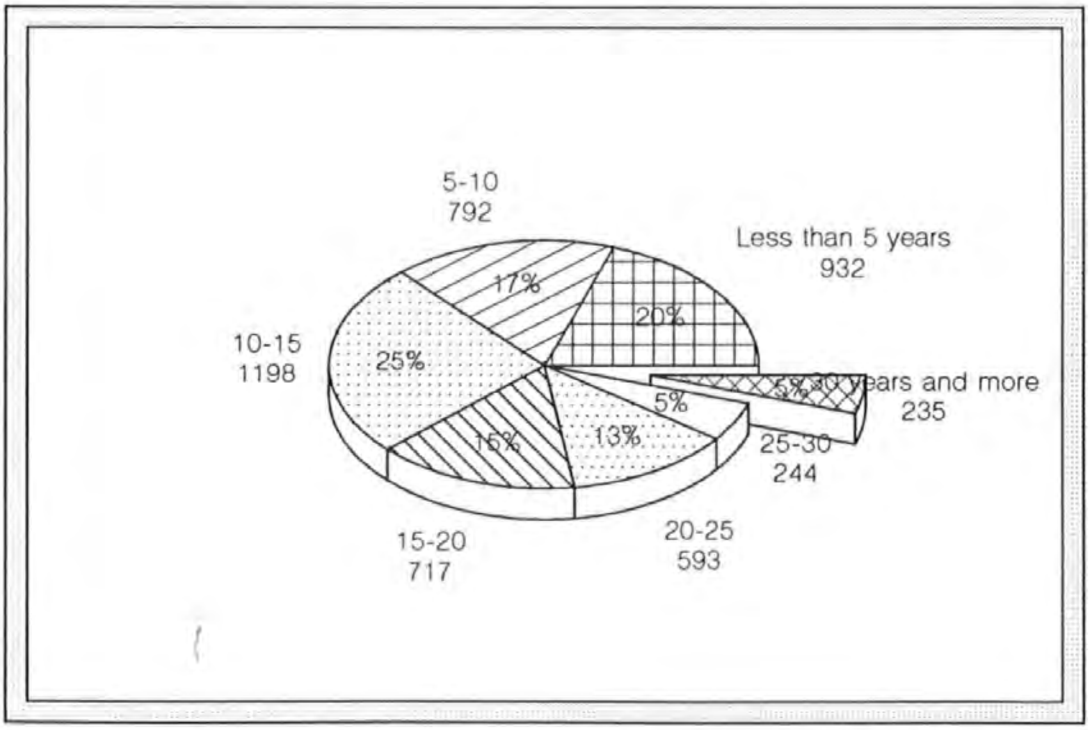
Source: Statistical yearbook (1991), KMPA

Fig 3.1 Trends of vessels registered



Source: Compiled by Author from Statistical Yearbook (1991), KMPA

Fig 3.2 Vessels registered by Age group (No. of ships)



Source: Compiled by Author from Statistical Yearbook (1991), KMPA

<u>(3) Vessels registered by ship's age:</u> Table 3.3 and Figure 3.2 show that 235 ships (5%) are over 30 years old vessel and 932 ships (20%) are new vessels (less than 5 years old). They, however, account for 0.4 percent and 33 percent respectively in terms of tonnage.

Table 3.3 Vessels registered by Ship's age - December 1990

Tonnage group	0 - 5 years	5 - 10 years	10 - 15 years	15 - 20 years	20 - 25 years	25 - 30 years	over 30 years	Total
- 99	782 15112	647 11909	954 20392	483 10800	441 11499	177 5012	196 4943	3680 79667
100- 499	54 11052	54 14000	125 28924	99 19383	79 17252	26 7390	28 5628	465 103629
500- 999	22 18779	19 14482	20 15000	24 19045	24 17774	18 14758	9 6104	136 105942
1000- 1999	16 26423	17 27383	23 36838	16 22648	9 14344	15 25533	1 1981	97 155150
2000- 4999	21 83616	17 58789	28 104060	42 142853	21 68770	6 17113	0 0	135 475201
5000- 9999	1 5645	3 25888	2 19537	9 62490	7 52787	0 0	0 0	22 166347
10000- 19999	0 0	9 138388	38 557426	27 406990	5 79552	1 12771	1 12644	81 1207771
20000- 49999	21 711039	22 650463	7 208073	10 344935	2 44762	1 24558	0 0	63 1983830
50000-	15 1469573	4 362405	1 64863	7 622232	5 318012	0 0	0 0	32 2837085
Total	932 2341239	792 1303707	1198 1055113	717 1651376	593 624752	244 107135	235 31300	4711 7114622

Source: Statistical yearbook (1991), KMPA

<u>(4) Vessel statistics of world fleet:</u> Table 3.4 shows that Korean shipping industry grew rapidly until the early of 1980s (1981), about 16 percent per annum in number of ships and about 35 percent in tonnage, while the growth of world merchant fleets was 3 percent and 6 percent respectively. Thereafter, however, the growth rate decreases to 3 percent per annum in number of ships and 5 percent in tonnage, while the world rates were 0.8 percent and 0.4 percent respectively in the same period.

Table 3.4 Korean Merchant fleets 1972-1991

	Korea		World	
	No.	GRT	No.	GRT
1972	446	1,057,408	57,391	268,340,145
1973	617	1,103,925	59,606	289,926,686
1974	650	1,225,679	61,194	311,322,626
1975	828	1,623,532	63,724	342,162,363
1976	936	1,796,106	65,887	371,999,926
1977	1,042	2,494,724	67,945	393,678,369
1978	1,148	2,975,389	69,020	406,001,979
1979	1,287	3,952,946	71,129	413,021,426
1980	1,426	4,334,114	73,832	419,910,651
1981	1,634	5,141,505	73,864	420,834,813
1982	1,652	5,529,398	75,161	424,741,682
1983	1,733	6,386,002	76,106	422,590,317
1984	1,799	6,771,402	76,068	418,682,442
1985	1,847	7,168,940	76,395	416,268,534
1986	1,837	7,183,617	75,266	404,910,267
1987	1,899	7,214,070	75,240	403,498,122
1988	1,930	7,333,704	75,680	403,406,079
1989	1,974	7,832,453	76,100	410,480,693
1990	2,110	7,783,075	78,336	423,627,198
1991	2,136	7,820,532	80,030	436,026,858

Source: *(1) Statistical yearbook*
(2) Lloyd's register of shipping

Table 3.5 Ship's age of merchant fleet (number of ships)

	Total	over 20 years	less than 5 years
Korean fleet	2,422	811 (33.5%)	374 (15.4%)
World fleet	80,030	28,748 (35.9%)	8,718 (10.9%)

Source: *(1) Statistical yearbook*
(2) Lloyd's register of shipping

Comparing ship's age overall the Korean fleet is younger than world average, but 811 ships out of 2,422 ships are over 20 years old (Table 3.5 & 3.6).

Table 3.6 Size and age of all steamships and motorships

Tonnage Group	0 - 4 years		5 - 9 years		10 - 14 years		15 - 19 years		20 - 24 years		25 - 29 years		30 years & over		T o t a l	
	No.	GRT	No.	GRT	No.	GRT	No.	GRT	No.	GRT	No.	GRT	No.	GRT	No.	GRT
100- 499	4,666	1,277,266	5,296	1,360,136	7,588	1,787,036	6,874	1,715,716	6,267	1,495,631	4,051	980,243	6,992	1,753,951	41,734	10,369,979
500- 999	799	574,336	1,159	874,889	1,447	1,107,649	1,500	1,149,530	1,228	924,211	727	544,650	1,240	886,794	8,100	6,062,059
1,000- 1,999	514	797,456	1,129	1,706,649	1,048	1,538,208	1,107	1,634,420	1,059	1,557,808	620	909,633	592	827,411	6,069	8,971,585
2,000- 3,999	686	1,981,266	1,032	3,104,031	1,217	3,671,308	1,151	3,439,148	1,154	3,270,281	582	1,686,809	409	1,223,828	6,231	18,376,671
4,000- 5,999	392	1,890,218	609	2,968,875	545	2,703,197	596	2,949,544	431	2,132,482	185	896,829	142	684,463	2,900	14,225,608
6,000- 6,999	113	723,940	145	944,943	178	1,148,255	196	1,922,907	109	696,449	46	297,188	41	265,715	928	5,999,397
7,000- 7,999	107	814,406	117	878,803	126	947,926	116	861,275	80	598,244	34	254,545	122	925,424	702	5,280,623
8,000- 9,999	108	972,121	237	2,135,286	460	4,228,651	459	4,234,146	479	4,380,304	149	1,354,831	130	1,170,487	2,022	18,475,826
10,000- 19,999	378	5,598,581	1,071	15,856,237	1,568	22,136,833	1,364	19,937,278	825	11,305,720	270	3,655,298	228	3,143,991	5,704	81,633,938
20,000- 49,999	631	20,936,035	1,382	41,259,108	835	25,824,593	706	22,253,781	293	9,121,481	108	3,046,983	54	1,374,777	4,009	123,816,758
50,000 & above	324	27,251,452	232	18,126,326	280	24,572,500	694	65,670,157	98	7,004,631	2	113,299	1	76,049	1,631	142,814,414
T O T A L	8,718	62,817,077	12,049	89,215,283	15,292	89,666,156	14,863	125,767,902	12,023	42,487,242	6,774	13,740,308	9,951	12,332,890	80,030	436,026,858

Source: Statistical yearbook, KMPA
Lloyd´s register of shipping

3.2 MOVEMENT OF VESSELS

3.2.1 TOTAL MOVEMENT IN PORTS

Table 3.7 and Figure 3.3 show that total vessel movements in Korean ports are increasing continuously by 4.6 percent per annum in number of ships and 13.5 percent per annum in terms of gross tonnage.

Table 3.7 Total vessel movement (arrival+departure)

(GRT: 1,000 tons)

Year	Grand total		Oceangoing				Coastal	
			Korean		Foreign			
	No.	GRT	No.	GRT	No.	GRT	No.	GRT
1981	193036	305344	27649	78541	12473	163113	152914	63690
1982	200242	344639	26940	99116	12734	176837	160568	68686
1983	206499	390267	26094	99821	13487	208556	166918	81890
1984	211679	415923	25631	104876	14054	225065	171994	85982
1985	217043	453857	25008	115990	15411	243056	176624	94811
1986	246626	508039	25444	120268	18602	285679	202580	102092
1987	245669	587949	25249	131952	21784	346738	198636	109259
1988	265526	632696	24873	138460	24385	368557	216268	125679
1989	273325	667007	25009	143430	28248	383475	219968	140102
1990	281355	716329	24006	164387	30923	393040	226426	158902

Source: Statistical yearbook (1991), KMPA

Table 3.8 shows the number of vessels and their gross ton entering ports by tonnage group. In terms of ship numbers, the 500-2,999 ton category has the highest incidence (9,693 ships), while the 20,000 and above category has the highest gross tonnage, being 173,617,648 tons for the ocean-going ships. In the case of coastal ships, however, the less than 100 ton category has the highest incidence of 50,781 ships, followed by the 100-499 ton category with 32,236 ships.

Ships of less than 3,000 grt amount to 85.4 percent of total traffic, however the percentage should be much greater taking into account fishing vessels' movements. Thus it can be said that coastal and small ocean-going ships are the main components of the coastal traffic in Korean waters.

Table 3.8 Vessel arrivals by tonnage group (1990)

Tonnage group	Total		Oceangoing		Coastal	
	No.	GRT	No.	GRT	No.	GRT
- 99	51621	2489530	840	34558	50781	2454972
100- 499	35572	12078107	3336	1256223	32236	10821884
500- 2999	32110	41327396	9693	14344234	22417	26983162
3000- 4999	8371	34268416	3418	14076591	4953	20191825
5000- 6999	1896	12836407	1452	10193752	444	2642655
7000- 9999	1900	18119913	1514	13967816	386	4152097
10000-19999	4180	60797055	3507	51513563	673	9283492
20000-	4075	176204380	4007	173617648	68	2586732
Total	139725	358121204	27767	279004385	111958	79116819

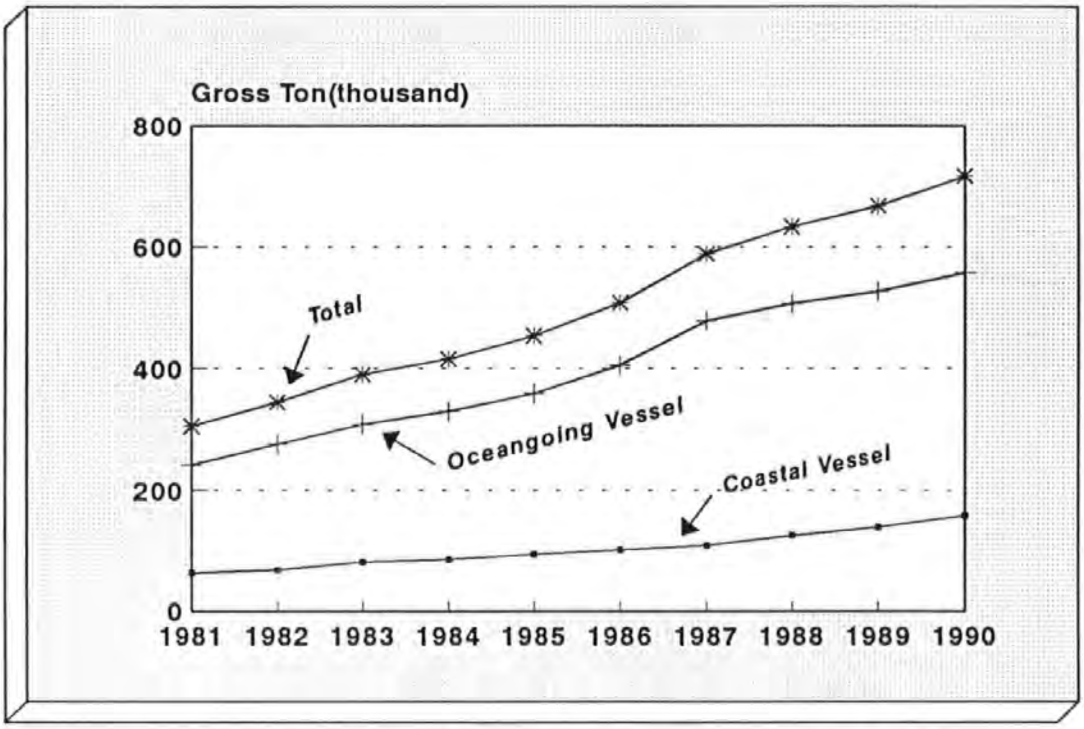
Source: Statistical yearbook (1991)

3.2.2 MONTHLY VESSEL MOVEMENT

Figure 3.4 indicates the seasonal variations in traffic for the period of five years (1986-90). In general there is less traffic in January(-10.4%) and February(-19.2%), more traffic in May(+6.5%), September(+3.2%), October(+6.5%), November(+5.8%) and December (+5.5%) with peak values in May and October. Oceangoing ships show less fluctuation than coastal vessels, peak value on December(+9.6%) and the lowest value on January(-11.7%). Coastal vessels, however, show peak values in May(+6.9%) and October(+6.8%) and the minimum value in February(-21%).

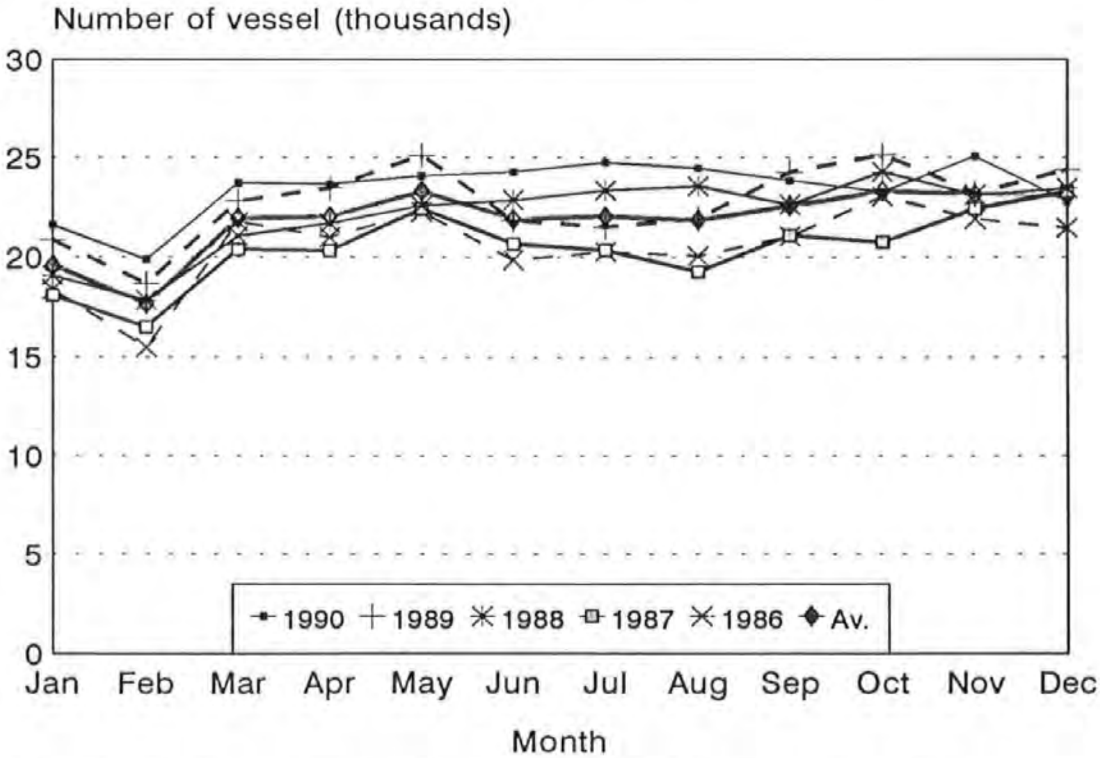
These can probably be explained by the financial year system (January 1 -

Fig 3.3 Vessel movement by gross ton



Source: Compiled by Author from Statistical yearbook, KMPA

Fig 3.4 Monthly vessel movement



Source: Compiled by Author from Statistical yearbook, KMPA

December 31), more export/import cargo rush into the last month of December but less cargo in January. Also there are less days in February and the long New Year(lunar) holiday (approximately one week long in most industries) in February.

3.2.3 FISHING VESSEL ACTIVITY

Since a considerable volume of marine traffic consists of fishing vessels in Korean waters, it is necessary to consider fishing vessel activity. COST 301 noted that:[3-2]

> As fishing vessels constitute more than half the traffic at certain times in some areas it was considered important that it should be taken into account both for its own sake and for the hazards created by fishing operations.

However, it is difficult to obtain data on fishing vessel traffic since fishing activities depend significantly on the location of fishing grounds. Possible ways to develop quantitative data or a general applicable model on fishing vessel movements are as follows.[3-2]

- Estimation of fishing vessel flows near port areas (departures and arrivals) may be possible by analysis of landed catches, and composition of vessel fleets.

- The provision of keeping log books for data collection of catches on fishing vessels could probably, at least in the future, open one way to estimate the number of fishing vessel movements at sea based on average data of catch per fishing effort.

However, such research will need an extensive local data collection combined with seasonal traffic counts for calibration process, and the log books are not yet fully adopted for operational purposes in Korea. This section describes general statistics of the Korean fishing fleet.

(1) Fishing fleet by tonnage group: Table 3.9 shows that total number of fishing vessels has been increased slightly; average rate of 2.7 percent per annum for the period of 1980-89. The number of ships under 5 gross tons account for 87 percent of the total fishing

fleet and 100 ton and over category account for 1.4 percent only.

Table 3.9 Fishing fleet by tonnage group

Year	Total	under 1 ton	1-5 ton	5-10 ton	1-20 ton	2-30 ton	3-50 ton	5-100 ton	1-200 ton	over 200
1980	77574	23314	42839	3507	3040	817	1220	1805	450	582
1981	80500	24743	44421	3491	2944	871	1166	1832	448	584
1982	86515	25092	50150	3610	2772	863	1084	1852	488	604
1983	88594	26139	51006	3672	2727	929	1044	1921	552	604
1984	90463	26666	52036	3804	2663	992	1056	2061	565	620
1985	90970	27603	52001	3599	2470	987	1025	2088	569	628
1986	93037	28525	52823	3745	2489	1029	1107	2085	587	648
1987	94153	29242	52916	3929	2492	1045	1150	2083	607	691
1988	99024	33252	53354	4230	2499	1080	1210	2046	613	740
1989	98455	33440	52816	4314	2329	1026	1186	1953	618	773

Source: Statistical yearbook of fisheries (1984)(1990)

(2) Fishing fleet by the type of construction material and age group:

Table 3.10 Number of fishing boats by the type of construction material and age group

	Total	under 5 years	6-10 years	11-15 years	16-20 years	over 21 years
Total	98455	28899	24654	29641	10674	4587
Wooden Non-power	19757	3838	6377	5922	2817	805
Power boat	69347	19591	16912	22636	7434	2774
Sub-total	89106	23429	23289	28558	10251	3579
Steel Power boat	4006	938	699	988	381	1000
F.R.P. Non-power	402	303	93	4	2	0
Power boat	4941	4229	573	91	40	8
Sub-total	5343	4532	666	95	42	8

Source: Statistical yearbook of fisheries (1990)

As can be seen in Table 3.10 and Figure 3.5, wooden boats account for 90 percent of the total number of fishing vessels, steel ships account for four percent only and non-power boats account for 20 percent of total fleet.

(3) Fishing fleet by type of fishing: Table 3.11 shows the number of fishing vessels and their tonnage by the type of fishing. Coastal and off-shore fisheries which have direct influence to coastal traffic involve the greatest number of vessels(58%) and tonnage(46%).

Table 3.11 Fishing fleet by type of fishing (1989)

Type of fishing	Total		Power vessel		Non-power vessel	
	No.	GRT	No.	GRT	No.	GRT
Distant water fisheries	799	434,429	799	434,429	-	-
Coastal/off-shore fisheries	56,966	447,366	48,272	434,585	8,694	12,781
Culture fisheries	37,418	45,587	27,611	37,080	9,807	8,507
Inland water fisheries	2,955	2,507	1,303	1,609	1,652	898
Others	317	33,342	309	33,334	8	8
Total	98,455	963,231	78,294	941,037	20,161	22,194

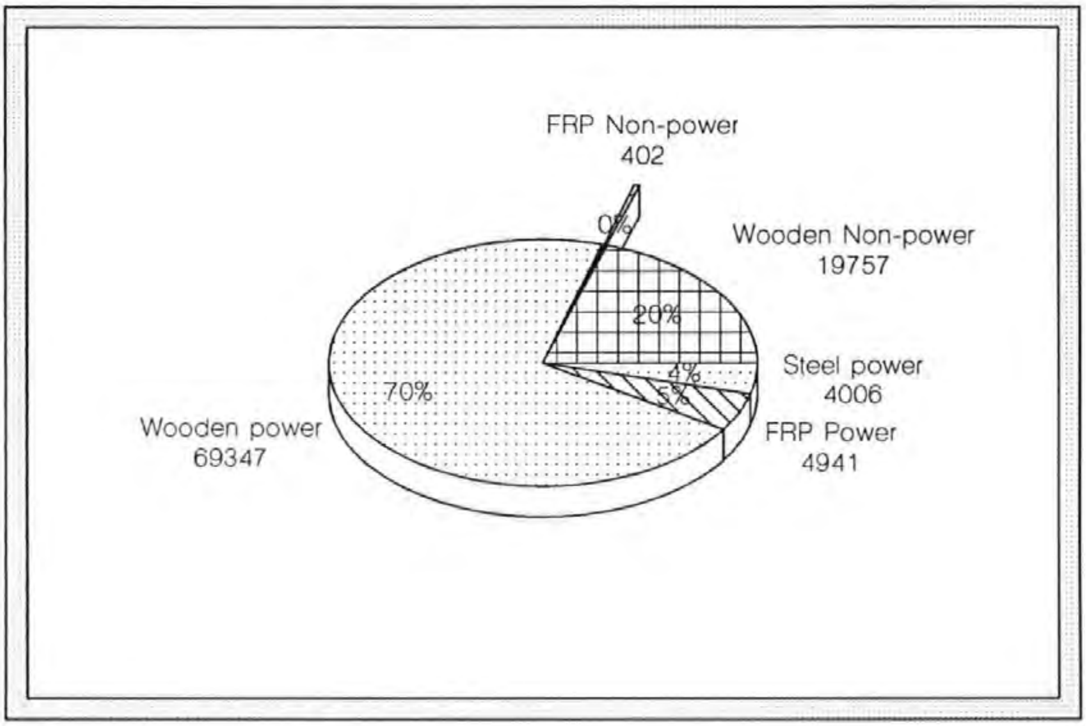
Source: Statistical yearbook of fisheries (1990)

3.3 SEA-BORNE CARGO TRAFFIC

3.3.1 TOTAL CARGO TRAFFIC

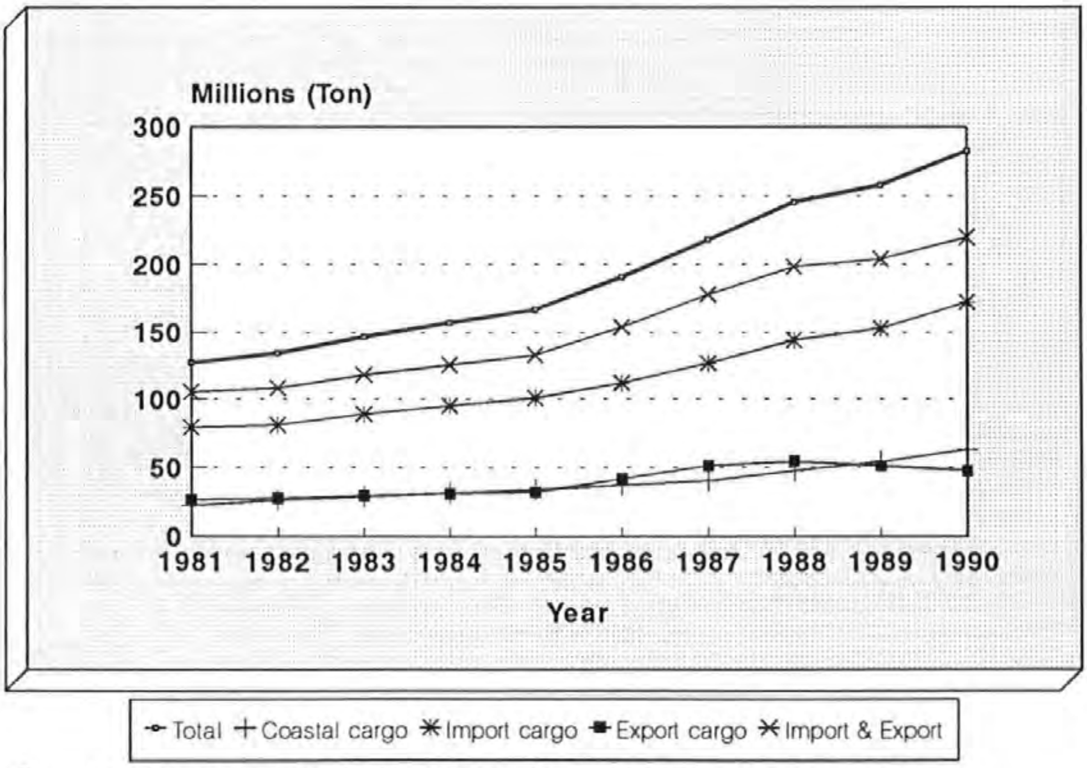
Cargo movement is an important measure of the volume of marine traffic. This section describes the cargo movements in ports in Korea.

Fig 3.5 Fishing fleet by Construction material



Source: Compiled by Author from Statistical yearbook of fisheries

Fig 3.6 Total cargo traffic



Source: Compiled by Author from Statistical yearbook, KMPA

Figure 3.6 show that total cargo traffic has been increasing continuously. For the period 1981-90 the average annual rate of increase has been 12 percent, while during the same period coastal traffic has experienced an annual increase of nearly 19 percent.

3.3.2 MONTHLY CARGO TRAFFIC

The monthly cargo movements for 5 years are summarised on Table 3.12. The figures indicate the mean monthly level of cargo traffic during five years(1986-90). The peak value of cargo traffic was in December and the lowest value in February.

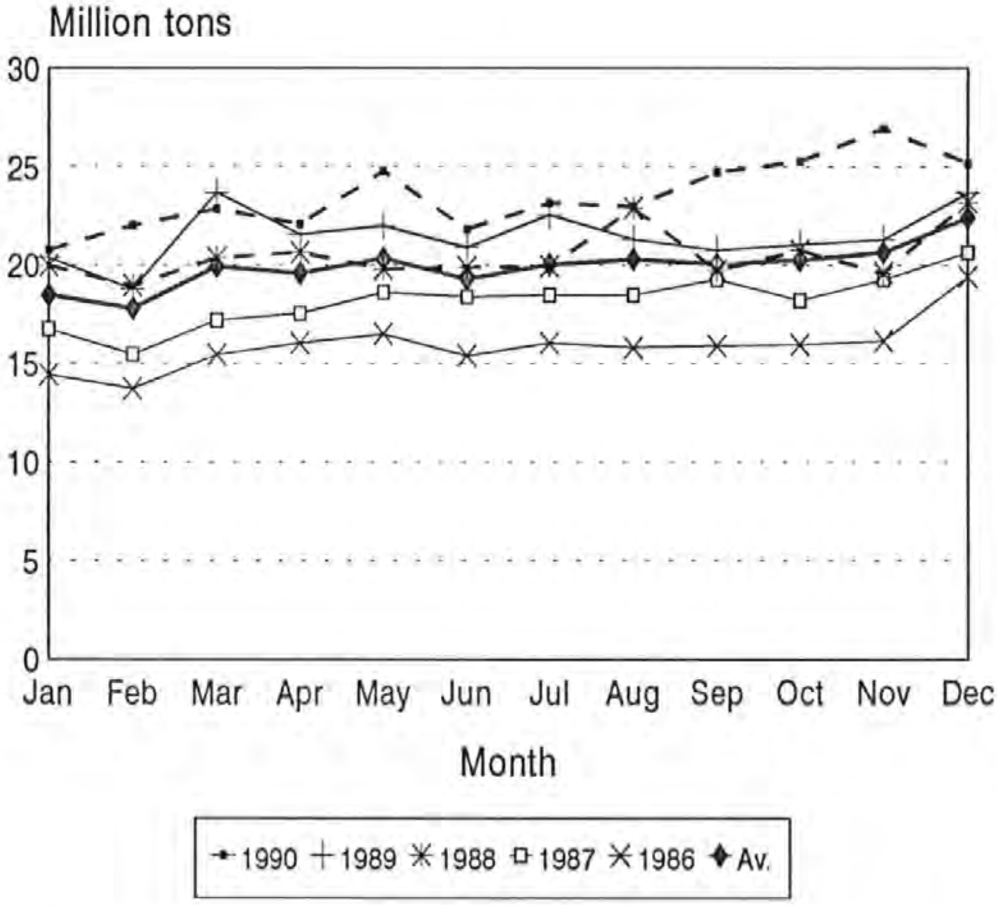
Table 3.12 Monthly cargo traffic (1986-1990) (unit: thousands ton)

Month	Foreign trade	Coastal trade	Total
January	14,808	3,646	18,454
February	14,365	3,417	17,782
March	15,917	3,993	19,190
April	15,574	4,005	19,579
May	16,322	4,015	20,337
June	15,374	3,905	19,279
July	16,164	3,866	20,030
August	16,335	3,957	20,292
September	16,206	3,866	20,072
October	15,788	4,456	20,244
November	16,288	4,361	20,649
December	17,658	4,767	22,425
Average	15,900	4,021	19,921

Source: Statistical yearbook (1987) - (1991), KMPA

Fig 3.7 shows graphically monthly cargo traffic figure for the same period. It indicate no significant seasonal variations, although there is less cargo traffic in January and February and peak value on December. This may be explained by the same reason in section 3.2.2.

Fig 3.7 Monthly cargo movement



Source: Compiled by Author from Statistical yearbook, KMPA

3.4 SUMMARY

(1) The register of Korean ships other than fishing vessels has grown slowly but continuously; average rate of 2 percent in numbers and 4.3 percent per annum in terms of tonnage.

(2) Total vessel movements in Korean ports are increasing significantly by 4.6 percent in number of ships and 13.5 percent per annum in terms of tonnage. Coastal and small size of ocean-going ships are the main components of the coastal traffic in Korean waters.

(3) Total number of fishing vessels has been increased slightly and the number of ships under five gross ton accounts for 87 percent of total fishing fleet. Coastal and off-shore fisheries which have direct influence on coastal traffic has the highest number of ships.

(4) Total cargo traffic has been increased continuously with an average annual rate of 12 percent for the period 1981-89, while coastal traffic has experienced annual increase of nearly 19 percent.

(5) There are no significant seasonal variations of cargo traffic.

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Chapter 4

SHIP CASUALTIES

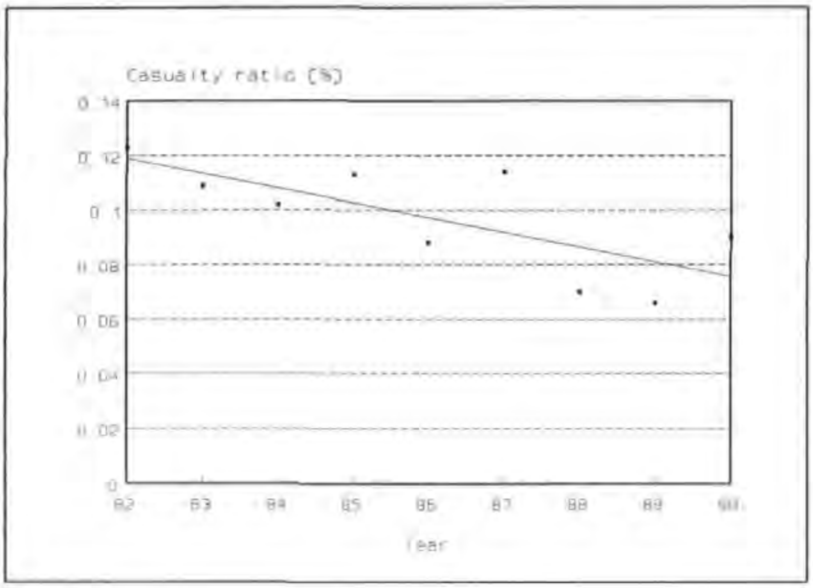
4.1 INTRODUCTION AND GENERAL TRENDS OF CASUALTIES

A systematic investigation of marine accidents in Korean waters began in the Marine Accidents Inquiry Agencies under the Marine Accidents Inquiry Act from 1971. The purpose of the Act is to clarify the causes of marine accidents through an inquiry of the Agencies, and to contribute thereby to the prevention of further occurrence of marine accidents. [4-1]

This chapter is a comprehensive examination of cause relationships of casualty data for the years 1986-1990. As part of the approach a statistical analysis of casualty has been carried out, but further consideration has been given to find out more about the cause relationships associated with ship casualties. The main emphasis of this chapter is placed on the quantification of effect level of causal factors related to the casualties, and also the identification of main contributory factors in different type of casualties and in different sub-areas.

The casualty ratio excluding fishing vessels shows decreasing trends as can be seen from Figure 4.1. The number of ships, however, involved in casualties are increasing whereas they are decreasing in many other countries (see pages 198-99).

Fig 4.1 Trends of marine casualties (1982-1990)



Note:
Casualty ratio = Number of ships involved in casualties ÷ No. of vessel movements

Source: Author compiled from Statistical Yearbooks, KMPA and Written Verdicts, MAIA

Table 4.1 shows that fishing vessels account for approximately 62 percent and cargo ships account for about 17 percent of the total casualties, while tankers account for five percent and passenger/ferries for about three percent.

Table 4.1 Number of ships involved in casualties by the type of vessel

Type	1986	1987	1988	1989	1990	Total	Ratio
Passenger	23	28	11	16	20	98	3.3
Cargo	98	118	81	103	113	512	17.4
Tanker	24	30	29	23	46	152	5.2
Fishing	296	378	357	405	397	1,833	62.2
Tugs	16	31	24	17	31	119	4.0
Others	56	72	41	22	42	233	7.9
Total	512	657	543	586	649	2,947	100 %

Source: Written Verdicts(1990). Seoul

Table 4.2 summarizes the number of casualties by types of incident. It is recognized that collision, stranding/grounding and foundering accidents account for approximately 50 percent of total casualties, and machinery damage accounts for 28 percent of casualties.

Table 4.2 Number of casualties by Type of incident

Type	1986	1987	1988	1989	1990	Total	Ratio
Collision	99	133	93	108	132	565	23.6
Stranding	71	92	56	51	56	326	13.6
Foundering	56	70	57	61	47	291	12.2
Machinery damage	96	125	141	159	160	681	28.4
Flooding	31	43	26	34	28	162	6.8
Fire	23	21	26	37	39	146	6.1
Death and injuries	17	11	12	11	13	64	2.7
Others	36	38	27	18	40	159	6.6
Total	429	533	438	479	515	2,394	100 %

Source: Written Verdicts (1990). Seoul

Table 4.3 Number of casualties by Time band

Time band	1986	1987	1988	1989	1990	Total	Ratio
0000-0400	81	85	74	91	81	412	17.2
0400-0800	68	102	83	75	96	424	17.7
0800-1200	61	96	74	79	93	403	16.8
1200-1600	67	82	72	86	83	390	16.3
1600-2000	81	84	73	87	93	418	17.5
2000-2400	63	71	57	60	66	317	13.2
Unknown	8	13	5	1	3	30	1.3
Total	429	533	438	479	515	2,394	100 %

Source: Written Verdicts (1990). Seoul

Table 4.3 presents the number of casualties by time band. Under chi-squared goodness of fit test the observed number of casualties in different time band is significantly different from a uniform distribution of casualties every time band, at the five percent level with five degrees of freedom; but the number of casualties occurring during first five time bands were found to be not significantly different to a uniform distribution, again at five percent level but for four degrees of freedom. It seems reasonable to conclude that the occurrence of casualties is significantly less during 2000-2400 hours time band.

Table 4.4 shows the number of casualties by waterway type. Approximately three quarters of all casualties occur in territorial water (with 12 miles off the coast) where shore-based navigational aids may be available. 23.5 percent of casualties were occurred in open sea and international waters.

Table 4.4 Number of casualties by Waterway type

Year	Confined waters	Territorial seas	Open sea	Total
1986	179	164	86	429
1987	294	128	111	533
1988	122	170	146	438
1989	98	211	170	479
1990	216	248	51	515
Total	909	921	564	2,394
Ratio	38.0 %	38.5 %	23.5 %	100%

Note: (1) Confined waters include port/harbour, approaches and narrow channels
(2) Territorial seas: within 12 miles off coast

Source: Author - modified from Written Verdicts (1990)

4.2 CASUALTY DATA BASE

4.2.1 DATA SOURCES

Generally casualty information is available from the following sources:

- Port/Government authorities
- Search and Rescue (SAR) Centre
- Underwriters & P+I Clubs
- Ship owners
- Classification societies
- Cargo operators

The primary source of data in this study is the Written Verdicts produced by the Central Marine Accident Inquiry Agency. Secondary sources are:

- Statistical Yearbook of shipping casualties by Marine Police, Korea
- Lloyd's Register of Shipping Statistical Tables
- Lloyd's Register of Shipping: Lloyd's Register of Ships
- Lloyd's Maritime Directory
- Fairplay's Commercial Shipping Fleets
- Fairplay World Shipping Directory

The Written Verdicts are published annually by the Central Agency and contain details of the casualties that have been examined during the year. The Verdicts give general information about casualties such as:

- ship's particulars
- the development of casualty
- the causes of casualty
- the decisions

Maritime casualties can be divided into two discrete groups according to their elementary causes: traffic accidents and technical accidents as described in section 1.3. For the purpose of this study the focus is concentrated on the accidents that could be influenced by shore-based navigational aids. Casualty data of collisions, strandings, groundings, rammings and founderings are analyzed for the areas concern over a five year period (1986-90).

The circumstances of each casualty are examined to determine the extent of the causal factors in each case.

4.2.2 DATA COLLECTION AND CLASSIFICATION

A good background of the variables that may lead to a casualty is given by Moon & Higgins,[4-2] and many other studies of ship casualties have classified the variables in a similar way.[4-3][4-4][4-5][4-6][4-7][4-8][4-9] This analysis deals with 36 variables of computerised data on casualties which include:

(a) general information: casualty type, year/month/date/time of day and day of week

(b) ship's elements: tonnage, type, length, beam, age, speed, draft, flag, etc.

(c) meteorological conditions: wind, sea, visibility, current, weather, etc.

(d) human elements: manning & watch system, etc.

(e) waterway configurations: waterway type, channel width and depth, etc.

(f) consequences of casualty: number of live lost or injuries, total loss, oil outflow, delays and damage to hull, cargo, machinery.

So far there are very few research results available related to cause relationships of casualties. Quinn & Scott[4-10], DnV[4-11] and Tuovinen[4-12] undertook the research to find out the inter-relationships between the causal factors.

The analysis of cause relationships in this study is based on the registering of causal factors derived from an examination of the Written verdicts and earlier researches. The factors vary between cases and about 80 different causal factors are identified. Therefore it is clear that these factors should be arranged into larger groupings in order to identify the main tendencies indicated by the casualty data. This study uses 12 sub-groups based on 82 causal factors, and these sub-groups cover three main groups. Annex-A illustrates how the mixed population of contributory factors is classified into various groupings with the code number.

The comparison of categorization of causal factors in different studies are made in Table 4.5.

Table 4.5 Comparison of grouping of causal factors

	PARK J S	DnV	QUINN	TUOVINEN
Main Group	3 groups	6 areas	4 dimensions	3 groups
Sub-group	12 sub-groups	21 groups		4 sub-groups
Factors	82 factors	200 factors	27 factors	60 factors

Source: Author- compiled from Annex-A and References [4-10] [4-11] [4-12]

4.2.3 EVALUATION OF CAUSAL FACTORS AND THEIR RELATIONSHIP

Earlier studies indicated clearly that information obtained from conventional statistics cannot provide guidance on detailed casualty analysis. Much more is needed if casualty statistics are to play a proficient and vigorous role in encouraging safety. Specific difficulties originate from making the causal relationships clear.

Symbolic modelling of functional block diagram and fault trees has proved to be an efficient aid in safety analysis [4-13], and fault tree analysis and block diagrams have proved to be useful tools for the evaluation of relationships between different causes of ship casualties[4-14]. These methods are used to indicate the relationships between individual physical factors. They are also used to determine the effects that may be generated by a change in any of the factors or in their inter-relationships. In addition these models permit easy understanding and recognition of the factors leading to individual casualty[4-15].

The block scheme that is presented in Fig 4.2 is used in this study to survey the cause relationships. The block scheme was used by Tuovinen(1983) to evaluate the causes of 471 ship casualties in the Baltic Sea. The grouping of causal factors, however, is not detailed and the list of causal factors does not cover the all possible causes identified in this study. Especially the human element contributory factors are very limited. Consequently the block scheme is enhanced to meet the requirements of this study. The purpose is to trace the sequence of events relevant to the casualty by connecting the appropriate blocks with lines. The block scheme is completed by the researcher on the basis of available information.

Figure 4.2

Sr. No.:
Ship's Name:
Date of Casualty:

CAUSAL FACTORS OF CASUALTY

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ENVIRONMENTAL CONDITIONS

EXTERNAL CONDITIONS

Daylight | Darkness | Twilight | Fog | Rain | Snow | Storm | Heavy Ship Motion | Poor Radar efficiency by Rain/Sea/Snow

WATERWAY CONDITIONS

Narrow Channel | Low water level | Poor/wrong marking of fairway | Faults of Light/Marks | Heavy surrounding Traffic | Small ships in Fairway | Other ship passing too close distance | Other ship on Collision Co. | Strong Current/Tidal streams

WORKING ENVIRONMENTS

Improper Rules (Road, Class....) | Deficiency on charted/ printed information | Other ship manoeuvring against rule | Other ship no-reaction to the critical situation | Other ship's equipment fault | Management pressure

TECHNICAL FAULT and DEFICIENCIES

[BREAKDOWN]

Main Engine | Aug. Engine | Steering | Rudder | Propeller | Radar | Compass | Nav. Light | Other Nav. equipments | Internal communication | External communication

Poor Design | Poor placing of equipment | Poor quality | Poor maintenance and inspection | Poor stowage and securing | Cargo shifting | Electricity blackout | Broken mooring rope | Fracture of ship structure | Lack of equipment

HUMAN FACTORS

HEALTH CONDITION

Sickness/ illness | State of tiredness | State of drunkeness | Stress | Sleepy | Drug | Physical handicap

ORGANIZATION & TRAINING

Improper harbour organization | Improper shipboard organization | Lack of seafaring experience | Lack of professional knowledge | No small correction | Error in voyage planning

IMPROPER SYSTEM INTERFACE

Ship to Office | Ship to Shore | Ship to Ship | Ship to Tug

WATCHKEEPING

No Officer on bridge | Captain left bridge in critical situation | Officer under other job | Misunderstanding of order | Negligence of lookout | Improper reporting/Take-over | Not use every available equipment/aids in the situation

Engineer | Watch officer | Captain | Pilot | Helmsman | Lookout | Captain on watch

CONTROL TASKS

Excessive speed under the circumstance | Not fix position regularly | Negligence in critical situation | Miscalculation of position | Misobservation of Nav. aids | Misobservation of other ship | Sailed on wrong side of fairway | Sailed in unmarked waters

Mis-read radar, compass & etc. | Improper decision | Improper order | Improper manoeuvre | No reaction to the critical situation

NATURE OF CASUALTY

Collision meeting | Collision crossing | Collision overtaking | Collision other | Stranding Grounding | Ramming to dock, lock | Ramming to others | Foundering | Others

CONSEQUENCES OF CASUALTY

Cargo damage ( ) | Engine damage ( ) | Hull damage ( ) | Rudder damage ( ) | Propeller damage ( ) | Fishing net damage( ) | Object damage ( )

Total loss (Y, N) | Oil outflow ( ) ton | Ship delays ( ) days | Live lost ( ) p | Injuries ( ) p

It is often assumed that an accident is caused by one definite factor, and if this factor could have been eliminated the undesired event would not have occurred. Although this position might be defensible in some rare cases, it oversimplifies the problem. In general a casualty is the result of several causes, or more correctly a chain of events. Using the block scheme described above the systematic tracing of the relevant sequence of events is possible. This combination of elements is then used for classification of individual factors in each casualty.

4.2.4 CODING AND PROCESSING

The large amount of information collected can be managed, described and analyzed most effectively on a computer. The casualty information is coded and a data file created. These data are then analyzed using the "Statistical Package for Social Science (SPSS)"[4-16] which has been found to be very suitable for this purpose. The data sheet of Annex-B, "Casualty card", has been used to input data into computer. The card corresponds to each variable described in section 4.2.2.

4.3 THE ANALYSIS OF MARINE CASUALTIES

4.3.1 SAMPLE ATTRIBUTES

The population of this study consists of all the collision, grounding, ramming and foundering accidents which have taken place in Korean waters during the period of 1986-1990. The primary source, the written verdicts, of data base in this study contains some of the cases that have been examined during each year, but not all the cases are published. Therefore it has not been possible to collect relevant information on the entire population, and the collected data base is a part of the population. The primary source of data base consists of:

Part I: accident inquiry reports and suit cases - taken as sample in this study,

Part II: list of accidents - population.

The part II gives only the ship's name, type of casualty, year/month/date/time of accident and the location. The additional information including ship type, tonnage, flag, waterway type were acquired by secondary sources.

In order to use the sample in making inferences about the population, the sample should be representative. This feature is guaranteed only in a probability or random sample. In United Kingdom the term random sample means "a sample drawn so that every member of the population had a non-zero chance of selection" whereas in U.S.A. this is termed a "probability sample".[4-17]

The sample comprises 381 ship-casualties, and Table 4.6 details the data obtained including the number of ship-casualties by the casualty type, by sub-area and the annual number of ships in casualties.

The fit was tested by means of "goodness of fit test" with a five percent significance level. In this case the null hypothesis H_0 would be that the sample used in this study are in approximately the same proportions as in the population from which they were taken. Under the test, the sample by casualty type is significantly different to that assuming same proportions as in the population. The discrepancies are mainly because the number of collisions in the sample is over-representative while the number of founderings is under-representative. There also are significant difference between the sample and population by year. The differences are because the number of sample in 1987 is under-representative but the number in 1988 is over-representative.

Table 4.6 Total number of ship-casualties *versus* samples

Sub-area		Total number	Sample
East	(Sub-area 1 & 2)	116	54
South-east	(Sub-area 3 & 4)	225	81
South	(Sub-area 5 & 6)	222	89
South-west	(Sub-area 7 & 8)	301	91
West	(Sub-area 9 & 10)	169	66
Total		1.033	381

Type of casualty	Total number	Sample
Collision	578	242
Grounding	249	81
Ramming	48	23
Foundering	158	35
Total	1,033	381

Year	Total number	Sample
1986	194	64
1987	252	74
1988	186	92
1989	176	67
1990	225	84
Total	1,033	381

Source: Author

Under a Chi-squared goodness of fit test. however, the sample by sub-area is not significantly different to the population at the five percent level with four degrees of freedom. though the number of accidents in south-west coast is under-representative whereas the number of accidents in east coast is over-representative. The conclusion therefore is that the sample used in this study does seem to include, in approximately the same proportions as in the population by sub-area. but does not seem to include the same proportions by casualty type and in terms of year.

However. the discrepancies between the sample and total population are beyond our control, because the sample has been determined by those responsible for producing the "Written verdicts" from which the data come. Furthermore the discrepancies are not of major significance because what this study is concerned with is establishing causality of marine accidents.

4.3.2 SAMPLE DISTRIBUTION

The use of the observed past frequency of marine casualties in prediction of the future frequency necessitates the development of a statistical model which fits the past data. Assuming that the model will continue to apply in the future the proper prediction can be made with some degree of confidence. For marine casualties, which are isolated events occurring in a continuum of time, it might reasonably be expected that the model most likely to describe their frequency of occurrence would be the Poisson distribution or a distribution derived from it.[4-18] Tuovinen[4-19] found the Poisson distribution is an adequate model for this purpose.

The basic condition for such a distribution is that events should be random in nature. In the context of marine casualties this means that the expected accident rate should be constant for every day in the year or every hour in the day depending on the chosen time base. Clearly this is unlikely in view of changes in identified variables such as: weather and traffic density. These variables can be allowed for by means of a modification known as the negative binomial distribution, sometimes referred to as the Pascal distribution after the French mathematician Blaise Pascal(1623-1662).

The negative binomial distribution has two parameters w and p where $p+q=1$, affording greater flexibility. If the average number of accidents per day is E(x) and the variance is V(x), then the mean of distribution is wq/p and the variance is wq/p^2. The probability of having x accidents in a day is given by the formula[4-20]

$$I(x) = \binom{x+w-1}{x} p^w q^x, \qquad 0 \leq x < \infty$$

Grimes[4-18] said that the negative binomial model produces a closer fit to the observed distribution than the Poisson and the "goodness of the fit" was confirmed by means of a χ^2 test. Cockcroft[4-21] has supported this point in his study 'Statistics of ship collisions'. Goodwin and Kemp[4-22] also pointed out that;

> If one considers the frequency distribution of the number of sea collisions per month over a recent 20-year period it may be shown that the Poisson distribution does not provide a good model because factors affecting collisions such as visibility do not remain constant from month to month. In fact the best model is given by the negative binomial distribution when the probability of success, or mean level of success, is not constant from trial to trial. The negative binomial distribution has been found to apply to the distribution of road accidents and air accidents together with marine casualties.

Table 4.7 shows the observed distribution of casualties in this study during the period of 1986-90 with the expected distributions produced by both Poisson and negative binomial models. In each case the number of days totals 1826 which includes the one leap year day. Clearly the negative binomial model presents a closer fit to the observed distribution than the Poisson. The fit was tested by means of χ^2 test with five percent significance level. If we let O_i be the frequency in the ith cell of the observed distribution and E_i of the expected distribution, then the test statistic is given by

$$\chi^2 = \sum_i \frac{[O_i - E_i]^2}{E_i}$$

In this case, the null hypothesis H_o would be that the sample distribution fits to negative binomial model. Under the null hypothesis our test value of χ^2 is 3.935 and the $\chi^2_{4,5\%}$ value is 9.488. So the null hypothesis is accepted. The conclusion therefore is that negative binomial distribution is an adequate model to be used in investigating marine accident frequencies.

The Poisson model fails mainly through its inability to fit at the upper end of the distribution, i.e. those few days when a large number of accidents occur. These could be the days when weather or traffic conditions are adverse to marine safety, and they are the days which the Poisson model can not allow for because of its basic requirement for constant expectation.[4-18]

The bottom row of Table 4.7 presents the negative binomial probabilities corresponding to the above distribution. Accordingly there is a 71 percent chance on any day that there will be no accident of collision, grounding, ramming & foundering anywhere in Korean waters. And there is a 22 percent chance that there will be one accident, a six percent chance of two accidents, 1.4 percent chance of three accidents and so on.

Table 4.7 Distribution of accidents in Korean waters

Number of accidents per day	0	1	2	3	4	5	6	7
Observed frequency (days)	1284	416	94	22	8	1	0	1
Poisson frequency (days)	1234	484	95	12	1	0	0	0
(Probability)	.676	.265	.052	.0067	.0007	.0001	.0000	.0000
Neg. binomial frequency (days)	1293	396	104	26	6	1	0	0
(probability)	.7083	.2166	.0567	.014	.0034	.0008	.0002	.0000

Source: Author

4.3.3 BREAKDOWN OF DATA

Casualty frequency for Korean ships for the period of 1986-90 is based on the mean number of registered ships and the number of casualties per annum. This is consistent with the technique adopted by the Det norske Veritas'(DnV) study[4-23]. It is evident from the Table 4.8 that, in common with the DnV study, the casualty frequency for ships below 100 ton gross is surprisingly low. This is probably due to inadequate reporting of casualties and longer port stay for this group. Smaller vessels operating in shallow waters out of shipping lanes may beach & recover easily and not be reported. This table also shows that the casualty rate is relatively constant but high for the tonnage group ranging between 500 and 4,999 ton gross. The casualty rate for ships above 5,000 ton gross shows a less frequency, lying at an average of 14.6 percent. This reduction can be prescribed to the fact that the latter mentioned group trades in foreign waters & open sea and is thus less exposed to the more difficult coastal waters. However the casualty frequency of Korean ships for above 500 tons is as much as 2.5 times of Norwegian figure even though the frequency for below 500 grt is nearly same as the frequency of Norwegian vessels.

Table 4.8 Mean casualty frequency based on number of registered (1986 - 1990)

Tonnage group (gross ton)	Number of registered vessels (B)	Number of casualties per annum (A)	Casualty frequency (A/B)
up to 19	2,310	12	0.5%
20 - 99	1,370	31	2.3%
100 - 499	465	46	9.9%
500 - 999	136	31	22.8%
1,000 - 4,999	232	43	18.5%
5,000 & over	198	29	14.6%
Total	4,711	192	4.1%

Source: Author - modified from Written Verdicts

However the casualty frequency based on vessel traffic is more analytic index than the frequency based on the number of registered vessels. The only available traffic data in Korean waters is the statistics of vessel movements. Table 4.9 shows the frequency based on the mean number of movement in ports and the mean number of casualties for the same period (1986-90). This table demonstrates different facts to the figure based on the mean number of registered vessel. The bigger size vessels have more casualty frequency than smaller ships.

Table 4.9 Mean casualty frequency based on number of movements (1986 - 1990)

Tonnage group (gross ton)	Number of movements in ports (B)	Number of casualties per annum (A)	Casualty frequency per 1,000 movements (A/B)
up to 100	99,020	43	0.43
100 - 499	65,845	46	0.70
500 - 4,999	74,977	74	0.99
5,000 & over	21,517	29	1.35
Total	261,359	192	0.73

Source: Author - modified from Written Verdicts & Statistical yearbook

4.3.4 TYPE OF CASUALTIES AND THEIR LOCAL AND SEASONAL DISTRIBUTIONS

The following definitions are used for defining a casualty of this study in this chapter. Same definitions are used in Lloyd's casualty information system[4-24].

(1) Collision striking or being struck by another vessel, regardless of whether underway, anchored or moored. This category does not include striking under water wrecks. Three different types of collision (meeting, crossing and overtaking) are distinguished as practicable.

(2) Stranding includes ships reported touching sea bottom, grounding, bumping over bars and entanglement on under water wrecks.

(3) Ramming striking or being struck by an external substances not being another ship or the sea bottom. This category includes striking dock, lock, buoy, breakwater, platforms/drilling rigs and fixed shore nets.

(4) Foundering includes ships which have sunk as a result of heavy weather, springing of leaks, list, breaking in two, etc., but not as a consequence of collision, stranding or ramming.

The following criteria are used for defining a waterway type in this study:

(1) Port/Harbour is a place in the port/harbour limit.

(2) Port approaches: there is no internationally recognized criteria defined. Port approaches, however, in this study is within approximately five miles from the port entrance.

(3) Coastal waters means territorial seas (12 miles off the coast).

(4) Sound/Passage is a place in the channel, passage, fairway and traffic lane.

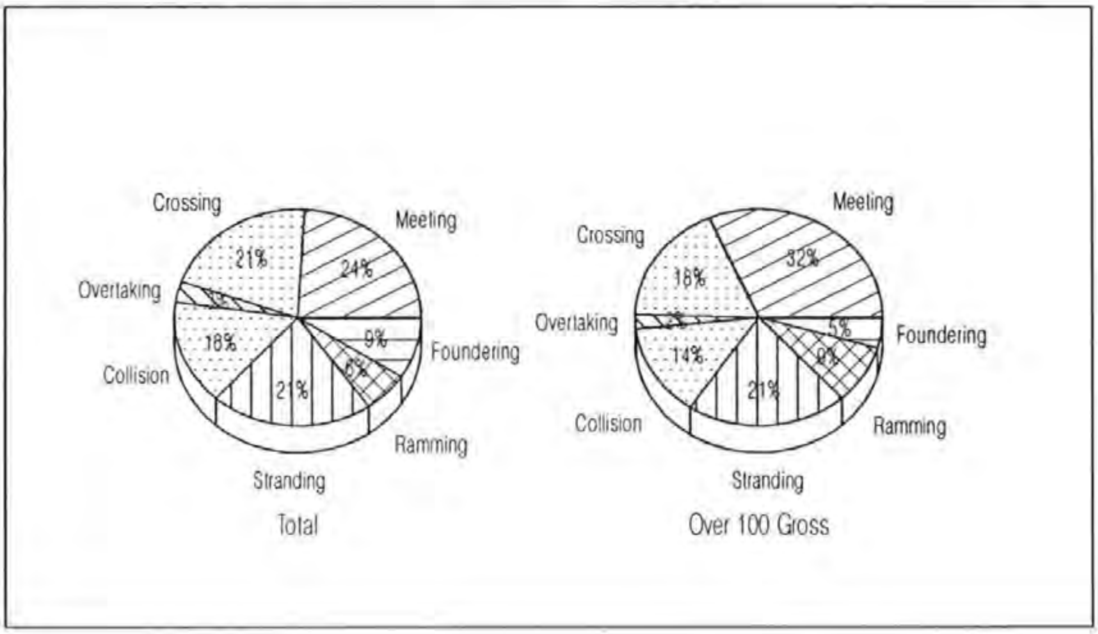
The incidence of the different types of casualty is shown in Figure 4.3. Collision accounts for 63.4 percent, stranding for 21.3 percent, ramming for 6.1 percent and foundering for 9.2 percent of all casualties. The 100 tons and above category of ship has more meeting collisions but less foundering casualties than all casualties.

145 fishing vessels (38%) are involved in casualties, especially 63 percent of foundering and 41 percent of grounding accidents are fishing vessels. Meantime 44 percent of ramming incidents are cargo ships. (see Table 1, Annex-C)

Table 4.10 and Figure 4.4 shows how casualties are distributed according to the type of waterway where the casualty took place. 60.9 percent of ramming casualties occur in ports & harbour, 41.7 percent of collisions and 42 percent of strandings occur in coastal waters. From Fig 4.4, it is apparent that fishing boat casualties are most frequent in coastal waters and open sea, while merchant ship casualties tend to occur in ports/harbour and coastal waters. Passenger ship casualties are more often(38.5%) in port & harbours. (see also Table 11, Annex-C)

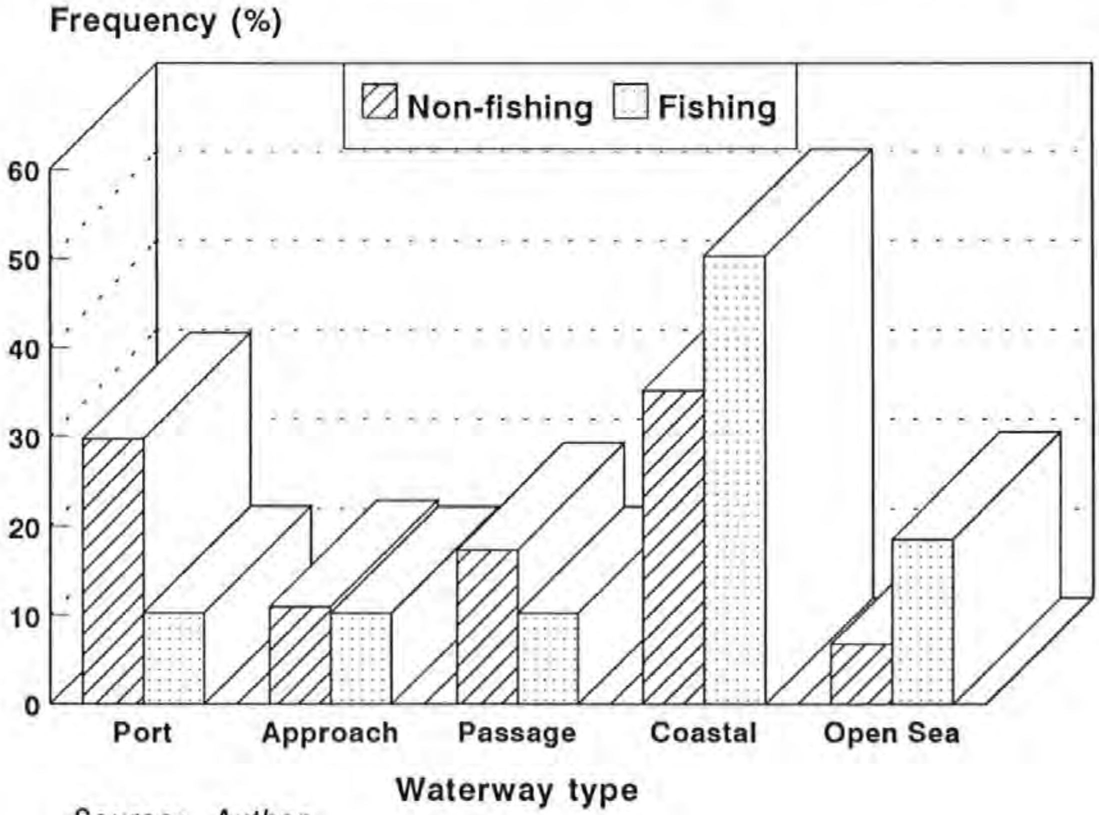
Fig 4.5 shows the geographical distribution of casualties in one degree squares. The highest number of casualties occur in the Pusan/Ulsan area, and the south coastal area has a higher number of accidents than the east & west coasts of Korea. Another identified danger area is the port of Inchon and its approaches. Clearly the principal port areas(e.g. Pusan, Inchon) have a higher portion of ramming accidents while more groundings are experienced in the areas (e.g. Cheju, Mokpo) where fishery bases exist. (see Table 7, Annex-C)

Fig 4.3 Total casualties by their type



Source: Author

Fig 4.4 Distribution of casualties by Waterway type



Source: Author

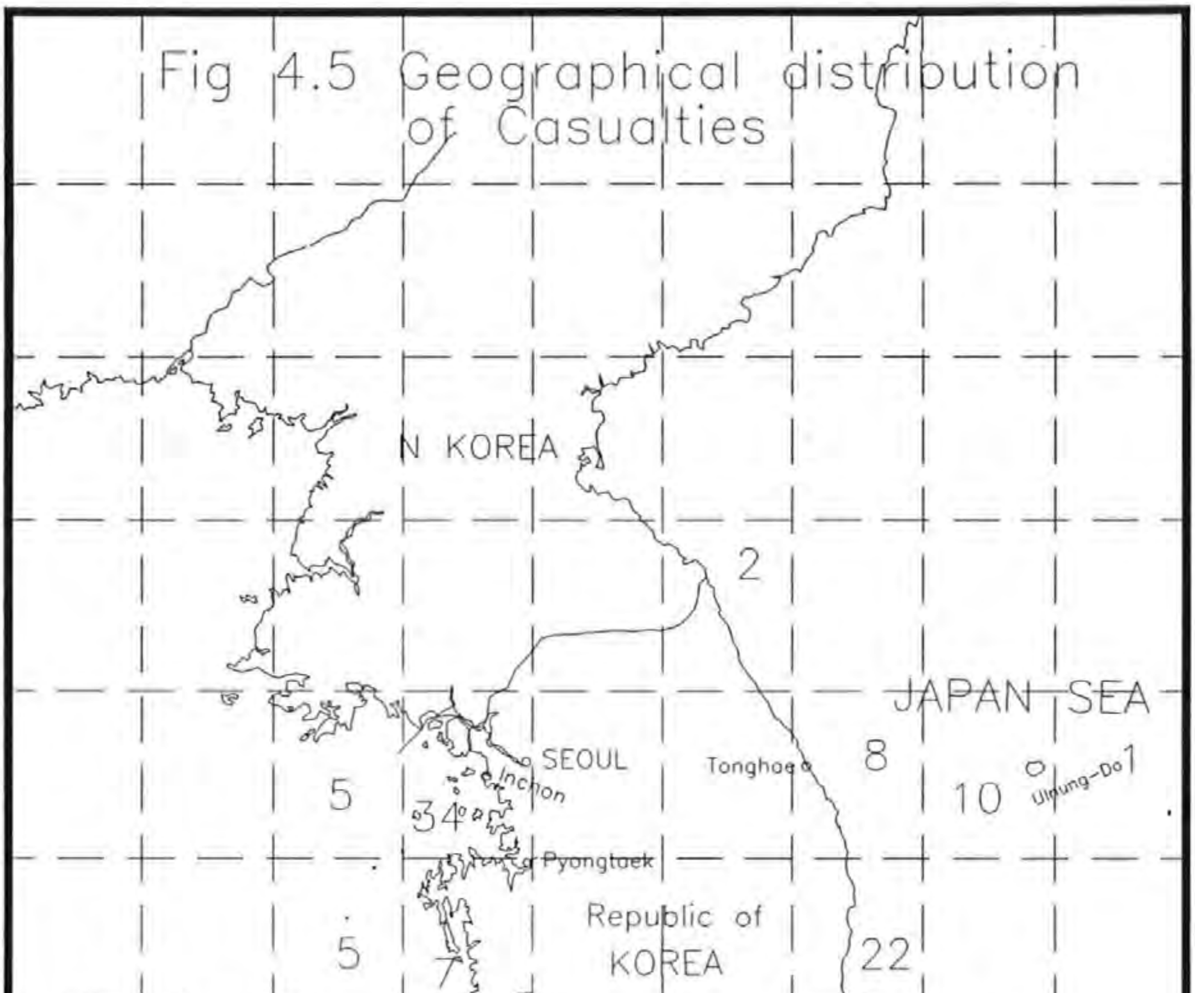


Fig 4.5 Geographical distribution of Casualties
N KOREA
2
JAPAN SEA
SEOUL
Inchon
Tonghae
8
10
Ulleung-Do
1
5
34
Pyongtaek
Republic of KOREA
5
7
22
YELLOW SEA
Kunsan
Pohang
14
8
Ulsan
5
64
2
Kwangyang
Masan
Pusan
KOREA STRAIT
1
Yosu
45
2
16
28
44
14
24
CHEJU HAEHYOP
1
5
Cheju
Cheju Do
7
4
KYUSHU
3
Source: Author & BA Chart No. 4509

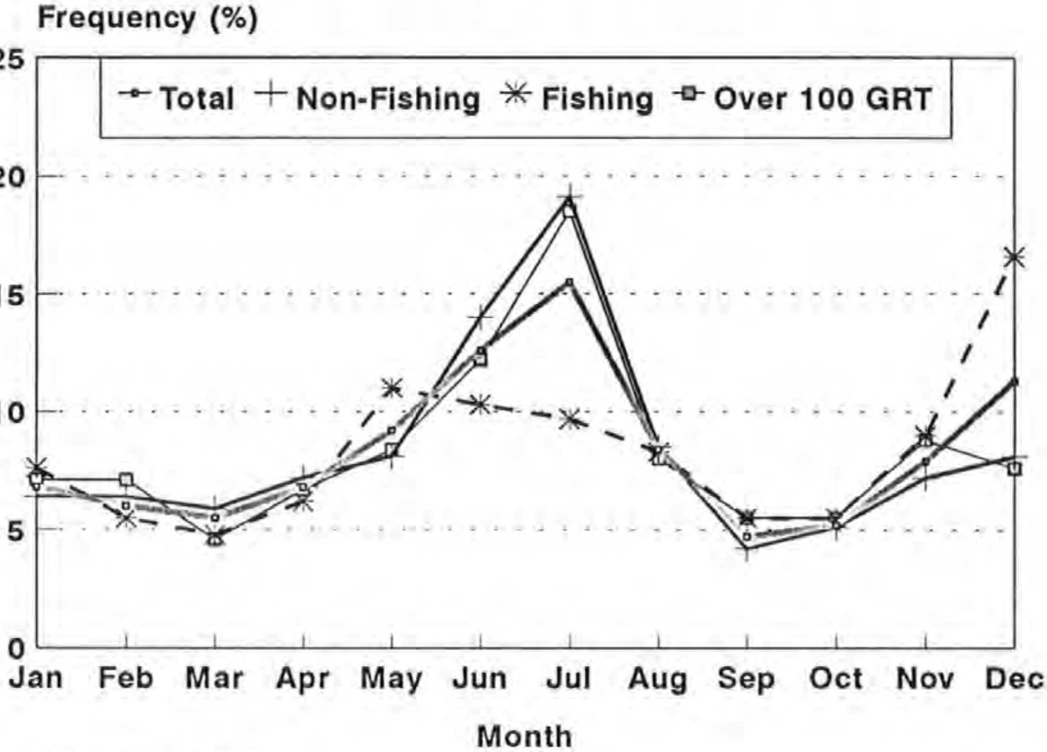
Table 4.10 Cross-tabulation of waterway type by casualty type

	Type of casualty				Row Total
	Collision	Stranding	Ramming	Foundering	
Port and Harbour	42 49.4% 17.4%	25 29.4% 30.9%	14 16.5% 60.9%	4 4.7% 11.4%	85 100.0% 22.3%
Port approaches	26 63.4% 10.7%	9 22.0% 11.1%	3 7.3% 13.0%	3 7.3% 8.6%	41 100.0% 10.8%
Sound and passage	42 75.0% 17.4%	13 23.2% 16.0%	1 1.8% 4.3%		56 100.0% 14.7%
Coastal waters	101 64.7% 41.7%	34 21.8% 42.0%	5 3.2% 21.7%	16 10.3% 45.7%	156 100.0% 40.9%
Open sea	31 72.1% 12.8%			12 27.9% 34.3%	43 100.0% 11.3%
Column Total	242 63.5%	81 21.3%	23 6.0%	35 9.2%	381 100.0%

Source: Author

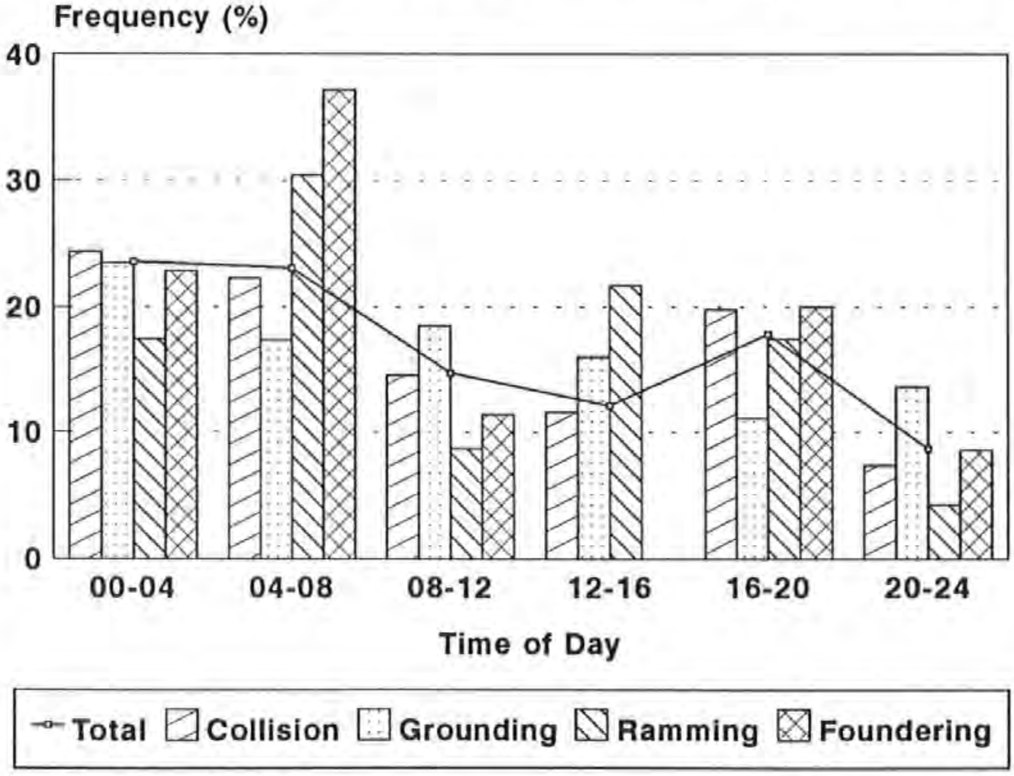
Fig 4.6 shows the total number of casualties per month and clearly indicates the seasonal variations. Generally more accidents happen in June, July & December. This may well be linked to existence of fog during June & July and with periods of high wind during winter, as described in Chapter 2. Fishing boats have more casualties during December & January, while larger vessels (100 grt & above) have more casualties during June & July (see also Table 6, 10 & 13 in Annex-C). The inference is that larger vessels are more adversely affected by low visibility, and smaller ships by wind and sea state. Table 18 and 19 in Annex-C support this inference; 36 ships (26.3%) below 100 tons are involved in casualties under wind force six and over whilst 41 ships (17.6%) above 100 tons are involved. However 91 ships (53%) above 100 tons are involved in casualties under reduced visibility (less than 0.5 mile) while 36 ships (38%) below 100 tons are involved.

Fig 4.6 Monthly numbers of casualties



Source: Author

Fig 4.8 Distribution of casualties by Watches



Source: Author

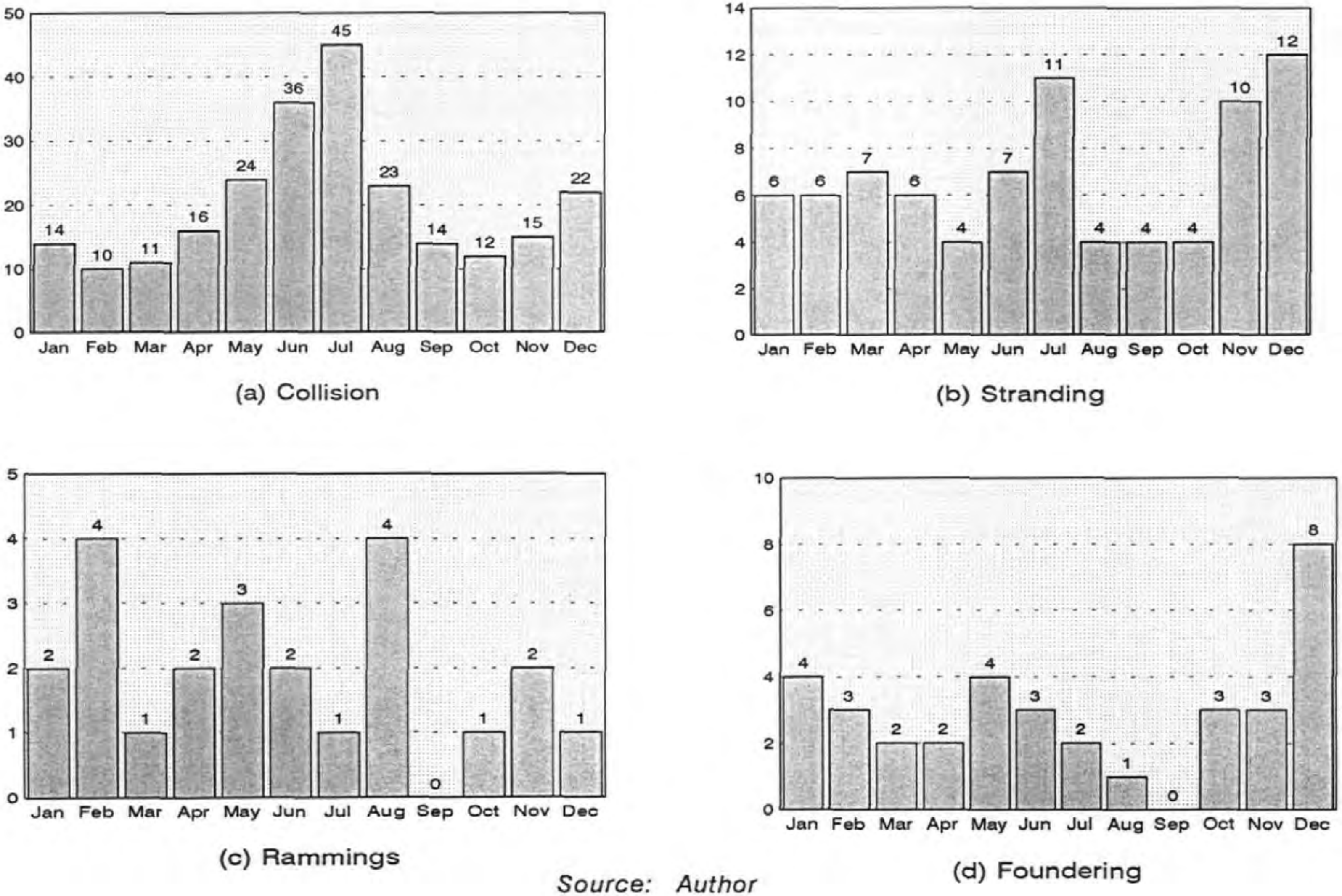
The monthly distribution of collisions shows a seasonal effect which is statistically significant under a Chi-squared goodness of fit test at the five percent level with 11 degrees of freedom. High numbers occur in the summer, with peak values in June & July and values slightly above in May, August & December. There are significantly less collisions in the periods of January to March and September to November inclusive (see Fig 4.7 a). It therefore seems reasonable to say that the occurrence of collision accidents does not occur uniformly over the month. This result is explained by the correlation between the low visibility on a certain month as described in Chapter 2, and also supported by the statistical analysis of the relationship between visibility and month. Table 14 in Annex-C shows that very high number of ships (64 ships out of 127) are involved in casualties during June and July under reduced visibility(less than 0.5 mile). By comparison, Glansdorp[4-25] reported that the monthly distribution of collisions have a slight trend towards peak values in the winter period for the European waters covered by COST 301.

The monthly distribution of groundings shows that higher numbers occur in July, November & December, and high numbers of foundering accidents occur in December. Although peaks appear at Fig 4.7 (b), (c) and (d), due to the relatively small number of accidents in the sample size, they are not significant.

4.3.5 TIME OF DAY AND DAY OF WEEK

Traditionally three watch system (4 on/8 off) is employed on bridge manning; first mate 0400-0800 and 1600-2000 hours; second mate 1200-1600 and 0000-0400 hours; third mate 0800-1200 and 2000-2400 hours. Different watch systems, however, may be adopted on smaller ships or coastal vessels. The master is on watch in some cases and two watch systems (6 on/6 off) are also operated.

Fig 4.7 Distribution of casualties by month



Source: Author

The minimum manning standards of ship-officers on Korean ships is mandated in Korea Ship-Officers Act. The ships registered in Korea should be manned by the following number of officers[4-26]:

(a) ocean-going ships (500 ton & above): a master and three deck officers duly certificated

(b) ocean-going ships (200 - 500 tons): a master and two deck officers

(c) ocean-going ships (less than 200 tons): a master and a deck officer

(d) coastal vessels: a master and a deck officer

(e) coastal ships(less than 1600 tons) but navigating inland water area: a master

General casualty data, including machinery as well as collision and stranding incidents, indicated at Table 4.3 in section 4.1 that time of day had little significance. Figure 4.8, however, shows that 46.7 percent of casualties occur between 0000 hours and 0800 hours in this sample, another high spot is between 1600 and 2000 hours whilst fewer casualties happen between 2000 and 2400 hours (see also Table 3 in Annex-C). This may be due to twilight and sea fog occurring between 0500 and 0800 hours usually. Also there may be more movement of ships for coming alongside and leaving the berths in port area to meet the work shift (day shift: 0800-1700 hours), thus more ships enter port before 0800 hours and leave after 1700 hours.

No exact information on the daily distribution of arrivals and departures from ports is available, but the peak period of rammings is coincident with the traffic peaks at ports. This is the type of waterway where most rammings take place, as seen in Table 4.10. Comparative more rammings occur between 0400 and 0800 hours than during other watches.

More grounding accidents were reported in 0800-1200 and 2000-2400 hours watch period, third officer's watch typically, whereas fewer groundings occurred in 0400-

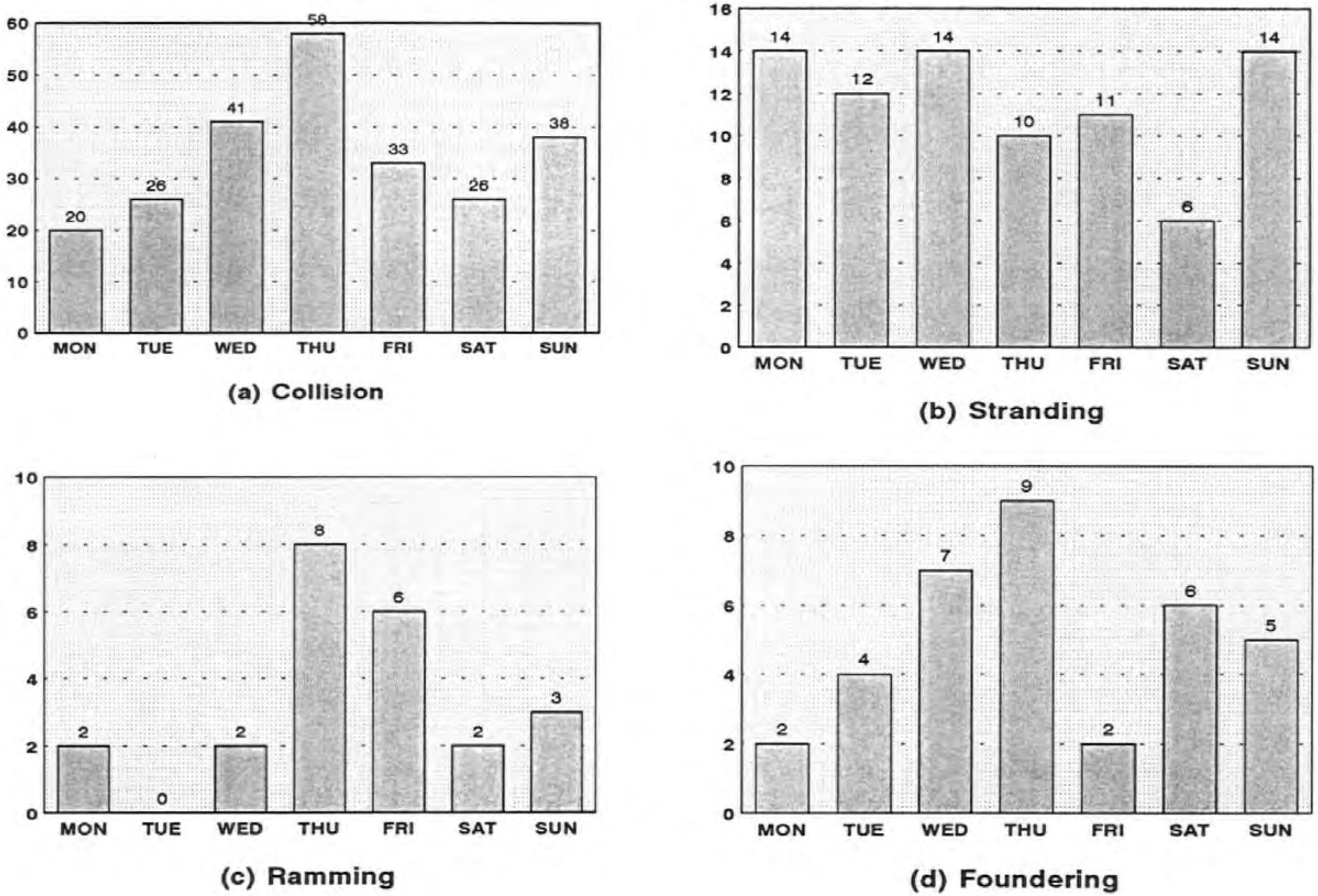
0800 and 1600-2000 hours periods comparing to total accident. This may well be linked to the experience and qualifications of the watchkeeper.

The daily distribution of casualties by day of week is presented in Fig 4.9. It clearly indicates daily differences. Peak values are on Thursday and lowest values on Monday (see also Table 5 in Annex-C). The daily distribution of collisions shows a peak value on Thursday and the lowest value on Monday (graph a). Under a Chi-squared goodness of fit test, the weekly distribution of collision is significantly different to that assuming no weekly variation at the five percent level with 6 degrees of freedom, but the distribution of groundings is not significantly different. Therefore it is reasonable to say that the collision accidents in Korean waters do not occur uniformly over the week.

The daily distribution of rammings shows a high value on Thursday (graph c) and more founderings were reported on Wednesday and Thursday (graph d). However, it is not possible to assume that the weekly distributions of ramming and foundering accidents are significant because the numbers involved are small.

Several studies show similar phenomena, for example, Glansdorp[4-25] reported a similar trend that peak value occurs on Thursday and the lowest value on Tuesday based on 446 collisions in COST 301 area, and Bowdidge[4-27] also reported a similar trend, based on 190 collisions in the Dover Strait area during the 17-year period 1960 to 1976 inclusive without further explanation. So far, however, it has not proved possible to identify any valid explanation for these variations. No evidence has been found from the earlier studies that there would be a correlation between the number of casualties at a certain day. This study attempted to trace the causes further back to the various related factors such as visibility, wind force and sea state.

Fig 4.9 Distribution of casualties by days of week



Source: Author

The further analysis revealed that much higher number of ships were involved in casualties on Thursday under reduced visibility(less than 0.5 mile), stronger wind(wind force 6 and over) and higher seas(sea state 5 and over). But only seven ships were involved in casualties on Monday under reduced visibility, less than 0.5 mile.

(1) 33 ships(26%) out of 127 were involved in casualties under low visibility
(2) 22 ships(29%) among 77 were involved under stronger wind
(3) 19 ships(28%) among 67 were involved under higher seas

The inference therefore is that the adverse environmental factors are the main cause for these variations rather than the diurnal changes of the physiological capabilities of navigators which are not possible to identify. (see Table 15, 16 & 17 in Annex-C)

4.3.6 SHIP TYPE, SIZE AND AGE

Table 4.11 shows the division of different casualty types between classes of ship. Passenger ship includes ferries, hydrofoil & hover craft. Cargo ship includes general cargo, bulk carriers and unitised cargo ships. Tanker includes chemical tanker, gas tankers and all kind of oil tankers. Others include tugs, naval ships and miscellaneous craft.

Passenger ships have more ramming accidents but no founderings while fishing vessels have much more foundering accidents but less rammings (see Table 1 in Annex-C). The possible reason why passenger ships are suffering ramming accidents is that passenger ships call at small ports frequently where the port facilities are not adequate, such as short wharf, insufficient breakwater and no tug boat available. On the other hand many fishing vessels are operating off shore and more exposed to danger of heavy weather.

Table 4.11 Cross-tabulation of casualties by ship type

Ship type	Type of casualty				Row Total
	Collision	Stranding	Ramming	Foundering	
Passenger	7 53.8% 2.9%	3 23.1% 3.7%	3 23.1% 13.0%		13 100.0% 3.4%
Tanker	45 71.4% 18.6%	12 19.0% 14.8%	4 6.3% 17.4%	2 3.2% 5.7%	63 100.0% 16.5%
Cargo	73 64.6% 30.2%	24 21.2% 29.6%	10 8.8% 43.5%	6 5.3% 17.1%	113 100.0% 29.7%
Fishing	87 60.0% 36.0%	33 22.8% 40.7%	3 2.1% 13.0%	22 15.2% 62.9%	145 100.0% 38.1%
Others	30 63.8% 12.4%	9 19.1% 11.1%	3 6.4% 13.0%	5 10.6% 14.3%	47 100.0% 12.3%
Column Total	242 63.5%	81 21.3%	23 6.0%	35 9.2%	381 100.0%

Source: Author

Fig 4.10 shows the distribution of casualties by ship size. Clearly it is the small ships (less than 100 ton account for 38%) that have the highest rate of accident. This can be explained by that such vessels are used mainly in coastal traffic where the closeness to land and heavier traffic density almost certainly accounts for the higher incidence of collisions and strandings. Another possible reasons are lack of professional knowledge due to low training, fewer number of officers and lack of navigation equipment.

Ship age distribution of all ships, cargo ships and tankers in this study are depicted in Fig 4.11, where also the corresponding distributions of all ships of the total Korean fleet excluding fishing vessels in the year of 1990 are given. The similarity between the sample and the Korean fleet distributions is evident from the graphs. It is therefore reasonable to assume that the age distribution of ships selected in this study does not differ substantially from that of the Korean fleet.

Table 4 in Annex-C, however, disclose that the age distributions in different types of casualties are not the same. The average age of ships in founderings(18.8 years) is much higher than in rammings (11.1 years) and collisions(12.8 years), and the mean age of vessels in groundings(14.8 years) is higher than in rammings and collisions. ***Tukey-b*** test is employed to test the differences between groups(type of casualty) which is the most widely used in multiple comparisons.[4-28] As usual the differences are taken to be statistically significant at the 0.05 significance level. The test presents that the ship age distribution in founderings is significantly different to the distributions in rammings and collisions.

4.4 ANALYSIS OF CAUSE RELATIONSHIPS

4.4.1 POSSIBLE CAUSES OF CASUALTIES

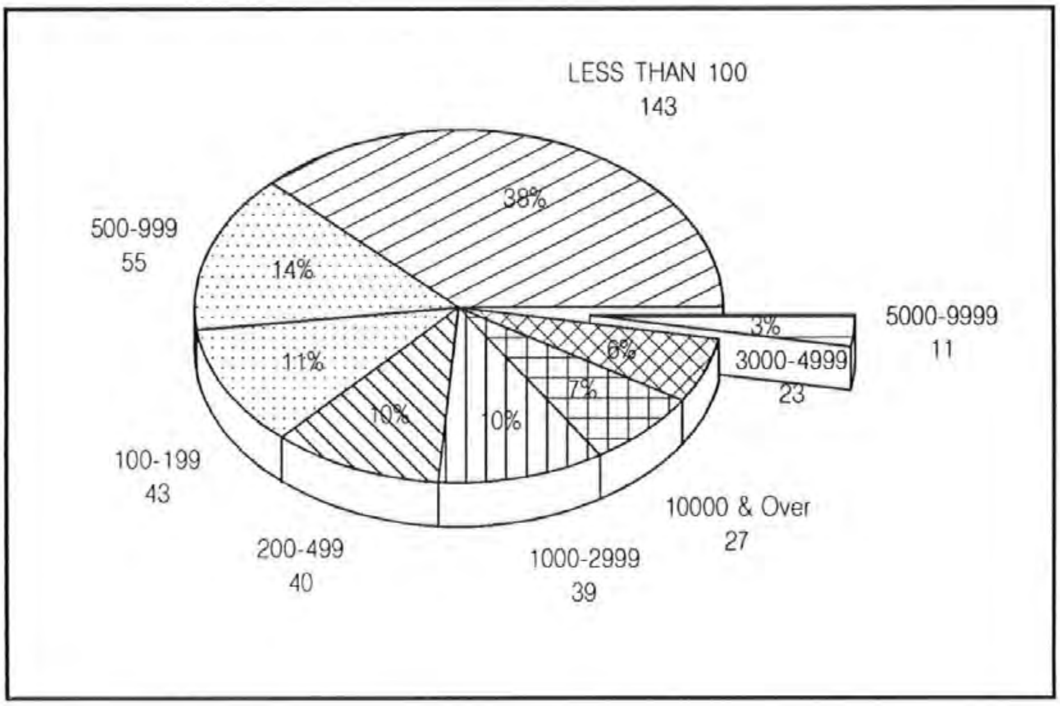
For an accident to occur there clearly has to be a cause. The potential number of causal factors and their combinations associated with marine casualties is extensive as indicated. The number of possible *permutations* ${}_nP_r$ of a group of n objects is the number of ways that a sub-group of r objects may be arranged when taken from the group. If three objects A,B & C are considered, and letting r=2, the possible permutations of the objects will be AB, BA, AC, CA, BC and CB. In other words, ${}_3P_2 = 6$. The number of permutations of n things taken r at a time is given by the formula

$$P(n,r) = n(n-1)(n-2) \ldots (n-r+1).$$

The formula can be simplified by the use of factorial notation. Factorial n, denoted by $n!$, means

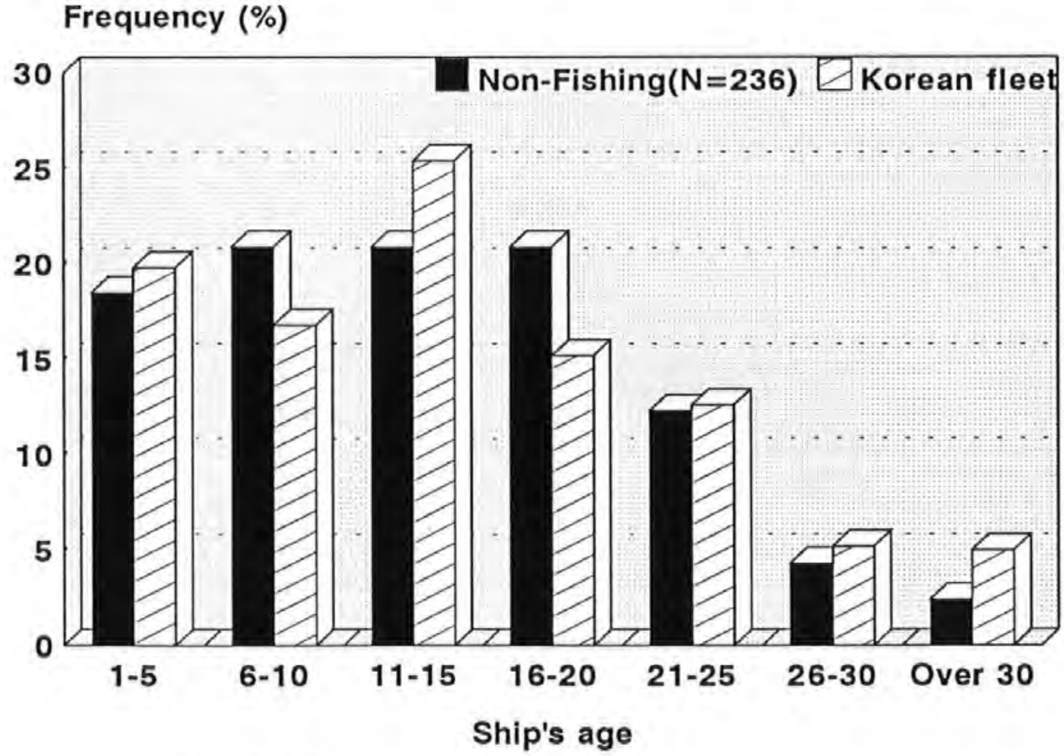
$$n! = n(n-1)(n-2) \ldots 3 \cdot 2 \cdot 1,$$ the product of integers from n to 1.

Fig 4.10 Distribution of casualties by Ship size



Source: Author

Fig 4.11 Distribution of casualties by Ship's age



Source: Author

In general,

$$nPr = \frac{n!}{(n-r)!}$$

The number of permutations of a group of objects includes groupings of the same objects in a different order. However, the order of grouping of the objects is often unimportant. For this case the number of *combinations* of the objects is under consideration. The number of possible combinations ${}_nC_r$ of a group of n objects is the number of ways that a sub-group of r objects can be taken from the group, without regard to order. Hence the possible combinations of two from the three objects A, B and C will be AB, AC and BC, so ${}_3C_2 = 3$. It is denoted by a variety of equivalent symbols, such as;

$$\binom{n}{r} \quad nCr \quad C(n,r)$$

and the formula is

$$nCr = \frac{n!}{r!\,(n-r)!}$$

As an example of this the causal factors given in the block scheme of Fig 4.2 are considered. 82 factors are listed in the scheme. In principle, if only one factor is taken as a cause of a casualty, there are 82 possible factors which can appear as a cause. If two factors are needed, there are **P**= 82 × 81= 6,642 possible different causal permutations, when order of the blocks is of importance. If no attention is paid to the order, the number of different causal combinations is C= ½ × 82 × 81= 3,321. In general, **k** factors of 82 can be combined in **P** or **C** ways which are calculated by the formulas[4-29].

$$P=\frac{82!}{(82-k)!} \quad C=\frac{82!}{k!(82-k)!}$$

The blocks of the scheme in Fig 4.2 form the possible causes of the accident. The analysis of each accident is limited to the possible causes identified in the "Written Verdicts". The variable possible causes are classified in one of the following categories in this study:

1. Essential: is given to those possible causes which most likely had a clear and undisputed affect on the circumstances leading to the accident.

2. Likely: is given to those factors which likely affected the circumstances leading to the accident although the information is not complete.

3. Possible: is given to those factors which have been judged to have less importance in contributing to the accident.

4. Conducing: is given to those factors which had a little influence on developing the accident or those factors on which there is lack of information and whose significance is therefore difficult to judge.

5. Indefinite: The causal relationship of a indefinite factor to the incidence of a accident is indefinite or insignificant.

Table 4.12 Weight coefficient used in this study

Category of the Factor	Weight Coefficient
Essential Factor	1.0
Likely Factor	.75
Possible Factor	.5
Conducing Factor	.25
Indefinite Factor	.0

The effect of each factor upon the casualty is measured by its weight coefficient.

The values of weight coefficients are determined after the classification of the factors according to the following table. Table 4.12 shows the maximum values of weight coefficients involved.

Helsinki University of Technology[4-30] study classified the factors in four categories (essential, part, conducing and indefinite) and three more weighting principles were added including:

(1) the sum of weight coefficients of the part and conducing factors for each casualty may not be greater than 1.

(2) if the sequence of events contains one or more essential factors belonging to the group "Actions" and the sum of coefficients of the part and/or conducing factors of the previous branches of the sequence is equal to 1, then the weight coefficient of these essential factors is taken to be 0.
This corresponds to the situation where environmental conditions and the condition of the navigator altogether exceed the human capability to take the right action.

(3) if the sequence of events of a casualty is not considered to be satisfactorily cleared up, then the sum of the coefficient of all factors should be less than 1.

As the result of those weighting principles, environmental factors were overestimated but human factors were far less evaluated in general. The most unexpected result was the low proportion of human factors in collisions, only 17 percent, though the usual figure most often quoted is about 70-90 percent.[4-31][4-32] One obvious reason for the low ratio is the weighting principle number (2).

The weighting principle number (2) is not employed in this study to avoid the distortion of results. The number (1) is a principle to get the probability of each factor, so it does not meet the purpose of this study. The published "Written Verdicts" is the report of accident inquiry even though it is not the detailed report, clearly the principle number (3) is also not necessary in this study.

Let the weight coefficient of a factor i in a casualty j be W_{ij}, and the number of factors included in the analysis n, and the number of the casualties in the data base m. Then the "**effect level**" e_i of a factor i is defined by the equation:

$$e_i = \frac{\sum_{j=1}^{m} w_{ij}}{\sum_{j=1}^{m} \sum_{i=1}^{n} w_{ij}}$$

The effect level is a useful measure in ranking different factors according to their overall effect on casualties.

A typical example of "Written Verdicts" is quoted below to demonstrate how the verdict is comprised and how to trace the possible causes from them.

CASE STUDY: M/V HANLIM MERCHANT COLLISION WITH M/V ORIENTAL FERM

(No. 90-45, Inchon District Marine Accident Inquiry Agency)

1. The text (findings)

The collision occurred due to reckless manoeuvring of M/V Hanlim Merchant having not considered the drift by tidal stream. The secondary factors were the act of M/V Oriental Ferm anchored at fairway and the negligence of the port control centre contribute to the accident.

2. Statement

Name of ship	Hanlim Merchant	Oriental Ferm
Port of registry	Inchon, Korea	Manila, Philippine
Owner	Hanlim shipping company	Dakila ocean navigation corporation
Gross tonnage	9,814.50 ton	22,145 ton
Engine power	Diesel 7,200 HP	
The examinee	xxx xxx xxx	xxx xxx xxx
Rank	Master	Pilot
Certificate	Class 1	Inchon pilot
Date of casualty	1808 hours June 13 1990	
Location of casualty	37° 21′ 23″.6 North, 126° 31′ 58″.8 East	

M/V Hanlim Merchant is a log/bulk carrier of 9,815 grt engaged in ocean-going trade. Built in 1969, this ship is powered by a 7,200 HP diesel engine giving a full speed of 13.5 knots, and is fitted with an automatic steering system. This ship is manned by a master and three qualified deck officers.

She sailed from Bangkok at 1755 hours on June 4 with 14,700 tons of raw sugar on board, draught 8.67 metres forward and 9.07 metres aft. She approached Inchon and anchored at 1255 hours on June 13 4.2 miles from the port limit due to congestion in the inner anchorage.

At 1715 hours she started to proceed under master's command through inbound route at half speed(10 knots) to take pilot at 1800 hours near the Palmi-do, and to anchor at inner anchorage(C-3).

When she was abeam to Pukchangja-so lighthouse at 1745 hours, the course was altered to 076 degree. At this time the ship(M/V Stephenson) was ahead of her and a LPG tanker was following. She adjusted her course to 078 degree at 1751 hours because she was drifting to port.

At 1753 hours when M/V Hanlim Merchant was passing No.8 buoy, the LPG tanker contacted her requesting to overtake on her port side and she agreed. The distance between the ships was 0.9 mile to the forward ship and 0.7 mile from the following vessel. At the same time she found an anchored vessel at 20 degrees to port, range 2 miles by radar and sight.

At 1756 hours she reduced her speed(slow) and at 1758 hours stopped engine in order to maintain the distance from the M/V Stephenson.

At 1802 hours she approached the waypoint. At this point the engine was used (dead slow) to facilitate course alteration onto 035 degrees intending to pass the stern of the anchored vessel, and then stopped engine again. At this time the distance to the anchored vessel was 0.7 mile and 0.4 mile to M/V Stephenson.

Suddenly M/V Stephenson turned to port and Hanlim Merchant found a barge ahead, outbound. The master ordered helm to port 15 degrees and used engine(dead slow) to enhance the rudder effect. Subsequently M/V Stephenson turned back to starboard and proceeded to pass astern of the anchored vessel.

The master of Hanlim Merchant decided to pass ahead of the anchored vessel. He had to take account of the proximity of M/V Stephenson (0.3 mile), anchored vessel (0.6 mile) and the outbound barge. Course was altered to 016 degrees at 1803 hours.

The master realised that she was being set to north-eastward by the tidal stream. Alteration of course to port was restricted by the proximity of the LPG tanker on the port bow. He finally adjusted her course to 015 degrees at 1806 hours despite realising that this would pass very close to the anchored vessel.

At 1808 hours he ordered 'stop engine' when collision was imminent. She finally collided with the anchored vessel with 45 degree of an angle of intersection.

The weather was fine with wind force 3 and sea state 2, but there were 1.5 knot of tidal stream north-eastward.

Meantime **M/V Oriental Ferm (the anchored vessel)** is a log/bulk carrier and manned by 24 Philippine crew. She anchored near to Jangan-so at 2200 hours on June 11 with 32,356 tons of American log. She proceeded to inner anchorage by the pilot and arriving at 2120 hours. The pilot anchored the ship in the fairway at 2120 hours on June 12 and reported to the port control centre.

In consequence of this accident, M/V Hanlim Merchant received hull damage (damage to No.2 guy stanchion and to hull) and cargo damage (4,600 tons lost). M/V Oriental Ferm received hull damage to bulbous bow and fore peak tank.

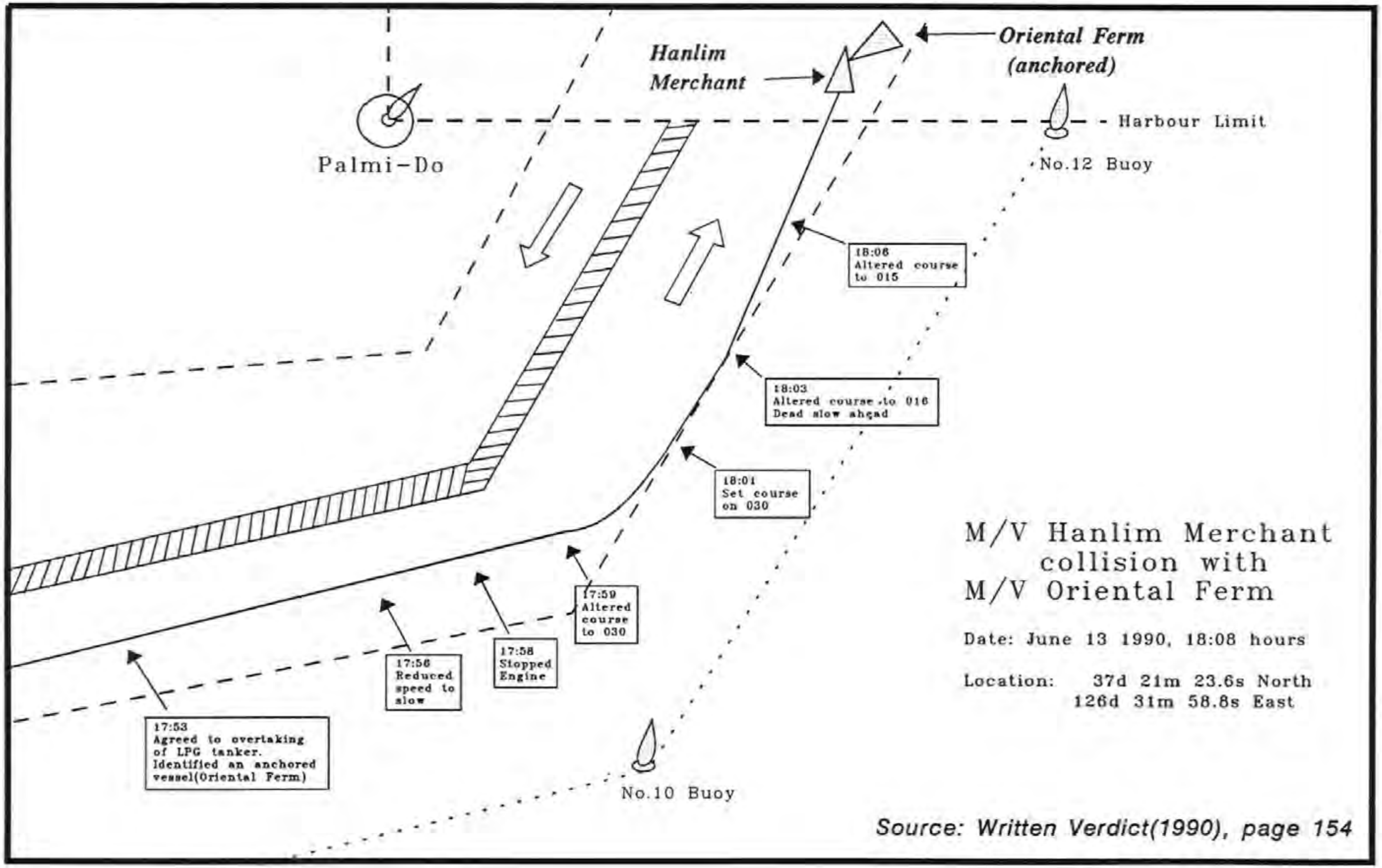
The total complement of Inchon port control centre is 15, comprising the chief, nine operators (for communication with ship), 3 engineers(maintenance) and 2 support staff. Normal 24 hour operation in the control room is maintained by 3 operators per watch.

The operator on watch was informed by the pilot that M/V Oriental Ferm was anchored at 0.8 mile east of Palmi-do, but he did not confirm the position or order further movement.

The port was heavily congested and the number of anchored ships were more than the usual port capacity.

November 1 1990 Inchon District Marine Accident Inquiry Agency

Fig 4.12 Diagram of the Collision case



Source: Written Verdict(1990), page 154

The causes (3 factors) of the accident identified in the inquiry are explained in "The text" above. However other possible causes can be traced from the statement. Considering the possible causal factors for M/V Hanlim Merchant, all together 7 factors are identified by the block scheme exhibited in Fig 4.2. The category of the causes are in the brackets.

Environment

1. Narrow channel (5)
2. Heavy surrounding traffic (4)
3. Other ship passing too close distance (3)
4. Strong tidal stream (2)
5. Other ship is on collision course (2)

Human factors

6. Improper harbour organization (4)
7. Improper decision of master (1)

The possible causes identified by the block scheme are listed below with the number of occurrences in brackets. The total number ship casualties considered was 381.

(1) Environment: This group deals with the environment of the ship such as weather conditions and waterway configurations.

1. Reduced visibility by fog	(122)
2. Reduced visibility by snow	(6)
3. Reduced visibility by rain	(20)
4. Ship was in stormy weather	(59)
5. Reduced efficiency of radar by rain/snow heavy sea	(11)
6. Reduced efficiency of equipment by heavy ship motion	(8)
7. Small ships are in the fairway	(31)
8. Heavy surrounding traffic	(25)
9. Other ship passing/overtaking too close	(18)
10. Other ship on collision course	(57)
11. Narrow channel or Passage	(77)

12. Low water level	(5)
13. Strong current or tidal stream	(31)
14. Faults/Deficiencies of navigational aids	(3)
15. Wrong/Poor marking of fairway	(3)
16. Deficiencies in charted information on chart or publications	(8)
17. Improper rules or regulations	(7)
18. Management pressure	(28)
19. Equipment fault or deficiency in other ship	(10)
20. Other ship - Manoeuvring against rules	(60)
21. Other ship - No reaction to the critical situation	(85)

<u>(2) Technical faults & deficiencies:</u> This group deals with technical problem like technical failures of equipment both on board and ashore.

1. Breakdown of main engine	(8)
2. Breakdown of auxiliary engine	(2)
3. Breakdown of steering	(1)
4. Breakdown of rudder	(1)
5. Breakdown of propeller	(5)
6. Breakdown of radar	(13)
7. Breakdown of compass	(2)
8. Breakdown of navigation lights	(6)
9. Breakdown of other navigation equipment	(2)
10. Breakdown of external communication equipment	(2)
11. Poor bridge design	(4)
12. Poor quality of materials	(6)

13. Poor maintenance or inspection	(10)
14. Lack of equipment	(17)
15. Poor stowage	(14)
16. Cargo shifting	(4)
17. Electricity blackout	(2)
18. Broken mooring ropes	(2)
19. Fracture of ship structure	(13)

<u>(3) Human element</u>: In spite of his propensity for making errors and despite any desire to eliminate him from systems in which he can generate damage, man is still the most important single item in any system, no matter how complex. Therefore five sub-groups were recognised, weighted taking into account importance and diversity.

<u>Personal factor</u>

1. Attack of sickness or illness	(1)
2. State of tiredness	(5)
3. State of drunkenness	(2)
4. Stress	(1)
5. Navigator asleep on duty	(6)

<u>Organization & Training</u>

6. Improper shipboard organization	(30)
7. Improper harbour organization	(25)
8. No/lack of seafaring experience	(8)
9. No/lack of professional knowledge	(15)

Watchkeeping

10. No Officer on the bridge (27)

11. Captain left bridge in critical situation or before officer was adapted to conditions (21)

12. Negligence of lookout (92)

13. Did not use every equipment available in the situation (56)

14. Navigator occupied in other tasks (25)

15. Improper reporting or take-over (11)

16. No small correction on chart or pubs (1)

17. Error in voyage planning (31)

System interface

18. Ship to shore (6)

19. Ship to ship (9)

20. Ship to tug (1)

21. Ship to office (10)

Control tasks

22. Wrong appreciation of other ship on radar or by sight (23)

23. Wrong appreciation of navigational aids on radar or by sight (3)

24. Excessive speed under the circumstances (92)

25. Negligence in the critical situation (98)

26. Sailed in wrong side of fairway (27)

27. Sailed in unmarked waters (4)

28. Miscalculation of position (1)

29. Did not fix position regularly or at all (46)

30. Improper decision (50)

31. No reaction to the critical situation (51)

32. Improper manoeuvre (engine, steering, etc.) (77)

33. Misuse/misread of radar, compass, etc. (5)

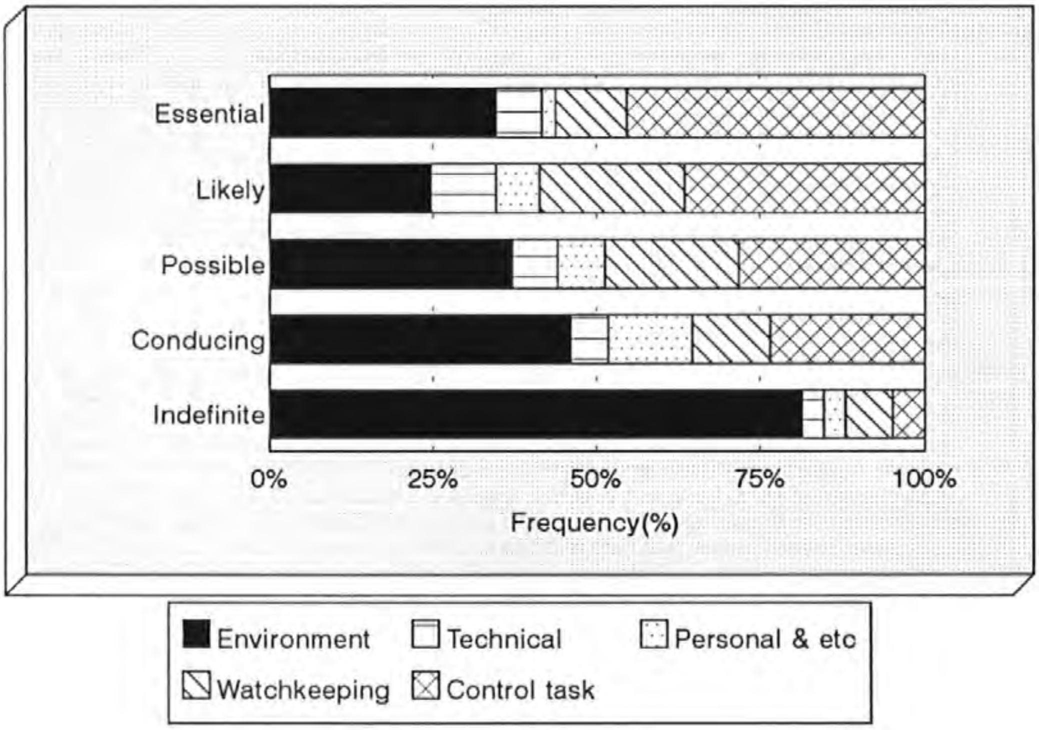
<u>(4) Summing up Possible Causes</u>: Table 4.13 summarizes all possible causes as revealed by the block scheme analysis. According to the table, 183 possible causes are of indefinite category. 380 items are classified as conducing, 175 of which belong to the environmental group. The group of essential causes comprises 245 as follows; "control tasks" - 111, "environmental factors" - 85, "watchkeeping" - 27, "technical factors" - 17 and "personal/training/system interface factors" - 5. Control tasks and environment seem to constitute the most serious problem areas in this sample. Fig 4.13 shows that in general, environmental and training/system interface are less important factors than technical, control tasks and watchkeeping.

Table 4.13 Possible causes

Causes/Category		1	2	3	4	5	Total
Environmental factors		85	93	172	175	149	674
Technical factors		17	37	32	22	6	114
Human factors	Health	3	7	1	4	0	15
	Organization & Training	2	18	27	26	5	78
	System Interface	0	0	6	19	1	26
	Watchkeeping	27	84	95	45	13	264
	Control tasks	111	137	131	89	9	477
Total		245	376	464	380	183	1,648

Source: Author

Fig 4.13 Frequency of possible causes



Source: Author

The basic descriptive statistics for possible causes for the five causal groups are shown in Table 4.14. The ship control tasks group has the lowest mean value which means the highest influence on the casualty, while the environmental causal group has the lowest significance index. The first group has somewhat higher standard deviation, 1.69, than the other groups and the standard deviations in the other four groups are fairly similar. Since all the groups contain sufficient number of cases, the standard error of the mean for each group is fairly small, 0.05 to 0.12.

Table 4.14 Descriptive statistics for the possible causes

Causal factor group	Count	Mean	Standard deviation	Standard error
Environmental group	674	3.3116	1.6918	0.0651
Technical group	114	2.6754	1.2300	0.1152
Watchkeeping group	264	2.7462	1.0342	0.0634
Ship control tasks group	477	2.4717	1.2035	0.0549
Other Human factor group	119	3.2185	0.9519	0.0871
Total	1,648	2.9272	1.4932	0.0368

Source: Author

4.4.2 MOST COMMON CAUSAL FACTORS

The most common causal factors in each type of casualty and in each sub-area are discussed in this section. The number of occurrences are in brackets. The most common causal factors in each type of casualty are:

(1) Collisions

ENVIRONMENTAL FACTORS	
1. Reduced visibility by fog	(98)
2. Other ship-No reaction to the critical situation	(84)
3. Other ship-Manoeuvring against to rules	(58)
4. Other ship on collision course	(50)
5. Narrow channel or passage	(47)

(continued)

TECHNICAL FAULTS & DEFICIENCIES	
1. Breakdown of navigation lights	(6)
2. Lack of equipment	(5)
3. Poor quality of materials	(4)
HUMAN ELEMENTS	
1. Negligence of lookout	(82)
2. Excessive speed under the circumstance	(78)
3. Negligence in the critical situation	(70)
4. Improper manoeuvre (engine, steering gear, etc)	(54)
5. No reaction to the critical situation	(44)

Reduced visibility by fog is the most common causal factor in collision accidents and Table 9 in Annex-C also supports this result (44% of collisions occur in fog).

(2) Groundings

ENVIRONMENTAL FACTORS	
1. Narrow channel or passage	(26)
2. Reduced visibility by fog	(21)
3. Ship was in stormy weather	(17)
4. Strong current or tidal stream	(14)
5. Reduced visibility by rain	(12)
TECHNICAL FAULTS & DEFICIENCIES	
1. Lack of equipment	(11)
2. Breakdown of radar	(9)
3. Breakdown of propeller	(3)
HUMAN ELEMENTS	
1. Did not fix position regularly or at all	(33)
2. Error in voyage planning	(21)
3. Negligence in the critical situation	(15)
4. Improper manoeuvre (engine, steering gear, etc)	(12)
5. Did not use every equipment available in the situation	(12)

(3) Rammings

ENVIRONMENTAL FACTORS	
1. Ship was in stormy weather	(12)
2. Reduced visibility by rain	(4)
3. Management pressure	(4)
TECHNICAL FAULTS & DEFICIENCIES	
1. Breakdown of main engine	(4)
HUMAN ELEMENTS	
1. Negligence in the critical situation	(6)
2. Did not fix position regularly or at all	(6)
3. Improper decision	(4)

(4) Founderings

ENVIRONMENTAL FACTORS	
1. Ship was in stormy weather	(21)
2. Management pressure	(9)
TECHNICAL FAULTS & DEFICIENCIES	
1. Poor stowage	(13)
2. Fracture of ship structure	(11)
3. Poor maintenance or inspection	(7)
HUMAN ELEMENTS	
1. Negligence in the critical situation	(9)
2. Improper manoeuvre (engine, steering gear, etc)	(9)
3. Improper decision	(5)

Source: Author

"Ship was in stormy weather" is the most common factor in ramming and foundering accidents and this phenomenon is also explains by Table 2 in Annex-C. 56 percent of ramming and 63 percent of foundering accidents occur in strong wind (force 6 and over) whilst only six percent of collisions occur under similar conditions.

The most common causal factors in each sub-area are:

(1) Tonghae area

ENVIRONMENTAL FACTORS	
1. Ship was in stormy weather	(6)
2. Other ship-No reaction to the critical situation	(5)
3. Reduced visibility by fog	(4)
TECHNICAL FAULTS & DEFICIENCIES	
1. Breakdown of compass	(2)
2. Fracture of ship structure	(2)
HUMAN ELEMENTS	
1. Did not use every equipment available in the situation	(7)
2. Improper harbour organization	(6)
3. Improper manoeuvre (engine, steering gear, etc)	(6)

(2) Pohang area

ENVIRONMENTAL FACTORS	
1. Other ship-No reaction to the critical situation	(7)
2. Reduced visibility by fog	(6)
3. Ship was in stormy weather	(5)

(continued)

TECHNICAL FAULTS & DEFICIENCIES	
1. Poor stowage	(2)
2. Lack of equipment	(2)
HUMAN ELEMENTS	
1. Negligence of lookout	(9)
2. Negligence in the critical situation	(9)
3. Improper manoeuvre (engine, steering gear, etc)	(6)

(3) Ulsan area

ENVIRONMENTAL FACTORS	
1. Other ship-No reaction to the critical situation	(6)
2. Other ship on collision course	(5)
3. Other ship-Manoeuvring against rules	(5)
HUMAN ELEMENTS	
1. No reaction to the critical situation	(5)
2. Negligence in the critical situation	(4)
3. Improper manoeuvre (engine, steering gear, etc)	(4)

(4) Pusan area

ENVIRONMENTAL FACTORS	
1. Reduced visibility by fog	(20)
2. Other ship-No reaction to the critical situation	(20)
3. Other ship on collision course	(17)
4. Ship was in stormy weather	(13)
TECHNICAL FAULTS & DEFICIENCIES	
1. Breakdown of auxiliary engine	(2)
2. Lack of equipment	(2)
HUMAN ELEMENTS	
1. Negligence in the critical situation	(24)
2. Excessive speed under the circumstance	(18)
3. Negligence of lookout	(16)
4. Improper manoeuvre (engine, steering gear, etc)	(13)

(5) Masan area

ENVIRONMENTAL FACTORS	
1. Reduced visibility by fog	(14)
2. Other ship on collision course	(8)
3. Other ship-Manoeuvring against rule	(8)
TECHNICAL FAULTS & DEFICIENCIES	
1. Poor quality of materials	(2)
2. Lack of equipment	(2)
HUMAN ELEMENTS	
1. Negligence of lookout	(11)
2. Negligence in the critical situation	(11)
3. Excessive speed under the circumstance	(10)

(6) Yosu area

ENVIRONMENTAL FACTORS	
1. Narrow channel or passage	(21)
2. Reduced visibility by fog	(17)
3. Other ship-No reaction to the critical situation	(15)
TECHNICAL FAULTS & DEFICIENCIES	
1. Lack of equipment	(3)
2. Breakdown of radar	(2)
HUMAN ELEMENTS	
1. Negligence of lookout	(24)
2. Excessive speed under the circumstance	(14)
3. Improper manoeuvre (engine, steering gear, etc.)	(12)

(7) Cheju area

ENVIRONMENTAL FACTORS	
1. Other ship-No reaction to the critical situation	(11)
2. Ship was in stormy weather	(10)
3. Reduced visibility by fog	(9)
TECHNICAL FAULTS & DEFICIENCIES	
1. Poor stowage	(5)
2. Breakdown of radar	(5)
HUMAN ELEMENTS	
1. Negligence of lookout	(12)
2. No officer on the bridge	(8)
3. Did not fix position regularly or at all	(8)

(8) Mokpo area

ENVIRONMENTAL FACTORS	
1. Reduced visibility by fog	(22)
2. Narrow channel or passage	(15)
3. Other ship-Manoeuvring against rules	(10)
TECHNICAL FAULTS & DEFICIENCIES	
1. Breakdown of radar	(3)
2. Poor bridge design	(2)
HUMAN ELEMENTS	
1. Negligence in the critical situation	(19)
2. Excessive speed under the circumstance	(13)
3. Improper decision	(11)

(9) Kunsan area

ENVIRONMENTAL FACTORS	
1. Reduced visibility by fog	(9)
2. Narrow channel or passage	(8)
3. Other ship on collision course	(5)
TECHNICAL FAULTS & DEFICIENCIES	
1. Breakdown of radar	(1)
2. Lack of equipment	(1)
HUMAN ELEMENTS	
1. Negligence in the critical situation	(6)
2. Improper manoeuvre (engine, steering gear, etc.)	(6)
3. Improper decision	(4)

(10) Inchon area

ENVIRONMENTAL FACTORS	
1. Narrow channel or passage	(17)
2. Reduced visibility by fog	(16)
3. Other ship-Manoeuvring against rules	(9)
TECHNICAL FAULTS & DEFICIENCIES	
1. Lack of equipment	(3)
2. Poor maintenance or inspection	(2)
HUMAN ELEMENTS	
1. Excessive speed under the circumstance	(14)
2. Negligence in the critical situation	(12)
3. Did not use every equipment available in the situation	(7)

Source: Author

4.4.3 EFFECT LEVEL OF CAUSAL FACTORS

The average effect of a causal factor of each group can be examined by calculating separately the mean value of the weight coefficients given to the factors of each group. The mean values of weight coefficients are shown in Table 4.15 which is based on all casualties in the sample. On the basis of Table 4.15 and Table 4.12 it is clear that health condition, working environment and ship control tasks, when those are present and have been identified as one of the causes of a casualty, have on the average a more marked effect on the occurrence of the casualty than the factors of other group. Technical faults & deficiencies and watchkeeping are another group of factors which have more effect on the occurrence of the casualty than the other group of factors.

Table 4.15 Mean weight coefficient by factor groups

Group	Sub-group	Number of factors weighted	Mean weight	
Environmental conditions	External conditions	226	0.44	0.42
	Waterway conditions	258	0.25	
	Working environments	190	0.63	
Technical fault and deficiencies		114	0.58	
Human factors	Health condition	15	0.65	0.59
	Organization/Training	78	0.46	
	System interface	26	0.30	
	Watchkeeping	264	0.56	
	Control tasks	477	0.63	

Source: Author

By employing the effect level the relative importance of the three factor groups can be compared. Table 4.16 shows the effect levels of the three main group with sub-groups.

Table 4.16 The relative importance of each group of causal factors

Main group	Sub-group	Effect level (%)	
Environmental conditions	External conditions	0.12	0.33
	Waterway conditions	0.08	
	Working environments	0.14	
Technical faults and deficiencies		0.08	
Human factors	Health condition	0.01	0.59
	Organization & Training	0.04	
	System interface	0.01	
	Watchkeeping	0.17	
	Control tasks	0.35	

Source: Author

Ship control tasks sub-group of human factors is the most important (35%) causal factors of marine casualty, watchkeeping conditions account for 17 percent, working environments for 14 percent, external conditions for 12 percent and so on. As a whole, 59 percent of collision, stranding, ramming and foundering accidents are attributable to human errors in this study.

Table 4.17 shows the effect levels of the three groups in different type of casualties. Human factors are the most dominant (63%) cause of collision incidents, environmental conditions accounts for 30 percent of groundings and technical faults and deficiencies (40%) is dominant in foundering incidents.

Table 4.17 The relative importance of the three factor groups in different type of casualties **(PARK J S)**

	Collision (n=242)	Grounding (n=81)	Ramming (n=23)	Foundering (n=35)
Environmental conditions	0.35	0.30	0.34	0.25
Technical faults and deficiencies	0.02	0.10	0.12	0.40
Human factors	0.63	0.60	0.54	0.35

Source: Author

By comparison, Tuovinen[4-33] reported that environmental factors are the most dominant(77%) cause of collision accidents, human factor accounts for 45 percent of groundings and technical deficiencies and their reasons are dominant(48%) in foundering incidents. Table 4.18 is the summary of the results of their study.

Table 4.18 The relative importance of the three factor groups in different types of casualties **(TUOVINEN P)**

	Collision (n=81)	Grounding (n=219)	Ramming (n=120)	Foundering (n=23)
Environmental conditions	0.77	0.44	0.49	0.41
Technical deficiencies	0.07	0.11	0.22	0.48
Human factors	0.16	0.45	0.29	0.11

Source: TUOVINEN P. et al (1983). page 52

Table 4.19 presents the most influential single factors in different type of casualties. In collision three factors belong to the group environmental conditions and two factors to the human factor group. But four factors belong to the group human factors and one to environmental conditions in grounding accidents. In foundering incidents, two factors belong to the group technical faults and two to the human factors group.

Table 4.19 The most influential factors in different type of casualties

Collision (n=242)	Effect Level
Negligence of lookout	0.10
Other ship - No reaction to the critical situation	0.10
Other ship - Manoeuvring against rules	0.09
Negligence in critical situation	0.08
Reduced visibility by fog	0.08
Grounding (n=81)	Effect Level
Not fix position regularly or at all	0.13
Error in voyage planning	0.07
Negligence in critical situation	0.05
Stormy weather	0.05
Reduced visibility by fog	0.05
Ramming (n=23)	Effect Level
Stormy weather	0.15
Negligence in critical situation	0.08
Not fix position regularly or at all	0.08
Breakdown of main engine	0.07
Improper decision	0.06

(continued)

Foundering (n=35)	Effect Level
Stormy weather	0.15
Poor stowage or securing	0.13
Fracture of ship structure	0.12
Negligence in critical situation	0.08
Improper manoeuvre	0.07

Source: Author

From the Table 4.19 the following conclusions can be drawn:

(1) In cases of collision the most probable causes seem to be related to the working environment or human error (negligence of lookout and negligence in critical situations show higher effect levels). Of environmental conditions, other ship's no reaction to the critical situation or other ship's manoeuvring against International rules and reduced visibility by fog are major factors in collisions.

(2) For vessels grounding navigational and ship control tasks seem to be the most significant factors such as not fixing vessel's position regularly, error in voyage planning and negligence in critical situations.

(3) In the cases of rammings stormy weather is the most influential factor whilst breakdown of main engines often occur.

(4) In the cases of founderings the most important causes seem to be of technical faults and environmental conditions (poor stowage and/or securing, fracture of ship structure and stormy weather show higher effect levels).

Table 4.20 shows the effect levels of the three groups in different part of the Korean coastal waters. Human factors are the most dominant cause in all the areas, 56 - 68 percent, environmental conditions group accounts for 27 - 41 percent and technical faults and deficiencies for 0 - 15 percent. Human factors group has a higher effect level in Ulsan, Masan and Yosu areas, while Kunsan, Mokpo, Pusan and Inchon areas have higher values in the environmental conditions group than others.

Table 4.20 The relative significance of the three factor groups in different sub-areas

Sub-area	Environmental conditions	Technical faults and deficiencies	Human factors
Tonghae area (n=23)	0.31	0.12	0.57
Pohang area (n=31)	0.31	0.12	0.57
Ulsan area (n=17)	0.32	0	0.68
Pusan area (n=64)	0.35	0.06	0.59
Masan area (n=32)	0.32	0.05	0.63
Yosu area (n=57)	0.33	0.07	0.61
Cheju area (n=42)	0.27	0.15	0.58
Mokpo area (n=49)	0.36	0.06	0.58
Kunsan area (n=22)	0.41	0.03	0.56
Inchon area (n=44)	0.35	0.08	0.57

Source: Author

Table 4.21 presents the most significant single causal factors and their effect levels in different parts of Korean waters. The noticeable point is that "not using every item of aid/equipment available in the situation" is the one of the most serious causal factors in the Tonghae area. Another conspicuous point is that reduced visibility by fog and rogue vessels are the most crucial causal factors in the Inchon area. The main causal factors in other areas are more or less the same; negligence of lookout, other ship's manoeuvring against rules, negligence in critical situations, improper manoeuvre and not using every item of equipment available in the situation show higher effect levels.

Clearly "reduced visibility by fog" is one of the top three causal factor in the west coast region and is ranked fourth or fifth place in the south coast area, but it is not the major factor in the east coast waters.

Table 4.21 The most influential factors in different sub-areas

Tonghae area (n=23)	
Not use every available aids/equipment in the situation	0.10
Improper manoeuvre	0.10
Other ship - No reaction to the critical situation	0.10
Improper decision	0.07
Stormy weather	0.07
Pohang area (n=31)	
Negligence of lookout	0.09
Other ship - No reaction to the critical situation	0.08
Negligence in critical situation	0.07
Improper manoeuvre	0.06
Poor stowage or securing	0.04
Ulsan area (n=17)	
Other ship - Manoeuvring against rules	0.12
No reaction to the critical situation	0.10
Other ship - No reaction to the critical situation	0.08
Improper manoeuvre	0.07
Error in voyage planning	0.06
Pusan area (n=64)	
Negligence in critical situation	0.11
Other ship - No reaction to the critical situation	0.08
Negligence of lookout	0.08
Improper manoeuvre	0.07
Reduced visibility by fog	0.07
Masan area (n=32)	
Negligence of lookout	0.12
Other ship - Manoeuvring against rules	0.12
Negligence in critical situation	0.10
Reduced visibility by fog	0.08
Not fix position regularly or at all	0.06
Yosu area (n=57)	
Negligence of lookout	0.12
Improper manoeuvre	0.07
Other ship - No reaction to the critical situation	0.07
No reaction to the critical situation	0.06
Reduced visibility by fog	0.06
Cheju area (n=42)	
Negligence of lookout	0.08
Other ship - No reaction to the critical situation	0.07
Not fix position regularly or at all	0.06
No reaction to the critical situation	0.06
Stormy weather	0.06

(continued)

Mokpo area (n=49)	
Negligence in critical situation	0.12
Reduced visibility by fog	0.09
Improper manoeuvre	0.07
Improper decision	0.07
Other ship - Manoeuvring against rules	0.05
Kunsan area (n=22)	
Negligence in critical situation	0.09
Improper manoeuvre	0.09
Reduced visibility by fog	0.06
Negligence of lookout	0.06
Improper decision	0.06
Inchon area (n=44)	
Reduced visibility by fog	0.07
Other ship - Manoeuvring against rules	0.07
Negligence in critical situation	0.06
Not use every available aids/equipment in the situation	0.05
Improper manoeuvre	0.05

Source: Author

4.5 CONSEQUENCES OF CASUALTIES

The most important known consequences of the casualties in this study are summarized in Table 4.22.

Table 4.22 Summing up consequences of casualties

Consequences	Number of accidents
Live lost	35 (139 lives lost)
Injuries	11 (54 persons injured)
Total losses	75
Hull damages	249
Engine damages	30
Cargo damages	24
Damage to objects	20
Propeller damages	17
Rudder damages	9
Oil outflow	16 (1,417 tons spilled)

Source: Author

The evident common measure of the seriousness of a casualty is the monetary value of the consequences. Unfortunately, however, the primary source of data in this study does not contain information on this aspect.

Table 4.23 shows the loss of life by casualty type, and the average and expected number of lives lost in each casualty type is given. It is evident that foundering is the most serious casualty type to threaten the lives of seaman.

Table 4.23 Lives lost by casualty type

Type of casualty	Number of cases	Lives lost	Number of casualties	Expected number per casualty
Collision	20	70	242	0.2893
Stranding	5	12	81	0.1481
Ramming	2	3	23	0.1304
Foundering	8	54	35	1.5429
Total	35	139	381	0.3648

Source: Author

The last column of Table 4.23 demonstrates the mean or expected number of lives lost in each ship involved in the casualty. In the case foundering accident 1.5 lives are expected to be lost per casualty, while 0.29 life is expected to be lost in collision incident.

Table 4.24 Total losses by casualty type

Type of casualty	Number of total losses	Number of casualties	Expected number per casualty
Collision	35	242	0.1446
Stranding	13	81	0.1605
Ramming	0	23	0
Foundering	27	35	0.7714
Total	75	381	0.1969

Source: Author

The 75 total losses out of 381 casualties are distributed by casualty types in Table 4.24. Clearly foundering accidents caused a higher rate of total losses, but no total losses were reported by ramming incidents. In general the expected number(0.1969) is high, and the number implies that approximately one of five ships involved in the casualties has met with total loss. The high total loss ratio of Korean fleet was reported by JAMRI (Japan Maritime Research Institute) that the ratio is twice the world average.[4-34]

Information on the 16 oil outflows was derived from a sample of 289 ships. More than 16 oil spills resulting from ship casualties are likely to have taken place in the Korean waters in the years 1986-90, but because of the publicity given to oil accidents the sizes and effects of the unknown cases are probably small.

Seven of the oil outflows were the consequence of collisions; seven took place in groundings and two in connection with founderings. The total amount spilled in the reported oil leakages was 1,417 tons, but the reported amounts are evidently very rough estimates. About 1,027 tons of the total amount was spilled in one tanker collision, about 154 tons in one cargo vessel grounding and about 100 tons in one tanker foundering, thus the remaining cases were of an essentially smaller order of magnitude.

Hull damage, cargo damage, damage to object, propeller damage and rudder damage were ranked in five different categories: no, slight, moderate, serious damage and unknown severity. This classification is susceptible to subjective interpretation, but it gives some measure to estimate the severity of the damages. Table 4.25 classifies severity of hull damage in different casualty types. Clearly collisions bring about more severe hull damage.

Table 4.25 Number of hull damage by casualty type

	Collision	Grounding	Ramming	Foundering	Row Total
No damage	41	4	12	0	57 18.6%
Slight damage	72	16	7	0	95 31.0%
Moderate damage	72	28	3	4	107 35.0%
Serious damage	21	17	0	0	38 12.4%
Unknown	1	3	1	4	9 2.9%
Column Total	207 67.6%	68 22.2%	23 7.5%	8 2.6%	306 100%

Number of Missing Observation : 75
Source: Author

4.6 SUMMARY

(1) The negative binomial model presents a closer fit to the observed distribution than the Poisson, when subjected to a chi-square test. The negative binomial model shows there is 71 percent chance that there will be no accident (of collision, grounding, ramming and foundering), and there is 22 percent chance of one accident on any day.

(2) The casualty frequency for Korean ships above 500 tons is very high, approximately 2.5 times that of Norwegian ships. Merchant ship accidents tend to occur in ports & harbours, while fishing vessel casualties are most frequent in coastal waters and open sea. The geographical distribution of casualties shows that the highest number of casualties occurs in the Pusan/Ulsan area, and the south coastal water has a higher number of accidents than the east & west coasts of Korea.

(3) The seasonal distribution of the number of ship casualties shows a clear periodic feature. Smaller ships have more accidents during winter whilst larger vessels have more in summer. High number of collisions occur in summer period and of founderings occur in winter period. This seasonal variation of collision accidents differs from that in European waters where more collisions occur in winter period.

(4) According to block scheme analysis of each accident environmental conditions are often present as important causes of casualties. Reduced visibility by fog is the most common causal factor. Human errors of seafarers are dominant (59%) causal factors in casualties: specially negligence in critical situation, negligence of lookout, excessive speed under the circumstances and improper manoeuvre.

(5) The average effect of a causal factor of each group was examined by calculating the mean values of weight coefficients. Health condition of watchkeepers, working environments and ship control tasks group, when those are present and have been identified as one of the causes of a casualty, have on the average a more marked effect on the occurrence of the casualty than the factors of other groups.

(6) By applying the effect level the relative importance of the causal factors were compared. In general the ship control tasks sub-group of human factors was the most significant marine casualty factor with 0.353 probability while the working environments sub-group of environmental conditions had a probability of 0.14. In collisions negligence of lookout and other ship's failure to the critical situations were the most important factors, while not fixing position regularly and error in voyage planning were principal factors in grounding incidents. Stormy weather was the most influential factor in rammings whereas stormy weather, poor stowage and fracture of ship structure were the factors in foundering accidents. 59 percent of casualties concerned was attributable to human error of the seafarers involved.

(7) The most influential single causal factors and their effect levels in different part of Korean waters were analyzed. Reduced visibility by fog and rogue vessels were the most important causal factors in the Inchon area. Another noticeable point is that "not using every item of aid/equipment available in the situation" was the one of the most serious causal factors in the Tonghae area.

(8) The consequences of casualties were examined. Foundering was the most serious casualty type to threaten the lives of seamen. Clearly foundering accidents caused a higher rate of total loss, but no total losses were reported by ramming incidents.

(9) The total amount spilled in the reported oil leakages was 1,417 tons, but the amount of spillage was small except in a few cases.

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Chapter 5

EVALUATION OF THE EFFECTIVENESS OF EXISTING TRAFFIC SERVICES

5.1 INTRODUCTION

In navigating on the high seas ships largely proceed in isolation. When occasionally they meet, all the measures needed to ensure their safe passage are covered by the established steering and sailing rules. By contrast, when navigating the waters nearer to ports of arrival and departure, the routes taken by shipping tend to converge and become constrained by underlying hydrographic features and adjacent coastlines, giving rise to areas of relatively high traffic concentration. Local movements by smaller vessels, ferries, fishing vessels and pleasure craft may add to congestion and the density of shipping may build up to such an extent that encounters between them no longer occur in isolation, as on the high seas, but rather in a sequence each offering varying degrees of hazard or, perhaps worse, simultaneously in the form of a complex multi-ship situation. It is in these circumstances where some level of marine traffic service operating in such a way as to complement and not to conflict with the normal rules for collision avoidance may, and experience would suggest does, help to reduce the attendant risks of collision and so contribute to overall safety of navigation.

The provision of a navigation service to shipping implies assisting vessels in some way with their passage. The issue of hydrographic data and establishment of navigational aids such as lights, buoys and other position fixing systems may therefore be regarded as the first basic steps towards an area traffic service. These should ensure that vessels are aware of any natural constraints on their choice of routes, but overall patterns will still be largely random, and to progress to an improved level of service the next logical step is to attempt to produce some orderliness in the traffic flow. The principle of traffic routeing, whereby vehicles on conflicting journeys are prevented from meeting in potential collision circumstances by following separated paths, is equally applicable to all modes of transport.

Unlike road or rail transport, where the constraints on direction of movement are largely achieved by engineering features implicit in the system design, at sea and in the air too, movement through navigable space can only be ordered in a practical way by the designation of artificial boundaries. It is just over 25 years since the particular configuration of the worlds' first marine traffic separation scheme, that in the Strait of Dover, was so designated and implemented by the Intergovernmental Maritime Consultative Organisation (IMCO), as a recommendation for all ships to follow.[5-1]

New traffic systems including Traffic Separation Schemes (TSS), may be evaluated through accident and traffic analysis. Referring to the Dover Straits, Bowdidge[5-2] stated that;

> Over the period examined, it can be fairly assumed that the introduction of traffic routeing and surveillance leading to the advent of the Channel Navigation Information Service (CNIS), has contributed significantly to the observed reduction in the average number of collisions from 17 to 5 per annum.

Dare and Lewison[5-3] analyzed the number of casualties and the amount of damage occasioned for the periods 1967-72 and 1973-79. They claimed that;

> There has been a reduction of about one half in the numbers of both collisions and strandings in the Dover Straits and a much greater reduction in the amount of damage.

Johnson[5-4] analyzed the time trends of collision incidents over 15 years (1962-1977) in the Dover Straits. From the results it is apparent that over the five year period following the introduction of the TSS there were 23 percent fewer collision than in the previous five years. During the next five year period, when the TSS routeing scheme was supported by the CNIS, there was a further 55 percent of reduction in the number of collisions. Cockcroft[5-5] has assessed the effectiveness of routeing off north west Europe by comparing collision statistics for every 5 year periods since 1957 to 1981 and asserted that there has been a considerable improvement in traffic safety in the coastal region after introducing routeing schemes.

Meantime, Fujii & Kaku[5-6] reported that MTSL (Maritime Traffic Safety Law) routeing in Tokyo Bay was effective in decreasing the number of collision & grounding accidents, and the introduction of a traffic service with an advisory centre contributed to a further drop in the number of accidents. From the data according to the authors, it is evident that over the five year period following the introduction of the TSS there were 15 percent fewer collision and 23 percent fewer grounding than in the previous five years. After the Tokyo Bay Traffic Advisory Centre became operational, there was a further 32 percent of reduction in the number of collisions.

Note (1) Comms: Communications

This chapter describes the effectiveness of the existing traffic services in Korean waters through the accident and traffic analysis, and introduces accident danger index to compare the level of danger in different time periods. The primary source of traffic data is the "Statistical Year Book of Shipping and Ports" by KMPA. And the primary sources of accident data are the "Written verdicts and their appendices" by the "Maritime Accidents Inquiry Agency" and the "Marine casualty diary (1962-1983)" by the "Korea Shipowners Association". Secondary sources are;

- Shipping directory Korea by Korea Maritime Research Institute
- The status quo of partners by Korea Shipping Association
- Register of ships by Lloyd's Register of Shipping
- Commercial shipping fleets by Fairplay information systems

The locations of existing traffic services including TSS and VMRS in Korean coastal waters are illustrated in Fig 5.1.

5.2 THE INCHON INBOUND AND OUTBOUND ROUTES

Inchon Hang(port) is the port of the capital city of Seoul, and has both inner and outer harbours. The outer harbour consists of an anchorage and some oil berths in the river, and two tidal basins. The inner harbour is a non-tidal basin which is entered through twin parallel locks. The inner harbour and two tidal basins have been built upon reclaimed land between the mainland coast and former islands. Extensive reclamation and harbour development has taken place and reclamation is still in progress. Inchon Hang has several characteristics including;

- a large rise and fall of tide, over 8.5 metres(28 ft) at spring tide with strong associated tidal currents of a maximum 3.3 m/sec on the flood and 2.1 m/sec on the ebb.

- fog occurs on about 58 days a year, mostly during the months of March to August, and snow occurs on about 25 days a year,

- inshore islands and shoals are a hindrance to navigation in the approach to Inchon Hang.

There has been a rapid growth of vessel movements in the port, as can be seen on Fig 5-2, at an annual rate of as much as 14 percent during the period to reach a total of 44,785 vessel movements in 1990. To cope with this situation, the Inchon traffic separation scheme was introduced for the inbound and outbound routes in the approach to Inchon Hang. The inbound routes of the scheme follows the channel through Tong-sudo (East channel), and the outbound route follows the channel through So-sudo (West channel) with the departure point in Pando-sudo. The scheme is not IMO adopted, but there are local regulations applying to it. The regulation came into force from 15th April 1981 and applies to all vessels of 500 tons or more (later amended to "not less than 30 metre length" on April 17 1991)[5-7]:

(1) Ships of 500 tons or more shall navigate within the traffic lane, incoming shipping to Inchon using Tong-sudo and outgoing shipping the So-sudo.

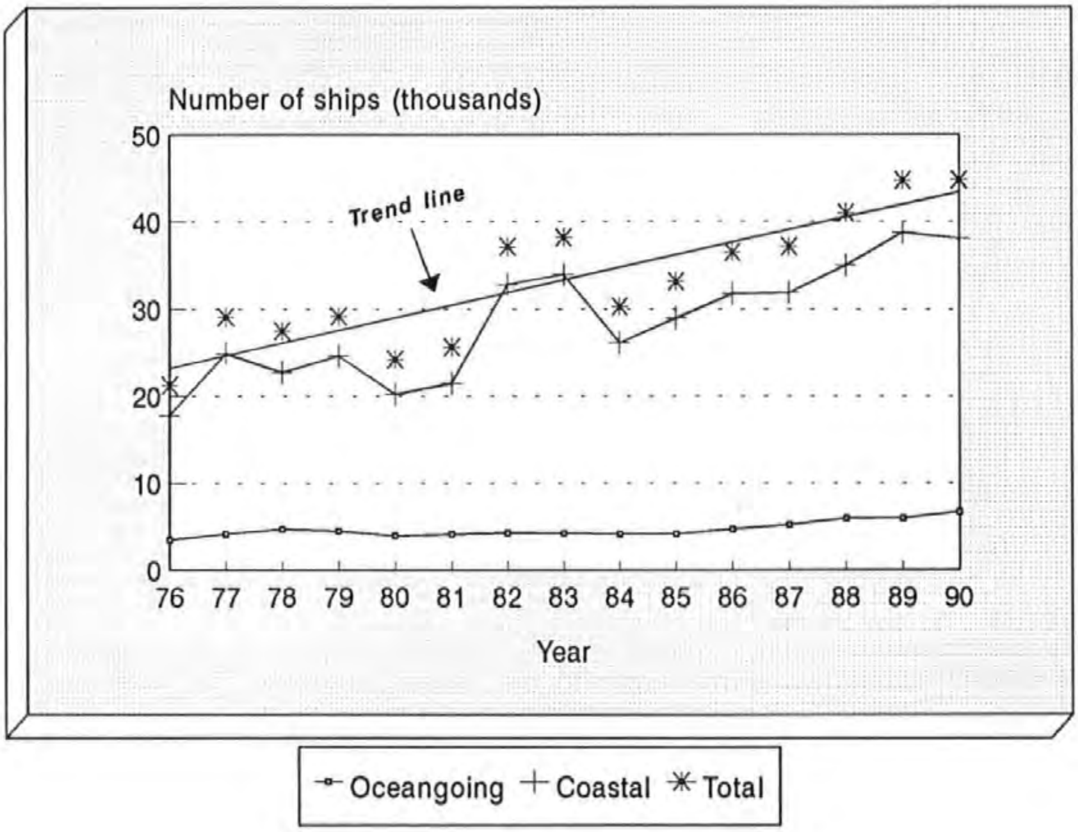
The ship proceed from Inchon Hang to Asan Man can navigate Tong-sudo and the ship proceed from the NW area of Tokchok-do to Inchon Hang can navigate So-sudo, but those ships shall navigate to the far right side of the route and shall not impede the passage of other traffic following the scheme.

(2) Ships of less than 500 tons shall navigate according to (1) as practicable and shall not impede the passage of other traffic following a traffic lane.

(3) If, however, there is any obstacles on the route and dangers to traffic, able to not follow the scheme. But those ships shall navigate to the far right side of the route and shall not impede the passage of other traffic following the scheme.

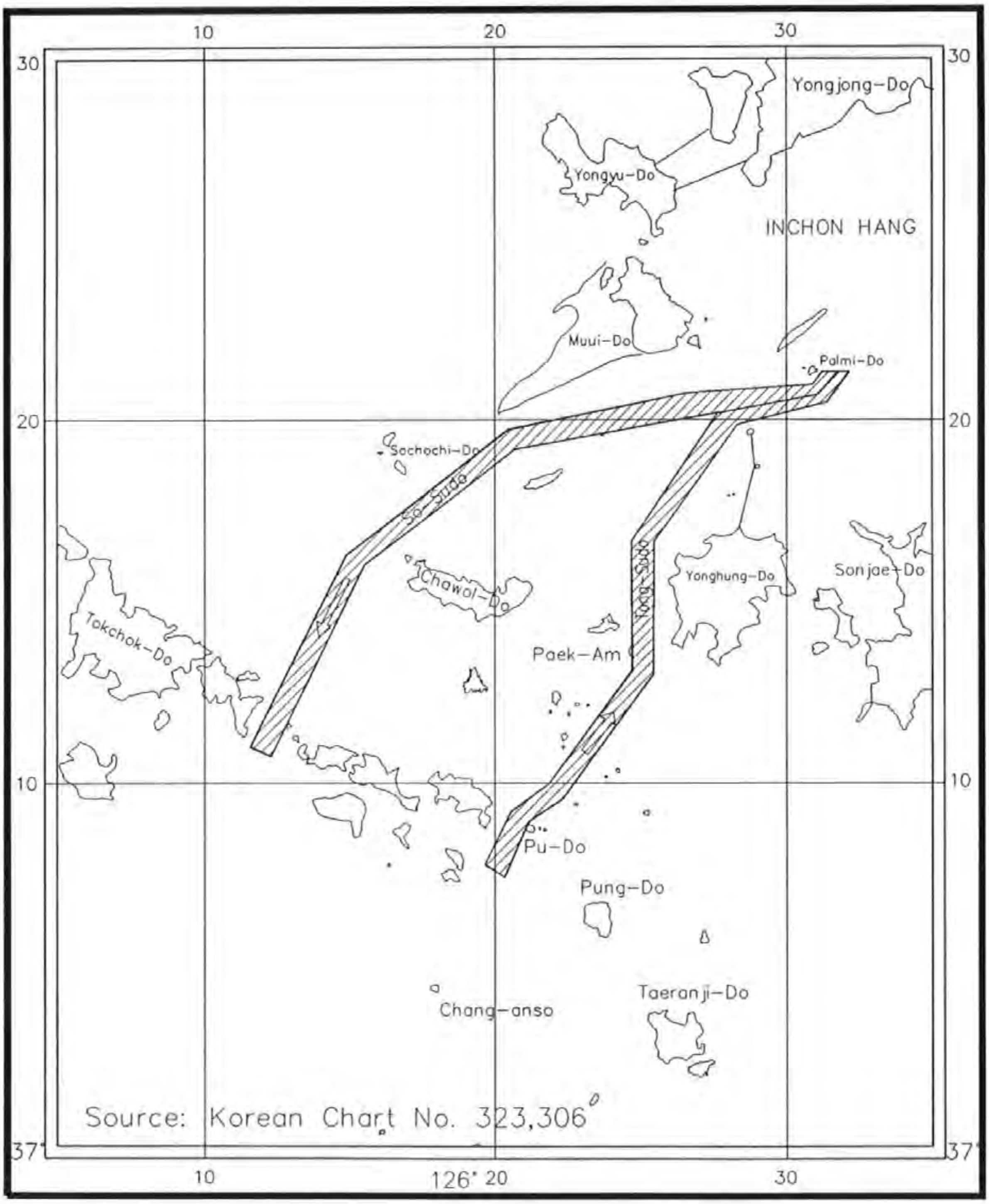
In essence an extension of the basic "keep to the right-rule of the road" determining flow in one-way main traffic lanes with inshore areas set aside for local shipping movements in any direction (see Figure 5.3), the Inchon traffic separation scheme existed for 12 years, but there was no documentation concerning numbers and types of vessels transiting.

Fig 5.2 Trends of vessel movements in Inchon
(Arrival + Departure)



Source: Statistical Yearbook, KMPA

Fig 5.3 Inchon Inbound/Outbound Route



5.2.1 SCOPE OF INVESTIGATION

(1) Sea area: The area covered, which is shown in Fig.5.3, includes not only the designated waterways but also regions where ships converge or cross before entering, and extends from latitude 37° 00′ north to 37° 25′ north, and from 126° 05′ east to 126° 35′ east. The Inchon and Pyongtaeg harbours are excluded.

(2) Types of casualties: The analysis includes casualties reported in "Written Verdicts" which satisfy one or more of the following conditions:

(i) collisions involving vessels not less than 500 gross tons, but excluding collisions with buoys, anchored vessel or floating objects.

(ii) groundings involving vessels not less than 500 GRT.

(3) Period: The 14 year span April 15 1976 to April 14 1990 can be divided into two five year periods and a four year periods:

Period	No. of years	Duration	Remarks
A	5	April 15 1976- April 14 1981	Pre-routeing period
B	5	April 15 1981- April 14 1986	Routeing scheme
C	4	April 15 1986- April 14 1990	Routeing scheme

5.2.2 TRAFFIC ACCIDENTS (COLLISIONS AND GROUNDINGS)

(1) Occurrence and time: In the 14 years period there were 18 collisions, involving 27 vessels and excluding ships below 500 tons, and six groundings in the area under study. Table 5.1 summarizes the number of accidents in the area of concern during the 14 year period. The table indicates that there was no difference in the number of accidents before and the first five year period after the introduction of routeing scheme, but

increase in the number of accidents during the period of C. The number of collision accidents was increased considerably during the period of C while the grounding incidents decreased remarkably. The difficulty, however, here is that the number of accidents are so small that it is impossible to test for significant differences.

Table 5.1 Number of accidents in Inchon routeing scheme

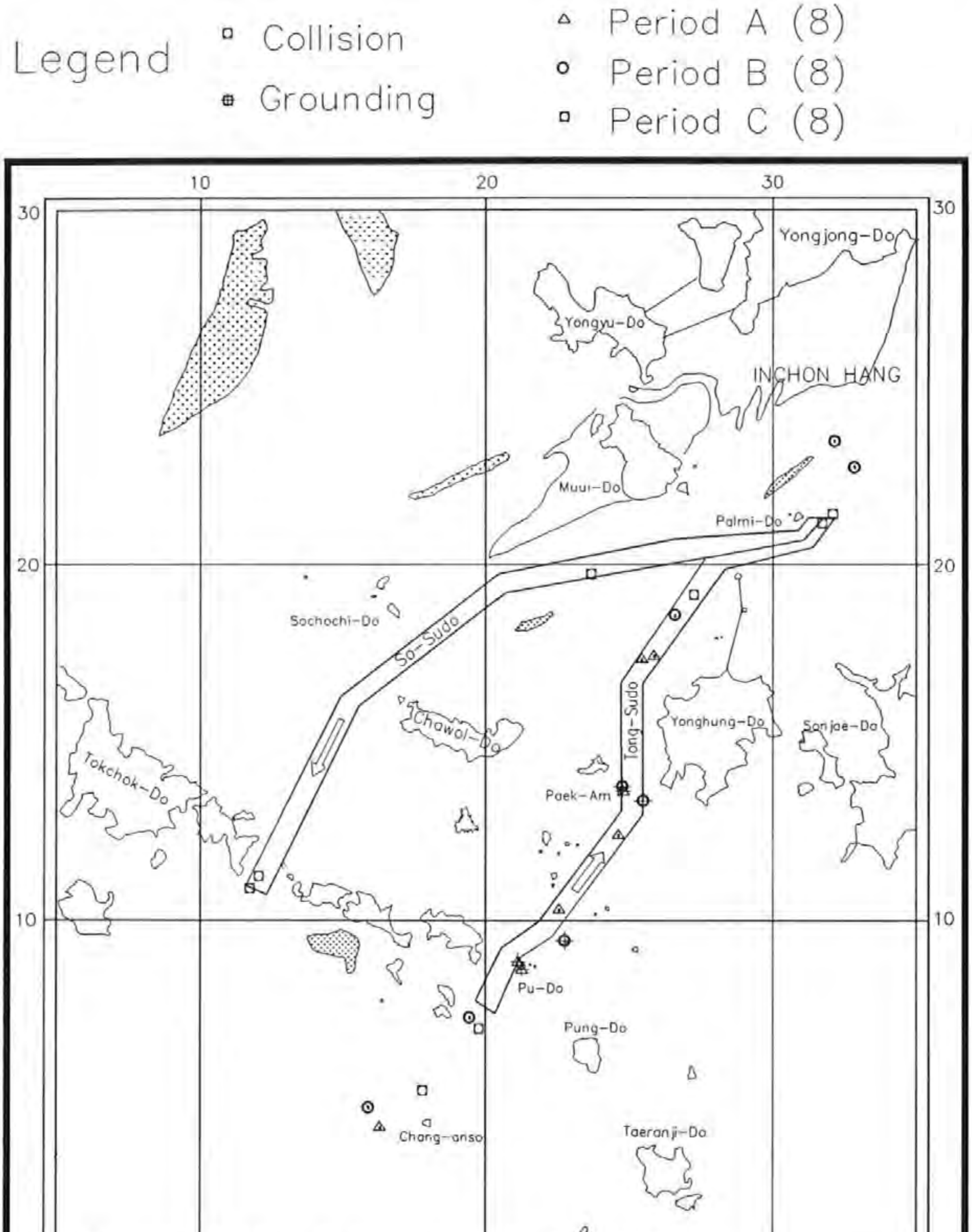
Period	A	B	C	Total
Number of collisions (Number of ships involved)	5 (9)	5 (7)	8 (11)	18 (27)
Number of groundings	3	3	0	6
Total number of accidents	8 (12)	8 (10)	8 (11)	24 (33)

Source: Author

(2) Position: As can be seen from Figure 5.4, which shows the position of accidents, the majority of accidents, 17 out of 24 incidents, occurred in the Tong-sudo or its southern approach, three accidents in So-sudo or its southern approach and four accidents at the northern end or approach of the routes. All the accidents before the routeing scheme was introduced occurred in Tong-sudo and its southern approach, six accidents in Tong-sudo and its southern approach and two at the northern approach to the routes during the period B. But the location of accidents was more spread over the whole area during the period C, namely three accidents in Tong-sudo and its southern approach, three in the So-sudo and its southern approach and two at the northern end of the routes.

The accidents, which the details are known, occurred after the introduction of the routeing scheme comprises: seven meeting collisions, one crossing collision and one grounding incident. Six cases occurred under reduced visibility (less than 300 metres visibility), and seven ships violated the "keep to the right-rule of the road".

Fig 5.4 Locations of Traffic Accident (Inchon)



A grounding occurred just off the route to avoid immediate meeting collision. Table 5.2 specifies the details of the accident.

Table 5.2 Accidents in Inchon after the introduction of routeing scheme

No	Ship	Type	Visibility	Pilot	Local rule	In/Outward
1	Ship A Ship B	Collision (M)	200m	N/A boarded	met violated	Inward Outward
2	Ship C	Grounding	clear	boarded	violated	Outward
3	Ship D Ship E	Collision (M)	200-250m	boarded N/A	met violated	Inward Outward
4	Ship F Ship G	Collision (M)	clear	N/A N/A	met O.K	Inward Outward
5	Ship H Ship I	Collision (M)	50m	N/A N/A	met violated	Outward Inward
6	Ship J Ship K	Collision (M)	30m	N/A boarded	violated violated	Outward Inward
7	Ship L Ship M	Collision (M)	200-300m	N/A N/A	met met	Outward Inward
8	Ship N Ship O	Collision (C)	300m	N/A boarded	violated met	Outward Inward
9	Ship P Ship Q	Collision (M)	clear	N/A N/A	met met	Inward Outward

Source: Author

(3) Size of Vessel (gross ton): Table 5.3 evidences the average size of vessels in the accidents in the waterway varied, from 11,769 tons to 7,247 tons and to 8,738 tons excluding unknown tonnages, but there is no indicative difference (8,815 to 7,247 tons and to 8,738 tons) if one large tanker of 44,263 grt is excluded during the pre-routeing period. So it appears possible that the introduction of routeing has led to a reduction in the number of ships involved in the traffic accidents for larger ships (10,000 g.r.t and over), but not for smaller vessels.

Table 5.3 Size of ships involved in accidents

GRT category	Period A		Period B		Period C		Total	
	No	GRT	No	GRT	No	GRT	No	GRT
500 - 2,999	3	4,308	3	3,789	2	2,248	8	10,345
3,000 - 4,999	2	6,942	2	7,901	3	9,879	7	24,722
5,000 - 9,999	1	6,333	0	0	2	13,053	3	19,386
10,000 - 19,999	5	79,378	3	46,288	2	27,942	10	153,608
20,000 & over	1	44,263	0	0	2	42,995	3	87,258
Unknown	0	0	2	α	0	0	2	α
Total	12	141,224	10	57,978+α	11	96,117	33	295,319+α

Source: Author

Since accident danger is proportional to traffic density, a simple formula can be used to estimate the accident danger(S_a) for one trip as $N/2Q$, where N and Q are number of traffic accidents in each period and the number of vessels entering Inchon Hang in the corresponding period.

Table 5.4 Number of vessels in traffic accident (N) and Number of vessels entering Inchon Hang (Q) for the period of A through C.

GRT category	500 - 2,999	3,000- 4,999	5,000- 9,999	10,000- 19,000	20,000 & over	Total
N_A	3	2	1	5	1	12
(percentage)	25.0	16.7	8.3	41.7	8.3	
N_B	3	2	0	3	0	8
(percentage)	37.5	25.0	0.0	37.5	0.0	
N_C	2	3	2	2	2	11
(percentage)	18.2	27.2	18.2	18.2	18.2	
Q_A	4,257	3,666	1,693	2,770	653	13,039
Q_B	9,217	4,083	1,816	3,236	1,276	19,628
Q_C	19,721	4,461	2,564	3,011	1,943	31,700
$N_A/2Q_A$	0.00035	0.00027	0.00030	0.00090	0.00077	0.00046
$N_B/2Q_B$	0.00016	0.00024	-	0.00046	-	0.00020
$N_C/2Q_C$	0.00005	0.00034	0.00039	0.00033	0.00051	0.00017
Total	0.00012	0.00029	0.00025	0.00055	0.00039	0.00024

Source: Author

The number of vessels entering Inchon Hang, ***Q***, is calculated from the Statistical Year Book issued yearly by Korea Maritime and Port Administration. ***2Q*** denotes the number of ships entering and departing Inchon Hang.

Table 5.4 suggests that the overall accident danger per trip was decreased considerably after introduction of the routeing scheme, 0.00046 to 0.00020, and slowly thereafter. It appears highly probable that the introduction of the routeing scheme has led to a reduction in accident danger for most size categories except the category of 3,000-4,999 and 5,000-9,999 gross tons.

(4) Type of Vessel: Distribution of traffic accidents by type of vessel are summarized in Table 5.5. Over 68 percent of the vessels involved in traffic accidents are cargo vessels and 18.8 percent are tankers. From the table, it is apparent that the number of tankers involved in casualties is decreasing, but that of cargo vessels has remained unchanged. The details of these collision and grounding incidents are included in the Annex D.

Table 5.5 The accidents by type of vessel

Vessel Type	Total		Period A		Period B		Period C	
	No	%	No	%	No	%	No	%
Tankers	6	18.8	3	25.0	2	22.2	1	9.1
Cargo ships	22	68.7	8	66.7	6	66.7	8	72.7
Fishing vessels	2	6.3	1	8.3	1	11.1	0	0
Naval ship	2	6.2	0	0	0	0	2	18.2
Unknown	1		0	0	1		0	0
Total	33	100.0	12	100.0	10	100.0	11	100.0

Source: Author

However, further analysis is not feasible due to lack of traffic data such as size and type of vessel distribution in different time periods.

5.3 TRAFFIC SEPARATION SCHEME OFF KANJOL-GAP

Kanjol-Gap is a point, fringed with rocks which extends one mile offshore, at south-east coast of Korea and is in between the port of Ulsan and Pusan, approximately five miles south from Ulsan and 20 miles north from Pusan.

There is heavy traffic with many tankers including LPG & chemical tankers using the two oil refineries and a heavy & chemical industrial complex at Ulsan. To cope with the situation, a traffic separation scheme (TSS) was introduced in October 1982. The scheme, comprising lanes 1 mile wide, for northbound and southbound traffic divided by a separation zone, two cables wide, established off Kanjol-Gap (see Figure 5.5). The scheme has not been adopted by IMO, but the following rules have been promulgated by the Korean authorities:

> Ships of 300 tons or more shall navigate within the traffic lanes, northbound shipping using the east lane and southbound shipping the west lane, and shall keep near to the outer limit of the lane. Ships of less than 300 tons shall adhere to the scheme if practicable and shall not impede the passage of other traffic following a traffic lane.
>
> Ships shall always keep a listening watch on VHF channel 16 within the limits of the traffic separation scheme.[5-8]

Although this traffic scheme has existed for 10 years, no documentation is available about the numbers and types of transiting.

5.3.1 SCOPE OF INVESTIGATION

(1) Sea Area: The area covered, which is shown in Fig.5.5, includes not only the designated TSS but also regions where ships converge or cross before entering the TSS, and extends from latitude 35° 10′ north to 35° 30′ north, and from longitude 129° 10′ east to 129° 35′ east. Harbours are excluded.

<u>(2) Type of casualties</u>: The analysis includes casualties reported in "Written Verdicts" which satisfy one or more of the following conditions:

(i) collisions involving vessels not less than 300 Gross Tons, but excluding collisions with buoys, anchored vessel or floating objects.

(ii) groundings involving vessels not less than 300 Gross Tons.

<u>(3) Period</u>: The 10 year span October 25 1977 to October 24 1987 can be divided into two equal periods:

Period	No. of years	Duration	Remarks
A	5	October 25 1977- October 24 1982	Pre-routeing period
B	5	October 25 1982- October 24 1987	Routeing scheme

5.3.2 TRAFFIC ACCIDENTS (COLLISIONS AND GROUNDINGS)

<u>(1) Occurrence and time</u>: In the 10 years there were 10 collisions (16 vessels involved excluding ships less than 300 tons) and two groundings in the area.

Table 5.6 Number of accidents off Kanjol-gap TSS

Period	A	B	Total
Number of collisions (Number of ships involved)	6 (9)	4 (7)	10 (16)
Number of groundings	2	0	2
Total number of accidents	8 (11)	4 (7)	12 (18)

Source: Author

Table 5.6 shows that before routeing was considered there were eight (11 ships involved) accidents, and four accidents after the introduction of the traffic separation scheme. So it appears likely that the introduction of routeing has led to a reduction in the number of accidents, and in the number of ships involved in the casualties. Accident danger index, however, can not be administered due to lack of traffic data in this area.

(2) Position: As can be seen from Fig 5.5, which shows the position of collisions and groundings, the majority of collisions occurred in or just to the north of the traffic lane, and all the groundings occurred on the shoal off Kanjol-gap and the nearby rock. If we consider those collisions occurred after introducing the traffic separation scheme, three out of four collisions were within the traffic lane. Therefore appropriate traffic surveillance is required to reduce the number of collisions in the area.

(3) Size of vessel(Gross tons): Table 5.7 shows tonnage category of ships involved in traffic accidents during the 10 years period. Considerable decrease in the number of ships in traffic accidents is recognized through all tonnage groups other than 3000-4999 grt. So it appears probable that the introduction of a traffic separation scheme has led to a reduction in the number of ships involved in traffic accidents.

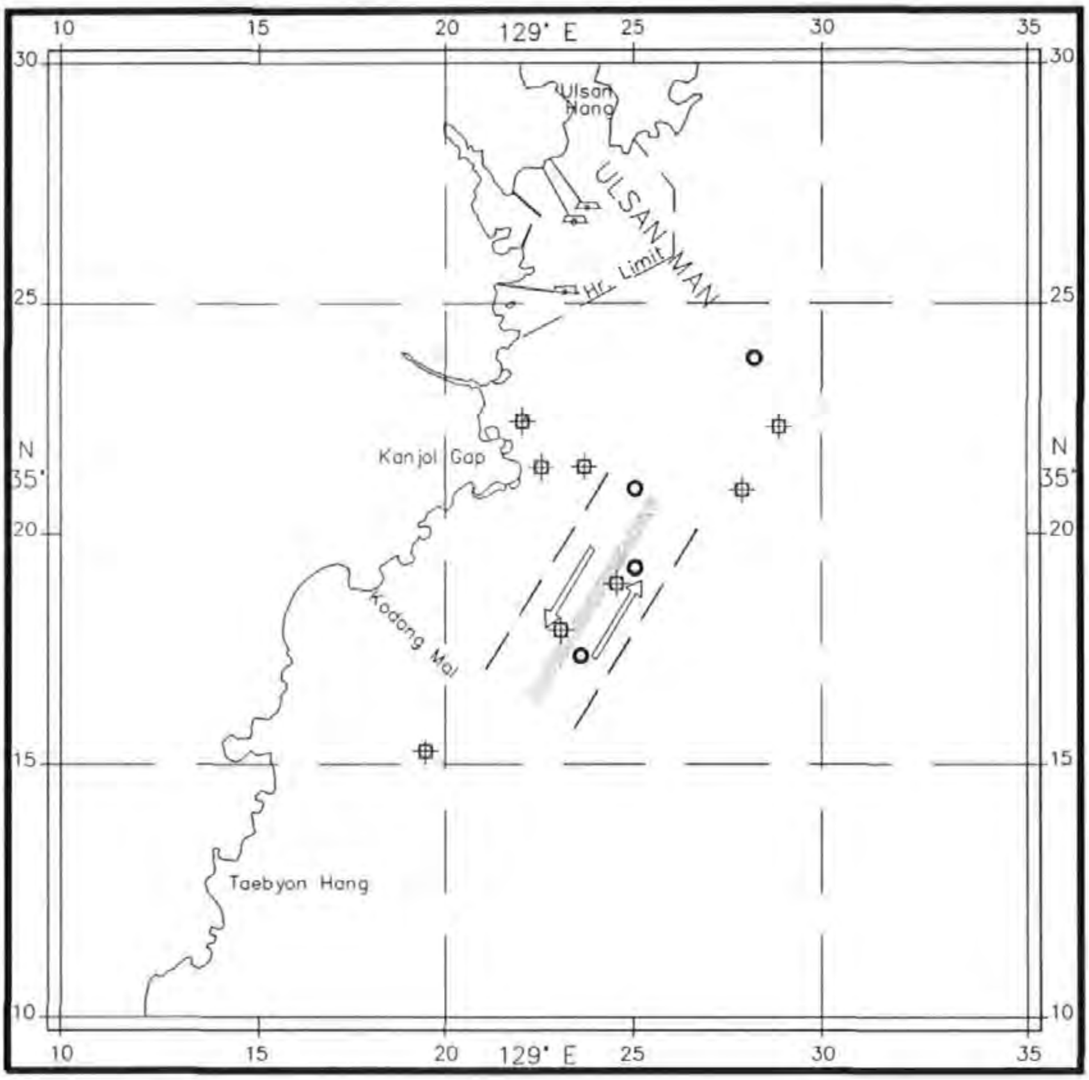
Table 5.7 Size of ships involved in accidents

Tonnage category	Period A		Period B	
	No.	GRT	No.	GRT
- 499	4	1,707	3	1,355
500 - 2,999	4	4,919	2	1,193
3,000 - 4,999	0	0	2	7,295
5,000 - 9,999	1	6,732	0	0
10,000 - 19,999	1	14,309	0	0
20,000 & over	1	104,902	0	0
Total	11	132,569	7	9,843

Source: Author

Fig 5.5 Traffic Separation Scheme off Kanjol–Gap

Legend
- ⌖ Location of accident during the period A
- o Location of accident during the period B



Source: Author & BA Chart No. 3666

(4) Type of vessel: The distribution of accidents by type of vessel is shown in Table 5.8. Over 55 percent of the vessels involved in traffic accidents were cargo vessels and 33.3 percent tankers. However, it should be noted that the number of tankers involved in the casualties remained unchanged. The details of these casualties are included in the Annex D.

Table 5.8 The accidents by type of vessel

Type of vessel	Total		Period A		Period B	
	No.	%	No.	%	No.	%
Tankers	6	33.3	3	27.3	3	42.9
Cargo ships	10	55.6	7	63.6	3	42.9
Fishing vessels	2	11.1	1	9.1	1	14.2
Total	18	100.0	11	100.0	7	100.0

Source: Author

Further analysis, however, is not possible due to lack of traffic data including size and type of vessel over different time periods.

5.4 JINHAE-MAN TRAFFIC SEPARATION SCHEME

Jinhae-man is a landlocked basin on the south-east coast of Korea between mainland and the NW side of Koje-Do with moderate depths and few dangers. There is considerable domestic ferry, passenger vessel, naval ship and coastal traffic in this area. To cope with the situation, the Traffic Separation Schemes in the approaches to Masan, Chungmu and Jinhae passages were introduced in this water in July 1982. Vessels not less than 20 metre length are required to navigate within the traffic lane[5-9]. The scheme was established leading through Gadeog-Sudo, thence NW through Budo-Sudo, W through Jinhae Man and NNE into Haengam Man. Vessels are recommended to adhere to the lanes, speed is restricted to 15 knots within 12 cables of the turn NE of Byeongsan-Yeoldo (see Figure 5.6). The Traffic Separation Scheme comprises Gadeog-sudo and Budo-sudo. The Gadeog-sudo is the entrance to the Jinhae-man, about 7.4 Km of width, 12.8-36 m of depth, about 33 Km of length to the port of Masan via Budo-sudo with many small islands and rocks. Although this traffic scheme has existed for 10 years, no documentation exists on details of transits.

5.4.1 SCOPE OF INVESTIGATION

<u>(1) Sea area</u>: The area covered, which is shown Fig. 5.6, includes not only the designed traffic separation schemes but extends from latitude 34° 50′ north to 35° 10′ north, and from longitude 128° 30′ east to 128° 55′ east. This area includes Gadeog-Sudo, Budo-Sudo and Jinhae-Man (harbours are excluded).

<u>(2) Type of casualties</u>: The analysis includes casualties reported in "Written Verdicts" which satisfy one or more of the following conditions:

(i) collisions involving vessels not less than 20 metre length (equivalent to 50 gross ton), but excluding collisions with buoys, anchored vessel or floating objects.

(ii) groundings involving vessels not less than 20 metre length (equivalent to 50 gross ton).

<u>(3) Period</u>: The 10 year span July 14 1977 to July 13 1987 can be divided into two equal periods:

Period	No. of years	Duration	Remarks
A	5	July 14 1977- July 13 1982	Pre-routeing period
B	5	July 14 1982- July 13 1987	Routeing scheme

5.4.2 TRAFFIC ACCIDENTS (COLLISIONS AND GROUNDINGS)

(1) Occurrence and time: In the 10 year period there were nine collisions (15 vessels involved excluding ships less than 50 tons) and six groundings in the area. The details of these casualties are included in the Annex D.

Table 5.9 Number of accidents in Jinhae-man TSS

Period	A	B	Total
Number of collisions (Number of ships involved)	3 (5)	6 (10)	9 (15)
Number of groundings	3	3	6
Total number of accidents	6 (8)	9 (13)	15 (21)

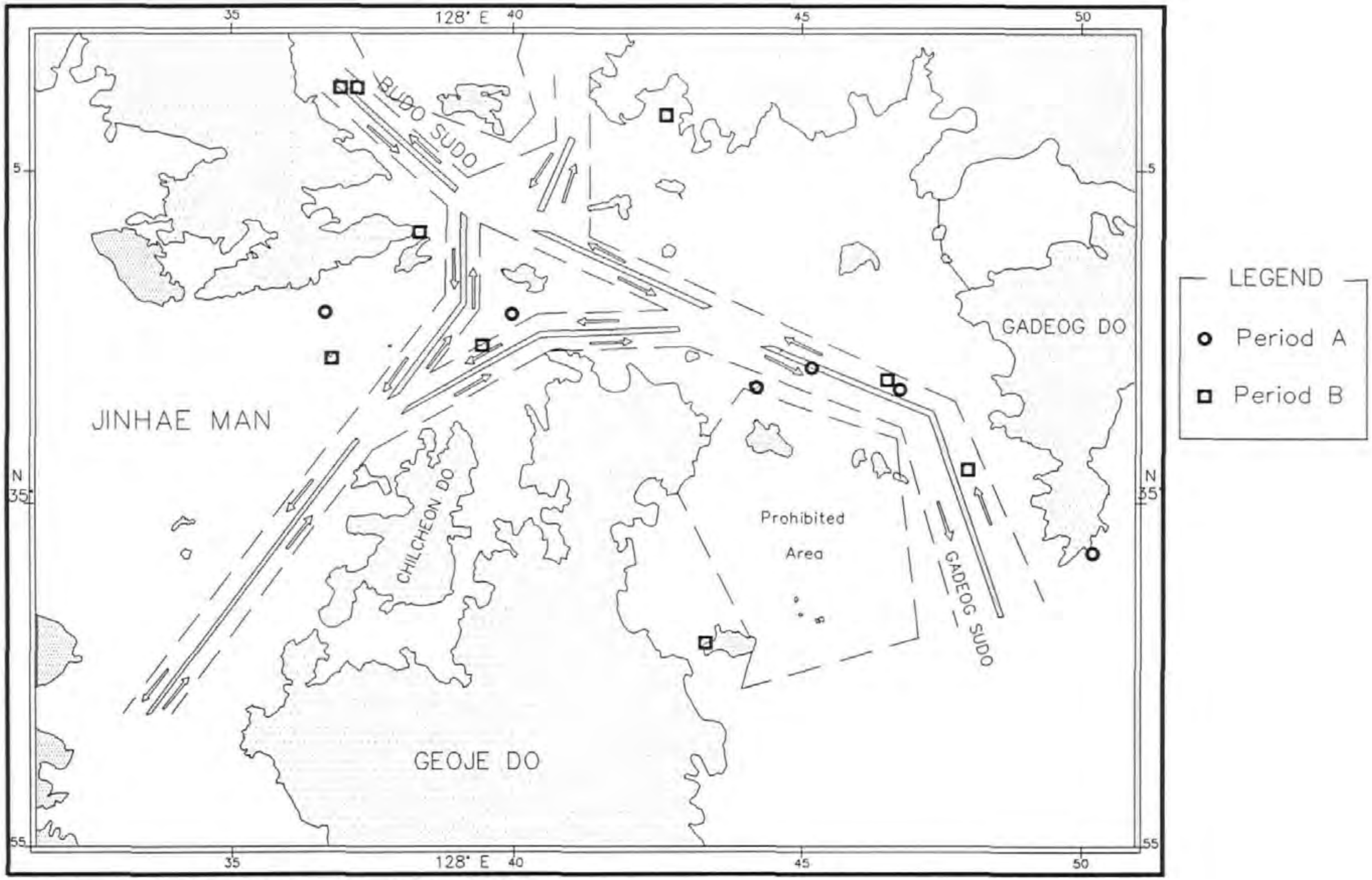
Source: Author

The Table 5.9 shows that before routeing was considered there were six accidents, and nine accidents after the introduction of the new scheme. The number of collision incidents increased after the introduction while the number of grounding incidents remained unchanged. Unfortunately, however, more detailed analysis is not feasible due to lack of detailed traffic data.

(2) Position: As can be seen from Fig 5.6, which shows the position of all collisions and groundings, seven collision incidents out of nine occurred in the traffic lane. If we consider the collisions occurred after introduction of the traffic separation scheme, five out of six collisions occurred within the traffic lane. Therefore appropriate traffic surveillance is required to reduce the number of collisions.

(3) Size of vessel(Gross ton): Table 5.10 shows, classified by tonnage, the number of ships involved in traffic accidents during the 10 year period.

Fig 5.6 Traffic Separation Scheme in Jinhae-Man



Source: Author & BA Chart No. 1065

This is one of the major routes for domestic ferry, passenger and cargo vessels. Consequently all vessels involved in incidents were smaller than those involved in Inchon and Kanjol-Gap area (the average size of vessels in the traffic incidents has increased from 326 tons to 864 tons). This is probably due to the average size of vessel using the traffic scheme increasing, however, detailed analysis is not feasible due to a lack of traffic data.

Table 5.10 Size of ships involved in accidents

Tonnage category	Period A		Period B	
	No.	GRT	No.	GRT
- 99	2	114	1	87
100 - 299	2	212	2	413
300 - 499	2	843	1	337
500 - 999	2	1,436	3	2,025
1,000 - 2,999	0	0	2	4,917
3,000 & over	0	0	0	0
Unknown	0	0	4	α
Total	8	2,605	13	7,779+α

Source: Author

<u>(4) Type of vessel</u>: The distribution of accidents by type of vessel is shown in Table 5.11. Over 47 percent of vessels involved in traffic accidents are cargo vessels, about 21 percent are passenger ships and 16 percent are tug boats.

Table 5.11 The accidents by type of vessel

Type of vessel	Total		Period A		Period B	
	No.	%	No.	%	No.	%
Cargo ships	9	47.4	3	37.5	6	54.5
Passenger ships	4	21.1	4	50.0	0	0
Tug boats	3	15.8	0	0	3	27.3
Tankers	2	10.5	1	12.5	1	9.1
Fishing vessels	1	5.3	0	0	1	9.1
Unknown	2		0	0	2	
Total	21	100.0	8	100.0	13	100.0

Source: Author

It is noted that no passenger ship incidents occurred after the introduction of the scheme, but the tug boat and cargo ship incidents were being increased significantly in period B. However, further analysis is not feasible due to lack of traffic data such as type and size of vessel movements in different time periods.

5.5 PUSAN VESSEL MOVEMENT REPORTING SCHEME

5.5.1 INTRODUCTION

Pusan Hang(port), one of the principal ports in Korea, is situated on the south-eastern corner of the Korean Peninsula and alternatively known as Busan. Pusan Hang is divided by Yeong Do(island) into two harbours. South harbour (used mainly by fishing and coastal vessels) lies south-west of the island and North harbour, (with the deep water berths), lies north-east of the island. Both harbours are divided into Outer and Inner harbours, both North harbour and Inner South harbour are protected by breakwaters. There are two other harbours for small ships within the harbour limits; the Kamchon harbour in the Gamnaepo (which will be Pusan's subsidiary port and a base for the deep-sea fishing industry), and Dadaepo which affords good shelter to small local vessels (the anchorage is used by fishermen as a place of refuge).

Since Pusan Hang is the busiest port in Korea, a Vessel Movement Reporting Scheme (VMRS) was introduced from September 1978 to cope with the traffic. Although this scheme has existed for 15 years, no detailed data are available.

The Korea "Open Port Orderliness Act" has been promulgated for the safety of traffic and to preserve order within the harbour limit. This Act gives the legal basis of the VMRS:

Ships incoming/outgoing into/from the harbour limit of Open port shall report to the District Maritime and Port Authority

Ships incoming/outgoing into/from the harbour limit and migrating within the limit of Open port shall comply with the port traffic control

The VMRS was introduced in most major ports in Korea as illustrated in Figure 5.1, Pusan Hang was chosen to determine the effectiveness of the VMRS in this study on the grounds that it is one of the principal ports and the busiest port for ocean-going vessels. Figure 5.7 shows the time trends of vessel's movements in Pusan Hang for 15 years, from 1976 to 1990. It clearly indicates the significant increase of vessel movements in the period.

5.5.2 SCOPE OF INVESTIGATION

(1) Sea area: The area covered, which is shown in Fig.5.8, includes not only "within the harbour limit" but also regions where ships converge or cross before entering the harbour and extends from latitude 35° 00′ north to 35° 10′ north, and from longitude 128° 55′ east to 129° 10′ east. The analysis is focused into the area of North harbour and it's approaches and the following areas are excluded:

- Dadaepo
- Gamnaepo and Kamchon Hang
- Inner harbour of the South Harbour

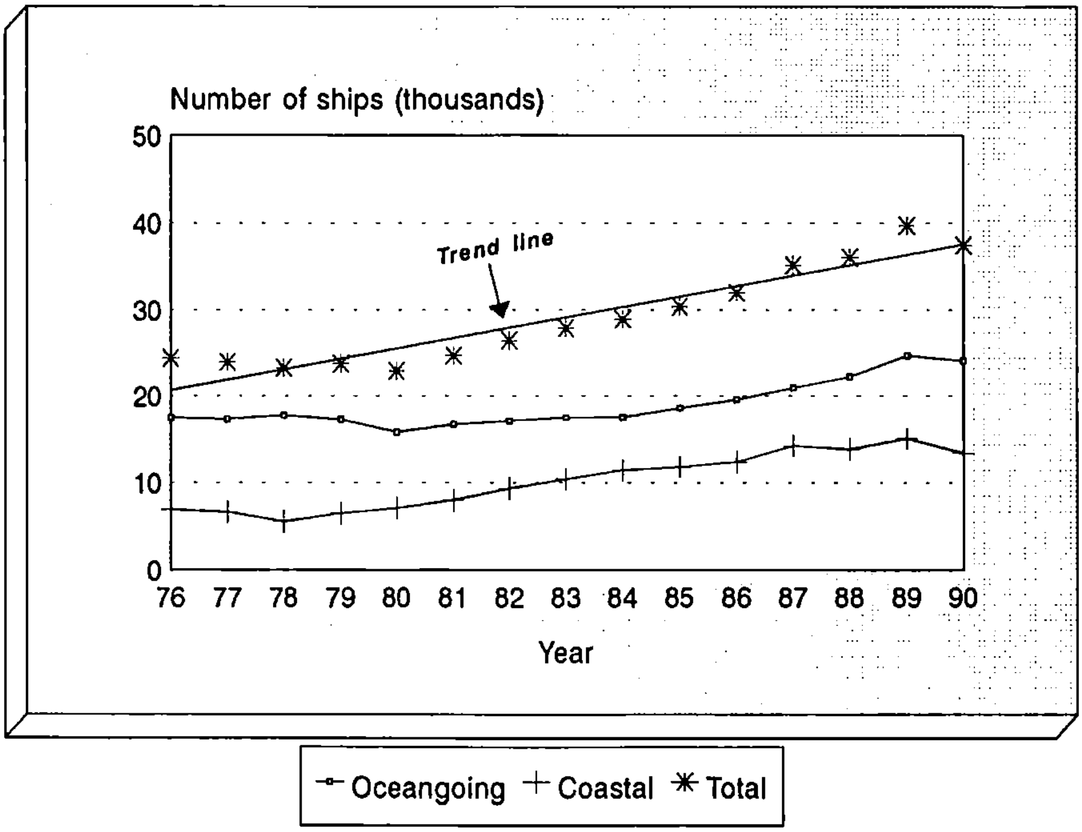
(2) Types of casualties: The analysis includes casualties reported in "Written Verdicts" which satisfy one or more of the following conditions:

(i) collisions excluding fishing vessels, miscellaneous vessels(non-powered barge, launch, yacht, a lighter and etc.) and vessels less than five gross tons.

(ii) groundings involving vessels as same as (1)

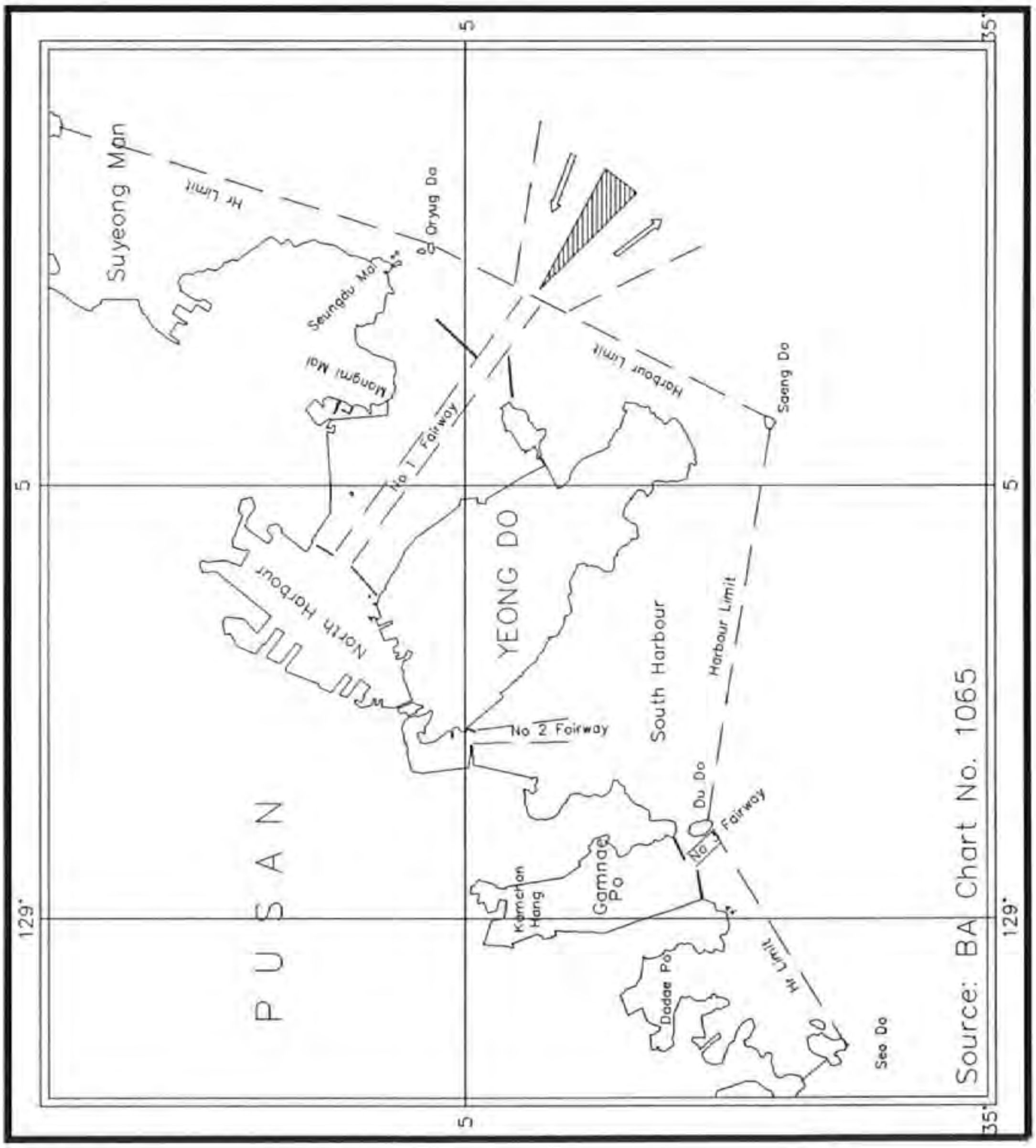
(iii) rammings including contact with anchored vessel, moored vessel, dock, breakwater, buoy and etc. involving vessels as same as (1)

Fig 5.7 Trends of vessel movements in Pusan
(Arrival + Departure)



Source: Statistical Yearbook, KMPA

Fig 5.8 Pusan and it's Approaches



(3) Period: The 15 year span October 1 1973 to September 30 1988 can be divided into three equal periods:

Period	No of years	Duration	Remarks
A	5	October 1 1973 - September 30 1978	No service
B	5	October 1 1978- September 30 1983	VMRS service
C	5	October 1 1983- September 30 1988	VMRS service

5.5.3 CASUALTIES

(1) Occurrence and time: In the 15 year period there were 77 collisions (135 vessels involved), 36 groundings and 59 rammings in Pusan Hang area. The details of these casualties are included in the Annex D. Although Table 5.12 indicates that before VMRS was introduced there were 61 incidents, 68 incidents for first five years after the introduction of VMRS and 43 incidents during the period C, there was no significant difference in the number of incidents per annum before and after the introduction of the vessel movement reporting scheme. There was increase rather than decrease in the total number of incidents and vessels involved during the first five year after the introduction of VMRS, but the number of incidents dropped considerably during the period C.

Table 5.12 Number of accidents in Pusan

Period	A	B	C	Total
Number of collisions (No. of ships involved)	29 (52)	26 (44)	22 (39)	77 (135)
Number of groundings	8	18	10	36
Number of rammings	24	24	11	59
Total number of accident	61 (84)	68 (86)	43 (60)	172 (230)

Source: Author

The number of collisions and the number of vessels involved in collisions decreased by approximately 10 percent and 15 percent respectively during the first five year period and 15 percent and 11 percent during the second five year period, so it appears probable that the introduction of VMRS has contributed to some extent to a reduction in the number of collision incidents.

Table 5.13 presents the influential causal factors of grounding incidents which occurred during the period A and B. From the table, it is apparent that leading contributory causal factors to the noted increased grounding incidents are heavy weather, inadequate voyage planning and the negligence of ship control tasks.

Table 5.13 Main causal factors of grounding incidents

Main causal factors	Period A	Period B
Environmental conditions		
Storm & bad weather	1	6
Watchkeeping situations		
Improper manning on bridge	1	0
Negligence of lookout	1	2
Lack of experience	0	1
Voyage planning	0	2
Old chart or no small correction	3	0
Ship control tasks		
Not fix position regularly	0	2
Unskilled/improper manoeuvring	0	2
Negligence in critical situation	2	2
Technical fault & deficiencies		
Poor inspection of main engine	0	1

Source: Author

<u>(2) Position</u>: Figure 5.9 shows the position of collision accidents, and Table 5.14 is a summary of the accidents by location of incidents.

Looking into the location of collision incidents, 25 (86%) collisions occurred in the north harbour and four (14%) in the approaches and outside the harbour limit before the introduction of VMRS, while 17 (65%) collisions were in the north harbour and two (8%) in the south outer harbour and seven (27%) in the approaches and outside harbour limits during the first five year period after the introduction of VMRS in the area. Meantime six collisions (27%) occurred in the north harbour, eight (36%) in the south harbour and eight (36%) in the approaches during the period C. The number of collision incidents in the north harbour is decreasing(25-17-6), while the number in south outer harbour is increasing(0-2-8) remarkably. One collision incident during the period B and three incidents during the period C occurred in or around the No.3 Fairway, where is the entrance of Kamchon Hang. So it appears that the south outer harbour and the entrance of Kamchon Hang is a further dangerous location meriting attention.

Table 5.14 Location of accidents

Location	Period A	Period B	Period C	Total
COLLISION				
at North Inner harbour	11	7	2	20
at North Outer harbour	14	10	4	28
at South Outer harbour	-	2	8	10
at Approaches (within the Hr limit)	3	1	3	7
at the outside of harbour limit	1	6	5	12
Total	29	26	22	77
RAMMING				
to pier (Inner Harbour)	14	14	5	33
to ship/breakwater/buoy/etc (Inner Hr)	3	2	1	6
to pier (Outer Harbour)	5	4	1	10
to ship/breakwater/buoy/etc (Outer Hr)	2	4	4	10
Total	24	24	11	59
GROUNDING				
Inner harbour east breakwater	3	1	1	5
on/around Ko-Am rock	1	3	1	5
on/around Tongmudari-Am rock	1	3	1	5
on the front Mangmi-Mal	-	6	1	7
on/around Saeng Do	-	2	0	2
on the front of Cheonghak pier	1	1	0	2
on the other obstacles	2	2	6	10
Total	8	18	10	36
Grand Total	61	68	43	172

Source: Author

If we look at the location of grounding incidents, three ships stranded on the Inner harbour east breakwater, one on the Ko-Am and one on the Tongmudari-Am before the introduction of VMRS, while one ship stranded on the Inner harbour east breakwater, three on the Ko-Am, three on the Tongmudari-Am, two on the Saeng-Do and six on the rocks in front of Mangmi-Mal during the first introduction period. So it can be said that Ko-Am, Tongmudari-Am, Saeng-Do and the rocks in front of Mangmi-Mal were the most dangerous places for the stranding of ships during the period B. The location of grounding incidents, however, during the period C is different to the period B.

(3) Size of vessel(Gross ton): Table 5.15 illustrates the number of ships by size classification involved in accidents. The average size of vessels has increased from 3,172 tons to 5,063 and to 5300 tons (excluding unknown tonnage). A considerable decrease in the number of ships involved is identified in the size group of 500-2,999 and 3,000-4,999 tons.

Table 5.15 Size of ships involved in accidents

Tonnage category	Total		Period A		Period B		Period C	
	No	GRT	No	GRT	No	GRT	No	GRT
- 99	20	1,129	5	343	7	319	8	467
100- 499	19	5,918	5	1,713	7	2,814	7	1,391
500- 2,999	89	114,774	41	47,736	31	39,871	17	27,167
3,000- 4,999	46	174,205	21	81,824	17	61,723	8	30,658
5,000- 6,999	5	30,066	2	11,819	2	12,109	1	6,138
7,000- 9,999	8	72,873	5	44,695	3	28,178	0	0
10,000-19,999	16	227,360	4	49,812	7	101,140	5	76,408
20,000 & over	10	305,073	1	28,488	5	153,803	4	122,782
Unknown	17	α	0	0	7	α	10	α
Total	230	931,398+α	84	266,430	86	399,957+α	60	265,011+α

Source: Author

Using the formula introduced in section 5.2.2 the period is divided into following three categories which is different from the criterion of the period used so far. It is due to the limitation of traffic data.

Period A: 1976 Jan. 1 - 1978 Sept. 30
Period B: 1978 Oct. 1 - 1983 Sept. 30
Period C: 1983 Oct. 1 - 1988 Sept. 30

Table 5.16 shows that overall traffic accident danger (S_d) notably decreased after the introduction of traffic measures, 0.00084 to 0.00068 and to 0.00031 thereafter. The reduction of accident danger is observed in most size categories of vessels except for small tonnage groupings. So it appears that VMRS is more effective for larger tonnage ships.

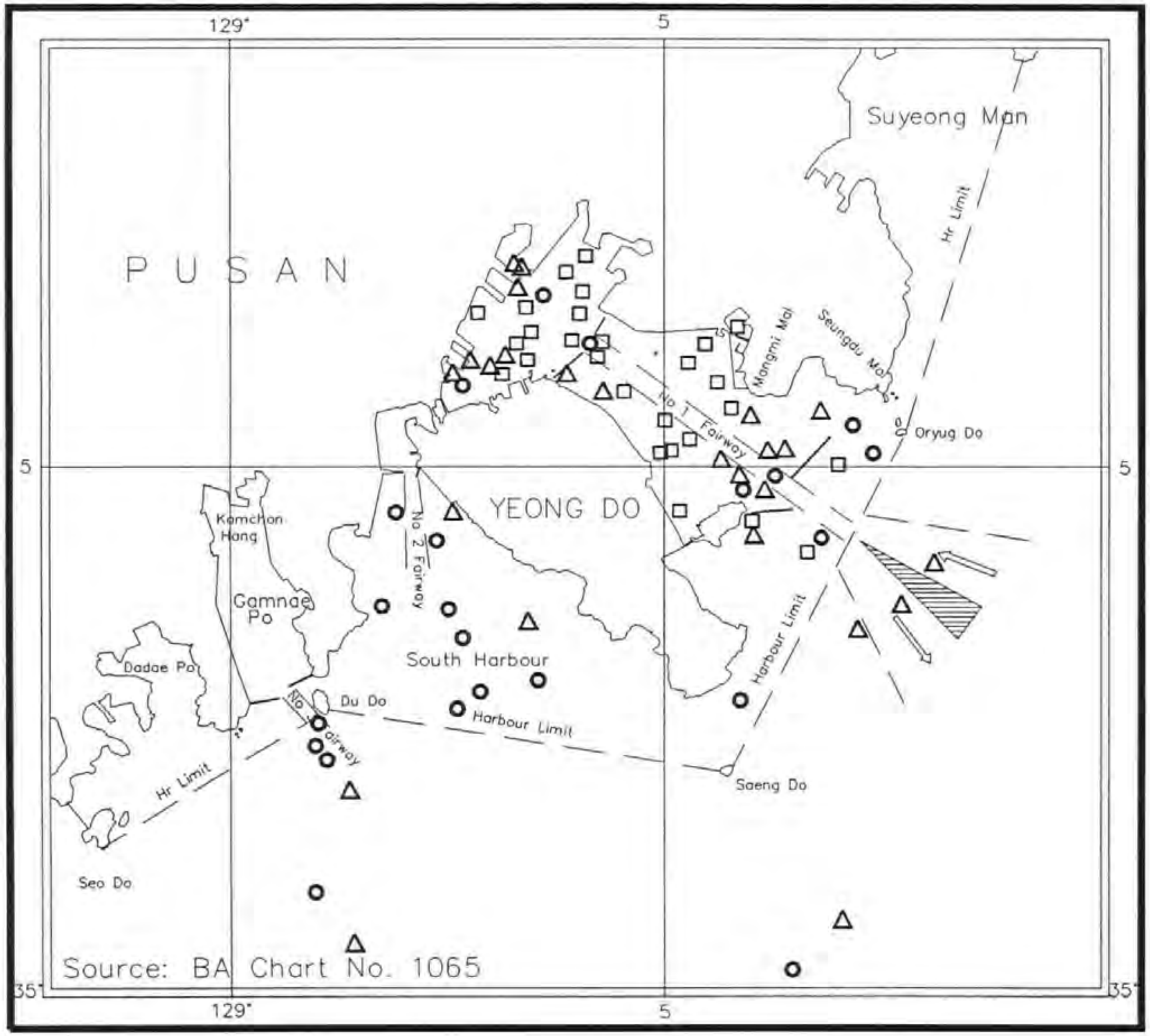
Table 5.16 Number of vessels in traffic accident(N) and Number of vessels entering Pusan Hang(Q) for period of 1976-1988

GRT category	Less 100	100-499	500-2999	3000-4999	5000-9999	10000-19999	20000 & over	Total
N_A	2	4	29	14	3	3	1	56
(%)	3.6	7.1	51.8	25.0	5.4	5.4	1.7	
N_B	7	7	31	17	5	7	5	79
(%)	8.9	8.9	39.2	21.5	6.3	8.9	6.3	
N_C	8	7	17	8	1	5	4	50
(%)	16.0	14.0	34.0	16.0	2.0	10.0	8.0	
Q_A	2,135	8,252	12,829	4,746	2,516	2,155	396	33,209
Q_B	2,685	11,122	23,382	7,010	4,442	6,158	2,875	57,674
Q_C	4,810	17,887	29,422	7,392	5,297	8,371	7,312	80,491
$N_A/2Q_A$	0.00047	0.00024	0.00113	0.00147	0.00060	0.00070	0.00126	0.00084
$N_B/2Q_B$	0.00130	0.00031	0.00066	0.00121	0.00056	0.00057	0.00087	0.00068
$N_C/2Q_C$	0.00083	0.00020	0.00029	0.00054	0.00009	0.00030	0.00027	0.00031
Total	0.00088	0.00024	0.00059	0.00102	0.00037	0.00045	0.00047	0.00054

Source: Author

(4) Type of vessel: The distribution of accidents by type of vessel is shown in Table 5.17. About 69 percent of the vessels involved in traffic accidents are cargo vessels and some 14 percent are tankers. The percentage contribution of cargo ships shows a tendency to decrease, 78.5 percent to 72 percent and to 50 percent, while the percentage contribution of passenger ships, tugs and other vessels have a significant upward trend.

Fig 5.9 Location of Collision accidents (Pusan)



LEGEND

- Collisions during Period A (29) (October 1973 – September 1978)
- Collisions during Period B (26) (October 1978 – September 1983)
- Collisions during Period C (22) (October 1983 – September 1988)

Further analysis, however, is not possible due to lack of traffic data including size and type of vessel movements in different time periods.

Table 5.17 The accidents by type of vessel

Type of vessel	Total		Period A		Period B		Period C	
	No	%	No	%	No	%	No	%
Cargo ships	151	69.3	66	78.5	59	72.0	26	50.0
Tankers	30	13.8	12	14.3	11	13.4	7	13.5
Passengers	12	5.5	2	2.4	4	4.9	6	11.5
Tugs	13	6.0	2	2.4	4	4.9	7	13.5
Other vessels	12	5.4	2	2.4	4	4.8	6	11.5
Unknown	12		0	0	4		8	
Total	230	100	84	100	86	100	61	100

Source: Author

5.6 SUMMARY

A casualty and traffic analysis is used to evaluate the effectiveness of the existing traffic services and an accident danger index is introduced to compare the accident danger in different time periods.

The difficulty in this chapter is that many of the number of accidents are so small that it is impossible to test for significant differences in different time periods. Another difficulty is that detailed analysis are not feasible in many parts due to lack of traffic data.

Even though the absolute number of collisions has increased, the overall accident danger index for one trip has reduced significantly following the introduction of a routeing scheme in Inchon. According to the analysis, there were;

- eight collisions (7 meeting & 1 crossing) and one grounding
- six incidents were under reduced visibility(less than 300 metres)
- six cases violated the local sailing rules

The analysis suggests that appropriate traffic surveillance and stricter enforcement of the routeing scheme are required here.

It appears likely that introduction of a Traffic Separation Scheme in Kanjol-Gap has led to a reduction in the number of accidents. But three collisions out of four after the introduction of TSS occurred within the traffic lane. Therefore appropriate traffic observation and surveillance are necessary to further reduce, perhaps with a view to repositioning the traffic lane or its navigation mark.

Numbers of collisions increased (three to six incidents) after the introduction of TSS in Jinhae-Man, but the number of groundings remain unchanged. All ships involved in accidents were less than 3,000 gross tons. Unfortunately, however, further analysis is not feasible due to lack of traffic data. It is recommended that data be gathered for further analysis.

Even though there is no significant difference in the number of accidents per annum before and after the introduction of a Vessel Movement Reporting Scheme in Pusan Hang and its approaches, the overall accident danger index reduced significantly.

The location of collision incidents were wide spread;

- ○ South outer harbour: no collision incidents before the introduction of VMRS, two incidents (8%) during the period B and 8 incidents (36%) during the period C.
- ○ Approaches and outside of harbour limit: four collision incidents(14%) before the VMRS, seven incidents (27%) during the period B and eight incidents (36%) during the period C.

Accordingly, adequate traffic observation and surveillance are necessary to increase the navigation safety in the Pusan Hang area.

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Chapter 6

QUESTIONNAIRE SURVEY ON THE MARINE SAFETY AND VESSEL TRAFFIC SERVICES IN KOREAN COASTAL WATERS

6.1 SURVEY DESIGN

Vessel Traffic Service(VTS) is a relatively new service offered by the Korea Maritime and Port Administration (KMPA). Its main objective is the safety of traffic, efficient traffic flow and affording aid to navigation through the reduction of vessel conflicts and the improved interchange of information. Fig 5.1 illustrates the locations and types of existing VTS systems in Korean waters.

As part of this analysis, the following objectives may be attained by means of the survey:

- to determine the perceived relative importance of the various factors associated with the environment, geography and traffic in the assessment of navigational and marine risk;
- to classify ports and sea areas on the basis of the risk perceived;

- to classify the marginal effectiveness of various options in reducing marine risk;
- to seek opinions on the type and level of VTS services that should be provided by area;
- to evaluate background and qualifications of VTS operators;
- to estimate the 'users' and 'operators' points of view with regard to VTS services.

After reviewing the relevant literature[6-1][6-2][6-3][6-4][6-5] and discussions with informants and interested organizations, and after studying the published research on this topic [6-4][6-5][6-6] and bearing in mind the objectives of this study, a preliminary questionnaire was designed (divided into five parts).

- Part A seeks basic information about the respondents, such as shipboard experience, marine background and the areas with which they are familiar;
- Part B is concerned with the factors which endanger safety of navigation and overall risk by areas;
- Part C is a survey of opinions on the options for risk reduction;
- Part D seeks an evaluation of the background and qualification of VTS operators;
- and finally, part E refers to the effectiveness of Vessel Traffic Service systems.

Each set of the questionnaire (English and Korean version) is given at Annex-F.

A pilot study using the Korean version of the questionnaire was carried out in January-February 1993 to ensure validity. The questionnaire responses are listed against shipboard experience and marine background in table 6.1 and 6.2 below which shows the background-wise spread achieved.

After correction and review, the Korean version of the questionnaire was mailed on 30th March 1993. A self-addressed envelope was enclosed with every questionnaire.

Table 6.1 Questionnaire responses by shipboard experience

Number of years	Number of responses
0 years	3
1 to 5 years	9
6 to 10 years	7
11 to 20 years	5
over 20 years	3

Source: Author

Table 6.2 Questionnaire responses by marine background

Marine background	Number of responses
Shipowners' representatives	3
Port/Harbour officials	6
Lecturers of education/training institute	5
Marine accident inquiry agency	5
Classification surveyors	2
Pilots	4
Other marine background	2

Source: Author

During the planning stage, considerable thought was given to the question "Whether it was preferable to have a relatively small number of responses from people who could be individually interviewed and were experienced in navigation in Korean waters, or whether to seek a wide response by post with no guarantee that those responding would have any useful experience or that they fully understood the questionnaire ?". Ideally, it would be desirable to extend the sample by continuing the interview technique to those who are known to have experience of navigating in Korean waters, but this is not feasible in this study. Consequently, it was decided that sufficient high quality and reliable responses would be preferable to a wide response of unknown quality.

The population surveyed comprised mariners navigating in Korean waters and persons in contact with the services provided by VTS. The "Shipping Directory Korea" and the "Membership List of Korea Merchant Marine Officers Association" was used to reach a population of some 860 persons with maritime interests (Table 6.3).

Table 6.3 List of population receiving the questionnaire

Masters/Chief mates of foreign trade ships	372
Masters of coastal ships	152
Pilots	75
Port/Harbour officials	53
VTS operators	85
Shipowners' representatives (Port captain & Marine superintendent)	41
Seafarers' education/training institute	24
Maritime organizations	31
Marine accidents inquiry agencies	18
Classification societies	12
Total	863

Source: Author

6.2 DATA BASE

There were 385, (207 from masters/mates and 178 from shore staff) duly completed questionnaires returned by August 31, 1993. Several measures were taken to respect respondents' anonymity. No names were attached to the questionnaire, and only statistical summaries of data are shown in this paper.

The large amount of information collected can be managed, described and analyzed most effectively by computer. The questionnaire responses were coded and a data file created. The analysis was made using the "Statistical Package for Social Science (SPSS/PC+)".[6-7] Annex-E presents the coding scheme for questionnaire with variable names, variable label and value labels.

6.3 RESPONDENTS' PROFILES

(1) Shipboard experience: Table 6.4 represents the respondents' profiles in 10 different occupational groups. They include 197 masters/mates of merchant vessel, who are now engaged full-time onboard ship; 10 masters/mates of passenger/ferry; 15 pilots; 28 shipowner's representatives who were previously masters or mates of merchant vessels; 15 port/harbour officials who have full-time shipboard experience, 15 lecturers of seafarers' education/training institutes and 13 officials of maritime organization who were previously master/mate of merchant ships.

Table 6.4 Shipboard Experience

Occupational Grouping	Number of respondents	Average Full-time Shipboard Experience (Year)
Masters/Mates of merchant vessel	197	15
Masters/Mates of ferry	10	18
Pilots	15	23
Lecturers of seafarers' education/training institute	15	11
Classification surveyors	6	5
Port/harbour officials	22	3
Government employees	12	8
Shipowners' representatives	28	9
Maritime organizations	13	11
VTS Operators	67	1

Source: Author

The average number of years of experience in the occupational group of masters/mates of merchant vessel, masters/mates of ferry, pilots, lecturers of education/training institute and staffs of maritime organization are 15, 18, 23, 11 and 11 years respectively. 24 VTS operators have, on the average, four years and 43 operators have no full-time shipboard experience.

The government employees are the officials of the Marine Accident Inquiry Agency, and the shipowners' representatives are the port captains or marine superintendents of shipowners. Maritime organization includes shipowners' association, shipping association, merchant marine officers' association and seafarers' unions.

Reference to the first three occupational groupings in Table 6.4 as "mariners", and to the subsequent groupings as "non-mariner" is then used.

It should also be noted that the number of respondents in each occupational grouping is relatively small except for masters/mates of merchant vessel and VTS operators. The following re-grouping is therefore adopted:

· Masters/Mates group - first two groupings (n=207)

· Pilot/Lecturer/Surveyors group - next three groupings (n=36)

· Government/Port officials group - next two groupings (n=34)

· Shipowners/Maritime organization group - next two groupings (n=41)

· VTS operator group (n=67)

<u>(2) The average size of vessel</u>: Table 6.5 shows the average size of vessel on which they have worked. Seven percent of them worked on the size group less than 1000, 16 percent on 1000-5000, 38 percent on 10000-30000 group and 31 percent on 30000 & over. In general 23 percent of them worked on coastal vessel(less than 50000 tons) and 77 percent on ocean going vessels. There were 52 respondents who have no ship-board experience.

Table 6.5 Average Size of Vessel

Value Label	Frequency	Percent	Cum. Percent
Less than 100	2	0.6	0.6
100-500 ton	9	2.7	3.3
500-1000 ton	12	3.6	6.7
1000-5000 ton	53	16.0	22.5
5000-10000 ton	30	9.0	31.6
10000-30000 ton	125	37.7	69.3
30000 & Over	101	30.4	100.0

Source: Author, Missing cases=1

(3) Familiar areas: Table 6.6 represents the familiarity of sub-areas. In all, 62 (16%) respondents claim to be currently familiar with the Tonghae area. Corresponding figures for the Pohang, Ulsan, Pusan, Masan and Yosu areas are 128 (33%), 152 (39%), 252 (65%), 87 (23%) and 151 (39%). A total of 84 (22%) respondents claim to be familiar with Cheju area, 94 (24%) with Mokpo area, 60 (16%) with Kunsan area and 169 (44%) with Inchon area.

Table 6.6 Familiar Areas

Area	Number of Mariners	Number of Non-mariners
Tonghae Area	41	21
Pohang Area	96	32
Ulsan Area	111	41
Pusan Area	182	70
Masan Area	64	23
Yosu Area	117	34
Cheju Area	65	19
Mokpo Area	73	21
Kunsan Area	46	14
Inchon Area	125	44

Source: Author

6.4 RISK PERCEPTION

Terry[6-8] explains that risk is a curious and complex concept. In a sense it is unreal in that it is always concerned with the future, with possibilities, with what has not yet happened. If there is certainty there is no risk. Thus risk is a thing of the mind, intimately linked to personal or collective psychology. The concept of risk being a product of probability and consequence is not readily grasped by the general public or, indeed, many professionals. The Royal Society has defined 'risk' as "the probability that a particular adverse event occurs during a stated period of time, or results from a particular challenge".

A number of different types of risk can be distinguished: individually perceived risk, collectively perceived risk, calculated risk and real risk.[6-9] We will consider 'perceived risk' in this section. Perceived risk is the risk that one thinks is the case. It might be personal risk to oneself, as with the possibility of personal injury, or the risk to other people or things.

<u>(1) Risk factors</u>: In question B1 the respondents were asked to what extent marine risks would be increased by certain risk factors. Table 6.7 shows the ranking of different risk factors by occupational groups. Masters/mates of merchant vessel and ferry, Shipowners' representative /maritime organization and VTS operators occupational groups agree that "reduced visibility by fog or snow" is the leading factor in increasing marine risk. Government employee/port officials and pilots/lecturers of education institute/and classification surveyor groups rank "human factor in ship handling" in first place.

Government employees/Port officials and pilots/lecturers of education institute/ and classification surveyor groups rank "reduced visibility" in second place, but masters/mates of merchant vessel and ferry group claims that "greater number of fishing boats in shipping routes" is the second important factor to increase the risks. Shipowners' representative/maritime organization group ranks "human factor in ship handling" in second place, and VTS operators group ranks "stormy weather" in second place.

Table 6.7 Ranking of risk factors by Occupational groups

Risk Factor	Occupational Groups				
	Masters/ Mates of vessel	Pilot/ Lecturer/ Surveyors	Govern't/ Port officials	Shipowners /Maritime organization	VTS Operators
Reduced visibility	1	2	2	1	1
Stormy weather	5	6	5	5	2
Strong current	8	7	8	9	10
More fishing boats in shipping routes	2	5	6	4	4
More pleasure boats in shipping routes	11	11	11	11	9
Narrow channel/passage	9	10	4	8	7
Higher density of traffic(merchant ship)	6	4	7	7	6
Poor design of fairway	10	9	10	10	11
Poor navigational aids	7	7	9	6	8
Human factor in ship handling	3	1	1	2	3
Violation of rules	4	3	3	3	5

Source: Author

Three occupational groups except VTS operator group rank "more pleasure boats in shipping routes" in the last place. Finally overall ranking of risk factors increasing marine risks is:

(1) Reduced visibility by fog or snow

(2) Human factors in ship handling

(3) Violation of rules and regulations

(4) Greater number of fishing boats in shipping routes

(5) Stormy weather

(6) Higher density of traffic (merchant vessels)

(7) Poor navigational aids

(8) Strong current or tidal streams

(9) Narrow channel or passage

(10) Poor design of fairway

(11) Greater number of pleasure crafts in shipping routes

There were several other factors manifested in increasing risks for the open question. Superannuated hull, machinery and navigation instruments and lack of equipment, especially radar, were supported by respondents (n=28). The following are other supported factors with the number of respondents in brackets.

- VTS: poor and unskilled services, inexperienced operators (11)
- Pilot: disobedience to boarding time, infringement of embarking and/or disembarking point (10)
- Miscellaneous vessel including barge and tugs: disordered operation and violation of rules and regulations (10)
- Fatigue and insufficient sleep due to frequent entering/leaving ports and small number of crew (8)
- Shipowner makes unreasonable demand of master; ask to sail in reduced visibility or heavy weather condition, ask to overload (8)
- Lack of information to mariners such as dredging, fishing farm or nets in fairway, construction works, etc. (7)
- Tug boats: superannuated tugs, insufficient power (4)

To test statistically if there is any significant difference between the views of the five occupational groupings, an analysis of variance(ANOVA) technique(***tukey-b*** multiple comparison test) was used. Differences are marked if the significance level is not less than 0.05. According to the test, the VTS operators group differs from the masters/mates group and pilot/lecturer/surveyors group in the views of the risk factor "reduced visibility". VTS operators group assesses that this factor would increase risk less than the other two groups. The VTS operators group opines that "stormy weather" would increase risk with a significance level of 0.05.

The VTS operators group differs from the pilot/lecturer/surveyors group, masters/mates group and shipowners' representative/officials of maritime organizations in a reduced view of the risk factor "strong current & tidal streams". Clearly the masters/mates group, however, differs from all of other four groups in the view of the factor "more fishing boats in shipping lane".

The VTS operators group differs from the pilot/lecturer/surveyors group and masters/mates group in the views of the risk factor "higher density of traffic". VTS operators group assesses that the factor would increase risk less than the other two groups. In addition the pilot/lecturer/surveyors group assesses the factor would increase the risk more than shipowners/maritime organization group.

The masters/mates and pilot/lecturer/surveyors group differ from VTS operators group in the opinions of risk factor "poor design of fairway" and "poor navigation aids". The former groups give a higher causal value than the latter.

The VTS operators group differs from all of the other four groups in their low scoring view of the risk factor "human factor in ship handling" and "rule violation".

In conclusion the VTS operators group assesses the risk factors with less weight than any other group. This curiosity may be well linked to less shipboard experience and lower qualifications.

<u>(2) Overall risk by sub-area:</u> The risk related to each geographical sub-area was investigated. The list below gives the rankings obtained from perceptions in the questionnaire with the number of respondents in brackets. Both mariners and shore staffs agree that Inchon area is the higher risk area with Pusan, Ulsan, Mokpo and Masan ranked in descending order.

(1) Taean Bando to Inchon area (n = 249)
(2) Pusan area (n = 286)
(3) Ulsan area (n = 235)
(4) Maemul, Maenggol Sudo & Mokpo area (n = 191)
(5) Masan,Jinhae, Kadok Sudo & Koje-do area (n = 186)
(6) Yosu, Kwangyang & Yosu Haeman area (n = 222)
(7) Kunsan, Changhang area (n = 161)
(8) Cheju area (n = 178)
(9) Pohang area (n = 205)
(10) Tonghae area (n = 160)

6.5 OPTIONS FOR IMPROVING MARINE SAFETY

<u>(1) Options:</u> Question C1 asked respondents to what extent certain options could improve marine safety. Table 6.8 shows the ranking of different options to reduce marine risk by occupational groupings. "Additional Vessel Traffic Services" is the option suggested by the questionnaire which receives the greatest approval of government/port officials, pilot/lecturer/classification surveyors and VTS operators groups.

Masters/mates consider "stricter enforcement of prohibition of fishing and excursion on shipping routes" the most important option for reducing marine casualties. According to shipowners' representative and officials of maritime organization "additional traffic separation schemes" is the principal solution to improve marine safety.

"Improved education and training for mariners" is ranked in second place by the government/port officials and pilot/lecturer/surveyors groupings. The masters/mates group ranks "additional traffic separation schemes" in second place, the shipowners/maritime organization group ranks "additional VTS" in second place. "Stricter enforcement of prohibition of fishing and excursion on shipping routes" is ranked in second place by VTS operators group.

Table 6.8 Ranking of options by Occupational groups

Options	Occupational Groups				
	Masters /Mates	Pilot/ Lecturer/ Surveyors	Government /Port officials	Shipowners/ Maritime organization	VTS Operators
Improved weather information	4	4	8	6	4
Institution of speed limit in more areas	10	10	10	10	10
Stricter enforcement of ship safety regulations	9	8	7	9	5
Additional dredging	8	9	9	8	8
Upgraded fixed and floating navigational aids	5	7	5	7	7
Additional Traffic Separation Schemes	2	3	3	1	6
Additional recommended courses on charts	6	6	6	4	8
Additional Vessel Traffic Services	3	1	1	2	1
Improved education and training for mariners	7	2	2	5	2
Stricter enforcement of prohibition of fishing and excursion on shipping routes	1	5	4	3	3

Source: Author

The following options are, repeatedly ranked as one of the last three by most occupational groupings:

- Institution of speed limit in more areas
- Stricter enforcement of ship safety rules and regulations
- Additional dredging in more areas

There were several other options suggested for the open question. Improved communication including; "legislation to install radio telephone on all kinds of vessel; encouragement to use more equipment and to communicate with other vessels in sight; and to establish separate channels for radio telephone lines between ship and shore avoiding congestion in channel 16" received the greatest approval by the respondents.

The same technique was employed to test statistically if there is any significant difference between the views of the five occupational groupings. Differences are annotated if the significance level is not less than 0.05. According to the multiple range test (*Tukey-B* procedure)[6-10][6-11][6-12], the masters/mates group and government employees/port officials group are significantly different at the 0.05 level in the opinions of the option "improved weather information". The former group gives more weight on the option than the latter.

The VTS operators group differs from the masters/mates group and the shipowners/maritime organization group in the view of the option "stricter ship safety regulation". The latter two groups are more pessimistic regarding the option.

The masters/mates group and VTS operators group are significantly different at the 0.05 level in the opinions of the option "upgraded navigational aids". The former group gives more weight on the option than the latter.

In the views of the option "more traffic separation scheme", the masters/mates group differs from VTS operators group and government employee/ port officials group. The masters/mates group is more optimistic for the option.

The VTS operators group differs from masters/mates, shipowners/maritime organizations and pilot/lecturer/surveyors group in the opinions of the option "more recommended routes". The operators group gives less weight than the others. However, the operators group gives more weight for the option "extended VTS service" than masters/mates group.

The masters/mates group minimises the importance of training of seafarers as compared with other groups. This group, however, gives much more weight on the option "prohibition of fishing/excursion on fairway" than other groups.

(2) Implementation and/or modification of Vessel Traffic Services: In Question C2 (questions), the respondents, who work in specific port or area only, were asked to express their views on how VTS should be implemented and/or modified. Consequently the number of respondents is small on these questions. Table 6.9 and 6.10 summarize their opinions with respect to each area.

A state-of-the-art VTS service is on operation at the port of Pohang from January 1993, thus half of respondents sought to maintain the present level in the Pohang area. Almost all respondents declared that the VTS service should be upgraded or implemented in where no service exists. No respondent wished to downgrade or close the VTS service, and only two respondents sought not to implement VTS in their area.

Table 6.9 Implementation/Modification to VTS

AREA	If area has VTS service now			No VTS service now	
	Downgrade or close	Maintain at present level	Improve or upgrade	Implement	Do not implement
Tonghae area	0	0	9	6	1
Pohang area	0	5	6	2	0
Ulsan area	0	1	7	7	0
Pusan area	0	0	31	6	0
Masan/Jinhae/Koje-do area	0	0	4	4	0
Yosu/Kwangyang area	0	0	1	12	1
Cheju Haehyup, Jangjug-sudo area	0	0	1	4	0
Maemul, Maenggol Sudo, Mokpo area	0	0	0	1	0
Kunsan/Changhang area	0	0	4	7	0
Taean-bando to Inchon area	0	1	18	16	0

Source: Author

Table 6.10 identifies levels of VTS provision and, represents the respondents' view on the adequate VTS level, VTS type and formal authority of VTS. A majority of respondents agreed that Level III and IV are adequate, and VTS for the port and their approaches is the suitable type. Port authority is the most acceptable organization as the formal authority of VTS by the questionnaire which receives the greatest approvals in all area, and very few respondents want the Coast Guard(Marine police in Korea) or Pilot association to be vested with formal authority. This view is supported by other research:

> All respondents were asked where the formal authority of VTS should be vested. There was a preference for the Harbour Authority, either in the person of the Port Director or the Harbour Master to the National Government. IMO was also mentioned, though more in the context of providing the formal framework to enable other authorities to establish their schemes.[6-13]

Table 6.10 VTS level, type and formal authority

AREA	Adequate VTS Level				Type of VTS			Formal Authority of VTS			
	I	II	III	IV	Port VTS	Port & approa-ches	Coas-tal VTS	Port Auth-ority	Coast Guard	Pilot Assoc-iation	Other
Tonghae	0	2	7	3	2	11	0	13	1	0	0
Pohang	0	0	5	3	3	6	2	10	0	1	1
Ulsan	2	0	5	6	3	10	2	10	0	4	1
Pusan	3	0	16	15	3	24	6	24	4	4	2
Masan	0	0	2	4	1	4	2	7	0	0	0
Yosu	1	0	11	0	2	11	1	13	1	0	0
Cheju	1	0	3	0	0	3	2	5	0	0	0
Mokpo	0	0	0	1	0	0	1	1	0	0	0
Kunsan	0	0	9	1	0	7	3	10	0	0	0
Inchon	1	0	16	8	2	20	4	21	4	1	0

Note 1) Level I : A vessel movement reporting system consisting of VHF communication and various vessel reporting

2) Level II : Basic radar surveillance; The VMRS of Level I coupled with basic radar surveillance. The radar assumed to be a standard shipboard radar without advanced features.

3) Level III : Advanced radar surveillance; This system includes complete communication plus an advanced state-of-art VTS radar surveillance system.

4) Level IV : Automatic dependent surveillance based on the use of differential GPS retransmissions. This system consists of an automated transponder installed on the participating vessel.

Source: Author

6.6 VTS OPERATORS

In recent years there has been a rapid growth in Vessel Traffic Services (VTS). This growth has led to a significant increase in the number of VTS operators required worldwide. The International Maritime Organization(IMO) has issued guidelines thus:

> The VTS authority should ensure that VTS operators have the qualifications and have received special training appropriate to their tasks within the VTS and meet the language requirements mentioned in paragraph 3.4, in particular with regard to VTS operators authorized to issue traffic instructions or to give navigational assistance.[6-14]

Despite these recommendations, there is little common ground in the qualification and training requirements of VTS operators worldwide or even between authorities within national boundaries. A study into these matters has, therefore, been carried out by the International Association of Lighthouse Authorities(IALA) VTS committee, and the results are published through IMO, so called "Guidelines on the recruitment, qualification and training of VTS operators". VTS operators are defined in these guidelines as follow;

> A VTS operator is the appropriately qualified person who performs the functions of the VTS. VTS operator further means a person who provides, if duly authorised, instructions and information to vessels and decides what action should be taken in response to data received. This person may be directly responsible for communications within a defined geographical within a VTS area, or may relay such information and decisions through an intermediary.

These guidelines use the seven prime functions identified as a basis for defining the tasks, skills and knowledge required by an effective VTS operator. These are [6-15]:

F1 - Acquiring data
F2 - Allocation of space
F3 - Routine control of vessels
F4 - Manoeuvres to avoid collisions
F5 - Enforcement function
F6 - Remedial function
F7 - Other functions

Of course, the tasks, skills and knowledge required by VTS operator depend on the level and type of VTS, each have special and differing operational and training requirements. COST 301 Task force identified the following seven general knowledge areas considered necessary to the VTS operator:

1. Knowledge and use of the English language
2. General nautical knowledge
3. Special nautical knowledge
4. Equipment handling expertise
5. Legal knowledge
6. Local geographic knowledge
7. General education.

The above areas are almost self evident. Barber & Hughes[6-16] claimed the following further skills are essential.

> Levels of training may vary, dependent on the level of the VTS operator, but for a modern system, including the radar surveillance of a busy port and its approaches, the following skills are essential:-
>
> 1. The ability to communicate clearly, concisely and correctly using modern V.H.F. equipment. This is a vital requirement at the heart of an effective Vessel Traffic System.
>
> 2. The ability to use and interpret radar tracking information correctly and to be aware of the limitations of radar surveillance equipment.
>
> 3. The ability to understand the problems of the mariner navigating within a VTS area - i.e. the Pilot/Master/VTS relationship.
>
> 4. The ability to create co-operation between the shore based operator and the mariner aboard ship, and to ensure that mariners in the Traffic area are aware of the VTS and of its purpose to enhance navigation safety.
>
> 5. The ability to solve problems and, in particular, to be able to deal with a number of different problems and tasks at the same time.
>
> 6. The ability to respond quickly and effectively to developing situations.
>
> 7. The ability to respond quickly and effectively to hazardous and emergency situations.
>
> 8. To be aware of the legal implications of VTS.

There are some 100 VTS operators in Korea, but the individuals are merely expected to communicate information to participating vessels. The services are limited within the harbour limits (Type: Port VTS), and to vessel movement reports (Level I) and basic radar surveillance (Level II) in the port of Inchon, Pusan, Ulsan and Pohang as illustrated in Figure 5.1.

The respondents were asked to express their views on the operators' background, experience and qualification to perform their tasks in Question D. This question is to seek opinions of respondents about the VTS operator who undertakes the tasks mentioned in the IMO's definition above.

As can be seen in Table 6.11, 94 percent of mariners and 87 percent of shore staffs group agrees that marine experience is essential for VTS operators to perform their tasks, where as only 25 percent of VTS operators agrees. Shore staffs include shipowners' representatives, port/harbour officials, lecturers of education & training institute, government employee, officials of maritime organization and classification surveyors.

48 percent of mariners and 61 percent of shore staffs consider that previous experience of ship handling is desirable for VTS operators, while eight percent of VTS operators considers so. According to VTS operators group, 77 percent of them suggests experience of ship handling and communication is advisable for the operators.

Master's experience is advised for VTS operators by half of the mariners(50%) and shore staffs (36%), while the majority (69%) of VTS operators group claims a radio operator's certificate is desirable for operators. Other experience in the third row of Table 6.11 includes ability of English and maritime related rules and regulations.

These results are supported by other research - "The Mariner's Requirements for VTS".[6-17]

> As a precursor to seeking the views of VTS authorities of the background and experience they sought from potential VTS operators, the users were asked what they expected.
> One continual complaint by mariners about VTS operators was that they did not appreciate the mariner's problem and the environment in which he worked, and in consequence the information and advice they offered fell short of what the mariner needed and expected. It was to be expected that the mariner would therefore look for reasonably high qualifications on the part of both the VTS officer-in-charge and the VTS operator. In the event, 80 percent of mariners expected the VTS officer-in-charge to be a pilot or possess a Master's certificate. The level required of the VTS operator was only slightly lower, with nearly half looking for the same qualifications as the officer-in-charge and the majority of the remainder stipulating a Class 3 certificate or better.

Table 6.11 VTS operators

	Mariners		Shore staffs		VTS Operators		Total	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
1. Is marine experience essential ?								
Essential	209	94%	83	87%	17	25%	309	80%
Not necessarily	13	6%	12	13%	47	70%	72	19%
Not necessary	0	0	0	0	2	3%	2	1%
No opinion	0	0	0	0	1	2%	1	0
2. What kind of previous experience is required ?								
Shiphandling	103	48%	53	61%	2	8%	158	48%
Communication	0	0	1	1%	4	15%	5	2%
Shiphandling & Com.	109	51%	33	38%	20	77%	162	49%
Other	3	1%	0	0	0	0	3	1%
3. What level of qualification is necessary?								
Pilot	4	2%	3	3%	1	2%	8	2%
Master's experience	108	50%	33	36%	2	4%	143	39%
Master's certificate	24	11%	12	13%	1	2%	37	10%
C/Mate's certificate	68	31%	26	28%	8	14%	102	28%
2nd Mate's certificate	12	5%	14	15%	5	9%	31	9%
Radio operator	2	1%	4	5%	38	69%	44	12%

Source: Author

6.7 EFFECTIVENESS OF VESSEL TRAFFIC SERVICES

Ten sub-sets of questions relating to the effectiveness of VTS were asked in section E of the questionnaire. Indices have been developed from the answers to those questions in order to provide a measure of the perceived importance and effectiveness of VTS. Table 6.12 provides the summary of the views of all respondents (n=385).

As shown in the table, the median is between 3.58 and 4.24. "VTS assistance in reduced visibility condition" has the highest median (4.24) and "assistance with communication problems" has the lowest median (3.58), however, VTS assistances are generally favourably rated by the respondents.

Views of the services in question are analysed in each question, focusing on the different viewpoints by the occupational groups. Figure 6.2, 6.3 and 6.4 show the effectiveness indices of VTS service by occupational groups. It shows that VTS operators assess the services with slightly more severity than any other group.

Table 6.12 Summary of views on the effectiveness of VTS

VTS ASSISTANCE	(0)	(1)	(2)	(3)	(4)	(5)	Median
IN REDUCED VISIBILITY CONDITIONS	1	2	2	10	117	253	4.24
IN ADVERSE WEATHER CONDITIONS	0	1	5	39	163	177	3.91
IN DENSE TRAFFIC AREAS	0	0	2	18	131	234	4.18
IN AREAS CONGESTED WITH FISHING OR PLEASURE BOATS ..	0	1	6	30	148	200	4.04
IN RESTRICTED WATERS ...	0	0	8	30	139	208	4.08
IN AREAS WITH VESSELS ACTING CONTRARY TO RULES	0	0	5	23	147	210	4.09
TO VESSELS IN EMERGENCY	0	0	5	23	121	236	4.19
WITH FOREIGN LANGUAGE PROBLEMS, LACK OF EXPERIENCE	1	0	11	56	180	137	3.69
WITH COMMUNICATION PROBLEMS	2	1	14	85	158	125	3.58
PROVISION OF NOTICES TO SHIPPING	0	0	4	25	168	188	3.98

Note: (0) No opinion (1) Very unimportant (2) Unimportant
(3) Average (4) Important (5) Very important

Source: Author

<u>(1) Assistance in reduced visibility conditions</u>: Vessel Traffic Services provide assistance in visibility reduced by fog, snow and/or rain. This assistance includes monitoring of ships' positions; provision of information on objects and floats; advice offered on request or when determined necessary.

Of all services performed by VTS, assistance in reduced visibility condition is perceived as the most important with the highest average index(4.6). Masters/Mates of merchant vessel and ferry, pilot/lecturer/surveyors and VTS operators group recognized these services as the most important.

(2) Assistance in adverse meteorological conditions: Vessel Traffic Services provide assistance to vessels in adverse meteorological conditions. This assistance includes provision of information on tides and currents; monitoring of ships' positions; provision of advice on request or when judged necessary.

These service are rated average(10%), important(42%) and very important (46%) by the groups. The highest average effectiveness rating for these services comes from the VTS operators group and the lowest from masters/mates group.

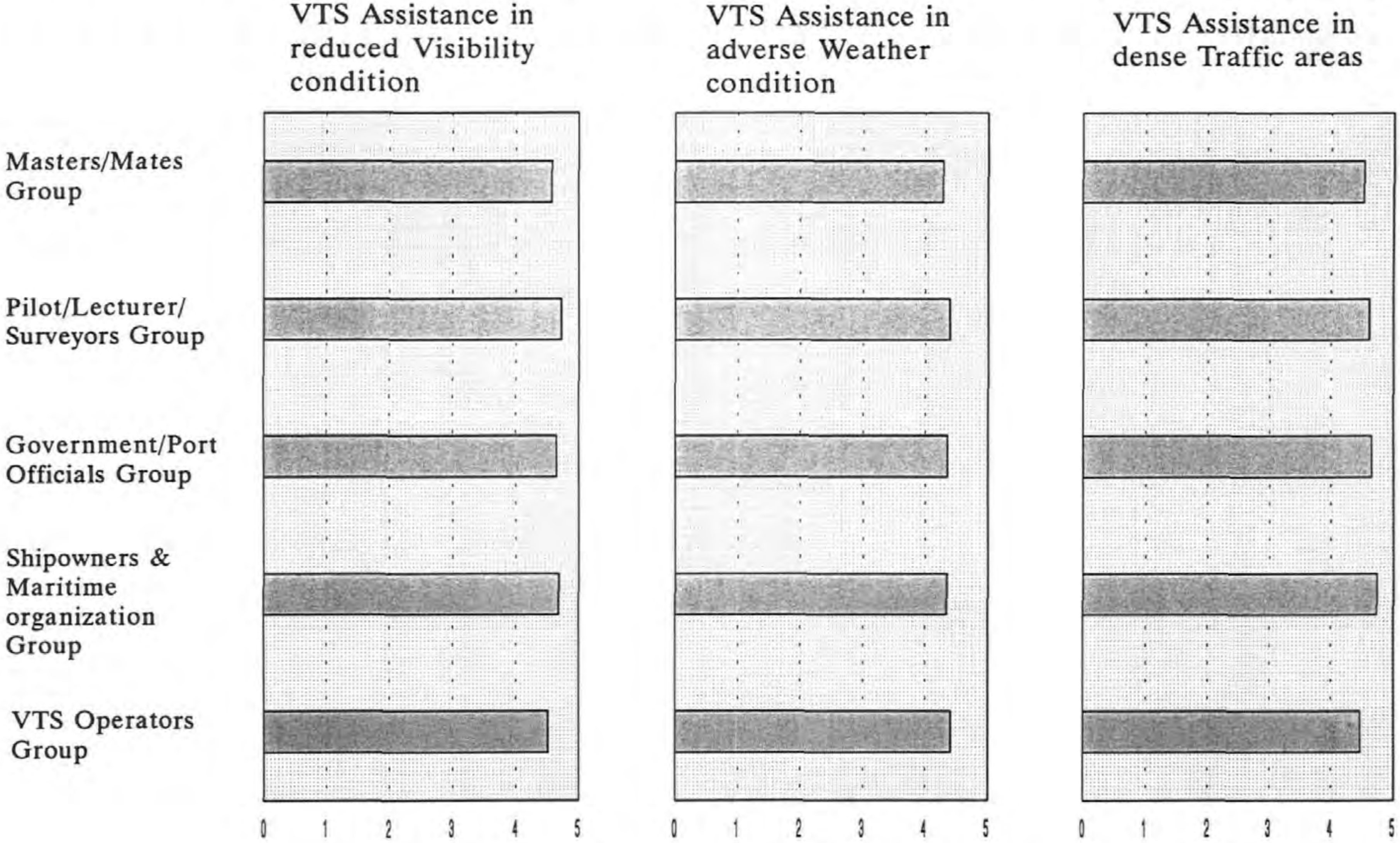
(3) Assistance in dense traffic areas: Vessel Traffic Service assists vessels flow in dense traffic areas. This assistance includes providing advance traffic information; establishing and maintaining radio contact among vessels; warning other traffic of vessel acting contrary to regulations or in an unexpected manner; monitoring ship's movement; providing advice on the timing of various manoeuvres to assist traffic and/or to avoid a potentially hazardous situation.

These services are rated average(5%), important(34%) and very important (61%) by occupational groups. Given their undoubted importance, these services have merited a higher effectiveness index that is the highest after that for assistance in reduced visibility conditions. Shipowners/maritime organization group recognized these services are the most important among all the services.

(4) Assistance in areas congested with fishing vessels and pleasure crafts: In areas congested with fishing boats and pleasure craft, VTS provides assistance by services such as; providing advance information to larger vessels on the presence & avoidance of fishing fleets or pleasure vessels; it also provides advance information to fishing boats on the approach of larger vessels.

Figure 6.1

Effectiveness Indices of VTS by Occupational grouping (1)



These services are rated average(8%), important(38%) and very important (52%) by the groups. The highest average effectiveness rating for these services comes from the pilot/lecturer/surveyors group and the lowest from VTS operators group.

(5) Assistance in restricted waters: VTS provides assistance to vessels in restricted waters, for example, near blind bends, narrow passages, rocks, shoals, shallow waters, structure on seabed, bridges and floating objects. These services consist of providing advance notice; and providing traffic information in the area of hazard; and monitoring ship's movements so as to regulate the flow of traffic.

The importance of these services are rated average(8%), important(36%) and very important(54%) by the occupational groups. The highest average effectiveness rating for these services comes from the government/port officials group and the lowest from the VTS operators group.

(6) Assistance in areas with vessels acting contrary to rules/regulations: VTS provides assistance to vessels acting contrary to rules & regulations such as excessive speed in reduced visibility or proceeding in the wrong side of fairway or unmarked waters. These services include warnings to other traffic on the presence of rogue vessels.

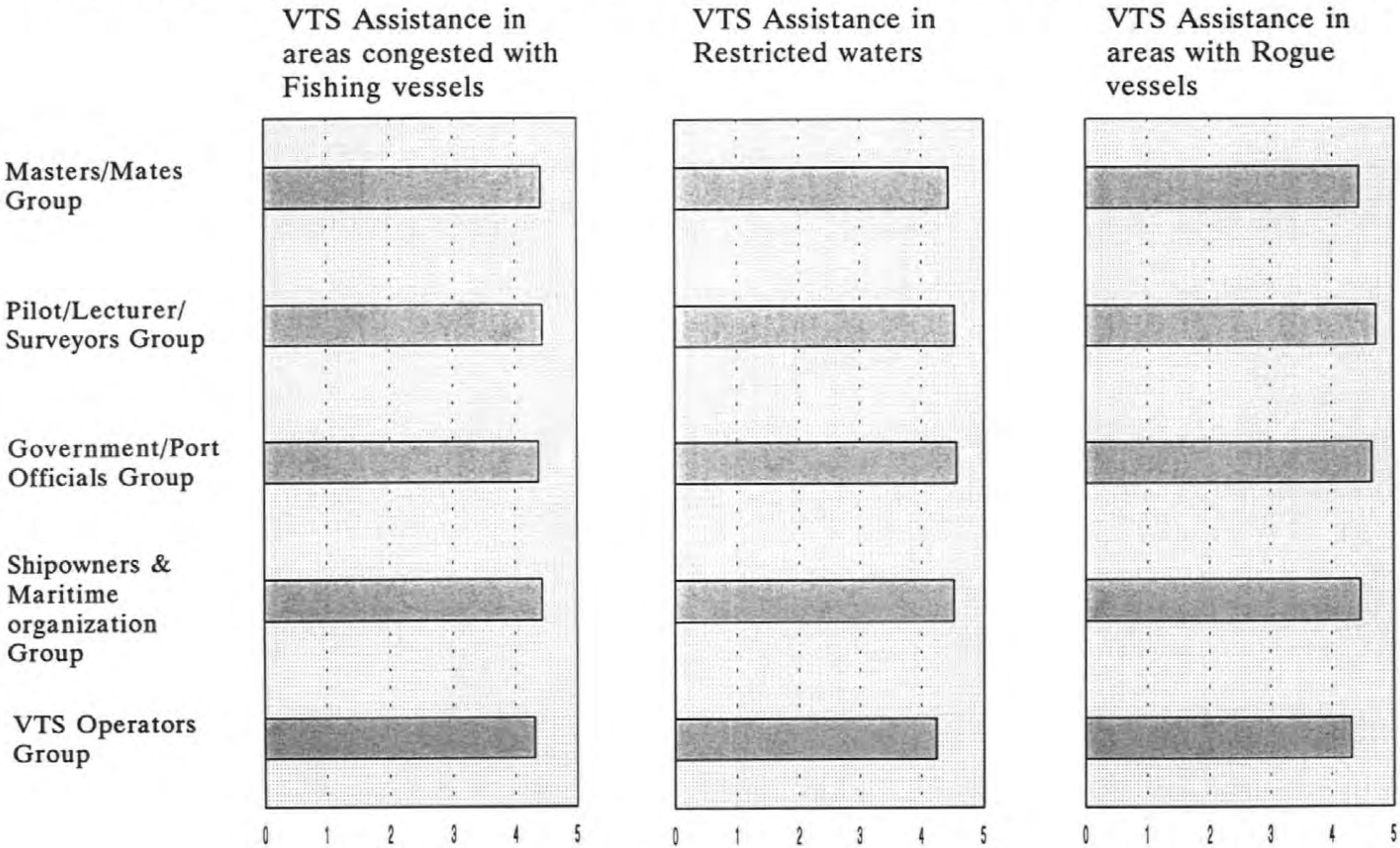
These services are rated average(6%), important(38%) and very important (55%) by the occupational groups. The highest average effectiveness rating for these services comes from the pilot/lecturer/surveyors group and the lowest from VTS operator group. Multiple range test was employed to test statistically if there is any significant difference between the views of the five occupational groupings.

According to the multiple comparison procedure, the pilot/lecturer/surveyors group differs from the VTS operators group in the views of the effectiveness in VTS assistance to vessels acting contrary to rules & regulations. Differences are marked by an asterisk if the significance level is not less than 0.05. No two groups are significantly different at 0.05 level in other sub-sets of VTS activities.

```
- - - - - - - - - - - O N E W A Y - - - - - - - - - - -

   Variable  EF_ROGUE    VTS ASSISTANCE FOR THE ROGUE VESSELS
By Variable  GROUP       Occupational Group

                                   Sum of         Mean            F       F
        Source           D.F.     Squares        Squares        Ratio   Prob.

Between Groups             4        5.2917        1.3229       3.0223   .0179

Within Groups            380      166.3343         .4377

Total                    384      171.6260

                                 Standard    Standard
Group        Count       Mean   Deviation     Error      95 Pct Conf Int for Mean

Masters/      207      4.4300      .6853      .0476      4.3360   To      4.5239
Pilot/Le       36      4.7222      .4543      .0757      4.5685   To      4.8759
Governme       34      4.6471      .5971      .1024      4.4387   To      4.8554
Shipowne       41      4.4634      .6744      .1053      4.2505   To      4.6763
VTS oper       67      4.3134      .7008      .0856      4.1425   To      4.4844

Total         385      4.4597      .6685      .0341      4.3927   To      4.5267

Group         Minimum      Maximum

Masters/       2.0000       5.0000
Pilot/Le       4.0000       5.0000
Governme       3.0000       5.0000
Shipowne       2.0000       5.0000
VTS oper       2.0000       5.0000

Total          2.0000       5.0000

Multiple Range Test
                              V M S G P
                              T a h o i
                              S s i v l
                                t p e o
                              o e o r t
                              p r w n /
                              e s n m L
     Mean        Group        r / e e e

     4.3134      VTS oper
     4.4300      Masters/
     4.4634      Shipowne
     4.6471      Governme
     4.7222      Pilot/Le     *
```

Figure 6.2

Effectiveness Indices of VTS by Occupational grouping (2)



(7) Assistance rendered to vessels in emergency: VTS assists vessels experiencing engine failure, fire on board, loss of control, radar failure, radio failure and any other emergency situation. These services consist of identifying the vessel in distress; routeing other vessels away from the scene of accident; closely monitoring the situation; providing all other required rescue services.

These services are rated average(6%), important(31%) and very important (61%) by the occupational groups. The highest average effectiveness rating for these services comes from the government/port officials group and the lowest from VTS operator group. Government/port officials group recognized these services are the most important among the all services.

(8) Assistance to vessels with foreign language difficulties, lack of experience or knowledge problems: VTS provides further service in the early identification and publicising of vessels whose crews are experiencing language difficulties in their communications.

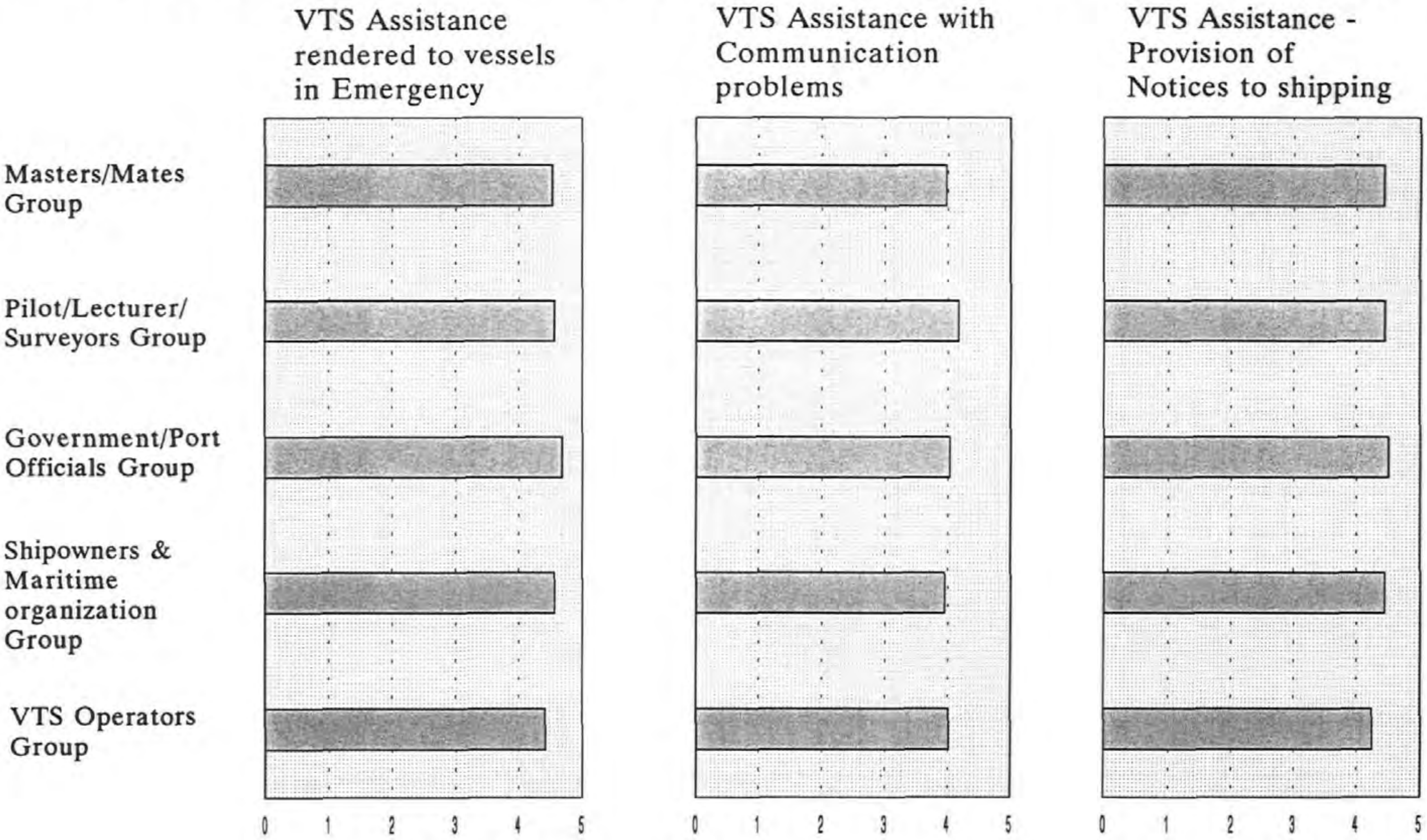
These services are rated average(15%), important(47%) and very important (36%) by the occupational groupings. The lowest average effectiveness rating for these services comes from the masters/mates group.

(9) Assistance with communication problems: As the VTS centre monitors all communications, it may provide assistance to vessels having communication difficulties, on request or when judged necessary. These services are, repeatedly ranked in the last place with lowest average index from all groups.

(10) Provision of Notices to Shipping: When VTS personnel are made aware of a new

Figure 6.3

Effectiveness Indices of VTS by Occupational grouping (3)



hazard to navigation, a Notice to Shipping is passed to the vessels. Theses services are rated average(7%), important(44%) and very important(49%) by the groups. The highest average effectiveness rating for these services comes from the government/port officials group and the lowest average effectiveness rating for these services comes from the VTS operators group.

It is acknowledged that perceptions and expert opinions require testing objectively. This remains a topic for further study.

6.8 SUMMARY

A questionnaire survey was carried out across the board of maritime industry including mariners navigating in Korean waters, pilots, shipowners' representatives, port/harbour officials, VTS operators and other maritime interests of some 860 persons. There were 385 duly completed questionnaires returned by the closing date.

The risk factor "reduced visibility by fog/snow" is the leading response factor in increasing marine risk with "human factors in shiphandling" second. "Greater number of pleasure crafts in shipping routes" ranks in the last place. There were some notable discrepancies between the views of occupational groups. Generally the VTS operators group assesses the risk factors with less weight than any other group. This curiosity may be explained by the relatively low shipboard experience and qualification.

The marginal effectiveness of various options to reduce marine risk was examined. "Additional Vessel Traffic Services" received the greatest approval from the respondents seeking to improve marine safety. And "prohibition of fishing in shipping routes" and "additional Traffic Separation Schemes" were ranked in second and third place in reducing marine risk.

In the question of the modification of VTS, almost all respondents declared that the VTS service should be upgraded or implemented where no VTS exists and no respondent has the expressed opinion to downgrade or close the service. The majority of the respondents agreed that Level III or IV are adequate in their area, VTS for the port and their approaches is the suitable type. The Port authority is the most acceptable formal authority for their VTS.

In the question of views on the VTS operators' background, experience and qualification, the majority of respondents agree that marine experience is essential for VTS operators to perform their tasks. The previous experience of shiphandling & communication is suggested by the majority of respondents.

The median with regard to ten sub-sets of VTS services & activities was examined in order to provide a measure of the perceived importance and effectiveness of VTS activities. The median was between 3.58 and 4.24, "VTS assistance in reduced visibility condition" has the highest value (4.24) and "VTS assistance with communication problems" the lowest value (3.48). VTS assistances, however, are generally favourably rated by the respondents. Views of the services are analysed, focusing on the different viewpoints by the occupational groupings. Generally VTS operators group assesses the services with slightly more severity than any other group.

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Chapter 7

EFFECTIVENESS OF VESSEL TRAFFIC SERVICES

7.1 INTRODUCTION

Vessel Traffic Services have been variously defined and exist in a number of configurations, but their fundamental objectives are "safety of traffic and efficient traffic flow" achieved by providing information and advice on other traffic and navigational hazards to the vessels participating in the system. In some cases the VTS centre has its own radar coverage of the waterway and directly maintains surveillance of vessel movements with complete communication systems. In other cases the centre will maintain the estimated track of vessels based on VHF communication and vessel reporting. This latter method is typically termed a Vessel Movement Reporting System (Level I), and other VTS systems are categorized into Basic radar surveillance (Level II), Advanced radar surveillance (Level III) and Automatic dependent surveillance (Level IV) in the United States Coast Guard study. The candidate VTS level in this study is Level III technology.

The estimation of the effectiveness of Vessel Traffic Services(VTS) is a diverse and complex problem. A review of the VTS effectiveness literature covering U.S.A, Canadian and European research suggests three potential approaches in estimating effectiveness:

- Simulation of a VTS system;
- Collection of opinions from experienced mariners and VTS operators;
- Statistical analysis of casualties in situations "with and without" VTS.

In the literature there has been some discussion in the use of simulation to address VTS effectiveness. This method includes the use of full bridge simulators coupled with a simulation of a VTS centre, as well as various forms of mathematical simulation. Some work of this type has been done in Europe.[7-1] However, such methods are nowhere near capable of addressing VTS effectiveness in the overall context of this study.

Synthesis of expert opinion, to collect the opinions of experienced mariners and VTS operators, has been used in the Canadian Coast Guard Study [7-2], COST 301 Study [7-3] and U.S. Coast Guard Study [7-4] in connection with the estimation of the effectiveness of varying levels of VTS in different waterway types. Responses to the questionnaire used in connection with this aspects of COST 301 show large variations. Even the discussions within COST 301 with VTS operators and other marine experts have confirmed that opinions on VTS effectiveness are highly subjective. Pilots are, as expected from the Canadian Coast Guard Study report, more pessimistic about the potential value of VTS in reducing collision and stranding rates than other occupational groupings.

Another method used to estimate the effectiveness of VTS is statistical analysis of casualties in situations "with and without" VTS. This method has been used in the COST 301 study.[7-5] A simplified fault tree analysis was used to indicate the complex relationships between factors. The causal relationships were collected and analyzed using a block scheme. The sequence of events relevant to the casualty is traced by connecting the appropriate blocks with lines. The effect of each factor upon the casualty is measured by a weighting coefficient. The study pointed out that usually a maritime casualty can be seen as a dynamic sequence of certain events in the control loop(s) which results in poor control of the process, or the breaking of the control loop.

The authors, however, feel there is a limitation in assessing the effectiveness of VTS by casualty analysis alone. In general, they conclude that all studies on causal factors of casualties are based on limited information collected after the casualties. This information does not usually cover the general situation in time or place. Therefore, the most important feature of the "ship plus VTS" system cannot be quantified. The effect of the VTS on the ship environment and time-dependent causal factors can not be studied. Although an analysis of VTS effects using the existing casualty data can consider tactical interactions by a VTS, but the positive effect of strategic planning of VTS can not be considered in full.[7-6]

The primary objective of the effectiveness analysis in this chapter is to determine the expected percentage of the "addressable" casualties that could be prevented with the introduction of some form of VTS. Figure 7.1 provides an overview of this analysis. In simplified form, it determines the VTS benefits by multiplying casualty rate reduction factors by the effect level of causal factors. This method is a new approach to quantify the VTS effectiveness unlike any other earlier studies. Combining the casualty rate reduction factors with the effect level of causal factors, it produces more rational index of the effectiveness than the only synthesis opinion of expert or statistical analysis. This approach could reduce the overestimation of the percentage of the benefit by the another filtering process (selection of VTS addressable factors).

As shown in Figure 7.1 the development of the casualty rate reduction factors was based on a synthesis of expert opinion in Chapter 6 and the estimation procedure in section 7.5, and the development of effect levels was based on the casualty analysis using functional block diagram in Chapter 4.

The casualties were based on the Written Verdicts by Marine Accident Inquiry Agency. From this a subset of "VTS addressable" causal factors was determined based on a detailed review of the Verdicts narratives. The "addressable" causal factors consisted of those where it was initially felt that a VTS system had at least some potential to prevent the accident from occurring. That a casualty was "addressable" did not mean that a VTS could prevent it with 100 percent probability.

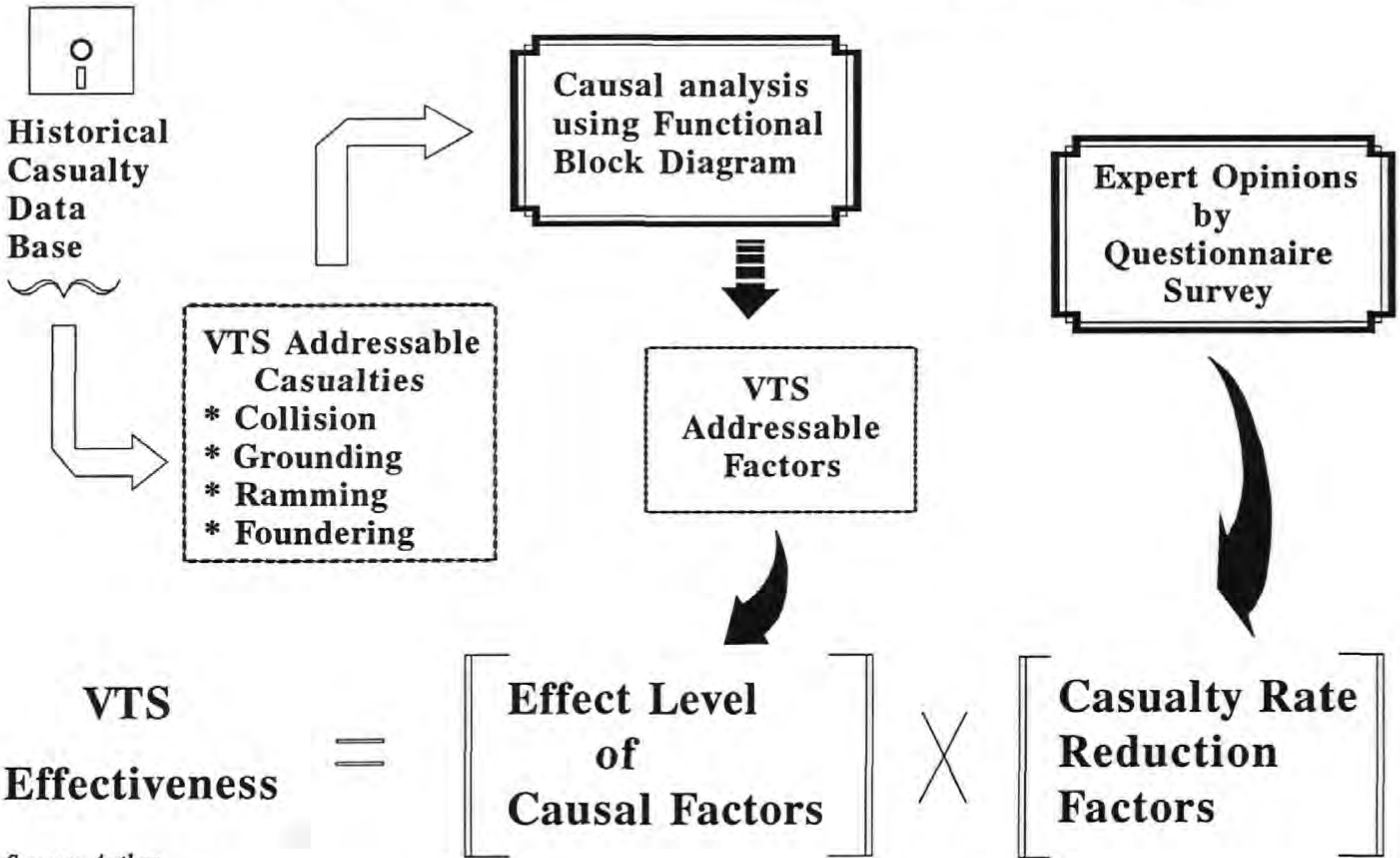
The causal factors of the casualties in the data base are constructed for Korean waters using the above-mentioned functional block diagram procedure in Chapter 4. As a result, the effect levels of the causal factors were obtained. These results will form the basis for an estimation of the effectiveness of VTS.

7.2 LITERATURE SURVEY RELATED TO VTS EFFECTIVENESS

7.2.1 RISK ASSESSMENT - PROBLEM AREA IDENTIFIER [7-7]

A further questionnaire was designed to assess the effectiveness of various levels of VTS systems on the collision and stranding(groundings) rate.

Figure 7.1 **Overview of VTS Effectiveness Analysis**



Source: Author

The questionnaire was personally administrated by researchers to mariners (mainly ship masters) with experience in a variety of European waters. The COST 301 study team felt that the best way to gather estimates was from personally administrating the questionnaires to the subjects to ensure they fully understood the questions.

From the questionnaire results (Table 7.1) the study noted three main conclusions related to the effectiveness of VTS on collision rates.

- The more complex the shore support facilities become, the less difference there is between the effectiveness ratings.

- The results suggest that experienced mariners see little or no benefit in terms of risk reduction in the introduction of a control service rather than an information service.

- The maximum benefit to be obtained through the introduction of a VTS system is approximately 60 percent overall.

The study then weights collision effectiveness by relative proportion of the different types of encounters (meeting, crossing and overtaking). For areas with a normal mix of the various types of encounters, the mean collision reduction rate was estimated to be approximately 0.5 for a VTS system with radar surveillance but no transponder identification.

The questionnaire results of the potential effectiveness of defined levels of VTS in reducing stranding rates are illustrated in Table 7.2. The study recognises two points of interest:

- The results are consistent with those for collision rates in that the subjects see only a small benefit in terms of risk reduction in the introduction of a control service rather than an information service at either of the VTS levels.

- The maximum benefit which is likely to be obtained through the introduction of any VTS system is estimated to be 55 percent.

The report also points out that the potential benefits of VTS for reducing stranding rates is somewhat less than for reducing collision rates.

Table 7.1

Estimated Effect of VTS on Collision Rate based on Expert Opinion from Research under the COST 301 Programme

	Estimated Reduction of Collision Rate		
Shore Support Level	Meeting	Crossing	Overtaking
International Collision Regulations Only	0	0	0
IMO Traffic Separation	.68	.25	.04
Vessel Traffic Information Service based on a Ship Reporting System	.47	.33	.22
Vessel Traffic Information Service based on Ship Reporting & Surveillance	.57	.45	.32
Vessel Traffic Information based on Transponder Identification, Location and Information Exchange	.61	.52	.42
Vessel Traffic Control Service based on a Ship Reporting System	.44	.42	.30
Vessel Traffic Control Service based on Ship Reporting & Surveillance	.53	.45	.39
Vessel Traffic Control Service based on Transponder Identification, Location and Information Exchange	.58	.54	.51

Source: *KEMP J.F., GOODWIN E.M. and PICK K.(1986). Risk Assessment - Problem Area Identifier. COST 301 Final Report on Task 2.46.*

Table 7.2

Estimated Effect of Shore Support on Stranding Rate based on Expert Opinion under the COST 301 Programme

Shore Support Level	Estimated Reduction of Stranding Rate
Existing Level of Lighthouse and Buoyage and Statutory On-Board Equipment	0
Enhanced Level of Lighthouse and Buoyage	.25
Accurate Radio Navigation Aid Coverage (i.e., Decca Navigator or Loran C) with Compulsory Carriage of Equipment on Ships	.44
IMO Traffic Separation	.29
Vessel Traffic Information Service based on a Ship Reporting System with Radar Surveillance	.40
Vessel Traffic Information Service based on Transponder Identification, Location, and Information Exchange	.49
Vessel Traffic Control Service based on Ship Reporting System with Radar Surveillance	.45
Vessel Traffic Control Service based on Transponder Identification, Location, and Information Exchange	.55

Source: KEMP J.F., GOODWIN E.M. and PICK K.(1986). Risk Assessment - Problem Area Identifier. COST 301 Final Report on Task 2.46.

7.2.2 NATIONAL VESSEL TRAFFIC SERVICES STUDY, CANADIAN COAST GUARD, 1984[7-8]

This study, conducted to measure the costs and benefits of the Canadian VTS, is one of the main documents specifically addressing the effectiveness of VTS. The level of system sophistication and the geographical configuration of the waterway were the key factors considered in the development of a detailed model of VTS costs and benefits. Four different waterway configurations and a number of alternative VTS system configurations are suggested for the estimation of the effectiveness of VTS. The four waterway types are;

- Open simple waterways (i.e., an open bay or wide strait),
- Open complex waterways (i.e., an approach to a busy harbour),
- Confined simple waterways (i.e., a river) and
- Confined complex waterways (i.e., a harbour).

Different VTS system features include;

- Traffic Separation Schemes (TSS);
- Movement Restriction Regulations (MRR);
- Bridge-to-Bridge VHF reporting at designated points (B/B);
- Ship-to-Shore VHF communications and information exchange plus simulated vessel tracking (S/S);
- Ship-to-Shore VHF communications and information exchange plus simulated radar surveillance supplemented by computerized target tracking, interactive target analysis, hazard warning, and data storage and retrieval (S/R+).

Estimates of VTS effectiveness in terms of the percent reduction in accidents for "VTS addressable" collisions, groundings, or strikings were developed using the knowledge and experience of a team of personnel with marine-related backgrounds.

Table 7.3

VTS Effectiveness for Addressable Casualties based on Canadian National VTS Study

(Percent Reduction in Casualties)

VTS System	Open Waters: Simple Traffic Pattern (OC)	Open Waters: Complex Traffic Pattern (OC)	Confined Waters: Simple Traffic Pattern (CS)	Confined Waters: Complex Traffic Pattern (CC)
B/B Bridge-to-Bridge				
without TSS/MRR	12	10	15	10
with TSS/MRR	35	25	20	15
S/S Ship-to-Shore				
without TSS/MRR	35	20	40	30
with TSS/MRR	40	30	45	35
S/R S/S plus Basic Radar Surveillance				
without TSS/MRR	45	50	45	50
with TSS/MRR	55	55	55	65
S/R+ S/R plus Automated Analysis				
without TSS/MRR	55	65	50	55
with TSS/MRR	65	70	60	70

Note: TSS: stands for Traffic Separation Scheme

MRR: stands for Movement Restriction Regulations

Source: Canadian Coast Guard (1984). Vessel Traffic Services, Final Report.

These persons consisted of former mariners, VTS regulators and consultants, as well as Coast Guard management. The results are illustrated in Table 7.3 by type of waterway and level of VTS service. According to Table 7.3, the various levels of VTS effectiveness in reducing accidents were estimated to range from 15 to 70 percent. When applied to the whole existing Canadian VTS systems the mean VTS effectiveness was approximated to be about 43.3 percent.

A VTS update study[7-9] was completed in 1988 by Government Consulting Group(GCG) for the Canadian Coast Guard. The same benefit/cost approach, employing a risk assessment framework, was used as the study completed in 1984. Both 1984 National VTS Study and 1988 VTS Update Study derived VTS risk reduction effectiveness percentages for four levels of service and for four types of waterways. Table 7.4 shows the results of the study. The VTS effectiveness in reducing casualties was estimated to range from 15 to 75 percent. The ship-to-ship system without a shore-based VTS centre is not shown in Table 7.4.

Table 7.4 VTS Effectiveness percentage used in the 1988 Update Study

LEVEL OF VTS	OPEN WATERS		CONFINED WATERS	
	SIMPLE	COMPLEX	SIMPLE	COMPLEX
VHF Only	25	15	40	20
Basic Radar	55	60	50	55
Advanced Radar	65	75	55	60

Source: Canadian Coast Guard, 1991 VTS Update Study, p.14

7.2.3 USCG - PORT NEEDS STUDY (VTS BENEFITS), 1991 [7-10]

This study was undertaken to estimate the benefits and costs of potential U.S. Coast Guard Vessel Traffic Services (VTS) in selected U.S. deep draft ports on the

Atlantic, Gulf and Pacific Coasts. The level of VTS performance, casualty type, vessel size and the waterway type were the primary factors considered in the development of a detailed model of VTS costs and benefits. The casualty risk model divides the 23 study zones into six waterway types (Sub-zone type). These consists of:

A. Open approach (i.e., entrance from sea)
B. Convergence area (converging of major traffic lanes or channels)
C. Open harbour or bay
D. Enclosed harbour
E. Constricted waterway (i.e., narrow passages with blind turns)
F. River

Three levels of VTS service have been defined, for which the effectiveness of VTS is estimated in combination with other factors (i.e., casualty type, waterway type, and vessel size). Two of the levels represent the technologies applied as part of the candidate VTS design (Level I & III).

- Level I — A Vessel Movement Reporting System consisting of VHF communication and various vessel reporting waypoints. No radar surveillance is included

- Level II — The VMRS of Level I coupled with basic radar surveillance. The radar technology was assumed to be a standard shipboard radar without advanced features.

- Level III — This system includes complete communication plus an state-of-the-art VTS radar surveillance system. This level represents the new Coast Guard Candidate VTS Design.

Three focus groups were formed to assess the effectiveness that various configurations of VTS systems would have in reducing casualties to vessels, including collisions, groundings and rammings. The objective of these focus groups was to provide detailed quantitative estimates of the effectiveness of alternative VTS system in reducing vessel accidents for a number of specific accident scenarios. These effectiveness estimates take the form of the percentage reduction in casualties for particular vessel accident scenarios. The focus groups each contained five or six individuals, each with some combination of deep draft vessel navigation experience, vessel traffic service experience and knowledge of the circumstance that have attended recent vessel casualties and/or 'near misses'.

Table 7.5 VTS Effectiveness Factors

	SUBZONE TYPES A, B OR C		SUBZONE TYPES D, E OR F	
	VTS LEVEL I	VTS LEVEL III	VTS LEVEL I	VTS LEVEL III
	LARGE AND MEDIUM VESSELS			
COLLISIONS				
TWO VTS PARTICIPANTS	.11	.68	.19	.52
ONE VTS PARTICIPANT	.00	.27	.00	.27
RAMMING				
NAV AIDS	.00	.00	.00	.00
OTHER	.22	.43	.22	.36
GROUNDING				
SHOAL	.10	.20	.10	.20
OTHER	.05	.46	.05	.25
	SMALL VESSELS			
COLLISIONS				
TWO VTS PARTICIPANTS	.13	.65	.18	.55
ONE VTS PARTICIPANT	.00	.27	.00	.27
RAMMING				
NAV AIDS	.00	.00	.00	.00
OTHER	.25	.50	.20	.38
GROUNDING				
SHOAL	.10	.20	.10	.20
OTHER	.06	.51	.02	.25

Source: U.S. Coast Guard (1991). Port Needs Study (VTS Benefits)

Table 7.5 presents a matrix of VTS effectiveness factors (i.e., casualty reduction factors) for the candidate VTS design. The study applies Levels I and III effectiveness factors to the forecasted NO-VTS case vessel casualties in each study sub-zone to estimate the avoided casualties attributable to the candidate design. The study applies the factors by casualty type, vessel size, and sub-zone type to each of the 99 sub-zones.

The VTS effectiveness factor for each of these VTS levels, casualty types and vessel sizes represents a judgement call. The VTS effectiveness factor matrix is the product of combining the results of recent published international research on VTS effectiveness with the results of a series of three Focus Group panel sessions conducted as part of this project, and application to the "VTS Addressable Casualties" from the Coast Guard historical file of vessel casualties.

7.2.4 1991 VESSEL TRAFFIC SERVICES UPDATE STUDY, CANADA [7-11]

Comments received after the 1988 VTS Update Study reference indicated that the effectiveness percentages shown in Table 7.4 were probably appropriate for VTS collision prevention, but were perhaps a little generous for groundings, particularly in river situations. Since the study was completed, the U.S. Coast Guard Port Needs Study, conducted by Volpe National Transportation Systems Centre, contracted A.T.Kearney, Inc. to review this whole area. Their study report reviewed the literature and concluded that the use of a focus group was the most viable approach for developing this system. The resulting VTS effectiveness numbers were divided into three major casualty types: collisions, groundings and rammings(strikings).

The major differences between the 1988 study values and the A.T. Kearney effectiveness percentages for collisions relate to the VHF Only option. There are also some slight differences between the numbers for simple and advanced radar in confined waterways. A compromise between the two sets of numbers would result in the modified VTS effectiveness percentages for collisions between participating vessels, for various casualty type. The VTS effectiveness percentages used in this study are summarized in Tables 7.6, 7.7 and 7.8.

Comparing these with Table 7.4, it is apparent that some of the revised percentages in Table 7.6 are lower than those used in the 1988 study. Similarly, the revised effectiveness percentages in Table 7.8 pertaining to all groundings are also lower for the VHF Only option; however, they are higher by about 15 percent for the Basic and Advanced Radar options in open waterways. Overall, the changes to the VTS effectiveness percentages are not significant, although they may be considered to improve the quantification of VTS effectiveness.

Table 7.6 Modified VTS Effectiveness Percentage for Collisions and Strikings involving participating vessels

	OPEN WATERS		CONFINED WATERS	
LEVEL OF VTS	SIMPLE	COMPLEX	SIMPLE	COMPLEX
VHF Only	20	10	35	15
Basic Radar	55	60	45	50
Advanced Radar	65	75	55	60

Source: Canadian Coast Guard, 1991 VTS Update Study, p.20

Table 7.7 Modified VTS Effectiveness Percentage for Non-participating vessels Colliding with Participating vessels

	OPEN WATERS		CONFINED WATERS	
LEVEL OF VTS	SIMPLE	COMPLEX	SIMPLE	COMPLEX
VHF Only	15	10	30	10
Basic Radar	40	45	35	40
Advanced Radar	50	55	40	45

Source: Canadian Coast Guard, 1991 VTS Update Study, p.20

Table 7.8 Modified VTS Effectiveness Percentage for all Groundings of participating vessels

	OPEN WATERS		CONFINED WATERS	
LEVEL OF VTS	SIMPLE	COMPLEX	SIMPLE	COMPLEX
VHF Only	10	5	20	10
Basic Radar	65	70	45	50
Advanced Radar	75	85	55	60

Source: Canadian Coast Guard, 1991 VTS Update Study, p.20

7.2.5 SURVEY ON VESSEL TRAFFIC MANAGEMENT SYSTEMS [7-12]

The second survey on 'Vessel Traffic Management systems and Brief Introduction to Marine Traffic Studies' was carried out by Fujii, Yamanouchi and Matsui in 1982 (published in 1984). The survey was based on response from 21 countries covering 246 VTSs and they summarized the reported gains:

1. Accident rate in fog was 1.1 per 1,000 trips in the New Rotterdam Waterway and it has decreased to 0.3 after the introduction of a VTS.

2. The average number of collisions per year in the St. Lawrence Seaway was 12 and operation of VTS resulted in a decrease to 3.

3. Loss due to delays in the Elbe Waterway in fog was alleviated by 3 million US dollars per year and a collision rate has decreased by half after the introduction of a radar chain.

4. The number of head-on collisions in the Dover Straits was 50 in five years which has decreased to 32 after the introduction of Traffic Separation Scheme, and then to 7 after the establishment of a traffic surveillance system. The number of all collisions in these three five-year periods were 69, 53 and 24.

5. The introduction of traffic routes in Tokyo Bay and establishment of VTS resulted in three years the following decrease in the number of casualties: all vessels, collisions 42, 20, 14 and groundings 49, 27, 9; vessels over 3,000 ton gross collisions 10, 6, 1, groundings 13, 8, 1.

7.2.6 VESSEL TRAFFIC SYSTEMS: ANALYSIS OF PORT NEEDS [7-13]

This study, undertaken as a follow-on effort to the U.S. Coast Guard Vessel Traffic Systems - Issue Study (March 1973), presented an analysis of port needs for vessel traffic systems; and recommended the priority by which these needs should be addressed. The overall purpose of this study was to rank 23 ports of the U.S. in order of their VTS needs. The ports were selected for analysis on the basis of tonnage of cargo handled, number of vessel transits, and number of vessels involved in collisions, rammings, and groundings (C/R/G) over a four year period (1969-72).

As part of this study, 1,827 collisions, ramming, and grounding casualties (involving 3,921 vessels) were analyzed. The circumstances of each casualty were examined in a case-by-case analysis to determine which accidents could have been prevented by VTS and what level of VTS would have been required. Table 7.9 summarizes the estimated reduction in vessel accidents by the different levels of VTS after casualty analysis.

Table 7.9 Estimated reduction in vessel accidents by VTS service level

VTS Service Level	Collision, Ramming, or Grounding	Collision only
Bridge to Bridge Radiotelephone	10%	21%
Regulations	13%	21%
Traffic Separation Schemes	12%	24%
Vessel Movement Reporting System	23%	49%
Basic Radar Surveillance	30%	60%
Advanced Radar Surveillance	32%	65%
Automated Advanced Surveillance	31%	65%

Source: *U.S. Coast Guard, 1973. Vessel Traffic Systems: Analysis of Port Needs, Final report*

7.2.7 CASUALTY ANALYSIS OF SELECTED WATERWAYS, 1978 [7-14]

As described in Section 7.2.6, the Analysis of Port Needs study analyzed the greatest number of reported marine casualties during fiscal years 1969 through 1972. The purpose of this paper is to update the analysis of several ports and waterways in light of marine casualties that have been reported during fiscal years 1973 through 1976. The selected areas are those listed on the original analysis. They are Delaware Bay, Chesapeake Bay, Tampa Bay, and two segments of the Gulf Intracoastal Waterway West, Mile 50-130 and Mile 260-290.

There are six levels of VTS that could be prescribed for a given casualty. They are same as the levels of VTS in Section 7.2.6 except the last level of VTS (Automated Advanced Surveillance).

(a) Delaware Bay: In this area, the casualty analysis (112 casualties) assumed that the Traffic Separation Scheme extends from the Bay entrance to the city of Trenton, a distance of approximately 120 miles of coverage. It was estimated that 32 accidents out of 112 could have been preventable through VTS (28.6%).

(b) Chesapeake Bay: It was assumed that the levels of VTS employing radar would only provided coverage at the entrance TSS, Thimble Shoals Channel, Hampton Roads and the ports therein. In this zone, it was estimated that 28.4 percent of the casualties could have been prevented by the presence of a VTS.

(c) Tampa Bay: In this case, the casualty analysis assumed that VTS having radar capability extended to all areas of the Bay navigable by deep draft vessels. It was judged that 53 casualties of 159 could have been prevented by VTS (33.3%).

(d) Gulf Intracoastal Waterway West Miles 50-130: It was assumed that all VTS levels could be applied to all the waterways interfacing this Mile 50-130 section of the Gulf Intracoastal Waterway. It suggested that approximately 28.4 percent of the casualties could have been preventable by VTS.

(e) Gulf Intracoastal Waterway West Miles 260-290: In this case, it was assumed that all levels of VTS could be extended over the entire waterway complex. It was estimated that approximately 40.3 percent of the casualties could have been preventable by VTS.

Table 7.10 shows the VTS preventable percentage of accidents from the five study areas.

Table 7.10 Estimated Percentage of Accidents Preventable by VTS

Study Area	Percent VTS Preventable
Delaware Bay	29 %
Chesapeake Bay	28 %
Tampa Bay	33 %
Gulf Intracoastal Waterway West	
Miles 50-130	28 %
Miles 260-290	40 %
Average Preventable Accidents	32 %

Source: ECKER W.J.(1978), Casualty Analysis of Selected Waterways

7.2.8 TRENDS IN NAVIGATION SAFETY IN THE DOVER STRAIT, 1978.[7-15]

Johnson analyzed the time trends of collision incidents over 15 years (1962-1977) in the Dover Straits. The Dover Straits Traffic Separation Scheme (TSS) was introduced in 1967 and the Channel Navigation Information Service (CNIS) in 1972.

Table 7.11 Summary of Collisions over 15 years in the Dover Strait

	Pre Routeing MID 62 - MID 67	IMO Routeing MID 67 - MID 72		Routeing with Surveillance and Information Service MID 72 - MID 77	
	All Waters	All Waters	Main Lanes	All Waters	Main Lanes
All Collisions	69	53	32	24	11
Ships on Opposing Course	50	32	16	7	1

Source: JOHNSON D.R.(1978). Recent Trends in Navigation Safety in the Dover Strait. Proc. Third International Symposium on Marine Traffic Service

From the Table 7.11 it is apparent that over the five year period following the introduction of the TSS there were 23 percent fewer collision than in the previous five years. Sixty percent of the collisions occurred in the main traffic lanes during the period. During the next five year period, when the TSS routeing scheme was supported by the CNIS, there was a further 55 percent of reduction in the number of collisions. 46 percent of the collisions occurred in the traffic lanes. The reduction of collisions in the traffic lanes indicates that the traffic surveillance has an effect on navigational safety.

7.2.9 SAFETY ASSESSMENT OF WATERWAY NETWORK IN TOKYO BAY AREA [7-16][7-17]

For the maritime safety in Japanese water, the Maritime Traffic Safety Law (MTSL) was enacted in 1973, by which routeing in congested waters was established. The Tokyo Bay Traffic Advisory Centre was also established in 1975 and its operation started in 1977. The authors examined the time trend of the number of traffic accidents in the Tokyo Bay to evaluate the effectiveness of the traffic services.

Table 7.12 Tokyo Bay Percent Index of Historical Accidents

Time Period	Collision	Grounding	Total
1969-1972 - Base	100 %	100 %	100 %
1973-1976 - TSS	85 %	77 %	82 %
1977-1982 - VTS	58 %	55 %	57 %

Source: FUJII Y. & KAKU S. (1981), KURODA K. & KITA H. (1990)

From the data according to the authors, it is apparent that over the five year period following the introduction of the TSS there were 15 percent fewer collision and 23 percent grounding than in the previous five years. After the Tokyo Bay Traffic Advisory Centre became operational, there was a further 32 percent of reduction in the number of collisions. During the same period vessel groundings were reduced another

29 percent and the overall accident rate was reduced by 30 percent.

The nationwide accident reduction during the period of 1977-82, however, was far less than for the Tokyo Bay; eight percent in the number of collisions and 13 percent in groundings. Accordingly it is apparent that the implementation of the Maritime Traffic Safety Law and the Tokyo VTS were beneficial in reducing the number of accidents in Tokyo Bay.

7.3 THE DEVELOPMENT OF VTS

An internationally agreed definition of a Vessel Traffic Services (VTS) is:

> any service implemented by a competent authority, designed to improve safety and efficiency of traffic and the protection of the environment. It may range from the provision of simple information messages to extensive management of traffic within a port or waterway [7-18]

VTS is a relatively recent addition to marine navigational aids and was originally applied to port approaches and provided shore-based navigational information to ships in the restricted approach waterways. World War II had seen the advent of Radar and VHF radio, making electronic surveillance and communication by voice efficient and easy [7-19]. Therefore it was hardly surprising that, in 1948, the world's first harbour surveillance was installed, overlooking the approach to the Port of Liverpool. The facility was supplemented by the use of portable VHF radio equipment. From this beginning, a wide variety of VTS has developed. Some facilities are to this day quite simple, being limited to the ability to broadcast routine general information. At the other extreme, highly complex traffic management centres exist.

At the latter centres, computers process and analyze not only the radar signals but a host of other data relevant to the movement of traffic in the area.

A VTS system might be required to perform functions ranging from the simple provision of routine information to the complex regulation of traffic. The specified role will govern the type of facility.

Vessel traffic services need not be limited to port and harbour areas but are also found associated with some traffic separation scheme (TSS). For example, in the case of the Dover Strait TSS, the Channel Navigation Information Service (CNIS) operates radar surveillance, broadcasts navigation information and co-ordinates a ship movement reporting scheme (MAREP) from the British side. A complementary service is operated by the French authorities from Cap Gris Nez. [7-20]

The rationale for the provision of this new type of service was to expedite the safe movement of shipping in congested waters and the use of VTS has extended from ports to waterways. Many nations have developed some form of VTS system.

U.S. Vessel Traffic Services dates back to 1952 with the establishment of the St. Mary's River control system between Lake Superior and Lake Huron. In 1968, the Coast Guard began a prototype Harbour Advisory Radar (HAR) experiment in the San Francisco Bay area [7-21] and the first VTS system was placed in San Francisco in 1972.

The Vessel Traffic Services programme of the Canadian Coast Guard has its roots in the twin concerns over the significant number of marine accidents taking place in Canadian waters in the 1960's, and the growing public awareness of the potential consequences of major environmental damage from shipping casualties. It commenced in 1967 with the establishment of the first VTS centre in Quebec City, and expanded rapidly to become a national programme. [7-22]

The Channel Navigation Information Service (CNIS) for the English Channel had been started at stations at Dover in 1972 and at Gris Nez in 1973 [7-23], and the Thames River Navigation Service, operated by the Port of London Authority, was originally established using VHF radio in 1959.

Rotterdam VTS has been functional since 1957, and the Marine Traffic Control system at Le Havre, France was established in 1973 as a radar based system.

In 1973, Maritime Safety Agency (MSA) of Japan established a harbour traffic control system at Kawasaki and later at the port of Yokohama. This is a completely television surveyed marine traffic control system using 10 CCTV cameras and one radar display to cover most of the navigable water in the approach of the harbour. MSA introduced VTS into Tokyo Bay in 1977, and started the practical use of VTS in the Seto Inland Sea in 1987.[7-24]

Korea Maritime and Port Administration introduced a Vessel Movement Reporting System (VMRS) at Pusan in 1978, and extended the service to all major ports thereafter. The Level II (VHF communication with basic radar surveillance) VTS service is provided in the port of Pusan, Inchon & Ulsan and the Level III (Advanced radar surveillance) in the port Pohang from January 1993. And the Level I (VMRS) service is in the port of Pyongtak, Masan/Chungmoo/Samcheonpo, Tonghae/Mukho, Kunsan/Daechun, Mokpo/Wando, Yosu and Cheju/Seoguipo using MF, SSB and VHF for 24 hours in operation except Pyongtak and Samcheonpo as can be seen on Figure 5.1.

7.4 VTS ADDRESSABLE CASUALTY AND CAUSAL FACTOR

Numerous casualties occur within the harbours, ports and coastal waters of Korea, but only a few are VTS addressable. Clearly VTS does reduce risk, but it is not a panacea. Many casualties are caused by actions or events on board ship that cannot be addressed by VTS, such as fire, explosion and shift of cargo. Mechanical casualties such as power failure, loss of propulsion or steering are not VTS addressable, yet may lead to situations where an operating VTS will benefit other traffic in the water by informing of the existing navigational risk, and preventing subsequent casualties. This includes notification and possible redirection of traffic in the vicinity.[7-25] Berthing and docking manoeuvres resulting in ramming of lock walls, docks, or moored vessels are not VTS preventable. Similarly groundings in narrow channels caused by bank suction and slight heading errors are not VTS addressable. In narrow channels, a casualty may occur before significant deviation can be determined by VTS.

Many dynamic casualties (i.e., collisions, groundings, and rammings) are potentially avoidable with a VTS operating in a port zone, and when one or more of the vessels participate. Open water collisions between two vessels caused by surprise, poor visibility, or simple miscalculation are classic examples of VTS addressable casualties. Collision avoidance, however, may be contingent, upon full communications, advance advisories to the vessels, and the ability of the vessels to react in sufficient time to avert a casualty.[7-26]

An analysis was undertaken in Chapter 4 of all casualties that occurred in VTS study areas from 1986-1990. Using the selection criteria for a VTS addressable casualty, 381 ship-casualties were identified involving in collision, grounding, ramming and foundering incidents. Several international studies[7-27] agree that such accidents, other than foundering, are generally VTS addressable (foundering incidents are included in this study). Even so it will not bias the final result through another filtering procedure(VTS addressable causal factors).

Many international studies agree that human error is the primary cause of all casualties. Whether the reason for this error is inattention, fatigue, mistakes in judgement (perhaps resulting from weather, hydrographic or traffic density factors), high-risk manoeuvres, or a lack of knowledge or experience, the underlying cause will be a lack of complete information on the bridge about what is happening around the vessel. Clearly, the mariner stands a better chance of making the correct decision if he has as much information as possible. The fundamental VTS role in reducing risk lies in their ability to provide the mariner with complete, accurate and timely information.[7-28]

Common causes of VTS addressable casualties include human error, restrictive hydrographic conditions, adverse environmental or weather conditions, and insufficient regulatory guidance. Clearly the following causal factors are VTS addressable;

- reduced visibility by fog/mist/snow/etc
- excessive speed under the circumstance
- sailed on wrong side of fairway or in unmarked waters

Factors such as: "no officer on the bridge or watchkeeper under other tasks", "physical/mental health condition of watchkeeper", "loss of propulsion or steering" and "accidental failure including electricity blackout, broken mooring rope and fracture of ship structure" are generally not VTS preventable.

7.5 ESTIMATION OF VTS EFFECTIVENESS

In the estimation of VTS effectiveness procedure used in this study the following assumptions and limitations are applied:

(a) Collisions, groundings, rammings and founderings are the only types of casualties considered in this study. It is assumed therefore that a VTS does not effect other types of casualties.

(b) The estimation of VTS effectiveness is based on existing aids including:
· Vessel Movement Reporting System (VMRS);
· Traffic Separation Schemes (TSS); and
· Conventional aids - lights, buoys, ranges and loran.

Therefore the casualties already prevented by existing VTS systems are not considered.

(c) The VTS level and effectiveness in the waters under consideration is assumed to be Level III (Advanced radar surveillance) system, and consequently only one level of VTS is evaluated.

The causal factors of the casualties in the data base have been analysed using the evaluation procedure described in Section 4.3. As a result, the effect level of the causal factors has been obtained. These results form the basis for the estimation of the effectiveness of VTS.

The perceived importance and effectiveness of VTS activities which have been developed from the answers in Section 6.7 form the risk reduction rates in the following procedure.

1) The possible effect of a VTS on a each activity (10 sub-sets) is expressed with a positive coefficient δ. The value of $\delta = 0$ indicates that VTS would have totally eliminated the causal factors contained in the activity. The value of $\delta = 1$ indicates that VTS would not have had any effect on the causal factors and intermediate values of δ are used. The effect of each VTS activity upon the casualty is measured by its coefficient. The values of weight coefficients are determined according to the following table.

Category of the VTS activity	Weight coefficient
Very unimportant Unimportant Average Important Very Important	1 0.8 0.6 0.4 0.2

2) The formula $\sum n\delta/n$, n is the number of respondents, yields the casualty reduction rate to each of the activity from the Table 6.12 in Section 6.7. For example, the rate of the "VTS assistance in reduced visibility condition" is 0.28 from the formula and the table.

VTS addressable causal factors are classified into ten sub-sets of VTS activities. For example, the causal factor "reduced visibility by fog/snow/etc" is classified into the activity sub-set "VTS assistance in reduced visibility condition", and "breakdown of navigation equipment" is categorized into "VTS assistance rendered to vessels in emergency", and etc.

The weight coefficients of the causal factors multiplied by their δs generate new collections of weight factors where the effects of a VTS are taken into account. For these collections new sets of effect levels can be calculated in the way explained in Section 4.3. The difference between the original and new sets is the total effectiveness of a VTS in reducing casualties.

A simplified example :

On the basis of casualty sequence and other information, relevant causal factors have been found out and their effect levels are given in the first column in the case a collision accident. Separately, for each relevant causal factor, possible effect of VTS is considered. Numerical value for this effect δ is then estimated according to the procedure which are explained above. Product of δ and the effect level produces the new effect level in the last column.

Causal factor	E/L	δ	New E/L
Reduced visibility by fog	0.25	0.28	0.07
Excessive speed under the circumstance	0.25	0.31	0.08
Narrow channel	0.25	0.32	0.08
Small ships on fairway	0.25	0.32	0.08
Did not fix position regularly	0.5	1	0.5
Sailed on wrong side of fairway	0.75	0.31	0.23
Did not use every equipment available	0.5	1	0.5

The procedure was applied to the all casualties considered in this study, and then estimates the effectiveness. According to these results, the maximum benefit to be obtained through the introduction of a VTS system is approximately 46 percent overall. The collision reduction rate was estimated to be approximately 50 percent for a VTS system with advanced radar surveillance, and 47 percent of grounding and 36 percent of ramming accidents could be reduced by an introduction of VTS. However, only 21 percent of foundering incidents could be decreased by a VTS.

Table 7.13 Estimated VTS Effectiveness Percentage

Type of Casualty	Causal Factor Group	Sum of Weight Coefficient		Reduction Rate
		Without VTS	With VTS	
Collision	Environment	185.25	59.43	- 0.679
	Human	326.75	195.85	- 0.401
	Technical	10.25	6.71	- 0.345
	Total	522.25	261.99	- **0.498**
Grounding	Environment	61.25	27.74	- 0.547
	Human	122.50	68.69	- 0.439
	Technical	19.75	11.94	- 0.395
	Total	203.50	108.37	- **0.467**
Ramming (Striking)	Environment	18.00	11.79	- 0.345
	Human	28.00	16.34	- 0.416
	Technical	6.25	5.37	- 0.141
	Total	52.25	33.50	- **0.359**
Foundering	Environment	18.75	14.12	- 0.247
	Human	26.50	16.36	- 0.383
	Technical	29.50	28.67	- 0.028
	Total	74.75	59.15	- **0.209**
Total	Environment	282.75	113.08	- 0.600
	Human	504.75	297.24	- 0.411
	Technical	65.75	52.69	- 0.199
	Total	852.75	463.01	- **0.457**

Source: Author

Table 7.13 summarizes the results of the estimation procedures by the type of casualty and by the causal factor groups

From the results, it is judged that VTS may reduce 68 percent of causal factors classified as environmental conditions, 40 percent of human factors and 35 percent of technical factors in collision accidents. In foundering accidents, however, only 26 percent of environmental factors, 38 percent of human factors and three percent of technical factors could be prevented by a VTS. As a whole 60 percent of environmental factors, 41 percent of human factors and 20 percent of technical factors may be prevented by a VTS. Typical examples are: VTS assistance in reduced visibility could prevent the accident, and VTS assistance in restricted/dense traffic waters may eliminate the causal factors including "excessive speed", "sailed on wrong side of fairway" and "heavy surrounding traffic".

The percentages shown in Table 7.13 correspond closely with the other quantitative results. For example: the collision reduction rate (50%) obtained from the estimation procedure is below the values obtained by the experts' group in the U.S.A and Canadian study, but same as the estimates of European study (COST 301). The grounding reduction percentage (47%) is also very close to the value of COST 301 and Japan, but higher than the estimates of U.S.A. study(1991), and lower than the value of Canada.

The estimated VTS effectiveness percentage for each sub-area is illustrated in Table 7.14. According to the table, it is apparent that Ulsan-area can benefit best from the introduction of VTS, while Tonghae-area is the least likely area to benefit. Pohang and Cheju sub-area have 40-41 percent of casualty reduction rate and six other sub-areas are more or less similar (46% - 50%). These order of VTS effectiveness by sub-area do not completely coincide with the ranking of overall risk obtained from perceptions in questionnaire in section 6.4. The last three sub-areas where is the least perceived risk, were Tonghae, Pohang and Cheju area. This corresponds to the order of VTS effectiveness by sub-area. Although there is no probabilistic basis, the following conclusions can be made taking into account of the ranking of risk perceived, the VTS effectiveness percentage, number of casualties per annum and the environmental conditions.

* Pusan-Ulsan coastal belt is the ports and waterway most in need of improved vessel traffic services.

* Taean Bando to Inchon area is the most hazardous waterway in Korea and is a strong candidate for vessel traffic services.

* Yosu/Kwangyang, Mokpo and Masan sub-area are the next waters in which planning for improved vessel traffic services should be pursued.

Table 7.14 Estimated VTS Effectiveness Percentage by Sub-area

SUB-AREA	TONGHAE	POHANG	ULSAN	PUSAN	MASAN
PERCENTAGE	30 %	41 %	53 %	47 %	49 %
SUB-AREA	YOSU	CHEJU	MOKPO	KUNSAN	INCHON
PERCENTAGE	49 %	40 %	48 %	50 %	46 %

Source: Author

7.6 SENSITIVITY ANALYSIS

Sensitivity analysis shows how the value of the criterion changes with changes in the value of any variable. This method is popularly used in project appraisal (Cost Benefit Analysis) and in optimization process. This consists essentially of varying key parameter values, usually one at a time but sometimes in combination, and assessing the effect of such changes on the outcome of the study. This can be useful if information about key parameters is such that some common yardstick can be used to assess how far each parameter should be varied; it is common to vary primary parameters by a fixed percentage (e.g. 10%).[7-29]

> In circumstances where firm probabilities cannot be attached to the future value of parameters which are likely to affect the outcome of a benefit/cost study, sensitivity analysis may represent the only method of describing, quantitatively, uncertain outcomes to decision-makers. In this simple technique, different values for uncertain variables are used to construct alternative scenarios of outcomes for presentation to the decision-maker.[7-30]

> In addition to the solution of the model, one must also secure, whenever possible, additional information concerning the behaviour of the solution due to changes in the system's parameters. This is usually referred to as sensitivity analysis. In particular, such an analysis is needed when the parameters of the system cannot be estimated accurately. In this case, it is important to study the behaviour of the optimal solution in the neighbourhood of these estimates.[7-31]

One or more of the key variable inputs of this study may be somewhat uncertain and therefore subject to sensitivity analysis. The key variable of the VTS effectiveness percentage is the value of weight coefficient δ. Consequently, differing values for this input are derived in this section and the impact that these variations have on the VTS effectiveness noted.

In this sensitivity analysis, the weight coefficient discussed in section 7.5 have been varied by +10 percent and by -10 percent. The values of weight coefficients are determined according to the following table.

Category of the VTS Activity	Weight Coefficient		
	Base	by -10%	by +10%
Very unimportant	1	1	1
Unimportant	0.8	0.9	0.7
Average	0.6	0.7	0.5
Important	0.4	0.5	0.3
Very important	0.2	0.3	0.1

In the first sensitivity analysis, the coefficient is increased by 10 percent. This implies that the casualty reduction rate to each of the VTS activity will be increased by 10 percent. For example, the casualty reduction rate by "VTS assistance in reduced visibility condition" is 0.18 from the Table 6.12 and the procedure described in section 7.5. The results indicate that further 7.1 percent of collision, 6.8 percent of grounding, 5.2 percent of ramming and three percent of foundering incidents could be reduced by the 10 percent increase of the weight coefficient value.

When the value is reduced by 10 percent, the maximum benefit to be obtained through the introduction of a VTS is approximately 39 percent overall. The collision reduction rate is estimated approximately 43 percent, 40 percent for grounding, 31 percent for ramming and 18 percent for foundering reduction rate. Table 7.15 shows the summary of sensitivity analysis of VTS effectiveness by the types of casualty.

Table 7.15 Sensitivity Analysis of VTS Effectiveness by Casualty Type

	Collision	Grounding	Ramming	Foundering	Total
Base	49.9	46.7	35.9	20.9	45.7 %
+ 10 %	57.0	53.5	41.1	23.9	52.3 %
- 10 %	42.7	39.9	30.6	18.0	39.1 %

Source: Author

As the results of sensitivity analysis of VTS effectiveness by ± 10 percent, the impact of the difference on the VTS effectiveness rate was estimated 4.3 - 7.8 percent by the different sub-areas. The Ulsan area is sensitive to large (7.6 - 7.8%) variations relatively ,while Tonghae area is sensitive to small (4.3 - 4.5%) changes.

Table 7.16 summarizes the results of sensitivity analysis of VTS effectiveness by different waters in Korea.

Table 7.16 Sensitivity Analysis of VTS Effectiveness by Sub-area

Sub-area	Base	+ 10 %	- 10 %
Tonghae area	30.2 %	34.5 %	25.7 %
Pohang area	41.0 %	46.9 %	35.0 %
Ulsan area	53.1 %	60.7 %	45.3 %
Pusan area	47.1 %	53.9 %	40.3 %
Masan/Koje-do area	49.0 %	56.1 %	41.9 %
Yosu/Kwangyang area	49.1 %	56.2 %	42.0 %
Cheju Haehyup/Cheju-do area	40.4 %	46.2 %	34.6 %
Maemul-sudo/Mokpo area	47.9 %	54.8 %	41.0 %
Kunsan/Changhang area	50.2 %	57.4 %	42.9 %
Taean Bando to Inchon area	46.0 %	52.7 %	39.3 %

Source: Author

As stated above, the VTS effectiveness varied by approximately 2.9 to 7.2 percent (± 10% error) by casualty type used in this study. And the value is changed roughly 4.3 to 7.8 percent (± 10% variation by different sub-areas). Even so, it still seems appropriate to use the original percentage derived in section 7.5. First, the values derived in section 7.5 agree closely with the other research in the literature. Second, the purpose of this study is to estimate the VTS effectiveness percentage rather than the cost-benefit analysis by monetary terms.

7.7 SUMMARY

The methods of estimation of VTS effectiveness are compared and the worldwide literature related to the VTS effectiveness is reviewed. The review suggests three potential approaches: simulation; synthesis of expert opinion and statistical analysis of casualties. This study adopted dissimilar approaches to estimate the VTS effectiveness to the earlier studies; the combination of synthesis of expert opinion and causal analysis of casualty.

The VTS effectiveness is derived by multiplying casualty rate reduction factors by the effect level of causal factors. The development of casualty rate reduction factors was based on the questionnaire survey, and the evolution of effect levels was based on the causal analysis using functional diagram.

According to these procedures, the maximum benefit to be obtained through the introduction of a VTS system was approximately 46 percent overall. The collision reduction rate was estimated to be approximately 50 percent for a VTS system with advanced radar surveillance. And 47 percent of groundings, 36 percent of rammings and 21 percent of founderings could be reduced by the introduction of VTS. These figures are more or less the same to the earlier studies.

The VTS effectiveness by the different causal factor groups was examined. VTS may reduce about 68 percent of causal factors classified as environmental conditions, 40 percent of human factors and 35 percent of technical factors in collision accidents. As a whole 60 percent of environmental factors, 41 percent of human factors and 20 percent of technical factors may be prevented by a VTS.

From the estimated VTS effectiveness percentage for each sub-area, it is apparent that Ulsan-area can benefit best from the introduction of VTS, while Tonghae-area is the least likely area to benefit. These procedure revealed that Pusan-Ulsan coastal belt is the area most in need of advanced VTS and the Inchon area is the next waters for VTS though there is no firm probabilistic background.

The key variable of the VTS effectiveness percentage is the value of weight coefficient δ. Therefore differing values for this input was discussed and the impact that these variations have on the VTS effectiveness noted. As the results of sensitivity analysis of VTS effectiveness by ± 10 percent, the effectiveness is varied approximately three to seven percent by casualty type. And the value is changed roughly four to eight percent by a ± 10 percent variation by different sub-areas.

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Chapter 8

CONCLUSIONS AND RECOMMENDATIONS

8.1 SUMMARY OF THE MAIN POINTS

1. The rapid growth of marine traffic by volume and number in the Korean waters has created difficulty in navigation, increased the risk in some areas and thereby necessitated measures to be taken to improve the traffic safety. Various measures have been taken during the same period to improve navigation safety. The navigational aids have been improved, traffic separation schemes have been established in coastal regions and vessel movement reporting scheme has been introduced in many port areas. Meanwhile, the advanced technology of Vessel Traffic Services (VTS) has been introduced in the marine field. In addition, the wide range of developments in the surveillance systems, monitoring equipment, electronic navigational aids and computerized data processing have suggested some utilization of these systems in traffic management.

2. Chapter 2 reviewed the environmental features in Korean water. Most of fog at sea occurs during summer months and fog being most frequent in July. And rainfalls are heaviest during summer months as well. Consequently there are more days of low visibility in summer. Winds are stronger during winter months in other hand.

3. Chapter 3 provided the information on the vessel traffic statistics in the waters. The number of Korean registered ships (excluding fishing vessels) has grown slowly but continuously. In addition total vessel movements in Korean ports are increasing considerably. Coastal and small size of ocean-going ships are the main components of the coastal traffic in Korean waters. Total cargo traffic has been increased significantly whilst coastal traffic has experienced higher increase than average.

4. Chapter 4 discussed the results from statistical and causal analysis of casualties.

(1) The negative binomial model is proved to be an adequate model in investigating marine accident frequency.

(2) The casualty frequency for Korean ships above 500 tons is very high, over twice that of Norwegian ships.

(3) Merchant ship casualties tend to occur in ports & harbours whilst fishing vessel accidents are most frequent in coastal waters and open sea.

(4) Geographical distribution of casualties shows that the highest number of casualties occur in the Pusan/Ulsan area, and the major port areas have more rammings while more groundings occur in Cheju and Mokpo areas where fishing base exists.

(5) Smaller ships have more accidents during winter whilst larger vessels have more in summer. High number of collisions occurs in summer period and of founderings occurs in winter period. This phenomenon correlates to the low visibility on a certain months. This seasonal variation of collision accidents is different to the European waters where more collisions occur in winter period.

(6) Older ships are identified to have more founderings than collisions or rammings by multiple comparison test.

(7) Environmental parameters are often present as important causes of casualties. Reduced visibility by fog is the most continual causal factor. Human errors of seafarers are dominant causal factors in casualties: specially negligence in critical situation, negligence of lookout, excessive speed under the circumstances and improper manoeuvre.

(8) The relative importance of the causal factors were compared by applying the effect level. The ship control tasks sub-group of human factors generates the most probable factors of marine casualty and the working environments sub-group of environmental conditions has a next probability. In collisions negligence of lookout is the most important factor, while not fixing position regularly and error in voyage planning are the factors in grounding incidents. Stormy weather is the most influential factor in rammings whereas stormy weather, poor stowage and fracture of ship structure are the factors in foundering accidents. 59 percent of casualties concerned is attributable to human error of seafarers involved. Reduced visibility by fog and rogue vessels are the most important causal factors in the Inchon area. Another noticeable point is that "not using every item of aid/equipment available in the situation" is the one of the most serious causal factor in the Tonghae area.

(9) Foundering is the most serious casualty type to threaten the lives of seamen. Clearly foundering accidents caused a higher rate of total loss, but no total losses were reported by ramming incidents. The total amount spilled in the reported oil leakages was 1,417 tons, but the amount of spillage is small except few cases.

5. Chapter 5 examined the effectiveness of existing traffic services including TSS and VMRS in Korean waters.

(1) The overall accident danger index has dropped remarkably since the introduction of routeing scheme in Inchon approaches.

(2) It appears likely that introduction of a Traffic Separation Scheme in Kanjol-Gap has led a reduction by half in number of accidents.

(3) Even though there was no significant difference in the number of accidents per annum before and after the introduction of a VMRS in Pusan, the overall accident danger index reduced significantly.

6. Chapter 6 discussed the questionnaire survey which was carried out across the board of maritime industry in Korea.

(1) Reduced visibility is identified as the leading factor in increasing marine risk and "human factors in shiphandling" is the second, while "greater number of pleasure crafts in shipping routes" is ranked in the last place. Generally the VTS operators group assessed the risk factors with less weight than any other group. This curiosity may be explained by less shipboard experience and lower qualifications.

(2) "Advanced VTS in more areas" is identified as the most preferable option to improve marine safety. And "prohibition of fishing in shipping routes" and "additional TSS" ranked in second and third place in reducing marine risk.

(3) In the question of the modification of VTS, almost all respondents declared that the VTS service should be upgraded or implemented in the area and no respondent has expressed opinion to downgrade or close the service.

(4) It is recognized that marine experience is essential for VTS operators to perform their tasks and the previous experience of shiphandling & communication is preferable.

(5) The median is determined between 3.58 and 4.24 for various VTS services & activities. "VTS assistance in reduced visibility" is approved as the most vital service rendered by VTS, while "VTS assistance with communication problems" has the lowest index. VTS assistances, however, were favourably rated by the respondents. Generally VTS operators assessed the services with slightly more severity than other groups.

7. Chapter 7 dealt with the estimation of VTS effectiveness(benefits).

(1) The maximum benefit to be obtained through the introduction of VTS (Level III) in Korea is determined approximately 46 percent overall. The collision reduction rate was estimated to be 50 percent, 47 percent for groundings, 36 percent for rammings and 21 percent for founderings. These figures are more or less the same to the earlier studies.

(2) It is estimated that about 68 percent of causal factors which is classified into environmental conditions may be eliminated by the proposed VTS, 40 percent of human factors and 35 percent of technical factors in collision accidents. As a whole 60 percent of environmental factor, 41 percent of human factor and 20 percent of technical factor may be prevented by VTS.

(3) Ulsan-area can benefit most from the introduction of VTS, while Tonghae-area is the least likely area to benefit.

(4) Sensitivity analysis (± 10 percent) presented that the effectiveness is varied approximately three to seven percent by casualty type. And the value is changed roughly four to eight percent by different sub-areas.

8.2 RECOMMENDATIONS AND CONCLUSIONS

(1) Although the routeing scheme in Inchon approaches brought reduction of accident rate, the majority of accidents still occur in the traffic lanes. Reduced visibility by fog and rogue vessels are identified as the most influential single causal factor in Inchon area. It is known that the major benefit of TSS is the prevention of meeting encounters, and thereby the reduction of meeting collision. There were, however, seven meeting collisions after the traffic scheme. This is probably due to the exception clauses of the regulation such as:

> The ship proceed from Inchon-hang to Asan-man can navigate Tong-sudo and the ship proceed from the NW area of Tokchok-do to Inchon-hang can navigate So-sudo.
>
> Ships of less than 500 tons shall navigate according to the regulations as practicable.
>
> If, however, there is any obstacles on the route and dangers to traffic, able to not follow the scheme.

Six incidents out of seven were occurred under reduced visibility (less than 300 metres), and seven ships violated the local regulations. Taking into account the facts described above, stricter enforcement of the routeing scheme is required to reduce the meeting encounters, and appropriate traffic surveillance and information service are potently recommended to cut down the incidents which is occurring under the reduced visibility and violating the traffic rules in the area.

(2) The main causal factors of incidents in Ulsan area were identified as "Other ship-Manoeuvring against rules" and "No reaction to the critical situation". The introduction of TSS in Kanjol-Gap (5 miles south from Ulsan) has led a reduction of accidents, but three collisions out of four after the TSS occurred within the traffic lane. Therefore appropriate traffic observation and surveillance are necessary to eliminate the rogue vessels, and thereby to reduce the accident rate further. Possibly repositioning of traffic lane or placing of buoy may improve the safety in the area.

(3) The examination of collision incidents in Pusan area revealed that the location of incidents have spread over the whole area, especially more collisions in South outer harbour and Pusan approaches after the introduction of VMRS. Consequently, advanced traffic observation and surveillance over the area are required to increase the navigation safety in Pusan Hang area.

(4) The introduction of traffic separation scheme or VMRS into three major ports (Inchon, Ulsan and Pusan) has led a significant reduction of accidents as recognised earlier. However the TSS and VMRS do not give adequate level of safety, traffic observation/surveillance and information exchange service are fundamental to reduce accident further. Accordingly it is necessary to extend advanced VTS (Level III or IV) to all parts of Korea.

Although there is no probabilistic basis, the following order of priority to establish VTS can be recommended taking into account the ranking of risk perceived, the VTS effectiveness percentage, number of casualties per annum and the environmental conditions.

1. Pusan-Ulsan coastal belt is the ports and waterway most in need of improved vessel traffic services.

2. Taean Bando to Inchon area is the most hazardous waterway in Korea and is a strong candidate for vessel traffic services.

3. Yosu/Kwangyang, Mokpo and Masan sub-area are the next waters in which planning for improved vessel traffic services should be pursued.

(5) Clearly the introduction of advanced VTS into coastal waters will increase the navigation safety. However it needs enormous amount of investment and takes several years to organize the system, so that following feasible schemes are recommended to place as an immediate need.

1. place more Traffic Separation Scheme in danger areas, specially in south-west and south coast of Korea

2. develop recommended route for small coastal ferries and passenger vessels

3. designate the 'navigation prohibition or pollution sensible area', and prohibit the passing of tankers and ships dangerous cargo boarded to minimize the pollution damage.

4. put advanced weather information service into operation collaborating with Korean Navy.

(6) Approximately 70 percent of VTS operators in Korea has no full-time shipboard experience and very few of them have shiphandling experience. However the results of questionnaire and other studies agreed that full-time shipboard experience is preferable for the VTS operators. Therefore it is recommended to recruit the operators who has shiphandling shipboard experience in future when they organize new systems.

It is of common knowledge that most (probably more than 95%) VTS operators in Korea have radio operator's certificate. It, however, is generally recognized that the operators in advanced VTS system should have the knowledge of English language, general & special nautical knowledge, equipment handling expertise, legal knowledge and local geographic knowledge. Even though it seems infeasible to recruit the operator having all the abilities, the appropriate training and certification programme should be prepared before organizing the new system.

(7) This thesis does not cover cost-benefit analysis following the introduction of VTS. So further research can be focussed on the cost-benefit analysis based on the consequence of casualties and the unique model developed in this thesis. Further research also can be concentrated on developing navigational risk index based on the casualty analysis in this thesis and traffic survey.

Annex

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Annex A

CAUSAL FACTORS OF CASUALTIES

Jinsoo PARK
Institute of Marine Studies
University of Plymouth

ENVIRONMENTAL FACTORS

I. EXTERNAL CONDITIONS

211. Reduced Visibility/ Maneuverability:
- 2111 by Fog/mist
- 2112 by Snow/hail
- 2113 Rain/drizzle
- 2114 Storm-Sea spray

212. Reduced efficiency of equipment by external factor :
- 2121 Radar by rain/snow/sea state,
- 2124 Heavy ship motion

241. Light condition:
- 2411 Daylight
- 2412 Darkness
- 2413 Twilight

II. WATERWAY CONDITIONS

223. Traffic situation:
- 2231 Small vessels in fairway
- 2232 Heavy surounding traffic
- 2233 Other ship passing/overtaking too close
- 2234 Other ship on collision course

221. Waterway configuration:
- 2211 Narrow channel passage
- 2212 Low water level
- 2213 Strong current/Tidal stream

222. Navigational aids:
- 2221 Faults of the aids(lights, marks)
- 2222 Wrong/poor marking of fairway

III. WORKING ENVIRONMENTS

2230. Deficiencies in charted information on chart & publications

231. Rules and Regulations:
- 2311 Improper rules (Road, Class, etc.)
- 2313 Management pressure(ETA, etc.)

232. Other ship's behaviour:
- : 2321 Equipment fault or Deficiency in other ship
- : 2322 Manoeuvering against rule
- : 2323 No-reaction to the critical situation

HUMAN FACTORS

I. HEALTH CONDITION OF WATCHKEEPER

111. Physical/Mental Health condition:
- 1111 Attack of sickness, Illness
- 1112 Physical handicap (sight)
- 1113 Tiredness
- 1114 Drunkeness
- 1115 Stress
- 1116 Sleepy
- 1117 Drug

II. TRAINING AND ORGANIZATION

112. Organization:
- 1121 Improper Shipboard organization
- 1122 Improper Harbour organization

113. Training:
- 1131 No/Lack of seafaring experience
- 1132 Lack of professional knowledge

117. Chart/Publication factor:
- 1171 No small corrections on charts/pub.
- 1172 Error in voyage planning

III. WATCHKEEPING SITUATION

114. Watchkeeping:
- 1141 No Officer on bridge
- 1142 Captain left bridge in critical situation
- 1143 Negligence of Lookout
- 1144 Not use every available aids/equipments in the situation
- 1145 Officer under other work
- 1148 Improper reporting/take-over
- 1149 Misunderstanding of order

IV. SYSTEM INTERFACE

116. System interfaces:
- 1161 Ship/Shore
- 1162 Ship/Ship
- 1164 Ship/Tug
- 1165 Ship/Head office

V. SHIP CONTROL TASKS

123. Wrong appreciation of traffic information:
- 1232 Misobservation of othr ship
- 1222 Misobservation of lights/marks

125. Navigation/Manouvering factors:
- 1251 Excessive speed under the circumstances
- 1252 Negligence in critical situation
- 1253 Sailed on wrong side of fairway
- 1254 Sailed in unmarked waters
- 1255 Miscalculation of position
- 1256 Not fix position regularly
- 1257 Improper order
- 1258 Improper decision
- 1259 No reaction to the critical situation

126. Misuse of Equipments:
- 1261 Improper maneuver - Mishandled M/E, Steering, etc.
- 1263 Misuse/misread of Radar, Compass, etc.

TECHNICAL FAULT/DEFICIENCIES

I. DESIGN, ARRANGEMENT AND SERVICEABILITY

3110. Poor design

3120. Poor placing of equipment

3130. Poor quality

3140. Poor maintenance or inspection

3150. Lack of equipment

II. EQUIPMENT BREAKDOWN

321. Propulsion and Steering:
3211 Main engine breakdown
3212 Aug. engine breakdown
3213 Steering gear breakdown
3214 Rudder
3215 Propeller

322. Navigation Equipments:
3221 Radar
3222 Compass
3223 Navigation lights
3224 Other navigation equipment

323. Communication Equipments:
3231 Internal communication
3232 External communication

III. MANAGEMENT OF CARGO

3310. Poor stowage/securing

3320. Cargo shifting

IV. ACCIDENTIAL FAILURE

3510. Electricity blackout

3520. Broken mooring wire

3530. Fracture of ship structure

* Note: the four digit numbers indicate the code of each factor

Annex B

CASUALTY CARD

Ship Name:
Judgement No.:

Jinsoo PARK
Institute of Marine Studies
University of Plymouth

GENERAL (1-7)

1. Serial number: ☐☐☐☐ 2. Casualty type: ☐

3. Year: ☐☐ 4. Month: ☐☐ 5. Date: ☐☐

6. Time: ☐☐☐☐ hours 7. Week: ☐☐☐

VESSEL PARTICULARS (10-23)

10. Gross tonnage: ☐☐☐☐☐☐ ton

11. Ship's Type: ☐☐ 12. Length of Ship: ☐☐☐ m

13. Beam: ☐☐ m 14. Ship's age: ☐☐

15. Ship's speed: ☐☐.☐ 16. Loading condition: ☐

17. Steering: ☐ (A or M) 18. Speed at casualty: ☐☐.☐

19. Movement: ☐ 20. Ship's draft: ☐☐.☐ m

21. Trading Area: ☐ 22. Flag of Vessel: ☐

23. Radio equipment: ☐

METEOROLOGICAL CONDITIONS (30-35)

30. Wind Force: ☐☐ 31. Sea State: ☐☐

32. Visibility: ☐☐.☐☐ mile   33. Current: ☐☐.☐ knots

34. Light Condition: ☐   35. Weather: ☐

HUMAN ELEMENTS (40-45)

40. Watch system : ☐

41. Number of Officers on Bridge: ☐

42. Subordinate on the bridge: ☐   43. Licence held: ☐

44. Age: ☐☐   45. Sea career: ☐☐ years

WATERWAY CONFIGURATION (50-56)

50. Waterway type: ☐   51. Latitude: ☐☐☐☐.☐ N

52. Longitude: ☐☐☐☐☐.☐ E

53. Channel width: ☐☐☐☐ m   54. Channel depth: ☐☐☐☐ m

55. Channel bend radius: ☐☐☐☐ m

56. Unobstructed line of vision of channel: ☐☐☐☐ m

CONSEQUENCES OF CASUALTY (60-70)

60. Lives lost: ☐☐☐   61. Injuries: ☐☐☐

62. Cargo damages: ☐   63. Engine damage: ☐

64. Hull damage: ☐   65. Damage to objects: ☐

66. Propeller damage: ☐ **67.** Rudder damage: ☐

68. Total loss: ☐ (Y or N) **69**: Oil outflow: ☐☐☐☐ tons

70. Delays by casualty: ☐☐☐.☐ days

CAUSES OF CASUALTIES (80-89) and EXTENT OF THE FACTOR (801-891)

80. Causal factor1: ☐☐☐☐ **801.** Extent of the factor1: ☐

81. Causal factor2: ☐☐☐☐ **811.** Extent of the factor2: ☐

82. Causal factor3: ☐☐☐☐ **821.** Extent of the factor3: ☐

83. Causal factor4: ☐☐☐☐ **831.** Extent of the factor4: ☐

84. Causal factor5: ☐☐☐☐ **841.** Extent of the factor5: ☐

85. Causal factor6: ☐☐☐☐ **851.** Extent of the factor6: ☐

86. Causal factor7: ☐☐☐☐ **861.** Extent of the factor7: ☐

87. Causal factor8: ☐☐☐☐ **871.** Extent of the factor8: ☐

88. Causal factor9: ☐☐☐☐ **881.** Extent of the factor9: ☐

89. Causal factor10: ☐☐☐☐ **891.** Extent of the factor10: ☐

Annex C

TABLES FROM STATISTICAL ANALYSIS OF MARINE CASUALTIES (1986-1990)

Table 1 Types of ship by Casualty type

Type of ship	TYPE OF CASUALTY							
	COLLISION		GROUNDING		RAMMING		FOUNDERING	
	Count	Column Percent	Count	Column Percent	Count	Column Percent	Count	Column Percent
PASSENGER......	7	2.9%	3	3.7%	3	13.0%	0	.0%
TANKER.........	45	18.6%	12	14.8%	4	17.4%	2	5.7%
CARGO..........	73	30.2%	24	29.6%	10	43.5%	6	17.1%
FISHING........	87	36.0%	33	40.7%	3	13.0%	22	62.9%
OTHERS.........	30	12.4%	9	11.1%	3	13.0%	5	14.3%

Note: Number of cases(n)= 381

Table 2 Wind force by Casualty type

Wind force	TYPE OF CASUALTY							
	COLLISION		GROUNDING		RAMMING		FOUNDERING	
	Count	Column Percent	Count	Column Percent	Count	Column Percent	Count	Column Percent
0.........	0	.0%	1	1.3%	0	.0%	0	.0%
1.........	2	.8%	1	1.3%	0	.0%	0	.0%
2.........	75	31.8%	8	10.5%	4	17.4%	3	8.6%
3.........	82	34.7%	19	25.0%	2	8.7%	4	11.4%
4.........	38	16.1%	9	11.8%	4	17.4%	2	5.7%
5.........	25	10.6%	10	13.2%	0	.0%	4	11.4%
6.........	8	3.4%	10	13.2%	4	17.4%	4	11.4%
7.........	2	.8%	5	6.6%	1	4.3%	12	34.3%
8.........	2	.8%	6	7.9%	1	4.3%	6	17.1%
9.........	2	.8%	6	7.9%	4	17.4%	0	.0%
10........	0	.0%	1	1.3%	1	4.3%	0	.0%
11........	0	.0%	0	.0%	2	8.7%	0	.0%

Wind force means Beaufort scale, Missing cases= 11, n= 381

Table 3 Time of day by Casualty type

Time band	TYPE OF CASUALTY							
	COLLISION		GROUNDING		RAMMING		FOUNDERING	
	Count	Column Percent	Count	Column Percent	Count	Column Percent	Count	Column Percent
00-04......	59	24.4%	19	23.5%	4	17.4%	8	22.9%
04-08......	54	22.3%	14	17.3%	7	30.4%	13	37.1%
08-12......	35	14.5%	15	18.5%	2	8.7%	4	11.4%
12-16......	28	11.6%	13	16.0%	5	21.7%	0	.0%
16-20......	48	19.8%	9	11.1%	4	17.4%	7	20.0%
20-24......	18	7.4%	11	13.6%	1	4.3%	3	8.6%

Number of cases= 381

Table 4 Ship's age by Casualty type

Ship's age	TYPE OF CASUALTY							
	COLLISION		GROUNDING		RAMMING		FOUNDERING	
	Count	Column Percent	Count	Column Percent	Count	Column Percent	Count	Column Percent
UPTO 5 YEARS..	46	24.7%	10	14.9%	3	15.0%	2	6.3%
6-10......	35	18.8%	13	19.4%	8	40.0%	3	9.4%
11-15.....	39	21.0%	12	17.9%	5	25.0%	8	25.0%
16-20.....	30	16.1%	16	23.9%	2	10.0%	6	18.8%
21-25.....	20	10.8%	10	14.9%	2	10.0%	6	18.8%
26-30.....	12	6.5%	5	7.5%	0	.0%	4	12.5%
OVER 30...	4	2.2%	1	1.5%	0	.0%	3	9.4%

Number of cases= 381

Table 5 Day of week by Casualty type

Day of week	TYPE OF CASUALTY							
	COLLISION		GROUNDING		RAMMING		FOUNDERING	
	Count	Column Percent	Count	Column Percent	Count	Column Percent	Count	Column Percent
MON........	20	8.3%	14	17.3%	2	8.7%	2	5.7%
TUE........	26	10.7%	12	14.8%	0	.0%	4	11.4%
WED........	41	16.9%	14	17.3%	2	8.7%	7	20.0%
THU........	58	24.0%	10	12.3%	8	34.8%	9	25.7%
FRI........	33	13.6%	11	13.6%	6	26.1%	2	5.7%
SAT........	26	10.7%	6	7.4%	2	8.7%	6	17.1%
SUN........	38	15.7%	14	17.3%	3	13.0%	5	14.3%

Number of cases= 381

Table 6 Month by Casualty type

Month	TYPE OF CASUALTY							
	COLLISION		GROUNDING		RAMMING		FOUNDERING	
	Count	Column Percent	Count	Column Percent	Count	Column Percent	Count	Column Percent
JANUARY..	14	5.8%	6	7.4%	2	8.7%	4	11.4%
FEBRUARY.	10	4.1%	6	7.4%	4	17.4%	3	8.6%
MARCH....	11	4.5%	7	8.6%	1	4.3%	2	5.7%
APRIL....	16	6.6%	6	7.4%	2	8.7%	2	5.7%
MAY......	24	9.9%	4	4.9%	3	13.0%	4	11.4%
JUNE.....	36	14.9%	7	8.6%	2	8.7%	3	8.6%
JULY.....	45	18.6%	11	13.6%	1	4.3%	2	5.7%
AUGUST...	23	9.5%	4	4.9%	4	17.4%	1	2.9%
SEPTEMBER	14	5.8%	4	4.9%	0	.0%	0	.0%
OCTOBER..	12	5.0%	4	4.9%	1	4.3%	3	8.6%
NOVEMBER.	15	6.2%	10	12.3%	2	8.7%	3	8.6%
DECEMBER.	22	9.1%	12	14.8%	1	4.3%	8	22.9%

Number of cases= 381

Table 7 Subarea by Casualty type

Subarea	TYPE OF CASUALTY							
	COLLISION		GROUNDING		RAMMING		FOUNDERING	
	Count	Column Percent	Count	Column Percent	Count	Column Percent	Count	Column Percent
Tonghae area	14	5.8%	5	6.2%	2	8.7%	2	5.7%
Pohang area.	21	8.7%	5	6.2%	2	8.7%	3	8.6%
Ulsan area..	12	5.0%	4	4.9%	1	4.3%	0	.0%
Pusan area..	47	19.4%	7	8.6%	6	26.1%	4	11.4%
Masan area..	26	10.7%	3	3.7%	2	8.7%	1	2.9%
Yosu area...	38	15.7%	10	12.3%	3	13.0%	6	17.1%
Cheju area..	16	6.6%	17	21.0%	0	.0%	9	25.7%
Mokpo area..	30	12.4%	13	16.0%	1	4.3%	5	14.3%
Kunsan area.	11	4.5%	9	11.1%	2	8.7%	0	.0%
Inchon area.	27	11.2%	8	9.9%	4	17.4%	5	14.3%

Number of cases= 381

Table 8 Light by Casualty type

Light condition	TYPE OF CASUALTY							
	COLLISION		GROUNDING		RAMMING		FOUNDERING	
	Count	Column Percent	Count	Column Percent	Count	Column Percent	Count	Column Percent
DAYLIGHT.......	115	47.5%	35	43.2%	10	43.5%	11	31.4%
DARKNESS.......	99	40.9%	40	49.4%	11	47.8%	21	60.0%
TWILIGHT.......	28	11.6%	6	7.4%	2	8.7%	3	8.6%

Number of cases= 381

Table 9 Weather by Casualty type

Weather	TYPE OF CASUALTY							
	COLLISION		GROUNDING		RAMMING		FOUNDERING	
	Count	Column Percent	Count	Column Percent	Count	Column Percent	Count	Column Percent
CLEAR/FINE	55	25.8%	14	20.3%	3	15.0%	9	39.1%
CLOUDY....	30	14.1%	15	21.7%	5	25.0%	1	4.3%
OVERCAST..	28	13.1%	4	5.8%	4	20.0%	9	39.1%
RAIN......	6	2.8%	17	24.6%	4	20.0%	1	4.3%
SNOW......	0	.0%	4	5.8%	1	5.0%	3	13.0%
FOG.......	94	44.1%	15	21.7%	3	15.0%	0	.0%

Number of cases =381, Missing cases= 56

Table 10 Tonnage group by Ship type

Gross tonnage group	SHIP'S TYPE									
	PASSENGER		TANKER		CARGO		FISHING		OTHERS	
	Count	Column Percent	Count	Column Percent	Count	Column Percent	Count	Column Percent	Count	Column Percent
UNDER 100...	1	7.7%	0	.0%	2	1.8%	115	79.3%	25	53.2%
100-199.....	5	38.5%	3	4.8%	6	5.3%	22	15.2%	7	14.9%
200-499.....	1	7.7%	11	17.5%	21	18.6%	4	2.8%	3	6.4%
500-999.....	4	30.8%	26	41.3%	23	20.4%	1	.7%	1	2.1%
1000-2999...	1	7.7%	15	23.8%	19	16.8%	2	1.4%	2	4.3%
3000-4999...	0	.0%	4	6.3%	12	10.6%	1	.7%	6	12.8%
5000-9999...	1	7.7%	1	1.6%	8	7.1%	0	.0%	1	2.1%
10000 & OVER	0	.0%	3	4.8%	22	19.5%	0	.0%	2	4.3%

Number of cases= 381

Table 11 Waterway by Ship type

Waterway type	SHIP'S TYPE									
	PASSENGER		TANKER		CARGO		FISHING		OTHERS	
	Count	Column Percent	Count	Column Percent	Count	Column Percent	Count	Column Percent	Count	Column Percent
PORT/HARBOUR...	5	38.5%	17	27.0%	30	26.5%	15	10.3%	18	38.3%
PORT APPROACHES	2	15.4%	11	17.5%	8	7.1%	15	10.3%	5	10.6%
SOUND/PASSAGE..	1	7.7%	10	15.9%	21	18.6%	15	10.3%	9	19.1%
COASTAL WATER..	5	38.5%	24	38.1%	41	36.3%	73	50.3%	13	27.7%
OPEN SEA.......	0	.0%	1	1.6%	13	11.5%	27	18.6%	2	4.3%

Number of cases= 381

Table 12 Sub-area by Ship type

Sub-area	SHIP'S TYPE									
	PASSENGER		TANKER		CARGO		FISHING		OTHERS	
	Count	Column Percent	Count	Column Percent	Count	Column Percent	Count	Column Percent	Count	Column Percent
Tonghae area	2	15.4%	1	1.6%	8	7.1%	9	6.2%	3	6.4%
Pohang area.	1	7.7%	4	6.3%	8	7.1%	15	10.3%	3	6.4%
Ulsan area..	0	.0%	3	4.8%	7	6.2%	2	1.4%	5	10.6%
Pusan area..	3	23.1%	9	14.3%	21	18.6%	20	13.8%	11	23.4%
Masan area..	0	.0%	8	12.7%	13	11.5%	9	6.2%	2	4.3%
Yosu area...	3	23.1%	14	22.2%	13	11.5%	19	13.1%	8	17.0%
Cheju area..	0	.0%	0	.0%	10	8.8%	31	21.4%	1	2.1%
Mokpo area..	2	15.4%	14	22.2%	9	8.0%	17	11.7%	7	14.9%
Kunsan area.	1	7.7%	6	9.5%	8	7.1%	6	4.1%	1	2.1%
Inchon area.	1	7.7%	4	6.3%	16	14.2%	17	11.7%	6	12.8%

Number of cases= 381

Table 13 Visibility by Casualty type

Visibility	TYPE OF CASUALTY								Total acses	
	COLLISION		GROUNDING		RAMMING		FOUNDERING			
Less than 0.03...	21	7.8%	4	1.5%	0	.0%	0	.0%	25	9.3%
0.03-0.09 miles..	50	18.7%	16	6.0%	3	1.1%	0	.0%	69	25.7%
0.10-0.49 miles..	26	9.7%	6	2.2%	1	.4%	0	.0%	33	12.3%
0.50-1.09 miles..	4	1.5%	4	1.5%	1	.4%	1	.4%	10	3.7%
1.10-2.19 miles..	8	3.0%	1	.4%	1	.4%	0	.0%	10	3.7%
2.20-5.39 miles..	8	3.0%	2	.7%	0	.0%	1	.4%	11	4.1%
5.40-10.99.......	79	29.5%	14	5.2%	8	3.0%	2	.7%	103	38.4%
11 and Over......	6	2.2%	1	.4%	0	.0%	0	.0%	7	2.6%
Total acses......	202	75.4%	48	17.9%	14	5.2%	4	1.5%	268	100%

Number of cases= 381, Missing cases= 113

Table 14 Month by Visibility

Month	VISIBILITY									
	Less than 0.03		0.03-0.09 miles		0.10-0.49 miles		0.50-1.09 miles		1.10-2.19 miles	
JANUARY.....	2	.7%	1	.4%	0	.0%	0	.0%	0	.0%
FEBRUARY....	0	.0%	3	1.1%	0	.0%	0	.0%	0	.0%
MARCH.......	3	1.1%	0	.0%	1	.4%	0	.0%	0	.0%
APRIL.......	0	.0%	2	.7%	3	1.1%	4	1.5%	0	.0%
MAY.........	1	.4%	10	3.7%	3	1.1%	2	.7%	2	.7%
JUNE........	10	3.7%	9	3.4%	10	3.7%	0	.0%	4	1.5%
JULY........	3	1.1%	21	7.8%	11	4.1%	2	.7%	2	.7%
AUGUST......	0	.0%	9	3.4%	4	1.5%	0	.0%	1	.4%
SEPTEMBER...	2	.7%	4	1.5%	0	.0%	1	.4%	0	.0%
OCTOBER.....	0	.0%	2	.7%	0	.0%	0	.0%	1	.4%
NOVEMBER....	4	1.5%	6	2.2%	0	.0%	0	.0%	0	.0%
DECEMBER....	0	.0%	2	.7%	1	.4%	1	.4%	0	.0%
Total Cases.	25	9.3%	69	25.7%	33	12.3%	10	3.7%	10	3.7%

(continued)

Month	VISIBILITY						Total Cases	
	2.20-5.39 miles		5.40-10.99		11 and Over			
JANUARY.....	0	.0%	11	4.1%	0	.0%	14	5.2%
FEBRUARY....	0	.0%	10	3.7%	2	.7%	15	5.6%
MARCH.......	3	1.1%	8	3.0%	0	.0%	15	5.6%
APRIL.......	2	.7%	10	3.7%	0	.0%	21	7.8%
MAY.........	0	.0%	6	2.2%	2	.7%	26	9.7%
JUNE........	0	.0%	8	3.0%	1	.4%	42	15.7%
JULY........	3	1.1%	6	2.2%	0	.0%	48	17.9%
AUGUST......	0	.0%	6	2.2%	0	.0%	20	7.5%
SEPTEMBER...	2	.7%	3	1.1%	0	.0%	12	4.5%
OCTOBER.....	0	.0%	8	3.0%	0	.0%	11	4.1%
NOVEMBER....	0	.0%	9	3.4%	0	.0%	19	7.1%
DECEMBER....	1	.4%	18	6.7%	2	.7%	25	9.3%
Total Cases.	11	4.1%	103	38.4%	7	2.6%	268	100.0%

Table 15 Day of week by Visibility

Day of week	VISIBILITY									
	Less than 0.03		0.03-0.09 miles		0.10-0.49 miles		0.50-1.09 miles		1.10-2.19 miles	
MON.........	2	.7%	4	1.5%	1	.4%	1	.4%	2	.7%
TUE.........	4	1.5%	4	1.5%	4	1.5%	1	.4%	2	.7%
WED.........	5	1.9%	8	3.0%	3	1.1%	0	.0%	0	.0%
THU.........	6	2.2%	22	8.2%	5	1.9%	1	.4%	4	1.5%
FRI.........	5	1.9%	7	2.6%	6	2.2%	0	.0%	2	.7%
SAT.........	1	.4%	11	4.1%	4	1.5%	0	.0%	0	.0%
SUN.........	2	.7%	13	4.9%	10	3.7%	7	2.6%	0	.0%
Total Cases.	25	9.3%	69	25.7%	33	12.3%	10	3.7%	10	3.7%

Day of week	VISIBILITY						Total Cases	
	2.20-5.39 miles		5.40-10.99		11 and Over			
MON.........	0	.0%	15	5.6%	0	.0%	25	9.3%
TUE.........	1	.4%	11	4.1%	0	.0%	27	10.1%
WED.........	5	1.9%	23	8.6%	3	1.1%	47	17.5%
THU.........	2	.7%	15	5.6%	2	.7%	57	21.3%
FRI.........	0	.0%	14	5.2%	0	.0%	34	12.7%
SAT.........	1	.4%	10	3.7%	0	.0%	27	10.1%
SUN.........	2	.7%	15	5.6%	2	.7%	51	19.0%
Total Cases.	11	4.1%	103	38.4%	7	2.6%	268	100.0%

Table 16 Wind force by Day of week

Wind force	DAY OF WEEK							
	MON		TUE		WED		THU	
0...........	1	.3%	0	.0%	0	.0%	0	.0%
1...........	0	.0%	0	.0%	0	.0%	0	.0%
2...........	9	2.4%	6	1.6%	16	4.3%	25	6.8%
3...........	9	2.4%	16	4.3%	26	7.0%	19	5.1%
4...........	7	1.9%	8	2.2%	7	1.9%	11	3.0%
5...........	0	.0%	3	.8%	10	2.7%	6	1.6%
6...........	2	.5%	1	.3%	1	.3%	6	1.6%
7...........	3	.8%	2	.5%	1	.3%	4	1.1%
8...........	4	1.1%	2	.5%	1	.3%	3	.8%
9...........	2	.5%	4	1.1%	0	.0%	6	1.6%
10..........	0	.0%	0	.0%	1	.3%	1	.3%
11..........	0	.0%	0	.0%	0	.0%	2	.5%
Total Cases.	37	10.0%	42	11.4%	63	17.0%	83	22.4%

Wind force	DAY OF WEEK						Total Cases	
	FRI		SAT		SUN			
0...........	0	.0%	0	.0%	0	.0%	1	.3%
1...........	2	.5%	1	.3%	0	.0%	3	.8%
2...........	9	2.4%	10	2.7%	15	4.1%	90	24.3%
3...........	14	3.8%	8	2.2%	15	4.1%	107	28.9%
4...........	6	1.6%	4	1.1%	10	2.7%	53	14.3%
5...........	8	2.2%	7	1.9%	5	1.4%	39	10.5%
6...........	5	1.4%	5	1.4%	6	1.6%	26	7.0%
7...........	5	1.4%	2	.5%	3	.8%	20	5.4%
8...........	2	.5%	3	.8%	0	.0%	15	4.1%
9...........	0	.0%	0	.0%	0	.0%	12	3.2%
10..........	0	.0%	0	.0%	0	.0%	2	.5%
11..........	0	.0%	0	.0%	0	.0%	2	.5%
Total Cases.	51	13.8%	40	10.8%	54	14.6%	370	100.0%

Table 17 Sea state by Day of week

Sea state	DAY OF WEEK							
	MON		TUE		WED		THU	
1...........	2	.5%	1	.3%	0	.0%	2	.5%
2...........	10	2.7%	17	4.6%	28	7.6%	32	8.7%
3...........	10	2.7%	11	3.0%	20	5.4%	22	6.0%
4...........	3	.8%	5	1.4%	8	2.2%	8	2.2%
5...........	3	.8%	2	.5%	2	.5%	10	2.7%
6...........	8	2.2%	5	1.4%	2	.5%	5	1.4%
7...........	1	.3%	1	.3%	1	.3%	4	1.1%
Total Cases.	37	10.1%	42	11.4%	61	16.6%	83	22.6%

Sea state	DAY OF WEEK						Total Cases	
	FRI		SAT		SUN			
1...........	2	.5%	1	.3%	5	1.4%	13	3.5%
2...........	17	4.6%	12	3.3%	17	4.6%	133	36.2%
3...........	11	3.0%	7	1.9%	17	4.6%	98	26.7%
4...........	8	2.2%	14	3.8%	10	2.7%	56	15.3%
5...........	12	3.3%	5	1.4%	3	.8%	37	10.1%
6...........	0	.0%	1	.3%	2	.5%	23	6.3%
7...........	0	.0%	0	.0%	0	.0%	7	1.9%
Total Cases.	50	13.6%	40	10.9%	54	14.7%	367	100.0%

Table 18 Wind force by Tonnage group

Wind force	GROSS TONNAGE									
	UNDER 100		100-199		200-499		500-999		1 000-2999	
0...........	0	.0%	1	.3%	0	.0%	0	.0%	0	.0%
1...........	1	.3%	0	.0%	1	.3%	0	.0%	1	.3%
2...........	21	5.7%	8	2.2%	15	4.1%	16	4.3%	13	3.5%
3...........	41	11.1%	8	2.2%	8	2.2%	19	5.1%	10	2.7%
4...........	25	6.8%	11	3.0%	4	1.1%	6	1.6%	2	.5%
5...........	13	3.5%	5	1.4%	3	.8%	4	1.1%	7	1.9%
6...........	14	3.8%	3	.8%	1	.3%	2	.5%	4	1.1%
7...........	12	3.2%	0	.0%	3	.8%	2	.5%	0	.0%
8...........	7	1.9%	5	1.4%	1	.3%	1	.3%	0	.0%
9...........	3	.8%	0	.0%	2	.5%	3	.8%	1	.3%
10..........	0	.0%	0	.0%	0	.0%	0	.0%	0	.0%
11..........	0	.0%	1	.3%	0	.0%	1	.3%	0	.0%
Total Cases.	137	37.0%	42	11.4%	38	10.3%	54	14.6%	38	10.3%

Wind force	GROSS TONNAGE						Total Cases	
	3000-4999		5000-9999		10000 & OVER			
0...........	0	.0%	0	.0%	0	.0%	1	.3%
1...........	0	.0%	0	.0%	0	.0%	3	.8%
2...........	8	2.2%	1	.3%	8	2.2%	90	24.3%
3...........	6	1.6%	7	1.9%	8	2.2%	107	28.9%
4...........	3	.8%	2	.5%	0	.0%	53	14.3%
5...........	3	.8%	0	.0%	4	1.1%	39	10.5%
6...........	0	.0%	1	.3%	1	.3%	26	7.0%
7...........	1	.3%	0	.0%	2	.5%	20	5.4%
8...........	0	.0%	0	.0%	1	.3%	15	4.1%
9...........	1	.3%	0	.0%	2	.5%	12	3.2%
10..........	1	.3%	0	.0%	1	.3%	2	.5%
11..........	0	.0%	0	.0%	0	.0%	2	.5%
Total Cases.	23	6.2%	11	3.0%	27	7.3%	370	100.0%

Table 19 Tonnage group by Visibility

Tonnage group	VISIBILITY Less than 0.03		0.03-0.09 miles		0.10-0.49 miles		0.50-1.09 miles	
UNDER 100......	11	4.1%	16	6.0%	9	3.4%	3	1.1%
100-199........	2	.7%	11	4.1%	2	.7%	1	.4%
200-499........	4	1.5%	8	3.0%	6	2.2%	2	.7%
500-999........	1	.4%	18	6.7%	5	1.9%	1	.4%
1000-2999......	3	1.1%	9	3.4%	3	1.1%	0	.0%
3000-4999......	2	.7%	6	2.2%	1	.4%	0	.0%
5000-9999......	0	.0%	0	.0%	2	.7%	1	.4%
10000 & OVER...	2	.7%	1	.4%	5	1.9%	2	.7%
Total Cases....	25	9.3%	69	25.7%	33	12.3%	10	3.7%

Tonnage group	VISIBILITY 1.10-2.19 miles		2.20-5.39 miles		5.40-10.99 miles		11 and Over		Total Cases	
UNDER 100......	5	1.9%	3	1.1%	43	16.0%	5	1.9%	95	35.4%
100-199........	2	.7%	2	.7%	9	3.4%	1	.4%	30	11.2%
200-499........	1	.4%	1	.4%	7	2.6%	0	.0%	29	10.8%
500-999........	1	.4%	3	1.1%	12	4.5%	0	.0%	41	15.3%
1000-2999......	1	.4%	1	.4%	14	5.2%	0	.0%	31	11.6%
3000-4999......	0	.0%	0	.0%	4	1.5%	0	.0%	13	4.9%
5000-9999......	0	.0%	0	.0%	5	1.9%	1	.4%	9	3.4%
10000 & OVER...	0	.0%	1	.4%	9	3.4%	0	.0%	20	7.5%
Total Cases....	10	3.7%	11	4.1%	103	38.4%	7	2.6%	268	100.0%

Note:

(1) Source of information: Author compiled the tables based on the statistical analysis of 381 ship-casualties

(2) Number of cases: 381 cases unless otherwise stated

Annex D

LIST OF TRAFFIC ACCIDENTS

1. INCHON INBOUND/OUTBOUND ROUTES

PERIOD A

1976

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
GRD	Jul 14	1021	Empire	Cargo	1599	37087	126210	Panama	Inaccurate position Inaccurate speed calculation

1977

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	May 3	0741	Bum Il	Tanker	6333	37122	126243	Korea	Violation of rules in fog

1978

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	May 21	1443	No.2 Lucky	Tanker	3561	37041	126159	Korea	Missed time to avert danger
			Operia	Cargo	16938	37041	126159	Liberia	Excessive speed

1979

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	Jul 4	1235	Lilac	Cargo	3381	37101	126223	Korea	V'tion of rules in narrow ch.
			Red Sky	Cargo	18723	37101	126223	Liberia	Neg. of l'out & Ex. spd in fog

1980

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	Feb 12	2105	Sewoon	Cargo	11998	37172	126251	Korea	
			Strait Dalia	Tanker	44263	37172	126251	Panama	V'tion of rules in narrow ch. N'gence to avert danger
GRD	Feb 24	0600	Korean Peace	Cargo	16897	37136	126246	Korea	Error in tidal range cal'tion
COL	May 14	2120	No.25 Shin-A	Cargo	1993	37172	126256	Korea	No fog signal & ex. speed
			No.1 Dae Jin	Fish	716	37172	126256	Korea	
GRD	Sep 7	0003	Hanwoo	Cargo	14822	37088	126209	Korea	Mishandled steering & strong current

PERIOD B

1981

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	Aug 28	2008	5 Kinsei Maru	LPG	615	37071	126191	Japan	Neg of l'out in narrow ch.

1982

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	Jul 3	0555	So-Yang	Cargo	1596	37232	126320	Korea	V'tion of rules in fog

1983

	Date		Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
GRD	Mar	25	2119	Hae Keum	Cargo	19276	37135	126252	Korea	Missed time to A/Co.
COL	Aug	6	0824	Hae Gui	Cargo	1578	37224	126327	Korea	V'tion of ship safety rules
GRD	Sep	15	0405	No.9 Kun-Shin	Fish	?	37095	126225	Korea	

1984

	Date		Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	Dec	27	2045	YoungChemicary	Tanker	3267	37046	126155	Korea	
				Se Kwang No.1	?	?	37046	126155	Korea	

1985

	Date		Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	Jun	22	1721	AtlasCounceller	Cargo	12771	37184	126262	Korea	(Reduced visibility)
				Oinos I	Cargo	14241	37184	126262	Greece	

1986

	Date		Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
GRD	Jan	10	2227	Negros	Cargo	4634	37137	126246	Panama	M'ring error of pilot

PERIOD C

COL	Jun	17	1209	Pacific Express	"	20664	37190	126269	Korea	
				17 Sung Un	"	649	(Tong Sudo)		"	V'tion of local rule

1987

	Date		Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	Jun	4	0010	A-Yong	Tanker	3859	37070	126193		
						(Budo SW 2.2')				Asleep & v'tion of s'ling rule
COL	Aug	13	1724	918 Ham	Naval	3020	37198	126234		Ex spd & v'tion of s'ling rule

1988

	Date		Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	Jun	8	1258	Korean Lifter	Cargo	1599	37210	126314		Not fix position
				Fighter	Cargo	16423	(S of Palmido)		Cyprus	Sail to left of Sudo
COL	Jun	18	2105	S. Venus	Cargo	22331	37111	126116		
							(Ent. of So-Sudo)			Ex spd & alter to port

1989

	Date		Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	May	28	1006	Kyungki Ham	Naval	3000	37214	126319		Ex spd & sailed on wrong side
				Vietnam Namtu	Cargo	5710	(Palmido)		Vietnam	

1990

	Date		Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	Jan	8	1955	S'pore Glory	Cargo	7343	37052	126175	Panama	No NUC light
COL	Apr	1	1840	Asean Victory	Cargo	11519	37109	126116	Panama	

2. KANJOL-GAP WATERWAY

PERIOD A

1978

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	Jan 7	0720	Asian Energy	Tanker	104902	35180	129230	Liberia	Negligence of lookout
COL	Jan 30	1915	Jin Hwa	Tanker	475	35215	129237	Korea	
			2 Kyung Jin	Cargo	384	35215	129237	Korea	Negligence of lookout lack of cooperation
COL	Feb 4	0030	7 Kwang Il	Fish	351	35153	129197	Korea	Negligence of lookout
GRD	Jun 4	1548	Kara	Cargo	1911	35215	129232	Korea	Lack of experience & unskilled navigation

1980

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
GRD	Nov 6	2010	Il Shin	Cargo	508	35225	129220	Korea	Reduced visibility B'down of radar

1981

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	Jul 6	2200	Shin-A	Tanker	1505	35190	129245	Korea	L'out & spd
			So Rim	Cargo	995	35190	129245	Korea	E'sive spd in fog
COL	Aug 21	1348	Ocean Ace	Cargo	14309	35210	129278	Korea	Spd in fog, avert danger
			Challix	Cargo	6732	35210	129278	?	Spd. fog signal, l'out

1982

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	Aug 10	0537	No.1 Bukpyung	Cargo	497	35223	129288	Korea	Rule in reduced vis.

PERIOD B

1984

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	Jul 15	1855	1 Hae Kyung	Tanker	500	35210	129250	Korea	

1985

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	Apr 8	1310	Tae Yang	Tanker	434	35193	129250	Korea	
			Dae Myung	Tanker	433	35193	129250	Korea	(New name: Taeyang)
COL	Jul 17	2050	Geum Sung	Cargo	693	35174	129236	Korea	
			Kaenary	Cargo	4285	35174	129236	Korea	A/Co to port in fog(TSS)

1986

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag	Main causal factor
COL	Oct 30	0350	Eastern Dragon	Cargo	3010	35238	129281	Korea	
			Hwa Rang	Fish	488	35238	129281	Korea	

3. GADEOG-SUDO AND JINHAE-MAN AREA

PERIOD A

1978

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag
COL	Oct 21	1027	101 Odae-Yang	Tanker	706	35020	128453	Korea
GRD	Dec 27	0238	17 Shin-Young	Cargo	446	35017	128443	Korea

1980

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag
COL	Jun 24	0813	Angel	Pass	58	35028	128400	Korea
			Angel NO.2	Pass	56	35028	128400	Korea

1981

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag
GRD	Jun 13	1725	Seven Star	Cargo	730	34593	128501	Korea
COL	Jun 16	1726	Angel NO.5	Pass	105	35017	128469	Korea
			Angel No.6	Pass	107	35017	128469	Korea

1982

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag
GRD	Feb 28	1820	Sewon	Cargo	397	35028	128368	Korea

PERIOD B

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag
COL	Jul 25	0915	1 Hae Yoon	Fish	337	35023	128395	Korea
			Keum Gang	Tug	236	35023	128395	Korea
GRD	Jul 29	0500	17 Pyung Kwang	Tug	?	34579	128434	Korea
COL	Aug 7	1055	7 Sunil	Cargo	1933	35040	128384	Korea
			Dong Myung	?	?	35040	128384	Korea

1983

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag
COL	Sep 16	0600	7 Hyun Sung	Cargo	177	35061	128373	Korea

1984

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag
GRD	Jun 4	2205	Jeon Jin	Cargo	995	35056	128427	Korea
COL	Sep 14	0200	1 Sung Kwang	Tug	?	35005	128481	Korea
			KalimantanEmpat	Cargo	2984	35005	128481	?

1985

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag
GRD	Sep 22	1030	11 Keum San	Cargo	87	35022	128368	Korea

1986

	Date	Time	Name	Type	GRT	Lat.	Long.	Flag
COL	Nov 22	0935	Heung Koog	TanKer	500	35061	128370	Korea
			22 Sein	?	?	35061	128370	Korea
COL	Dec 31	0450	9 Hwa Pyung	Cargo	730	35020	128467	Korea

4. PUSAN HANG AREA

PERIOD A

1974

Date		*Time*		*Name*	*Type*	*GRT*	*Lat.*	*Long.*	*Main causal factor*	
1	11	1630	RAM	Borneo	Cargo	3920	35066	129029	Excessive speed	
2	16	0945	RAM	Global Pioneer	Cargo	1566	35067	129030	Unexpected gale	
							(No.3 pier)			
4	1	1254	RAM	Beatris	Cargo	3908	35062	129027	Strong wind	
							(No.2 pier)			
4	4	0300	COL	Bal-san	Cargo	8432	35061	129053	Improper m'ring in gale	Liberia
				Nosan Star	Cargo	2765	35061	129053		Panama
4	12	2340	COL	Mount Atos	Cargo	14133	35043	129067	Negligence of lookout	
4	21	0230	RAM	New Samshin	Cargo	501	35063	129054	Negligence to danger	
5	14	0935	RAM	Lilac	Cargo	3381	35065	129039	Negligence to gale	
5	24	2345	COL	Koryo	Cargo	6819	35055	129050		
				Fun Clift	Cargo	8785	35055	129050	Cross other ships course	Norway
11	11	1823	COL	9 Heung-A	Cargo	556	35001	128582		
12	4	2330	GRD	Daiho Maru	Cargo	999	35064	129042	Unexpected gale	
12	12	0530	RAM	3 Shin-A	Tanker	902	35059	129034	Mishandled M/engine	

1975

Date		*Time*		*Name*	*Type*	*GRT*	*Lat.*	*Long.*	*Main causal factor*	
2	13	0500	GRD	Sea Wings	Cargo	820	35060	129027	Negligence to ship operation	
							(No.1 pier)			
3	9	1740	RAM	1 Lucky	Tanker	3561	35068	129044	Negligence to bad weather	
3	25	0915	RAM	Mok-Ryun	Cargo	3806	35061	129040	Negligence to danger	
4	2	1013	RAM	Global Exporter	Cargo	1569	35067	129031	Unskilled & careless manoeuvring	
4	21	1400	RAM	3 Lucky	Tanker	3350	35068	129044	Improper manning on bridge	
8	9	1800	GRD	Tongwoon 1206	Cargo	91	35063	129042	Negligence to danger	
10	2	1518	RAM	New Hanjin	Cargo	550	35062	129028	Negligence to danger	
							(No.2 pier)		Too close to pier	
10	14	2035	RAM	15 Shin-A	Tanker	885	35045	129065	Negligence of lookout	
10	27	0750	RAM	Sea Wings	Cargo	820	35060	129027	E'sive speed	
10	30	2200	GRD	13 Bum yang	Fishcarry	90	35061	129049	Negligence of lookout	
11	19	1805	COL	7 Keum Shin	Cargo	502	35066	129035	Cross other ships course	
				Pacific Conbay	Cargo	472	35066	129035	Negligence to danger	Liberia
11	23	1242	COL	Manwa	Cargo	9159	35046	129052	Not obey the order	
				Hanbada	Training	3491	35046	129052		
12	5	1815	COL	Dolphin	Ferry	59	35059	129030	Excessive speed	

1976

Date		*Time*		*Name*	*Type*	*GRT*	*Lat.*	*Long.*	*Main causal factor*	
3	23	0815	COL	1 Do-shin	Cargo	999	35065	129029	Didn't find other ship	
				Arecos	Cargo	10309	(Centre pier)			
4	17	1747	COL	Aroho	Cargo	4967	35065	129040		Japan
				Yushio Maru	Cargo	1995	35065	129040	Anchored close to other	Japan
4	20	1555	COL	11 Hakuyo Maru	Tug	80	35066	129040		Japan
				Yushio Maru	Cargo	1995	35066	129040	Negligence of lookout	Japan
4	23	0230	GRD	Lord	Cargo	4673	35061	129049	Old chart	Panama
5	1	0835	COL	15 Shin-A	Tanker	885	35062	129042		
				3 Nitsho Maru	Cargo	188	35062	129042	No knowledge of regulation	

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor	
6	8	0230	COL	Venus	Cargo	1998	35069	129040		
				Mok Hwa	Cargo	3653	35069	129040	Negligence to storm/gale	
6	9	0656	RAM	Mi-yang	Cargo	3787	35069 (No.4 pier)	129032	B'down of shore bitt	
7	21	0915	COL	Han Yong	Cargo	3924	35062	129040	Improper manoeuvre	
				5 Jung-Geum	Cargo	941	35062	129040	Not proper signal	
12	2	1140	COL	Hae-hyun	Cargo	4009	35058	129055		
				Silver Pagoda	Cargo	13370	35058	129055	Improper anchoring	
12	20	0900	RAM	Chun-Ri	Cargo	501	35062	129026	Mishandled M/engine	

1977

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor	
1	13	0830	COL	1 Hyoam	Cargo	508	35061	129042	Violation of rules	
				Hae Il	Cargo	110	35061	129042		
3	13	1930	RAM	Queen Dragon	Cargo	997	35064	129055	Negligence to bad weather	
4	6	1400	RAM	Shin-A	Cargo	1505	35063	129054	Negligence to bad weather	
4	7	0725	RAM	5 Yoo Nam	Cargo	3949	35055	129055	Dragging anchor	
4	13	0839	GRD	Ruby Star	Cargo	3963	35048	129050	No small correction	
4	19	1310	COL	Odae ho	Cargo	8991	35056	129057	Negligence of ship operation	
				Narcissus	Cargo	4000	35056	129057		Panama
5	1	2200	RAM	Dae-an	Cargo	999	35063	129053	N'gence to storm	
5	23	0647	COL	Marine Star	Cargo	3009	35051	129051		
				World amber	Tanker	28488	35051	129051	Main engine failure	Liberia
6	1	2340	COL	5 Yoo Nam	Cargo	3949	35063	129058	Storm	
				Silver Fun	Cargo	5000	35063	129058	Negligence of lookout	
6	2	0010	COL	5 Min Woo	Tanker	673	35062	129055		
				72 Chil Sung	Cargo	476	35062	129055	Negligence of refuge	
7	3	1614	COL	2 In Wang	Cargo	4237	35052	129052	Dence fog, excessive speed	
				Tokerau	Cargo	9328	35052	129052		Panama
7	8	1433	COL	15 Shin-A	Tanker	885	35060	129034	Violation of col. rules	
8	3	1205	GRD	Nambang	Cargo	1974	35059	129037	Improper manning on bridge	
12	8	1740	COL	Doraji	Ferry	890	35061	129033	Violation of rules	
				Chun Yang	Tug	23	35061	129033	No reaction to col. danger	
12	15	0745	RAM	Merry Star	Cargo	1999	35062	129026	Improper manoeuvre	
12	18	1200	COL	8 Heung-A	Cargo	558	35057	129045	Improper manoeuvre	
12	29	1200	RAM	Korean Lifter	Cargo	1598	35063	129057	Didn't use anchor in docking	

1978

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor	
2	13	1131	RAM	Myung Sung	Tanker	998	35068	129044	Negligence of manoeuvring	
3	9	0159	COL	Sung Ryong	Cargo	599	35051	129050		
				Grand Opal	Cargo	12000	35051	129050	Storm & improper manoe'g	Liberia
3	10	2013	COL	2 Donam	Cargo	1998	35066	129041	Negligence of duty	
				Mok Geun	Cargo	3767	35066	129041	Lack of knowledge on ship manv'g & improper decision	
4	5	1720	COL	Daeduk	Cargo	1190	35068	129038		
				2 Yamaume Maru	Cargo	1874	35068	129038	Improper manoeuvring (anchor)	
4	28	1817	GRD	1 Hansung	Cargo	993	35045	129051	No new chart	
6	7	2020	RAM	Pegasus Plenty	Cargo	4520	35068	129038	Anchored too close to Hanyong	
6	25	0926	COL	1 Mano	Cargo	1995	35061	129033	B'down of steering(ex. sp'd	
7	6	1843	COL	Dong Sung	Tanker	467	35050	129070	No fog signal	
				2 Sam Bu	Tanker	523	35050	129070	Excessive speed in fog	

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor
7	13	2010	RAM	Queen dragon	Cargo	997	35062	129026	Lack of docking ability
7	22	0356	COL	20 Chemicarry	LPG	635	35045	129060	No reporting
				Dong Yang	Cargo	1599	35045	129060	Negligence of lookout

<u>*PERIOD B*</u>

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor
12	21	1809	GRD	5 Min Woo	Tanker	673	35060	129037	Unskilled manoeuvring
12	31	1817	GRD	Sam Jung	Cargo	998	35061	129049	Not fix posision
									Negligence of lookout

<u>1979</u>

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor	
1	4	2028	COL	Myung Sung	Tanker	998	35006	129015	No warning signal.viol'n rule	
1	15	1418	GRD	5 Yoo Nam	Cargo	3949	35060	129036	Poor inspection of M/E	
4	14	0825	RAM	Aurora	Cargo	4252	35071	129038	Unskilled manoeuvring	
4	19	2020	RAM	101 O-dae-yang	Tanker	706	35060	129037	Other ship crossed ahead	
4	21	0200	GRD	2 Han Sung	Cargo	991	35054	129045	Error in voyage planning	
4	23	1030	RAM	Eun sung	Cargo	702	35063	129054	Reckless sailing	
4	24	0705	GRD	Yulsan Poseidon	Cargo	13193	35058	129065	Negligence to bad weather	
4	24	0914	GRD	Trident	Cargo	15533	35053	129059	Negligence to bad weather	
5	1	1810	GRD	Tahang	Cargo	1785	35019	129057	Improper manoeuvring	
6	26	0756	COL	Kyung Yang	Factory	5377	35055	129069	Improper anchoring	
				Cho Yang	Cargo	3668	35055	129069	Negligence of routine	
7	14	1345	COL	17 Dong-A	Tug	27	35043	129060	No fog signal. excessive	
				Hakori Fur	Fishcarry	328	35043	129060	speed. negligence to danger	
7	19	1219	RAM	Sealand Leader	Cargo	17376	35047	129066	Misobservation of	
							(No.2 buoy)		surroundings	
8	1	1913	RAM	Queendom Venture	Cargo	30000	35071	129037	E'sive speed to berth	
8	17	1732	COL	Chestnut Heroine	Cargo	29411	35055	129060	Typhoon (Erbing)	
				Kwang Fung	Cargo	4300	35055	129060		
10	21	1710	GRD	Hanla Pride	Cargo	9953	35055	129056	Lack of experience	
12	31	1735	COL	Sea Bear	Cargo	1978	35059	129030	Improper anchoring	Korea
				BiBi	Cargo	16000	35059	129030		Liberia

<u>1980</u>

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor	
1	11	0820	RAM	Nam Kyung	Cargo	502	35069	129033	Excessive speed	
									Failure of telegraph	
3	4	1114	GRD	Namyang Ace	Cargo	3003	35058	129045	Storm	
3	5	1700	GRD	New Songdo	Cargo	11760	35053	129059	Negligence of lookout	
									improper manoeuvring	
3	21	2300	RAM	Seed Reef	Fishcarry	1391	35057	129043	Dragging anchor	Panama
4	5	1540	GRD	In Wang	Cargo	3451	35057	129061	Negligence to storm	
4	5	1650	COL	Queen Dragon	Cargo	993	35057	129043	Negligence to storm	
				Bowoon 5	Tanker	1938	35057	129043	Dragging anchor	
4	5	1800	GRD	2 In Wang	Cargo	4237	35053	129059	Dragging anchor	
4	8	1630	GRD	Young Dong	Tanker	431	35061	129049	Not fix position.	
									unskilled manoeuvring	
4	19	1430	RAM	Glory Ocean	Cargo	2593	35060	129026	Gust during docking	
4	19	1740	GRD	Kordes	Tanker	483	35063	129042	Negligence to bad weather	
5	16	0218	GRD	5 Yoo Sung	Tanker	1114	35027	129009	Error in voyage planning	

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor	
6	9	0900	COL	Kwang Yang	Tanker	64	35069	129032	Unskilled manoeuvring	
7	19	0755	COL	Chun Kyung	Cargo	1241	35050	129057	No plotting, misread radar,	
				7 Hwa Pyung	Cargo	530	35050	129057	negligence to danger	
7	22	1733	RAM	Salix	Cargo	6732	35072	129041	Failure of M/engine & negligence to bad weather	
8	31	1600	RAM	Global Moon	Cargo	14200	35066 (Centre pier)	129028	Poor placing of fender at pier	
10	14	0810	RAM	Global Venture	Cargo	1567	35068	129030	Improper manoeuvre	
12	3	1610	COL	Buk Neung	Factory	8506	35019	129013	Failure of main engine	
12	12	1950	GRD	7 Shin-A	Tanker	337	35021	129056	No fog signal	
12	26	1830	COL	Dong Nam	Cargo	3003	35049	129060	Cross other's course.	

<u>1981</u>

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor	
1	2	1720	COL	American Mark	Cargo	1574	35057	129043	No voyage planning	
				18 Heung-A	Cargo	999	35057	129043		
3	3	2010	COL	Moon Star	Cargo	1840	35060	129028	Negligence of cooperation	
				36 Hee Young	Tug	29	35060	129028	Negligence of lookout, violation of rules, improper manning(no certi)	
3	27	1730	RAM	Hwapyung Jinju	Cargo	1595	35060	129027	Mishandled M/engine	
6	8	0753	GRD	5 Yu Sung	Tanker	1114	35059	129036	Error in position of anchor	
6	16	1503	COL	5 Hwa Pyung	Cargo	365	35051	129062	Negligence in dence fog	
				Constadoula Bacolista	Cargo	?	35051	129062		
7	9	0742	COL	1 Chang Sung	Cargo	480	35040	129081	Excessive speed in dence	
				Sunny Rose	Cargo	3453	35040	129081	fog, negligence to danger	
7	15	2215	COL	1 Do Nam	Cargo	1998	35009	129072	Excessive sp'd in fog	
				Silver Star	Cargo	3000	35009	129072		
7	16	0748	COL	American Merchant	Cargo	21687	35048	129062	Other ship's rule v'tion	
8	26	0600	COL	Seo Kwang	Tug	19	35045	129025		
9	1	0030	RAM	Pacific Dragon 2	Cargo	?	35063	129056	Typhoon (Agnes)	
9	3	0455	COL	One-west 9	Cargo	?	35060	129031		
				Kota Sejati	Cargo	9719	35060	129031		S'pore
10	19	0746	RAM	Korean Wonisone	Cargo	23930	35047	129066	Ramming to buoy	
11	22	0743	RAM	9 Heung-A	Cargo	556	35060 (No.1 pier)	129027		
12	29	1852	RAM	Inchon	Cargo	3818	35032	128582	Fish farming net	

<u>1982</u>

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor	
1	1	0930	GRD	Sam Han	Cargo	390	35061	129049	Too close to rock	
2	26	1000	RAM	Hae Gui	Cargo	1578	35072	129042	Ramming to pier	
3	9	0718	COL	New Dolphin	Pass	73	35059	129025		
				Doraji	Pass	890	35059	129025		
3	15	0850	RAM	18 Chemicarry	Tanker	1586	35063	129056	Ramming to pier	
3	31	1125	COL	Coral Star	Cargo	4100	35035	129034		Panama
7	22	0850	COL	Se Hwa	?	?	35036	129077		
8	24	0115	COL	6 Heung-A	Cargo	558	35051	129063		
				Shogo Maru	Cargo	48775	35051	129063		Japan
12	9	1755	RAM	New Dolphin	Pass	73	35059	129025	(Ferry dolpin)	

1983

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor
1	5	0723	RAM	Arirang	Pass	915	35058 (Ferry pier)	129025	
3	16	1630	COL	2 Sun Il Naeoi 9	Cargo ?	3336 ?	35059 35059	129038 129038	
3	26	1245	RAM	6 Donam	Cargo	3839	35060	129026	Storm, unskilled m'ing
5	5	0808	COL	Brother Star Crimson Concord	Cargo Cargo	13078 3425	35034 35034	129073 129073	Violation of rules(fog) Neg. of cooperation
5	6	0905	RAM	Bochurn	Cargo	3049	35059	129030	
7	1	0730	COL	Merry Star 5 Samsam	Cargo ?	1999 ?	35067 35067	129033 129033	
8	23	1210	RAM	Dae Myung	Tanker	433	35055	129043	(New name: Taeyang)
9	11	1355	COL	7 Donam 5 Dongho	Cargo Tug	3840 34	35060 35060	129028 129028	
9	28	0400	RAM	Dol Jin	Cargo	1969	35071	129049	

PERIOD C

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor
11	7	0554	COL	Phoenix Hae Duk	Pass ?	77 ?	35023	129010	
11	9	1824	COL	Kuk Hwa 2 Il Jin	Tug Tanker	185 130	35067 (front of No.4 pier)	129035	

1984

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor
1	4	0313	COL	New Man Sun Wave	? ?	? ?	35030 (S outer Hr)	129035	
2	6	1030	COL	103 Nam Sung 9 Yoo Sung	F.Carry Tug	299 29	35036 (S outer Hr)	129017	
3	14	1140	GRD	9 Shin-Ah	Tanker	840	35063 (Tongmyung pier)	129057	(New name: Woo Ryong)
4	18	1620	COL	Saebada Three Ocean	F.Factory ?	2275 ?	35028 (S outer Hr)	129028	
6	20	0528	COL	Hwapyung Songdo Lady Josephine	Cargo ?	1000 ?	35048	129058	
8	21	1000	RAM	Hae Gui	Cargo	1578	35071	129042	(No 7 pier) (New name:Haesung 7)
10	23	1510	RAM	Hae Sung	Cargo	1984	35071	129042	(No 7 pier)
11	21	2340	GRD	5 Dae Yang	Tanker	596	35060	129036	

1985

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor
1	28	2330	COL	Ocean Blue Seed Reef	Tanker F.Carry	2697 1391	35036 (S outer Hr)	129024	(New name: Moogal)
2	19	0630	RAM	Ilshin	Cargo	3600	35055	129043	(Cheonghakdong pier)
3	23	0505	COL	1 Hyo Dong Pheonix	Tug Passenger	58 77	35051 (Q. anchorage)	129074	
3	25	1100	GRD	Haeyoung Silver	Cargo	15000	35033	129044	(S outer Hr)
5	8	2145	RAM	Hangang Glory	Cargo	4996	35067 (No.3 Pier)	129030	RAM to other ship
6	11	1720	COL	Pegasus Peace Jin Yong	Cargo Tanker	2161 1429	35042 (S outer Hr)	129023	(New name: Grace Liberty II)

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor
6	19	0900	RAM	Sunny Ocean	Cargo	3373	35067	129030	(New name: Dooyang Garnet)
							(No.3 pier)		RAM to other ship
6	19	1051	RAM	71 Chil Sung	Cargo	853	35063	129054	(New name: Nam Kwang 1)
							(Shell pier)		RAM to other ship
8	10	1940	GRD	Haeyoung Light	Cargo	15000	35033	129045	(S outer Hr)
8	29	2050	GRD	6 Mi Yang	Tanker	884	35059	129067	(Honam Pier) New Name:Dae Woong
9	1	1610	COL	Sambo Expert	Cargo?	?	35026	129026	
				Korean Chance	Cargo	37277	(S outer Hr)		(New name: Choyang Chance)
10	5	0827	COL	Ferry Pukwan	Ferry	6138	35058	129026	
				Korea Carferry 1	Ferry	2904			(New name: Car Ferry Queen)
10	5	1330	RAM	5 Reefer	Cargo	3009	35053	129062	RAM to anchored ship
							(A-2 anchorage)		
10	13	0055	RAM	Hwang Yong	Cargo	22953	35063	129035	(New name:Global Fame)
							(E-4 anchorage)		RAM to anchored ship
12	13	0745	GRD	Chun Yang T-1	Tug	111	35063	129041	
12	18	0353	RAM	Aurora	Cargo	4253	35053	129063	RAM to anchored ship
							(A-2 Anchorage)		
12	28	0600	COL	Tae Kwang	Cargo	2544	35022	129011	Crossing
							(S of Dudo)		V'tion of give way rule

1986

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor
4	23	0838	COL	Royal Star	Cargo	3131	35043	129068	(New name: Cargobay)
				Botany Triton	Tanker	3890			
6	12	1530	RAM	Yong Bi	Tug	56	35072	129039	(No.6 pier)
7	31	0755	GRD	105 Sang Hae	?	?	35061	129049	
8	28	1405	GRD	Haebaraki	Cargo	?	35060	129068	

1987

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor
2	19	0505	COL	Pal Pal	?	?	35011	129010	
				11 Young Bu	?	?	(1.7' S of Dudo)		
4	21	1048	GRD	Global Star	Cargo	15545	35053	129059	(Near No.4 Buoy)
7	16	0345	GRD	Probo Hawk	Cargo	31276	35044	129016	(S outer Hr)
8	17	1937	COL	77 Dong Bang	F.Carry	1527	35025	129010	
				Olympic	Passenger	199	(S of Dudo)		V'tion of give way rule
9	25	0614	COL	6 Jang Young	Cargo	523	35054	129071	
9	28	2055	COL	Hyundai 14	Cargo	14433	35049	129062	
				Namgang Glory	Cargo	4406	(Fairway)		(New name: Trade Resources)
11	7	1010	COL	67 Jin Young	Tug	50	35061	129041	(near Breakwater)
11	29	0100	RAM	Sun Hanjin	Cargo	1981	35061	129049	(Ko-Am)

1988

Date		Time		Name	Type	GRT	Lat.	Long.	Main causal factor
1	23	0330	COL	51 Dong Sam	Tug	90	35046	129019	Anchored - no proper Lt
				702 Mi Haeng	F.Carry	228	(S outer Hr)		Lack of Lookout
4	1	0007	COL	7 Bo Kyung	F.Carry	239	35001	129065	Crossing
				Dutch Senator	Cargo	16430	(S of Saengdo)		V'tion of give way rule
4	10	1800	COL	3 Chang Sin	Tug	30	35027	129058	Lack of Lookout
							(near Taejongdae)		Meeting
7	2	1740	COL	Probo Bani	Cargo	31276	35033	129027	(S outer Hr)

Annex E

CODING SCHEME FOR QUESTIONNAIRE

Jin-Soo PARK
Institute of Marine Studies
University of Plymouth

No.	VARIABLES	VARIABLE LABEL	VALUE LABELS
BASIC INFORMATION (1-5)			
1	SERIAL	Serial number	
2	EXPERIE	Shipboard experience	Number of years
3	LASTRANK	Last rank on board	1= Master/mate of merchant vessel 2= Master/mate of ferry 3= Master/mate of tug 4= Master/mate of fishing vessel 5= Master/mate of military, government vessel 6= Master/mate of other vessel 7= Radio operator 8= Pilot 9= Marine engineer 10= Others
4	BGROUND	Marine background	1= Shipping company 2= Port/harbour official 3= Education or research institute 4= Government employee 5= Coast guard 6= Marine union or association 7= Classification or survey 8= Others 9= VTS Operators
5	SHIPSIZE	Average size of vessel	1= Less than 100 gross ton 2= 100 - 500 ton 3= 500 - 1,000 ton 4= 1,000 - 5,000 ton 5= 5,000 - 10,000 ton 6= 10,000 - 30,000 ton 7= 30,000 ton and over
FAMILIAR AREAS (6-15)			
6	FAREA1	Tonghae area	1= Yes 2= No
7	FAREA2	Pohang area	1= Yes 2= No
8	FAREA3	Ulsan area	1= Yes 2= No
9	FAREA4	Pusan area	1= Yes 2= No
10	FAREA5	Masan/Jinhae area	1= Yes 2= No
11	FAREA6	Yosu/Kwangyang area	1= Yes 2= No
12	FAREA7	Cheju haehyop/Jangjug sudo area	1= Yes 2= No
13	FAREA8	Maemul sudo/Mokpo area	1= Yes 2= No
14	FAREA9	Kunsan/Janghang area	1= Yes 2= No
15	FAREA10	Taean bando/Inchon area	1= Yes 2= No

RISK FACTORS *(16-27)*

16	VISIBIL	Reduced visibility	0= No opinion/don't know 1= Very seldom increases risk 2= Seldom increases risk 3= Sometimes increases risk 4= Often increases risk 5= Very often increases risk
17	STORM	Stormy weather	
18	CURRENT	Strong current/tidal stream	
19	FISHBOAT	More fishing boats in shipping lane	
20	PLEABOAT	More pleasure boats in shipping lane	
21	NARROWCH	More narrow channel/passage	
22	TRAFFIC	Higher density of traffic (merchant)	
23	FAIRWAY	Poor design of fairway	
24	NAVAIDS	Poor navigational aids	
25	HUMAN	Human factor in manoeuvring	
26	RULEVIO	Rule violation	
27	OFACTOR	Other factors to increase marine risk	

OVERALL RISK BY AREA *(28-37)*

28	TONGHAE	Tonghae area	0= No opinion/don't know 1= Very low risk 2= Low risk 3= Moderate risk 4= High risk 5= Very high risk
29	POHANG	Pohang area	
30	ULSAN	Ulsan area	
31	PUSAN	Pusan area	
32	MASAN	Masan/Jinhae area	
33	YOSU	Yosu/Kwangyang area	
34	CHEJU	Cheju haehyop/Jangjug sudo area	
35	MOKPO	Maemul sudo/Mokpo area	
36	KUNSAN	Kunsan/Janghang area	
37	INCHON	Taean bando to Inchon area	

ALTERNATIVES FOR RISK REDUCTION *(38-48)*

38	WEATHER	Improved weather information	0= No opinion 1= Very little 2= Little 3= Moderate 4= Significant 5= Very significant
39	SPDLIMIT	Institution of speed limits in more areas	
40	SAFEREG	Stricter enforcement of ship safety regulations	
41	DREDGING	additional dredging	
42	UPNAVAID	Upgraded floating/fixed navigational aids	
43	ADDTSS	Additional traffic separation schemes	
44	ADDCO	Additional recommended courses on charts	
45	ADDVTS	Additional VTS	
46	IMTRAIN	Improved education and training for mariners	
47	PROFISH	Stricter enforcement of prohibition of fishing/excursion on fairway	
48	OTHERALT	Other alternatives	

__MODIFICATION TO VTS__ *(49-54)*

49	PORTNAME	Name of your port or area	1= Tonghae 2= Pohang 3= Ulsan 4= Pusan 5= Masan/Jinhae 6= Yosu/Kwangyang 7= Cheju 8= Mokpo 9= Kunsan 10= Inchon
50	VTS_GRAD	Up/downgrade existing VTS	1= Downgrade or close 2= Maintain at present level 3= Improve or upgrade 4= No opinion
51	VTS_IMP	In case of no VTS service	1= Implement 2= Do not implement 3= No opinion
52	VTS_LEVL	What level of VTS is adequate ?	1= Level 1 2= Level 2 3= Level 3 4= Level 4
53	VTS_TYPE	What kind of VTS is adequate ?	1= Port VTS 2= Port and its approaches 3= Coastal VTS 4= Other type of VTS
54	VTS_AUTH	Formal authority of VTS	1= Harbour authority 2= Coast Guard 3= Pilot association 4= Other

__VTS OPERATOR__ *(55-57)*

55	OPR_MAR	Marine experience is essential ?	1= Essential 2= Not necessary 3= No 4= No idea
56	OPR_EXP	What kind of previous experience ?	1= Ship handling 2= Communication 3= Other experience
57	OPR_QUA	What level of qualification ?	1= Pilot 2= Master's experience 3= Master's certificate 4= Chief mate's certificate 5= Second mate's certificate 6= Radio operator's certificate

__EFFECTIVENESS OF VTS__ *(58-68)*

58	EF_VISIB	Assistance in reduced visibility conditions	0= No opinion 1= Very unimportant 2= Unimportant 3= Average 4= Important 5= Very important
59	EF_METEO	Assistance in adverse meteorological conditions	
60	EF_TRAFF	Assistance in dense traffic areas	
61	EF_FISHG	Assistance in areas with fishing/pleasure boats	
62	EF_RESTR	Assistance in restricted waters	
63	EF_ROGUE	Assistance in areas with rogue vessels	
64	EF_EMERG	Assistance to vessels in emergency	
65	EF_LANGU	Assistance with language/experience/knowledge	
66	EF_COMMU	Assistance with communication problems	
67	EF_NOTIC	Provision of notices to shipping	

Annex F

QUESTIONNAIRE ON MARINE SAFETY AND VESSEL TRAFFIC SERVICES IN KOREAN COASTAL WATERS

Dear Colleague,

We are presently undertaking a research programme on marine safety and Vessel Traffic Services (VTS) in Korean coastal waters. As part of this research, we are now seeking the opinions of marine experts of these systems so that their attitudes toward the existing service and their perception of marine risk may be analysed.

A large sample of mariners across Korea is being surveyed. We are requesting you, as a marine experts, to complete the enclosed questionnaire stating your opinions. Although it may seem long, the questionnaire is easy to answer.

The success of the survey depends on you. Your views will be incorporated into our study. We have taken care to ensure each respondent's anonymity. After your answers have been coded for analysis, the questionnaires will be destroyed.

We would be grateful if you could complete and return this questionnaire by August 31st 1993. Please return it in the self-addressed envelope which is addressed to Korea Maritime University for your convenience. Extra copies of the questionnaire can be obtained from the following address:

Department of Maritime Transport & Science
Korea Maritime University
1 Dongsam-dong
Yeongdo-ku
Pusan 606-791

Thank you for your cooperation and input to this study.

Jin-Soo PARK

Navigation Group
Institute of Marine Studies
University of Plymouth
Drake Circus
Plymouth, Devon
PL4 8AA U.K.

QUESTIONNAIRE ON MARINE SAFETY AND VESSEL TRAFFIC SERVICES IN KOREAN COASTAL WATERS

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A. BASIC INFORMATION

1

A1. FULLTIME SHIP-BOARD EXPERIENCE ?

Please indicate your number of years of fulltime shipboard experience: .... years 2

If your answer is 0, please go to question A3

A2. THE LAST RANK YOU HAVE POSSESSED ON BOARD ?

Please indicate your occupation during your most recent year of fulltime shipboard experience.
If you are currently engaged fulltime onboard ship, indicate your present occupation.
Circle the appropriate number. 3

(1) Master/Mate of a merchant vessel
(2) Master/Mate of a ferry/passenger vessel
(3) Master/Mate of a tug
(4) Master/Mate of a fishing vessel
(5) Master/Mate of a military or other government vessel
(6) Master/Mate of other vessel, please specify ....
(7) Radio operator
(8) Pilot
(9) Marine engineer
(10) Other, please specify...

A3. OTHER MARINE BACKGROUND

If you are not currently engaged fulltime onboard ship, please indicate your present link with the marine community by circling the appropriate number(s). 4

(1) Shipping company, Agent
(2) Port/Harbour official, please specify...
(3) Seafarer's education and research institute
(4) Government employee, please specify...
(5) Coast Guard
(6) Official of mariner's/marine industry/commercial organization
(7) Classification surveyor
(8) Other, please specify..

A4. THE AVERAGE SIZE (Gross Ton) OF VESSEL YOU HAVE SERVED ? 5

Please circle appropriate number.

(1) less than 100 (2) 100-500 (3) 500-1,000 (4) 1,000-5,000
(5) 5,000-10,000 (6) 10,000-30,000 (7) over 30,000 grt

A5. FAMILIAR AREAS

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Please indicate the geographical areas with which you are currently familiar by circling respectively. (More than one number may be circled)

(1) Tonghae and its approaches	6	
(2) Pohang and its approaches	7	
(3) Ulsan and its approaches	8	
(4) Pusan and its approaches	9	
(5) Masan/Chinhae, Kadok sudo and Koje-do area	10	
(6) Yosu/Kwangyang, Yosu Haeman and its approaches	11	
(7) Cheju Haehyop(North of Chejudo, Geomundo, Chuja Gundo, Wando) and Jangjug Sudo area	12	
(8) Maemul Sudo, Maenggol Sudo, Heugsan Jedo, Mokpo and its approaches	13	
(9) Kunsan/Changhang and its approaches	14	
(10) Taean Bando to Inchon area	15	

B. RISK PERCEPTION

B1. RISK FACTORS

Various factors contribute to accidents or to situations where the chance of an accident increase. Based on your total experience, please indicate how often, in your opinion, the factors below would increase marine risk in Korean coastal waters. Circle the appropriate number on each line.

	No opinion don't know	Very seldom increases risk	Seldom increase risk	Sometimes increases risk	Often increase risk	Very often increase risk		
Reduced visibility (fog, snow, rain)	0	1	2	3	4	5	16	
Stormy weather	0	1	2	3	4	5	17	
Strong current or tidal stream	0	1	2	3	4	5	18	
More fishing boats in shipping lanes	0	1	2	3	4	5	19	
More pleasure boats in shipping lanes	0	1	2	3	4	5	20	
More narrow channel and passage	0	1	2	3	4	5	21	
Higher density of traffic (merchant ships)	0	1	2	3	4	5	22	
Poor design of fairway (sharp bend, shallow water)	0	1	2	3	4	5	23	
Poor navigational aids (fixed and floating)	0	1	2	3	4	5	24	
Human factor in ship handling	0	1	2	3	4	5	25	
Violation of rules and regulation	0	1	2	3	4	5	26	
Other, please specify	0	1	2	3	4	5	27	

....

B2. OVERALL RISK BY AREA

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For each area with which you are familiar, and for the generally prevailing conditions, please indicate its overall risk as you see it by circling the appropriate number.

	No opinion don't know	Very low risk	Low risk	Moderate risk	High risk	Very high risk		
Tonghae area	0	1	2	3	4	5	28	
Pohang area	0	1	2	3	4	5	29	
Ulsan area	0	1	2	3	4	5	30	
Pusan area	0	1	2	3	4	5	31	
Masan/Chinhae/Kadok Sudo/ Koje-do area	0	1	2	3	4	5	32	
Yosu/Kwangyang/Yosu Haeman area	0	1	2	3	4	5	33	
Cheju Haehyop/Geomun-do/Chuja Gundo/Wando/Jangjug Sudo area	0	1	2	3	4	5	34	
Maemul Sudo/Maenggol Sudo/ Heugsan Jedo/Mokpo area	0	1	2	3	4	5	35	
Kunsan/Changhang area	0	1	2	3	4	5	36	
Taean Bando to Inchon area	0	1	2	3	4	5	37	

C. ALTERNATIVES FOR RISK REDUCTION

C1. ALTERNATIVES

There are different ways of improving marine safety. Please indicate the contribution of the following methods in improving marine safety. Circle the appropriate number on each line.

<u>IMPROVEMENT IN MARINE SAFETY</u>

	No Opinion	Very little	Little	Moderate	Significant	Very significant		
Improved weather information	0	1	2	3	4	5	38	
Institution of speed limits in more areas	0	1	2	3	4	5	39	
Stricter enforcement of ship safety regulations	0	1	2	3	4	5	40	
Additional dredging	0	1	2	3	4	5	41	
Upgraded fixed and floating navigational aids	0	1	2	3	4	5	42	
Additional traffic separation schemes	0	1	2	3	4	5	43	
Additional recommended courses on charts	0	1	2	3	4	5	44	
Additional VTS	0	1	2	3	4	5	45	
Improved education and training for mariners	0	1	2	3	4	5	46	
Stricter enforcement of prohibition of fishing/excursion on fairway	0	1	2	3	4	5	47	
Other, please specify......................	0	1	2	3	4	5	48	

C2. MODIFICATION TO VTS (*** these questions are answered by the persons who work in specific port or area ***) | Office Use Only

IMO Guidelines define VTS as:

"A VTS is any service implemented by a competent authority, designed to improve safety and efficiency of traffic and the protection of the environment. It may range from the provision of simple information messages to extensive management of traffic within a port or waterway"

For your area, please indicate how in your opinion VTS services should be modified by circling the appropriate number.

C2.1. The name of your port or area ? (..) 49 ☐

C2.2. If your area has VTS service now 50 ☐

(1) Downgrade or close (2) Maintain at present level (3) Improve or upgrade (4) No opinion

C2.3. If your area has no VTS service 51 ☐

(1) Implement (2) Do not implement (3) No opinion

C2.4. If "Improve or upgrade" or "Implement", what level of VTS is adequate in your area ? 52 ☐

(1) Level I: VMRS (A vessel movement reporting system consisting of VHF Communication and various vessel reporting)

(2) Level II: Basic Radar Surveillance (The VMRS of Level I coupled with basic radar surveillance. The radar is assumed to be a standard shipboard radar without advanced features)

(3) Level III: Advanced Radar Surveillance (This system includes complete communication plus an advanced state-of-art VTS radar surveillance system including; automatic vessel track analysis, track and collision alarms,advanced rain and sea clutter control, high resolution, overlaid port chart system, provisions for vessel identifiers and particulars)

(4) Level IV: Automatic Dependent Surveillance (based on the use of differential GPS retransmissions. This system consists of an automated transponder installed on the participating vessel that determines the vessel's position via differential GPS, and transmits this information automatically, along with vessel identification and ship particulars to the VTS control centre)

C2.5. What kind of VTS is adequate in your area ? Office Use Only

(1) Port VTS 53
(2) Port and its approaches
(3) Coastal VTS
(4) Other (..)

C2.6. Where the formal authority of VTS should be vested ? 54

(1) Harbour Authority (2) Coast Guard (3) Pilot Association (4) Other (....................)

D. The VTS Operator

IMO Guidelines defines the VTS Operator as:

"A VTS operator is the appropriately qualified person who performs the functions of the VTS. VTS operator further means a person who provides, if duly authorised, instructions and information to vessels and decides what action should be taken in response to data received. This person may be directly responsible for communications within a defined area, or may relay such information and decisions through an intermediary"

Please indicate your answer by circling to appropriate number.

D1. Do you think that marine experience is essential for VTS operators to perform their tasks and duties ? 55

(1) Essential (2) Not necessarily (3) No (4) No opinion

D2. If "Essential", what kind of previous experience ? 56

(1) Ship handling (2) Communication (3) Ship handling and Communication

(4) Other (..............................)

D3. What level of qualification is necessary to perform the functions ? 57

(1) Pilot (2) Master's experience (3) Master's certificate (4) Chief Mate's certificate
(5) Second Mate's certificate (6) Radio Operator's certificate

E. EFFECTIVENESS OF VESSEL TRAFFIC SERVICES

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Each of following questions are based on the analysis of marine casualties in Korean coastal waters that are the most incidental causal factors of accident.
Please read the following questions and indicate your answer by circling to appropriate number.

E1. ASSISTANCE IN REDUCED VISIBILITY CONDITIONS

VTS provides assistance to vessels in reduced visibility conditions by fog, rain and/or snow such as: monitoring the position; providing advice on request or when determined necessary; providing information on objects and floats, etc.

How important are these services to marine safety ? 58 ☐

No opinion	Very unimportant	Unimportant	Average	Important	Very important
0	1	2	3	4	5

E2. ASSISTANCE IN ADVERSE METEOROLOGICAL CONDITIONS

VTS provides assistance to vessels in adverse meteorological conditions(stormy weather, strong current or low water, etc) by services such as: providing information on tides and currents; monitoring the position and providing advice on request or when determined necessary, etc.

How important are these services to marine safety ? 59 ☐

No opinion	Very unimportant	Unimportant	Average	Important	Very important
0	1	2	3	4	5

E3. ASSISTANCE IN DENSE TRAFFIC AREAS

VTS provides assistance to merchant vessels in dense traffic areas by service such as: providing advance traffic information; establishing/maintaining radio contact among vessels; warning other traffic of vessel acting contrary to regulations or in an unexpected manner; monitoring vessel's movements; providing advice on the timing of various manoeuvres to assist traffic and/or to avoid a potentially hazardous situation, etc.

How important are these services to marine safety ? 60 ☐

No opinion	Very unimportant	Unimportant	Average	Important	Very important
0	1	2	3	4	5

E4. ASSISTANCE IN AREAS CONGESTED WITH FISHING VESSELS OR PLEASURE CRAFTS

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In areas congested with fishing vessels or pleasure crafts, VTS provides assistance by services such as: provide advance information to large vessels on the presence of the group of small vessels; providing advance information to fishing vessels on the approach of larger vessels; advising larger vessels of courses that will avoid concentrations of small vessels, etc.

How important are these services to marine safety ? 61 ☐

No opinion	Very unimportant	Unimportant	Average	Important	Very important
0	1	2	3	4	5

E5. ASSISTANCE IN RESTRICTED WATERS

VTS provides assistance to vessels in restricted waters (e.g. near blind bends, narrow passage, rocks, shoals, shallow water, structure on seabed, tunnels, bridges, caissons, narrow channels, or floating objects) by services such as: providing advance notice of the hazard where necessary (to foreign vessels, or where the hazard is new); providing traffic information in the area of the hazard; monitoring vessel's movements so as to regulate the flow of traffic and reduce risk, etc.

How important are these services to marine safety ? 62 ☐

No opinion	Very unimportant	Unimportant	Average	Important	Very important
0	1	2	3	4	5

E6. ASSISTANCE IN AREAS WITH VESSELS ACTING CONTRARY TO RULES

VTS provides assistance to vessels acting contrary to rules & regulations such as excessive speed under the condition, sail in wrong side or unmarked waters, and etc. by services such as: providing information to other traffic on the presence of rogue vessels; warning all traffic of a vessel acting contrary to regulations or in an unusual manner, etc.

How important are these services to marine safety ? 63 ☐

No opinion	Very unimportant	Unimportant	Average	Important	Very important
0	1	2	3	4	5

E7. ASSISTANCE RENDERED TO VESSELS IN EMERGENCY

VTS assists vessels experiencing engine failure, fire on board, loss of control, radar failure, radio failure and other emergency situation by services such as: identifying the vessel in distress; routeing other vessels away from the scene of accident; closely monitoring the situation; providing any other required assistance.

How important are these services to marine safety ? 64 ☐

No opinion	Very unimportant	Unimportant	Average	Important	Very important
0	1	2	3	4	5

E8. ASSISTANCE WITH FOREIGN LANGUAGES PROBLEMS, LACK OF EXPERIENCE OR KNOWLEDGE PROBLEMS

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VTS provides assistance to vessels having such problems by services such as: the early identification of vessels whose crews are experiencing language difficulties in their communications; warning other traffic of the presence of such vessels; helping to communicate each other; providing assistance on request, etc.

How important are these services to marine safety ? 65

No opinion	Very unimportant	Unimportant	Average	Important	Very important
0	1	2	3	4	5

E9. ASSISTANCE WITH COMMUNICATION PROBLEMS

VTS centre monitor the communications between vessels, ship and shore, ship and tug. VTS provides assistance to vessels having communication difficulties, on request or when determined necessary.

How important are these services to marine safety ? 66

No opinion	Very unimportant	Unimportant	Average	Important	Very important
0	1	2	3	4	5

E10. PROVISION OF NOTICES TO SHIPPING

When VTS personnel are made aware of a new hazard to navigation, a Notice to Shipping is passed to the vessel.

How important are these services to marine safety ? 67

No opinion	Very unimportant	Unimportant	Average	Important	Very important
0	1	2	3	4	5

Thank you for your cooperation and input to this study !!

한국연안해역의 항행안전 및 선박교통관제(VTS)에 관한 설문조사

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1. 기본사항

1

1.1 귀하의 승선경력(fulltime shipboard experience)은 몇년입니까 ? (...........)년
만일 승선경력이 없으시면 1.3항으로 가십시요. 2

1.2 승선근무시 최종직책은 무엇이었읍니까 ?

가장 최근 승선시의 직책을 표시해 주시고, 현재 승선근무중이시면 현재의 직책을 표시해주십시요. 3

(1) 상선의 선장/항해사
(2) 여객선 및 훼리의 선장/항해사
(3) 예선의 선장/항해사
(4) 어선의 선장/항해사
(5) 군함, 경비정 또는 기타 정부관청 소속 선박의 선장/항해사
(6) 기타선박의 선장/항해사 (어떤 종류의 선박인지 적어주십시요..................................)
(7) 통신장(사)
(8) 도선사
(9) 기관장(사)
(10) 기타 (...)

1.3 기타 해운경력

현재 승선중이 아닌 경우, 어떤 분야에 종사하시는지 적당한 번호에 O표하여 주십시요. 4

(1) 해운기업 (선박회사, 대리점, 운송주선업, 선박관리업 등)
(2) 항만청: 어느분야이신지 O표해 주십시요 (선박직, 통신직, 행정직, 기타)
(3) 해기교육기관 및 연구기관
(4) 항만청이 아닌 정부기관: 어느기관이신지 O표해주십시요 (해난심판원, 기타)
(5) 해양경찰
(6) 각종협회 및 단체 (해기사협회, 노조, 선주협회, 해운조합, 통신사협회, 기타)
(7) 선급협회 및 감정업체 (KR, 외국선급, 감정업)
(8) 기타 (어느분야인지요? ....)

1.4 귀하께서 승선하셨던 선박의 평균 규모(Average size: Gross ton)는 어느정도이었는지 적당한 번호에 O표해 주십시요. 5

(1) 100톤 미만 (2) 100-500톤 (3) 500-1,000톤 (4) 1,000-5,000톤 (5) 5,000-10,000톤
(6) 10,000-30,000톤 (7) 30,000톤 이상

1.5 아래지역중 귀하께서 자주 입출항해 보신 지역이나 잘 알고 있는 지역의 번호들에 O표해 주십시요 (2개 이상 표시해도 됩니다)

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(1) 동해항 및 인접수역	6	
(2) 포항항 및 인접수역	7	
(3) 울산항 및 인접수역	8	
(4) 부산항 및 인접수역	9	
(5) 마산/진해항, 가덕수도, 거제도 부근해역	10	
(6) 여수/광양항, 여수해만 및 인접수역	11	
(7) 제주도 북안으로부터 거문도, 추자군도, 완도, 장죽수도로 이어지는 제주해협 부근수역	12	
(8) 매물수도, 맹골수도, 흑산제도, 목포항 및 부근수역	13	
(9) 군산/장항항 및 인접수역	14	
(10) 태안반도에서 인천항으로 이어지는 수역	15	

2. 한국연안 수역에서의 항행 안전에 관한 내용

2.1 해난위험요소

해난사고의 원인이 되는 요소는 여러가지가 있을 수 있읍니다. 귀하의 해상 또는 해운관련업체에서의 근무경험을 통하여 아래에 열거한 요소들이 해난발생에 어느정도 영향을 미친다고 생각하시는지 각 문항의 적당한 번호에 O표하여 주십시요.

	잘모르겠다 의견없음	거의 영향을 미치지않는다	영향을 미치지 않는다	때때로 영향을 미친다	자주 영향을 미친다	아주 자주 영향을미친다	Office Use Only
(1) 제한된 시정 (안개, 눈, 비)	0	1	2	3	4	5	16
(2) 강풍, 높은 파도 등	0	1	2	3	4	5	17
(3) 강한 조류 및 조석	0	1	2	3	4	5	18
(4) 어선의 항로상 조업행위	0	1	2	3	4	5	19
(5) 유람선등의 항로상 유람행위	0	1	2	3	4	5	20
(6) 수로의 협소함	0	1	2	3	4	5	21
(7) 높은 선박교통밀도 (상선)	0	1	2	3	4	5	22
(8) 항로설계상의 잘못	0	1	2	3	4	5	23
(9) 항로표지 미비	0	1	2	3	4	5	24
(10) 선박조종상의 인적요소	0	1	2	3	4	5	25
(11) 항법 및 항행규칙의 위반	0	1	2	3	4	5	26
(12) 기타 (내용을 적어주십시요)	0	1	2	3	4	5	27

....

2.2 각 해역별 위험수준

귀하께서 잘 아시는 해역에 대하여, 귀하께서 느끼고 있는 위험수준은 어느정도인지 각 항목의 적당한 번호에 O표하여 주십시요.

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	모르겠다	매우 낮다	낮다	보통이다	높은편이다	매우높다		
(1) 동해항 및 인접수역	0	1	2	3	4	5	28	
(2) 포항항 및 인접수역	0	1	2	3	4	5	29	
(3) 울산항 및 인접수역	0	1	2	3	4	5	30	
(4) 부산항 및 인접수역	0	1	2	3	4	5	31	
(5) 마산/진해항, 가덕수도, 거제도 부근해역	0	1	2	3	4	5	32	
(6) 여수/광양항, 여수해만 및 인접수역	0	1	2	3	4	5	33	
(7) 제주도 북안의 제주해협 부근수역	0	1	2	3	4	5	34	
8) 매물수도, 맹골수도, 흑산제도, 목포항 및 부근수역	0	1	2	3	4	5	35	
(9) 군산/장항항 및 인접수역	0	1	2	3	4	5	36	
(10) 태안반도에서 인천항으로 이어지는 수역	0	1	2	3	4	5	37	

3. 해난위험을 감소시키기 위한 대안

3.1 대안

해상에서 선박항행상의 안전을 증진시키기 위한 방법은 여러가지가 있을 수 있읍니다. 다음에 열거한 방법들이 항행상의 안전을 증진시키는데 어느정도 기여할 수 있다고 생각하시는지, 각각의 대안에 대해 O표 하여 주십시요.

	항행상의 안전 증진에 대한 기여도							
	의견없음	아주약간	약간	보통	현저하게	매우 현저하게		
향상된 기상정보 제공	0	1	2	3	4	5	38	
더 많은 지역에 대해 속력제한을 실시	0	1	2	3	4	5	39	
선박안전 관계 법규를 강화	0	1	2	3	4	5	40	
추가 준설 실시	0	1	2	3	4	5	41	
항로표지 개선	0	1	2	3	4	5	42	
통항분리제도(Traffic Separation Scheme)를 확대	0	1	2	3	4	5	43	
해도상에 추천항로를 확대	0	1	2	3	4	5	44	
선박교통관제(Vessel Traffic Services) 확대 실시	0	1	2	3	4	5	45	
선원 교육 및 훈련 개선	0	1	2	3	4	5	46	
어선 및 유람선의 항로상 조업(유람)행위 단속강화	0	1	2	3	4	5	47	
기타 (...)	0	1	2	3	4	5	48	

3.2 선박교통관제 (VTS) 시스템의 개선 (** 특정 항만이나 지역에 근무하시는 분에게만 해당 되는 사항임 **)

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국제해사기구(IMO)에서 정한 VTS의 정의는 다음과 같읍니다.

"항행상의 안전, 선박교통의 효율성 및 환경보호를 증진시키기 위하여 주관청(competent authority)에 의해 제공되는 모든 종류의 서비스를 말한다. VTS는 한 지역(within a port or waterway)내에서 단순한 정보를 제공해 주는 것으로부터 광범위한 선박교통관리 까지를 포함한다."

위의 VTS에 대한 정의를 참고하시어, 귀하께서 속해있는 항만지역의 VTS를 어떻게 개선함이 바람직하다고 생각하시는지 각 문항의 적당한 번호에 O표하여 주십시요.

49 ☐

3.2.1 귀하께서 근무하고 있는 항만 또는 지역의 명칭은 ? (..)

3.2.2 귀하께서 근무하고 있는 지역에 이미 VTS를 실시중인 경우; 50 ☐

(1) 서비스 수준을 낮추거나 서비스를 중단함이 바람직하다 (2) 현 서비스 수준을 유지하는 것이 바람직하다
(3) 현 서비스 수준을 개선 및 향상시키는 것이 바람직하다 (4) 의견 없음

3.2.3 귀하께서 근무하고 있는 지역에 VTS를 아직 실시하지 않고 있는 경우; 51 ☐

(1) 실시해야 된다 (2) 실시하지 않는 것이 바람직하다 (3) 의견 없음

3.2.4 (3.2.2)항에 대해 "현 서비스 수준을 개선 및 향상" 이라고 응답하신 분과, (3.2.3)항에 대해 "실시해야 된다"고 응답하신 경우, 다음에 열거한 VTS Level중 어느 것이 귀하의 지역에 적당하다고 생각하시는지요 ?

(1) Level I : 선박 입출항 및 이동보고 (Vessel Movement Reporting System= VHF 교신과 선박으로부터의 각종 보고로 이루어지는 시스템) 52 ☐

(2) Level II : 기본적인 레이다 감시 (Basic Radar Surveillance= Level I의 VMRS에다가 기본적인 레이다감시로 이루어지는 시스템으로, 여기에서 말하는 레이다는 최신기능이 없는 일반 선박용레이다를 말함)

(3) Level III: 진보된 레이다 감시 (Advanced Radar Surveillance= 종합적인 통신장비(Communication) 및 최신 레이다를 이용한 감시 시스템으로, 이 레이다는 자동항로추적 및 분석 기능, 항로이탈 및 충돌위험 경보장치, 최신 sea and rain clutter control, 고감도, overlaid port chart system등의 기능을 가진 최신형 레이다)

(4) Level IV : Automatic Dependent Surveillance (VTS 대상 선박에 자동 트랜스폰다(Transponder)를 설치함으로서 GPS를 통해 본선위치를 자동으로 얻게되고, 이 위치와 함께 본선 사양(Particulars)을 VTS센타에 자동으로 재송신해주는 기능까지를 포함하는 시스템)

3.2.5 귀하의 지역에 적합하다고 생각되는 VTS 서비스 형태는 어느것입니까 ?

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53 ☐

(1) 항만 VTS (2) 항만과 그 접근수역까지를 포함하는 VTS (3) 연안수역까지 포함하는 VTS
(4) 기타 (..)

3.2.6 VTS의 주관청을 어디로 하는 것이 바람직하다고 생각하십니까 ?

54 ☐

(1) 각 지방해운항만청 (2) 해양경찰 각 지구대 (3) 각 항만의 도선사협회
(4) 기타 (..)

4. 관제요원 (VTS Operator)

국제해사기구(IMO)에서 정한 관제요원(VTS Operator)의 정의와 아래 설명을 참고하시어 아래 문항(4.1 - 4.3)의 적당한 번호에 O표해 주십시요.

"관제요원(VTS Operator)이란 VTS의 제 기능을 수행하는데 적합한 자격을 가진 사람을 말한다. 또한 주관청으로부터 임무를 부여받은 경우 통항선박에게 지시와 정보(Instructions and Information)를 제공하기도 하며 자기가 수집한 Data를 어떻게 처리하고, 그 Data에 어떻게 대응할 것인지를 결정하는 사람이기도 하고, 자기가 근무하는 지역내에서의 모든 교신(communications)에 대해 직접적인 책임이 있고 그로부터 얻은 정보나 결정사항을 관련부서에 중계하는 책임이 있는 자이다."

4.1. 위와 같은 업무 및 기능을 수행하는 관제요원(VTS Operator)에게 해상경력(marine experience)이 필수적으로 요구된다고 생각하십니까 ?

55 ☐

(1) 필수적이다 (2) 반드시 해상경력이 요구되는 것은 아니다 (3) 필요없다 (4) 모르겠다

4.2. 만일 "필수적이다"라고 응답하신 경우, 어떤 종류의 해상경력이 필요하다고 생각하십니까 ?

56 ☐

(1) 항해 및 선박조종 (ship handling) (2) 통신(communication) (3) 항해, 선박조종 및 통신

(4) 기타 (.........................)

4.3. 위와 같은 업무 및 기능을 수행하는 관제요원(VTS Operator)에게 요구되는 자격은 ?

57 ☐

(1) 도선사 (2) 선장 경력 (3) 선장면허 (4) 1등항해사 면허 (5) 2등항해사 면허 6) 통신장면허

5. VTS 효과 (Effectiveness of Vessel Traffic Services)

아래의 각 문항은 한국연안에서의 해난사고를 분석한 결과, 가장 빈번하게 발생하는 사고원인들입니다. 각 항만 및 연안수역에 Level III (Advanced Radar Surveillance; 앞의 3.2.4 문항 참조)의 VTS를 설치하였다고 가정할 때, VTS의 효과에 관한 아래 물음에 대하여 적당한 번호에 O표하여 주십시오.

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5.1. <u>시정이 제한된 상태에서 선박에 대한 VTS의 지원</u>

안개, 비 또는 눈으로 인하여 시정이 제한된 상태에서, VTS센타에서는 선박의 이동상황을 레이다로 관찰추적하고 본선으로부터 요청이 있을 때, 위험상황이 예상될 때 및 필요하다고 인정될 때에는 선박교통상황정보, 위험물 또는 장이물에 관한 정보 등을 사전에 알려주는 등과 같은 서비스를 제공할 수가 있는데, 이러한 서비스의 제공이 선박의 안전항행 및 사고예방에 어느정도 효과가 있을 것으로 보시는지요 ?

의견 없음	전혀 중요하지 않다	중요하지 않다	보통이다	중요하다	아주 중요하다
0	1	2	3	4	5

58 ☐

5.2. <u>기상상태가 좋지않은 경우 선박에 대한 VTS의 지원</u>

기상상태가 좋지않은 경우(폭풍우, 저조시 또는 강조류 등), VTS센타에서는 조석이나 조류에 대한 정보의 제공, 레이다를 통한 본선위치의 관찰 및 추적, 본선으로부터 요청이 있을 때 또는 필요하다고 판단될 때 본선에 대한 지원 등과 같은 서비스를 제공할 수가 있는데, 이러한 서비스의 제공이 선박의 안전항행 및 사고예방에 어느정도 중요하다고 보시는지요 ?

의견 없음	전혀 중요하지 않다	중요하지 않다	보통이다	중요하다	아주 중요하다
0	1	2	3	4	5

59 ☐

5.3. <u>교통이 혼잡한 지역에서 통항선박에 대한 VTS의 지원</u>

교통이 혼잡한 지역에서, VTS센타에서는 통항선박에 대해 사전통항정보의 제공, 선박과의 무선교신 유지, 항법을 위반하여 항행하고 있는 선박에 관한 위험정보의 제공, 선박통항에 대한 관찰 및 감시, 기타 선박통항과 관련된 정보의 제공 등과 같은 서비스를 제공할 수가 있는데, 이러한 서비스의 제공이 선박의 안전항행과 사고예방에 어느정도 중요하다고 보시는지요 ?

의견 없음	전혀 중요하지 않다	중요하지 않다	보통이다	중요하다	아주 중요하다
0	1	2	3	4	5

60 ☐

5.4. **어선 또는 소형선박이 밀집하여 있는 지역에서의 VTS 지원**

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어선 또는 유람선 등과 같은 소형선박이 밀집되어 있는 지역에서, VTS센타에서는 이러한 소형선 밀집 상황에 대한 사전 정보를 대형선에 제공하거나, 대형선의 접근사실을 소형선에 사전에 알려주는 일, 또는 소형선군을 효과적으로 피해갈 수 있는 침로를 대형선에 알려주는 등의 서비스를 제공할 수가 있는데, 이러한 서비스의 제공이 선박의 안전항행과 사고예방에 어느정도 중요하다고 보시는지요 ?

의견 없음	전혀 중요하지 않다	중요하지 않다	보통이다	중요하다	아주 중요하다
0	1	2	3	4	5

61 [ ]

5.5. **협수로 등에서의 VTS 지원**

협수로, 천수지역, 만곡부, 교량, 또는 부유물등이 있는 지역에서, VTS센타에서는 이러한 위험상황에 대한 정보의 사전제공, 위험수역에서의 교통정보 제공, 선박의 이동상황 관찰 및 필요시 이러한 위험을 줄이기 위하여 선박교통을 조정하고 통제하는 등의 서비스를 제공할 수가 있는데, 이러한 서비스의 제공이 선박의 안전항행 및 사고예방에 어느정도 효과가 있을 것으로 보시는지요 ?

의견 없음	전혀 중요하지 않다	중요하지 않다	보통이다	중요하다	아주 중요하다
0	1	2	3	4	5

62 [ ]

5.6. **항법위반 선박 또는 결함선박이 있는 경우의 VTS 지원**

정해진 항로를 벗어나 항행하고 있는 경우, 규정된 속도를 넘어 항행하고 있는 경우, 정해진 항법(병렬항행 규지, 추월선항법 등)을 위반하여 항행하고 있는 경우 또는 예견되는 위험에 대해 아무런 조치도 취하지 않는 선박이 있는 경우에 VTS센타에서는 당해선박에 대한 위반사실의 지적 및 권고와 주변을 항행중인 다른선박에 대하여는 위반선박의 위치등에 관한 정보제공 등의 서비스를 제공할 수가 있는데, 이러한 서비스의 제공이 선박의 안전항행 및 사고예방에 어느정도 효과가 있을 것으로 보시는지요 ?

의견 없음	전혀 중요하지 않다	중요하지 않다	보통이다	중요하다	아주 중요하다
0	1	2	3	4	5

63 [ ]

5.7. **긴급상태에 있는선박에 대한 지원**

VTS센타에서는 기관고장, 화재, 타기고장, 추진기고장, 레이다고장, 통신장비고장 및 기타 응급상태에 있는 선박의 식별 및 지원, 주위를 통항하는 선박에 대해서는 이러한 고장선박을 비켜갈 수있도록 정보를 제공하는 등의 서비스를 제공할 수가 있는데, 이러한 서비스의 제공이 선박의 안전항행 및 사고예방에 어느정도 효과가 있을 것으로 보시는지요 ?

의견 없음	전혀 중요하지 않다	중요하지 않다	보통이다	중요하다	아주 중요하다
0	1	2	3	4	5

64 [ ]

5.8. <u>외국어로 인한 교신상의 어려움, 경험부족 또는 전문지식 부족으로 어려움을 겪고 있는 선박에 대한 VTS 지원</u>

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VTS센타에서는 상기의 이유로 인하여 어려움에 처해있는 선박을 조기에 식별하여 움직임을 관찰하고 주위를 항행중인 다른 선박에 대하여는 이러한 선박이 있음을 알려주며, 본선으로부터의 요청이 있을 때 이를 지원하여 주는 등의 서비스를 제공할 수가 있는데, 이러한 서비스의 제공이 선박의 안전항행 및 사고예방에 어느정도 효과가 있을 것으로 보시는지요 ?

의견 없음	전혀 중요하지 않다	중요하지 않다	보통이다	중요하다	아주 중요하다
0	1	2	3	4	5

65 □

5.9. <u>무선교신 내용 청취를 통한 지원</u>

VTS센타에서는 선박과 선박, 선박과 육상, 선박과 예선 및 선박과 도선선 간의 교신내용을 청취할 수가 있는데, 이를 통하여 교신상의 어려움이 인지될 때는 이를 중계 또는 조정할 수가 있고, 교신내용을 분석해본 바 위험이 예견될 때에는 이에 대한 교정 및 권고를 하는 등의 서비스를 제공할 수가 있는데, 이러한 서비스의 제공이 선박의 안전항행 및 사고예방에 어느정도 효과가 있을 것으로 보시는지요 ?

의견 없음	전혀 중요하지 않다	중요하지 않다	보통이다	중요하다	아주 중요하다
0	1	2	3	4	5

66 □

5.10. <u>통항선박에 대한 정보제공 서비스</u>

VTS센타에서는 관제요원(VTS Operator)이 인지한 항행상의 새로운 위험사실 (항로표지의 고장이나 이동 등, 해도나 수로서지상의 변경사항, 부유물, 등등)에 대한 정보를 주변의 통항선박에게 알려주는 등의 서비스를 제공할 수가 있는데, 이러한 서비스의 제공이 선박의 안전항행 및 사고예방에 어느정도 효과가 있을 것으로 보시는지요 ?

의견 없음	전혀 중요하지 않다	중요하지 않다	보통이다	중요하다	아주 중요하다
0	1	2	3	4	5

67 □

끝까지 설문에 응답해 주셔서 대단히 감사합니다 !!

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