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# A study for upgrading the vessel traffic services [VTS] in Korean coastal waters

Hyung-Taek Jung
*WMU*

AuPJ

**WORLD MARITIME UNIVERSITY**
Malmö, Sweden

# A STUDY FOR UPGRADING THE VESSEL TRAFFIC SERVICES IN KOREAN COASTAL WATERS

By

**JUNG HYUNG-TAEK**
**The Republic of Korea**

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1996

DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

Jung. Id. T. (Signature)

18 October 1996 (Date)

Supervised by:

Name : Captain Poul G. Jeppesen

Office: Lecturer
World Maritime University

Assessed by:

Name : Captain Fernando Pardo

Office: Professor
World Maritime University

Co-assessed by:

Name : Captain Lennart Andersson

Office: Captain / Ship Surveyor
Swedish National Maritime Administration

# ABSTRACT

Title of Dissertation: **A Study for Upgrading the Vessel Traffic Services in Korean coastal waters**

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The rapid growth of marine traffic volume in the Korean waters has created difficulties in navigation, and increased the risk in those areas during the last three decades. In addition to the traffic volume increase, ship's higher speed tendency and larger size tendency lead to more frequent and bigger casualties occurring in those areas.

Various measures have been taken to improve navigation safety in those areas such as, aids to navigation, vessel movement reporting systems, traffic separation schemes, and the radar surveillance systems in some port areas also.

However, casualties occurred in those areas has not decreased. They are still increasing. If there is no adequate device provided, those tendencies regarding the casualties are expected to be increased more in the future.

For the purpose of developing safe navigation and preventing traffic accidents in Korean coastal areas, it is needed to examine maritime environment and to analyze the casualties occurred in those areas, in order to identify the issues and problems existing in those areas.

This study used many statistical data in examining the maritime environment, analyze marine casualties, and evaluate existing traffic services in Korean coastal areas. Meanwhile, research has been carried out on the VTS concept, equipment, its future trends, and also case studies carried out on VTS status and its effectiveness has taken place in foreign countries.

Finally, on the basis of the findings in this study, it is suggested to maintain adequate VTS in Korean coastal areas to prevent accidents and to help safe navigation.

The conclusions include recommendations to extend the advanced VTS system to major ports in Korea and consolidate the VTS authority to extend their services to fully operational VTS functions.

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## ABBREVIATIONS

| | |
|---|---|
| Av.T.R. | Average Tidal Range |
| bps | Bits per Second |
| CNIS | Channel Navigation Information Service |
| COLREG | International Regulation for Preventing Collision at Sea |
| COST 301 | Cooperation in the field of Science and Technologies |
| DF | Radar Direction Finding |
| ETA | Estimated Time of Arrival |
| FDM | Frequency Division Multiplexing |
| GMDSS | Global Maritime Distress and Safety System |
| GRT | Gross Registered Tons |
| H.H.W. | Highest High Water |
| H.W.O.S.T. | High Water Ordinary Spring Tides |
| HAR | Harbour Advisory Radar |
| HCC | Harbour Coordination Center |
| IALA | International Association of Lighthouse Authority |
| ILLLTV | Intensified Low-Level-Light Television |
| IMCO | Intergovernmental Maritime Consultative Organization |
| IMO | International Maritime Organization |
| IMO MSC | IMO Maritime Safety Committee |
| KMAIA | Korea Maritime Accident Inquiry Agency |
| KMPA | Korea Maritime and Port Administration |
| KMU | Korea Maritime University |
| L.W.O.S.T. | Low Water Ordinary Spring Tides |
| LGLLLTV | Laser-Gated Low-Level-Light Television |
| LLLTV | Low-Level-Light Television |
| LORAN | Long-Range Navigation |
| M.S.L. | Mean Sea Level |
| MARAD | Maritime Safety Administration |
| MAREP | Ship Movement Reporting System for English Channel |
| MBC | Meteor-burst Communications |
| NAVSTAR | Navstar Global Positioning System |
| NNSS | Navy Navigation Satellite System |

# CHAPTER 1
# INTRODUCTION

## 1.1 BACKGROUND

Korean coastal waters have geographically many islands, reefs, and narrow straits between the coast line and islands. Traditionally there are a great number of ships concentrated in Korean coastal areas, especially in the west and south, since they are surrounded by the Chinese sub-continent and by the Japanese islands respectively. A continuous expansion of the sea trade in these areas due to the Japanese and Korean national industrialization, the recent Chinese economic growth, and the development of Korean coastal fisheries, is making the vessel traffic heavy. The increase in marine traffic often results in marine casualties with the consequence of loss of life, damage to property and marine pollution.

In addition to the above the larger size of ships and their higher speeds along with the increase in the dangerous cargoes has led to the more frequent occurrence and larger size of marine casualties when they occur in those areas.

According to the statistics published by the Korea Maritime and Port Administration (KMPA) in 1996, maritime external growth is enormous in its size. For example, ship registered tonnages has increased by 7.3 times during the last two decades ( 1.6 million tonnes in 1975, 11.6 million tonnes in 1995), and the total marine cargo traffic both in import, export and including cabotage has increased by 9 times ( 57 million tonnes per year in 1975, 533 million tonnes per year in 1995) during the same period.

On the other hand, the ratio of marine casualties ( the number of ships involved in casualties per year/ the number of ship's registered, 0.41% in 1982 and 1.11% in 1995) has not decreased. In other words, the number of marine casualties per year has increased significantly by 135.5% ( 301 cases in 1982, 709 cases occurred in 1995) during the last ten years.

The risk to shipping may be reduced by better navigational aids, ship routing, traffic separation schemes, and by shore based aids to navigation. But there is no tendency to a decrease in the marine casualties in the Korean coastal areas during the last two decades. The loss of life increased from 95 persons in 1975 to 240 persons in 1995, and marine pollution( tonnage of oil spill) increased from 490 tonnes in 1979 to 13,600 tonnes in 1995. This indicates that, relatively little research has been done in this field in Korea.

The increasing number of ship's calling at ports and increasement of the dangerous cargoes according to the seaborne trades increasement in Korean coastal areas has increased the complexity of traffic flow in approaches to ports and narrow fairways. This has led to a higher probability of marine accidents and considerable delays in shipping movements. Therefore, the cost of marine traffic and port operations has increased together with the probability of accident occurring. This situation can create the possibility of the risk to life, property and also to the environment. These problems can be overcome by means of monitoring the movement of shipping in those areas.

Furthermore, information, advice and instructions to shipping have been developed. These provide a service and interact with shipping and organize the traffic flow in order to maximize the efficiency of the ports and harbours.

This study, attempts to suggest the adequate Vessel Traffic Services (VTS) in Korean coastal areas for the purposes of minimization the loss of life at sea, not only for the enhancement of the safety and efficiency of shipping but also for the marine environment protection from oil pollution due to shipping casualties in those areas.

## 1.2 OBJECTIVES AND EXTENT OF THE STUDY

From ancient times until now there has been a continuous need for safe and accurate navigation. According to the continuous need, many of the developments have been achieved in this field. Some authorities provided aids to navigation in their waterways to assist safe navigation long ago. We can find records of some form of traffic control, and a legal system for vessel operations, that existed in the Grand Canal in China during the sixth century. Later canal systems such as the Suez and Panama Canals likewise necessitated a mandatory system for traffic movement.

However, until the Second World War it was a kind of passive traffic management technique such as the establishment of Traffic Separation Schemes, ship's speed limits, establishment of areas to be avoided in navigation, precautionary zones, recommended traffic flows, and other related routeing measures.

After the Second World War, seaborne trade increased rapidly, and a systematic vessel traffic control system started gradually to develop along with the development of radar and VHF radio communications.

In 1946, an International Meeting on Radio Aids to Marine Navigation took place dealing with the importance of radar for shore surveillance purposes as an aid to marine navigation. In 1948, in order to assist ships navigating in port, the first shore-based radar station and VHF communication network was established. By 1950, only 2 ports( Liverpool and Long Beach) had established a VTS system operating with radar. During the next 20 years, similar systems were established in many European and North American ports and harbours.

In the late 1960s and during the 1970s, several major tanker groundings and collisions occurred in various parts of the world. The resulting oil pollution from those accidents attracted public awareness due to its tremendous damage to the marine environment, and questions were asked of maritime authorities concerning what measures could be taken to reduce the risk of such accidents occurring. Some of the maritime authorities identified the need of means of vessel movement monitoring systems in sensitive areas, and expanded VTS in their major ports and harbours. It is sure that VTS had a major role to play in the overall maritime safety and pollution prevention infrastructure.

In this study, firstly the maritime environment in Korean coastal areas is assessed including topographical and meteorological features, vessel traffic data, and ship casualty status. Secondly, a case study of VTS implementation in foreign countries is studied including those who are successfully operating the VTS system with the achievement of some goals in those areas. Thirdly, the effectiveness of existing traffic services and expectations of VTS effectiveness in those areas is evaluated through the analysis of traffic data and casualty status. Finally, the most adequate VTS in those areas is suggested for the effectiveness of maritime safety and environment protection.

## 1.3 THESIS ORGANIZATION

This thesis comprises six chapters.

Chapter 2 discusses some maritime environments in Korean coastal areas. These include meteorological and topographical factors that are considered to affect marine casualties, the details and data of marine traffic including vessel statistics, vessel movements and cargo traffic, and an analysis of the trend of marine casualties in those areas.

Chapter 3 studies the concept of Vessel Traffic Service (VTS) System. This study includes the basic function of VTS, VTS equipment, operational personnel of VTS, and the future trends of VTS.

Chapter 4 researches the successful case study of VTS implementation in foreign countries.

Chapter 5 evaluates the effectiveness of existing traffic services in Korean coastal areas, summarizes the findings through the former chapters in order to identify the issues and problems.

Chapter 6, finally, making conclusions with suggestions and recommendations for the most adequate VTS in Korean coastal areas to prevent accidents and to help safe navigation.

# CHAPTER 2
# MARITIME ENVIRONMENT IN KOREAN COASTAL AREAS

## 2.1 MARITIME TOPOGRAPHY

### 2.1.1 General

The Korean peninsula is located approximately in between latitude 33° north and 43° north, and longitude 124° east and 131° east (including North Korea). It protrudes south to nearly 350 miles from the eastern seaboarder of the Asian Continent to the east side of the Yellow Sea, and it is separated from Japan by the Korean Strait and the East Sea(another name is Tonghae or Japan Sea).

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 a narrow coastal plain separating it from the spinal ridge; there are few harbours on that side and the rivers are small.

The west and south coasts of Korea are 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.

### 2.1.2 Currents and Tide

As we know currents and tidal streams have little influence on the incident of collisions between ships, but they have much influence on strandings, and contact between ships and fixed objects.

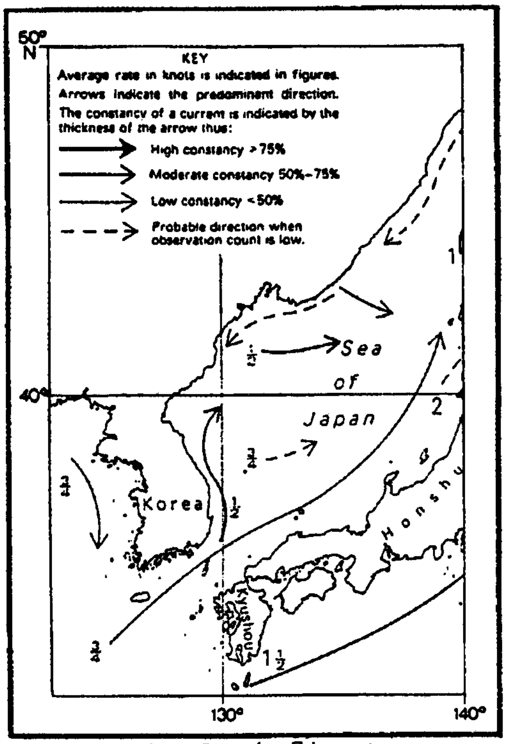
**(A) Currents**

Seasonal changes in the area are evident as illustrated in Figure 2.1. In this figure, the 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.

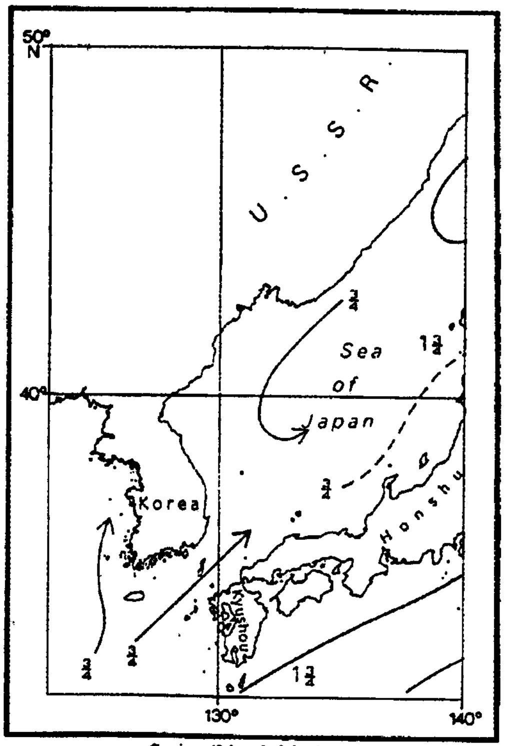
**Kuro Shio Current** : A warm current of Pacific origin flows northeast towards Kyushu and Tsushima. To the south of Cheju-do it subdivides with the weaker stream flowing to the Yellow Sea and the stronger flow turning northeast to pass either side of Tsushima into the East Sea. During the summer season water passing through the north and northwest sides of Tsushima bifurcates at the northeast end of the Korean Strait with average rates of one knot which is at a maximum. But during the winter season this current sometimes flow reversely as the Liman Current extends south and also because the flow through the Korean Strait is at a minimum at that time of the year.

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

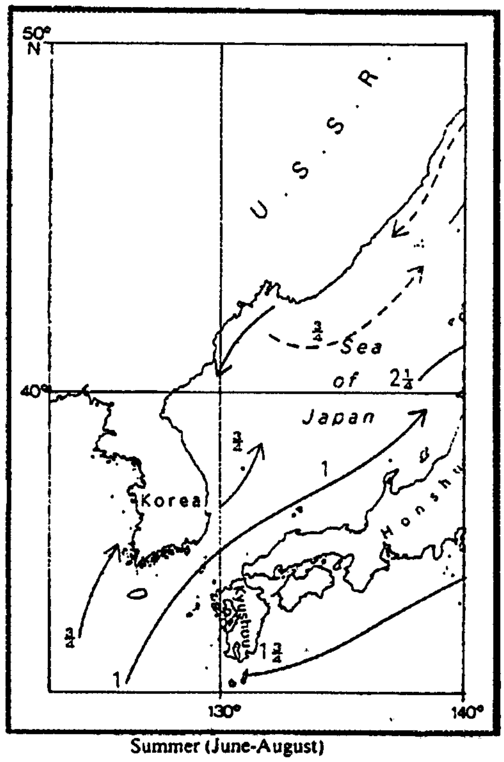
Figure 2.1 Predominant currents in Korea



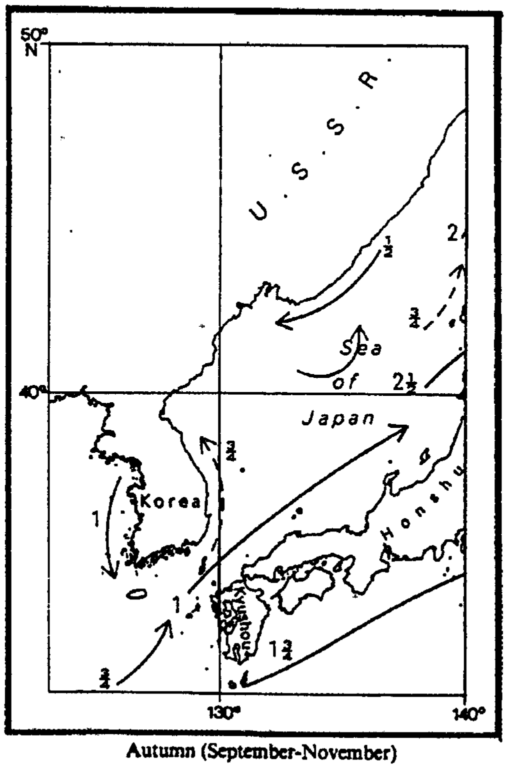
Winter (December-February)



Spring (March-May)



Summer (June-August)



Autumn (September-November)

*Source : Admiralty Coast Pilot No. 43 (1983)*

Currents within the central part of the East Sea are somewhat variable as the result of branching from both the Tsushima and Liman Current. In the winter the current most likely sets south and in the summer north, but constancy cannot be relied upon.

### (B) Tides and Tidal Streams

The range of tides on the east coast of Korea is only 0.3 meters and 1.2 meters in the southeast, but the southwest area has a 3 meter tidal range and the west coast has a range from 3 meters to 8 meters. The rising tide sets north from the Pacific Ocean into the Yellow Sea, and thence northwest into Bo Hai, by following the west coast of Korea and south coast of Liaodong Bando.

Table 2.1 shows the tidal characteristics in the major ports in Korea.

Table 2.1 Tidal features in major ports

| Port | Water Level (Cm) | | | | | Tidal Speed (m/s) | |
|---|---|---|---|---|---|---|---|
| | H.H.W. | H.W. O.S.T. | M.S.L. | L.W. O.S.T. | Av. T.R. | Flood | Ebb |
| Inchon | 927.0 | 862.4 | 463.5 | 64.6 | 527.4 | 3.30 | 2.10 |
| Kunsan | 682.0 | 624.4 | 341.0 | 57.9 | 419.2 | 1.90 | 1.70 |
| Mokpo | 467.6 | 411.9 | 233.8 | 55.7 | 269.0 | 5.10 | 8.00 |
| Yosu | 361.6 | 329.4 | 180.8 | 32.2 | 202.4 | 0.60 | 0.60 |
| Masan | 214.8 | 203.0 | 107.4 | 11.8 | 129.8 | 0.50 | 0.50 |
| Pusan | 128.2 | 122.3 | 64.1 | 5.9 | 78.8 | 0.60 | 0.80 |
| Ulsan | 60.8 | 54.5 | 30.4 | 6.3 | 32.6 | 0.75 | 1.18 |
| Pohang | 24.6 | 20.1 | 12.3 | 4.5 | 6.2 | 0.00 | 0.00 |
| Samcheog | 35.0 | 29.2 | 17.5 | 10.0 | 11.6 | 0.35 | 0.23 |
| Cheju | 283.4 | 243.1 | 141.7 | 40.3 | 142.6 | 1.40 | 1.60 |
| Soguipo | 303.2 | 242.7 | 151.6 | 50.5 | 151.4 | 0.50 | 0.70 |

*Source: Statistical Yearbook (1991), KMPA, Seoul*

In general the tidal streams have a maximum rate of one to three knots, except where local topography causes a significant increase. Along the east coast of Korea the flood stream sets southward but is generally negligible because it is a relatively deep sea and the range of the tide is low. But along the south coast of Korea, among the islands offshore and in the northern half of the Korean Strait the flood stream sets west at one to two knots, increasing to five knots between the islands.

Especially the approach to Inchon is an interesting area where streams of six knots or more are found between the islands in the vicinity.

It should be remembered that the set due to the tidal stream 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.

### 2.1.3 Coast and Ports

The length of South Korea's coastline is 5,560 Km around the peninsula and 7,229 Km around the islands, which is 12,789 Km in total. There are 27 open ports for foreign trade and 18 ports for cabotage along the coastline.

The ports on the east coast have no difficult approaches, because the coast line is not complex and there are no islands off the east coast where the water depth is deeper. But 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 on the west coast is the tidal range of approximately three to eight meters, 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 meters out to approximately 20 miles from the shore line and approximately 12 miles from the shore line on the south coast.

## 2.2 METEOROLOGICAL FEATURES

### 2.2.1 General

The Korean peninsula is affected by both marine and continental air masses. The most influential air masses are the Siberian air mass and the North Pacific Ocean air mass. Many frontal systems pass through the region, and the weather generally changes from west to east. Meteorological features in Korea can be summarized as follows;

a. The temperature range between the hottest and coldest periods of the year, and the daily highest and lowest are relatively wide.

b. Rainfall is concentrated to the summer season.

c. Sea and swell directions and heights are determined almost entirely by the circulation of the northwest monsoon in winter and the southeast monsoon in summer.

d. Fog at sea mostly occurs in April to July during the southeast monsoon period.

Some meteorological factors which may influence marine casualties are discussed in this chapter.

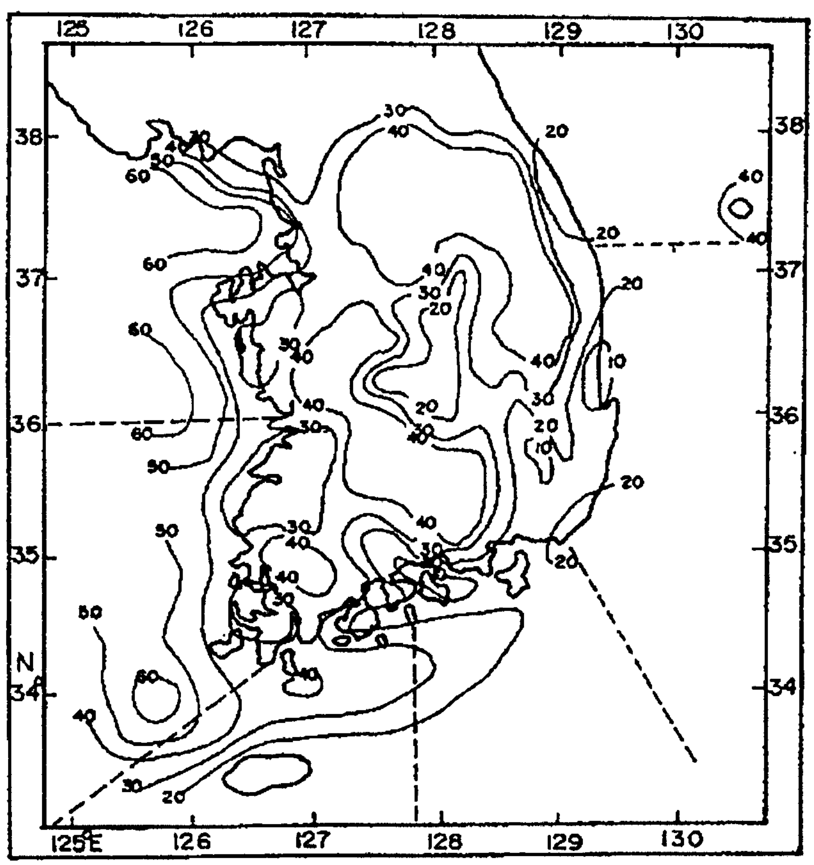
### 2.2.2 Fog and Visibility

Fog is formed by tiny water droplets held in suspension at or near the surface so as to reduce a navigator's visibility to less than 1 Km. Visibility is an important factor in relation to collisions, contacts and strandings. Collisions occur more frequently in areas where there is a high incidence of low visibility, and the fog is considered as the greatest enemy to navigators.

Bearing in mind the importance of visibility as a factor for navigation safety, some detailed analysis were carried out on the foggy days when visibility was restricted to less than 1 Km in each area. Figure 2.2 and Table 2.2 show the average number of foggy days in each area per year. As shown in the figure and table the frequency of foggy days is 40 to 50 or more days on the west coast, and 20 to 40 days on the south and southwest coasts per year.

Sea fog is rare during the months from August to March, the frequency is usually less than five percent. Most of the sea fog occurs in the months from April to July, and the peak time is in July. It also shows that 68 percent of sea fog occurs during the four months from April to July, 23 percent occurring in during July.(Fig. 2.3)

Figure 2.2 Foggy days per year (1980-1984)



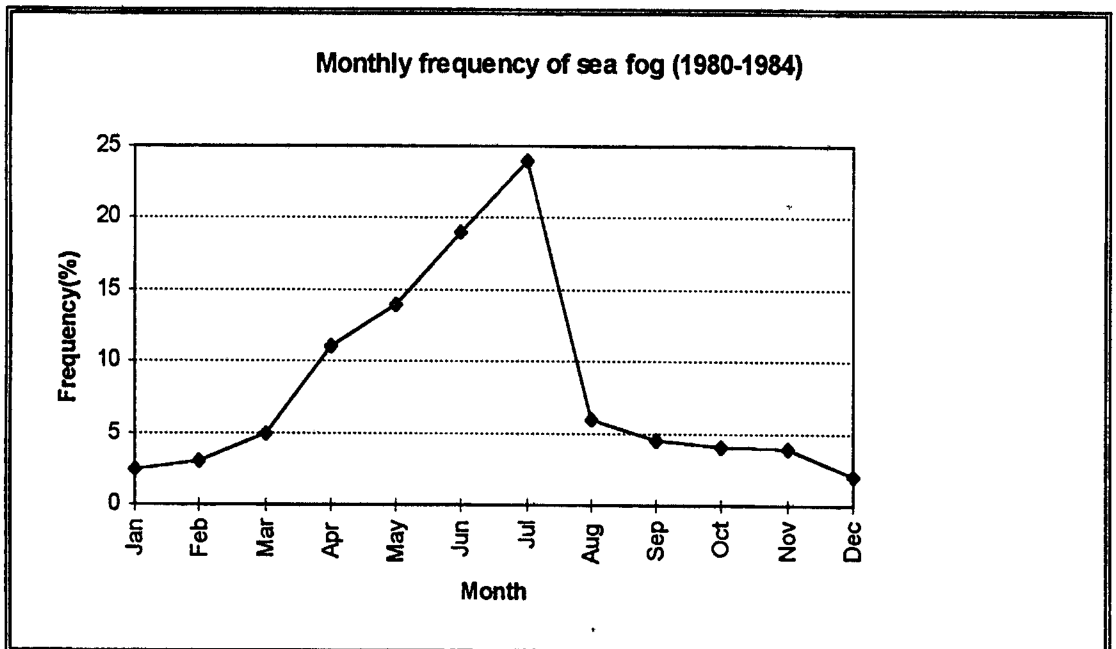

*Source: The ministry of Science and Technology(1986),Seoul*

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 | TTL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 44.0 |
| 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 | 38.0 |
| 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 | 21.2 |
| 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 | 23.4 |
| 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 | 16.7 |
| 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 | 15.6 |
| 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 | 14.2 |
| 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 | 21.6 |
| 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 | 11.3 |
| 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 | 9.3 |
| Tonghae | 0.2 | 0.3 | 0.1 | 1.4 | 1.9 | 2.2 | 3.2 | 1.6 | 0.6 | 0.5 | 0.1 | 0.0 | 12.1 |
| Average | 5.7 | 7.1 | 12.5 | 23.3 | 30.8 | 47.6 | 52.0 | 10.1 | 9.4 | 12.2 | 8.5 | 8.2 | |

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

Figure 2.3 Monthly frequency of sea fog



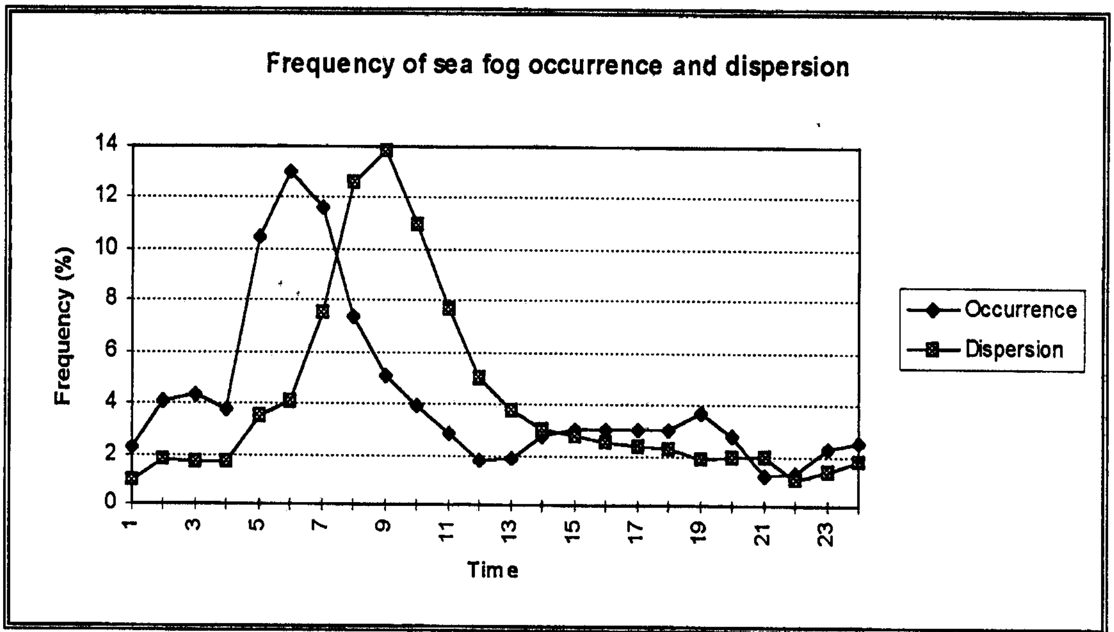

*Source: The Ministry of Science and Technology(1986),Seoul*

As shown in Fig 2.4, sea fog usually occurs between 5 and 8 o'clock in the morning and disperses before noon. The average duration time of sea fog is 4.5 hours.

On the west coast of Korea and on the Yellow Sea, dust and sand storms may occur at times. The dust and fine sand is carried by winds from the deserts in China during the spring season and sometimes visibility is reduced to a score of meters in the worst cases.

Most of the sea areas have good visibility in autumn and winter except during precipitation.

Figure 2.4 Frequency of sea fog occurrence and dispersion (1980-1984)




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

### 2.2.3 Precipitation

The main effect of precipitation in the form of rain or snow is a decrease in visibility and a interference with the radar operation preventing the detection of targets. Annual rainfall varies from 800 to 1,200 mm, but most of the rainfall is concentrated to the summer season as shown in Table 2.3. It becomes more frequent and widespread in the south than the north, and more frequent in the west than in the east in those areas. A distinctive feature of precipitation in the region is very large amounts of rainfall over a short period. Visibility is seriously reduced when the moderate rain falls in strong winds.

Table 2.3 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 |
| Seguipo | 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 |
| Tonghae | 41 | 39 | 64 | 99 | 71 | 119 | 165 | 309 | 184 | 114 | 71 | 44 | 110 |
| Average | 25 | 46 | 70 | 119 | 101 | 194 | 200 | 226 | 126 | 69 | 60 | 30 | |

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

### 2.2.4 Wind

Wind force is one important factor which may influence casualty rates, particularly in the case of strandings. The winter monsoon starts in September and continues to February or March, generally with winds from the north or northwest. The average wind force in January is five on the Beaufort Scale and there are gales on about five to ten percent of occasions in December and January.

The winds in the summer season from June to August are east or southeast with an average force of three to four on the Beaufort Scale.

The west and southwestern part of the Korean peninsula has relatively strong winds compared to the eastern part.

## 2.3 VESSEL TRAFFIC DATA

### 2.3.1 General

The Korean merchant fleet and cargo movement to and from Korean ports has been increased tremendously as a result of the recent Korean national industrialization. This status has resulted from the increase in vessel and cargo movement and is one of the most important factors in maritime environment assessment.

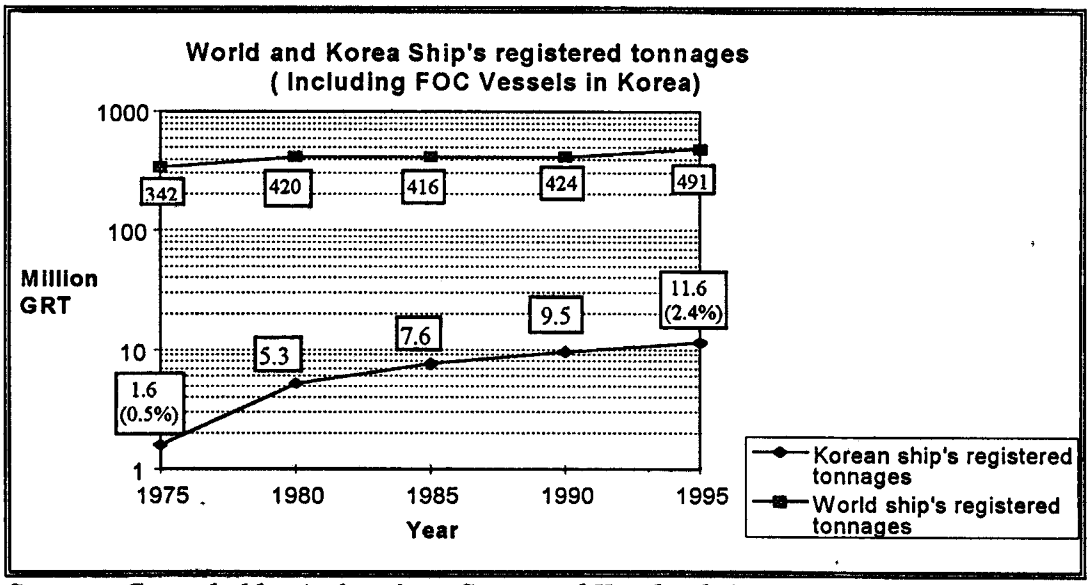
Therefore a survey and analysis on vessel tonnage and movement of ships and cargoes is given in this subchapter.

### 2.3.2 Vessel Statistics

#### (A) Vessels Registered

The vessels registered, other than fishing vessels has grown tremendously during the last two decades as shown in Fig. 2.5.

Figure 2.5 Ship's Registered Tonnages in the World and in Korea




*Source : Compiled by Author from Statistical Yearbook (1996), KMPA*

It grew rapidly up until the early 1980s, but thereafter the rate slowed down to an average rate of 4.3 percent per annum in terms of tonnage ( 2 percent per annum in number), while the world rates was 0.4 percent in terms of tonnage ( 0.8 percent in number) in the same period.

**(B) Vessels registered by tonnage group**

Table 2.4 shows the number of ships and their gross tonnage by tonnage group. The number of ships of less than 100 gross tonnes accounts for 77 percent of all registered ships, but only 1.5 percent in terms of total tonnage.

Table 2.4 Vessels registered by Tonnage

December 1995, ( GRT: 1,000 tonnes)

| Group | Passenger | | Cargo Ship | | Tanker | | Tugs | | Others | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | grt | No. | grt | No. | grt | No. | grt | No. | grt | No. | grt |
| less than 99 | 78 | 5 | 291 | 9 | 323 | 10 | 803 | 30 | 2313 | 37 | 3808 | 92 |
| 100 - 499 | 80 | 18 | 99 | 31 | 121 | 26 | 194 | 33 | 74 | 16 | 568 | 124 |
| 500 - 999 | 4 | 2 | 67 | 55 | 74 | 661 | 3 | 2 | 13 | 10 | 161 | 130 |
| 1000 - 1999 | 1 | 1 | 60 | 98 | 48 | 744 | 0 | 0 | 7 | 10 | 116 | 183 |
| 2000 - 4999 | 11 | 34 | 97 | 339 | 31 | 100 | 0 | 0 | 7 | 25 | 146 | 498 |
| 5000 - 9999 | 3 | 18 | 12 | 84 | 4 | 36 | 0 | 0 | 1 | 8 | 20 | 146 |
| 10000 - 50000 | 0 | 0 | 118 | 2797 | 4 | 92 | 0 | 0 | 2 | 35 | 124 | 2924 |
| 50000 -100000 | 0 | 0 | 16 | 1265 | 2 | 183 | 0 | 0 | 0 | 0 | 18 | 1448 |
| 100000 over | 0 | 0 | 7 | 787 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 787 |
| Total | 177 | 78 | 767 | 5466 | 607 | 582 | 1000 | 65 | 2417 | 141 | 4968 | 6332 |

*Source: Statistical Yearbook (1996), KMPA*

Until the early 1980s, it grew 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 decreased 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.

### 2.3.3 Movement of Vessels

Table 2.5 shows that total vessel movements in Korean ports are increasing continuously by 3 percent per annum in number of ships and 21.7 percent per annum in terms of gross tonnage. This means that ships calling at Korean ports are tending to be larger.

Table 2.5 Total vessel movement (arrival and departure)

(GRT : 1,000 tonnes)

| Year | Grand Total | | Oceangoing | | | | Coastal | |
|---|---|---|---|---|---|---|---|---|
| | | | Korean | | Foreign | | | |
| | No. | grt | No. | grt | No. | grt | No. | grt |
| 1981 | 193,036 | 305,344 | 27,649 | 78,541 | 12,473 | 163,113 | 152,914 | 63,690 |
| 1983 | 206,499 | 390,267 | 26,094 | 99,821 | 13,487 | 208,556 | 166,918 | 81,890 |
| 1985 | 217,043 | 453,857 | 25,008 | 115,990 | 15,411 | 243,056 | 176,624 | 94,811 |
| 1988 | 265,526 | 632,696 | 24,873 | 138,640 | 24,385 | 368,557 | 216,268 | 125,679 |
| 1990 | 281,355 | 716,329 | 24,006 | 164,387 | 30,923 | 393,040 | 226,426 | 158,902 |
| 1992 | 300,145 | 906,329 | 22,306 | 158,571 | 44,277 | 541,102 | 233,562 | 206,657 |
| 1995 | 274,676 | 1,232,936 | 23,187 | 167,021 | 61,271 | 806,187 | 190,318 | 269,728 |

*Source: Statistical Yearbook(1996),KMPA*

Table 2.6 shows the number of vessels and their gross tonnes entering ports by tonnage group. In terms of ship numbers, ships of less than 3,000 grt, including both oceangoing and coastal vessels, amount to 85.4 percent of total traffic in those areas . It can be said that coastal and small ocean going ships are the main components of the coastal traffic in Korean coastal waters.

Table 2.6 Vessel arrivals by tonnage group (1995)

( GRT : 1,000 tonnes)

| Tonnage Group | Total | | Oceangoing | | Coastal | |
|---|---|---|---|---|---|---|
| | No. | GRT | No. | GRT | No. | GRT |
| - 99 | 11,158 | 594 | 591 | 30 | 10,567 | 564 |
| 100 - 449 | 36,005 | 9,919 | 2,495 | 837 | 33,510 | 9,082 |
| 500 - 1,000 | 29,802 | 23,216 | 4,089 | 3,163 | 25,713 | 20,503 |
| 1,000 - 3,000 | 25,736 | 45,383 | 10,888 | 19,554 | 14,848 | 25,829 |
| 3,000 - 5,000 | 13,435 | 53,886 | 6,629 | 26,628 | 6,806 | 27,258 |
| 5,000 - 10,000 | 6,432 | 44,597 | 4,359 | 31,148 | 2,073 | 13,450 |
| 10,000 - 20,000 | 6,527 | 93,576 | 5,733 | 81,129 | 794 | 12,446 |
| 20,000 - 100,000 | 7,497 | 279,330 | 6,961 | 260,179 | 536 | 19,151 |
| 100,000 Over | 503 | 65,183 | 503 | 65,183 | 0 | 0 |
| Total | 137,095 | 615,684 | 42,248 | 487,851 | 94,847 | 127,833 |

*Source : Statistical Yearbook (1996), KMPA*

In addition to the above, it is necessary to consider fishing vessel activity because a considerable volume of marine traffic in Korean coastal waters consists of fishing vessels. Fishing activities depend significantly on the location of fishing grounds so it is difficult to get data on fishing vessel movement. But COST 301( Co-operation in the field of Science and Technologies) noted that:

> ' 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.'

It further stated on the general model of fishing vessel movements that:

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

Table 2.7, general statistics of registered fishing vessels, shows the Korean fishing fleet by tonnage group. It shows a slightly increased average rate of 2.7

percent per annum for the period 1980-89. The number of ships under 5 gross tonnes account for 87 percent of the total fishing fleet and the 100 tons and over category accounts for 1.4 percent only.

Table 2.7 Fishing fleet by tonnage group

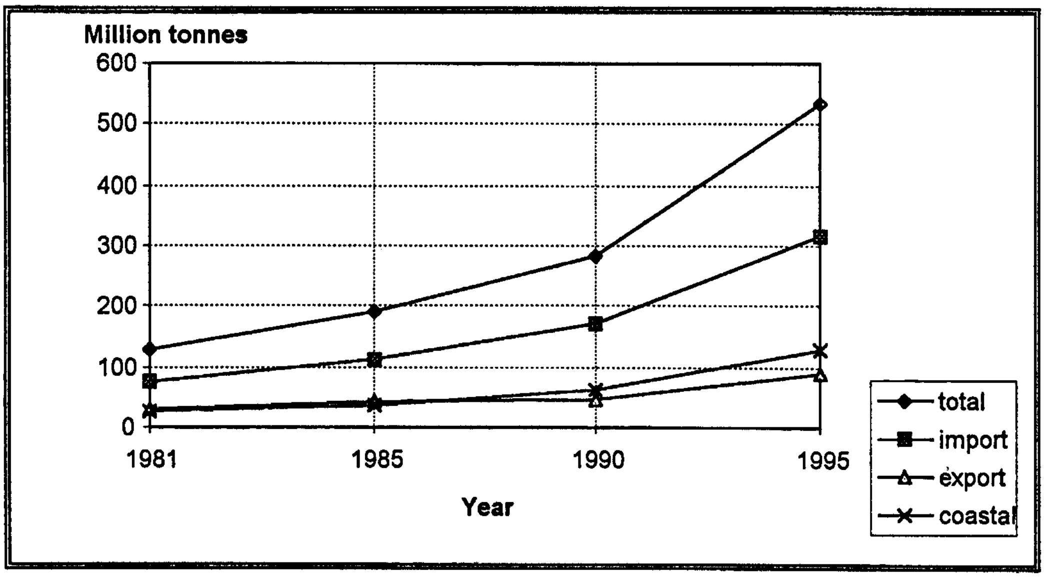
| Year | Total | under 1 ton | 1-5 ton | 5-10 ton | 10-20 ton | 20-30 ton | 30-50 ton | 50-100 ton | 100-200 ton | over 200 ton |
|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 77,574 | 23,314 | 41,839 | 3,507 | 3,040 | 817 | 1,220 | 1,805 | 450 | 582 |
| 1985 | 90,970 | 27,603 | 52,001 | 3,599 | 2,470 | 987 | 1,025 | 2,088 | 569 | 628 |
| 1989 | 98,455 | 33,440 | 52,816 | 4,314 | 2,329 | 1,026 | 1,186 | 1,953 | 618 | 773 |

*Source : Statistical Yearbook of fisheries(1985)(1990)*

### 2.3.4 Movement of Cargo

Cargo movement is an important measure of the volume of marine traffic.

Figure 2.6 Total cargo traffic in Korea




*Source: Compiled by Author from Statistical Yearbook(1996), KMPA*

Figure 2.6 shows that total cargo traffic has increased rapidly, the annual rate of total cargo movement has increased by 22.1 percent per annum, and coastal cargo traffic has increased by 29.7 percent per annum during the same period, 1981-1995. The monthly cargo movements are almost the same. This means that there are no significant seasonal variations in cargo traffic in those areas.

## 2.4 STATUS OF SHIP CASUALTIES

### 2.4.1 General

Maritime casualties can be of various types, such as, collision, stranding, ramming , foundering, fire, death and injury, machinery damage. The casualty analysis has two tasks; one is to identify the problem areas where incidents are most likely to happen, and the other is to study their causes. Anyway, in this study, the main purpose of the maritime casualty analysis is to assist in planning the casualty prevention measures ( such as VTS system) for the area by letting the planners know where and how the casualties can be prevented.

To do so, the following definitions from Lloyd's casualty information system, are used for defining a casualty in this chapter :

Collision : Striking or being struck by another vessel, regardless of whether underway, anchored or moored.

Stranding : Includes ships reported touching sea bottom, grounding, bumping over bars and entanglement on under water wrecks.

Ramming : Striking or being struck by any external substances not being another ship or the sea bottom. This includes striking dock, lock, buoy, breakwater, platforms/drilling rigs and fixed shore nets.

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

And the following criteria are used for defining waterway types in this study:

Port/Harbour : A place in the port/harbour limit.

Port approaches : The area within five miles from the port entrance.

Coastal waters : Territorial water within 12 miles off the coast line.

Sound/Passage : A place in the channel, passage, fairway and traffic lane.

### 2.4.2 Trends of Casualties

Ship casualty ratio has not been decreased but still increased.

Table 2.8 Ship casualty ratio(by the number of ship registered and ship movement)

| | Ship movements (A) | Ship registered (B) | No.of ship (C) | Ratio (C/A) % | Ratio (C/B) % |
|---|---|---|---|---|---|
| 1982 | 200,242 | 90,520 | 373 | 0.19 | 0.41 |
| 1983 | 206,499 | 92,749 | 362 | 0.18 | 0.39 |
| 1984 | 211,679 | 94,717 | 556 | 0.26 | 0.59 |
| 1985 | 217,043 | 95,144 | 503 | 0.23 | 0.53 |
| 1986 | 246,626 | 97,273 | 512 | 0.21 | 0.52 |
| 1987 | 245,669 | 98,491 | 657 | 0.27 | 0.67 |
| 1988 | 265,526 | 103,573 | 543 | 0.20 | 0.52 |
| 1989 | 273,325 | 103,065 | 586 | 0.21 | 0.57 |
| 1990 | 281,355 | 104,369 | 649 | 0.23 | 0.62 |
| 1991 | 312,916 | 108,644 | 678 | 0.22 | 0.62 |
| 1992 | 300,145 | 99,085 | 606 | 0.20 | 0.61 |
| 1993 | 232,365 | 92,464 | 678 | 0.29 | 0.73 |
| 1994 | 254,406 | 82,356 | 868 | 0.34 | 1.05 |

*Source: Statistical Yearbook(1996),KMPA and Written Verdicts(1990),(1995),KMAIA*

Table 2.8 shows that the casualty ratio by the number of ships registered increased from 0.41 % in 1982 to 1.05 % in 1994. (Casualty ratio by the number of ship's movement increased from 0.19 % to 0.34 % respectively).

The number of ships involved in casualties increased significantly from 373 ships in 1982 to 868 ships in 1994.

If nothing changes in the future, we may predict that the casualty ratio will not decrease but will increase continuously according to the traffic volume increase in those areas which were studied in the earlier Subchapter 2.3.

### 2.4.3 Casualties Analysis

#### (A) Type of Casualties

Table 2.9 summarizes the number of casualties by type of casualty. It should be remembered that the so-called traffic accidents, such as collisions, rammings, and strandings are accounting for 36.2 percent of the total casualties. This is followed by machinery damage which accounts for 27 percent of total casualties. Among the so-called traffic accidents, collisions and rammings account for almost two thirds.

Table 2.9 Number of casualties by accident type ( Unit : Case)

| Casualty Type | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | Total | Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Collision(incl. Ramming) | 99 | 133 | 93 | 108 | 132 | 120 | 123 | 131 | 178 | 1,117 | 24.0 |
| Stranding | 71 | 92 | 56 | 51 | 56 | 63 | 53 | 49 | 78 | 569 | 12.2 |
| Foundering | 56 | 70 | 57 | 61 | 47 | 76 | 73 | 64 | 92 | 596 | 12.8 |
| Machinery Damage | 96 | 125 | 141 | 159 | 160 | 157 | 116 | 144 | 160 | 1,258 | 27.0 |
| Fire | 23 | 21 | 26 | 37 | 39 | 35 | 46 | 41 | 59 | 327 | 7.0 |
| Death & Injury | 17 | 11 | 12 | 11 | 13 | 10 | 3 | 10 | 5 | 92 | 2.0 |
| Others | 67 | 81 | 53 | 52 | 68 | 94 | 62 | 90 | 127 | 694 | 14.9 |
| Total | 429 | 533 | 438 | 479 | 515 | 555 | 476 | 529 | 699 | 4,653 | 100% |

*Source: Written Verdicts (1990), (1995), KMAIA*

**(B) Type of vessel involved in casualties**

The number of ships involved in casualties by the type of vessel can be found in Table 2.10. The table shows that fishing vessels account for 63.4 percent of the total number of ships involved in casualties and cargo ships account for 16.3 percent, while tankers, tugs, and passenger/ferries account for between 3 and 6 percent of it.

Table 2.10 Type of vessel involved in casualties

( Unit : Ship )

| Ship Type | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | Total | Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Passenger ship | 23 | 28 | 11 | 16 | 20 | 24 | 16 | 18 | 25 | 181 | 3.1 |
| Cargo ship | 98 | 118 | 81 | 103 | 113 | 107 | 107 | 93 | 123 | 943 | 16.3 |
| Tanker | 24 | 30 | 29 | 23 | 46 | 52 | 32 | 39 | 50 | 325 | 5.6 |
| Fishing vessel | 296 | 378 | 357 | 405 | 397 | 419 | 379 | 444 | 580 | 3,655 | 63.4 |
| Tugs | 16 | 31 | 24 | 17 | 31 | 29 | 28 | 40 | 37 | 253 | 4.4 |
| Others | 56 | 72 | 41 | 22 | 42 | 47 | 44 | 44 | 53 | 421 | 7.2 |
| Total | 513 | 657 | 543 | 586 | 649 | 678 | 606 | 678 | 868 | 5,778 | 100% |

*Source: Written Verdicts (1990),(1995), KMAIA*

**(C) Ship tonnage group in casualties**

Table 2.11 shows that ships of less than 100 gross tonnes account for 59.7 percent of the total casualties. Ships between 100 and 500 gross tonnes account for 15.9 percent, so three quarters of the casualties occur in ships of less than 500 gross tonnes.

Table 2.11 Ships tonnage group involved in casualties ( Unit : Ship)

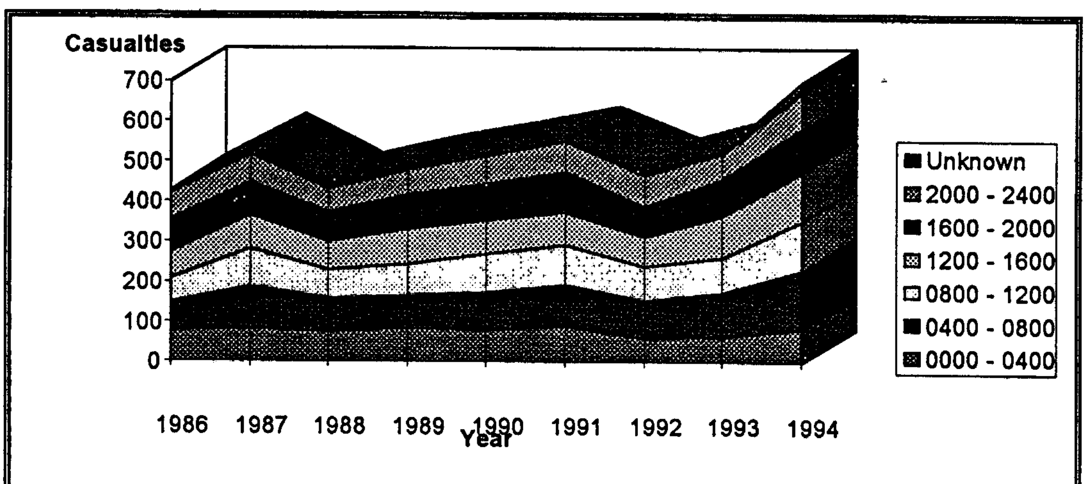
| Ship's Tonnage | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | Total | Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Less than 20 | 116 | 160 | 129 | 147 | 150 | 170 | 142 | 199 | 253 | 1,466 | 25.4 |
| 20 - 100 | 148 | 197 | 209 | 212 | 219 | 238 | 219 | 229 | 308 | 1,979 | 34.3 |
| 100 - 500 | 91 | 111 | 79 | 93 | 110 | 99 | 108 | 108 | 122 | 921 | 15.9 |
| 500 - 1,000 | 29 | 33 | 37 | 30 | 39 | 54 | 32 | 31 | 39 | 324 | 5.6 |
| 1,000 - 5,000 | 38 | 60 | 38 | 43 | 61 | 57 | 47 | 54 | 71 | 469 | 8.1 |
| 5,000 - 10,000 | 6 | 12 | 2 | 6 | 9 | 5 | 10 | 4 | 6 | 60 | 1 |
| 10,000 and over | 20 | 33 | 23 | 17 | 25 | 21 | 21 | 21 | 32 | 213 | 3.7 |
| Unknown | 65 | 51 | 26 | 38 | 36 | 34 | 27 | 32 | 37 | 346 | 6 |
| Total | 513 | 657 | 543 | 586 | 649 | 678 | 606 | 678 | 868 | 5,778 | 100% |

*Source: Written Verdicts (1990),(1995), KMAIA*

**(D) Number of casualties in different time band**

Figure 2.7 presents the number of casualties in time bands. There is no significant difference of casualty occurrence between the different time bands, but 0400-0800 hours and 0800-1200 hours are slightly higher than the other time bands, and 2000-2400 hours is less than the other time bands.

Figure 2.7 Number of casualties in different time band




*Source: Compiled by Author from Written Verdicts (1990),(1995), KMAIA*

### (E) Number of casualties in different waterway types

Table 2.12 shows that almost three quarters of all casualties occur in territorial waters ( within 12 miles off the coast) where shore-based navigational aids may be available.

Table 2.12 Number of casualties by waterway type

| Waterway type | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | Total | Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Confined waters | 179 | 294 | 122 | 98 | 216 | 175 | 114 | 127 | 183 | 1,508 | 32.4 % |
| Territorial waters | 164 | 128 | 170 | 211 | 248 | 244 | 233 | 288 | 339 | 2,025 | 43.5 % |
| Open Sea | 86 | 111 | 146 | 170 | 51 | 136 | 129 | 114 | 177 | 1,120 | 24.1 % |
| Total | 429 | 533 | 438 | 479 | 515 | 555 | 476 | 529 | 699 | 4,653 | 100 % |

*Source: Written Verdicts (1990),(1995), KMAIA*

### (F) Seasonal(monthly) and local distribution of casualties

For the purpose of this study, the data regarding so-called traffic accidents are needed more than any other casualties.

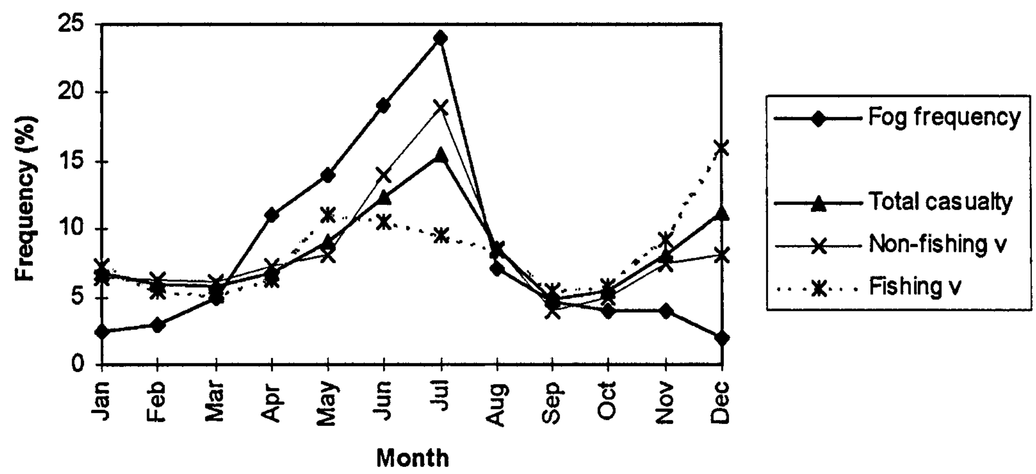
An interesting study was carried out through a survey on the marine safety and VTS in Korean coastal waters by J.S.Park ( professor in Korea Maritime University) in 1993. The sample casualties were selected in terms of random sample from all of the collisions, groundings, rammings and foundering accidents, so-called traffic accidents, which have taken place in Korean coastal waters during the period of 1986-1990. 381 sample casualties were chosen as shown in Table 2.13, and analyzed. Monthly distribution of these casualties is shown in Figure 2.8. It clearly indicates the seasonal variations. The curve of non-fishing vessels in Figure 2.8, is much similar with the curve of monthly frequency of sea fog as shown in Figure 2.8. This may well be linked to a certain low visibility due to the existence of fog during June and July.

Table 2.13 Cross-table of waterways type and casualty type

| Type of waterway | Type of casualty | | | | Raw Total |
|---|---|---|---|---|---|
| | Collision | Stranding | Ramming | Foundering | |
| Confined waters | 110 60.4% 45.5% | 47 25.8% 58.0% | 18 9.9% 78.3% | 7 3.9% 20.0% | 182 100% 47.8% |
| Coastal waters | 101 64.7% 41.7% | 34 21.8% 42.0% | 5 3.2% 21.7% | 16 10.3% 45.7% | 156 100% 40.9% |
| Open sea | 31 72.1% 12.8% | | | 12 27.9% 34.3% | 43 100% 11.3% |
| Total | 242 63.5% 100% | 81 21.3% 100% | 23 6.0% 100% | 35 9.2% 100% | 381 100% 100% |

*Source: J.S.Park(1994),Marine traffic engineering in Koran coastal waters*

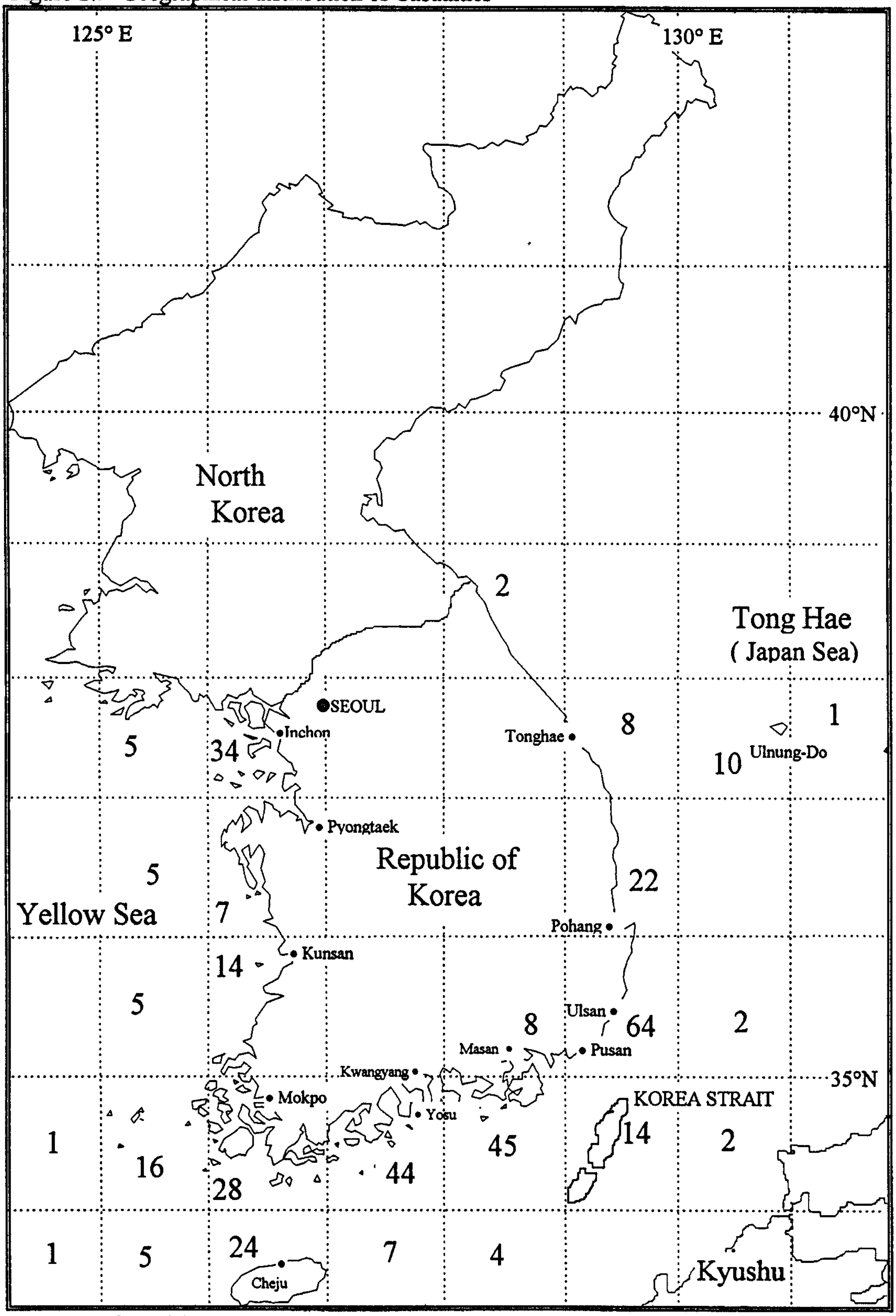
Figure 2.8 Monthly distribution of casualties and Fog frequency




*Source: Author compiled from Marine traffic engineering in Korean coastal waters(1994)*

And, Figure 2.9 shows the geographical distribution of casualties in one degree of latitude and longitude squares. The highest number of casualties occurred in Pusan/ Ulsan area, and the south coastal area had a higher number of casualties than the east and west coastal areas. The other identified areas with high casualties are the Inchon and Mokpo areas.

Figure 2.9 Geographical distribution of Casualties




*Source : J.S.Park(1994),Marine traffic engineering in Korean coastal waters*

# CHAPTER 3

# CONCEPT OF VESSEL TRAFFIC SERVICE SYSTEM

## 3.1 GENERAL

Ever since ships were originated by men and used as a means of transportation for goods and people, much has progressed in the field often referred to as the 'shipping industry' according to the needs of local, and international trade. Furthermore, after the steamship's appearance, distances of world trade have been shortened at an astonishing pace, and accordingly interaction among nations has been increasing rapidly. The world has become smaller and closer. And sea transportation has a great strength in its cost effectiveness compared with any other transportation means.

In this regard, nowadays most international trade is done by seaborne trade. It is no exaggeration to say that the progression from a world of isolated communities to today's integrated global community was made possible by shipping and sea trade.

On the other hand, in contrast with the above affirmative features, there have been shipping accidents occurring constantly, ranging from mere superficial damage to a total loss of the vessel including all the crew and passengers.

Since the Titanic disaster until now, there has been some enormous strides forward to improve maritime safety. Much has progressed in ship design and construction as a result of more knowledge about art, science and technology, and also shipboard navigational aids. Furthermore, the usual upward trend of general progress has been helped for maritime safety; such as the role enhancement of the MARAD ( Maritime Administration, including Maritime Safety Administration) in each national government, institutional developments like the growth of the classification societies, and enforcement of the international maritime safety standards by the International Maritime Organization (IMO).

Generally shipping has become a much less dangerous business compared with a century ago. But, in spite of the above mentioned progress and development, the enormous increase in traffic flows according to the rapid overall growth of world trade and fishing activity has led to catastrophic disasters once they have occurred. Maritime casualties are still occurring constantly. And so-called traffic accidents, such as collisions, rammings, and stranding accidents are generally much concentrated to the near shore where the ports and harbours are located. Among the ship casualties, especially oil pollution from ships near shore such as loaded oil tankers arouse public awareness of the devastating damage to a local marine environment that can occur.

In this connection, some maritime authorities identified the need of certain active and integrated countermeasures, the vessel movement monitoring systems in sensitive areas, to prevent ship casualties in near shore and concentrated vessel traffic areas.

VTS is a relatively recent additional marine navigational aid. It was originally applied to port approaches and provided shore-based navigational information to ships in the restricted approaches to ports and harbours.

Since the advent of radar and VHF radio, when the world's first harbour surveillance system was established in the port of Liverpool in 1948 with VHF radio communication equipment, VTS has developed considerably. Currently more than 500 VTS services in various forms are operational throughout the world and it is expanding more and more. 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 centers exist.

### 3.2 DEFINITION OF VTS

In many VTS areas a number of safety measures are taken in addition to the VTS. These measures include:

- Traffic separation schemes
- Prohibited area to navigation and precautionary zones
- Aids to navigation, such as lights, buoys, fog signals, radio and radar beacons, ranges
- Regulations for speed limits

Compared with the above listed measures, the so-called passive traffic management/ control technique, VTS can be called an active traffic management/control technique.

In IMO Resolution A 578(14), Guidelines for Vessel Traffic Services, VTS is defined as:

> ' 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 '

Furthermore, the COST 301 characterized the VTS as follows during their work to assess any potential benefits which VTS could bring to the safety and efficiency of traffic, and the reduction of pollution risk in European waters;

> ' any service, implemented by a competent authority, which interacts directly with the traffic and in response to that traffic in real time in order to improve safety and efficiency of traffic and to preserve the integrity of the environment.'

## 3.3 FUNCTION OF VTS

As defined in the definition, VTS is a kind of active vessel traffic management technique. To provide an active role in vessel traffic management, four basic functions are performed.

The first function is collecting data on the vessels in harbour or waterways, such as vessel position, speed, size, destination, and cargo.

The second function is processing the required information to provide the total picture of vessel traffic in the area.

The third function is displaying the information in a coherent visual form that lends itself to rapid assimilation by those with the need to know.

The fourth function is distributing the information to vessels in the area so that they can use it to navigate safely.

These functions can be categorized into two. One is physical function and the other is operational function. Information collecting, processing, and displaying functions are physical (internal), and distributing is operational (external).

### 3.3.1 Physical functions

The physical functions are implemented by a combination of personnel, hardware, software and procedures, under the direction of human VTS operators. Such operators use various technical options.
These include:

- Acquiring information to provide a global or overall picture of the traffic situation in the area
- Evaluating and Processing the information acquired
- Making a decision and distributing it in the form of services to ships or any others who demand

The options for acquisition of information may require some co-operation on the part of the ship in case of using VHF voice communications, VHF Direction Finding(DF) and transponders. But radar, visual optro-electronics are essentially not needed co-operation on the part of the ship.

### 3.3.2 Operational functions

Operational functions are related to the services provided by VTS. VTS interacts with traffic by implementing one or more of a number of external functions, The essential functions of VTS can be described as:

- General Information Service
- Navigation assistance
- Traffic organization
- Pollution monitoring
- Search and Rescue (SAR)
- Remote medical assistance (Relaying information)

## 3.4 VTS EQUIPMENT AND TECHNOLOGIES

Equipment used to perform the four basic functions varies from VTS system to system, but several elements are common to most of the sites. Collecting data/ information is performed by shore-based radar, Low-Level-Light Television(LLLTV), and VHF communications between the Control Center and the vessels. Processing of the data/information is handled manually, with the aid of a computer, or by a combination of both. Displaying the data/information is usually done by the plan position indicator(PPI) of the radar system or by use of a manual plotting board.

Distributing data/information is typically done by communications, but distribution by television broadcasts is possible as well as linked radar systems.

### 3.4.1 Collecting the information

Collecting the navigation and safety information in the VTS area is done by radio, microwave, cable, coaxial cable, fiber optics, satellite, meteor-burst communications, and Global Maritime Distress and Safety System(GMDSS). VHF radio is generally used by the VTS operator to collect information from the vessels in voice. Microwave and some dedicated circuits are presently used to transfer video, radar, and voice signals from remote sites to the Vessel Traffic Center (VTC).

One method of reducing dependence on voice radio communication is automatic collection of radionavigation or satellite navigation information from vessels. This process requires a radionavigation or satellite navigation receiver on the vessel, a data link between the vessel and the VTC, and the necessary interfaces and control mechanism at the VTC.

The position information is transferred from the radionavigation or satellite navigation receiver's data port to the vessel processor and through the modem to the radio transmitter. The information is received by the VTC receiver and transferred through the modem to the VTC processor where it is manipulated with other sensor information. This concept of collecting data is using a meteor-burst communication system.

The other methods are Digital Selective Calling(SELCAL) system and Simplex Teletype Over Radio(SITOR) system. In the SELCAL system the VTC SELCAL receiver will ignore all transmissions except those properly coded.

In the SITOR system the mariners could generate teletype messages to alert the VTC of their anticipated arrival and to provide pertinent information, such as ships name, location, estimated arrival or departure time, speed, course, and final destination.

### 3.4.2 Processing the information

Processing the information is performed manually by the operator or automatically by a computer processor. Each source of information requires a unique interface to properly transfer the information into the computer. A computer with multiple interfaces can be used to accept and process the information from several sources to establish accurate positioning information, although the software needed is complex.

The computers within the receivers can process the information from DECCA, LORAN, OMEGA, and satellite navigation systems to provide the most accurate and complete information at any given instant.

### 3.4.3 Displaying the information

Displaying the information is performed by the Plan Position Indicator (PPI) of a radar system or by an electronic chart that presents the output of a computer. The PPI displays the radar information only, but the electronic chart displays all information accepted and processed by the computer.

Digital image processing techniques can be used to enhance the visual images provided by cameras and infrared sensors. Video compression can reduce the bandwidth requirements for video transmission. And as a partial alternative to video compression, radar scan conversion is a useful method of converting raw radar data into raster-scan video suitable for display on a standard television monitor.

### 3.4.4 Distributing the information

The primary method for distributing processed information to a vessel is VHF voice radio. However, this needs a large amount of VTS operator's time. There are several methods of reducing the voice radio communication for distributing information, such as VHF Radio Broadcast, Television Broadcast, NAVTEX Broadcast, and GMDSS.

A combination of these various options can result in the most operational sound for performing the distribution function.

### 3.4.5 Each piece of equipment's profile

#### (A) Communication and Transmission

**VHF Radio :**

Radio is a communication system that uses the atmosphere as the transmission medium and electronic devices, called transmitters and receivers, to generate and detect electromagnetic signals that carry intelligent information.

Among radios, VHF radio is used by VTS to communicate with shipboard personnel for the purpose of collecting and distributing information. VHF transmission systems in VTS use frequencies between 155 and 162 MHz since they are allocated for the maritime radio channels.

VHF communication is an extremely cost-effective means of collecting navigation and safety information not available from other sensors. Currently, it is the only means of distributing the processed information to mariners.

**Terrestrial Microwave :**

Terrestrial microwave systems operate in the upper region of the radio frequency spectrum to provide wide bandwidth capacity for transmission of analog and data information. They are available by operating in the upper ultra high frequency(UHF) and super high frequency(SHF) bands, wide bandwidths of 5 MHz or greater.

Microwaves connect the remote radar, camera, and voice communication facilities to the VTC and provides the watchstander with the data needed for VTS operation. With the proper equipment arrangements, one medium-capacity digital microwave link could transmit radar, camera, and radio signals from a combined site.

Microwave links currently provides reliable and cost-effective transmission of VTS data and will continue to do so in the future.

**Telephone company-provided facilities :**

The most common telephone company-provided facilities are voice-grade circuits, digital data service, T1 circuits ( a digital circuit that operates at 1.544 M bps), and wideband facilities. The different types of services are normally provided by one integrated communication network. The network consists of many individual transmission links, using copper cable, microwave radio, coaxial cable, and satellite links. Various types of frequency division multiplexing(FDM) and time division multiplexing(TDM) equipment are used to maximize the capacity of each transmission link.

**Fiber optics :**

A fiber-optic transmission system propagates visible light energy through a very small diameter glass fiber to communicate information between locations. Fiber-optic systems usually operate at wavelengths of 0.6 to 1.6 micro-meters or microns. A basic fiber-optic transmission link includes an optical source, glass fiber transmission medium, and optical detector. The optical source converts electrical information signals to optical energy and couples the energy into the glass fiber. The optical detector reconverts the optical energy to electrical signals.

Fiber optic's strengths are a large data-carrying capacity, long repeater spacing, immunity to radio frequency interference, and nonconductivity to electrical power.

**Meteor-burst communications :**

Meteor-burst communications (MBC) is a method of intermittent communications in the lower VHF band, which is possible due to ionization trails created 85 to 115 km above the Earth's surface by the billions of meteors that enter the atmosphere daily. Meteors of sufficient size result in ionized trails that reradiate or reflect, depending on electron density, radio signals back toward the Earth's surface.

MBC could be used to extract long-range navigation (LORAN) or satellite navigation information from vessels, and also to activate "canned" VHF radio messages at harbour entrances or at narrow or severe curve points in the waterways.

If MBC were used to automatically extract navigation information, much of the time that the watchstander spends communicating with the vessels would be eliminated.

**Satellite communication :**

Satellite communication systems operate on the same principle as the terrestrial microwave systems. The major difference is that the satellite contains a radio frequency repeater or transponder that dramatically extends the link distance. Generally Satellite Communication systems demand higher costs. But Very Small Aperture Terminals (VSAT) are useful for VTS. VSAT's strengths are low cost, unlimited transmission distance, portability, and easy installation.

## (B) Closed Circuit Television

### Low-Level-Light Television :

Every TV camera contains a pickup element that converts light from a scene into an electrical signal. This pickup device, in all but the newest cameras, is known as a vidicon. It contains a light-sensitive surface that is scanned by an electron beam. This Low-Level-Light Television(LLLTV) system is fit for television surveillance in a wide range of light conditions.

There are more improved ones in LLLTV systems, Intensified LLLTV (ILLLTV) and Laser-Gated LLLTV (LGLLLTV). ILLLTV's reduced blooming and increased light sensitivity are an advantage for VTS locations with extensive night operations. ILLLTV will help the watchstander identify targets during night operations. LGLLLTV is a recent development in low-level-light cameras, using a laser pulse in coordination with the "gating on" of the TV camera. LGLLLTV enhances camera performance in fog or other conditions of reduced visibility.

### Digital Image Processing :

Digital image processing is the analysis and manipulation of visual information by a digital computer, converting the information from analog to digital format. The performance characteristics of digital image processing are similar to those of the camera, computer, and monitor that comprises the system. Digital image processing helps the human eye extract as much information as possible from a visual image, and could assist the watchstander in the analysis and interpretation of video images provided by camera or radar systems.

### Video Compression :

Video compression is the technology of reducing the communication bandwidth required to transmit a video signal between two locations. Possibly one low-capacity digital microwave radio could replace the pair of analog microwave radios required for a remote site having both cameras and radar.

### (C) Radar

**Radar :**

Radar (Radio Detection and Ranging) is an equipment using electromagnetic devices to determine the range and bearing to distant objects. Radars operate from the upper end of the ultra high frequency (UHF) spectrum to the infrared spectrum. Radar system components are the antenna, transmitter, receiver, modulator, power supply, and indicator. Radars can be classified from L-band Radar to Laser Radar by the frequency band which is used by them. Table 3.1 shows each radar band's frequency.

Table 3.1 Comparison of Radar Bands and Standard Frequency Bands

| Radar Band Designator | Radar Frequency | Standard Frequency | Standard Band Designator |
|---|---|---|---|
| L Band | 1 GHz - 2 GHz | | |
| S Band | 2 GHz - 4 GHz | 3 GHz - 30 GHz | SHF |
| C Band | 4 GHz - 8 GHz | | |
| X Band | 8 GHz - 12 GHz | | |
| Ku Band | 12 GHz - 18 GHz | | |
| K Band | 18 GHz - 27 GHz | | |
| Ka Band | 27 GHz - 40 GHz | 30 GHz - 300 GHz | EHF |
| mm Band | 40 GHz - 300 GHz | | |
| Laser Band | Above 300 GHz | 300 GHz - 300,000 GHz | Infrared |

*Source: Vessel Traffic Services Equipment and Technology Report(1987),RJO*

L-Band radar is limited to use on aircraft models. It is not viable for the VTS system due to the high sea clutter effects. Usually S-Band radar and X-Band radar are used in VTS, the X-Band for clear weather and the S-Band for rain and sea clutter conditions. The S-Band has strength of good performance in rain and heavy sea conditions, and X-band has strength in its accuracy.

The C-band radar is between S-Band and X-Band in its capability. From Ku-Band to Laser Radars all have high accuracy but poor performances in rain and/or similar conditions. X-band radar systems are the most common of any commercial marine radars and also for the VTS systems.

**Radar Beacons:**

Radar beacons are transmitters, operating in or near marine radar bands, that produce distinct indications on the radar displays of vessels within range of their signals. Radar beacons could assist the watchstander by accurately locating navigation aids and major obstacles. Radar beacons, if they were placed properly, could help VTS with clearly defined reference points, such as bridges, navigation aids, and other permanent or temporary obstacles.

**Radar Scan Conversion :**

Radar scan conversion processes raw video from the radar receiver into raster-scan video suitable for display on a standard TV monitor. Using a radar scan converter to display radar for VTS has some advantages;

- Scan-converted radar video can be mixed with electronic chart graphics for integrated display.
- Scan-converted radar/electronic chart graphics video is directly compatible with a VCR and can be recorded.

**Radar Direction Finding :**

Radar direction finding (DF) is conceptually similar to radio direction finding. Radar DF uses two or more land-based radar receivers to detect radar pulses emitted from shipboard radar transmitters. The land-based receivers, using directional antennas, determine the bearing to the pulse transmitting source, and the intersection of two or more bearings from the land-based systems identify potential target locations. It is not useful for the high traffic density environment of VTS.

### (D) Aids to navigation

Aids to navigation are manmade structures or systems to help mariners navigate safely. They include conventional aids such as Lights, Buoys, Day Beacons, Fog Signals, and radionavigation/electronic systems such as Long-Range Navigation (LORAN), Omega Navigation system, Decca Navigation system, Radio Direction Finding, Radio Beacons.

Conventional aids to navigation do not directly assist the VTS in fulfilling the vessel tracking function. However, the aids contribute to the overall safe operation of the waterway. VTS must be aware of the condition and location of all conventional aids to navigation in its area for the safety of waterways.

Radionavigation uses the radio frequency spectrum for navigation and positioning. Some of the radionavigation systems are applicable to the VTS system as a supplement radar or position-locating system.

Also satellite navigation and positioning systems such as Navy Navigation Satellite System (NNSS), Navstar Global Positioning System (NAVSTAR) would be able to replace or supplement a radar system.

### (E) Other Systems

There are many other systems which collect, process, and display information such as Laser Ranging, Infrared Sensing and Imaging, Acoustic Sensing, and Pressure Sensing. Each of them has advantages and disadvantages in its capabilities. Figure 3.1 shows the various pieces of equipment and technologies relative to applicability to VTS, accuracy, useful availability, ease of integration, mariner acceptance, and overall usefulness including cost effectiveness.

Figure 3.1 Equipment and Technologies Matrix

| Evaluation Criteria | Collecting: Detecting and Identifying | | | | | | | | | Collecting: Communicating | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Radar | LLLTV | VHF Radio | Radio Navigation | Satellite Navigation | Laser Sensing | Infrared Sensing | Acoustics/Sonar | Pressure Sensing | GMDSS | Microwave | Cable (Telco) | Coax | Fiber Optics | Satellite Communications | Meteor Burst | Miscellaneous Systems |
| Applicability to VTS | 5 | 5 | 5 | 3 | 3 | 2 | 3 | 2 | 1 | 3 | 5 | 4 | 3 | 2 | 2 | 3 | 1 |
| Accuracy/Quality | 4 | 3 | 4 | 3 | 5 | 5 | 3 | 3 | 2 | N | 5 | 3 | 4 | 5 | 4 | 3 | 2 |
| Cost Effectiveness | 5 | 5 | 4 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 4 | 2 | 2 | 2 | 3 | 2 |
| Useful Availability | 5 | 5 | 5 | 3 | 2 | 3 | 4 | 4 | 2 | 2 | 5 | 4 | 3 | 3 | 4 | 3 | 2 |
| Ease of Integration | 4 | 2 | 4 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 2 |
| Mariner Acceptance | N | N | 5 | 5 | 2 | N | N | N | N | 2 | N | N | N | N | N | N | N |
| Overall Usefulness | 5 | 5 | 5 | 3 | 3 | 2 | 3 | 2 | 1 | 3 | 5 | 4 | 2 | 2 | 2 | 3 | 1 |

| Evaluation Criteria | Processing & Displaying | | | | | | Distributing | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Computers | Digital Image Processor | Video Compression | Target Tracking | Electronic Charts | Radar Scan Conversion | VHF Radio | VHF Broadcast | Television Broadcast | NAVTEX | GMDSS |
| Applicability to VTS | 5 | 2 | 2 | 5 | 5 | 5 | 5 | 4 | 3 | 3 | 3 |
| Accuracy/Quality | 5 | 3 | 3 | 4 | 5 | 3 | 4 | 4 | 4 | 2 | 3 |
| Cost Effectiveness | 4 | 3 | 1 | 3 | 4 | 3 | 4 | 5 | 3 | 2 | 3 |
| Useful Availability | 5 | 3 | 3 | 4 | 4 | 4 | 5 | 4 | 3 | 2 | 3 |
| Ease of Integration | 3 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 3 | 2 | 3 |
| Mariner Acceptance | N | N | N | N | N | N | 5 | 4 | 3 | 2 | 3 |
| Overall Usefulness | 5 | 2 | 3 | 5 | 5 | 5 | 5 | 5 | 3 | 3 | 3 |

Note : Each piece of equipment and technology is rated from 1 to 5, with 5 being the highest rating and 1, the lowest

*Source : Vessel traffic services equipment and technology report(1987),RJO*

## 3.5 VTS OPERATIONAL PERSONNEL

### 3.5.1 VTS operator functions

In order to achieve the safe and efficient movement of maritime traffic, including environment protection, in VTS areas, VTS operators play an important role. It is difficult to accomplish their task without a certain quality and specialty. Guidelines for VTS, IMO Resolution A. 578 (14), states that:

> "The VTS authority should ensure that VTS operators have the qualification 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."

In spite of these guidelines, there is little common ground in the qualifications and training requirements for VTS operators worldwide or within national boundaries. For this reason, the International Association of Lighthouse Authorities (IALA) VTS committee carried out a study into these matters under the requisition of IMO. The results, so-called "Guidelines on the recruitment, qualifications and training of VTS operators" defined VTS operators as follows:

> " 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 authorized, 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 six primary functions identified as a basis for defining the tasks, skills and knowledge required by an effective VTS operator. These are:

- Acquisition of data
- Allocation of space
- Routine control of vessels
- Maneuvers to avoid collisions
- Enforcement functions
- Remedial functions

**3.5.2 VTS operators required knowledge and skills**

There are various levels of VTS and also various types of VTS. Of course, the tasks, skills, and knowledge required by a VTS operator depend on the level and type of VTS. COST 301 Task force identified the seven general knowledge areas considered necessary to the VTS operator as follows:

- Knowledge and use of the English language
- General nautical knowledge
- Specific nautical knowledge
- Equipment handling expertise
- Legal knowledge
- Local geographic knowledge
- General education

The above areas are almost self evident. P. Barber and T. Hughes (1992) emphasized and identified in their report further skills as follows:

" 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 VHF equipment. This is a vital requirement at the heart of an effective VTS 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/Mater/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 "

### 3.5.3 Entry qualifications and training

#### (A) Entry qualifications

VTS operators must have a good appreciation of a marine environment and the ability to understand the mariner's problems under certain circumstances, because their tasks are specialized, demanding and often in an atmosphere under create physical pressure. So, not only must a potential operator have the right background but also any other operators must have the ability to solve problems and absorb information from a variety of sources.

A potential recruit should have certain minimum qualifications. According to the IMO MSC/Circ. 578 these are stated as:

"Authorities should establish entry standards for new VTS operators coming into the system in terms of prior skill, knowledge, and personal suitability characteristics relevant to the tasks of functions they will be required to perform. These skills and knowledge may in part be assessable through existing qualifications ( e.g. master or pilot's license)."

Indeed, in the United Kingdom, a potential recruit should have the minimum qualification of a UK Class 4 certificate or equivalent. But P. Barber and T. Hughes (1992) present the status in their report as follows:

"In general VTS operators at present are selected or chosen from the following disciplines:-

| | |
|---|---|
| 1) Maritime | Qualified Master Mariner |
| 2) Maritime | Qualified Deck Officer |
| 3) Maritime | Qualified Pilot |
| 4) Maritime | Tug, launch, local craft personnel |
| 5) Maritime | Coastguard(in UK, US) train own staff |
| 6) Radio Operator/Communicator | Often ex.military personnel in UK |
| 7) Radar operator | VTS |
| 8) Air Traffic Control | Uncommon in UK VTS |
| 9) Other Non Maritime | No previous applicable training " |

**(B) Training**

Training is important not only for the new VTS operators coming into the system but also for the existing operators. The training scheme outlined should be governed by the following principles:

1) Be flexible to deal with different levels of experience.

2) Enable VTS authorities to access aptitude.

3) Be flexible to deal with different levels and types of VTS.

4) Include a formal system of certification.

5) Include a formal system of validation of the training scheme and training establishments.

6) Include simulator based modules.

7) Include updating training at regular intervals for qualified VTS operators and for those being considered for promotion.

## 3.6 EFFECTIVENESS AND BENEFITS OF VTS

### 3.6.1 Effectiveness of VTS

Evaluation on the effectiveness and benefits of VTS can be carried out by combining the following methods:

- Questionnaring
- Evaluation experiment
- Simulation
- Analytical method

There is interesting data in Table 3.2 which was gathered through a questionnaire survey on the marine safety and VTS in Korean coastal waters by the Korea Maritime University in 1993. It was intended to identify the perceived importance and effectiveness of VTS.

They chose randomly a population of some 860 persons with maritime interests, and the respondents to the questionnaire numbered 385 (207 from master/mates and 178 from shore staff). As shown in the Table 3.2, 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 favorable rated by the respondents.

Table 3.2 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 meteorological 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 vessels | 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/regulations | 0 | 0 | 5 | 23 | 144 | 210 | 4.09 |
| Rendered to vessel in emergency | 0 | 0 | 5 | 23 | 121 | 236 | 4.19 |
| To vessels with foreign language difficulties, lack of knowledge problems | 1 | 0 | 11 | 56 | 180 | 137 | 3.69 |
| With communication problems | 2 | 1 | 14 | 85 | 158 | 125 | 3.58 |
| Provision of notice 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 : J.S.Park(1994),Marine Traffic Engineering in Korean coastal waters*

### 3.6.2 Benefits of VTS

The primary mission of the VTS is promoting safe navigation, transportation efficiency, and protecting the marine environment. So what kinds of benefits can be achieved by VTS implementation?

Firstly, reduction in maritime casualties in VTS areas. As can be seen in Table 3.2, most mariners and shore staff recognized that VTS can help safe navigation in VTS areas. In fact, Professor Louis A. LeBlanc, of Indiana University, examined vessel casualty statistics on the lower Mississippi river for four years in 1981. The research resulted in about four accidents less per year in the studied area.

A second benefit is the public's peace of mind. In accordance with reducing marine casualties, VTS provides peace of mind to not only the mariners navigating in VTS areas but also to millions of residents living and working in those regions.

Thirdly, VTS improves transportation efficiency. In addition to increased safety, the information provided by the VTS to vessel operators may allow the vessel movements to operate more smoothly and quickly through the waterways, resulting in increased port efficiency.

Lastly, we can consider the secondary benefits. In addition to increased maritime safety and transportation efficiency, information provided by the VTS often results in secondary benefits to the government, shipping and concerned industries. For example, accurate vessel arrival information provided by VTS can help in the increase of efficient loading and unloading of vessels, upon request, to the ship's agent or facility operators. This information is used to more precisely schedule line handlers and stevedores.

## 3.7 FUTURE TRENDS IN VTS

As stated in IMO Res. A.578 (14), VTS performs the following missions:

- data collection
- data evaluation
- information service
- navigational assistance service
- traffic organization service
- support of allied activities

It seems that there is no more need for extending the above list which encompasses the complete set of VTS activities for the time being and also for the future. The only question is not to make the list more complete, but to foresee if VTS will, and if so, to what extent such as:

- participate actively in traffic accident prevention
- improve the efficiency of use of navigable space
- allow for remote pilotage
- improve the efficiency of allied services, such as port services, and also salvage and search and rescue

For accomplishing each of the tasks listed in the above, VTS operators need a good traffic image in relevant area. It can be done not only by radar surveillance system but also by communications between ship and VTS operator. In this regards, extended ship reporting systems can help the VTS operator to get a good traffic image. If as expected the intended extensions of ship reporting systems provides better services, mariners at sea also will be willing to participate in the system.

The gathering of information for the traffic image, in the future, can be done by a shipborne transponder system designed to operate in conjunction with a VTS, i.e. Identification, Polling, Tracking, and Automatic Reporting by the computerized equipment. The advantages to VTS would be clear: positive identification and elimination of language problems, resulting in increased accuracy in the information collected, as well as reduced operator time collecting information, resulting in more time available for analysis of collected information. Spencer Martin (1992) named it as " The Silent VTS" in his report which is submitted to the 7th International Symposium on VTS in Vancouver, 1992. It is one of the future trends in VTS.

The other one of the future trends in VTS is linking VTS and GMDSS(Global Maritime Distress and Safety System). GMDSS, using digital selective calling techniques and satellite communications, provides means to perform the following functions:

- alerting
- SAR coordinating communications
- on scene connections
- locating signals
- dissemination of marine safety information
- general radiocommunications
- bridge to bridge communications

J. Prunieras (1987) stated in his report 'The Next Generation of VTS' as follows:

> "Although the expression 'traffic image' is not used in the IMO document, what really GMDSS is intended to do is to provide to every participant in search and rescue operation a traffic image. This traffic image constitutes the data base by means of which actions can be decided and followed up"

The traffic image acquired by the regional VTS and more precisely by means of GMDSS, will be used as a reliable input to local VTS. Qualities of traffic images provided by long range and short range systems respectively will be complementary, so that both traffic images will be of interests to VTS authorities.

Therefore GMDSS will be linked with VTS. Each of them will provide nearly all the necessary data which could definitely make VTS able to play a decisive role in the navigation process to the benefit of safety and efficiency of maritime traffic.

# CHAPTER 4

# CASE STUDY ON VTS IN FOREIGN COUNTRIES

## 4.1 GENERAL

The fundamental objectives of VTS are " promoting safe navigation, efficient traffic flow, and protecting the marine environment" achieved by providing information and advice on other traffic and navigational hazards to the vessels participating in the system. There are various types and various levels of VTS, three types can be identified as follows:

| | |
|---|---|
| Coastal(Strait) VTS : | Channel Navigation Information.<br>(ex. Dover Strait, Tokyo Bay, etc.) |
| Estuarial(River) VTS : | London - Thames Navigation Service.<br>(ex. Port of London, Mississippi River,etc.) |
| Port VTS : | Port and Approaches Service<br>( Dover Harbour, and usual ports ) |

Most ports are located on a coastline on the seashore or in the wide bay, so the passages to port areas and/or approaches to the ports are usually short. In such cases all the traffic in these areas can be encountered and managed by port VTS. But in some cases, ports and harbours are located on the upperstream area of a river or on the hindered area in a narrow and long bay. In such cases, all the traffic cannot be controlled by only the port VTS. The river or strait VTS are needed according to the specific circumstances.

In addition to the above types of VTS, there are various levels of VTS. In some cases the VTS center has its own radar coverage of the waterway and directly maintains surveillance of vessel movements with complete communication systems. In other cases the VTS center maintains the estimated track of vessels only based on VHF communication and reported data from vessels without radar. The former is termed Advanced Radar Surveillance System and the latter Vessel Movement Reporting System.

The levels of VTS have been defined in the Port Needs Study (Vessel Traffic Services Benefits, 1991) by US Coast Guard as follows:

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

Level II — Shore-based Traffic Services with radar, CCTVs, and VHF communication facilities for traffic surveillance and information services.
The radar technology was assumed to be a standard shipboard radar without advanced features.

Level III — This system includes complete communication plus VTS radar surveillance system. This level included computerized radar data processing system, and distributed information/data processing system.

The VTS authorities are also different from country to country. It is stipulated as "a competent authority" in IMO Res. A 578 (14), Guidelines for Vessel Traffic Services. According to the result of the third survey on VTS in the world ( Fujii, Wakao, and Yamanouchi ,1989), the VTS authority is generally run by the Coast Guard, Maritime Administration, Port Authority, and Pilot Association in their countries. In some countries the Navy , Canal/Strait Authority, or Oil/Shipping

Company is in charge of the VTS authority. Table 4.1 shows the VTS authority status in each region of the world.

Table 4.1 VTS authorities in each region

| VTS authority / Region | Navy | Coast Guard | MARAD | Canal/Strait Authority | Port Authority | Pilot Association | Oil/Ship Company |
|---|---|---|---|---|---|---|---|
| Western Europe | | 6 | 34 | | 35 | 33 | |
| Russia & E. Europe | | | | | 9 | | 1 |
| Asia | | 12 | 9 | 2 | 14 | | 4 |
| North America | 1 | 22 | 1 | 1 | 1 | | |
| Central & S.America | 2 | | | 1 | | | |
| Australia | | | 6 | | 6 | 1 | |
| Africa | | | | 1 | 1 | | |
| Total | 3 | 40 | 50 | 5 | 66 | 34 | 5 |
| % | 1.5 | 19.7 | 24.6 | 2.5 | 32.5 | 16.7 | 2.5 |

*Source: Compiled by Author from the third survey on VTS in the world(1989)*

Bearing in mind the above mentioned various types· levels· and different VTS authorities, a case study on VTS status and its effectiveness in developed countries is given in this chapter.

## 4.2 CASE STUDY ON VTS IN FOREIGN COUNTRIES

Since the world's first harbour surveillance was installed in 1948, VTS has expanded widely throughout the world and developed in a wide variety of ways. Some facilities are still quite simply equipped with only a VHF radio, but the others are highly complex ones with computer processing in addition to the radar surveillance. 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 should not be limited to ports/harbours and approaches but are also found associated with some traffic separation schemes (TSS). For example, in the case of 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.

The rationale for the provision of this 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.

### 4.2.1 United Kingdom

The world's first VTS establishment was in 1948 in the port of Liverpool. But in their main port the port of London, the Thames Navigation Service (TNS) did not develop VTS until 1959 at the same time as Southampton Port Radio. In the 1960's, Belfast Port Radio, Medway Navigation Service, Tees Harbour Radio, and Humber Ports Operation and Information Service were established. Bermuda Harbour Radio, Clydeport Harbour Control, Milford Haven Port VTS, Harwich Harbour Operations, Pentland Firth and Seapa Flow VTS, and Sullom Voe Harbour Radio were established in the 1970's.

The port of London takes in sixty-eight nautical miles of navigable water, including four approach channels through the Thames estuary, covering one river channel along which are clustered at random with a mixture of small wharves and large terminals. The increasing ship speed, size, and draft, together with a demand for shorter time in port, and the usual poor visibility in these areas, compulsory reporting points during transit all called for a VTS.

Since 1959 the Thames Navigation Service has been developed and is now the recognized focal point for information between all parties directly involved. These include the Port Authority itself, owners/agents, berths/terminals, pilots, tugs, watermen, customs, and health. TNS helps manage both the commercial and safety aspects of the port. The Port Authority also developed a vessel data management system in 1985 for recording and displaying information concerning arrivals and departures. TNS has been very successful in keeping accidents well down and materially increasing throughput in times of poor visibility.

Just down the Thames, there is one of the world's great maritime chock points, the Strait of Dover. It is not only congested, it is also one of the most difficult of the narrow seas to navigate. The weather is poor with storms and fog. Winds, tides, and currents are extremely variable and strong. In 1961, the UK, France, and West Germany began studies on methods of traffic control for the Strait, and in 1967, an internationally recognized TSS - sponsored by IMCO - was introduced in the Strait, although compliance was then only on a voluntary, passive basis.

In 1972, the Channel Navigation Information Service (CNIS) was introduced. It provides a twenty-four hour radio safety service for all shipping in the Strait. Traffic was from this time on monitored by radar. In 1977, the revised 1972 International Regulations for Preventing Collisions at Sea (COLREG) came into force, and compliance with the TSS is now mandatory for all ships.

In 1979, a vital new element was added to the Dover scheme- the Movement Reporting Scheme for the English Channel (MAREP) system. Under this program, certain categories of vessel moving through the Channel are invited to report their progress to designated British or French shore stations. Progress of these vessels is continuously monitored by the shore stations, which should then receive early warning of any possible mishap.

Johnson (1978) analyzed the trends of collision incidents over 15 years (1962-1977) in the Dover Strait. Table 4.2 shows that during 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. In the next five-year period, when the TSS was supported by the CNIS, there was a further 55 percent reduction in the number of collisions. 46 percent of the collisions occurred in the traffic lanes during that period.

According to Johnson's analysis (1978), the reduction of collisions in the traffic lanes indicates that the traffic surveillance system has an effect on navigational safety.

Table 4.2 Summary of collisions over 15 years in Dover Strait

| | Pre Routing Mid 62-Mid 67 | TSS Introduced Mid 67- Mid 72 | | CNIS Introduced Mid 72 - Mid 77 | |
|---|---|---|---|---|---|
| | All Waters | All Waters | Main Lanes | All Waters | Main Lanes |
| All Collisions | 69 | 53 | 32 | 24 | 11 |

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

### 4.2.2 United States of America

US 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. Until the collision of two tankers under the Golden Gate Bridge in 1971, there were no laws requiring installation and monitoring of VHF-FM radiotelephones on vessels in US waters. This collision provided the US Congress impetus to mandate the use of radiotelephones in US waters. The Coast Guard was authorized by the Ports and Waterways Safety Act of 1972 and the Port and Tanker Safety Act of 1978 to operate VTSs in ports, harbours, and other waters subject to congested vessel traffic.

The Coast Guard conducted a VTS Analysis of Port Needs Study in 1973. Twenty-two major ports and waterways were examined in this study, and the result was a list ranking the twenty-two ports and waterways in order of priority for a VTS.

Based on this study, San Francisco(1972), Puget Sound (1972), Houston/ Galveston (1975), New Orleans (1977), and New York (1985) were finally selected for the establishment of VTSs.

As a part of this study, 1,827 collisions, ramming, and grounding casualties 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. The reduction in vessel casualties by the various levels of VTS were estimated as shown in Table 4.3.

Table 4.3 Estimated reduction in vessel casualties 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 | 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*

Separate from this study, the St. Lawrence Seaway VTC ( 1954, by St. Lawrence Seaway Development Corporation, Waterway Authority), Marine Traffic Control Honolulu ( 1963, by State of Hawaii), Cape Cod Canal Traffic system (1971, by US Army Corps of Engineers), Louisville Vessel Management System (1973, by US Coast Guard), Vessel Traffic Services Berwick Bay (1974, by US Coast Guard), Kerch-Yenikale Channel Radar System ( 1973, by Kerch Port Authority), Black Sea Vessel Traffic System ( 1981, by Ilichevsk Port Authority), and Los Angeles- Long Beach Voluntary Vessel Traffic Information Service ( 1983, by Marine Exchange of Los Angeles - Long Beach Harbour Inc.) were established and began operations.

There is another paper, by Ecker W.J. (1978), updating the analysis of several ports and waterways in the light of marine casualties that have been reported from 1973 to 1976. The selected areas are Delaware Bay, Chesapeake Bay, Tampa Bay, and two segments of the Intracoastal Waterway West, Mile 50-130 and Mile 260-290. An estimate of accidents prevented by VTS was carried out under the given VTS levels in each area as follows:

<u>Delaware Bay:</u> The casualty analysis (112 cases) assumed that the TSS extends from the Bay entrance to the city of Trenton.

<u>Chesapeake Bay:</u> It was assumed that the level of VTS employing radar would only provide coverage.

<u>Tampa Bay:</u> It was assumed that VTS having radar capability extended to all areas of the Bay navigable by deep draft vessels.

<u>Gulf Intracoastal Waterway West Miles 50-130:</u> It was assumed that all VTS levels could be applied to all the waterways miles 50-130.

<u>Gulf Intracoastal Waterway West Miles 260-290:</u> It was assumed that all levels of VTS could be extended over the entire waterway complex.

The results of the estimates are as shown in Table 4.4.

Table 4.4 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*

According to Courtesy U.S. Coast Guard (1982), VTS and its effectiveness was described as follows:

> " Four of five largest ports in the US are now covered by a VTS. During the same year, 54 percent of all waterborne commerce in the US moved under the watchful guidance of a VTS. Significant reductions in collisions, rammings, and groundings are evident in those VTS ports."

### 4.2.3 Canada

The VTS programme of the Canadian Coast Guard has its roots in the twin concerns over the significant number of marine casualties 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 with the establishment of the first VTS center in Quebec City in 1967, and expanded rapidly to become a national programme.

Montreal Traffic Center and Montreal Information Center were established in the 1960's, Halifax ( Chebucto Head), Maritimes Traffic Centre, Sarnia, St. John's, Placenia Bay, St. John (Fundy), Iqaluit ( Forbisher Bay),and Port Aux Basques were established in 1970's, and Les Escoumins, Vancouver, Tofino, and Prince Rupert were established in 1980's.

The Canadian Coast Guard operates its 15 centers with a VTS staff of 350. All major Canadian waterways, with the exception of a portion of the Great Lakes, are effectively covered by one form of VTS or another. The marine safety information function is carried out for all Canadian waters.

In Canada, a VTS update study was carried out by a Government Consulting Group for the Canadian Coast Guard in 1988. 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. Four different waterway configurations and a number of alternative VTS system configurations are suggested for the estimation of the effectiveness of VTS. The VTS effectiveness in reducing casualties was estimated to range from 15 to 75 percent as shown in Table 4.5.

Table 4.5 VTS effectiveness percentage ( Unit : % )

| 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*

### 4.2.4 Japan

For maritime safety in Japanese waters, the Maritime Traffic Safety Law was enforced in 1973, through which routeing in congested waters was established. Kushiro and Osaka Harbour Vessel Traffic Services were established in 1964, and Kawasaki and Yokohama Port Traffic Control in 1973 and 1974. The Tokyo Bay Traffic Advisory Center was established in 1975.

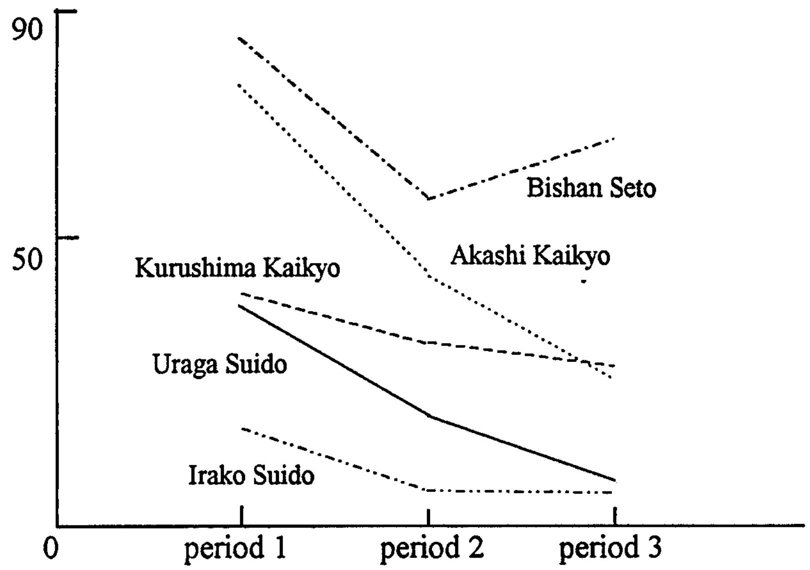
Tokyo Port, Kobe, Innoshimabashi, Omishima, Wakamatsu Port Traffic Control, and VTS in Seto Inland Sea were established in the 1980's. Some other VTS stations were established by regional authorities and/or private oil companies other than the above listed stations. Most VTS Centers in Japan are managed and operated by the Maritime Safety Agency ( Coast Guard).

The VTSs using radar are in four places in Japan. Tokyo Bay VTS started operations in 1977. Subsequently, from 1987 a part of Seto Inland Sea VTS started operations. Besides the VTSs taking the periphery of ports as the object are in Osaka Port and Kushiro Port.

Figure 4.1 shows the change in the yearly number of ships involved in collision accidents which required rescue in the main congested waters in Japan.

Kiyoshi H (1988) shows in his report, Period 1 six years before the Maritime Safety Law was enforced, Period 2 six years since the same law was enforced, and Period 3 the period after Tokyo Bay VTS was established.

Figure 4.1 Number of vessels involved in collisions and strandings




*Source: Kiyoshi H.(1988), Progress of VTS and its studies in Japan*

In another report, the Safety Assessment of Waterway Network in Tokyo Bay Area, the authors ( Fujii Y. & Kaku S. 1981, Kuroda K. & Kita H. 1990) examined the time trend of the number of traffic accidents in Tokyo Bay to evaluate the effectiveness of the traffic services.

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 collisions and 23 percent groundings than in the previous five years. After the Tokyo Bay Traffic Advisory Center became operational, there was a further 32 percent 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 as shown in Table 4.6.

Table 4.6 Tokyo Bay percent index of historical accident

| 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)*

The nationwide accident reduction during the period of 1977-1982 was, however, far less than for the Tokyo Bay; 8 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.

### 4.2.5 Netherlands (Rotterdam)

Rotterdam lies in the northeastern exit of the Strait of Dover. Rotterdam combines all the characteristics of a river port with many of those identified with Dover. Rotterdam built its first VTS in 1956, chain of seven shore-based radar stations along the New Waterway, reaching from what was then the coast into the heart of the city. The original main objective of the VTS establishment in those areas was to render assistance to shipping on the river when visibility was bad. The system was divided into blocks, and ships were passed from one block to the next block. Pilots were equipped with portable radios to communicate with the radar operators, keeping them informed of the position of their own ships, other vessels in the vicinity, and other matters of interest.

At the end of the 1960s, the VTS, now operating twenty-four hours a day regardless of visibility, was extended. Despite the expanding harbour traffic, there was a fourfold reduction in vessel collisions at the approach to the harbour.

In a parallel effort, which did not come under the cognizance of the VTS, a dedicated Decca chain was installed. With transmitters on both sides of the river, Decca's signal contours coincided in port with the main axis of the channels. This was a significant contribution to traffic safety. Pilots were issued special portable receivers, enabling them to precisely position their ships with regard to their intended track. Results complemented the work of the VTS, as the Rotterdam-based chain still does.

In early 1986, the new VTS system acceptance tests began. Once the proper operation and reliability of the entire VTS under full operational load had been checked, the system was accepted. By the end of 1986 the data processing elements were functioning and the system updates and extensions were completed. The new VTS included a Harbour Coordination Center (HCC), located in Rotterdam; three Regional Traffic Centers, located at the Hook of Holland, Botlek, and Stad (Waalhaven); and twenty six radar stations along with the waterway. An unmanned hydrographic data measuring station had been set up fifty-seven kilometers off the coast, transmitting water level, wave height and direction, barometric level, and wind force to the shore.

Today the VTS is staffed with over two hundred civilians, and operated by the Netherlands Defence Ministry. Each traffic controller must possess a master's licence. Personnel are selected and trained with great care. More than anything else, this is probably what has made the VTS such a success.

## 4.3 SURVEY ON VESSEL TRAFFIC MANAGEMENT SYSTEMS

There is a interesting survey report for VTS entitled Survey a Vessel Management Systems and Brief Introduction to Marine Traffic Studies, which was carried out by Fujii Y., Yamanouchi H. and Matsui T. in 1982 ( published in 1984).

The survey was based on response from 21 countries covering 246 VTSs, and can be summarized as follows:

1. Accident rate in fog was 1.1 per 1,000 trips in the New Rotterdam Waterway and 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 decreased to 3 after VTS was introduced.
3. Loss due to delays in the Elbe Waterway in fog was alleviated by 3 million US dollars per year and the collision rate 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 but has decreased to 32 after the introduction of a Traffic Separation Scheme, and then to 7 after the establishment of a traffic surveillance system. The total number of all collisions in these 3 five-year periods were 69, 53 and 24.
5. The introduction of traffic routes in Tokyo Bay and the establishment of VTS resulted over three years in 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.

# CHAPTER 5
# EVALUATION OF EXISTING TRAFFIC SERVICES AND SUMMARY OF THE ISSUES IN KOREAN COASTAL AREAS

## 5.1 GENERAL

When ships are navigating on the high seas, they proceed largely in isolation. But, when navigating in coastal waters or approaching ports and harbours, ships become constrained by underlying hydrographic features such as adjacent coastlines, islands, shallow waters, which give rise to areas of relatively high traffic concentration. Local movements by smaller vessels near to the shore may add to the traffic density. In these circumstances, a certain level of marine traffic service, which is not in conflict with the normal rules for collision avoidance, can help to reduce the attendant risks of collision and so contribute to the overall safety of navigation.

The issue of hydrographic data and establishment of navigational aids such as lights, buoys and other ship position fixing systems may be regarded as the first basic steps towards an area traffic service. The next step is traffic routeing. Vessels on conflicting journeys are prevented from meeting in potential collision circumstances by following separated schemes.

The first Traffic Separation Scheme (TSS) was designated and implemented by the International Maritime Consultative Organization (IMCO) in Dover Strait as a recommendation for all ships to follow. It was evaluated through accident and traffic analysis. Referring to the Dover Strait, Bowdidge (1977) 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 Services (CNIS), has contributed significantly to the observed reduction in the average number of collisions from 17 to 5 per annum."

Dare and Lewison (1980) analyzed the number of casualties and the amount of damage occasioned for the periods 1967-72 and 1973-79, and 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."

Further, earlier studies in Chapter 4, table 4.2 showed that the traffic surveillance system in Dover Straits had a significant effect on navigational safety, and table 4.6 showed that the implementation of a traffic surveillance system in Tokyo Bay was beneficial in reducing the number of accidents in those areas.

Bearing in mind the above mentioned, this chapter describes the status of existing traffic services in Korean coastal waters, evaluates the effectiveness of those traffic services through accident and traffic analysis, and summarizes the issues in these areas.

## 5.2 STATUS OF EXISTING TRAFFIC SERVICES

### 5.2.1 Vessel Movement Reporting System (VMRS)

According to the rapid growth of registered vessels, vessel movements, and cargo movements in Korean coastal areas, Korea Maritime and Port Administration (KMPA) introduced a Vessel Movement Reporting System (VMRS) at the Port of Pusan from September 1978. Since the Port of Pusan was the biggest and busiest port in Korea until now, a VMRS was firstly introduced to cope with the traffic increasing.

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 as follows:

"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."

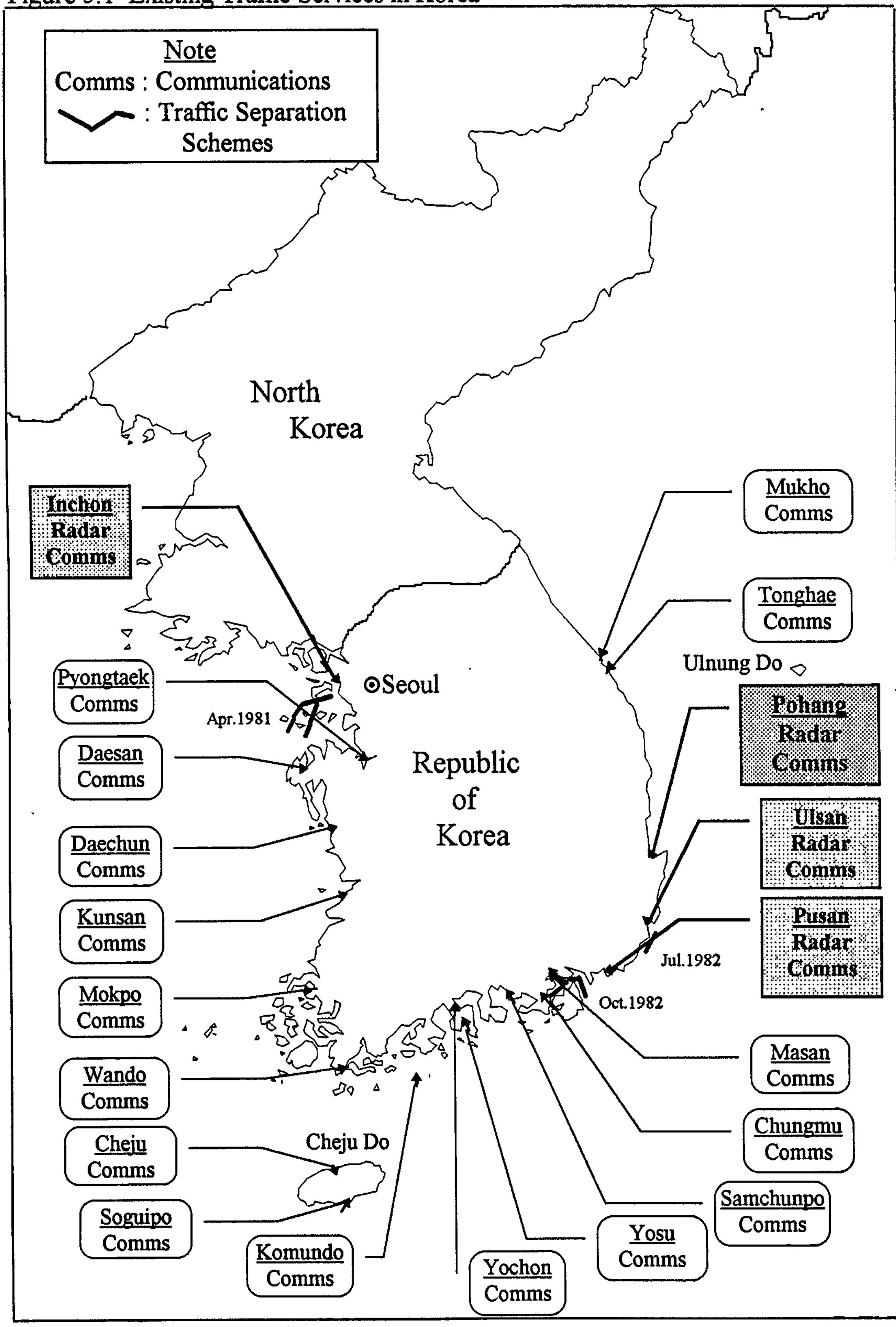
Since the introduction of VMRS at the Port of Pusan, the services have been extended to all major ports in Korea; Port of Pyongtaek, Tonghae/Mukho, Masan/ Chungmu/Samcheonpo, Kunsan/Daechun/Daesan, Mokpo/Wando, Yochon, and Cheju/ Seoguipo, are still in the Level I (VMRS) service using MF, SSB, and VHF for 24 hours in operation. The locations of existing VMRS in Korean coastal areas are shown in Figure 5.1.

In VMRS, MF can be communicated within about 580 km, usually used in foreign trade vessels' ETA reporting to the port authorities. SSB can be communicated within about 740 km, usually used in coastal passenger ships' every hour position reporting to the port authorities. VHF is used in short distance communication in port/harbour areas and its approaches to port/harbour. Table 5.1 shows communication equipment for VMRS established in each port.

VMRS is basically consists of VHF communications and various reporting waypoints, but no radar surveillance is included. VMRS is operated by information reported from ships and by operators visual observations. It can be achieved only as passive traffic control, because it is difficult to get certain accurate information regarding ship positions, ships moving from and to the port, and ship maneuvering status without ships reporting.

The main function of VMRS in Korean ports concentrates on the smooth operation of port and coastal passenger ships every hour position reporting.

Figure 5.1 Existing Traffic Services in Korea




*Source: Author - Compiled from Open Port Orderliness Act*

Table 5.1 Existing VMRS equipment in each port

| Port Authority | Port | MF | SSB | VHF |
|---|---|---|---|---|
| Pusan | | 4 | 5 | 8 |
| Inchon | Inchon | 4 | 4 | 5 |
| | Dock Gate | | | 2 |
| | Pyongtaek | | | 3 |
| Masan | Masan | 2 | 3 | 5 |
| | Chungmu | | 2 | 2 |
| | Samcheonpo | | | 3 |
| Tonghae | Tonghae | 2 | 2 | 3 |
| | Mukho | | | 3 |
| Ulsan | | 3 | 4 | 6 |
| Kunsan | Kunsan | 2 | 4 | 4 |
| | Daechun | | 4 | 3 |
| | Daesan | | | 2 |
| Mokpo | Mokpo | 1 | 4 | 3 |
| | Wando | | 3 | 3 |
| Yosu | Yosu | 3 | 4 | 3 |
| | Yocheon | | | 2 |
| | Keomoondo | 2 | 3 | 3 |
| Pohang | | 3 | 3 | 3 |
| Cheju | Cheju | 2 | 4 | 3 |
| | Seoguipo | | 4 | 3 |
| Total | | 28 | 53 | 72 |

*Source: KMPA (1993)*

### 5.2.2 Traffic Separation Schemes (TSS)

Traffic Separation Schemes in coastal areas, including in port and harbour limits, are established by KMPA. Existing TSSs in Korean coastal areas are also shown in Figure 5.1. The locations of existing TSSs correspond to the areas where the geographical distribution of casualties are higher than the other areas as shown in Figure 2.8.

**Inchon Traffic Separation Scheme:**

The Port of Inchon is located near the capital city of Seoul. It has both inner and outer harbour. The inner harbour is a non-tidal basin which is entered through twin parallel locks. The outer harbour consists of an anchorage and some oil berths in the tidal basins. The Port of Inchon has several characteristics including;

- A big rise and fall of tide, over 8.6 meters at spring tide. Tidal currents are also strong, maximum 3.3 m/sec on the flood and 2.1 m/sec on the ebb. ( Refer to Table 2.1)
- Fog occurs about 50 days per year, mostly during the months of April to July. (Refer to Figure 2.2 and Table 2.2)
- Inshore islands and shoals are a hindrance to navigation in the approach to the Port of Inchon.

There has been a rapid growth of vessel traffic and cargo movement in the port area along with the Korean national industrial growth, and the Port of Inchon is the second largest and busiest port in Korea. In total 39,611 vessel movements and 105 million tonnes cargo movement were recorded in 1995. This is 14.4 % of the total vessel movements in all Korean ports and 19.7 % of total cargo movements in all Korean ports in the same year.

To cope with this situation, the Inchon traffic separation scheme was introduced for inbound and outbound routes in the approach to the Port of Inchon. The inbound routes of the scheme follow the channel through Tong-sudo (East channel), and the outbound route follows the channel through Seo-sudo (West channel). There are local regulations applying to it, which came into force on 15th April 1981 which apply to all vessels of 500 GRT or more ( later amended to "not less than 30 meters in length" on 17th April 1991) as follows:

(1) Ships of 500 GRT or more shall navigate within the traffic scheme, inbound ships to Inchon using Tong-sudo and outbound ships using Seo-sudo.

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

(3) If, however, there are any obstacles on the route and danger to traffic, it is not able to follow the scheme. Those ships shall navigate to the far

right side of the route and shall not impede the passage of other traffic following the scheme.

It is an extension of the basic traffic rule to keep to the right of the route.

**Kanjol-Gap Traffic Separation Scheme:**

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

The Port of Pusan is the largest and busiest port in Korea, and there are two oil refineries and a heavy & chemical industrial complex at Ulsan. So there is heavy traffic with many tankers including LPG & chemical tankers in or near the Ports of Pusan and Ulsan. To cope with this situation a TSS was introduced in October 1982. The scheme comprises lanes 1 mile wide, for northbound and southbound traffic divided by a separation zone, two cables width, established off Kanjol-Gap. There are also local regulations which apply as follows:

(1) Ships of 300 GRT or more shall navigate within the traffic lanes, northbound ships using the east lane and southbound ships using the west lane, and shall keep near to the outer limit of the lane. Ships of less than 300 GRT shall adhere to the scheme if practicable and shall not impede the passage of other traffic following a traffic lane.

(2) Ships shall always keep a listening watch on VHF channel 16 within the limits of the traffic separation scheme.

**Jinhae-man Traffic Separation Scheme:**

Jinhae-man is a landlocked basin on the south-east coast of Korea between the mainland and the NW side of Koje-do. There is considerable coastal traffic of domestic ferries, passenger vessels, naval ships and fishing vessels in this area. To cope with the situation, TSS in the approaches to Masan, Chungmu and Jinhae passages were introduced in July 1982. The local regulations are as follows:

(1) Ships not less than 20 meters in length are required to navigate within the traffic lane.

(2) Ships are recommended to adhere to the lane, speed is restricted to 15 knots.

### 5.2.3 Radar Surveillance System

The Radar surveillance System is also established and operated by KMPA. The existing Radar Surveillance System is provided in the ports of Pusan · Inchon · Ulsan, and Pohang as shown in Figure 5.1.

The ports of Pusan(1984) · Inchon(1986) · Ulsan (1986) are in Level II (VHF communication with basic radar surveillance) VTS services, and the port of Pohang is in Level III (advanced radar surveillance) VTS services from January 1993. However, their service quality is no more than VMRS. This can be easily identified from the equipment established in each port. The services are limited within the harbour limits. The operational personnel belongs to the Department of Port Management in each Maritime District and Port Authority.

The port of Pohang has two radar sites, one is on top of the control tower in the harbour and the other is on the Janggi-Gap in the entrance of Youngil Bay. The port of Pohang is located in the basin of Youngil Bay, which is 12 miles from the Bay's entrance. The port of Pohang VTC can track out the vessels by their own radars from the entrance of Youngil Bay to the inner harbour and vise versa. There are five radar operators working in the VTC.

However, the ports of Pusan · Inchon · Ulsan, have only one radar site in each harbour. The radars have only basic functions like common ship's radar without the function of tracking out the vessel automatically. Their radar sites are also located only on top of the control tower, and there are two radar operators working in the VTC in each port. It is impossible to carry out sufficient surveillance in those areas with this equipment and operational personnel, because the radar site is only on top of the VTC and cannot cover the whole harbour/port area. Further, two radar operators cannot work all around the clock.

There are in total 139 VTS operators in Korea, but the individuals are merely expected to communicate information to participating vessels. The services are limited within the harbour limits ( port VTS), and to vessel movement reports and basic radar surveillance in those areas. Table 5.2 shows VTS ( including VMRS) operators' background and radar sites established at each port.

Table 5.2 VTS(VMRS) operators and Radar sites at each port

| Port | VTS operators | | | RADAR |
|---|---|---|---|---|
| | Radio Opr. Background | Navigator Background | Total | |
| Head Quarter | 8 | | 8 | |
| Pusan | 13 | 2 | 15 | 1 |
| Inchon | 17 | 2 | 19 | 1 |
| Masan | 13 | | 13 | |
| Ulsan | 10 | 2 | 12 | 1 |
| Yosu | 17 | | 17 | |
| Kunsan | 12 | | 12 | |
| Mokpo | 10 | | 10 | |
| Pohang | 7 | 5 | 12 | 2 |
| Tonghae | 12 | | 12 | |
| Cheju | 9 | | 9 | |
| Total | 128 | 11 | 139 | 5 |

*Source: KMPA (1994)*

## 5.3 EVALUATION OF EXISTING TRAFFIC SERVICES

### 5.3.1 Statistical Survey

Since VMRS was adopted and extended to all major ports in Korea from 1978, and TSS was established at the port of Inchon from 1981, and Kanjol-Gap, Jinhae-man from 1982, the overall accident danger probabilities should have been reduced. But, in fact, the casualty occurrence has increased continuously, the rate being quite over the increasing rate of ship's movement as shown in Table 5.3.

Table 5.3 Casualties and Ship Movements

| Year | Casualties | | | | | | Ship Movements |
|---|---|---|---|---|---|---|---|
| | Total Casualties | Type of Casualties | | Casualties in Waterway Type | | | |
| | | Traffic Accidents | Other Accidents | Confined Water | Territorial Water | Open Sea | |
| 1982 | 301 | 175 | 126 | 87 | 73 | 141 | 200242 |
| 1983 | 300 | 147 | 153 | 89 | 95 | 118 | 206499 |
| 1984 | 486 | 180 | 306 | 103 | 189 | 194 | 211679 |
| 1985 | 408 | 180 | 228 | 123 | 164 | 121 | 217043 |
| 1986 | 429 | 170 | 259 | 179 | 164 | 86 | 246626 |
| 1987 | 533 | 215 | 318 | 294 | 128 | 111 | 245669 |
| 1988 | 438 | 149 | 289 | 122 | 170 | 146 | 265526 |
| 1989 | 479 | 159 | 320 | 98 | 211 | 170 | 273325 |
| 1990 | 515 | 188 | 327 | 116 | 248 | 51 | 281355 |
| 1991 | 555 | 183 | 372 | 175 | 244 | 136 | 312916 |
| 1992 | 476 | 176 | 300 | 114 | 233 | 129 | 300145 |
| 1993 | 529 | 180 | 349 | 127 | 288 | 114 | 232365 |
| 1994 | 699 | 256 | 443 | 183 | 339 | 177 | 254406 |
| 1995 | 709 | 262 | 447 | 145 | 347 | 217 | 274676 |

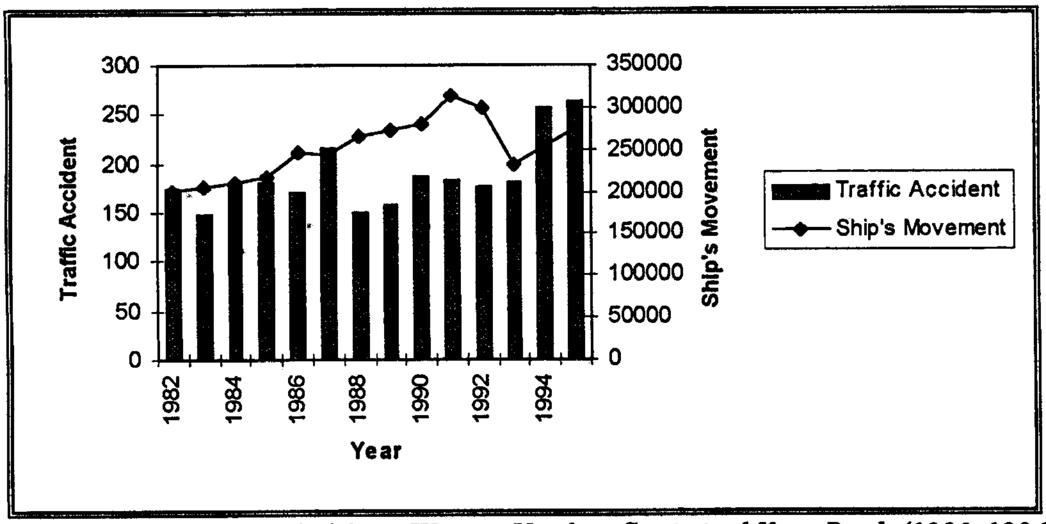
*Source: Statistical Year Book (1983-1996), KMPA*
*and Written Verdict (1983-1996), KMAIA*

Ship movements has increased 37.2 percent from 1982 to 1995 ( 200,242 ship movements recorded in 1982, and 274,676 ships in 1995), but the number of casualties has increased 135.5 percent during the same period ( 301 cases occurred in 1982 and 709 cases in 1995). During the same time the so-called traffic accident

( collisions, rammings, and strandings) has increased 49.7 percent ( 175 cases in 1982, 262 cases in 1995).

Compared with the increase in total casualties and traffic accidents, the traffic accident increase rate is much lower than the total casualties increase rate. This means that existing traffic services has contributed something to the traffic safety. However, it is difficult to find similar records for foreign countries as in the case studies in chapter 4. Traffic accident occurrence has not decreased, but has increased over the increasing rate of ship movement even though VMRS has been adopted and extended to all major ports as shown in Figure 5.2.

Figure 5.2 Traffic Accidents and Ship Movement

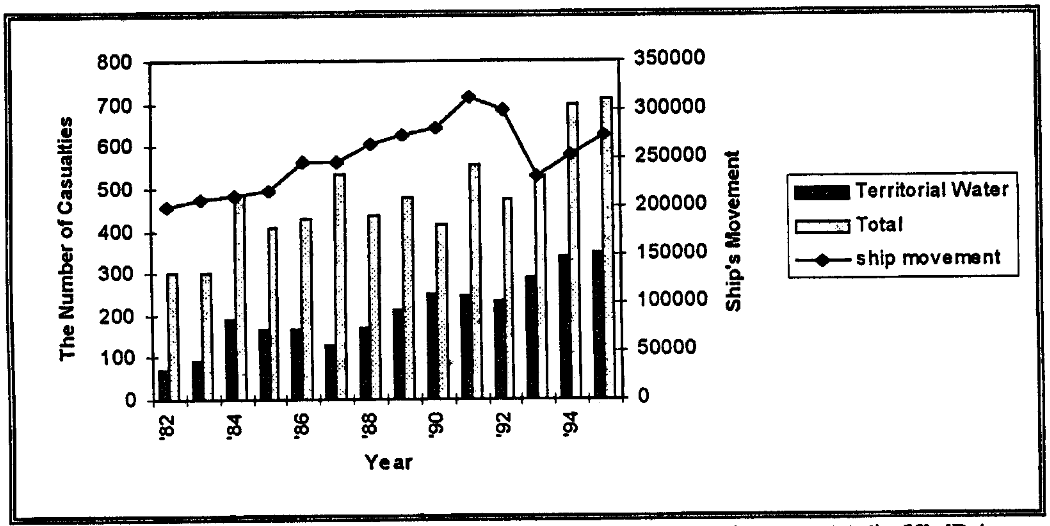



*Source: Author compiled from Written Verdict, Statistical Year Book (1983-1996)*

In the number of casualties occurring in different waterway types, the number of casualties in open sea has increased 53.9 percent (141 cases in 1982, 217 cases in 1995) and in confined waters has increased 66.7 percent ( 87 cases in 1982, 145 cases in 1995), but in territorial waters has increased 364.4 percent ( 73 cases in 1982, 347 cases in 1995) during the same period, as shown in Figure 5.3.

When considering the situation that most traffic accidents usually occur in territorial waters (within 12 miles off the coast) including confined waters and where shore-based navigational aids may be available in those areas, it can be identified that the existing traffic services in Korean coastal areas are not sufficient for safe navigation and to prevent accidents occurring in those areas.

Figure 5.3 Number of casualties in territorial waters and ship movement



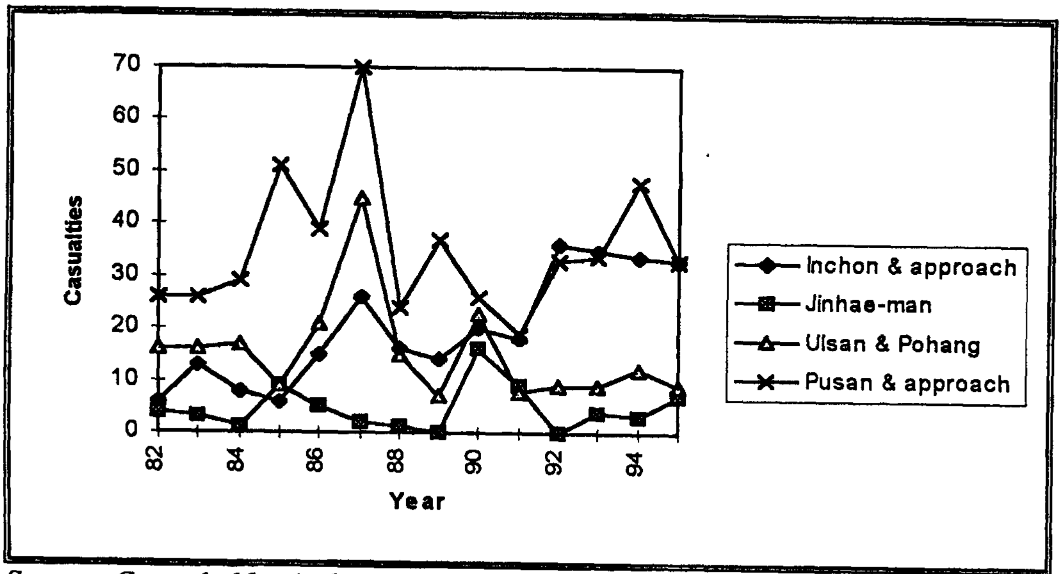

*Source: Compiled by Author from Statistical Year Book(1983-1996), KMPA and Written Verdict (1983-1996), KMAIA*

Furthermore, investigating TSS implemented areas (Inchon, Jinhae-man area) and radar surveillance system implemented areas (Inchon, Ulsan, Pohang, and Pusan area), the number of casualties occurring in those areas from 1982 to 1995 are shown in Figure 5.4.

The numbers of casualties occurring in those areas have continuously increased even though VMRS· TSS and radar surveillance system (VMRS: introduced at port of Pusan firstly in late 1978 and extended to all major port / TSS: Inchon in 1981, Jinhae-man and Kanjol-Gap in 1982 / Radar Surveillance System: Pusan in 1984, Inchon and Ulsan in 1986, Pohang in 1993) had been implemented in those areas.

This means that a more appropriate traffic surveillance system and a stricter enforcement of the routeing scheme other than existing vessel traffic services are needed in those areas.

Figure 5.4 Casualties in TSS and radar surveillance system implemented areas




*Source: Compiled by Author from Written Verdict (1983-1996), KMAIA*

### 5.3.2 Questionnaire Survey

As mentioned in Chapter 3, p.49, there is interesting data which was gathered through a questionnaire survey on the marine safety and VTS in Korean coastal waters by the Korea Maritime University in 1993. One piece of data is concerned with the implementation and/or modification of Vessel Traffic Services.

The total number of respondents was 385 as mentioned in chapter 3. Among this total (207 from masters/mates and 178 from shore staff), certain respondents, who work in specific ports or areas only, were asked to express their own views on how VTS should be implemented and/or modified. Consequently the number of respondents was small in these questions, but almost all respondents declared that the VTS service should be upgraded or implemented where no service exists. No respondent wished to downgrade or close the VTS service. Their opinions were summarized in a table.

Table 5.4 Desired VTS level and type through questionnaire survey

| AREA | Adequate VTS Level | | | | Type of VTS | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | Port VTS | Port & Approaches | Coastal VTS |
| Tonghae | 0 | 2 | 7 | 3 | 2 | 11 | 0 |
| Pohang | 0 | 0 | 5 | 3 | 3 | 6 | 2 |
| Ulsan | 2 | 0 | 5 | 6 | 3 | 10 | 2 |
| Pusan | 3 | 0 | 16 | 15 | 3 | 24 | 6 |
| Masan | 0 | 0 | 2 | 4 | 1 | 4 | 2 |
| Yosu | 1 | 0 | 11 | 0 | 2 | 11 | 1 |
| Cheju | 1 | 0 | 3 | 0 | 0 | 3 | 2 |
| Mokpo | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Kunsan | 0 | 0 | 9 | 1 | 0 | 7 | 3 |
| Inchon | 1 | 0 | 16 | 8 | 2 | 20 | 4 |
| Total | 8 | 2 | 74 | 41 | 16 | 96 | 23 |

Note : Level I : A vessel movement reporting system consisting of VHF communication and various vessels reporting.

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.

Level III: Advanced radar surveillance: This system includes complete communication plus an advanced VTS radar surveillance system.

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

*Source: J.S.Park(1994),Marine traffic engineering in Korean coastal wreas*

Table 5.4 shows that the identified levels of VTS provision and represents the respondent's view on the adequate VTS level and type. Exceptionally, some of the respondents expressed that the port VTS is needed only in some ports, and some of the respondents expressed that the coastal VTS is needed in some port areas, especially in the port of Pusan and Port of Inchon and surrounding areas.

A majority of respondents agreed that levels III and IV, rather than levels I and II, are adequate in major ports in Korea, and VTS for the port and their approaches rather than the port VTS and/or the coastal VTS, is the suitable type for the most of them.

## 5.4 SUMMARY OF THE ISSUES IN KOREAN COASTAL AREAS

For the purpose of developing a VTS in Korean coastal areas, it is needed to summarize some of the main points of findings in former studies:

1. Maritime topography and meteorological features
   - Most ports on the west and south coasts have relatively difficult navigational approaches with a large number of offshore islands and a big tidal difference.
   - Most fog at sea occurs in the months of April to July, sea fog usually occurs between 5 and 8 o'clock in the morning and disperses before noon.
   - Rainfall is concentrated to the summer season, and the wind force is stronger in winter than in summer ( The average wind force in January is Beaufort scale 5)

2. Traffic data
   - The vessels registered other than fishing vessels in Korea have grown continuously, average rate of 2 percent in number and 4.3 percent per annum in terms of tonnage. But the number of ships of less than 100 gross tonnes accounts for 77 percent of all registered ships ( in 1995).
   - Total vessel movements in Korean ports has increased significantly by 3 percent in number of ships and 21.7 percent per annum in terms of tonnage. Coastal and small sized ocean-going ships are the main components of the coastal traffic in Korean waters.

- Total number of fishing vessels has increased slightly and the number of ships under five gross tonnes accounts for 87 percent of total fishing fleet. Coastal and off-shore fisheries, which have direct influence on coastal traffic, have the highest number of ships.
- Total cargo traffic has increased rapidly, the annual rate of total cargo movement increasing by 22.1 percent per annum.

3. Ship casualties
   - The casualty ratio by the number of ship's movements increased from 0.19 percent in 1982 to 0.34 percent in 1994.
   - In type of vessel involved in casualties, fishing vessels account for over 60 percent of the total casualties.
   - In ships tonnage group involved in casualties, ships of less than 100 gross tonnes account for about 60 percent of the total casualties.
   - Almost three quarters of all casualties occur in territorial waters including confined waters where shore-based navigational aids may be available.
   - Traffic accident occurrences are higher in June and July than any other months. This may be linked to a certain low visibility due to the existence of fog during June and July.
   - The geographical distribution of casualties on the west and south coast are higher than the east coast.

4. Evaluation of existing traffic services
   - The traffic accidents increasing rate is lower than the total casualties increasing rate. This means that the existing traffic services have contributed something to prevent traffic accidents. But the increasing rate of traffic accidents is over the increasing rate of ship movements.

- In the number of casualties occurring in different waterway types, the number of casualties in territorial waters has increased significantly where shore-based navigational aids may be available.
- According to a questionnaire survey, a majority of respondents agreed that levels III and IV of VTS are adequate in major ports in Korea, and VTS for the port and their approaches is the suitable type for the most of them.

# CHAPTER 6

# CONCLUSIONS AND RECOMMENDATIONS

In maritime transportation there are so many navigational hazards existing as a ship plies from the port of departure to the port of arrival, the situation at sea is best viewed as a war of all against all. When ships are navigating the coastal waters, they are more constrained by underlying hydrographic features and traffic density. To achieve safe navigation and accident prevention in such circumstances the first basic step towards area traffic services is the establishment of aids to navigation, and the next step is traffic management/control, including passive and active ones.

VTS as originally conceived, is intended primarily as a space manager, to "comb out" vessel traffic into regularly spaced, orderly, predictable streams, increasing safety through measures taken by competent authorities to regulate traffic.

VTS is not the only method to prevent casualties, but theoretical studies and historical accident analyses conducted in places as far apart as the United Kingdom, the United States of America, Canada, and Japan tend to indicate that an appropriate, well-run VTS can reduce accident rates in a given area of water by as much as 40 to 70 percent.

There is no doubt through the former Chapters in this thesis that it is necessary to implement and/or to extend Vessel Traffic Services in Korean coastal areas for the achievement of safe navigation and accident prevention in those areas. The issue is how to adequately establish/extend and run well the appropriate VTSs in those areas.

VTSs, as a fully developed traffic system, should be composed of traffic separation schemes, movement reporting , sufficient surveillance with a well equipped traffic control center, and enforcement of the laws concerned. In this connection, it is suggested to extend VTSs in Korean coastal areas as follows:

**1. Aids to navigation**

Among the passive traffic management technique, aids to navigation are the basic safety measures for safe navigation. Most of the difficulties in coastal navigation and port approaches due to the large number of offshore islands and complexity of coast line can be solved by the establishment of adequate aids to navigation which should be maintained efficiently. They are also very helpful to achieve safe navigation in restricted visibility situations, such as rain fall and fog.

Navigation aids that are well located and in good order contribute much in preventing casualties such as strandings. Most ports on the west and south coasts have relatively difficult navigational approaches. A more thorough establishment and maintenance of navigation aids in these areas can help to achieve safer navigation and prevent casualties.

**2. Traffic separation schemes (TSS)**

As can be seen in Figure 5.1, TSSs were introduced in the approach to the port of Inchon (1981), Kanjol-Gap and Jinhae-man (1982) to cope with the significant traffic volume increase in Korean coastal areas. In view of the traffic accident increase rate being much lower than the total casualties increase rate, existing TSSs must have contributed in reducing the number of accidents.

However, it is identified that more TSSs should be introduced in the approaches to the Port of Mokpo and Port of Yosu/Kwangyang areas where the geographical distribution of casualties is higher than in other areas ( Figure 2.9).

Meanwhile, appropriate traffic surveillance and stricter enforcement of the routeing schemes are needed in these areas.

### 3. Extending the advanced VTS system to major ports

At present, the radar surveillance system is provided in the ports of Pusan, Inchon, Ulsan, and Pohang in addition to the VMRS services in all major ports in Korea. Their services quality is no more than VMRS services, the main function of VMRS in Korean ports being for the smooth operation of ports.

The increasing rate of traffic accidents is well over the increasing rate of ship movements in coastal areas during the past 15 years. The VMRS and TSS in Korea do not give an adequate level of safety, traffic surveillance and information exchange service which are fundamental in reducing the number of accidents in coastal areas.

In this connection, it is needed to extend advanced VTS (Levels III or IV) to all considerable parts of Korean coastal areas in addition to the above mentioned aids to navigation, VMRS, and TSSs established in those areas.

The following items should be noted when the advanced VTS is extended in those areas:

A. Extending the existing VTS service area

Existing VTS services ( Pusan, Inchon, Ulsan: Level II / Pohang: Level III ) are concentrated to contribute to the port operational efficiency and are also limited to within the harbour limits, except at the port of Pohang.

In order to prevent traffic accidents and to achieve safe navigation in port/ harbour approaches including territorial waters, existing VTS services should be extended to cover certain areas where the danger possibilities exist. For example, there is heavy traffic with many dangerous cargo ships in Kanjol-Gap TSS area which is located only five miles south of Ulsan and twenty miles north of Pusan. In this case, Pusan and Ulsan VTSs should extend their service coverage areas upto the Kanjol-Gap TSS area, and if they are operated together it would be more helpful for safe navigation in that area.

The Port of Inchon is a similar case. Its approach comprises inbound and outbound routes which are both over than 30 miles in length, and there are navigational difficulties existing on both routes due to so many inshore islands and shoals around the routes. Inchon VTS also should extend its service upto the entrance of the port approaches.

B. Order of priority to establish/extend the advanced VTS

Levels III or IV are more useful for the VTS service such as; general information service, navigation assistance, traffic organization, search and rescue, pollution monitoring, remote medical assistance, in contributing to safe navigation and accident prevention. This is presented in Chapter 4 in the case study of VTS in foreign countries.

The existing advanced radar surveillance ( Level III ) system is the only one in the port of Pohang which started its service in January 1993. According to the questionnaire survey examined by KMU, it is also identified that the level III and/or IV are adequate in major ports in Korea.

The order of priority to extend and/or newly establish an advanced VTS in each port shall be considered by the combination of the order of geographical distribution of casualties in Figure 2.9 and the order of a large number of respondents in the questionnaire survey in Table 5.4. The order of priority can be identified; the higher priorities are in Pusan, Inchon, Ulsan, Yosu, the medium priorities are in Masan, Kunsan, Mokpo, Pohang, and the lower priorities are in Tonghae and Cheju.

C. Upgrading the quality of VTS operators

As studied in Chapter 3, VTS operators play an important role in VTS areas. They must be qualified persons in their fields, with a knowledge of nautical, legal, local geography, equipment theory and handling, general education, and use of the English language.

They need sufficient shipboard experience and also shiphandling experience since the problems in certain situations cannot be solved without a good appreciation of the marine environment.

So, a potential recruit should have certain minimum qualifications. Further, training schemes both for the newly joined VTS operators and for the existing operators should be established and developed.

D. Considering small vessels and fishing vessels

In VTS services, the primary method for distributing information to vessels is VHF voice radio. Further, it can be distributed by several other methods, such as VHF radio broadcast, television broadcast, NAVTEX broadcast, and GMDSS. But there is a problem that most small vessels and fishing vessels operating in confined waters and territorial waters commonly lack the equipment to receive the distributed information.

To solve this problem and achieve safe navigation, legislation enforcement regarding the establishment of radio equipment on small vessels and fishing vessels is required. Furthermore, it is reasonable to consider that the VTS authority operates patrol boats in VTS areas for the control and surveillance of small vessels and fishing vessels in VTS areas.

Fortunately, the Korean government has a new understanding of the importance of maritime affairs, and in August 1996 reorganized a part of the governmental organizational structure in the maritime field concerned. The Ministry of Maritime Affairs and Fisheries was newly established, and all the functions concerning maritime affairs were moved from their Ministries and/or Administrations to the new Ministry. All maritime affairs will be handled by the new Ministry; for example, shipping, fisheries, maritime safety, marine environment protection, marine resources. Previously they were spread throughout the Ministry of Transport and Construction, Ministry of Agriculture and Fisheries, Ministry of Environment, Ministry of Home Affairs, and Ministry of Science and Technology. It is considered that a functional unification will promote the most effective development of maritime affairs.

In this regards it is recommended that the VTS organizations should be reorganized. The present VTS organizations belong to the port management department in each District Maritime and Port Authority, their services being limited to ports/harbour limits and no more services being provided other than those concerning port operation efficiency. The VTS organization should be reorganized as an independent department in each District Maritime and Port Authority for their services not to be limited to port/habour areas and to extend their services to fully operational VTSs' functions.

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