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Study on the information of ships' early-warning system and implementation in the Jinzhou water area

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STUDY ON THE INFORMATION OF SHIP' EARLY-WARNING SYSTEM AND IMPLEMENTATION IN THE JINZHOU WATER AREA

By

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DECLARATION

I certify that all the material in this research paper 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 research paper reflect my own personal views, and are not necessarily endorsed by the University.

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ABSTRACT

Title of research paper: **Study on the Information of Ships' Early-Warning System and Implementation in the Jinzhou Water Area**

Degree: **MSc**

In recent years, with the development of maritime transport, the types, number, tonnage and speed of ships have increased dramatically. As a result, how to protect marine traffic safety has become a topic for scholars all over the world. (Liu Wenyuan, 2013) When sailing at sea, ships may encounter some risks, but there is certain regularity in the occurrence of accidents which may occur in stages.

Early warning ideology and theories can play a role in preventing or slowing down accidents. Jinzhou area, as an important water area in northern China, is an important transfer station and responsible for the transportation to the northern inland areas. Therefore, the safe navigation in Jinzhou area waters has attracted increasingly more attention. In order to improve the traffic safety in the Jinzhou area, and to guarteen the safe transportation of goods, this paper, based on an analysis of early warning theory, intends to study on domestic and foreign experiences in relevant fields on early warning system and then explore and study maritime warning system and establish a complete set of maritime warning system.

First of all, this paper gives a brief introduction to the theory of early warning and its research, application and research methods in various fields. On this basis, this paper expounds the meaning of maritime warning, analyzes the alarm origin from the

following three aspects, namely, natural, ship structure and management, and then, by drawing lessons from other fields' experiences on conducting maritime warning grade division, sets up the system of maritime early warning. On the basis of the above, through data analysis, this paper establishes a complete early-warning system of in Jinzhou area.

Key words: Index, Early-Warning, Jinzhou area, Maritime

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LIST OF ABBREVIATIONS

MID	Marine Insurance Department
MSA	Marine Safety Administration
IMO	International Maritime Organization
HSAS	Homeland Security Advisory System
AIS	Automatic Identification System
VTS	Vessel Traffic Service
DHS	Department of Homeland Security

CHAPTER 1

INTRODUCTION

1.1 Background of research

Water traffic safety in recent years has become a heated topic attracting wide attention of numerous scholars. With the development of science and technology, the safety of water traffic has been gradually changed from "ex post processing" to "ex ante prevention", and the early warning of the warning work is an important way to achieve “ex ante prevention”.

As an important part of early warning of risk management, through the analysis of risk factors, before the crisis arrival forecast the development of events, rapid release of early warning information so that people can get ready for the emergency before the danger arrives, to minimize the loss caused by risk.（Xu, 2007, pp.392-394) Severing as an important transport station in the inland North China, with the depth of waters of its coastline being about 3000 km, and with a huge number of ships navigating in it, Bohai bay plays an important role in the domestic and international transportation.

In recent years, in this area the loss of human life and property caused by water traffic accidents has attracted more and more attention, and has a negative impact on society as a whole.

In recent years, the accidents at sea occurred in the Bohai bay is shown below:

On November 24, 1999, the ship, "Dashun" encountered a wind of 10 level, and

caught fire in big waves. There were 304 people on board. Among them, 282 were killed, and only 22 survived.

On October 28, 2001, on the way from Longkou to Lvshun, the ship "Tonghui", encountering a sea wind of 8-9 level, and wave height of 3-5 m, exploded and the fire killed 27 people.

On March 22, 2003, Yantai- Dalian Ro-Ro ship "Liao brigade ferry" on the way from Liaoning Lvshun to Shandong Longkou, suffered bad sea conditions, resulting in tilted hull and lost power, and some of the crew died.

On November 16, 2004, the passenger ship "Liaohai" owned by Dalian Xinhai shipping limited liability company, encountering a sea wind of 6 level when it sailed in the waters near Dalian Port Island, bursted fire. Passengers and crew were all rescued, and the ship was towed away from the main channel of the port to safe waters, without explosion or sink occurring.

Through the cases above, it is easy to find that the area of the Bohai bay has a great impact on the ship's safe navigation. The main weather conditions affecting the navigation of the Bohai Bay include cold air, extra tropical cyclones and tropical cyclones. Each year from October to April strong cold air and extra tropical cyclones are often accompanied by violent winds and waves. At the same time, complicated topography and geomorphology and tidal activities lead to extremely uneven distribution of wind and waves, which pose a serious threat to ships operating in the area of Bohai.（Sun, 2010, pp.36-37.）

On the other hand, there are many vessels in the Bohai Bay waters, with various

types and complex and dense routes. Bohai is an important transport station in the sea, so a large number of ships in the waters have the busy exchanges, and access to the waters area. Bulk cargo ships, container ships, frozen ships, cruise ships, liquefied natural gas carriers, Ro-Ro ships, and other types of ships all sail in the water, carrying out the heavy work of transporting passengers and freight.

But through the analysis of the accidents, we found that if these accidents can be well predicted before their occurrence, we may prevent them from happening, or at least come up with effective corresponding measures when the accidents are coming. Therefore, it is urgent to establish an effective early warning system to prevent or mitigate accidents in Bohai Bay area, furthermore the Jinzhou area.

1.2 Achievements in early warning at home and abroad

1.2.1 The Early-warning theory

Early-warning, an emergency signal issued before the disaster, is the possibility precursor that based on previous regularities or observations and capable of being monitored. Before an accident occurs, early-warning can send urgent signals and report dangerous situations to relevant departments, so as to avoid the occurrence of damage in the absence of knowledge or preparation, or minimize the damage caused by the disaster.
(Source:http://baike.baidu.com/link?url=sPwLrhZYTMK8ymu9uDVkWcAVPiVC9nUrm97OlTGkIiGhaWlJT0iRfbt6Cr3nlJcWHTxj8VzmhlspYfNqKLFJqovp69SDBQUtqddgjjtuli7）

1.2.2 Simulation of early warning process

The early warning process can be divided into three steps: risk detection, risk identification and risk evaluation. Through the monitoring of unsafe factors, the risk degree of each factor was analyzed. Use mathematical methods for evaluation, determine the safety level and achieve the target of early warning.

Figure 1.1 Security early warning process（Source：Given by Zhu Yuzhu）

1.2.3 Previous research on early warning abroad

International research on early-warning is developed from economic warning firstly, and all studies are focused on economic early-warning. It mainly includes the study of enterprise crisis management in the middle of 1980s in America and the research of enterprise crisis management in Japan in the late 1980s and early 90s. However, all of these studies have focused on the emergency response after the crisis. There is still a lack of rational analysis and empirical studies on the causes of the crisis.

In the economic field, early warning research includes two aspects: macroeconomic warning and micro economic warning. In the 30s of last century, Moore, an American economic statistician, used a multiple index method—diffusion index to build the U.S. macroeconomic warning system. So far, this kind of monitoring and warning system, which divides the economic indicators into three types of "first",

"consistent" and "lagging" to reflect the macroeconomic status, has been used so far. In 1978, the organization of economic cooperation and development, with more than 20 western industrial countries, established an institutional framework for monitoring the economic movements of member countries by applying an advanced indicator system. In 1979, the United States International Economic Cycle Research Center established the international economic indicators warning system. (Yu, 2003, pp.23-29）

Erika Magalettia and Francesca Garaventab developed an early warning system which can determine alien species invasion through test methods, in the ballast water management at the stage of the risk identification of early warning systems. (Erika, 2017)

1.2.4 Previous research on early warning at home

The investigation into theory of early warning management in China started in the late 90s and early 1980s. Professor Yu Lian, in his book *Traffic Disaster*, analyzed factors that caused water traffic accidents, road traffic accidents, railway traffic accidents, and civil aviation traffic accidents. He put forward the method of early warning analysis and pre control countermeasures to effectively realize the monitoring, identification and diagnosis of various disaster causing factors, as well as the daily monitoring management and the exception management under the crisis situation.（Yu, 1998）

Wang Lin and Tang Xiaodong investigated the influence of economic fluctuation on enterprises, from the three aspects of policy warning, external economic warning and internal economic warning; the enterprise early-warning system is constructed.

（Wang, 2000, pp.90-93.）

In Shang Guanwei and Wang Zhiming's study, the theory of practical thermodynamics is applied in the early warning process of fishing vessels. The early warning model of fishing vessels is established based on entropy theory and thermodynamic collision theory.（Shang, 2016, pp.23-28.）

Zhang Wenjuan in the bridge area ship navigation risk early warning system research, the basic idea of early warning is to predict, and then distinguish the situation, and finally warning. Real time dynamic warning of ships on the voyage: First need to obtain real-time navigation and real-time data navigation environment, then the real-time prediction of ship track, according to the track forecast results to determine whether there is threaten, according to the identification results are given early warning information.（Zhang, 2013）

In a word, the early warning theory, which originally appeared in the military field, has been widely applied in the fields of social economic life and natural activities. People have fully realized the importance of setting up early warning systems and warning mechanisms. Various fields have begun to study and set up early warning system and early warning mechanism. Water safety has always been one of the most important issues in water transportation. The application of early warning ideas and theories to the field of water safety will certainly have a positive impact on water traffic, and promote navigation safety and marine cleanliness.

1.3 Research objectives

Through the research of this topic, this paper aims to achieve the following

objectives:

（1） Identify potential risk factors affecting ship navigation safety in the Bohai bay.

（2） Analyses risk factors, and establish a related early warning index system.

（3） Determine maritime warning levels by evaluation to achieve early warning objectives.

（4） Establish an effective early warning system based on previous studies, and develop an effective early warning program to ensure the safety of ship navigation.

1.4 Research significance

Through the research of this topic, we should achieve the following meanings:

（1） Establish an effective early warning mechanism to ensure the most efficient use of resources.

（2） Play a typical and exemplary role in the National Maritime system.

1.5 Research methods

This article mainly combines the quantitative and qualitative research methods. According to the way of looking for the warning origin, analysis the warning index and discuss the warning level this basic research thinking. (Zhu Yuzhu，2015，handout) Combined with research situation of Bohai bay, through analysis of the warning origin, ensure the marine early-warning index system, and then detailed analysis the Jinzhou area water transport ship and related meteorological situation.

Set up a reasonable mechanism to ensure a safe and fast marine traffic environment.

CHAPTER 2

Early warning theory & Definition of maritime early warning theory

2.1 Review of early warning theory

"Early warning" originated in the military field. Early warning is the decisive link in the success or failure of military operations, and also the key factor in the outcome of the war.（Ma, 2009）That is thought aircraft, radar, satellite or other tools to detect in advance, it analyzes and judges the enemy's offensive signal, and reports the threat degree of the offensive signal to the command department, so as to help the command department take countermeasures in advance. In natural disasters, there are earthquake early warning, typhoon early warning, and debris flow early warning and so on. These early warnings mainly depend on advanced forecasting tools to detect the seismic waves, tropical air flow, mud rock flow in the rainstorm and geological changes to analyze whether there will be an accident. If it is the possible to cause a danger signal, it is may be use the electrical signal and the earthquake wave, the typhoon, the debris flow time difference to the corresponding disaster area to warn. Through the establishment of a rapid response mechanism, to minimize the risk of non-resistance caused by casualties and disaster losses.

Early warning, as an important part of emergency management, aims to make early diagnosis and treatment of possible events, so as to avoid the occurrence of some event or to minimize the damage and losses caused by the event. (Wu, 2011)

2. 2 Meaning of each element in the early warning

Thought the research, it is found that there are not very mature and comparatively unified theories in economic or any other fields, and different scholars in different fields and even in the same area have different opinions. Therefore, this paper mainly refers to the national economic security warning experience and divides the elements of early warning into three aspects: warning origin, warning index, and warning grade. So this paper will study the early warning system from the following three perspectives: finding the warning origin, analyzing each index in the early warning system, and clarifying the warning grade.

2.2.1 Warning origin

Warning origin is the root cause of the accident generation, just like "kindling". From the point of view of generating mechanism, the warning origin can be divided into two categories: one is the source from natural factors, that is, the natural warning origin, and the other is the source brought by human social activities. Natural warning sources include meteorological factors, geological factors, marine factors, and resource factors. If these four types of natural factors change abnormally, they will cause serious natural disasters. These natural disasters will further induce social disasters, not only causing property losses, but also undermining the normal operation of all aspects of society. Social sources include grain factors, energy factors, economic factors, political factors, military factors, cultural factors, information factors, scientific and technological factors, population factors and so on. (Li， 2007, pp.149-151)

2.2.2 Warning index

Warning index is reflecting the dangerous situation. In the early warning system of

natural warning, the prediction of early warning response can be measured by unit index. For example: warning of floods is rainfall, warning of fire is fire behavior, and warning of earthquake is shock wave, etc. Therefore, it is necessary to analyze the response indicators of various early warnings so as to establish a sound system to evaluate the early warning.

2.2.3 Warning grade

Warning grade is a yardstick to measure the risk degree of early warning objects. In the warning grade, how many early-warning grades should be set up? Whether there is a principle that we may follow? How are the standards for each grade determined? Are there any objective methods that can be used to determine the level of judgment? And so on. These are some of the problems that early warning grades need to solve. In the practice of early warning grades, different warning grades can be set according to different early-warning objects. However, some basic principles should be taken into consideration when determining the warning grade:

（1） Upper limit principle. The set of warning grade should be made to ensure that people are able to make semantic distinctions.

（2） Objectivity principle. Different people have different views on certain things. Therefore, at the warning grade, on the basis of the line principle, it should be classified as many as possible, so as to reduce the uncertainty caused by human factors.

（3） Practical principles. In early warning work, we should try to refine the indicators of early warning level, so that in the relevant work to allow staff to

better determine the level of standards, without the occurrence of high or low levels of warning grade.

2.3 Definition of maritime warning theory

Maritime early warning is an important part of maritime emergency management. It mainly refers to the maritime safety administration, according to maritime accidents and the accident data and information, and the relevant departments of the forecast information, using the method of logical reasoning and scientific analysis, predicted and evaluated the risk grade. Then, according to certain standard rules, corresponding warning level information and warning information are issued. In order to the status of the relevant units, crew members and the public know the information in advance, learn how to protect themselves and improve the skills, and therefore can effectively prevent and reduce dangerous situations and accidents at sea.

The maritime warning in this paper is mainly a prediction of the extent of damage to the sea by possible incidents of human life, property and environmental safety. So that people can fully understand, pay enough attention, and be ready to respond.

Maritime warning can be divided into 5 main aspects: information collection, arrangement information, information delivery, ensuring the warning level, and related unit response. The functions include warning function, prevention function, slowing and delaying function, preventing and resolving function, etc.（Liu, 2005, pp.35-37）

The process of maritime warning is shown as below：

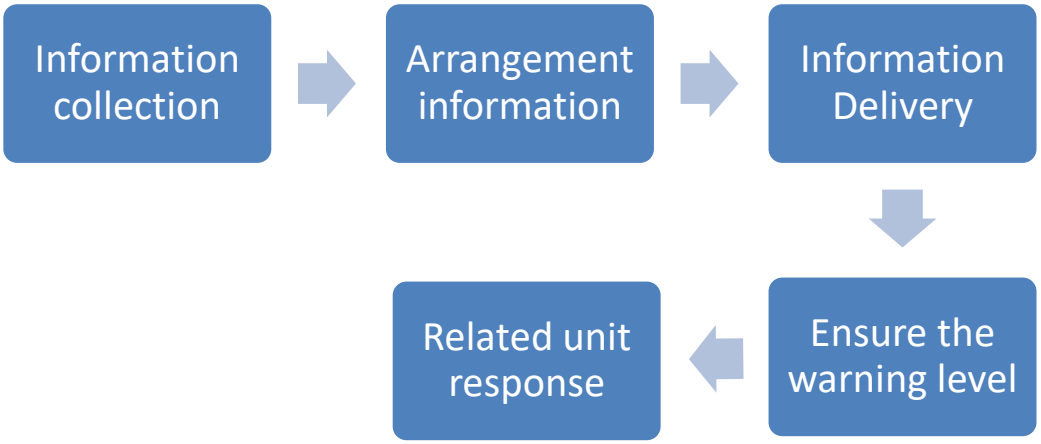

Figure 2.1 The flow of the risk early-warning of maritime（source: given by Zhu Yuzhu handout）

The release of warning grade information and relevant recommendation information system mainly refers to the use of modern information technology means, will be assessed by the warning grade and based on past experience accumulated response measures proposed timely release. This system is similar to the collection of information, here mainly through the Internet network, AIS, VTS, fax and other ways to achieve the release of information.（Xu, 2005, pp.124-125）

2.4 Chapter summary

This chapter reviews the theory of early warning, introduces the meaning of early warning and the meaning of each element. Then, it defines maritime early warning, and analyzes the process of maritime early warning. At the same time, the paper gives a brief analysis and explanation of the maritime warning information and the mode of broadcasting.

CHAPTER 3

Analysis of maritime warning source

From the traditional concept of marine traffic safety, the marine traffic safety system is a complex system with many factors consisting of human, machine and environment.（Sao, 1999, pp.41-44.）Therefore, many scholars, also from the three aspects of human, ship and environment, give a systematic analysis of marine risk, but there is another factor worth considering, that is management.（Baumler, 2017） The navigation safety of ships is not only the result of the independent navigation of a ship, but also related to the management system of ships' company. A good management system can better guarantee the sailing safety of the ship. In the early warning of maritime, the factors on human are not good enough to control, so it is not discussed here for the time being.

Therefore, this paper analyses the maritime warning sources, and generally divides them into the following three aspects:

Natural environment: natural phenomena such as wind, wave, flow, fog, rain, night and so on.

Ship conditions: The type of ships (This paper focuses on merchant ships).

The structure of a ship (It mainly refers to single shell oil tankers in this paper).

Management: company safety management system.

3.1 The natural environment aspects

3.1.1 Wind

Wind is one of the most important factors that affect the safety of ship navigation in Bohai area. Bohai is the inland sea connecting the mainland on the three sides of China. It is affected by land and hydrology greatly. At the same time, due to the shallow water depth of Bohai Bay, it has the characteristics of obvious monsoon and uneven wind distribution.

The influence of wind on ship navigation is mainly embodied in two aspects: on the one hand, it can let the ship deflection affect the ship keep direction capacity; on the other hand, the wind pressure difference forces the ship to form a downwind power.（Wang, 2002, pp.60-63.）The wind exerts different influences on ships with different construction. But the security impact on the ship and the extent of the damage mainly depend on the wind speed and wind angle. The impact of wind conditions on the ship navigation safety is shown below:

Table 3.1 The impact of wind conditions on the ship navigation safety

The angle between the ship and the wind	Below 6 level	7-8 level	9-10 level	Above 10 level
80 °-90 °	Medium	Big	Greater	Maximum

65 °-80 °	Small	Medium	Big	Greater
25 °-65 °	Small	Normal	Medium	Big
0 °-25 °	Small	Medium	Big	Greater

(Source: Wang, 2007)

In addition, the research conducted by Sun Zhenyue shows that when the wind is below the 4 level, the number of maritime changes is not obvious, but when the wind reaches 6 level and above, the probability of maritime occurrence increases significantly.（Sun, 1991, pp.14-18.）

The wind level 0-11 is shown below：

Table 3.2 The level of wind power

Wind level	Name of the wind	Wind speed(km/h)	Land Situation
0	Calm	Less than 1	Quiet
1	Light air	1—5	The wind vane doesn't move
2	Light breeze	6—11	The wind vane just move
3	Gentle breeze	12—19	Leaf of the tree sway
4	Moderate breeze	20—28	Can blow ground paper
5	Fresh breeze	29—38	Baby trees shake
6	Strong breeze	39—49	The branches swayed
7	Moderate gale	50—61	Shake the whole tree
8	Fresh gale	62—74	Twig break
9	Strong gale	75—88	Building small damage
10	Whole gale	89—102	Building damage

11	Storm	103—117	Much damage

（Source：https://wenku.baidu.com/view/67bf7833cc7931b765ce15ed.html）

3.1.2 Wave

Waves usually include wind wave, swells, and mixed waves. The waves caused by the direct action of sea surface wind are wind waves which leave the wind area to the distance or after the wind stroke; the more regular and longer period waves are called swells, the swells go into the area have wind waves that is the mixed waves. (Wang, 1989, pp.16-24)The wave is the main environmental factor that makes the ship stall and endanger the ship safety. The wave level is shown below:

Table 3.3 The level of wave power

Wave level	0	1	2	3	4	5	6	7	8	9
Wave high	0	0-0.1	0.1-0.5	0.5-1.5	1.5-3.0	3.0-5.0	5.0-7.5	7.5-11.5	11.5-18.0	>18

（Source：Sun, 2008）

The influence of sea wave on ship navigation is divided into three aspects: horizontal, vertical and transverse. The period of wave encounter is the symbol of measuring the influence degree, that is to say, the wave and the period of the ship in motion. The period of encounter is inversely proportional to the degree of wave influence. That means, the greater the cycle is, the smaller the influence is. When the ship encounters the period approximately equal to the free swinging period of the ship, the ship will have harmonic motion. Specifically, the transverse wave produces the maximum

heeling moment, and the excessive horizontal inclination may cause the ship's wave on the deck, leading to the displacement of the cargo and increasing the impact force of the free surface; longitudinal waves can cause bow waves and tail flooding, and in severe cases, ship bottom wave, propeller idling and so on; the influence of the vertical is reflected by the heave of the ship under the fluctuation of the wave, which leads to the decrease of the displacement and stability of the cargo.

Table 3.4 The impact of wave conditions on the ship navigation safety

Angle between waves and the ship	0—3	4—5	6—7	7—9
0 °—15 °	Medium	Big	Bigger	Biggest
15 °—45 °	Small	Medium	Big	Biggest
45 °—90 °	Small	Bigger	Biggest	Biggest

（Source：Ye, 2015, pp. 65-67.）

3.1.3 Visibility

With the continuous development of electronic information technology, a large number of electronic navigational aids are emerging, but whether the visibility is good or bad still has a considerable impact on the ship's safe sailing. Visibility is a very important index in navigating a ship at sea. It is crucial to understand the sailing conditions of other ships near the route. “International Regulations for Preventing Collisions at Sea” put the visibility at the first description of safe speed. (MID, 1981)

According to international practice, the visibility grade is divided into 0-9, ten levels

in total, as shown in the table below:

Table 3.5: Grade of the visibility

Grade Level	Visibility distance(km)	The sea situation
0	Less than 0.05	Dense fog
1	0.05—0.2	Heavy fog or snowstorm
2	0.2—0.5	Big fog or heavy snow
3	0.5—1.0	Fog or snow
4	1—2	
5	2—4	Light fog or rainstorm
6	4—10	
7	10—20	Light rain
8	20—50	No rain
9	More than 50	Air is clean

（Source：Zuo, 2007, pp.13-15）

3.1.4 Ice

The influence of sea ice is also very serious in many factors that affect the ship's safe sailing. In order to ensure the sailing safety, it is necessary to have a good understanding of the ice condition information. The influence of sea ice is mainly embodied in two aspects:

（1） Influence on people: First of all, when the ship is anchored in the anchorage or the offshore facilities and platforms are frozen, the supply of oil, food and fresh water is difficult, which affects the normal life of the people on the ship,

offshore facilities and platforms; Secondly, the sea ice caused by cold weather and the icing on the deck of the ship have increased the difficulty and burden of crew outdoor work, and will affect the physiological and psychological health of the crew; Finally, for people in distress at sea, drowning people to sustain life in the sea water containing the shorter time than ordinary in seawater, and maritime search and rescue work is also more difficult, thus increasing the risk of drowning person.（Liu, 2012, pp.30-33）

（2） Influence on ships: the influence of sea ice on ships is manifold. The direct effects on the safety of ship navigation include the followings: it may cause the blockage of ship's submarine door and pipeline, so that the main engine cannot operate properly; a large area of ice or ice floe together, make the ship deceleration, the steerage will be bad and resulting in serious difficulty in ship handling affecting the safe sailing of ships; ship and ice collision, easy to cause deformation or damage to hull plate; Sea ice can affect the normal propagation of radio waves, radar echoes, etc.（Li, 2003, pp.4-5）

The influence of ice on ships is shown in the following table:

Table 3.6: The impact of ice on the ship navigation safety

Level of the ice	1	2	3	4	5
Scope of the ice （n mile）	Less than 10	11-15	16-25	26-35	>35
Impact of ice	Small	Medium	Big	Biggest	Serious

(Source: Zhu Yuzhu, 2015)

3.2 Ship aspect

The ship is an important component of the marine traffic system. It is of great significance to analyze the factors of the ship accurately for maritime warning. The factors of a ship include its type, structure, age and so on.

3.2.1 Ship type

With the rapid development of the world economy and science and technology, more and more kinds of ships are available. At present, the types of vessels navigating in Bohai waters include passenger ships, Ro-Ro ships, oil tankers, container ships, bulk cargo ships, bulk carriers, liquefied natural gas carriers, chemical vessels, etc. According to the statistics of IMO, general cargo ship accidents caused by the most serious, followed by bulk carriers and oil tankers, the most easy to cause serious pollution of the ship for the tanker, the Ro-Ro ferry accident resulted in the death toll.

(source: http://www.imo.org/en/Pages/Default.aspx）

3.2.2 Ship structure

In the previous study of ice conditions, it was found that ships have certain requirements for ship hull strength in the area covered by sea ice. Here, due to the timeliness and urgency of the warning, we only consider the direct factors: Problems related to single hull tankers. General specification for design of wind resistant grades of ships.

3.2.3 Ship age

Ship age is a factor which has a great influence on ship safety. With the increase of ship age, the strength of ship structure decreases, and the technical condition of ship equipment decreases, and as a result, the amount of faults increases, and the probability of water traffic accidents increases. Especially, ships with age over 15 years will generally enter the period of failure. As a result of aging, fatigue, corrosion and other reasons, the failure will increase year by year.（Dong, 2007）

3.3 Safety management aspect

The IMO Marine Safety Committee and the Marine Environment Committee jointly issued the term "human factors unified term" in June 1997 after a long period of study by experts from relevant countries.（Li, 1997）This term divides management factors into 10 categories, of which, this paper only considers the implementation of safety management rules and regulations. The main application of safety management rules and regulations refers to the overall safety management rules and regulations themselves. Perform the safety management rules and regulations to regulate the safe operation of the company and the safe operation of the ship, to prevent, reduce and eliminate accidents.

3.4 Chapter summary

This chapter introduces the warning source of maritime warning; it is analyzed from three aspects of nature, ship and safety management. Naturally, the wind, waves, visibility and sea ice are mainly analyzed; in ship aspect, the type, structure, and age of ships are mainly analyzed; with regard to safety management, the safety

management of shipping company is mainly analyzed. The summary and analysis of warning sources lays the foundation for the following warning index.

CHAPTER 4

Establishment of maritime warning index system

4.1 Establishment principle of index system

In the establishment of the index system, we should follow the following principles:

4.1.1 Systematic principle

The maritime early warning system is a complex system determined by many factors. The concept of system requires that the object under investigation should be considered as a whole or a system. Therefore, the indexes selected in the study should be extensive and systematic, so as to reflect and measure the problems in a complete, comprehensive, and multi-dimensional way.

4.1.2 Objectivity principle

As an index of maritime warning, it should be evaluated objectively. Through a certain index, we can objectively describe or express the characteristics of the corresponding aspects of the problem. The selected index value should be objective and real, in order to achieve the objective of the model to reflect the actual situation objectively and truly.

4.1.3 Operability principle

As an index of maritime warning, it should be more obvious and easy to observe and

describe in the real work. Index values should be easily collected and arranged for easy handling. The index system can be adjusted according to the actual needs, and it has certain operability.（Ceng, 2010, pp.77-80.）

4.2 Establishment of index system

4.2.1 Construction of marine early warning index system

According to the establishment principle of maritime warning index system, and in the third chapter of this paper, based on the analysis of maritime warning source, this paper establishes the maritime warning index system and divides it into three aspects: environment, ship and safety management.

The index system of the whole early-warning construction is shown as below:

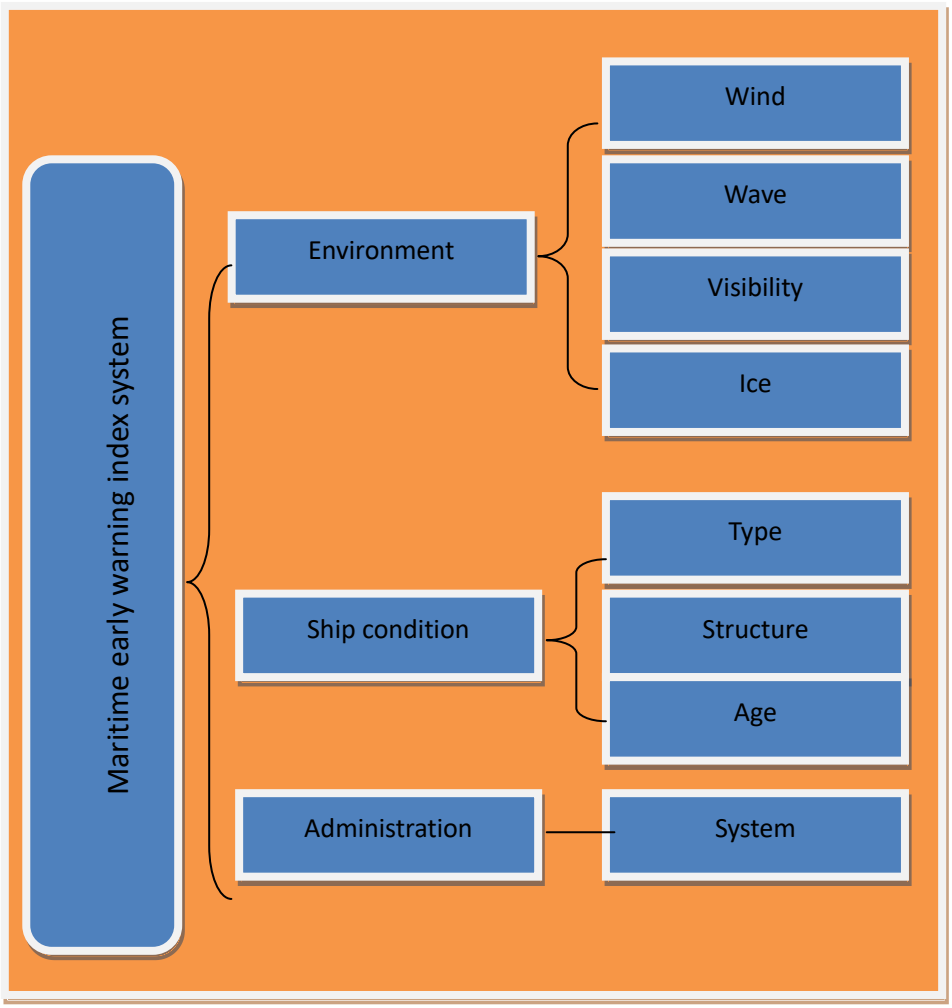

Figure 4.1 The index system of the early warning for maritime (source: by author)

4.2.2 Analysis of the nature of maritime warning index

The diversity and complexity of the content contained in marine early warning determine the types of indicators. The indexes designed in this paper can be divided into qualitative and quantitative indexes.（Wu, 2006）

Quantitative indexes are used to reflect one of the attributed of the warning source. Generally, they can be described by numerical valued, and the initial data can be obtained directly when the source information is obtained.

Qualitative indexes are used to reflect the characteristic attributes of a maritime warning source. They are often based on empirical or intuitive judgments of descriptive data and therefore can generally be "have" or "no", "yes" or "no" and so on.

In the maritime warning index system, the indexes are divided into statistical forms, as shown in Table 4.1:

Table 4.1 Nature chart of maritime warning index

Type	Name	Character
Environment	Wind	Quantity
	Wave	Quantity
	Visibility	Quantity
	Ice	Quantity

Ship	Type	Quantity
	Structure	Quantity
	Age	Quantity
Administration	System	Quality

(Source: by author)

4.3 Handling of maritime warning index

4.3.1 Quantitative index processing

For the dimensionless treatment of quantitative indicators, there are three common methods: closed value method, normalization method and standardization method. The normalization method, also called the range normalization method, is frequently used.

$$X_i^* = \frac{X_i - X_{min}}{X_{max} - X_{min}}$$

In the above equation, X_{max} is the index maximum, and X_{min} is the index minimum. The dimensionless method is essentially the ratio between the actual and minimum values of the calculated index and the total distance of the index, and its range of values 【0，1】.

（ http://baike.baidu.com/link?url=BnQjlhQiC_Ytymx0oItM5Ju0KveVv4nRUXAvzynU-KFjKqtyA48NoG_tN-vvVqT33PWlcrlb4XENZhuHIZRVfFB-zWpQkVfYQLRH71nia8XbGuC8r_JG9dzF91aTbjmo3KnT53VyiUEO5ReFo5mtKq）

In this paper, the method of judging the quantitative index is mainly based on the influence of relevant data which had already discussed in Chapter 3, and a decision is

made by the discussion.

4.3.2 Qualitative index processing

For qualitative indicators, there must be a certain evaluation criteria, so as to make a corresponding evaluation. In order to adapt to people's habits and easy to have the decision for the evaluation so the evaluation criterion should be the odd number of grades. This paper first sets the grade to three, and the corresponding comment is "good", "middle" and "bad". The following are the qualitative indicators of the evaluation criteria described.

Table 4.2 The evaluated standard to the index of the early warning for maritime

Type	Content	Comment
System	System is perfect, the safety policy is clear, Smooth running	Good
	System simply formulated, safety policy is not very clear, can simply running	Medium
	Lack of written system and explicit safety policy	Bad

(Source: by author)

Through the description of the above evaluation criteria, this paper adds a grade between "good" and "middle", "middle" and "bad", and the evaluation of qualitative indicators is divided into five grades. They are "good", "better", and “medium", "poor" and "bad". The evaluation criterion of "better" is between "good" and "medium", and the evaluation criterion of "poor" is between "middle" and "bad".

4.4 Chapter summary

On the basis of the previous chapter, according to the construction principle of the index system, this chapter establishes the maritime warning index system, which mainly includes three aspects: environment, ship, and management. It also gives a brief analysis of the nature of the index, and gives the quantitative indicators and the evaluation criteria of the qualitative indicators.

CHAPTER 5

Establishment of maritime warning grade

5.1 Classification of warning levels at home and abroad

5.1.1 Introduction of warning grades in foreign countries

（1） Classification of United States public security early-warning:

The western developed countries generally attach great importance to the pre classification of public security, and implement different levels of early warning management measures for different levels of public events. The Department of Homeland Security, after the "911" terrorist attacks, started to use the Homeland Security Advisory System, to warn sudden public parts, including terrorist attacks.（Tang, 2006）

The HSAS deals with the public emergencies and according to their severity which is divided into five levels, namely, orange, red, green, blue, and yellow. Among them, the green is a low risk state; the blue is concerned with the state of caution; the yellow threatens to be in a higher risk state; the orange is imminent, approaching high risk; and the red is a high risk state.（Zhang, 2006, pp.14-19）

（2） Classification of European flood prevention early warning:

There are two main categories of European flood warning classification methods. The first category is represented by France according to the flood severity

classification of warning levels: Green represents the normal state, yellow represents mild floods, orange represents severe floods, and red represents major floods. The second is represented by the United Kingdom, according to the characteristics of disaster prevention process classification of warning levels: Green stands for safety, yellow stands for alert, orange stands for preparation, and red for action.（Cheng, 2010 pp.26-31.）

5.1.2 Introduction of warning grades in China

According to the possible development trend, urgency, harm degree and influence range of meteorological disasters, there are generally four categories of warning grades (typhoon), the warning followed by red, orange, yellow and blue. Or three categories of warning grades (rainstorm), red, orange, yellow.（Yang, 2011）

5.2 Classification of maritime warning grade

Through study on the classification of the warning level at home and abroad, it is found that the warning grade is divided into 3 or 5 categories or colors. According to the situation of other area warning grade, this paper divides the maritime warning grades into 4 categories. The warning is red, orange, yellow and blue. And the blue grade is the reference grade, no need release the information. At the same time, the classification of maritime warning can be divided according to the possible influence situation. The classification standard of the early warning for maritime is shown below:

Table 5.1 Classification standards of the early warning for maritime

Warning level	Content

Red	It has a great influence on the safety of ship navigation; the most urgent measures must be taken.
Orange	It has a more influence on the safety of ship navigation, some measures must be taken.
Yellow	It has some influences on the safety of ship navigation, some measures should be done.
Green	It will have some influences on the safety of ship navigation, some measures are advised to done.

5.3 Chapter summary

This chapter based on the analysis of other areas of warning classification at home and abroad, divides the maritime warning grades. According to the criterion of warning grade, set the four levels of maritime warning grades, namely, red, orange, yellow, and green. Then, combined with study on the other area warning grade describe, ensure the maritime warning grade describe.

CHAPTER 6

Establishment of maritime warning system in Jinzhou area

6.1 Introduction to the basic conditions of the area

The shoreline length of Jinzhou maritime area is 134km, the coast length is 124km and island coast is 10km with a total area of 2890km^2. The existing 3 anchorages are 1 nautical miles radius of the round waters, with a total area of 32.31km^2.The territorial waters of Jinzhou are divided between the following eight points:

Table 6.1 The point of Jinzhou area

A	40°49′17.12″N/121°00′10.88″E	E	40°13′00″N/121°31′53.03″E
B	40°46′09.47″N/121°01′02.80″E	F	40°36′00.67″N/121°31′53.03″E
C	40°45′50.66″N/121°02′00″E	G	40°50′03.27″N/121°31′34.48″E
D	40°13′00″N/121°02′00″E	H	40°52′36.87″N/121°34′15.77″E

(Source:Jinzhou MSA)

And the area on the map is shown below:

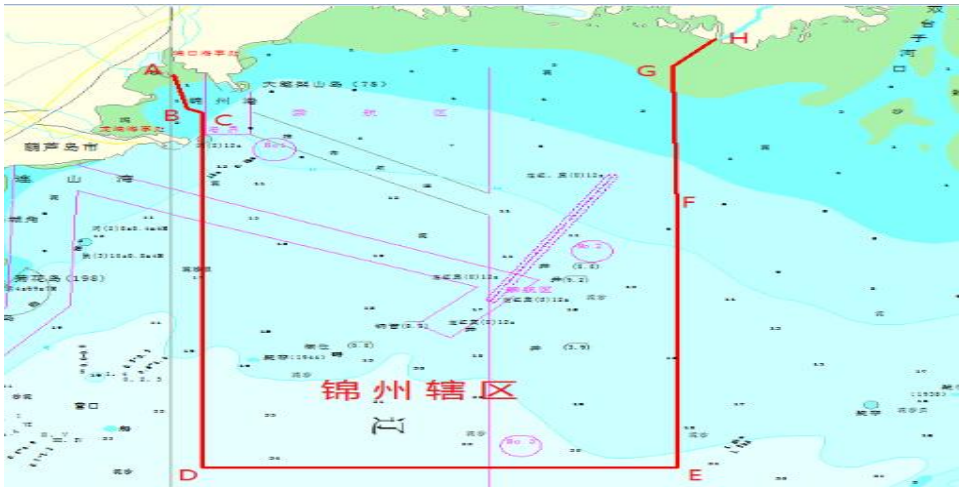

Figure 6.1The jurisdiction area of Jinzhou（source：Jinzhou MSA）

Through the analysis of the early warning situation before, this paper basically determines the relevant procedures of the Jinzhou maritime warning system, which can be divided into 6 parts, as shown in the figure below:

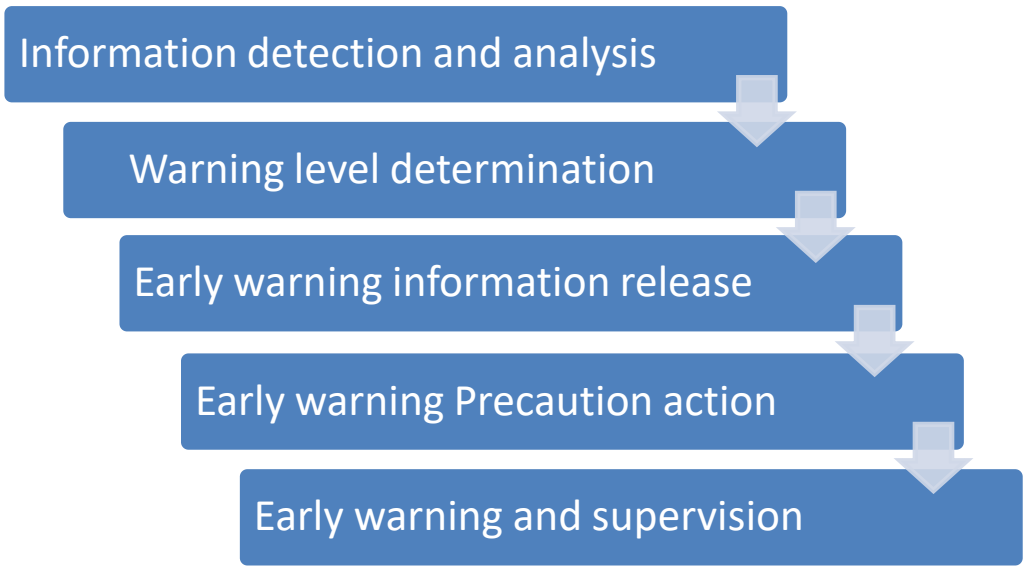

Figure 6.2 The early warning system process of the Jinzhou area (Source: by author)

6.2 Information detection and analysis

6.2.1 Wind

Jinzhou is mostly NNW direction wind in winter, and in summer is SSW direction wind.

Normal wind direction: NNW direction wind with the frequency of 20.9%;

Second wind direction: SW direction wind with the frequency of 18.3%;

Strong wind direction: NNW Measured maximum wind speed 23m/s;

Second strong wind direction: SSW Measured maximum wind speed 23m/s.

The inspection data are generally determined by means of the Beacon Hill inspection station, the Jinzhou harbor real time wind measuring apparatus, and the method of asking past ships.

The wind rose diagram of the Beacon Hill inspection station is demonstrated as follows:

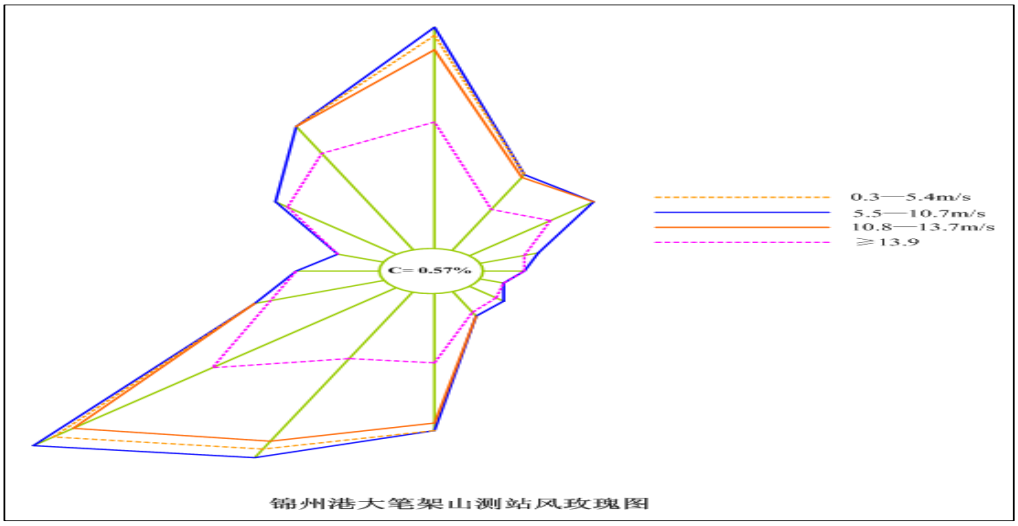

Figure 6.3 The wind rose diagram in Jinzhou (Source: Jinzhou MSA)

6.2.2 Wave

According to the statistical data of Beacon Hill station for 1986~1995 years:

Normal wave direction: SSW, The frequency of occurrence is 28.70%;

Second normal wave direction: S, The frequency of occurrence is 10.55%.

The wave rose diagram of the Beacon Hill inspection station is depicted as follows:

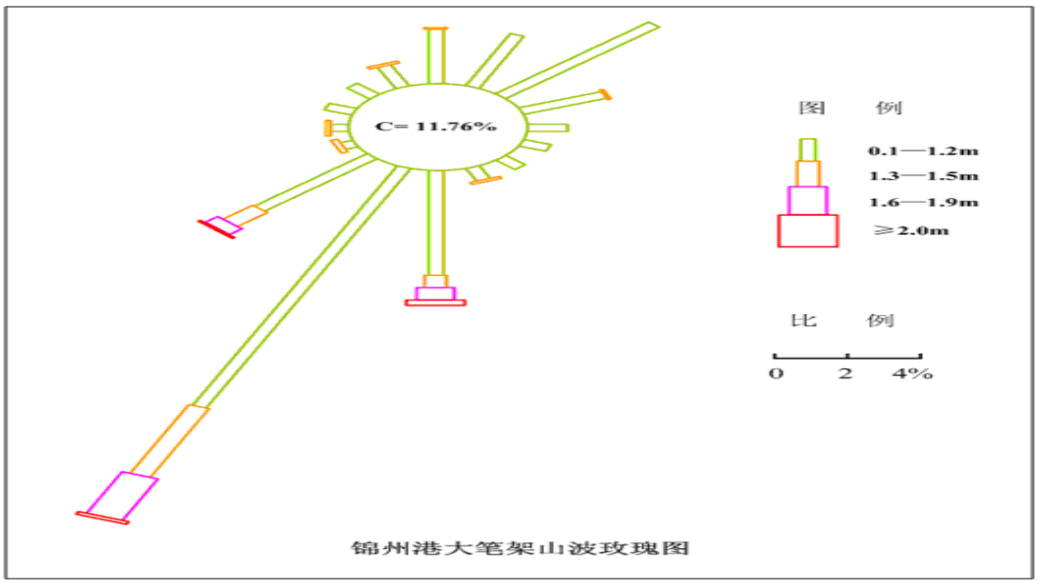

Figure 6.4 The wind rose diagram in Jinzhou (Source: Jinzhou MSA)

The inspection data are generally determined by the Beacon Hill station, measures for real-time wind instruments in Jinzhou harbor and methods for inquiring past ships.

The sea area of Jinzhou is dominated by tidal currents and basically presents reciprocating flow patterns. The average flow direction of the tide is between 330 and 350 degrees, and the average flow direction of the ebb current is between 180 and 200 degrees; the maximum velocity is 0.44m/s, the flow is 342 degrees, the maximum ebb velocity is 0.53m/s, and the flow is 236 degrees. The maximum velocity and mean velocity distribution are as follows: the surface velocity is larger than the middle velocity, and the middle velocity is larger than the bottom flow velocity.

6.2.3 Ice

According to the observation data of ice condition at Beacon Hill marine station in Jinzhou harbor, the statistical results show that: The total ice age in the sea area is

about 90 days per year, and the Jinzhou harbor enters the initial stage period around mid December, in the middle of January goes into the serious stage, and enters the final stage in late February to early March; the average fixed ice age is about 60 days a year, the average width of fixed ice is about 1000 to 1400m, with the single layer ice thickness being generally 12-25cm, the largest being about 40-60cm, and sea ice maximum edge being about 70 nautical miles.

The figure of sea ice monitoring survey of satellite remote sensing is shown below:

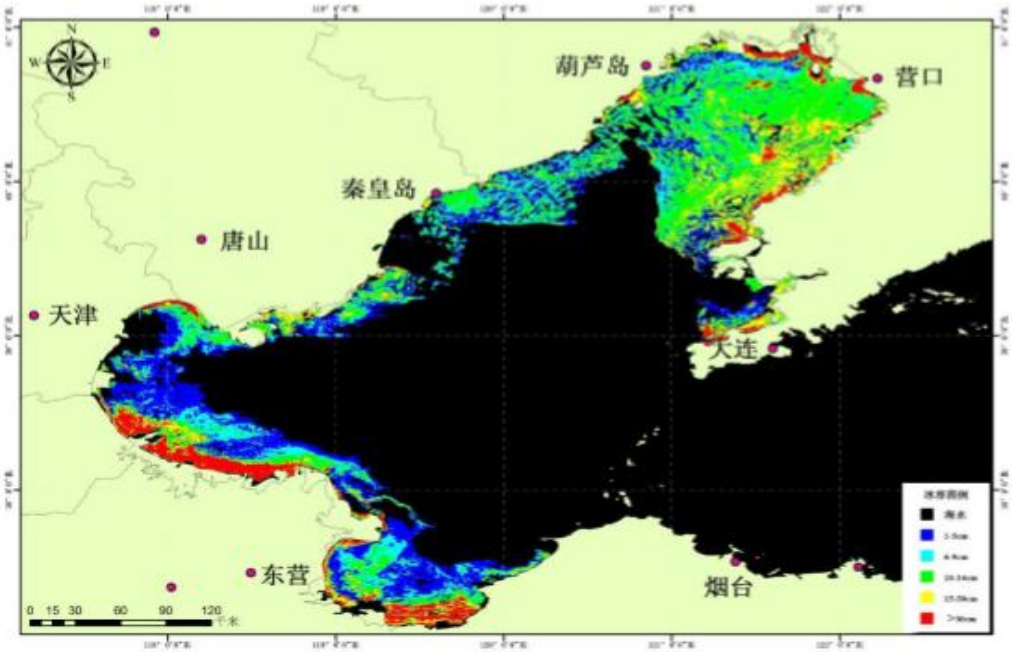

Figure 6.5 Monitoring of sea ice by satellite remote sensing (Source: Jinzhou MSA)

The detection of ice conditions is mainly carried out by means of satellite remote sensing to determine the thickness of ice sheets, patrolling at sea, on-site inspections, and inquiring about passing ships.

6.2.4 Visibility

Fog often occurs in Jinzhou area, and the observation of fog in Jinzhou harbor is mainly through visibility observation instrument, on-site inquiries from ships, and visual inspection by relevant personnel at the port.

6.3 Early warning evaluation determination and ensure the grade

Combined with the previous research on the impact of the storm, visibility, sea ice and other conditions in the natural environment on the ship navigation, and the concept of related early warning classification, according to the relevant data of the natural environment in Jinzhou area, the early warning evaluation system analysis as follows:

6.3.1 Early warning analysis of visibility bad weather

1. When the visibility is less than 500 meters, the following measures should be taken:

1) All cargo ships are prohibited from berthing, unberthing, or dock operation;
2) The anchoring liquid cargo ships are prohibited from sailing;
3) It is suggested that the vessel within the jurisdiction area of should anchor or pick up the anchor at the nearest anchorage.

2. When the visibility is greater than 500 meters and less than 800m, take the restrict of navigation measures:

1) The liquid cargo ships are prohibited from berthing, unberthing, or dock

operation;

2) Other vessels are allowed to berth, unberth or perform dock operation, but they must strictly enforce the fog navigation regulations, and adopt speed limits, vehicle stand by and anchor stand by in the port area and main navigation channel.

3. When the visibility is greater than 800 meters and less than 1.5km, the following suggestions and measures should be adopted:

Ships must strictly enforce the fog navigation regulations, and adopt speed limits, engines on standby and anchor on stand by in the port area and main navigation channel.

6.3.2 Early warning analysis of the wind

1. When the wind is greater than 8 level, to take measures:

All vessels are prohibited from berthing, unberthing, or dock operation.

2. When the wind is between 7-8 level, take the limit of navigation measures：

1) The liquid cargo ships are prohibited from berthing, unberthing, or dock operation;
2) Ships, above 3000GT, carrying steel, ore, bulk grain and other special cargo shall, if applied for berthing, issue a written declaration to the Marine administration before sailing;
3) Ships below 3000GT, if applied for berthing, are forbidden to download special cargo such as steel, ore, bulk grain and so on;

4) Ships carrying other goods may berth on the basis of the master's assurance of safety.

3. When winds are observed at 6 to 7 levels. This period of time, the wind class force timely observation, if 1 hours, the wind stability below 7. The measures taken mainly

1) Ships, above 3000GT, carrying steel, ore, bulk grain and other special cargo shall, if applied for berthing, issue a written declaration to the Marine administration before sailing;
2) Ships, such as containers, are free to depart.

6.3.3 Early warning analysis of the ice

1. When sea ice range exceeds 35 n mile:

Prohibit the old ships more than 15-year-old and single hull oil tankers to enter in Jinzhou area.

2. When sea ice range exceeds 26-35 n mile：

Prohibit single hull oil tankers enter into Jinzhou area and old vessels aged over 15 years are not recommended to enter the Jinzhou area.

3. When sea ice range exceeds 16-25 n mile:

Old ships more than 15 years and single hull oil tankers are not recommended to enter into the Jinzhou area.

4. When sea ice range is in 15 n miles:

To broadcast information about the old ships more than 15 years of age and single hull oil tankers.

6.3.4 Early warning analysis of the wind forecast within 24 hours

1. Forecast within 24 hours of offshore wind force greater than 9:

1）It is recommended to berth at the anchorage for shelter from the anchorage;
2）All cargo ships in the area are advised to shelter from the anchorage;
3）Large tankers and container liners with a tonnage of 50 thousand tons or more are required to issue a written declaration of the ship before sailing.

2. Forecast within 24 hours of offshore wind force greater than 8:
1）Ships with their safety within the airworthiness scale, should issue a written declaration of the ship before sailing.
2）It is suggested that ships under 10000GT, carring steel, ore, bulk grain and other special cargo shall be sheltered from the anchorage.
3）Ships, with a tonnage of 3000GT or less, are prohibited from berthing.

3. Forecast within 24 hours of offshore wind force greater than 7-8:
1）Ships with their safety within the airworthiness scale can berth.
2）Ships, with a tonnage of 3000GT or less, are suggested to anchor.

6.3.5 Early warning analysis of the company administration

The company's management system is also a key factor affecting the safety of the ship's sailing. Through the above analysis, the company's management system is evaluated show as below:

Table 6.2 The evaluated of company management system.

Type	Content	Comment
System	System is perfect, the safety policy is clear, Smooth running	Good
	The contents are between the good and the medium	Better
	System simply formulated, safety policy is not very clear, can simply running	Medium
	The contents are between the medium and the bad	Poor
	Lack of written system and explicit safety policy	Bad

(Source: by author)

6.3.6 Determination of maritime warning grade in Jinzhou area

Through the determination and analysis of the assessment before and the maritime classification method determined above, the maritime warning level in the Jinzhou area shall be determined as follows:

Table 6.3 The Jinzhou area warning level index

	Red	Orange	Yellow	Green

Wind（level）	More than 8	7-8	6-7	Less than 6
Visibility（m）	Less than 500	500-800	800-1.5kn	More than 1.5kn
Ice（n mile）	More than 35	26-35	16-25	Less than 15
Forecast 24h（level）	More than9	More than 8	More than 7-8	More than 6-7
Company	Bad	Poor	Medium	Better

(Source: by author)

6.4 Early warning information release

Here mainly through the Internet network, AIS, VTS, fax and other ways to achieve the release of information. By means of information broadcasting, relevant shipping companies, crew members, companies, etc. are informed. This allows the relevant departments to estimate the level of maritime danger that may occur in a given period of time, in order to prepare for prevention in advance, they can choose a targeted response to the best program.

6.5 Early warning precaution action

Through the publication of relevant information mentioned above, maritime departments, port departments, relevant shipping enterprises, and related emergency operations such as medical, fire and other departments' relevant emergency plans can be implemented. Ensure effective protection under the premise of successful maritime warning. Ensure the safe navigation of the ship and the smooth operation of the port operation.

6.6 Early warning and supervision

Through the previous release of various emergency plans, we must ensure that the relevant work has been carried out. Therefore, the surveillance of early warning action is very important. At the same time, from a successful early warning the relevant departments should find the shortcomings and insufficiency, to ensure that the next warning work can be carried out smoothly.

6.7 Chapter summary

This chapter discusses the related processes of Jinzhou maritime warning system through the previous research, analyzes the related factors, and determines the warning grades under different situations. At the same time, the warning information release, the relevant department action has a brief description.

CHAPTER 7

SUMMARY and CONCLUSIONS

Security is a state of staying away from danger or threat.（Wang, 2004, pp.19-21.）。Security is relative, not absolute. Everything has risks, and risks are everywhere, at all times, but because of the different stages, there are different risks. With the development of event, the risk may gradually increase, and then form a crisis, crisis management will lead to accidents. Early warning is to prevent the occurrence of accidents, that is, to prevent or alleviate the emergence of crisis situations. In this paper, the idea and theory of early warning are introduced into the field of maritime affairs, and exploratory research is conducted.

Firstly, this paper analyzes the warning sources of maritime early warning from three aspects of nature, ship, and safety management. Then, from these three aspects, and according to the principle of constructing index system, we construct a marine warning index system combining quantitative indicators with qualitative indicators. Referring to the international and domestic standards and methods about the warning grades, the maritime warning grade is divided into four grades: red, orange, yellow and green. Based on the analysis of the relations between the different sources of ships and the relevant meteorological information in the Jinzhou area, the maritime warning system in Jinzhou area is determined.

As mentioned earlier, this paper does exploratory research on the application of early warning ideas and theories in the field of maritime affairs. But in the selection of maritime early warning indicators, the construction of early warning index system and the classification standards and methods of maritime early warning level, it is

inevitable to take the ill considered places into consideration. The author believes that with the maturity of the warning theory and more people's research on maritime warning, the application of early warning in the maritime field will be gradually improved.

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