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Research on ship pilotage risk management and decision making in Guangzhou Port

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Research on ship pilotage risk management and decision-making in Guangzhou port

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 dissertation reflect my own personal views and are not necessarily endorsed by the University.

Signature: **YAN GENGSHUO**

Date: 28 June.2019

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ABSTRACT

Title of Dissertation: **Research on ship pilotage risk management and decision-making in Guangzhou port**

Old ship pilotage, water diversion, pilots, with water or where, in a certain ports, canals, rivers and estuaries, difficult navigation channel or on inland waters, professional personnel on a ship (he does not belong to the boat crew), and the safe navigation problems related to the ship reached the destination, provide Suggestions and advice for the captain, or without lifting the captain's responsibility, instead of manipulating the ship captain. As an important link in port operation, ship pilotage is an important guarantee to maintain the normal production and operation order of ports and serve the safe production of ports. It is directly related to the comprehensive competitiveness of ports, national sovereignty and the overall image of opening to the outside world. Strengthening the control of pilotage risk is of great significance to ensure the safety of navigation of ships and the normal operation of port production and operation, as well as to promote the healthy, orderly and high-quality development of port economy.

With the development of science and technology, people's understanding of ship pilotage accident has been deepening, and the concept of safety management has been constantly improved. At present, the management and control of ship pilotage accidents have presented some new trends and characteristics. The emergency treatment of accidents has been transformed into future-oriented crisis prevention, and pre-accident prediction and early warning have been implemented. These changes essentially reflect the shift from qualitative accident and safety analysis to quantitative risk analysis and precontrol.

Based on FAS safety assessment technology and relevant theories and methods, this paper investigates and analyzes the current situation of ship pilotage safety in Guangzhou port, and analyzes the pilotage accidents occurred in recent ten years. On this basis, the pilotage risk of Guangzhou port is evaluated. Then, according to the results of pilotage risk assessment and analysis of Guangzhou port, the paper adopts bayesian risk prediction theory to predict the pilotage risk of Guangzhou port. Finally, according to the conclusions of pilotage risk assessment and prediction, the corresponding guiding ideology and basic tasks of pilotage risk precontrol management of Guangzhou port are pointed out, and the specific measures of pilotage risk precontrol of Guangzhou port are put forward.

By applying the FSA and bayesian theory of ship piloting risk and some of the risk of future trends of research, help pilot management decision makers to know and control the uncertainty of the future, give full consideration to the future possible status, and risk constraints, so as to make the risk control scheme is more scientific and feasibility of for Guangzhou port of ship piloting management departments to provide effective decision support.

KEY WORDS: Ship pilotage. FSA   risk prediction precontrol

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LIST OF ABBREVIATIONS

FSA	Formal Safety Assessment
UC	Unsafe Condition

CHAPTER1
INTRODUCTION
1.1 Research Purpose and Significance

The ship pilotage at Guangzhou port spans six public waterways in the pearl river estuary (including Zhuhai, Shenzhen, zhongshan, dongguan and Guangzhou), which has: Long channel and limited scope of navigable waters, bend and complex flow, the ship type and number density, navigation etc, although in the pilot cadres, the worker's solid hard work and enterprising, Guangzhou port pilot enterprise has realized leap-forward development, effectively service to the port construction and development, to ensure the safety of the port production, however, with the continuous development of our country's economy, the increase in the Numbers of large ships, some building berth or terminal constantly put into use, Guangzhou port waters of ship navigation environment will become more complex, the ship piloting risk will also increase. Therefore, this paper makes full use of the relevant theory of risk management to carry out an in-depth investigation on the risk of pilotage in Guangzhou port, and carefully analyzes the risk existing in the ship pilotage work for many years and its causes. By introducing the theory and method of risk prediction, combining with the actual situation of pilot station of Guangzhou port and pilotage area of Guangzhou port, this paper analyzes and predicts the risk of ship pilotage theoretically, and puts forward some decision-making Suggestions on the precontrol of pilotage risk of Guangzhou port.

Ship pilotage safety has always been a research hotspot in the international shipping industry and has always been a great concern of the governments of various countries. In order to promote and improve the government management of the pilot safety work, the international maritime organization (IMO) at the end of last century requires member states to apply the FSA in maritime security in the field of study, encourages member states to adopt the FSA to ship pilotage safety management of special research, and apply the advanced comprehensive safety assessment method to avoid the ship pilotage accident, to ensure the safety of ship navigation work. FSA (Formal Safety Assessment, hereinafter referred to as FSA, comprehensive Safety

Assessment) is an advanced structured and systematic comprehensive Safety Assessment method, which has been actively applied and promoted abroad. It through the risk identification, risk assessment and risk control plan, cost and benefit evaluation, policy recommendations, such as standardization of five steps, the comprehensive summary and analysis of the present situation of pilot safety, combined with the actual working condition and needs, to improve or develop safety standards or operating norms, making pilot related management to improve and perfect, and make the countermeasure measure to achieve coordination between the costs and benefits. The results of FSA can be used as supporting data to modify pilotage safety standards and formulate pilotage safety measures, so as to improve the level of ship pilotage safety management.

At present, the navigation environment of Guangzhou port is complex and the traffic flow density of vessels is high. Through the method and technology of FSA, the collected data and data are counted, analyzed and processed. On this basis, the safety situation of ship pilotage management in Guangzhou port is qualitatively and quantitatively assessed to find out various risks that may lead to pilotage accidents. Through the analysis of the causes of risks and consequences, determine may cause accident of high risk area, identify the main factors influencing the level of risk, and explain the scope of risk analysis results, and according to the dangerous degree of sorting, clear to solve the main problems of pilotage safety work, and puts forward the prevention and control pilot and reduce pilotage accident risk decision-making advice, measures and implementation.

1.2 Research Status at Home and Abroad

1.2.1 Foreign Research Status

A great deal of work has been done on maritime navigation safety in foreign countries, especially by Japanese experts or scholars in Marine traffic engineering who use the methods of Marine traffic flow simulation and ship handling simulator simulation, and make remarkable achievements in the evaluation of ship handling environment and navigation environment safety. Britain's Vldimierm. Trbojevic &

barryj. Carr proposed a port navigation safety management system based on risk. Many ship traffic safety is assessed through safety analysis, and then the improvement scheme of management is proposed. Hin three inoue, for example, in the context of quantitative evaluation of ship manoeuvring burden from two aspects: the quantitative processing the potential risk of collision, a waters is a ship sailing in the waters during how many ships will meet with him, every time a boat will meet to fuck increase how much burden, and a quantitative representation as the traffic conditions of navigation potential dangerous levels of indicators; After the EXXON VALDEZ accident in 1989, the deep research and application of risk analysis and risk management were initiated. Probabilistic Risk Assessment (PRA), which is widely used in other engineering fields, is gradually applied to ship Risk analysis.

In recent years, the research and application of comprehensive safety assessment method (FSA) on ship navigation safety has been carried out all over the world. As the pioneer of ship safety assessment research, Britain has made a lot of achievements in its research and application. British scholars and experts have conducted in-depth studies on the application of oil tankers, cargo ships, container ships, passenger ships, offshore drilling platforms and other operating ships, accidents and risks of ships at sea and other Marine engineering aspects, and put forward some Suggestions to reduce risks and provide safety level.

1.2.2 Domestic Research Status

In the research and application of the comprehensive safety assessment method (FSA) to ship risk management in China, researchers from various research institutions and universities have also carried out some work. Some domestic experts and scholars have also studied the methods of data processing and quantitative analysis in the evaluation method, and discussed the application in hull strength, ship loading and unloading, transportation of toxic liquid substances and ship accidents, and made some progress in this research work.

Combining the applicable scope and object of standardized safety assessment, Xuanshaoyong tries to put forward a relative risk assessment model based on membership function from the perspective of accident representation for the first time, and applies it in the research of standardized safety assessment of pilotage safety of a certain port in China.

Ma fei studied pilotage safety by using two risk analysis methods based on asset vulnerability analysis method and accident tree analysis method, and reached basically the same conclusion when using accident tree analysis method and analysis method based on asset vulnerability risk assessment model to conduct risk analysis of ship pilotage.

Hong zhibing studied the ship pilotage under bad weather conditions, and put forward the safe pilotage methods under various bad weather conditions.

To some extent, these researches provide basic ideas, methods, procedures and means for risk management and countermeasures of ship pilotage, and have certain theoretical and practical significance.

1.3 Main Contents of the Study

The main research contents of this paper are as follows:

(1) Adopt FSA safety assessment technology and its corresponding theories and methods to investigate the current situation of vessel safety pilotage in Guangzhou port in various ways in recent years, so as to accurately grasp the actual situation and relevant data of vessel safety pilotage in Hong Kong;

(2) Systematically process and analyze the survey data and data, comprehensively identify various risks existing in the pilotage work of Guangzhou port, as well as the causes and possible consequences of these risks. On the basis of determining the existence of risk and its objective distribution, various factors affecting the risk degree are analyzed.

(3) Quantified the frequency, risk and consequences of various risks in pilotage accidents, and found out the high risk areas and the key factors affecting the risks, as well as the causal relationship caused by these high risk areas and the key risk factors;

(4) Fully consider the practical needs of pilotage safety of ships, combine modern science and technology, put forward corresponding measures to reduce risks in high-risk areas and key risk factors after sequencing, and formulate feasible risk control plans;

(5) Comprehensively consider the feasibility and effectiveness of different risk control schemes, put forward the final project report of pilotage FSA application, risk prediction and pre-control, and put forward reasonable decision-making Suggestions for improving and improving pilotage safety of Guangzhou port.

Chapter 2

Analyzes the Current Situation of Ship Pilotage Safety in Guangzhou Port

2.1 Overview of Guangzhou port

Guangzhou port is located in the pearl river delta heartland, in Guangzhou, dongguan, Shenzhen, Zhuhai, zhongshan city, because of the many islands of pearl river mouth, waterways densely, Humen, Manila, hong special waterway sea door, make Guangzhou China ocean shipping port of excellence and the entry and exit ports of the pearl river basin, is China's major coastal ports and important hub of national comprehensive transportation system, is the main port of transshipment, energy supplies and raw materials in Guangdong province and the pearl river delta oil, coal, grain and other important goods distribution center.

In recent years, the scale of Guangzhou port has been continuously expanded and the port level has been significantly improved. The vessel flow in Guangzhou port waters has been increasing significantly year by year, and the intensity of navigation has been increasing day by day. The difficulty and risk of pilotage safety management have also been increasing.

2.1.1 Water Area

(1) Harbour waters

The waters of the harbour are composed of the pearl river trunk stream and related tributaries within the boundaries of the east, west, south and north. The Middle East boundary consists of dongjiang estuary, mayong estuary, freshwater estuary, dongguan estuary, xienwu yongkou and chuanbi estuary. The western boundary consists of huangqi waterway and chencun waterway. The southern boundary is bounded by datangwei pilotage anchorage. The northern boundary is composed of liuxi river and ishii river. (2) inland river waters

(2) inland river waters

Inland river port waters are navigable inland river waters outside the harbor waters of Guangzhou administrative region.

2.1.2 Pilotage Area

At present, the pilotage area of Guangzhou port covers the whole water area of Guangzhou port, and downstream along the pearl river successively involves the water area of inner port, Huangpu water area, Xinsha water area, Nansha water area and Humen water area. The pilotage waters of guangzhou port span five cities, namely, Guangzhou, dongguan, Shenzhen, Zhuhai and zhongshan. Pilotage area is divided as follows according to pilotage operation characteristics:

(1) within Hong Kong waters: guide (including the dock) within village oil terminal wharf, buoy, anchorage, including the original eight area within the scope of the west river, east river channel and south channel, including sand port, Chau head mouth, big head sand wharf, Guangzhou shipyard, etc., mainly for Guangzhou and the pearl

river delta regional energy, raw materials, food, bulk cargo and container loading and unloading and passenger transport services. The inner harbor channel has wide ship international, there are large ships, special ships in and out.

(2) the Huangpu waters: refers to the Huangpu waterway channel, iron pile (DCF model - a new creation) near the docks, buoys, anchorage, main is a traditional Guangzhou port waters, including Whampoa the old port wharf, Guangzhou petrochemical wharf, Whampoa oil terminals, west coal terminal, Xingang seaport, pineapple temple shipyard, wen Chong shipyard and Huangpu shipyard, etc., mainly to undertake coastal, JinYang container transport and food, coal, chemical fertilizer, product oil and other bulk cargo transport. The Dongjiangkou operation area contains the yard container terminal and Yihai terminal for outward transportation, and the entry and exit of small and medium-sized container ships and general cargo ships. The flow of Dongjiang estuary is complex and the flow of ships is large, which is easy to cross with the large and medium-sized ships entering and leaving Huangpu waters of Guangzhou port. In the operation area of Huangpu new port, there are large and super-large bulk carriers operating at departure and turning around all the year round. These operations are difficult and have a great impact on the normal navigation of ships. It is particularly worth mentioning that the D7 turning area located in the channel is the turning area of berthing ships and has a high traffic density.

In addition, there are three shipyards (Wenchong shipyard, captain pineapple temple and Guangdong cosco shipping) in pineapple temple waterway, which is connected with Huangpu waterway.

(3) Xinsha water area: refers to the anchorage of Lianhua mountain, Chisha waterway, dahaozhou waterway, wharf, buoy and anchorage near pineapple temple waterway. Located in dongguan city, the wharf is located at the east bank of lianhua shandong channel from mayong estuary of pearl river main stream to broken water sluice. The navigation section is narrow, the slope ratio is only 1:5, and the rock section is 1:2, which makes ship operation difficult.

(4) Nansha waters: it is the navigable waters located at the west bank of Nansha district, Guangzhou city, and the west bank of Shishiyang and lingdingyang sections of the pearl river trunk stream. This area includes Erhu anchorage, as well as important wharf berths such as container terminals of various stages in Nansha waters, ro/ro loading terminal of Shazai island, xiaohu island dangerous goods main wharf and longxian shipbuilding base. In this area, the anchorage ships enter and leave frequently, large container ships turn around, berthing operations are intensive, and there are many dangerous goods ships entering and leaving the port. In addition, this section collects all the ships entering and leaving the sea channel from Guangzhou port, and is the only way for the ships entering and leaving Xinsha water area, Huangpu water area, inner port water area and humen port of dongguan, with a high traffic density.

(5) dongguan waters: refer to the wharf, buoy and anchorage near the east side of Junbanzhou to Dahaozhou 1 anchor section in the main shipping channel of Guangzhou port, except Xinsha pier. Close to the sea channel of Guangzhou port, especially the three major operating areas (west daitan, lisha island, xinshannan) and the two estuaries (shatin estuary, freshwater estuary), the traffic flow is complex, and the ship traffic density is high. The wharfs in the waters (50,000-ton class) are all located on the east bank of the sea channel of Guangzhou port. The sea channel of Guangzhou port (Lianhua-shandong channel) at the front of the wharf is used as the braking water area, which brings difficulty in maneuvering and avoiding.

2.1.3 Port Meteorological Conditions

(1) wind condition

From September to march of the next year, the wind is mostly northeast and north, among which from November to January of the next year, the wind is strong and lasts for a long time in winter. Generally, the wind force is 4-5, and the number of days above wind force 6 can last for 7 days, at least 12 days per month, and the maximum wind force is 9. In April and may, the wind is mostly southeast and east, with a force of 3-4; from June to August, the wind is mainly south to southwest, with a force of 3-4. There are few gales in summer, but there are thunderstorm gales from may to September every year, and the wind force can reach 10. In addition, may to November is often affected by the periphery of tropical cyclones and even the typhoon center. According to the statistics from 1949 to 1980, the average number of tropical cyclones landing on the coast of Guangdong is 6.2 times per year, and the average number is 4-5 times per year. The most frequent is from July to September, and the average number of harmful tropical cyclones landing on the pearl river estuary is 2 times per year, and the maximum wind power is over 12. From November to march the next year, it is often affected by cold wave, with wind force of 5-8.

Among them, tropical cyclones, especially typhoons in the south China sea, have varied paths and fast moving speed. When passing through, they cause high winds and waves in the whole water area, posing a serious threat to ships, and have caused many shipwrecks or casualties. Ships should pay great attention to the harmfulness of tropical cyclones.

Due to the strong wind and large waves, the cold wave in winter seriously threatened the navigation safety of ships in the waters near the pearl river estuary, and also caused serious accidents.

Thunderstorms and strong winds often occur in the pearl river mouth door, because of sudden attack, it is difficult to prevent, to inland river ships caused a certain threat, 70 to 80 years had caused a group of deaths and injuries of malignant accident.

(2) the fog

The pearl river estuary is one of the four foggy centers along the south China coast. December to the next year in May for the fog season, the annual average fog days (visibility less than 1000 meters) have 28 days, including march fog days the most, the monthly average fog days for 7.9 days, the most up to 13 days, October, November the least. Fog days usually last 2-3 days. The annual average number of days with visibility less than 4000 m was 38, with 12 days being the most in March.

Heavy fog poses a serious threat to ship navigation. In recent years, collision accidents between cargo ships and fishing boats often occur, causing serious economic losses and casualties.

(3) thunderstorms

The annual average is 39 days, with may having the most days with an average of 7 days. The earliest day of the thunderstorm is February 11, the latest day of November 8, the latest day of April 28, the earliest day of September 9. Thunderstorms often occur in the pearl river estuary, which poses a certain threat to inland ships.

2.1.4 Port Hydrological Conditions

(1) tides

The pearl river estuary tide is an irregular semi-diurnal mixed tidal type with the tidal coefficient between 0.94 and 1.77. The tidal cycle is about 12 hours and 25 minutes. The average sea surface is 1.2 ~ 1.4 meters. The average tidal range of each tidal station along the sea passage in Guangzhou port is not more than 2 meters, which is a weak tidal estuary.

The tidal wave motion direction of Lingdingyang estuary is south-to-north, and there is certain potential difference due to the long distance between north and south. Guishan island was the first to feel the tide, followed by Chigwan and neilingding, and then the tidal peak lagged behind, such as junbanzhou, humen, etc., for 1 ~ 1.5 hours later than neilingding, and the tidal valley lagged behind 1.5 ~ 2 hours.

During the upstream propagation of tidal waves in the lingdingyang estuary, wave energy accumulates under the influence of the horn-shaped boundary, leading to increasing tidal range along the way and the maximum average tidal range near humen. From then on, the tidal range decreases gradually under the influence of runoff and bed energy dissipation. In the transverse aspect, the tidal range of the east bank is greater than that of the west bank, which makes the tidal capacity of humen much higher than the three mouths (jiaomen, hongqili and hengmen) in the northwest of lingdingyang.

(2) trend

The tidal current in the waters of Guangzhou port belongs to irregular half-day tidal current, which basically presents reciprocating current. Due to the difference of location and landform, tidal current characteristics in Humen inner and outer waters are different.

The tidal current of Lingdingyang is irregular half-day tidal current. North of inner Lingding island, the tidal current is reciprocating flow, and south of inner Lingding island, the tidal zone is rotating. In general, the flow direction is NW at high tide, and east and west at low tide. The maximum velocity occurred between Humen and Lunbanzhou, with a surface ebb velocity of 2 m/s (about 4 knots).

The river channel within Humen is narrow and affected by the beam flow on both sides of the river.

(3) waves

Guishan island station is dominated by wind and waves, with frequent waves to the southeast, accounting for 5 8.5%, followed by southwest and northwest, accounting for 18.0% and 15.4%, respectively. The average wave height is 0.53 meters, the maximum wave height is 2.56 meters, and the average cycle is 3.3 seconds, and the maximum cycle is 6.5 seconds. Neolingding island station is mainly composed of wind and waves, which are usually in the southeast, followed by northeast and southwest. The frequency is 20.6%, 18.8% and 16.1% respectively. The average wave height is 0.4 meters, the maximum wave height is 1.9 meters, and the average cycle is 2.1 seconds and the maximum cycle is 4.5 seconds. The whole Lingdingyang ocean is gradually weakened from south to north.

2.1.5 Anchorage

Guangzhou port has 88 anchoring places and 23 pontoons, with a maximum anchoring capacity of 300,000 tons. Its main functions are ship tide waiting, joint inspection, berth waiting, wind shelter, ship turning and transfer operations. Among them, Guishan anchorage is the general pilotage, quarantine and platform proof anchorage; south of spider island and Daitanwei anchorage are the large pilotage anchorage; Sanmen island anchorage is the main mooring, quarantine, platform proof and transfer anchorage.

2.1.6 Channel

The main channel is composed of the main channel to the sea and the main channel in the inner harbor waters.

The main sea channel from the pearl river estuary Guishan anchorage GS18 to Huangpu waters, the total length of which is about 153 kilometers, including Dahao waterway, Rongshutou waterway, Lingding waterway, Chuanbei waterway, Dahu waterway, Nizhoutou waterway, Lianhua mountain west waterway, Xinsha waterway, Chisha waterway, Dahaizhou waterway and Huangpu waterway. Among them, the bottom elevation of the sea channel (east channel) from the west Tenchi tou area of Huangpu water area to Nansha water area is -13.0 meters with a width of 160 meters. The bottom elevation of the sea channel from Nansha waters to Guishan anchorage of pearl river estuary is -17.0 meters, and the bottom width is 243-385 meters.

The total length of the main channel in the inner harbor is about 39 kilometers, including Xihe channel, Nanhe channel, Lijiao channel, Fenshuitou channel, Haixingang channel, newly built channel and iron pile channel.

2.1.7 Dock Facilities

The port now has 617 berths of various types, including 51 berths for 10,000-ton class or above. Among them, 45 container berths (12 berths for 10,000-ton class or above); 24 special coal berths (7 berths for 10,000-ton class or above); 49 special berths for petrochemical industry (6 berths for 10,000-ton class or above); 2 ore berths (14 grain berths).

2.2 Hazard Analysis of Ship Pilotage in Guangzhou Port

n the study of system safety, it is considered that the existence of hazard is the fundamental cause of accidents, and the prevention of accidents is to eliminate and control the hazard in the system.

Hazard source refers to the position, area, place, space, post, equipment and its location in a system that has potential energy and material release hazards and can be transformed into accidents under the action of certain trigger factors. That is to say, the source of danger is the core of concentration of energy and dangerous substances, which is the place where energy comes out or breaks out. Hazard sources exist in the identified system, and the hazard areas are different in different system ranges. For ship pilotage, ship and traffic environment are the source of danger. Hazard source is the potential unsafe factor that may lead to the accident.

2.3 Summary of Vessel Pilotage Safety at Guangzhou Port

By analyzing the characteristics of pilotage safety accident in Guangzhou port, the following conclusions can be drawn:

(1) with the rapid development of the international shipping industry, the port throughput increases rapidly. The number of large ships and super-large ships coming to the port increases year by year. In addition, the construction of various types of engineering ships in the port, resulting in the traffic density of Guangzhou port is extremely high. From 5,753 ships in 2000 to 14,949 ships in 2011, the number of pilotage operations in Guangzhou port is setting new records every year. The increasing pilotage volume of ships in and out of port brings new changes and requirements to pilotage safety.

(2) the overall accident rate of Guangzhou port is not very high, and the annual average accident rate is only about 1/1000, indicating that the pilotage of ships in Guangzhou port is generally at a safe level. However, the annual accident rate was relatively high in 2000, the lowest in 2001, and then rose again in 2003 and 2006, and remained at a relatively low level until 2011.

(3) from the perspective of accident occurrence time, march and April are the months with the most accidents, and this time of year is the season transition period, with frequent fog days. The most common time of day for accidents is between 1300 and 1500, and between 1500 and 1700, when people feel the most tired.

(4) from the point of view of accident location, a high proportion of accidents occurred in Xinsha water area, Lingding water area and Huangpu water area, followed by Shajiao water area, Nizhoutou water area and Erhu water area; Accident prevention in these areas should be a major concern.

(5) from the perspective of accident water area type, it is necessary to focus on the navigation channel and near the wharf, while accidents occur less in the navigation channel and anchorage.

(6) from the perspective of the ships involved in the accident, there are more accidents on ships with a length of 150-250 meters; Ships with a draft of 5-10 meters have many accidents. More accidents happen on ships with a gross tonnage of 10,000-30,000 tons; The accident that general cargo ship produces is much, it is container, tanker, bulk carrier next.

(7) according to the ship dynamics at the time of the accident, a high proportion of ships have accidents during the voyage, followed by berthing from berth, and mooring accidents are the main ones during berthing from berth.

(8) in terms of the nature of the accident, contact damage and collision accidents occur frequently, followed by stranding, while most of the contact damage accidents are collision with wharf.

(9) as for pilots, the proportion of pilots aged 31-40 who have accidents is high, while the proportion of pilots aged over 51 who have accidents is small; Pilotage almanac has a high proportion of accidents in 6-10 years, followed by pilotage almanac of 1-5 years.

(10) the collision accident of Lingding waterway, the collision and grounding accident of Xinsha water area, the grounding accident of Nizhoutou water area and Whampoa water area should be paid attention to. Attention should be paid to navigation accidents in Lingding waterway and Xinsha water area and docking accidents in Xinsha water area and Huangpu water area.

Chapter 3

Risk Assessment of Vessel Pilotage in Guangzhou Port

3.1 Elements and Composition of Vessel Pilotage Risk in Guangzhou Port

Conduct risk analysis of identified hazard requirements in accordance with the steps of comprehensive safety assessment (FSA) risk analysis. This analysis requires more quantitative analysis. This part discusses the standardized identification and analysis of the risk of pilotage safety of ships, so as to put forward reasonable and effective Suggestions and measures to control the risk, so as to improve the safety work and improve the safety level.

3.1.1 Research Steps of Risk Analysis

Risk analysis is to determine the existence of risk and its objective distribution on the basis of analysis of various factors affecting the degree of risk. The high risk areas and key risk factors can be found through the primary and secondary ranking method, and the relationship between accident occurrence and accident consequences can be analyzed, so as to modify the existing standards or regulations and formulate new standards or regulations, so as to achieve the purpose of reducing the existence and occurrence of risks.

In the process of risk analysis, the following steps are adopted:

(1) determine the risk types analyzed and the corresponding risk measurement units;

(2) adopt risk analysis models indicating risk distribution paths in different accident categories and subcategories as required;

(3) after statistical analysis of relevant accident data, determine the frequency and consequence distribution of risks of various accident types, as well as all factors affecting risks;

(4) adopt appropriate methods to calculate various risk values, including the commonly used FN curve (frequency consequence curve) which can reflect the quantified risk level of a certain type of accident;

(5) according to various calculated risk values, appropriate risk standards are selected for analysis and comparison, and then risk results are classified into three different risk categories: "negligible", "intolerable" and "reasonably feasible low-risk area".

Through risk analysis, we can determine the high risk areas to be considered for different types of risks, identify the main factors affecting the risk level and explain the scope of the risk results analyzed. The main tasks are:

(1) probability. Find out the area with high probability of accidents, regardless of the severity of consequences;

(2) severity: find out the area with the most serious consequences of the accident, and ignore the probability of the accident;

(3) risk level, considering the frequency of accidents and severity of consequences. An accident with an "intolerable" risk level becomes a point of attention.

(4) degree of reliability: identify the area with considerable uncertainty in terms of risk, severity of consequences or probability in the risk contribution tree.

Before carrying out the above, statistical analysis should be carried out to determine the influencing factors of risks and conduct numerical quantification. It is divided into three stages: (1) quantifying the frequency of various accidents and sub-classification accidents by the frequency of accidents (i.e., assigning frequency data to separate causal events); (2) quantitative magnitude of accident consequences; (3) use the risk value to represent the distribution of the risk of a certain type of accident, indicating the contribution of all kinds of accidents to the overall risk.

3.1.2 Research Methods and Principles of Risk Analysis

1. Risk analysis

In terms of safety, risk is an objective quantity describing the risk degree of the analysis object. The main considerations are :(1) risk is regarded as the possibility of harmful or abnormal events in the system; (2) risk is regarded as the degree to which a harmful event or abnormal event causes harm. Risk has dual characteristics of frequency and degree of consequence, namely:

$$Risk = f(F, N) \quad (3\text{-}1)$$

Where, F: event occurrence frequency, N: event consequence degree.

In the above definition of risk, no matter the loss or consequence, it is defined for accidents, including accidents that have happened and accidents that will happen. Since risk is a measure of the risk of a system, it is not sufficient to measure the risk of a system only in terms of accidents, unless all possible forms of accidents can be identified.

2. Frequency standard

Frequency is a common measure of probability that describes the probability of a harmful or abnormal event occurring. For ship navigation, frequency is the ratio between the number of events and the amount of ship activities per unit time. Equation 3-2 is the calculation equation.

$$F = \sum C_i \Big/ \sum Q_i \quad (3\text{-}2)$$

Where, is the equivalent number of accidents, is the equivalent amount of ship activity.

In the process of FSA analysis, the quantitative value of frequency is required to be qualitatively divided. In general, descriptions of frequency are used frequently, probably, occasionally, rarely, etc.

3.1.2.1 Criteria of Consequences

The consequence is to describe the degree of damage caused by a harmful or abnormal event. The quantification of consequences is a complicated problem in safety analysis. Depending on the different research and analysis angles, the quantitative analysis of the consequences involves different scope. For ship navigation, the consequences are divided into three categories:

(1) loss of life, including injury or death, caused by harmful or abnormal events from the perspective of safety.

(2) from the perspective of business losses, direct economic losses caused by harmful or abnormal events, including shipwreck losses.

(3) environmental pollution losses caused by harmful or abnormal events from the perspective of environmental pollution.

In the analysis of actual accident consequences, various risks need to be considered, such as the risk to personnel or the risk of economic loss. As the risk to the environment is the joint risk or secondary risk of ship navigation, more attention should be paid to the risk of traffic safety in the risk analysis. In view of this content, the consequences caused by accidents often involve the above two categories (1) and (2). Therefore, the standard of consequences is "equivalent consequences of accidents". For example, the consequences of the loss of life caused by seriously injuring one person are equivalent to the consequences of the direct economic loss of 300,000 yuan.

For ship navigation, accident consequence N is the ratio of the sum of the equivalent consequence of the occurrence of events in unit time and the sum of the occurrence times of events. Equation 4 is the calculation equation.

$$N = \frac{\sum pN_i}{\sum C_i} \qquad (3\text{-}3)$$

Where, is the equivalent accident consequence of the accident, is the equivalent number of accidents.

In the process of FSA analysis, it is required to assign quantitative values to the qualitative division of consequences. In general, the description of the consequences is very serious, severe, moderate, mild, etc.

3.1.2.4 Risk Criteria

In order to comprehensively consider the accident frequency and consequences, the calculation of risk can be expressed by the calculated value of risk in each state, and the calculation equation is equation (3-4).

$$Risk = F \times N$$

$$Risk = \frac{\sum C_i}{\sum Q_i} \bullet \frac{\sum pN_i}{\sum C_i} = \frac{\sum pN_i}{\sum Q_i} \qquad (5)$$

For different types of problems, a variety of risks may need to be considered, such as risks to people (both personal and social), risks to the environment, or risks leading to economic losses. Different risk measurement units are generally adopted to represent different risks. There are basically two kinds of risk measurement, personal risk and social risk. The two measures differ slightly. Generally speaking, personal risk is analyzed by risk matrix, while social risk is analyzed by FN curve.

FN curve can comprehensively analyze the risk situation including property loss and human casualties, and is the most effective and accurate method for system risk analysis.

The risk matrix is also used in FSA analysis. Risk matrix is an effective classification and identification method for risk analysis. The risk matrix can comprehensively represent two elements of risk: accident frequency and consequence severity. According to the calculated results, the risk of the analysis is classified into three different risk categories: "negligible risk area", "reasonable and feasible low risk area (ALARP)" and "intolerable high risk area". In table 3-1, the dark color area (R8 ~ R11) is the "intolerable high risk area", the light color area (R5 ~ R7) is the "reasonable and feasible low risk area", and the white area (R2 ~ R4) is the "negligible risk area", as shown in figure 3-1.

very serious	F1S7(R8)	F2S7(R9)	F3S7(R10)	F4S7(R11)
[redacted]	F1S6(R7)	F2S6(R8)	F3S6(R9)	F4S6(R10)
	F1S6(R7)	F2S5(R7)	F3S5(R8)	F4S5(R9)
	F1S6(R7)	F2S5(R7)	F3S5(R8)	F4S4(R8)
general	F1S3(R4)	F2S5(R7)	F3S5(R8)	F4S3(R7)
	F1S3(R4)	F2S2(R4)	F3S5(R8)	F4S3(R7)

slight	F1S3(R4)	F2S2(R4)	F3S1(R4)	F4S3(R7)

Source: Xuan Shaoyong. Master's thesis of Shanghai maritime science, 2005.

Figure 3-1 schematic diagram of risk matrix data

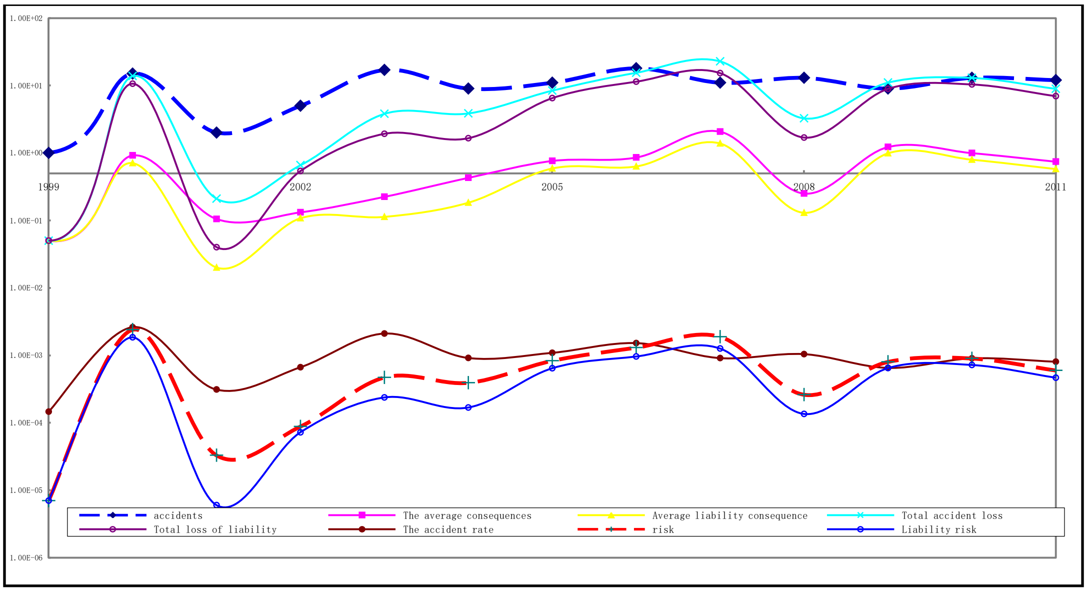
The risk level obtained from the analysis should be identified by comparison to determine whether the risk is within the tolerable range, and appropriate and reasonable risk standards should be selected as the discriminant criteria. In general, decisions should be made not on the basis of a single acceptable risk criterion, but on the basis of a standard of risk coverage. For example, individual risk criteria, social risk (also known as group risk or catastrophe risk) criteria and so on. In the absence of acceptable risk standards available for risk, the applicable standards of other industries can be used for reference.

The issue of safe navigation of ships requires consideration of various risks, such as the risk to personnel or the risk of economic loss. As the risk to the environment is the joint risk or secondary risk of ship navigation, more attention should be paid to the risk of traffic safety in the risk analysis.

3.1.3 Risk Analysis

Aiming at the pilotage accidents occurred in the pilotage center of Guangzhou port from 1990 to 2011, statistics and analysis of the accident data are carried out on the basis of systematical arrangement and analysis of accident data and establishment of pilotage accident database system, as shown in figure 3-2. In order to properly collect and reflect the pilotage accident involved in all kinds of the outside world and the influence of artificial factors, according to the needs, information and data in specially designed the detailed accident investigation, on the basis of registration forms, through comprehensive solicit opinions of the pilot's representative and safety management personnel, lead ship in the pilot work of Guangzhou port and accidents of various types, different segment of pilotage, the wind flow and conditions of the limitation of individual elements of human factors, people - interface, people -

hardware interface and software interface and the actual situation of the interface of people and environment, analyses the risk of Guangzhou port pilot.



Source: Duan Aiyuan. Research on the application of comprehensive safety assessment (FSA) in ship traffic safety management in port waters.

Figure 3-2 historical analysis of pilotage risk

1. Pilotage Risks in Different Pilotage Waters of Guangzhou Port

As shown in table 3-1, pilot water areas with high accident frequency are Xinsha water area, Lingding water area, Huangpu water area, Shajiao water area, Nizhoutou water area and Erhu water area.

Pilot waters with serious accident consequences are: Shajiao water area, Erhu water area, Lingding water area, Huangpu water area, Xinsha water area and Nizhoutou water area.

Pilotage areas with high risks are: Sha kok waters, Lingding waterway, Xin Sha waters, Huangpu waters, Erhu waters and Ni chau tau waters.

Table 3-1 risk analysis table of pilotage waters of Guangzhou port

water area	frequency	accident consequences	Responsibility for the consequences	Liability risk	risk
*Inner harbour waters	0.0023%	0.20	0.13	0.0002%	0.0003%
*Huangpu waters	0.0130%	0.63	0.46	0.1052%	0.1522%
*Xinsha waters	0.0250%	0.27	0.20	0.1194%	0.1627%
*Nansha waters	0.0023%	0.20	0.20	0.0003%	0.0004%
*Dongguan waters	0.0023%	0.49	0.37	0.0003%	0.0005%
Nizhoutou water area	0.0068%	0.73	0.52	0.0304%	0.0444%
Two tigers waters	0.0068%	2.03	1.62	0.0976%	0.1395%
ShaJiao waters	0.0085%	2.90	2.10	0.2353%	0.3613%
Guishan waters	0.0028%	0.20	0.14	0.0003%	0.0005%
Lingding waterway	0.0142%	0.73	0.41	0.0899%	0.1852%
Lantau waters	0.0011%	0.70	0.14	0.0001%	0.0002%

2. Pilotage Risks of Different Pilotage Dynamics at Guangzhou Port

Pilotage risk statistics of different pilotage dynamics in Guangzhou port are shown in table 3-2, 3-3.

Table 3-2 dynamic risk analysis table of each pilotage of Guangzhou port

The ship dynamic	frequency	accident consequences	Responsibility for the consequences	Liability risk	risk
sailing	0.0520%	1.14	0.79	2.9125%	4.5451%
Berthing (floating/alongside)	0.0210%	0.48	0.40	0.0561%	0.0029%
Berthing (floating/parallel)	0.0057%	0.31	0.21	0.0066%	0.0057%
Turn around	0.0091%	0.18	0.08	0.0216%	0.0232%
Anchoring	0.0028%	0.29	0.25	0.0121%	0.0175%

Table 3-3 detailed analysis table of each pilotage dynamic risk of Guangzhou port

The ship dynamic	dynamic	frequency	accident consequences	Responsibility for the consequences	Liability risk	risk
sailing	sailing	0.0520%	1.14	0.79	2.9125%	4.5451%
Berthing	Department of floating	0.0057%	1.33	1.09	0.0453%	0.0645%
	From the floating	-	-	-	-	-
	mooring	0.0148%	0.16	0.15	0.0108%	0.0132%
	The navigation	0.0057%	0.31	0.21	0.0066%	0.0080%
	reach port	0.0006%	0.20	0.04	0.0000%	0.0000%
	From the port	-	-	-	-	-
Turn around	Turn around	0.0091%	0.18	0.08	0.0216%	0.0232%
Anchoring	Anchoring	0.0028%	0.29	0.25	0.0121%	0.0175%

From the perspective of pilotage dynamics, the frequency of navigation accidents is high, the consequences of accidents are the most serious, and the risks are also high. The second is berthing alongside, with lower frequency, consequence and risk than sailing.

In the mooring-off dynamic, the accident consequence and risk are high when mooring, but the accident frequency is lower than mooring, and the consequence and risk of the latter is lower than that of the former. The second is berthing. The frequency of accidents is the same as that of mooring, but the consequences and risks are much lower than the former.

3.2 Cause Analysis of Vessel Pilotage Risk in Guangzhou Port

The database of ship pilotage accident is established by summarizing and organizing the data and data of ship pilotage accident in Guangzhou port pilotage station from 1988 to 2011. Through the statistics and processing of all kinds of data and data in the database, the following statistics and analysis are made on all the causes of pilotage accidents in the pilot station of Guangzhou port in recent years.

3.2.1 Comprehensive Cause Analysis of the Accident

According to the classification and definition of the factors affecting the accident, the primary causes can be divided into natural causes, channel/wharf causes, traffic reasons, other ship reasons, ship reasons, crew reasons, tug reasons and pilot reasons. The causes of accidents are listed in table 3-9 and figure 3-3.

Table 3-9 comprehensive cause analysis table

	Natural causes	Channel/dock reasons	Transportation reason	Other ship reasons	Ship reason	The crew reason	Tug reason	Pilot man
%	53.6%	9.4%	15.2%	14.5%	22.5%	10.9%	4.3%	93.5%

As can be seen from the above statistical table, among all the ship pilotage accidents, the pilot's human factors involved account for 93.5% of the total number of accidents, that is to say, most of the accidents involve pilot's human factors, and pilot's human factors take the first place. In addition to pilot's personal factors, natural causes account for 53.6%, ship's causes account for 22.5%, ranking second and third respectively, while other factors account for a smaller proportion.

3.3 Conclusions of Vessel Pilotage Risk Analysis in Guangzhou Port

Through the above analysis, the ship pilotage risk in Guangzhou port has the following characteristics:

(1) according to pilot water area analysis, pilot water areas with higher risks are in order: Shajiao water area, Erhu water area, Huangpu water area, Lingding water area, Xinsha water area and Nizhoutou water area;

(2) according to the analysis of water area types, pilotage water areas with higher risks are in the channel, near the wharf, anchorage, and out of the channel in order;

(3) according to the dynamic analysis of ships, the dynamics of ships with higher risks are in order: sailing, docking and leaving, anchoring and making a u-turn;

(4) according to the analysis of accident nature, the accident nature with higher risk is in order: collision, contact loss, loss of control, grounding

(5) according to the two-factor analysis, the risk is relatively high: contact loss accident occurs when docking, and pilotage operation is conducted in Shajiao water area. Secondly, the risk level is relatively high: Huangpu water area -- navigation, Xinsha water area -- navigation and docking, collision and contact damage, Nizhoutou water area -- navigation, Erhu water area -- navigation and docking, Shajiao water area -- collision, Lingding water area -- navigation and collision.

(6) according to the cause analysis of pilotage risk, pilot personnel ranks the first, followed by natural causes, ship reasons, traffic reasons, other ship reasons, crew reasons, channel/dock reasons and tug reasons.

(7) the analysis of pilotage technology and behavior shows that there is an increasingly close connection between pilot's navigation alert, lack of safety pilotage awareness and pilotage accident and risk. The increasing difficulty and risk of pilotage in Guangzhou port put forward higher requirements for pilot's technology, especially the emergency handling ability under special circumstances. The traffic density and order of Guangzhou port increase the difficulty of pilotage, which is the direct external factor of pilotage risk.

(8) the safety of the port waters of increasingly change the test of traffic conditions, under the condition of channel terminal condition and natural pilot operations suffered a growing challenge, called for further consideration, ship and environment, especially the navigable environment under the condition of changing new pilot job specification and psychological quality.

Chapter 4

Risk Prediction of Pilotage Safety of Ships in Guangzhou Port

4.1 Concept and Function of Prediction

Prediction is a scientific theory that describes and analyzes the trend and condition of the future development of things according to the past and present development law of objective things, and forms scientific reasoning, hypothesis and judgment with the help of scientific methods and means.

The basis of prediction is the correct understanding of the change law of objective things. So forecasting is a science. Due to the influence of various possible factors on the development and change of things, prediction should not only use reasonable assumptions, logical reasoning and scientific analysis methods, but also rely on the professional knowledge, experience and judgment ability of the forecaster. And the ability to extract useful information from incomplete data collected. In this sense, forecasting is an art.

From the point of view of management science, prediction is the use of modern management, mathematical and statistical methods to make scientific inferences about the possible trend and level of things in the future. Simply understood, prediction refers to the results that can be obtained by following the current law, provided that neither the environment nor the law changes or changes are known. It can be seen that prediction studies are random events, because only random events have the necessity to study their possible trends and levels in the future according to the objective change process of the past. Quantitative prediction is a very important part in the field of prediction. It focuses on the quantitative prediction of things, mainly on mathematical derivation, and adopts many mathematical models. The development of computer science provides the most modern computing means for quantitative prediction, which makes quantitative prediction method more and more popular and develop rapidly.

Since the 1980 s in our country to carry out the accident forecast and the safety evaluation work, early stage mainly introduce and digest the foreign studies of various prediction methods, to solve the problem basically is the system of local problem, in recent years, with the gradual improvement of the understanding of system security, all kinds of forecasting method has been applied to the level of the whole system.

4.2 Risk Prediction Techniques and Methods

In order to make the safety work targeted, it is necessary to carry out scientific analysis of the past accidents, find out the rules of accidents, so as to make prediction and forecast. Therefore, the purpose of accident prediction is to prevent accidents, grasp the rules of accidents, take effective preventive measures, minimize casualties to the maximum extent possible, and establish a good safe and orderly living and production environment for the society.

Prediction of pilotage accident is to reasonably estimate the possible accident in the future, analyze the law of accident occurrence and the development trend under the existing traffic conditions, and provide a reliable theoretical basis for scientifically formulating the countermeasures and technical measures of pilotage safety management, which is an important content to improve the level of pilotage safety management.

Water traffic accident is a small probability random event, its occurrence is a variety of factors in their own development process of mutual influence, interaction results. From this point of view, the overall development level and trend of water traffic accidents can be analyzed and predicted by appropriate mathematical methods, because accidents always have their inherent regularity, no matter how many kinds of causes there are and how complicated the interactions are.

As mentioned above, the occurrence of accidents has randomness and contingency, as well as causality and inevitability. Its latent, development and outbreak all have coherence, analogy and correlation. On this basis, people can understand and grasp the future development law and trend of accidents to a certain extent, and use mathematical methods to build a "prediction model" to seek the law of the system through modeling, and make macro and micro predictions.

In particular, accident forecasting is not about predicting what kind of accidents will happen when and where. Given the nature of the accident, this is hard to do. If this can be done, then water traffic accidents can be completely avoided, which is of course the result of all aspects of the transport industry, but it can only be a hope. In practical work, we can only take various effective measures to ensure that accidents do not happen in a certain period or reduce the probability as much as possible. In the long run and on a larger scale, accidents are inevitable because they are random events. What is the general development trend of accidents in a certain area or a certain water area in a certain period of time in the future, and what level will it reach, especially the recent development trend and level, which is the main concern of traffic safety management departments. If reliable data in this regard can be obtained effectively, it will be very helpful to take corresponding effective measures according to the characteristics of traffic accidents in local areas and waters and control the accidents within a certain limit.

For risk control, prediction of the main functions are: to help analysts for the research object as a whole and some of the risk of future trends have a certain understanding, helping analysts to understand and control the uncertainty of the future, reduce ignorance was reduced to a minimum, for the future forecast risk control plan implementation may appear later, give full consideration to the future possible status, and risk constraints, so as to make the risk control scheme is more scientific and feasibility.

Due to the diversity of prediction methods and their extensive and complex application, there are many kinds of prediction methods, but there is no unified classification at present.

If divided into large categories, we can divide the forecasting methods into qualitative forecasting method, quantitative forecasting method and comprehensive forecasting method.

1. Qualitative prediction method

The qualitative prediction method is also called the intuitive prediction method or the judgment prediction method, it mainly relies on the analyst or the forecaster itself to carry on the forecast to the experience and the comprehensive analysis ability to the thing. It USES intuitive materials and relies on experts' experience to judge and analyze the trend of future development. This kind of method is simple and feasible, and can be used for forecasting in the absence of historical data. The commonly used qualitative prediction methods include Delphi method, scenario prediction method, expert system prediction method, trend extrapolation method, trend impact analysis method, outline method, prospect analysis method and so on.

2. Quantitative prediction method

Quantitative prediction method is based on historical data and using numerical analysis method to predict the development trend of things. Common methods include time series analysis, regression analysis, grey theory analysis, neural network analysis, bayesian theory analysis, etc.

Using the bayesian method is of significance to predict the ship navigation risk, using the method to predict the ship navigation risk either through the bayesian statistics to predict the future accidents and accidents, but can be by bayesian network to predict the conditional probability of interest, it is also important is: it can fully combines a priori information and sample information to or for the future of various conditions to predict the probability of accident, it was less than other methods.

3. Analysis of prediction methods

One model certainly cannot replace all the existing prediction models, we need to do a specific analysis of specific problems, according to the development trend of water traffic accidents, according to the different data and use different prediction models, we cannot ignore the conditions and apply. For example, for accident data with linear stationary trend, a linear regression model or a quadratic exponential smoothing model should be selected. A simple exponential regression model or GM (1, 1) model should be selected for the accident data with exponential change rule. For the accident data with high random volatility, the prediction should be made by the cubic exponential smoothing model or the gray markov model.

Different accident prediction methods have their own advantages, characteristics and limitations. In the application, we should pay special attention to the matching of prediction model and sample data of different types of water traffic accidents. Traffic safety system is a complex system, and traffic accidents on water have randomness, volatility and uncertainty. Therefore, it is necessary to comprehensively consider various prediction methods when carrying out the prediction, so as to make the prediction analysis results more reliable and provide effective decision support for the water traffic safety management department. It is worth mentioning that the prediction analysis results depend on the accuracy of the original data, and no prediction method can surpass this point.

In conclusion, it is more reasonable to focus on the analysis of the accident rate of pilotage.

4.3 Ship Pilotage Risk Prediction based on Bayesian Statistics in Guangzhou Port

Mentioned above, the ship pilotage risk is the possibility of accident. There are two schools of analysis on the possibility problem: classical statistics school and bayesian school.

In 1763, British scholar t. bayes put forward a theory of inductive reasoning in on solving the problem of opportunity, which was later developed by some statisticians into a systematic statistical reasoning method, called bayesian method. All the results obtained by using this method for statistical inference constitute the content of bayesian prediction. Bayesian school believes that bayesian method is the only reasonable statistical inference method, and it has developed into an influential school by the 1950s and 1960s. Today, its influence is growing.

Assume the given training data is D, assume the hypothesis space H, and define the most probable hypothesis under the knowledge of prior probability of the given data D and different assumptions in H as the best hypothesis.

Bayesian forecasting theory combines the overall information, sample information and prior information of all, is a relatively reasonable prediction method all information integrated application of a kind of effective method, especially in the aspect of the application of a priori information, it has its own set of theory system, in without a priori information, for example, you can use the method, under the condition of a priori information, a method that can be used by all formed the relevant system.

In the whole bayesian statistical prediction process, two parameter estimates are needed, one is to estimate the overparameters in the prior probability distribution, and the other is to estimate the posterior probability parameters after the calculation of bayesian rule. The estimation methods are divided into point estimation and interval estimation.

Point estimation is a function of the unknown parameters or unknown parameters contained in the population distribution according to the sample estimation. Usually they are some characteristic value of the population, such as mathematical expectation, variance and correlation coefficient. The point estimation problem is to construct an estimate of a function that depends only on the sample as an unknown parameter or unknown parameter.

It is generally believed that prediction is to construct and use model to evaluate unlabeled sample class, or to evaluate the attribute value or interval value that a given sample may have. When the bayesian theory is used for prediction, the bayesian statistical prediction is to deal with the predicted continuous value, that is, to predict the accident rate. The prediction of bayesian network is to deal with the evaluation of unlabeled samples, that is, to predict the conditional probability.

4.3.1 Bayesian Analysis of Ship Pilotage Risk in Guangzhou Port

1) binomial distribution: this distribution is applicable to n-weight Bernoulli test. If the probability of occurrence of A in each test is equal to θ , the number of occurrence of event A in n tests k obeys binomial distribution.

For example, under the premise of n total pilotage of ships, the probability of accident is θ , then the number of accidents k in n tests obeys the binomial distribution, whose expression is:

$$P(X = k) = C_n^k \theta^k (1-\theta)^{n-k}, k = 0,1,2...,n \quad (4\text{-}1)$$

Its expected value is $n\theta$, its variance is $n\theta(1-\theta)$, and its binomial distribution is $b(n, p)$.

(2) poisson distribution: this distribution should have two preconditions. Firstly, in any two intervals of equal length, the probability of occurrence of events is equal. Second, the occurrence of events in any interval is independent of the occurrence of events in any $[t_o, t_o + t]$. Suppose that the number of ships' navigation accidents k in any time interval follows the poisson distribution, and the expression is:

$$p(X=k)=\frac{(\lambda t)^k}{k!}e^{-\lambda t}=\frac{\mu^k}{k!}e^{-\mu},k=0,1,2,\ldots \quad (4\text{-}2)$$

The expected value is λt , the variance is λt , and the poisson distribution is $P(k)$.

The poisson distribution has the following properties:

1) the mathematical expectation $E(k)=\mu=n\theta$ of the number accidents k occurring in a certain time or a specific area is known.

2) the mathematical expectation $E(k)$ of the number of occurrence of a specific event is proportional to the size of the selected time t region, and the relationship is: $E(k)=\lambda t$.

(3) exponential distribution: this distribution is used for product life analysis and is the probability distribution of a continuous random variable. In fact, the exponential distribution is the time distribution between two accidents, and the exponential distribution is a simplified poisson distribution. The distribution function can be expressed as follows:

$$F(t)=\lambda e^{-\lambda t},t\geq 0 \quad (4\text{-}3)$$

Its expected value is $1/\lambda$ the variance is $1/\lambda^2$.

(4) conjugate distribution: the distribution of sample set x is $\{f(x|\theta):\theta\in\Theta\}$,the prior distribution is $\pi(\theta)$ that if the prior distribution $\pi(\theta)$ and the posterior distribution $h(\theta\mid x)$ type belong to the same distribution, the distribution of conjugate prior distribution is called $f(x|\theta)$,because $h(\theta\mid x)\propto\pi(\theta)L(\theta\mid x)$ can know the information is required for conjugate prior distribution and sample distribution (likelihood function) $L(\theta\mid x)$ after the information provided by the integrated, don't change the θ distribution type. The following is the conjugate prior distribution of common probability distribution:

When the population distribution is binomial distribution $B(n,\theta)$, the conjugate prior distribution β is distribution $\beta(a,b)$, and the posterior distribution is:

$$\beta(a+x, n+b-x) \quad (4\text{-}4)$$

When the overall distribution is poisson distribution $P(\theta)$, the conjugate prior distribution is distribution $\Gamma(\alpha,\lambda)$, and the posterior distribution is:

$$\Gamma(\alpha+t, \lambda+n) \quad (4\text{-}5)$$

Among them $t=\sum_{i=1}^{n} x_i$;

When the population distribution is exponential $E(\theta)$, the conjugate prior distribution Γ is distribution $\Gamma(\alpha,\lambda)$, and the posterior distribution is:

$$\Gamma(\alpha+n, \lambda+t) \quad (4\text{-}6)$$

When the population distribution is exponential $E(1/\theta)$, the conjugate prior distribution $I\Gamma$ is distribution $I\Gamma(\alpha,\lambda)$, and the posterior distribution is:

$$I\Gamma(\alpha+n, \lambda+t) \quad (4\text{-}7)$$

4.3.2 Bayesian Estimation of Ship Pilotage Accident Rate in Guangzhou Port

If the pilotage of the ship obeys the benuri test conditions, that is, the probability of accidents θ under the premise of the total pilotage of the ship n, then the number of k accidents in the test n obeys the binomial distribution.

In the binomial distribution, according to the above conclusions of conjugate prior distribution and posterior distribution, it can be known that: Generally, they can be obtained from the processing β of historical data $\beta(a,b)$, so prior mean $\bar{\theta}$ and prior variance $S_\theta^{\ 2}$ can be calculated:

$$E(\theta) = \bar{\theta} = \frac{1}{n}\sum_{i=1}^{n}\theta_i \ , \quad Var(\theta) = S_\theta{}^2 = \frac{1}{n-1}\sum_{i=1}^{n}(\theta_i - \bar{\theta})^2 \tag{4-8}$$

Then make them equal to the expectation β and variance $\beta(a,b)$ of the distribution respectively, and we can get:

$$\begin{cases} \dfrac{a}{a+b} = E(\theta), \dfrac{ab}{(a+b)^2(a+b+1)} = Var(\theta) \end{cases} \tag{4-9}$$

The hyperparameters can be obtained from the above equations.

$$\begin{cases} \hat{a} = E(\theta)[\dfrac{(1-E(\theta))E(\theta)}{Var(\theta)} - 1] \\ \hat{b} = (1-E(\theta))[\dfrac{(1-E(\theta))E(\theta)}{Var(\theta)} - 1] \end{cases} \tag{4-10}$$

Then the point θ estimate and interval estimate of the probability (α = 5%) satisfy the following conditions:

$$\begin{aligned} &\hat{\theta}_E = \frac{a+k}{a+b+n}, \theta_{MD} = \frac{a+k-1}{a+b+n-2} \\ &\hat{\theta}_L = \beta(\frac{\alpha}{2}, a+k, b+n-k) \\ &\hat{\theta}_U = \beta(1-\frac{\alpha}{2}, a+k, b+n-k) \end{aligned} \tag{4-11}$$

Based on this, the bayesian estimation of the pilotage accident rate of Guangzhou port can be carried out. The accidents of ship pilotage in Guangzhou port from 1999 to 2011 are shown in table 4-1.

Table 4-1 ship pilotage accidents in Guangzhou port from 1999 to 2011

year	accidents k	Level of accident	Total ships n	accident rate θ
1999	1	0	6827	0.0001
2000	15	2	5753	0.0026

2001	2	0	6438	0.0003
2002	5	0	7524	0.0007
2003	17	0	8098	0.0021
2004	9	2	9858	0.0009
2005	11	1	10113	0.0011
2006	18	1	11880	0.0015
2007	11	2	12099	0.0009
2008	13	0	12502	0.0010
2009	9	1	13815	0.0007
2010	13	1	14433	0.0009
2011	12	3	14949	0.0008

Note: the number of grade accidents refers to the number of accidents above grade of general accidents (including), excluding minor accidents and minor incidents.

Assuming that ship pilotage activities obey the benuri test conditions (independent of each other), then the number of accidents meets the binomial distribution, which can be solved as follows：

$$P(\theta) = \frac{\theta^{2.57}(1-\theta)^{2452.1}}{\beta(2.57, 2452.1)}$$

$$\hat{\theta}_E = \frac{a+k}{a+b+n} = 0.001006$$

$$\hat{\theta}_{MD} = \frac{a+k-1}{a+b+n-2} = 0.001013 \qquad (4\text{-}12)$$

$$\hat{\theta}_L = 0.0008, \theta_U = 0.0012 \qquad (4\text{-}13)$$

4.3.3 bayesian estimation of the number of ship pilotage accidents in Guangzhou port

Now it is assumed that the number of pilotage accidents of ships obeys the poisson distribution in a period of time. According to the statistical data of historical data, the number of accidents θ is taken as the median value in the table. See table 4-1:

In the poisson distribution, according to the above conclusions of conjugate prior distribution and posterior distribution, it can be known that:

If several estimated values of the number of accidents θ can be obtained based on prior information are denoted as: $\theta_1, \theta_2, \ldots, \theta_n$ they can generally be obtained from the processing of historical data, so prior mean $\bar{\theta}$ and prior variance $S_\theta^{\ 2}$ can be calculated:

$$\begin{cases} E(\theta) = \bar{\theta} = \dfrac{1}{n}\sum_{i=1}^{n}\theta_i \\ Var(\theta) = S_\theta^{\ 2} = \dfrac{1}{n-1}\sum_{i=1}^{n}(\theta_i - \bar{\theta})^2 \end{cases} \tag{4-14}$$

Then make them equal to the expectation and variance of gamma distribution $\Gamma(\alpha, \lambda)$ respectively, and we can get:

$$\begin{cases} \dfrac{\lambda}{\alpha} = \bar{\theta} = E(\theta) \\ \dfrac{\lambda}{\alpha^2} = S_\theta^{\ 2} = Var(\theta) \end{cases} \tag{4-15}$$

The hyperparameters can be obtained from the above equations.

$$\begin{cases} \hat{\alpha} = E(\theta)^2 / Var(\theta) \\ \hat{\lambda} = E(\theta) / Var(\theta) \end{cases} \tag{4-16}$$

Then the point θ estimate and interval estimate of the number of accidents (α =5%) meet the following criteria:

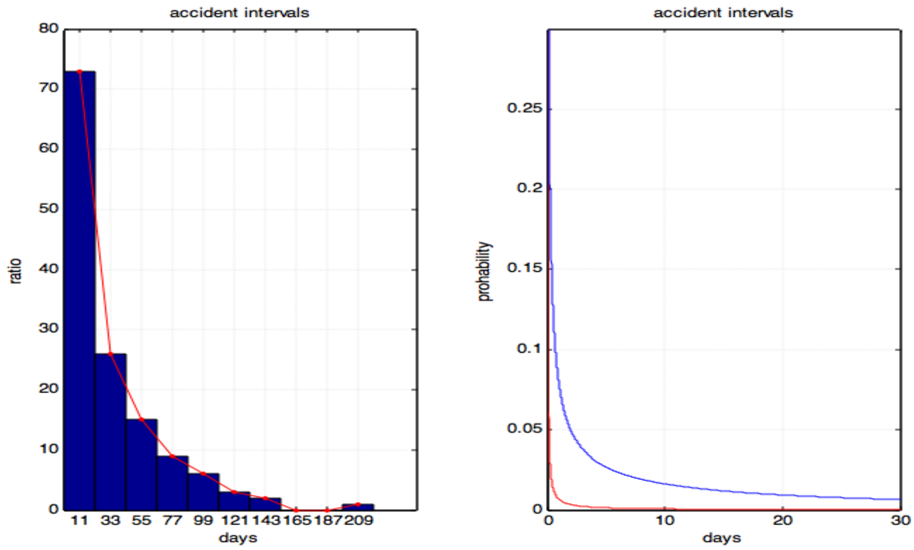
$$\begin{cases} \theta_U = \dfrac{\Gamma(\frac{\alpha}{2}, \hat{\alpha} + \sum \theta)}{n + \hat{\lambda}}, \theta_L = \dfrac{\Gamma(1 - \frac{\alpha}{2}, \alpha + \sum \theta)}{n + \lambda} \\ \hat{\theta}_{MD} = \dfrac{n}{n + \hat{\lambda}} \bullet \bar{\theta} + \dfrac{\hat{\lambda}}{n + \lambda} \bullet \dfrac{\hat{\alpha} - 1}{\lambda} = \dfrac{\sum \theta + \hat{\alpha} - 1}{n + \lambda} \end{cases} \quad \textbf{(4-17)}$$

Combined with the actual pilotage accident of guangzhou port, the number of accidents meets the poisson distribution, and the solution is as follows:

$$\begin{cases} \theta_U = 9.5 \\ \theta_L = 13.2 \\ \hat{\theta}_{MD} = 10.3 \end{cases} \quad (4\text{-}18)$$

4.3.4 Bayesian Estimation of Vessel Pilotage Accident Interval in Guangzhou Port

Now it is assumed that the time interval of pilotage accidents of adjacent ships obeys the negative exponential distribution. According to the statistical data of historical data, the time interval of accidents is shown in figure 4-4.



Source:Fang Quangen. Comprehensive safety assessment (FSA) and its application in ship safety [J] China Marine, 2004, (1):1-6.

FIG. 4-4 time interval and bayesian estimation of ship pilotage accident in Guangzhou port

In the exponential distribution, according to the above conclusions of conjugate prior distribution and posterior distribution, it can be known that:

If several observed values of accident time interval θ can be obtained according to prior information, they are denoted as: $\theta_1, \theta_2, \ldots, \theta_n$ they can generally be obtained through sorting out historical data, so prior mean $\bar{\theta}$ and prior variance S_θ^2 can be calculated:

$$\begin{cases} E(\theta) = \bar{\theta} = \dfrac{1}{n}\sum_{i=1}^{n}\theta_i \\ Var(\theta) = S_\theta{}^2 = \dfrac{1}{n-1}\sum_{i=1}^{n}(\theta_i - \bar{\theta})^2 \end{cases} \tag{4-19}$$

Then make them equal to the expectation and variance of inverse gamma distribution $I\Gamma(\alpha,\lambda)$ respectively, and we can get:

$$\begin{cases}\dfrac{\lambda}{\alpha-1}=\bar{\theta}=E(\theta),\dfrac{\lambda^2}{(\alpha-1)^2(\alpha-2)}=S_\theta{}^2=Var(\theta)\end{cases} \quad (4\text{-}20)$$

The hyperparameters can be obtained from the above equations.

$$\begin{cases}\hat{\alpha}=\dfrac{E(\theta)^2}{Var(\theta)}+2\\ \hat{\lambda}=E(\theta)(\dfrac{E(\theta)^2}{Var(\theta)}+1)\end{cases} \quad (4\text{-}21)$$

Then the point θ estimate and interval estimate of the number of accidents (α'=5%) meet the following criteria:

$$\begin{cases}\theta_U=\dfrac{\sum\theta_i+\hat{\lambda}}{\Gamma(\dfrac{\alpha'}{2},\hat{\alpha}+n)},\theta_L=\dfrac{\sum\theta_i+\lambda}{\Gamma(1-\dfrac{\alpha'}{2},\alpha+n)}\\ \hat{\theta}_{MD}=\dfrac{\sum\theta_i+\hat{\lambda}}{n+\hat{\alpha}+1}=\dfrac{n\bar{\theta}+\hat{\lambda}}{n+\alpha+1}\end{cases} \quad (4\text{-}22)$$

According to the actual pilotage accident of Guangzhou port, the time interval of the accident satisfies the negative exponential distribution, and the solution is as follows:

$$\begin{cases}\theta_U=38.9\\ \theta_L=27.9\\ \hat{\theta}_{MD}=32.5\end{cases} \quad (4\text{-}23)$$

Since the probability density function of accident time interval is:

$$E(1/\theta)\sim I\Gamma(2.78,91.25).$$

According to the properties of the probability density function, it can be concluded that the average interval is 32 days. In view of the need of actual safety work, the period of safety education work should be about 30 days.

4.4 Conclusions of Vessel Pilotage Risk Prediction in Guangzhou Port

(1) the application of various prediction models should consider their respective applicable conditions. One model can not replace all the existing prediction models. It is necessary to make specific analysis of specific problems and adopt different prediction models according to the different development trend of water traffic accidents and the different data acquired. Bayesian statistical inference and network inference are analyzed on the basis of probability model.

(2) based on the conditions of vessel pilotage probability in Guangzhou port from 1999 to 2011, the accident rate (including small events) of vessel pilotage risk in Guangzhou port is 8~12 per 10,000 in the foreseeable year.

(3) based on the conditions of ship pilotage accidents (including minor incidents) occurring from 1999 to 2011, the number of accidents in the ship pilotage risk of Guangzhou port is expected to be 9-14 in a year.

(4) based on the time interval between accidents from 1999 to 2011, according to the nature of probability density function, it can be concluded that the average interval is 32 days. However, in view of the actual needs of safety work, the cycle of safety education work should be about 30 days.

(5) the average hourly navigable capacity saturation of the sea channel of Guangzhou port is 0.37, which is good. However, as the ship flow in Guangzhou port is greatly affected by tides, the statistical analysis of observation data shows that the ship flow in the high tide period is more than 2 times of the average hourly flow, and the ship flow in the high tide period is even 10 times of the ship flow in the low tide period. In this appeal, the relevant administrative departments as soon as possible to study the pearl river navigation, traffic density, traffic order management to formulate management measures.

Chapter v

Precontrol of Pilotage Risk of Ships in Guangzhou Port

Practice tells people that accidents originate from risks and accidents are the concentrated appearance of various risks in production safety. For high-risk ship pilotage, only scientific risk precontrol can prevent the accident and reduce the loss caused by the accident.

For a long time, pilot station of Guangzhou port is always insist on "safety pilotage" as the center of the working principle, seriously implement the safety production and safety of navigation of ships and other relevant laws and regulations, actively carry out pilot safety scientific research work, improve the management system and system, carried out fruitful work in the security management, achieved good results.

In recent years, with the rapid development of social economy, the cargo throughput of Guangzhou port continues to increase, and the vessel traffic in the pearl river trunk line becomes increasingly busy, and the number of vessels led by the pilot station of Guangzhou port also increases greatly. At the same time, due to the large-scale and diversified development of ships arriving in Hong Kong, as well as the increasing number of port construction projects such as the hong kong-zhuhai-macao bridge, the navigation conditions of Guangzhou port become more complex, bringing unprecedented pressure to the safety of ship pilotage. In order to meet the challenge brought by the severe situation, ensure pilotage safety and provide better pilotage service for the economic development of Guangzhou region, it is very necessary and urgent to carry out scientific and effective risk precontrol management for ship pilotage.

In view of the actual situation mentioned in the previous sections of this research report, this paper puts forward the following Suggestions on the risk precontrol management of ship pilotage operations in Guangzhou port from the aspects of guiding ideology, basic countermeasures, specific measures and methods of ship pilotage risk precontrol.

5.1 Guiding Ideology of Pilot Safety Risk Precontrol Management

As a high-risk industry, fully implementing the guiding ideology of "safety first, prevention first and comprehensive treatment" has more significant and far-reaching significance for the safety management of ship pilotage.

Safety is the first, established safety in pilot work in the first place, pointed out that the main task of pilot work is to effectively protect the safety of life, ships, goods and environment. Under the new historical conditions, it is also the inevitable requirement of carrying out the people-oriented scientific development concept and constructing harmonious pilotage.

To give priority to prevention means to always move forward the threshold of safe production and take precautions in advance in pilotage work, to establish a progressive and three-dimensional accident hidden danger prevention system of ship pilotage pre-teaching, prediction, prediction, early warning and prevention, so as to improve pilotage safety and prevent pilotage safety accidents.

Comprehensive treatment, it is to point to to meet the requirements of pilot security situation and consciously comply with the laws of the pilot production safety, and to face the pilotage safety work in the long-term, arduous and complexity, seize the pilotage safety work, the main contradiction and the key link, the integrated use of economic, legal, administrative and other means, through the tube, the rule of law, dimension is multi-pronged approach, and give full play to the community, employees, public opinion supervision function, effectively solve the problem of pilotage safety field.

The safety policy of "safety first, prevention first, comprehensive treatment" is an organic and unified whole. Safety first is the commander and soul of prevention first and comprehensive treatment first. Without safety first thinking, prevention first will lose its ideological support and comprehensive treatment will lose its basis for improvement. Prevention is the fundamental way to achieve safety first. Only by putting the emphasis on the establishment of the accident hidden danger prevention system and preventing in advance, can the accident losses be effectively reduced and safety first be realized. Comprehensive management is the means and method of putting safety first and prevention first. Only by constantly improving and improving the comprehensive governance mechanism can we effectively implement the safety policy, put safety first and prevention first, and create a new situation of safety pilotage work.

5.2 Basic Tasks of Pilotage Safety Risk Precontrol Management

In order to do a good job in Guangzhou port of ship piloting risk precontrol, pilot station of Guangzhou port and the leadership of the staff must be according to the requirements of national safety management departments at all levels in the clear pilot risk precontrol, on the basis of the guiding ideology and principle of the safety planning, safety input, the progress of science and technology, education training, assessment and safety laws and regulations, incentive and constraint, safety regulation and emergency management system, etc., have specific aim to develop a series of practical and effective countermeasures and basic requirements, so we can at the same time of effective work in the pilot risk precontrol, promptly solve affect restricted pilotage safety work of deep, historic problems, We will accelerate the establishment of a long-term mechanism for pilotage safety.

From the perspective of the basic elements constituting safe pilotage, the following five aspects should be carefully considered in the work of formulating the basic countermeasures and requirements for the pre-control of pilotage risk of ships in Guangzhou port:

First, pilot safety culture. Pilotage safety culture is the sum of pilotage safety value and pilotage safety code of conduct, which embodies the attitude, thinking degree and behavior mode of pilotage safety of pilotage unit and each individual. The unsafe behavior of personnel is the biggest hidden danger of accidents, and the safety quality and ability of personnel mainly come from the effect of effective education and training and cultural atmosphere. Therefore, the construction of pilotage safety culture is to create a safe atmosphere inside the pilotage station, to transform the safety needs of all employees into specific goals, credos and codes of conduct, to form the spiritual power of employees' safety production, and to strive for the goal of pilotage safety.

Second, pilotage safety system. Safety management should be enforced through system construction. The construction of pilotage safety system must abide by relevant laws and regulations on pilotage and safety as well as industrial rules and regulations, and formulate specific detailed rules and operating standards that are humanized, standardized, targeted and operable based on the actual situation of the operating waters. In pilotage practice, there should be rules to be followed, rules to be followed, rules to be observed strictly, rules to be corrected, and safety walls to prevent accidents should be set up.

Third, pilotage safety responsibility. Establish a mechanism of accountability for pilotage safety, clarify the responsibility of leaders, functional departments and pilots at all levels of pilotage stations for pilotage safety work, implement various safety measures, set up layers of defenses, and cut off the chain of accidents and errors.

Fourth, pilotage safety technology. Scientific and technological progress is not only the unremitting driving force of pilotage development, but also the important guarantee of pilotage safety. It is an effective means to ensure pilotage safety to actively carry out research on pilotage safety technology and safety environment and popularize and apply new technologies and equipment of pilotage safety.

Fifth, pilotage safety and economy. Correctly understand the dialectical relationship between safety and benefit, increase the preventive investment of safety guarantee measures, eliminate accidents before germination.

Above all, the basic task of the Guangzhou port of ship piloting risk precontrol management is to promote the pilot safety culture construction, improve the pilot safety rules and regulations, to carry out the pilot work safety responsibility, to carry out the pilot study of safety science and technology, increase investment in pilotage safety, the pilot station and form a "safe pilotage" values, and through the system support, technology support to actively prevent and control the risks affecting the safety of pilot.

5.3 Specific Measures of Ship Pilotage Risk Precontrol in Guangzhou Port

5.3.1 Strengthen Pilotage Safety Culture and Education Training

For a long time, Guangzhou port pilot station attaches great importance to safety production, and has achieved effective results, has objectively formed and has a good pilotage safety culture and foundation. Therefore, in the process of actively promote pilot safety culture, can continue to adhere to a high starting point, high standard, the "safety first, prevention first, comprehensive management" as the soul of the pilot safety culture, "people-oriented" as the essence of pilotage safety culture, "in a safe pilotage as the center, pay attention to safety, care for life" as the core values of pilotage safety culture, the related national safe production laws, regulations, and pilot and safety management system as the system guarantee of pilotage safety culture, the construction has the characteristics of Guangzhou port pilot piloting safety culture. Therefore, in the construction of pilotage safety culture, we should focus on the following work:

1. Continuously strengthen the training of safety pilotage knowledge and skills.

Through publicity and education, case analysis and on-site guidance, the pilot should actively popularize safety knowledge, improve the concept of safety pilotage resources management, especially pay attention to the remoulding of the concept of safety management.

2, timely and regular safety meeting.

Pay full attention to the rules of pilotage accidents in Guangzhou port, actively carry out all kinds of safety education activities, regularly hold safety meetings when appropriate, especially to strengthen and do a good job in the navigation high-risk areas must be careful and safe pilotage publicity work. At the end of each year, comprehensive statistics and analysis should be conducted on pilotage accidents throughout the year to find out new trends and characteristics of pilotage accidents, select typical pilotage accidents from them and compile them into a book, organize study and discussion, and draw lessons from them.

3. Cultivate and improve pilots' sense of teamwork in pilotage work

To strengthen the education of pilots' mutual respect, humility, cooperation and cooperation in their work; Cultivate and improve the pilot work in leading the team cooperation consciousness, improve the bridge team work ability, the correct understanding between pilot and captain complex legal relations and have their own advantages and disadvantages, and pilot captain/relationship between drivers, always keep good safety work attitude, careful completes the pilot work, to ensure the safety of the pilot. At the same time, on the basis of ensuring safety and national interests, the pilots' sense of service should be constantly strengthened, so as to provide high-quality services for the guided ships as much as possible.

4. Improve the education and training system and improve the comprehensive quality of pilots

In recent years, under the circumstance of busy task and shortage of pilot, Guangzhou port pilot station still insists on carrying out business training work irregularly. With the continuous development of navigation and pilotage technology today, it is necessary to proceed from the needs of pilotage safety work and long-term interests, combine with the actual situation and needs of pilotage work at present, continue to do pilot business training work, so as to improve the overall technical ability and level of pilot team. These include:

(1) hold general lectures for pilots in various forms. If you can continue to invite experts from schools, scientific research institutions and other communities to guide the navigation station to hold lectures on behavioral science and safety, social psychological science, latest navigation technology and other relevant knowledge; Pilots can also be arranged to participate in academic activities organized by schools or other academic institutions as required.

(2) arrange special training for pilots of different levels. For example, senior pilots and junior pilots are arranged to discuss and exchange the application method and

experience of key practical operation technology under special circumstances in pilotage work. It is necessary to give full play to the role of senior pilots and promote the rapid growth of young pilots through "passing, helping and leading" in practical work.

(3) according to the needs of the pilot work in the future, can be based on the realistic and pragmatic principles, arrange pilot gradually to participate in such as a large vessel, ro-ro, chemicals, liquefied gas and other special vessels operating special training and pilot in the security of psychological skills, team work, emergency training, in order to meet the needs of the development of pilot work in the future.

(4) organize pilots to carry out pilot theory research in the station, so as to mobilize pilots' enthusiasm to study their business.

5.3.2 Improve the Construction of Safe Pilotage System and Strengthen the Execution

After years of accumulation, Guangzhou port pilot station has basically formed a relatively complete management system and operating procedures. In particular, according to the requirements of safety management, the safety management system has been established and implemented, which provides an effective working platform for the standardization of safety quality management. However, with the continuous change of objective conditions such as navigation environment and pilot structure of Guangzhou port, pilotage safety must organize effective supervision, inspection and monitoring, so as to further improve the current management system and operating procedures. Timely and effective pilotage safety management and control mechanism requires pilotage station to further sort out relevant laws, regulations and rules on the basis of existing safety management system, and correctly identify and evaluate pilotage risks through various methods. According to each pilotage risk, effective risk control measures shall be formulated to improve the operation mechanism and control mechanism, achieve standardization and standardization, and realize the overall control of identified risks.

1. On the basis of the existing work, procedures and regulations for key ships, key parts and key personnel should be built to further improve the existing rules and regulations of pilot stations, refine rules and define responsibilities, so as to make them more operable and evaluable.

According to the actual situation of pilotage safety at Guangzhou port, the following work should be emphasized:

(1) make pilotage plans scientifically, and arrange the time of import and export, docking and berthing reasonably. And to ensure the effective linkage of pilot station, piloted ship, tug, dock and other relevant parties, to ensure the accurate implementation of pilotage plan, improve the safety and efficiency of pilotage operations.

(2) putting people first, according to the actual situation and characteristics of pilot teams and pilotage operations, scientifically formulate pilot scheduling plan to avoid fatigue pilotage. Such as reducing the continuous night shift as much as possible, take measures such as segmentated pilotage or double pilotage.

(3) carry out research and demonstration on the cases exceeding the norm, and introduce the corresponding management system and work standards.

(4) further refine the matters that should be paid attention to when piloting in the case of poor visibility, and reiterate that speeding and other illegal behaviors are strictly prohibited.

2. Responsibility system construction

We should further evaluate the scientificity of the existing safety management organization and post setting, optimize the safety management organization and post setting, improve the operation efficiency and ensure the effective implementation of the safety management system. Further clarify the interim provisions on double and multiple pilotage responsibilities.

3. Strengthen pilot's consciousness of abiding by rules and regulations.

The execution of safe pilotage system is one of the important factors that determine the success or failure of pilotage management, and also the core of pilotage work. Only when the pilot completes the transition from passive execution to voluntary compliance can the enforcement of rules and regulations be improved. Only with these rules and regulations can the shipping in and out of Guangzhou port be in an orderly and controlled state, thus greatly reducing the possibility of human error resulting in accidents caused by disorder and chaos. With the strict operation rules, the pilot's casual and risky behavior is greatly restricted, and the young pilot's lack of experience is made up to some extent. It can be seen that compliance with rules and regulations is completely necessary and necessary, and the implementation of rules and regulations cannot be guaranteed by management and supervision alone. Pilots should not be complacent with the experience of not having accidents due to violation of rules and regulations, but should reflect on the serious consequences that may be caused and learn lessons, so as to improve the consciousness of compliance and discipline.

5.3.3 Strengthen the Construction of Pilot Team

The construction of pilot team is an important guarantee for safe pilotage. Pilot station should be on the basis of past achievements, firmly establish the concept of human resource is the first resource, overall planning, through the introduction, training, assessment, incentives and other ways to cultivate a abundant and structure optimization, the configuration is reasonable, quality excellent pilot team, efforts to create men, efficient operation of human resource environment, lay a solid foundation for the safety pilotage.

(1) formulate the construction plan of pilot team scientifically

First of all, the development situation of Guangzhou port should be accurately grasped through full investigation, and the demand of pilotage business for port production in present and future years should be grasped. Then, according to the actual composition of the pilot team, the present situation and shortage of the team construction in terms of quantity, structure and business ability are analyzed objectively. Finally, on the premise of ensuring normal working intensity (avoiding fatigue pilotage), based on the principle of sustainable development, the construction plan of pilot team of Guangzhou port is formulated.

(2) study the pilot's grading management method

According to the pilot measures for the registration and qualification management has been focused on the overall spirit of the Guangzhou harbor pilot qualification requirements, formulate appropriate pilot level and class management regulation, different levels and different class pilot for promotion of qualification requirements, fine management was carried out on the pilot.

(3) strengthen human resource management and enhance pilotage cohesion

Improve the human resource management system, implement open, standardized and humanized management of pilot's employment, training, assessment and promotion, and form a long-term talent training mechanism with reasonable flow and equal competition within the pilot station. Establish an effective reward system to motivate pilots' working enthusiasm. Establish a reasonable vacation system to fully release the physical and mental pressure of pilots and ensure good working conditions of pilots. We will further improve the pilot's salary and welfare system to ensure the steady increase of pilot's income, especially to reduce the pressure on young pilots. Establish the communication platform and mechanism between the leadership and front-line pilots, pay close attention to the health and needs of pilots, enhance the sense of identity and sense of belonging of units, and enhance the cohesion of pilot stations.

Through the above various forms of learning and guidance, pilots can not only further improve the operational skills of ship pilotage business, but also master the good skills of modern information transmission and feedback, so as to give full play to and improve the role of communication and communication in practical pilotage, and promote and ensure the safety of pilotage work.

5.3.4 Increase Security Input

Actively strive for more money and increase the scale of investment in science and technology innovation, set up special funds to support the innovation and development of different departments, to carry out extensive cooperation innovation, science and technology innovation platform construction and talent development, and strengthen and standardize the management and use of the existing capital item, give full play to the efficiency and effectiveness of economic investment.

1. Reasonable incentive mechanism can promote effective pilotage safety management.

Pilot stations need to further improve and improve the safety responsibility reward and punishment mechanism and strict assessment system. First, the method combining material and spirit rewards can be adopted, including bonus treatment, spirit encouragement and other incentive pilots, so as to actively mobilize the enthusiasm of personnel to participate in safety production. The second is to improve the safety accountability system, the quality of safety work directly with the interests of each post. In case of pilotage accident, investigation and analysis shall be organized carefully, and the persons responsible shall be held accountable when necessary, so as to finally promote the safety of pilotage.

2. Investment in pilotage technology should be increased.

The pilot station should pay attention to the development of international pilotage technology, introduce advanced pilotage facilities and equipment in time according to the actual situation of Guangzhou port, improve the pilot's technical equipment level, ensure that the pilotage technology, facilities and equipment of Guangzhou port are at the leading level in China, and ensure the safety of pilotage work of Guangzhou port.

(1) on the basis of the input and completion of the AIS new pilotage safety navigation monitoring system, competent supervision and management personnel should be trained and equipped to give full play to the role of high-tech equipment.

(2) in addition to perfecting and improving pilotage safety navigation system, it can also increase investment in innovation of ship pilotage technology research and pilotage scheduling.

5.3.5 Further Strengthen Communication with Relevant External Competent Departments and Units

Ship pilotage involves many competent authorities and port and navigation enterprises. In order to ensure the smooth development of pilotage, pilot stations should strengthen the communication with relevant departments and port and navigation units, and strive to achieve a working environment of information sharing and mutual support.

In Guangzhou port navigation, one of the most familiar with and understand the unit of Guangzhou port pilot station must also do our best to actively through different ways to navigation management departments at all levels, relevant Suggestions and ideas for the sailing ship safety, in order to attract their attention, and can actively take corresponding methods to promote the navigation safety management work.

Therefore, on the basis of maintaining good relations with competent departments, the pilot station of Guangzhou port can continue to deal with relevant matters, and finally form an interactive and harmonious relationship of "maritime management promotes pilotage safety and pilotage safety improves maritime management level".

At the same time, in order to adapt to the development of shipping industry at home and abroad and in line with international standards and to coordinate the development of Guangzhou port pilotage, the pilot station of Guangzhou port is necessary to continue to make full use of social resources and power, and strengthen the contact with navigation and piloting the academic community at home and abroad, the existing knowledge update series of lectures, pilotage development forum, on the basis of academic activities, such as the persistence of experts and scholars launched pilot business technology training, etc., come up with new ideas for Guangzhou port pilot work safety, promote and mutual cooperation and development.

Chapter 6

Conclusion

In this paper, FSA comprehensive evaluation method and bayesian prediction theory are used to evaluate and forecast the pilotage risk of Guangzhou port.

Guangzhou port of ship piloting risk precontrol management basic task is to promote the pilot safety culture construction, improve the pilot safety rules and regulations, to carry out the pilot work safety responsibility, to carry out the pilot study of safety science and technology, increase investment in pilotage safety, the pilot station and form a "safe pilotage" values, and through the system support, technology support to actively prevent and control the risks affecting the safety of pilot, so as to adapt to the development of the domestic and international shipping and port industry to play a role of mainstay of Guangzhou international shipping center building.

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