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Risk Management during Spring Tide in Yangtze River Shanghai Section

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RISK MANAGEMENT DURING SPRING TIDE IN YANGTZE RIVER SHANGHAI SECTION

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A dissertation submitted to the World Maritime University in partial fulfillment of the requirements for the award of the degree of Master of Science in Maritime Affairs
2023

DECLARATION

I certify that all the materials in this research paper that are not my own work has been identified, and that on materials are included for a degree has previously been conferred on me.

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

(Signature) : ....

(Date): ....

Supervised by: ....

Supervisor’ s affiliation: ....

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Last but not least, I am very grateful to my family and friends for their strong support and contentious encouragement.

ABSTRACT

Title of Dissertation: **Risk Management during Spring Tide in Yangtze River Shanghai Section**

Degree: **Master of Science**

Yangtze River Shanghai Section is located in the Delta region. As the connection between Yangtze River and East China Sea, the spring tide effect in this section have posed a significant threat to the maritime safety. Through collecting and analyzing the accidents data in recent years(from 2016 to 2022), it can be concluded that accidents rate during spring tide days is much higher than that in non-spring tide days. Research on risk management during spring tide in Yangtze River Shanghai Section has crucial practical significance. This paper firstly conducts a comprehensive analysis of the traffic flow during spring tide in Yangtze River Shanghai Section. Through literature review and accident analysis, the risks factors during spring tide are summarized. For ranking the factors and clearing out the main problems, a combination of expert questionnaire survey and analytic hierarchy process was used. The experts consulted must be particularly familiar with the navigation environment and spring tide in the Shanghai section of the Yangtze River, from VTS, Shanghai pilot stations, experienced navigators and shipping company managers. Finally, taking the actual situation into consideration, the author puts forward the suggestions to risk management .

KEY WORDS: Spring Tide; Yangtze River Shanghai Section; Risk Management; Analytic Hierarchy Process;

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LIST OF ABBREVIATIONS

AHP	Analytic Hierarchy Process
AIS	Automatic Identification System
AM	Access management
CJK	Changjiangkou
DWT	Deadweight Tonnage
cm	Centimeter
FSA	Formal Safety Assessment
FSC	Flag State Control
GT	Gross Tonnage
IMO	International Maritime Orgnization
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
m	Meter
MOT	Ministry of Transport of the People's Republic of China
MSA	Maritime Safety Administration
nm	Nautical mile
PSC	Port State Control
TEU	Twenty-Foot Equivalent Unit
VTS	Vessel Traffic Service
UKC	Under Keel Clearance
YRSS	Yangtze River Shanghai Section

Chapter 1 Introduction

This chapter mainly introduces the significance of risk management of spring tides in the Shanghai section of the Yangtze River and the current status of related research on tidal characteristics, navigation safety and outlines the main contents of this research paper.

1.1 Background

The Yangtze River Shanghai Section(YRSS), extending 65 nautical miles from the CJK area's lightship to the Baoshan area's lightboat, is a critical waterway for ships navigating to and from the Shanghai port. This section is one of the busiest waterways worldwide, reflecting its importance for regional economic activity (Li, 2022). In 2022, Shanghai Port's container throughput reached a record-breaking 47 million TEUs, leading the world for 13 consecutive years. Additionally, the cargo volume on the Yangtze River's mainline exceeded 3.5 billion tons, with a container throughput of 22.82 million TEUs, setting new historical records (MOT, 2022).

Figure1. Trajectory heat map of bulk carriers over 100,100 DWT.Source:www.shipxy.com

Figure.2 shows that increasing ship traffic places a strain on navigation resources within the YRSS (Liu, 2022). Large vessels must synchronize their entry and exit with the tide due to draft limitations and water depth availability, while small vessels often follow the tide for economic reasons. Consequently, ship traffic becomes exceedingly dense during specific periods, leading to a complex navigation environment that affects both efficiency and safety.

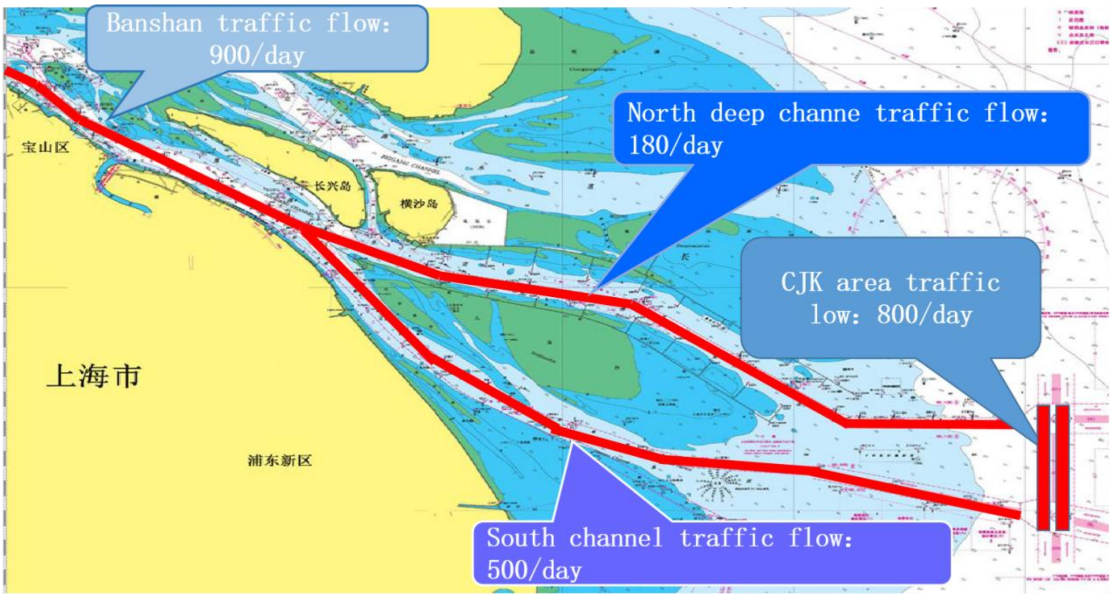

Figure 2. The traffic flow in YRSS. Source: Shanghai MSA, made by author.

The Yangtze River's Shanghai section features irregular semi-diurnal tides due to its estuarine nature, which impacts the entry and exit patterns of most vessels (Hu & Zhou, 2021). Spring tides, caused by the alignment of the Moon and Sun's gravitational forces, result in higher than normal high tides and lower than normal low tides (NOAA, n.d.). Spring tides typically occur on the first four days and the fifteenth to eighteenth days of the lunar calendar, totaling eight days. During these periods, the tidal range expands, water flow speeds accelerate, and tidal characteristics become more complex, leading to increased ship traffic congestion and operational difficulties.

Risk management is crucial for maintaining safety and efficiency in the Yangtze River's Shanghai section, especially during spring tides. By prioritizing risk management and adopting a comprehensive approach, administration can address the challenges posed by spring tides in the YRSS, ultimately enhancing safety, reducing the likelihood of accidents, and improving overall navigation performance.

1.2 Significance

The major water traffic safety accident involving the vessel "Changping" collided with the anchoring vessel "Xinwang 138" during the spring tide at Wusongkou anchorage, resulting in ten fatalities, highlighting the importance of risk management for spring tide. Furthermore, statistics from January 2016 to December 2022 show a total of 46 minor accidents, 18 general accidents, two large accidents, and three major accidents in the YRSS, with 81.2% of the accidents being collision-related, and 18.8% being other accidents. The details are shown in Table 1 and Figure 3.

Table 1. Accidents Statistics in YRSS(2016-2022).

	Minor	General	Large	Major	Sum
2016	10	2	1		13
2017	12	8			20
2018	4	1		2	7
2019	2				2
2020	7	3			10
2021	5	2	1	1	9
2022	6	2			8
Sum	46	18	2	3	69

Source: Shanghai MSA. Made by author.

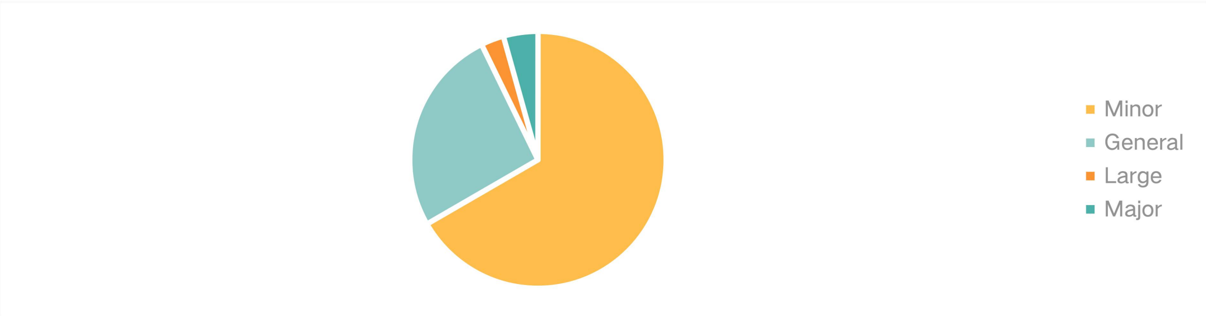

Figure 3. Proportion of different grade of accidents.
Source: Shanghai MSA. Made by author.

According to domestic custom, the spring tide's arrival is generally delayed by three days. Counting the first to the fourth day and the fifteenth to the eighteenth in a lunar month as the period of the spring tide. In this way, eight days per month are spring tides, a total of 96 days per year, accounting for 26.3% of total in a year. Collate all accident data according to the time of occurrence during spring tides and non-spring tides, as shown in the table below.

Table 2. The occurring time of accidents distributed into spring tides and non-spring tides (2016-2022)

	Minor	General	Large	Major	Number of accidents	Number of days
Spring tides	18	6	0	2	37.7%	26.3%
Non-spring tides	28	12	2	1	62.3%	73.7%

Source: Shanghai MSA. Made by author.

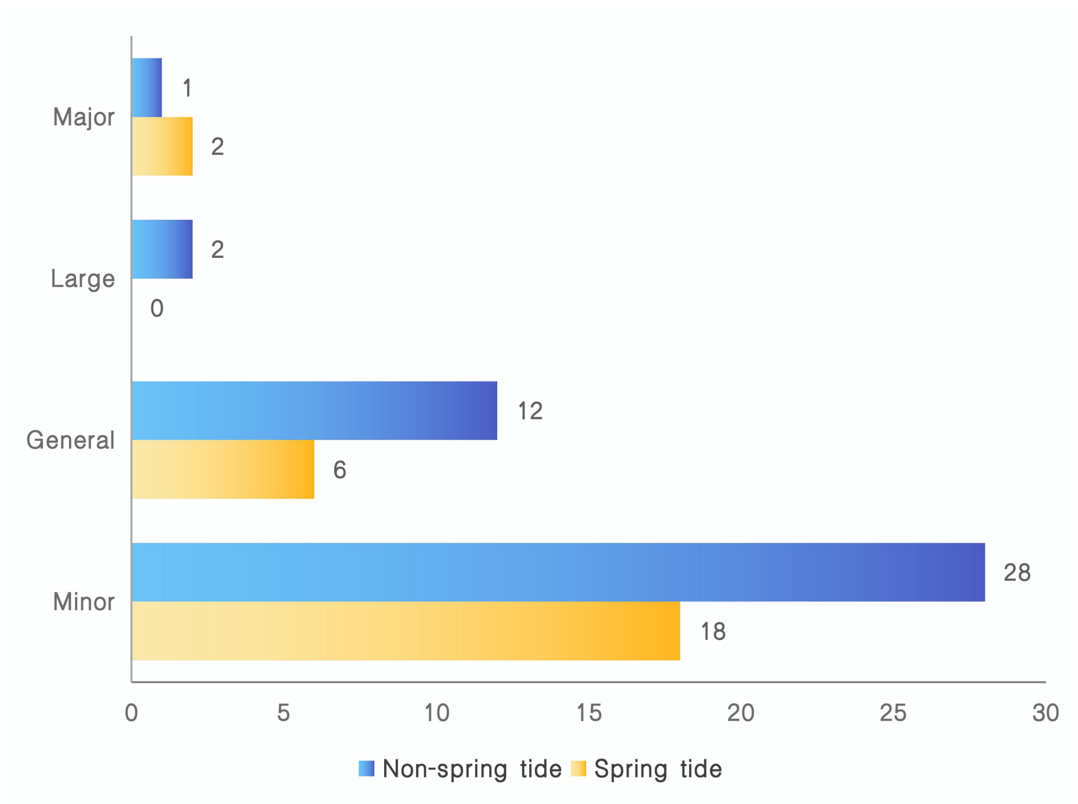

Figure 4. Comparison of different grades.
Source: Shanghai MSA. Made by author.

From Table 2 and Figure 4, it can be found that from 2016 to the end of 2022, a total of 46 minor accidents occurred in the Shanghai section of the Yangtze River; 18 occurred during spring tides, accounting for 39.1%; Among the 18 accidents of general grade, six occurred during spring tides, accounting for 33.3%; two of the three significant accidents occurred during the spring tide, accounting for 66.6%, which shows that the accident rate during the spring tide period is significantly higher than that during the non-spring tide period.

Table 3. Accidents loss statistics in YRSS(2016-2022)

	Number of Accidents	Ship sunk per accident	The average loss per accident (million)	Average dead or miss per accident
Spring tide	26	0.11	341.1	1.17
Non-spring tide	43	0.18	159.0	0.30

Source: Shanghai MSA. Made by author.

Table 3 shows that the water traffic accidents occurred during the spring tide caused an average of 0.11 ships sinking, 1.17 deaths and missing people, and 3.41 million yuan of economic losses per accident. Water traffic accidents during non-spring tide periods caused an average of 0.18 ships sinking, 0.30 deaths and missing people, and 1.59 million yuan of economic losses per accident.

Given the circumstances, it is imperative to investigate the correlation between ship accident rates and spring tide, thoroughly examine the risk factors associated with the latter, assign weights accordingly, implement corresponding measures, and minimize the occurrence of hazardous situations during the spring tide, thereby enhancing the safety of the YRSS.

1.3 Research Status

In this part, the author does not divide the literature review into domestic and foreign fields, but classifies the literature review according to the tide and spring tide, the tide characteristics of YRSS, and the impact of spring tide on ships.

1.3.1 Research on the tide and spring tide

Most geology, astronomy, and oceanography fields today are introduced to tides and tidal processes through equilibrium tidal theory (Open University Course Team, 1999; Duxbury et al., 2002). Tides refer to the cyclical rise and fall of sea levels resulting from the gravitational forces exerted by the Moon and the Sun on the Earth (Pugh & Woodworth, 2014). A spring tide occurs when the Earth, the Moon, and the Sun are aligned in a straight line (Komar, 2010), producing the highest high tides and the lowest low tides, leading to significant differences between high and low water levels. Since Peregrine (1976), an English researcher, discussed the diverse physical circumstances under which interactions between water waves and currents occur, leading to an impact on ships and maritime safety in Bristol Port, researchers in China and other countries have undertaken several studies in different areas, including Maputo Bay, Van Uc Estuary, Santa Catarina Island Bays, ShiJiu Port, Zhapu Port, Dongying Port, and Shanghai Port (Chen et al., 2013; Paulo et al., 2021; Violaine et al., 2020; Eliziane et al., 2019; Liu, 2018; Huang et al., 2020; Yang, 2021; Wang, 2020).

1.3.2 Research on tide characteristics in YRSS

Many scholars have focused on the tides of the YRSS. The Yangtze River is the longest in Asia and has a complex tidal system due to its extensive drainage basin and estuary (Feng, 2022). Wang (2013) studied the recent characteristics of the tidal current in the CJK area, and Guo (2015) pointed out that, based on various hydrological surveys and numerical models, the three-dimensional robust tide features of the Yangtze River estuary are widely acknowledged.

Yang (2001) applied three-dimensional marine dynamics to simulate the four main tide divisions at the mouth of the Yangtze River. It concluded that tidal currents are the most critical dynamic factor in the area. Feng (2022) conducted research based on an analysis of continuous multi-station tidal level data in the Yangtze River estuary and found significant inter-month changes in the tidal wave characteristics of the estuary, particularly during spring tides. This phenomenon threatens the estuary area's shipping, agricultural management, and safety risk prevention.

1.3.3 Research on the impact of tides on ships and maritime safety

Beji (2020) explored the relationship between tides, currents, and ships controlling, especially the low speed and deep draft ships are more easily influenced by tides. In Yang's (2021) experiments, tug thrust was unable to offset the lateral hydrodynamics during the spring tide, causing giant ships to be far from the berth and unable to complete the berthing task. Huang et al. (2020) used monthly tide data in Zhapu Port to calculate the berthing time window basing on industry norms and port berthing operation practices. Likewise, Liu (2018) examined the natural environmental conditions of the Rizhao Port Area and found that it was greatly affected by wind, tide, and fog. Especially during spring tide, the deep drafts, large tonnages, relatively clumsy maneuvering performance ultra-large ships in the channel under complex conditions is vulnerable.

1.3.4 Conclusion about the research status

In summary, after reading numerous literature, many researchers have analyzed the causes and characteristics of tides from different perspectives. Some scholars have studied the impact of spring tides on ship maneuvering and navigation safety from theoretical and practical aspects. However, the author found that rare researcher has analyzed the danger of tides from the perspective of accidents. Therefore, this dissertation intends to start from the accident data collected and organized over six years and qualitatively analyze the hazards of spring tides by comparing the accident rates during the spring and non-spring tide periods. Subsequently, through a questionnaire survey, the risk factors behind the spring tides will be quantitatively analyzed, which is also the innovation point of this dissertation.

1.4 Research Contents and Route

1.4.1 Research Content

This paper first summarizes the causes and characteristics of tide and spring tide, as well as their impact on navigation safety, by reviewing relevant literature and the latest research. It focuses on collecting and organizing maritime safety accidents that occurred in the Shanghai section of the Yangtze River in the past seven years, concluding that the probability of maritime safety accidents during spring tide periods is higher than during non-spring tide periods. Based on field research, this study analyzes the weight of various risk factors during spring tides and proposes corresponding solutions.

1.4.2 Route

Figure 5. shows the technical route of this dissertation. The literature review method was used in the early stage, and the third chapter is the focus of the dissertation, using the AHP method to calculate the weight of risk factors.

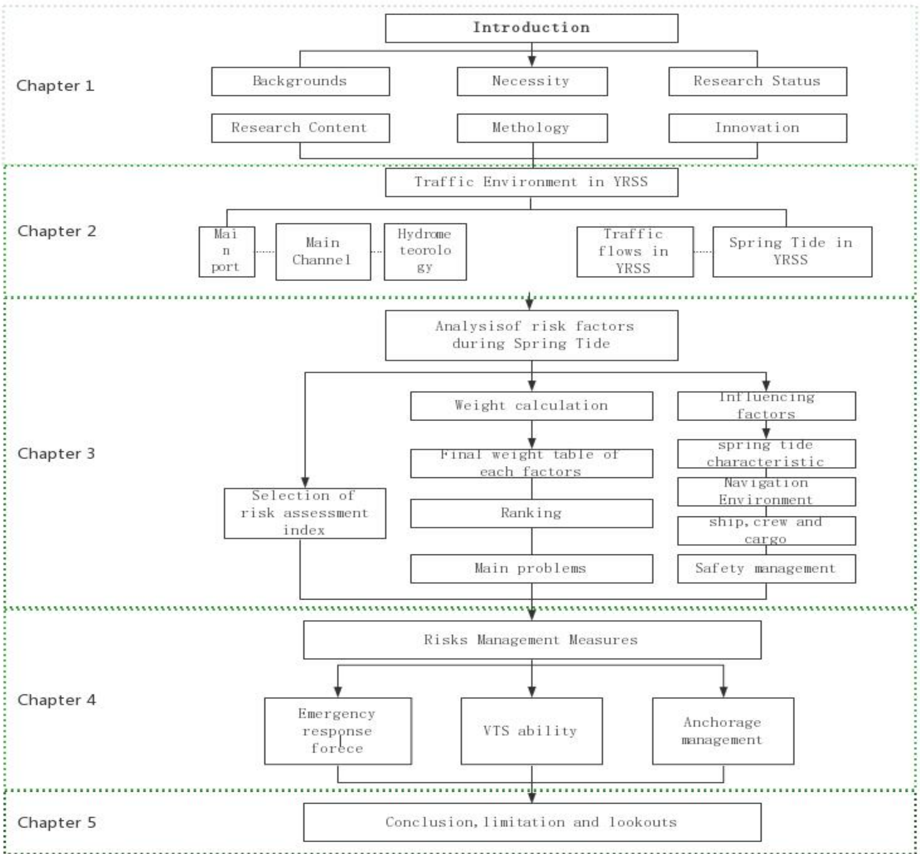

Figure 5. Technical route of this dissertation. Made by author.

Chapter 2 Traffic Environment

This chapter takes full advantage of literature review materials to introduce the basic overview, hydro-logical characteristics, tidal features, and traffic flow characteristics of the Shanghai section of the Yangtze River during spring tides.

2.1 General situation of of the YRSS

2.1.1 Main port

Shanghai Port is one of the main ports in the Yangtze River's Shanghai section. It can be found at 31°14′00″N, 121°29′02.95″E, situated in the middle of China's mainland coastline. This bustling port city sits on the south coast of the Yangtze River inlet, conveniently located near the river and the sea. Interwoven rivers surround the port, the Yangtze River delta, and the entire Yangtze River basin, making it a vital regional hub (Figure 6). Its abundant resources, developed economy, dense population, and convenient water and land transportation contribute to its unique geographical environment and favorable shipping conditions.

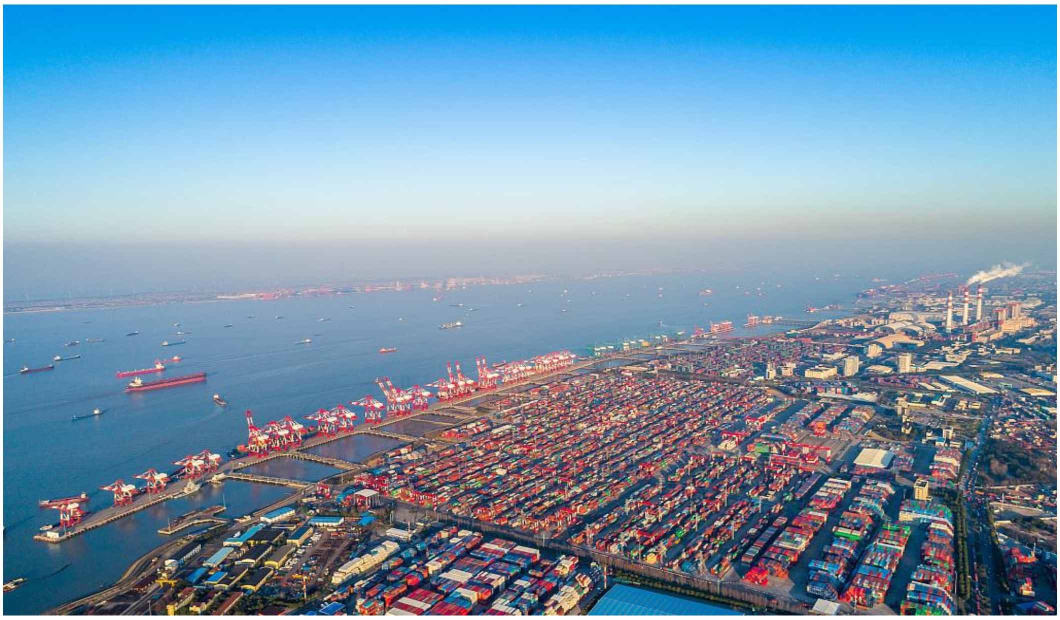

Figure 6. Shanghai port. Source:www.vcg.com

2.1.2 Main channel

The Shanghai section of the Yangtze River, situated in the delta region, encompasses the north deep water channel, the south channel, the Waigaoqiao channel, and the

Baoshan channel. This stretch is the primary passage for vessels entering and departing the Yangtze and Huangpu rivers(see Figure 7).

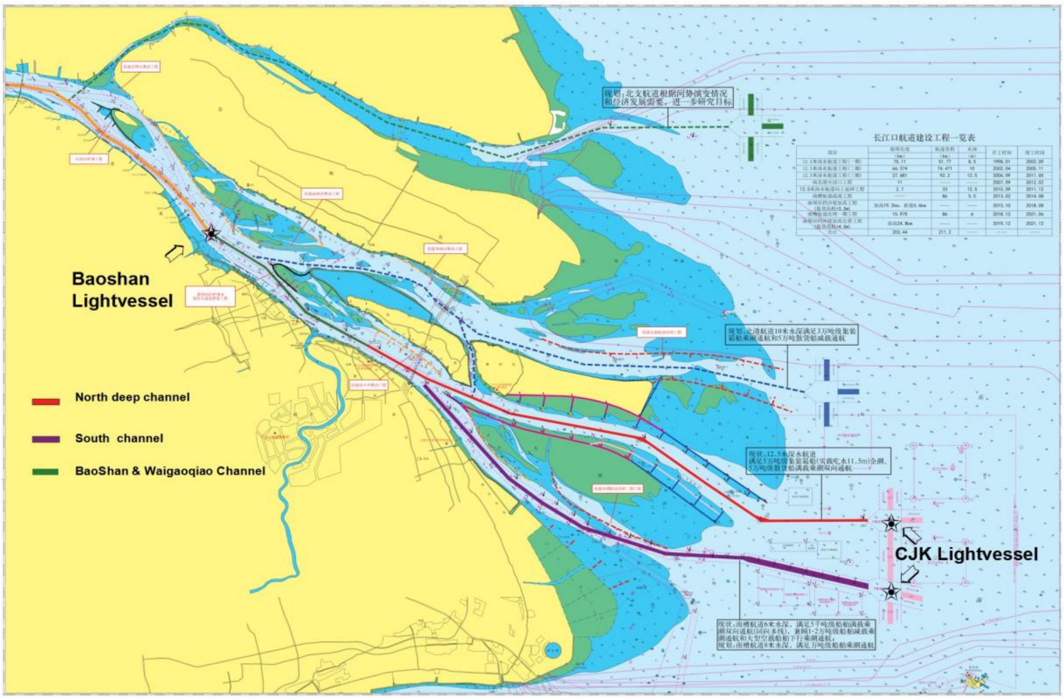

Figure 7. Main Channel of YRSS.
Source: Shanghai MSA. Made by author.

2.1.3 Hydro-meteorological condition

Shanghai has a northern subtropical maritime monsoon climate with four distinct seasons, mild and humid climate throughout the year, abundant rainfall, rich sunshine, long frost-free period, and seasonal changes in the wind are prominent.

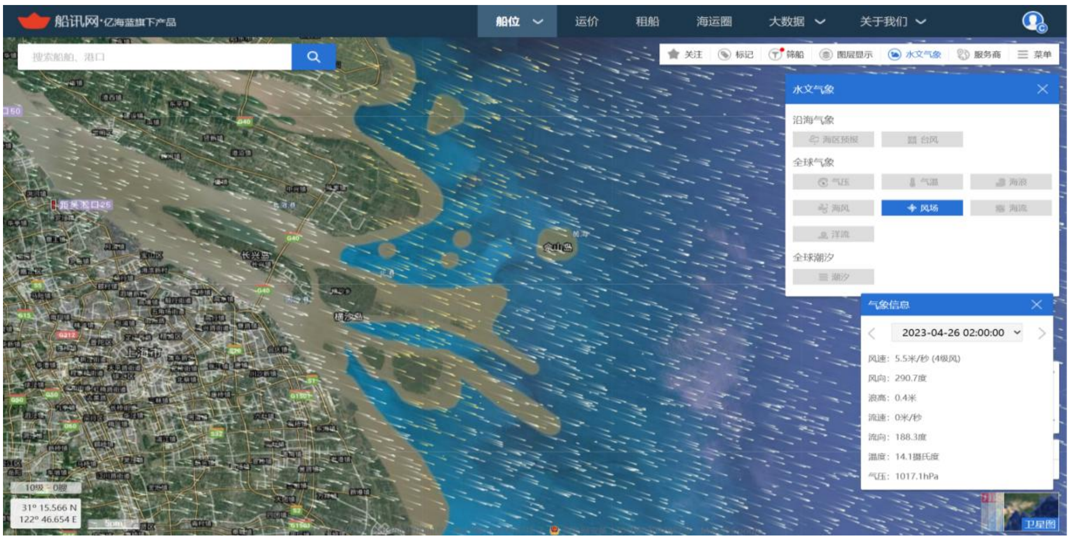

Figure 8. Wind farm near YRSS in spring, 2023.
Source：www.shipxy.com.

Figure 8 shows that there are more east and southeaster winds in spring and summer and early autumn and more northwest winds in late autumn and winter. In addition, winter and early spring are frequently attacked by the cold wave of cold air from the north; spring and early summer have more low-pressure gales, and high summer and early autumn have more tropical storms, typhoons, and intense convective weather and thunderstorms.

2.2 Particulars of spring tide

2.2.1 Spring tide in YRSS

(a) Shanghai port belongs to irregular semi-daily tide

There are two high tides and two low tides within 24 hours and 50 minutes, and unequal daily tides are relatively significant. The average time of high tide and low tide is delayed 48 minutes per day compared with the previous day. Usually, the first and the fifteenth day in the lunar calendar is the spring tide; the first three days(the first to the third day in a lunar calendar) and middle three days(the fifteenth to seventeenth day in a lunar calendar) are the spring tide period; Similarly, the lunar calendar, the ninth and twenty-fifth day is the neap flood. The high tide level during a spring tide is 4-4.5 m, and the high tide level of a spring tidal flood can reach 4.5 m or more(see Table 4).

Table 4. spring tide grade in YRSS

Categories	Very Small	Small	Medium	Large	Very Large
Tide height in ZhongJun station	Above 3m	3-3.6m	3.6-4.0m	4.0-4.5m	Over 4.5m
Tide difference in ZhongJun Station	Above 0.9m	0.91-1.81m	1.83-2.74m	2.74-3.66m	Over 3.66m

Source: Internet. http://swj.sh.gov.cn/

(b) Day and night tide size change cycle

Every day, the height of two high tide and low tide are different. The day or night is also constantly changing, its cycle for a year. The night tide is larger than the day tide during the flood season; the timeline of interchange lies in the vernal and autumn equinox; that is, after the vernal equinox, the night tide gradually increases, the day tide gradually decreases, and after the autumn equinox, the situation is the opposite.

(c) Tide pattern

YRSS gradually shrinks from a wide sea surface to a narrow estuary from the outside to the inside. The Yangtze River tidal flow is restricted by the shoreline on both sides and the morphology of the river bottom, forming three flow patterns:

1. Rotating flow - the tide flow direction rotates with time. In the waters near the CJK area, the tide is a rotating flow; the flow direction changes to the local spring tide moment as the starting point, clockwise changes, different tide measurement positions, the rotation of the situation is also different(see figure 9).

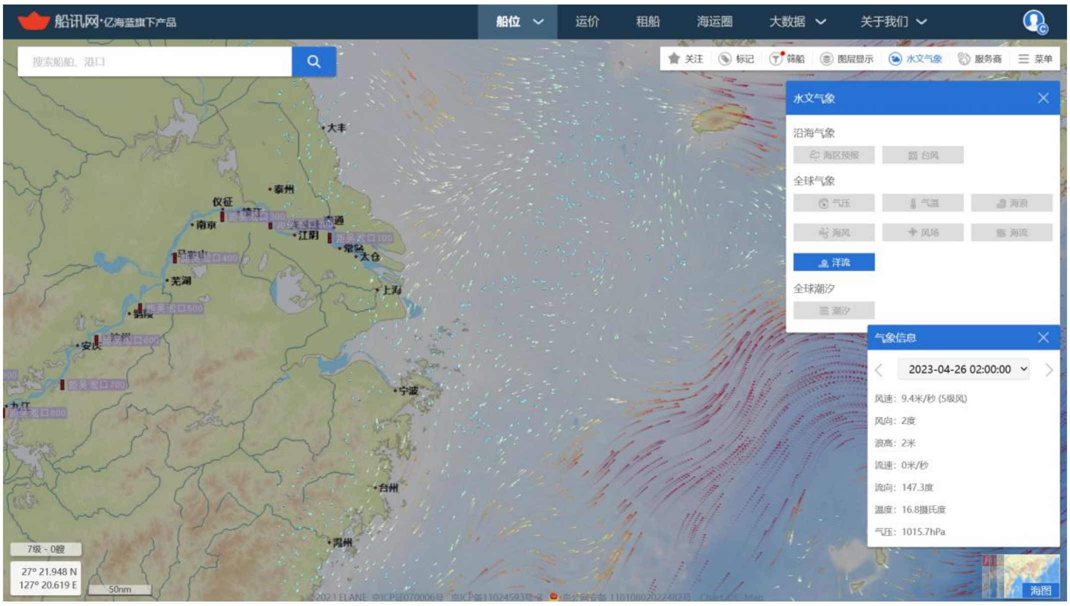

Figure 9. Rotating flow outside of YRSS.
Source: www.shipxy.com

2. Deformed rotating flow - is the transition form of rotating flow to reciprocating flow conversion; the change of flow direction is not only uneven rotation but also not completely stable in the opposite two directions(see figure 10).

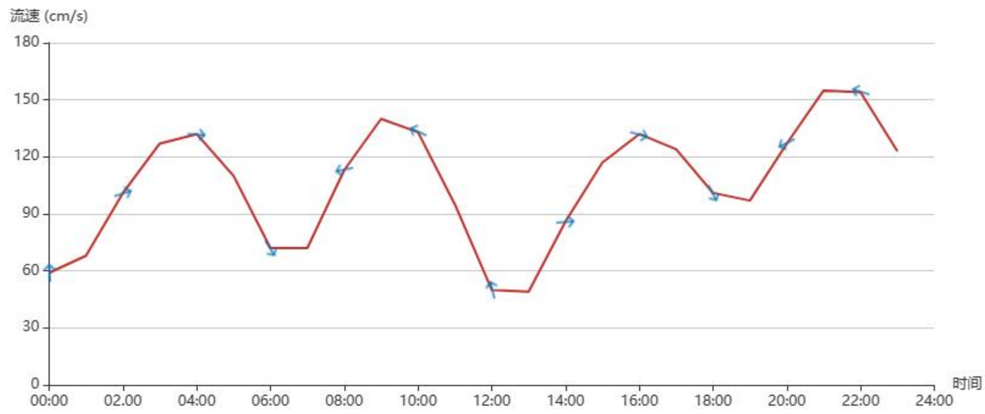

Figure 10. Deformed rotating flow in CJK area. Source: NIDMS.
(Longitude:122.317, Latitude:31.350)

3. Reciprocal flow - the flow direction of high tide and low tide is only stable in two opposite or nearly opposite directions(see Figure 11). The the nine-dash precaution area is the dividing line between the rotating and reciprocating flow in YRSS.

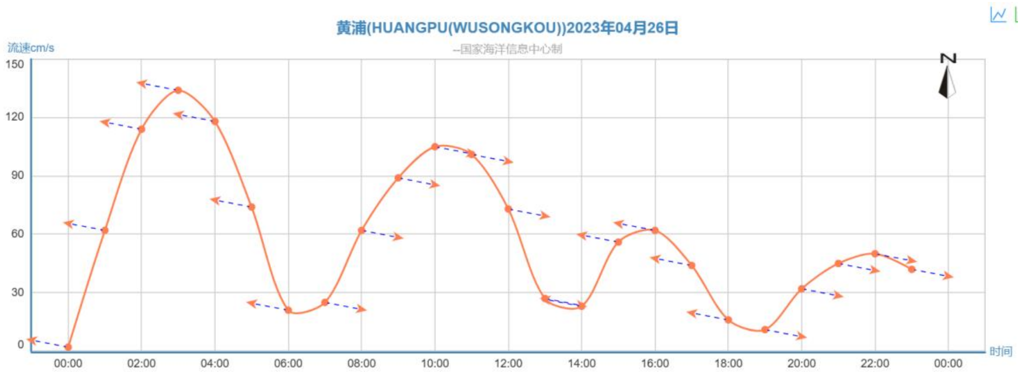

Figure 11. Reciprocal flow in HUANGPU. Source: NIDMS. Download by author.

2.2.2 Traffic flows in YRSS

(a) North deep channel

Figure 12. shows the traffic flows changes with the tide time in the north deep channel. From seven hours before the high tide in Changxing(one of the tide stations) to one hour is the peak. During that time, ships with large drafts (8~12.5m) queue in line every six minutes(Zhang, 2022). When encountering the spring tide, the density is more extensive than usual. Because the high current speed makes it challenging to maintain the required speed, it can easily cause channel congestion, and the ship cannot ensure sufficient safety spacing.

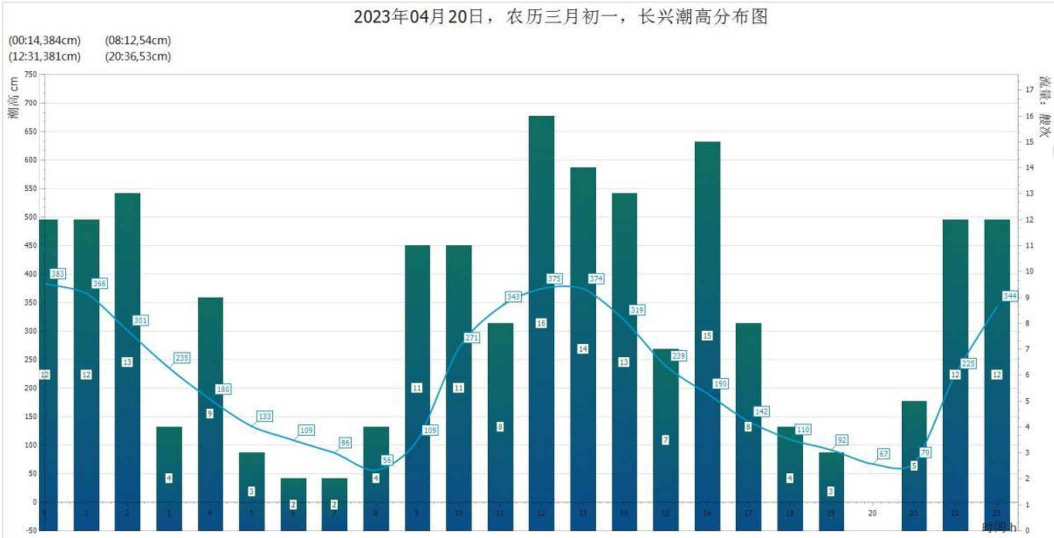

Figure 12. Traffic flows during spring tide in deep water channel.
Source: Shanghai MSA

The most obvious place of rotating flow in the deep water channel is near the D12 buoy(see Figure 13), the flow direction of the rising and falling tide flow constitutes an intersection angle of 10~30 ° with the direction of the channel, and the rising flow pressure is more evident during the spring tide, which makes it difficult to control the ship position under the influence of the flow pressure. The ships entering the channel easily sail into the exit channel, forming a dangerous situation.

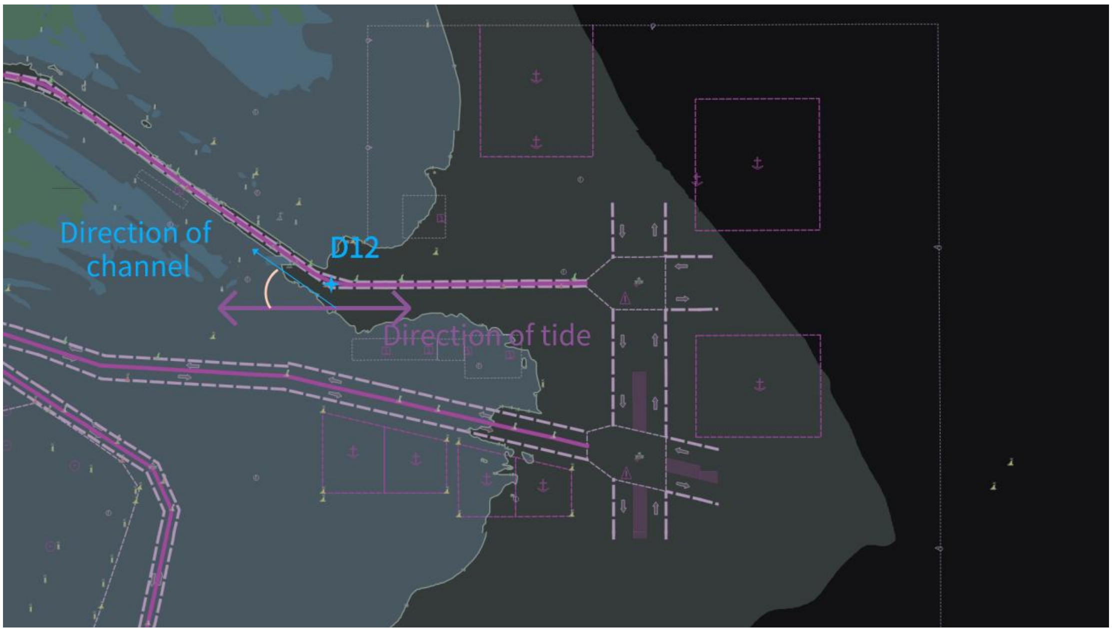

Figure 13. Angle between channel and tide at D12 buoy in deep channel.Source: Shanghai MSA, made by author.

(b) South Channel and South Branch Channel

Figure 14. shows that in the early rise time, the south branch channel has many small inbound boats (for economic concern) from the nine-dash precaution area. Encountering with the south channel traffic flow of big ships(for drafty concern), heading on the formation of a cross situation(Feng, 2017).

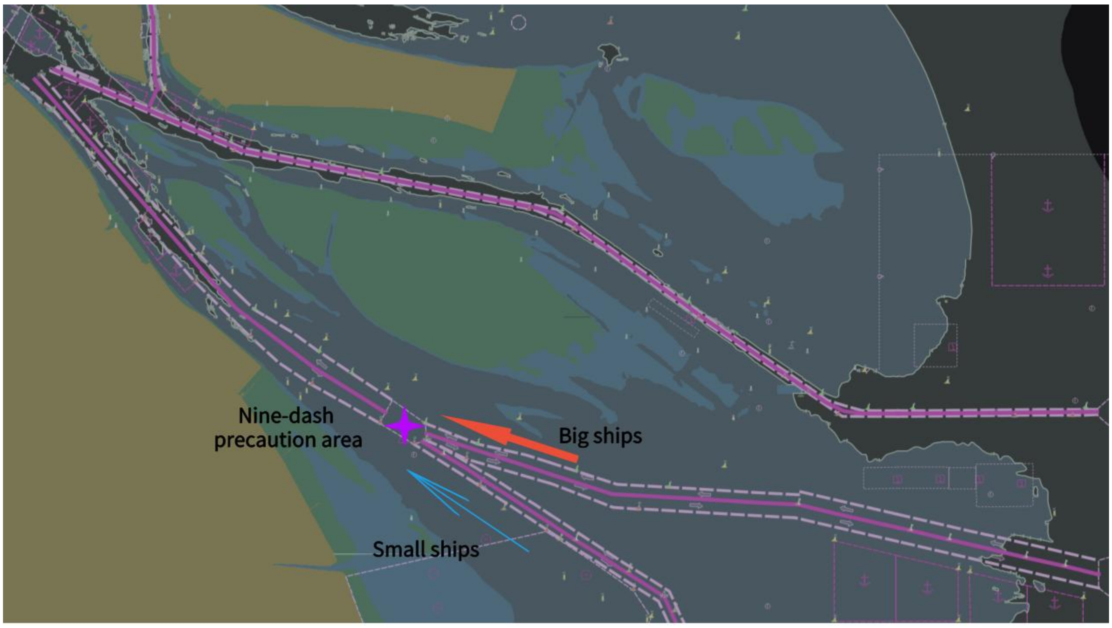

Figure 14. Big ships and small ships encountered in precaution area during spring tide.Source: Shanghai MSA, made by author.

Figure 15. shows the traffic flow in the south channel. It is evident that the flow changes with the tide. In peak time, many ships navigate in the channel together, adding to the solid northward flow pressure, making the ships challenging to maneuver, quickly leading to an urgent situation(Yang, 2017).

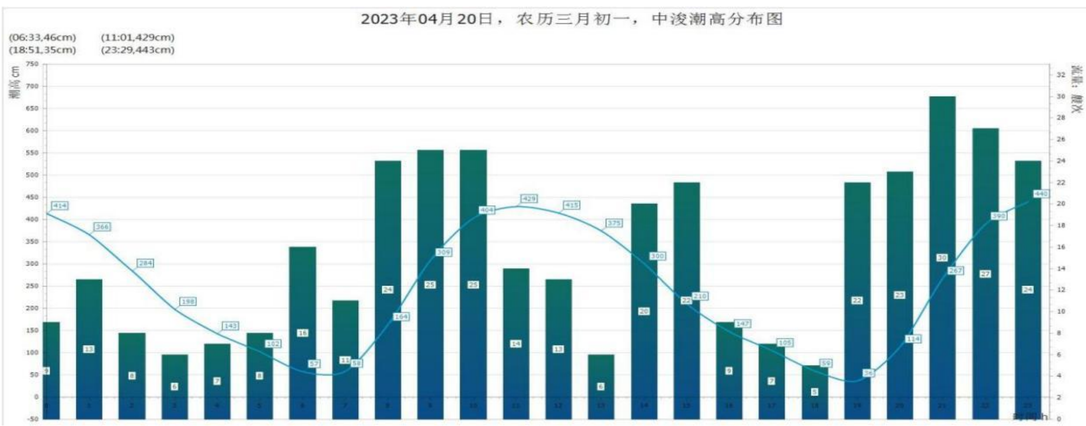

Figure 15. Traffic flows in South Channel.Source: Shanghai MSA

(c) Waigaoqiao channel

The tide flow direction in Waigaoqiao follows the direction of the channel. The peak time is two hours before and 1 hour after the high tide in Wusong(one of the tide stations). Thus, north and south inbound traffic flow emerged in the Yuanyuansha precaution area. Many ships navigated side by side; it is challenging to maintain a safe distance. At the same time, the ships berthing and leaving the Waigaoqiao harbor will make dangerous intersections with the traffic flow(Lin & Liu, 2022).

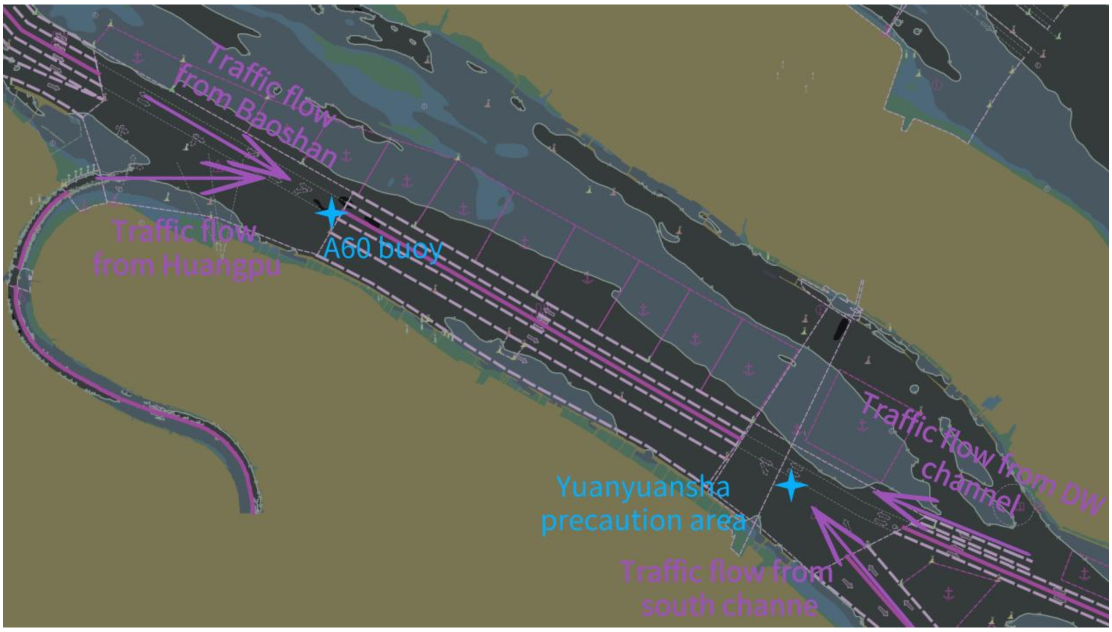

Figure 16. Traffic flow in Waigaoqiao channel.Source: Shanghai MSA, made by author.

During the low tide, the ships outbound in the Wusongkou precaution area have two traffic flows before arriving at Waigaoqiao channel, one is the outbound ship from Huangpu River or Baoshan port pool, and the other is the outbound ships from the Yangtze River upstream via Baoshan channel, and the two ship flows have a small angle crossing before arriving at A60 buoy(see Figure 16).

Figure 17. shows the traffic flows in the Waigaoqiao channel. During the high tide flood, a large number of imported vessels cannot berth directly, resulting in great demand for anchorages, and due to the staggered control, vessels with anchoring needs cannot anchor immediately, while the need for a larger anchor distance during

the high tide flood leads to a tight anchorage. In addition, the water depth on the north side of Wusong anchorage becomes shallow, so the anchored ships are not safe under keel clearance(UKC) after the tide falls and are prone to run aground.

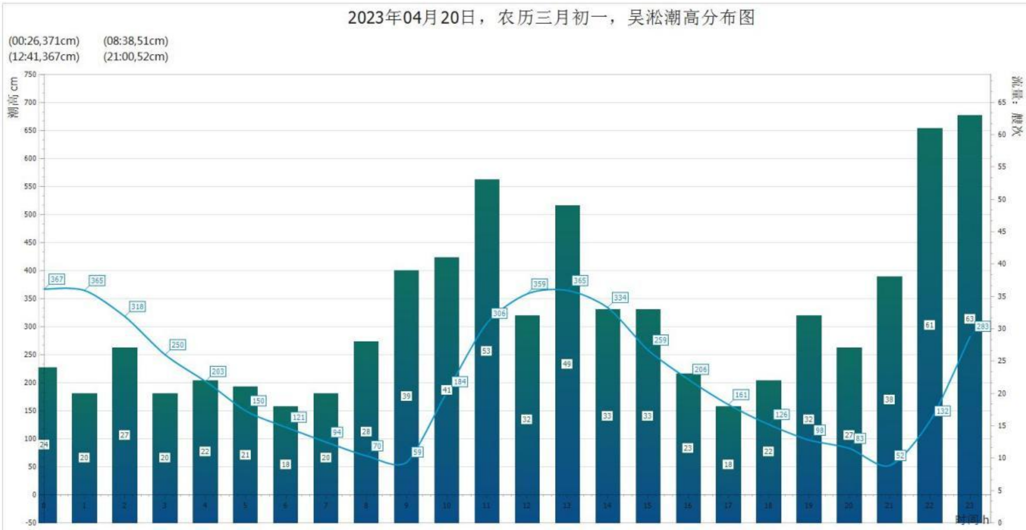

Figure 17. Traffic flows during spring tide in Waigaoqiao Channel.
Source: Shanghai MSA.

(d) Baoshan channel

Figure 18. is the basic situation of the Baoshan channel. The tide of Baoshan channel is reciprocal flow; the bottom flow direction is basically parallel to the channel, the surface flow direction is slightly different from the waterway; the rising tide flow direction is 300°~315°; the falling tide flow direction is 120°~130°.

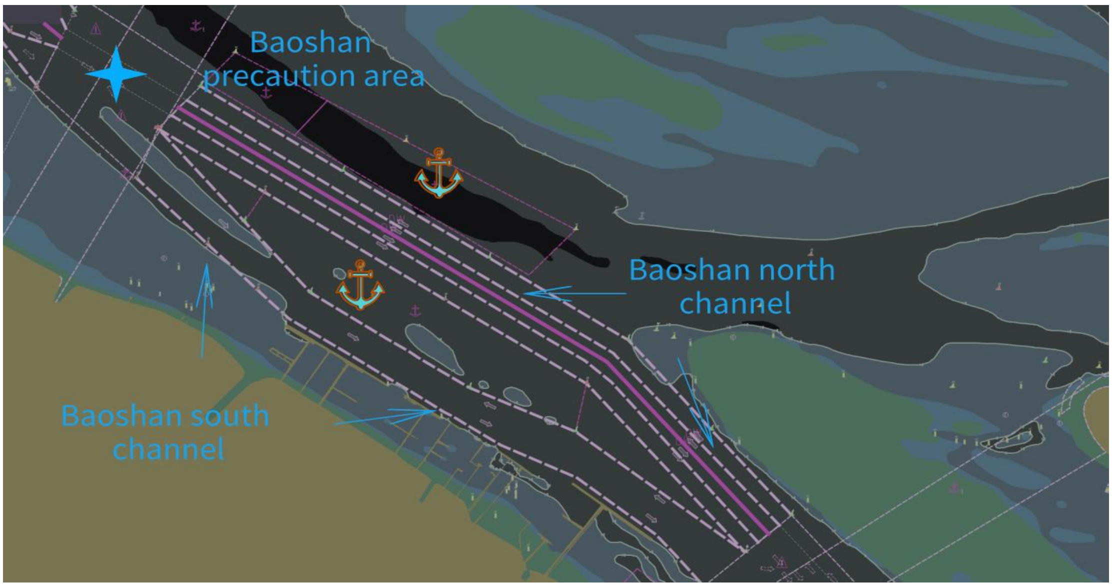

Figure 18. Traffic flow in Baoshan channel.
Source: Shanghai MSA, made by author.

Baobei and Baonan channels are navigable in both directions, and the middle is the extension of a deep water channel for large draft ships to navigate. At the same time, in the initial rise stage, there are a large number of river vessels from the Huangpu River outbound into the Yangtze River, which poses a huge threat to the big vessels(see Figure 19).

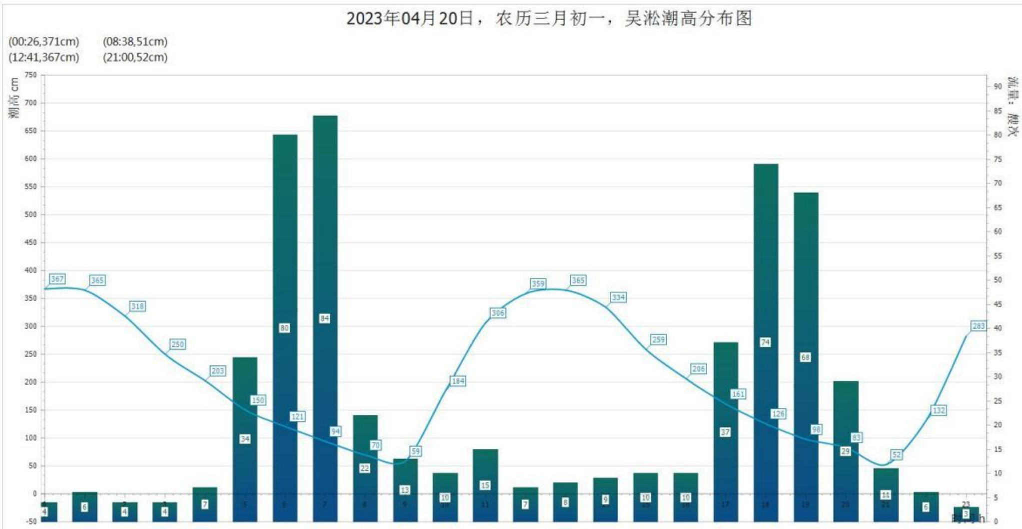

Figure 19. Traffic flows during spring tide in Baoshan Channel
Source: Shanghai MSA.

Chapter 3 Analysis of Risk Factors

This chapter thoroughly analyzes accident data, focusing on the impact of spring tides on collisions, dragging anchors, grounding, and loss of propulsion incidents. Using the Analytic Hierarchy Process(AHP) and collected survey questionnaires as data sources, weights are assigned to various risk factors, resulting in a risk structure diagram.

3.1 Selection of spring tide risk assessment index

It is very complex to analyze the risks of spring tide in YRSS, and various factors need to be taken into account, such as the meteorological and hydrological conditions, the channel capacities, the maritime management, and the ship condition(Shuai, 2016). Therefore, this work needs to be carried out by means of a complete evaluation index system. This paper intends to analyze the various factors during spring tide in YRSS and form a risk assessment system.

Formal Safety Assessment (FSA) is a structured and systematic methodology aimed at enhancing maritime safety, including the protection of life, health, the marine environment, and property, by using risk analysis and cost-benefit assessment(IMO, 2018). By using the system risk assessment, it can be found which areas of intervention will be more effective(Shuai, 2016). In this paper, several steps of the FSA(issued by IMO) are used for the establishment of a spring tide risk system in YRSS.

3.2 Influencing factors of risk assessment

3.2.1 Spring tide characteristic factors

(a) High traffic density

A large number of inland river vessels in and out of the Yangtze River coastline of major ports will give priority to the rising and falling water. The figure shows that, in the peak period, there are often multiple ships side by side(see Figure 20,21), leaving little space for the ships to do collision avoidance. Then taking the suction effect into consideration, a little carelessness will cause the ship to scrape and collide. In addition, the high-density ship flow will also bring a shortage of VHF radio resources; during the peak of the ship flow, public channels are noisy, it is difficult to contact the target ship the first time, the dynamic between ships is not clear, increasing the risk of ship collision(Hu, 2021).

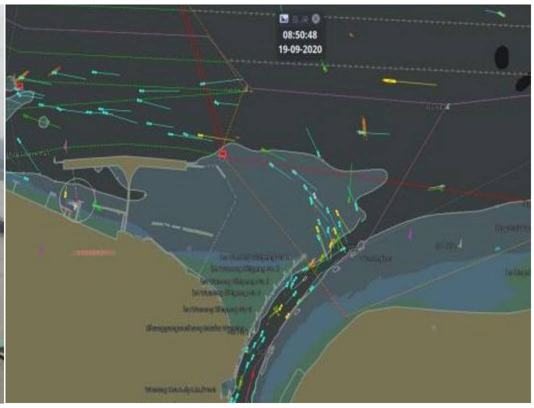

Figure 20. Photos of high traffic density. Figure 21. AIS map of ships in WSK.
Source: Shanghai MSA.

(b) Big tide difference

During the spring tide, the high tide level is above 4 meters, and the tidal difference in the Shanghai section of the Yangtze River is more than 3 meters; the maximum tidal difference is about 4.5 meters. When the tide level is high, the tide difference is large. The vessel at anchor and navigation, if not leave enough UKC, it is easy to run aground and cause other dangerous accidents.

Table 5.Statistics of grounding ships in YRSS.

Years	Days of spring tide	Grounding ships during spring days	Grounding ships per spring day	Days of non-spring days	Grounding ships during non-spring days	Grounding ships per non-spring day
2016	100	21	0.210	266	35	0.132
2017	99	20	0.202	266	30	0.112
2018	100	17	0.170	265	29	0.109
2019	100	18	0.180	265	31	0.117
2020	99	10	0.101	267	19	0.071
2021	100	13	0.130	265	24	0.090
2022	99	15	0.151	266	22	0.083
2016-2022	697	114	0.163	1859	190	0.102

Source: Shanghai MSA. Made by author.

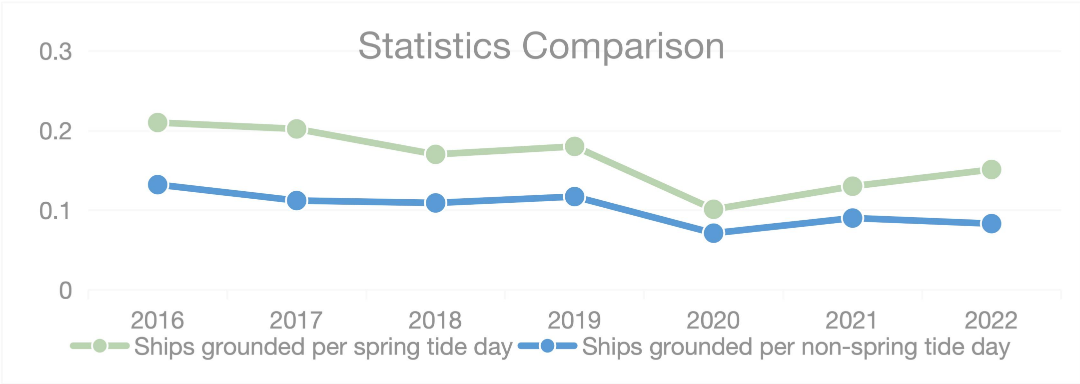

Figure 22. Ground ships comparison between spring day and non-spring day
Source: Shanghai MSA. Made by author

Table 5. and Figure 22 shows that the probability of ship running aground during spring tides is significantly higher than that during non-spring days.

(c) High current speed

During the spring tide, the current speed can reach 4 knots, and it is difficult to control the ship's position when the speed of the ship is low. And it is easy to form an urgent situation with the anchored ships in the anchorage and the ships sailing in the channel.

Figure 23. shows a major accident caused by high current speed during spring tide. At 2330 hours on January 2, 2018, the bulk carrier "Changping" collided with the anchored vessel "Xinwang 138" during heaving up his anchor and navigating out of No.8 anchorage in Wusongkou. The accident caused the sinking of the "Changping" ship, three crew members were rescued, and ten crew members died. When the accident happened, the ship was under the influence of the strong rising tide, and when the ship sailed from the anchorage to the main channel of Waigaoqiao, the ship drifted in the direction of the right side of the ship under the combined effect of the flow and wind, causing the accident.

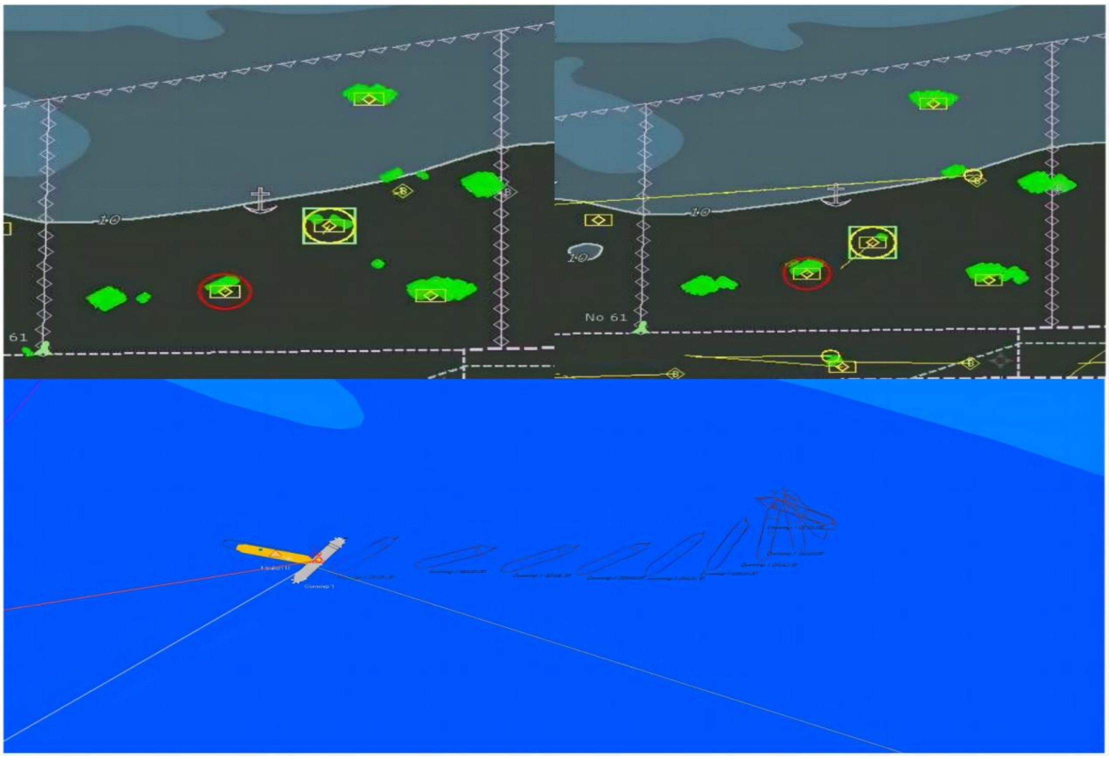

Figure 23. Collision diagram of "Changping" and "Xinwang 138". Source: Shanghai MSA. Made by author.

3.2.2 Navigation Environment factors

(a) Meteorological condition

Meteorological factors such as wind, waves, and visibility can significantly impact the safe navigation of ships in YRSS, especially during extreme weather events such as typhoons. Figures showed that, in 2022, there were seven typhoons impacting Shanghai(see Figure 24). These weather conditions can have a significant impact on the marine environment, including tidal changes. Research has found that during typhoons, tides usually experience significant fluctuations, often rising several tens of centimeters or even more above normal levels (Wu et al., 2017). In addition, the wind direction and speed of typhoons can also affect the direction and speed of tides, resulting in different characteristics of tides in different locations (Zheng et al., 2019).

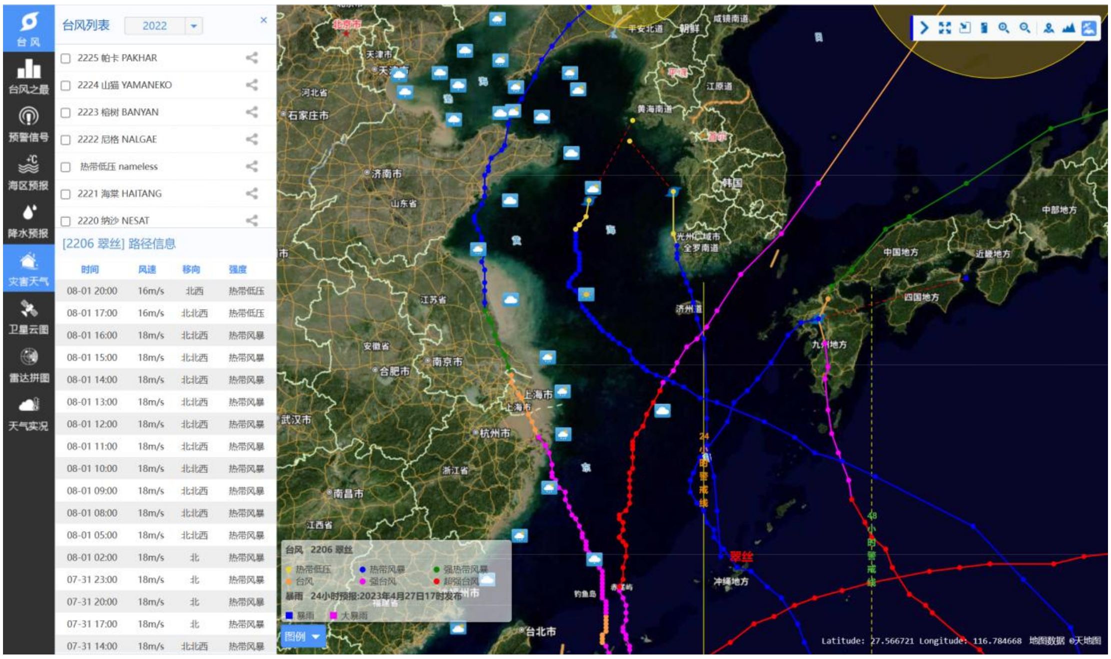

Figure 24. The typhoon in 2022. Source: www.typhoon.nmc.cn

(b) Channel condition

The condition of the channel mainly includes the width, depth, elbow, obstacles, navigation aid. The channel of the YRSS is limited by natural conditions, and the maximum water depth allowed for ships to navigate is 12.5 meters, and the minimum width is about 100 meters. Moreover, there are many navigation aids, some lights are physical buoys, and some lights are virtual AIS buoys. Figure 25 shows the navigation aids in YRSS.

Figure 25. Navigation aids in YRSS.
Source: www.shipxy.com

3.2.3 The factors from ship,crew and cargo

(a) Ship factor

There are various types of ships, and their susceptibility to tides and currents can depend heavily on various factors such as the ship's type, tonnage, and age. A study by Xu and colleagues (2017) investigated the influence of tide and current on ship navigation in the Bohai Sea of China. They found that smaller ships were more affected by tidal currents compared to larger ships. Similarly, a study by Vakakis and colleagues (2015) investigated the influence of currents on the motion of a small boat in the Aegean Sea. The authors found that the boat's motion was strongly influenced by the current and that the boat's small size and low mass made it more vulnerable to the effects of the tide current.

Besides, according to Huang and Gu's (2016) study on the influence of ocean currents on the maneuverability of ships, an increase in ship age may cause a decline in ship performance, including structural strength, stability, and mechanical equipment, which may affect the ship's ability to adapt to ocean currents.

(b) Crew factor

According to the International Maritime Organization, human error, including errors made by crew members, is a significant contributing factor in more than 80% of all accidents at sea(IMO, 2018). Research has shown that crew training, rest, and support are essential for mitigating the risks associated with human error (Johnsen & Hystad, 2018; Yu et al., 2020). Therefore, whether the crew has been trained or educated with the knowledge of spring tide is crucial for dealing with the emergency caused by spring tide.

(c) Cargo factor

During the spring tide periods, the tidal range is larger, and the tidal current is stronger, which could cause greater impact and lateral forces on the ship's stability during entry and exit of the port. In addition, the change in water level during the tide could also affect the ship's draft, leading to reduced stability and potential safety hazards, particularly for ships carrying heavy and dense cargoes like steel (Guo et al., 2019). The interaction between the tidal current and the ship's hull could result in a strong lateral force that affects the ship's stability, causing it to tilt or even capsize (Ma et al., 2020). Additionally, the change in water level during the tide could also lead to a change in the ship's draft, which could further affect its stability and safety.

3.2.4 Safety management factors

(a) Maritime safety administration(MSA)

The MSA is responsible for safety supervision during spring tide. Whether the MSA can monitor maritime operations, provide warnings and advisories, coordinate with other agencies, and enforce regulations towards spring tide is crucial. There are many indicators to judge the performance of the MSA, including the number of competent officers, the number of patrol boats, the location of the emergency response force, and VTS monitoring ability.

(b) Shipping company management

The management level of the shipping company also directly affects the probability of accidents during spring tide. Whether the shipping companies pay enough attention to risks caused by spring tide is important for the ship and crew to handle the spring tide appropriately and effectively. Assessment indicators include providing training to the crew, establishing working procedures whether, ensuring proper vessel maintenance, whether enhancing the safety awareness of the crew.

In reference to FSA, after listing factors, the risk evaluation system is established, as shown in Table 6.

Table 6. The Risk Evaluation System

Goal Level （A）	Criterion Level （B）	Index Level I （C）	Index Level II （D）
Safety risks of ships in YRSS during spring tide	Spring tide characteristics factors(B1)	High Traffic Density (C11)	Complex situation in precaution area(D111)
			Difficulty to cross the channel(D112)
			Difficulty to berth and leave(D113)
		Big Tide Difference (C12)	Grounding in anchorage(D121)
			Grounding in channel(D122)
		High Current Speed (C13)	Easy to dragging (D131)
			Difficulty in maneuverability(D132)
			Below or over required speed(D133)
	Navigation Environment factors (B2)	Meteorological condition (C21)	Strong wind or typhoon season(D211)
			Poor visibility(D212)
			Storm surge(D213)
		Channel condition （C22）	Width （D221）
			Depth （D222）
			Navigation Obstruction （D223）
		Anchorage zone (C23)	Quantity
			Quality
			Anchorage management

	The factors from ship,crew and cargo (B3)	Ship factor (C31)	Type (D311)
			Tonnage（D312）
			Age（D313）
		Crew factor (C32)	Knowledge of spring tide(D321)
			Familiar with navigation environment in YRSS(D322)
			Experience(D323)
		Cargo factor (C33)	Cargo type(D331)
			Cargo density(D332)
	Safety management factors (B4)	Maritime safety supervision (C41)	Relative regulation or countermeasures(D411)
			VTS monitoring ability(D412)
			Emergency response force(C423)
		Shipping company management (C42)	Rules,regulations, implementation (D421)
			Relative training(D422)
			Procedures or checklists on spring tide(D423)

Source: Author. Made by author.

Goal level refers to the overall objective of the risk assessment system. This dissertation focuses specifically on the risk management of spring tides in the Shanghai section of the Yangtze River.

Criterion level is the standard level. As the spring tide risk assessment system consists of many interrelated factors, these factors can be broadly categorized into four categories, including the characteristics of spring tides, the navigational environment, ship, crew, and cargo, and safety management.

Index I level and index II level, the evaluation index factors should be further refined for each category of evaluation criteria. This involves describing all relevant factors to obtain the lowest evaluation index, and this process should be repeated for each major category of indicators using the same steps and requirements.

3.3 Risk assessment index weight calculation

After establishing the above risk assessment system, the next important step is to calculate the weight of each factor. This paper adopts the research method of a questionnaire survey. Considering that the participants must be very familiar with spring tide in YRSS, the researcher has targeted pilots from Shanghai Pilot Station, VTS operators from Shanghai MSA, navigators who often arrive at Shanghai Port, and shipping company managers based in Shanghai.

3.3.1 Introduction of Analytic Hierarchy Process

Analytic Hierarchy Process(AHP) is a mathematical framework for structuring the multiple criteria decision-making process that is widely used in almost all the applications related to decision-making in fields such as government, business, industry, healthcare, and education(Saracoglu, 2013; Vaidya &Kumar, 2006; Hoshida, 2006; Saaty &Kirti, 2008). By applying this method, the decision maker can analyze different levels of risk factors through comparison and calculation, then get a weight matrix and offer support for the solutions.

Figure 26. shows the main steps of AHP in this dissertation: Firstly, structure the risk factors during the spring tide model in a hierarchy of different levels, including goal, criteria, index, and sub-index. Secondly, construct a judgment matrix according to the hierarchy. Thirdly, calculate the matrix by comparing each element at the same level

and calibrating them on the numerical scale. Finally, check the consistency of the results.

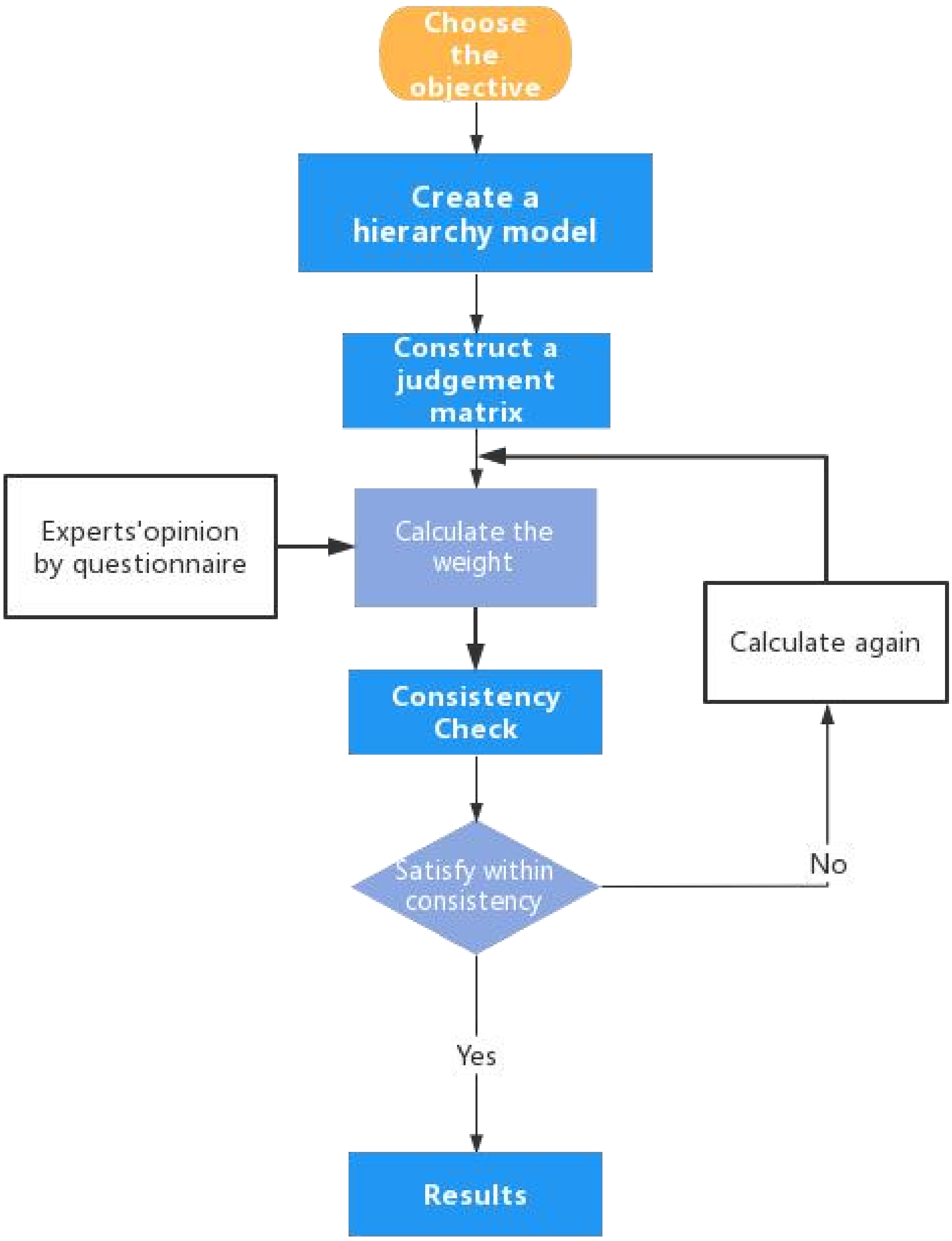

Figure 26. The steps of AHP. Source: Internet. Made by author.

(a) Structure a hierarchy model

When applying AHP to analyze decision-making problems, it is first necessary to organize and hierarchy the problem and construct a hierarchical structural model. Under this model, complex problems are solved into parts of elements(Hu, 2019). These elements, in turn, form layers according to their properties and relationships.

The elements of the previous level serve as guidelines and dominate the relevant elements at the next level. The number of layers in a hierarchy is related to the complexity of the problem and the level of detail that needs to be analyzed, and the number of general strata is not limited.

(b) Construct a judgment matrix

Hierarchies reflect the relationships between factors. However, each criterion in the criteria layer does not necessarily have the same weight in measuring objectives, and each has a certain proportion in decision-makers minds.

Table 7. Judgement matrix number scale and its meaning.Source: Internet

A_{ij}	Meaning
1	A_i is equally important than A_j
3	A_i is slightly more important than A_j
5	A_i is more important than A_j
7	A_i is much more important than A_j
9	A_i is significantly more important than A_j
1/3	A_j is slightly more important than A_i
1/5	A_j is more important than A_i
1/7	A_j is much more important than A_i
1/9	A_j is significantly more important than A_i

Note: if A_{ij} = 2,4 ,6,8 or 1/2,1/4,1/6,1/8 means that The importance is between two adjacent scale.

The main difficulty in determining the proportion of influencing factors is that these weights are often not easily quantified. Saaty et al. suggest that a pairwise comparison of factors can establish a pairwise comparison matrix(see Table 7).

(c) Calculate the weight

The judgment matrix A corresponds to the eigenvector W with the largest eigenvalue λ_{max}, and after normalization, it is the ranking weight of the relative importance of the corresponding factor at the same level to a factor at the previous level, which is called hierarchical single sorting.

Although the above method of constructing a pair comparison judgment matrix can reduce the interference of other factors, it can more objectively reflect the difference in the influence of a pair of factors. However, when all the results are combined, it is inevitable that there will be some degree of inconsistency(Ye, 2021).

(d) The steps of the consistency check

Calculate paired matrix A inconsistency, CI=(λ_{max} - n) /(n-1), λ_{max} is the maximum eigenvalue of matrix A, RI is the average random consistency index, which is determined by the order of the matrix.

Table 8. Consistency check RI value table.Source: Internet

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.56

Calculate the random consistency ratio CR of matrix A: CR=CI/RI(see Table 8.), When CR<0.1, the judgment matrix A has satisfactory consistency or its inconsistency level is within an acceptable range: otherwise, matrix A needs to be adjusted until it has a suitable consistency(Zhang, 2019).

3.3.2 Calculation of risk factors during spring tide based on AHP

According to the basic steps of the AHP, the characteristics of spring tide, the navigational environment, the factors from ship crew and cargo, and the safety management are calculated by the Matlab program. The specific process is as follows:

(a) Experts' opinions by questionnaires

A questionnaire survey collects information by formulating a detailed questionnaire and asking respondents to answer accordingly(Xiao, 1995). For calculating the weight of each factor, the questionnaire survey is used in this study. With the help of the Shanghai Maritime Safety Administration(MSA), 16 questionnaires were filled out by targeted participants, including four VTS operators, four pilots from the Shanghai pilot station, four captains who often sail in Shanghai, and four managers from a shipping company based in Shanghai.

(b) The balance of experts' opinion

In this study, 16 experts from four fields were likely to produce inconsistencies due to the different knowledge backgrounds of each expert, the different degrees of understanding of the spring tide in YRSS, and the interference of the experts' preferences, the evaluation of the matrix(collected from questionnaires). For the evaluation results of each expert, how to divide the expert matrix with great differences, then adjust it, and finally unify the opinions of the expert group decision-making has become a big problem of this research.

Hua et al. (2003) introduced a formulation to make the inconsistency adjustment of the individual expert judgment matrix, which give different coefficient to experts in different fields. In other cases, the authors applied the validation process: benchmarking was applied for comparison with the application of the method for other organizations(Durán & Aguilo, 2008); some(Celik & Deha, 2009; Sarkar & Ray, 2012; Rostamzadeh & Sofian, 2011) used a sensitivity analysis; In this research, considering that experts in this research are very familiar with spring tide in YRSS, the number of each field is equal. In this part, the opinions of 16 experts are averaged and presented in a matrix. The final values are compared to Saaty's(2008) nine-scale numerical table(Table 7.), and the nearest number scale is selected.

(c) Construct a comparison matrix

After balancing the experts' opinions, the final judgment matrix is constructed. Then, author used the Matlab program to calculate the judgment matrix and check the consistency, the results are shown in the following tables, and the calculating process is in the appendix 3.

Table 9. Criterion Level Comparison Matrix

	B1	B2	B3	B4	W_i
Spring tide characteristic factors (B1)	1	3	4	1	0.3713
Navigation Environment factors (B2)	1/3	1	2	1/5	0.1256
The factors from ship,crew and cargo (B3)	1/4	1/2	1	1/3	0.0935
Safety management factors (B4)	1	5	3	1	0.4096

Source: author

According to results obtained from the judgment matrix of the criterion level, the characteristic vector is W=[0.3713, 0.1256, 0.0935, 0.4096], and the maximum characteristic root is λ_{max} =4.1252. And CR=0.0464<0.1 shows that judgment matrix has satisfactory consistency. The same steps used to calculate the weight of the index layer are as follows.

Table 10. Comparison matrix of spring tide characteristic factors

	C11	C12	C13	W_i
High Traffic Density(C11)	1	1/2	1/5	0.1220

Big Tide Difference(C12)	2	1	1/3	0.2297
High Current Speed(C13)	5	3	1	0.6483

Source: author

λ_{max}=3.0037, CR=0.032<0.1 , with satisfactory consistency.

Table 11. Comparison matrix of navigation environment factors

	C21	C22	C23	W_i
Meteorological condition (C21)	1	1/3	1/2	0.1571
Channel condition (C22)	3	1	3	0.5936
Anchorage zone (C23)	2	1/3	1	0.2493

Source: author

λ_{max}=3.0536, CR=0.046<0.1 , with satisfactory consistency.

Table 12. Comparison matrix of ship, crew and cargo factors

	C31	C32	C33	W_i
ship(C31)	1	1/7	1/4	0.0786
Crew(C32)	7	1	3	0.6586
Cargo (C33)	4	1/3	1	0.2628

Source: author

λ_{max}=3.0324, CR=0.028<0.1 , with satisfactory consistency.

Table 13. Comparison matrix of safety management factors

	C41	C42	W_i
Maritime safety supervision (C41)	1	5	0.8333

Shipping company management (C42)	1/5	1	0.1633

Source: author

λ_{max}=2, the program cannot get the value of CR , without satisfactory consistency.

Table 14. Comparison matrix of high traffic density factors

	D111	D112	D113	W_i
Complex situation in precaution area(D111)	1	3	8	0.6817
Difficulty to cross the channel (D112)	1/3	1	3	0.2363
Difficulty to berth and leave (D113)	1/8	1/3	1	0.0819

Source: author

λ_{max}=3.0015, CR=0.0013<0.1 , with satisfactory consistency.

Table 15. Comparison matrix of big tide difference factors

	D121	D122	W_i
Grounding in anchorage(D121)	1	5	0.8333
Grounding in channel(D122)	1/5	1	0.1667

Source: author

λ_{max}=2, the program cannot get the value of CR , without satisfactory consistency.

Table 16. Comparison matrix of high current speed factors

	D131	D132	D133	W_i
Easy to dragging (D131)	1	2	3	0.5278
Difficulty in maneuverability(D132)	1/2	1	3	0.3325
Below or over required speed(D133)	1/3	1/3	1	0.1396

Source: author

λ_{max}=3.0536, CR=0.0046<0.1 , with satisfactory consistency.

Table 17. Comparison matrix of Meteorological condition factors

	D211	D212	D213	W_i
Strong wind or typhoon season(D211)	1	1/5	1/3	0.1047
Poor visibility(D212)	5	1	3	0.6370
Storm surge(D213)	3	1/3	1	0.2583

Source: author

λ_{max}=3.0385, CR=0.032<0.1 , with satisfactory consistency.

Table 18. Comparison matrix of channel condition factors

	D221	D222	D223	W_i
Width （D221）	1	2	8	0.5947
Depth （D222）	1/2	1	6	0.3404
Navigation Obstruction （D223）	1/8	1/6	1	0.0649

Source: author

λ_{max}=3.0183, CR=0.025<0.1 , with satisfactory consistency.

Table 19. Comparison matrix of Anchorage zone factors

	D231	D232	D233	W_i
Quantity(D231)	1	4	1/3	0.2706
Quality(D232)	1/4	1	1/6	0.0852

Anchorage management(D233)	3	6	1	0.6442

Source: author

λ_{max}=3.0536, CR=0.046<0.1 , with satisfactory consistency.

Table 20. Comparison matrix of ship factors

	D311	D312	D313	W_i
Type (D311)	1	2	1/7	0.1312
Tonnage (D312)	1/2	1	1/9	0.0760
Age (D313)	7	9	1	0.7928

Source: author

λ_{max}=3.0217, CR=0.019<0.1 , with satisfactory consistency.

Table 21. Comparison matrix of crew factors

	D321	D322	D323	W_i
Knowledge of spring tide(D321)	1	1	3	0.4054
Familiar with YRSS(D322)	1	1	5	0.4806
Navigation Experience(D323)	1/3	1/5	1	0.1140

Source: author

λ_{max}=3.0291, CR=0.0259<0.1 , with satisfactory consistency.

Table 22. Comparison matrix of cargo factors

	D331	D332	W_i
Cargo type(D331)	1	1/3	0.2500

Cargo density(D332)	3	1	0.7500

Source: author

λ_{max}=2, the program cannot get the value of CR , without satisfactory consistency.

Table 23. Comparison matrix of maritime safety supervision factors

	D411	D412	D413	W_i
Relative regulation or countermeasures(D411)	1	1/5	1/9	0.0629
VTS monitoring ability(D412)	5	1	1/3	0.2654
Emergency response force(C423)	9	3	1	0.6716

Source: author

λ_{max}=3.0291, CR=0.025<0.1 , with satisfactory consistency.

Table 24. Comparison matrix of shipping company management factors

	D421	D422	D423	W_i
Rules,regulations,implementation(D421)	1	1/9	1/7	0.0572
Relative training(D422)	9	1	2	0.5969
Procedures or checklists on spring tide(D423)	7	1/2	1	0.3458

Source: author

λ_{max}=3.0217, CR=0.019<0.1 , with satisfactory consistency.

3.3.3 Calculate the weight to evaluation table

Based on the above comparison matrix in different levels, the final weight of each factors are shown in Table 25.

Table 25. Final weight of each factors.Source: author.

Goal Level (A)	Criterion Level (B)	Weight	Index Level I (C)	Weight	Index Level II (D)	Weight
Safety risks of ships in YRSS during spring tide	Spring tide characteristic factors (B1)	0.3713	High Traffic Density (C11)	0.045	Complex situation in precaution area(D111)	0.031
					Difficulty to cross the channel(D112)	0.011
					Difficulty to berth and leave(D113)	0.004
			Big Tide Difference (C12)	0.085	Grounding in anchorage(D121)	0.071
					Grounding in channel(D122)	0.014
			High Current Speed (C13)	0.240	Easy to dragging (D131)	0.127
					Difficulty in maneuverability(D132)	0.080
					Below or over required speed(D133)	0.034
	Navigation Environment factors (B2)	0.1256	Meteorological condition (C21)	0.019	Strong wind or typhoon season(D211)	0.002
					Poor visibility(D212)	0.070
					Storm surge(D213)	0.005
			Channel condition (C22)	0.074	Width (D221)	0.044
					Depth (D222)	0.025
					Navigation Obstruction (D223)	0.005
			Anchorage	0.031	Quantity	0.008

			(C23)		Quality	0.003
					Management	0.020
	The factors from ship,crew and cargo (B3)	0.093 5	Ship factor (C31)	0.007	Type (D311)	0.001
					Tonnage（D312）	0.001
					Age（D313）	0.006
			Crew factor (C32)	0.061	Knowledge of spring tide(D321)	0.025
					Familiar with YRSS(D322)	0.030
					Experience (D323)	0.007
			Cargo factor (C33)	0.023	Cargo type(D331)	0.006
					Cargo density(D332)	0.017
	Safety management factors (B4)	0.409 6	Maritime safety supervision (C41)	0.341	Relative regulation or countermeasures (D411)	0.021
					VTS monitoring ability(D412)	0.091
					Emergency response force(C423)	0.229
			Shipping company management (C42)	0.068	Rules,regulations,imple mentation (D421)	0.004
					Relative training(D422)	0.041
					Procedures or checklists	0.026

					(D423)	

3.4 Analysis of main problems in risk management during spring tide

The above table is obtained after the comprehensive score of 16 experts, and then calculated by the program, by analyzing the weight of each layer factor in the above table, the main analysis of risk management and control during the great tide in the Shanghai section of the Yangtze River can be obtained.

3.4.1 Rank the factors

According to Table 26, in the criterion layer, the safety management factors accounts for most among all the four criterion factors. The characteristic of spring tide stands at the second position. Compared with the above two, the factors from navigation environment and ship, crew and cargo is very small, which illustrates that "spring tide" ,itself brings huge risks to maritime safety in YRSS. And the experts give the most weight to safety management factors, because they believe that through some management measures from both MSA and shipping company, the risks of spring tide can be managed or eliminated accordingly.

Table 26. Ranking of factors in criterion level

Goal Level （A）	Criterion level （B）	Weight	Rank
Safety risks of ships in YRSS during spring tide	Spring tide characteristic factors (B1)	0.3713	2
	Navigation Environment factors (B2)	0.1256	3
	The factors from ship,crew and cargo (B3)	0.0935	4
	Safety management factors (B4)	0.4096	1

Source: author.

According to Table 27, in the index level I, the maritime safety supervision(C41) has the biggest weight among all the factors, and shipping company management (C42) stands at the fifth. From these two factors, we could know that the compared with

MSA, the shipping company has very small weight. Besides, three characteristics of spring tide including high current speed, big tide difference and high traffic density stands at 2nd ,3rd and 7th respectively. But, weight of high current speed is much bigger than that of others. The channel condition(C22) ranks at 4th in the table, because the channel of YRSS is not very good due to its width, depth and obstruction. Compared with other factors, factors from ship has the smallest weight in this level really surprised me. And the factors from crew ranks at 6th is much bigger than that from ships, which shows that if the crew onboard can understanding the characteristics of spring tide and make good prepare, the risks can be reduced.

Table 27. Ranking of factors in index level I

Goal Level（A）	Index Level I（C）	Weight	Rank
Safety risks of ships in YRSS during spring tide	High Traffic Density (C11)	0.0453	7
	Big Tide Difference (C12)	0.0853	3
	High Current Speed (C13)	0.2407	2
	Meteorological condition (C21)	0.0197	10
	Channel condition (C22)	0.0746	4
	Anchorage (C23)	0.0313	8
	Ship factor (C31)	0.0073	11
	Crew factor (C32)	0.0616	6
	Cargo factor (C33)	0.0233	9

	Maritime safety supervision (C41)	0.3413	1
	Shipping company management (C42)	0.0682	5

Source: author

According to Table 28, in the index level II, among 31 factors, emergency response force(C423) has the largest weight. Similarly, the VTS monitoring ability ranks at 3rd , which shows that when handling the risks brought by spring tide, the experts believe that the emergency response force is not enough, also the VTS monitoring ability is still below their expectation. From the table, easy to dragging(D131) and grounding in anchorage(D121) ranks at 2nd and 5th respectively, which shows that during spring tide, the risk level in anchorage is quite high. On the one hand, the big tide difference causes seafarer's wrong judgement on the depth of the anchorage. On the other hand, the high current speed also leads to the ship dragging.

Table 28. Ranking of factors in index level II

Goal Level（A）	Index Level II（D）	Weight	Rank
Safety risks of ships in YRSS during spring tide	Complex situation in precaution area(D111)	0.031	10
	Difficulty to cross the channel(D112)	0.011	19
	Difficulty to berth and leave(D113)	0.004	25
	Grounding in anchorage(D121)	0.071	5
	Grounding in channel(D122)	0.014	18
	Easy to dragging (D131)	0.127	2
	Difficulty in maneuverability(D132)	0.080	4
	Below or over required speed(D133)	0.034	9

	Strong wind or typhoon season(D211)	0.002	28
	Poor visibility(D212)	0.070	6
	Storm surge(D213)	0.005	23
	Width （D221）	0.044	7
	Depth （D222）	0.025	14
	Navigation Obstruction （D223）	0.005	24
	Anchorage Quantity	0.008	20
	Anchorage Quality	0.003	27
	Anchorage Management	0.020	16
	Ship type (D311)	0.001	29
	Ship tonnage （D312）	0.001	29
	Ship age （D313）	0.006	21
	Knowledge of spring tide(D321)	0.025	13
	Familiar with YRSS(D322)	0.030	11
	Experience(D323)	0.007	21
	Cargo type(D331)	0.006	21
	Cargo density(D332)	0.017	17
	Relative regulation or countermeasures (D411)	0.021	15
	VTS monitoring ability(D412)	0.091	3
	Emergency response force(C423)	0.229	1
	Rules,regulations,implementation (D421)	0.004	25
	Relative training(D422)	0.041	8

	Procedures or checklists on spring tide(D423)	0.026	12

Source: author

Combination with the real situation in YRSS, the author lists the main problems with big weight in the above table.

3.4.2 Problems from emergency response force

As the main force of emergency response working in YRSS, there are seven patrol boats in Wusong MSA(one branch of Shanghai MSA). As shown in Table 29, four boats are standing by at 24 hours. There are also 2 boats working in daytime for transition of PSC or FSC officials. Sea Particular 1001 for special use which act as a tow ship or a firefighting ship, always stand by at berth only for emergency. Four of seven boats are 26 meters in length, on the one hand, they have the characteristics of fast speed and flexible operation, on the other hand, these four boats also have the disadvantages of poor wind/wave resistance, especially when facing the challenge of spring tide, the performance of small boats are severely restricted(Shuai, 2016).

Table 29. The patrol boats in Wusong MSA.

Name	Size(m)	Working type	Location
Sea Patrol 01013	26	24H	Wusongkou Anchorage
Sea Patrol 01014	26	8H	Berth
Sea Patrol 01017	26	24H	Lightbouy 101
Sea Patrol 01018	26	8H	Berth
Sea Patrol 0105	46	24H	Yuanyuansha Precaution Area
Sea Patrol 012	57	24H	CJK area
Sea Particular 1001	38	Emergency	Huangpu River

Source: Wusong MSA.

Figure 27. shows the standby location of 24 hours boats. Compared with 65 nm coastline from Baoshan lightboat to CJK lightboat, these sea patrol force is not enough to handle the emergency situation.

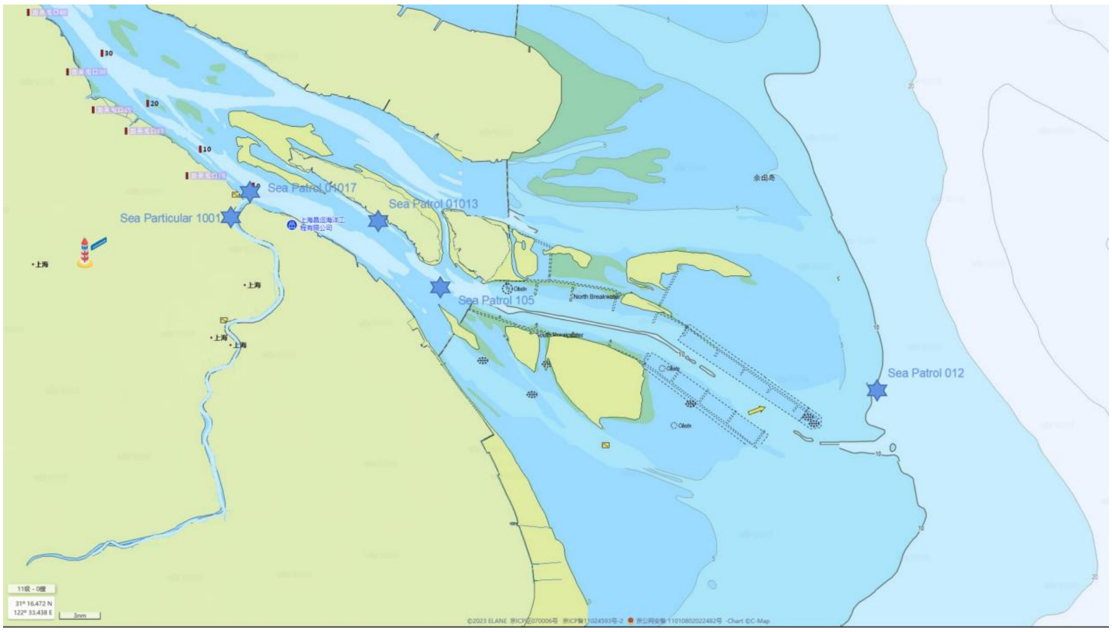

Figure 27. Regular location of the patrol boat in Wusong MSA
Source: Wusong MSA, made by author

3.4.3 Problems from VTS monitoring ability

Wusong VTS Center was established on September 12, 1993, and officially put into operation in 1994, which is one of the earliest VTS systems built in China. VTS Center fulfills the duties of ensuring the safety of water traffic, protecting the cleanliness of the water environment, protecting the overall rights and interests of the crew, and safeguarding the national maritime sovereignty(IALA, 2016). With the vigorous development of Wusong MSA, Wusong VTS system has also undergone three generations of changes, with more sophisticated equipment and instruments, a growing team of personnel, and more scientific management of the jurisdiction(see figure 28).

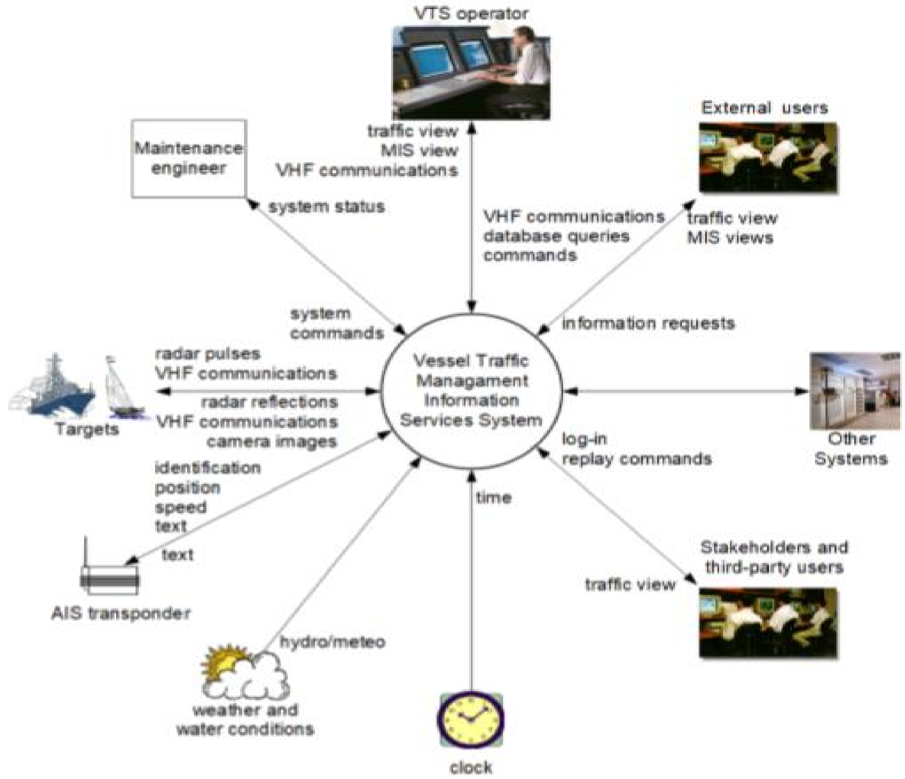

Figure.28 Components of VTS system. Source: Wusong MSA

Since 2019, it has undergone the third upgrade. The new system includes radar, AIS, CCTV, VHF, MIS, RDF and other equipment. However, in terms of hydro-logical perception, it still relies on the original sensors, resulting in the quality and quantity of hydro-logical sensors being difficult to cope with new development needs. When the spring tide comes, these sensors can not give the accurate data.

3.4.4 Problems from anchorage management

Figure 29. shows the location of anchorage in YRSS. Compared with the massive traffic flow, the number of anchorage is not enough(Guan, 2018; Ran, 2018). Especially when meeting the spring tide, the tidal difference is big, the tidal current is fast, small ships are waiting for tidal current in anchorage. The anchorages in YRSS are very crowded. It brings huge challenge to VTS operators to do anchorage management.

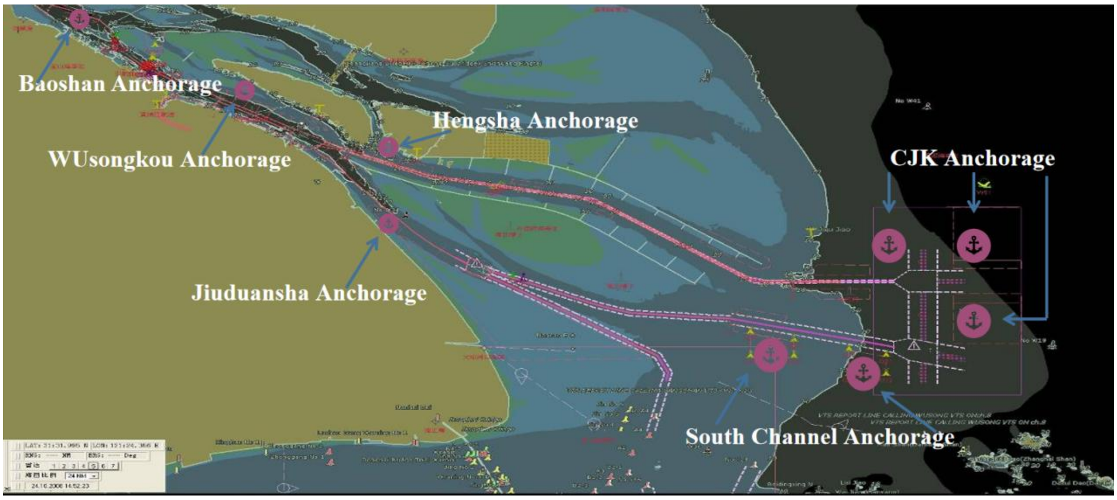

Figure 29. Location of anchorage in YRSS. Source: Shanghai MSA

Table 30 shows the details of anchorage, including the average depth,accommodation, and other information. Statistics show that the total accommodation is 315. But the real situation is that, some ships do not anchor at the accuracy position, which is a waste of anchorage resources. And there are thousands of ships in and out at the same time, the VTS operators are busy in dealing with the dynamic situation. Seldom can they recheck the anchor position of each ship(Zhu, 2017).

Table 30. Details of anchorage in YRSS

Name	Depth (m)	Accommodation	Special
CJK anchorage	50	120	For ships with big draft to enter port
South channel anchorage	35	40	For ships with small draft waiting to enter port
Hengsha anchorage	30	20	For emergency/dangerous cargo ship
Jiuduan anchorage	15	25	For small ships waiting for tide
Wusongkou anchorage	10	70	For ships waiting to berth or enter Huangpu river
Baoshan anchorage	15	40	For ships waiting to berth or exchange pilot

Source: Shanghai MSA, made by author

3.4.5 Problems in crew quality

Figure 30. shows the real-time ships under 80m in YRSS. Shanghai Port is an international port and a crucial river-sea transition harbor in the Yangtze River. Due to the draft or other reasons, big ships unload the containers in Shanghai port, then the tiny ships load these containers and sail to the upper river. Therefore, the amount of small ships is enormous in this section.

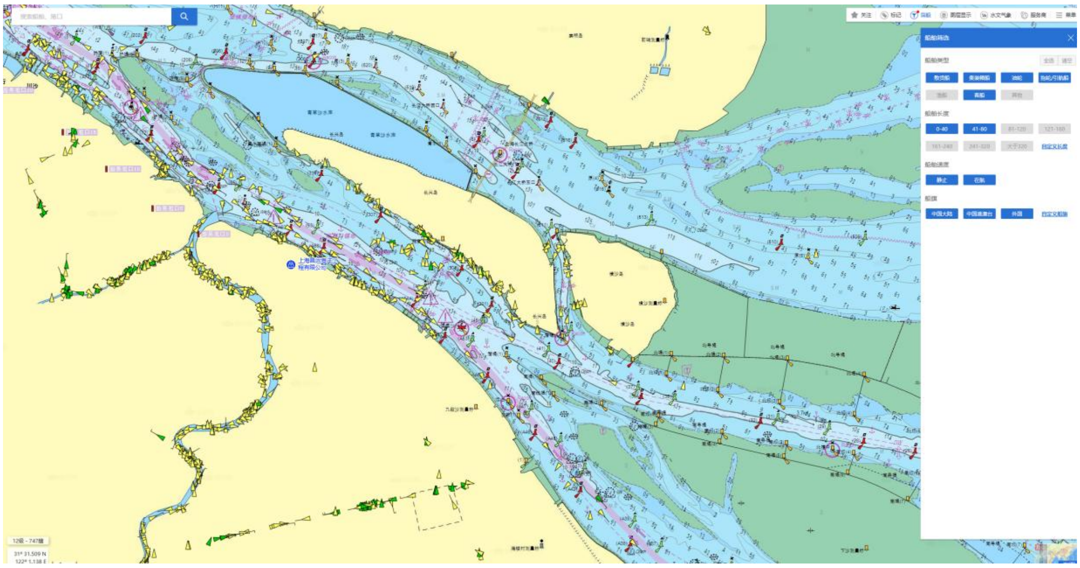

Figure 30. The real time ships under 80m in YRSS.Source: shipxy.com.

Usually, the education level of these small ship crews is lower than those of international seafarers. These crew may know that sailing with the tide is economical but need help to understand the characteristics of spring tide. They do not know the seriousness of the spring tide in YRSS,either. Although these crew may have sailed for years and the sea experience is rich, sometimes the experience makes them overconfident, which leads to their low risk awareness of spring tide.

Chapter 4 Suggestions for risk management

In the last chapter, author has made it clear the ranking of factors and the main problems reflected by experts. In order to reduce or eliminate the influence of the factors mentioned above, the author will give some suggestions based on the characteristics of the jurisdiction, the risks during the spring tide, and the risk prevention experience.

4.1 Strengthen safety supervision during spring tide

Analyzing the statistics, the ships in this region are prone to navigate with tide, which leads to very heavy traffic in certain time. It is urgent for MSA to solve this problem.

4.1.1 “Peak shifting” to divert the traffic flow.

Learn from Shanghai's practice of "switching to cross the road" to ensure order during the peak tourist hours on Nanjing Road, and through "peak shifting" management in command, the same organizational method of "switch pass" for ships is used to cross the channel. In the peak time, ships needing to cross Waigaoqiao channel are "closed", and after the peak time, the ships are "opened" and allowed to cross the channel(see figure 31). On the one hand, this is a good solution to reduce the conflict in channels during spring tide. On the other hand, the “closed” time may influence the port efficiency and ships’ voyage plan. The maritime decision-makers should take both effect and side-effect into consideration.

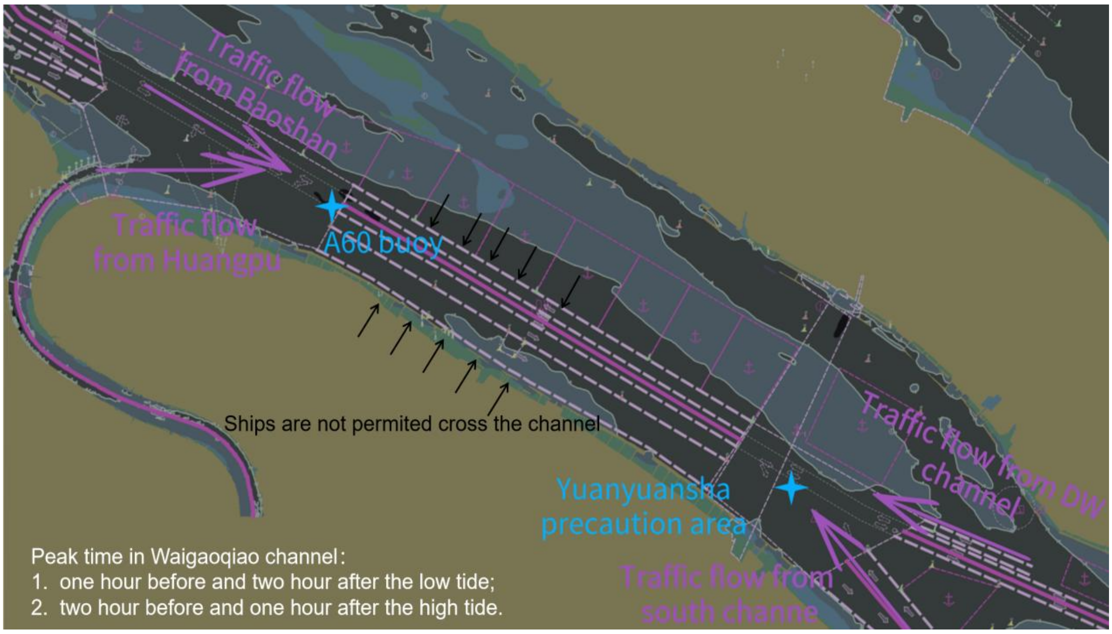

Figure 31. Peak shifting in Waigaoqiao channel. Made by author

4.1.2 Improve monitoring ability of VTS

VTS should be managed and operated more efficiently. In the face of the challenge of spring tide, the monitoring ability of VTS should be transformed into regional coordination and three-dimensional. The effective coordination and cooperation of adjacent VTS not only contributes to the construction of a maritime supervision system for information exchange, regulatory interaction and resource, but also helps to improve comprehensive navigation support capabilities and maritime emergency rescue capabilities(Jia, 2011). With the technological innovation of 5G technology, block-chain, big data, artificial intelligence and other scientific and technological innovations, the monitoring ability of VTS can be expected in the future. Besides, VTS operators need to update their knowledge and working procedures about spring tide should be established and evaluated in VTS center.

4.1.3 More patrol boats on standby

During the spring tide, the MSA should organize and dispatch a number of on-scene patrol boats for emergency, and cooperate with the VTS center to carry out the fixed-point standby. For example, the Waigaoqiao waterway gathers the inbound and outbound ship traffic flow of the North and South channel, Baoshan and Huangpu

River, with a large traffic flow and high density. One or two patrol boats is far from enough. When encountering spring tide, a designed person needs to be in place, the responsibility of patrol boats should be cleared and the working plan should be strictly followed.

4.2 Enhancing emergency response ability

Efforts should be made to strengthen the emergency response force during spring tide, including emergency prevention and preparation, emergency support, monitoring and early warning, emergency response and rescue, post-incident handling and recovery(see figure 32).

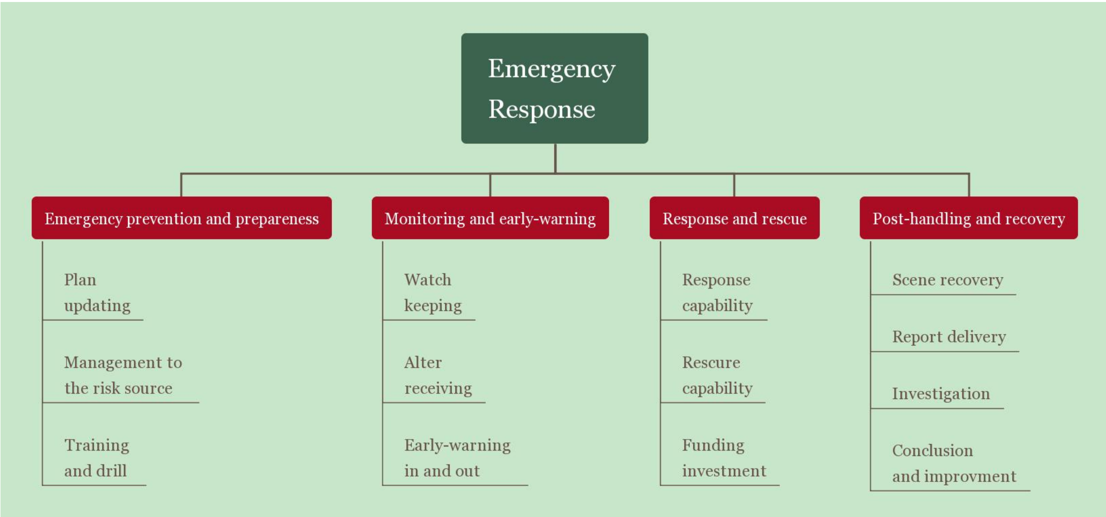

Figure 32. Establishment of emergency response force in YRSS. Made by author

4.2.1 Emergency Prevention and Preparation

In the stage of emergency prevention and preparation, it is necessary to formulate an emergency plan for spring tide and keep it updated, and at the same time, conduct detailed investigation and registration of risk sources and dangerous areas under the jurisdiction(Ren, 2014; Xiao, 2016; Du, 2022). Meanwhile, it is necessary to strengthen training, exercises, publicity, and education to ensure that emergency plans and safety knowledge are in place and that timely and effective responses can be made during accidents caused by a spring tide.

4.2.2 Monitoring and early warning

Every spring tide period and its influence are predictable(Chen & Lu, 2011). In combination with the extreme weather condition in YRSS, the VTS should give early warning to the ships by broadcast, Wechat group, moments, email, AIS message, and telephones. At the same time, the VTS operators should thoroughly prepare for the coming spring tide, including monitoring the traffic flow and giving instructions to small ships requiring more considerable anchoring distances.

4.2.3 Response and Rescue

Emergency response capability refers to having standardized emergency procedures, accurate and effective decision-making, and rapid emergency response. Emergency rescue capability means that the responsibilities of personnel at all levels are clear and the emergency rescue organization is highly coordinated. The investment of maritime emergency funds should be reasonable and maximize the effect of emergency operations as much as possible.

4.2.4 Post-incident Handling and Recovery

This part includes the publication of information related to the accident near future, accident investigation, and analysis of various emergency actions taken and education, and summarizes experience and lessons learned to improve emergency response capabilities continuously.

4.3 Optimize the anchorage management

Maritime transportation operations, which constitute the backbone of the maritime industry, involve serious risks by nature(Mehmet, 2021). Especially in anchorage, the anchorage resources are limited compared with the massive traffic flow in YRSS. Optimizing anchorage management is crucial for safety.

4.3.1 Reducing the grounding accidents

The first is to find out the shallow points in anchorage. The administration can sort out the high-frequency grounding points by collecting and analyzing the grounding accidents in anchorage. Then the operators can label them in the VTS system to remind the relevant ships to leave. In addition, cooperate with the channel dredging unit to conduct regular operations in shallow waters to reduce the risk of ships running aground.

4.3.2 Reducing the dragging accidents

The vital action is to implement the refined management of anchorages. Due to the limited resources of anchorage, when the number of anchoring ships reaches a limitation, the ships entering and leaving the anchorage are registered individually. Significantly in spring tide, this limitation should be adjusted according to the tide grade. For ships applying for anchoring, VTS reminds them to pay attention to the influence of current pressure, keep a safe distance from surrounding anchorage vessels, and do an excellent job of safety information broadcasting and point-to-point reminders.

4.4 Other suggestions

In addition to the above suggestions, there are also other suggestions worth the administration's attention.

4.4.1 Charts and nautical publications

Considering that small ships still use paper charts, the shipping company should provide the latest version of the nautical charts, tide tables, and other library materials on time and, at the same time, update and correct the existing library materials on board to ensure that the library materials involved in the voyage are the latest, most accurate and most applicable. A large company should provide timely updates to electronic charts. The administration should increase the severity of punishment for the lack of information and failure to rectify it promptly.

4.4.2 Establishment of checklists of spring tide

During the spring tide, before the ship enters the channel of the Shanghai section of the Yangtze River, the captain and chief engineer should reconfirm that the ship's main engine, rudder, and bridge navigation aids are in normal working condition and that the emergency equipment and facilities are in a state of ready use. Special personnel are arranged to prepare anchors in case of emergency. Then, a checklist should be finished and sent to the VTS center. During the channel navigation, the captain is responsible for the bridge's command, the division of labor in each department is clear, the task is assigned, and the efficiency of managing the bridge resources is assured.

4.4.3 Cooperating with another department

When encountering spring tide, MSA, ports, wharves, and other relevant units should cooperate, strengthen communication and contacts, jointly discuss maritime management and maritime construction countermeasures, jointly participate in maritime governance, share maritime information, resources, and achievements(Chen, 2013; Li, 2014; Qiu, 2016). Facing the big challenge, all the units should work together to accelerate the transformation of maritime institutions from management to service, keep pace with the times, constantly discover and solve emerging contradictions and problems. Shanghai MSA should urge shipping companies to organize educational training courses and print leaflets to strengthen awareness of safe navigation during spring tide.

Chapter 5 Conclusion

5.1 Conclusion

Shanghai is at the time-space intersection of the "Belt and Road" and the "Yangtze River Economic Belt." Opportunities are rare and challenges are daunting. Shanghai is facing the golden period of rapid development of the shipping economy. However, there are still some problems and deficiencies in risk management during spring tide, including the emergency response force, VTS monitoring ability, anchorage management, and crew quality. Given these problems, this dissertation researched the risk factors of spring tide by questionnaire. It used AHP to suggest reasonable suggestions, including strengthening safety supervision, enhancing emergency response-ability, and optimizing anchorage management.

5.2 Limitations

In the writing process of this dissertation, from both qualitative and quantitative aspects, starting with accident data during the spring tide period, it is analyzed that the daily accident rate during the spring tide is higher than that during non-spring tide periods. Then, through expert scoring, determine the weight of each risk factor of the spring tide, rank them, and then determine the main problems, which is the highlight and innovation of this paper.

However, it is undeniable that this dissertation still has many shortcomings, such as:

1. Whether establishing the risk evaluation system is scientific and accurate enough.

2. When balancing experts' scoring, the author uses the arithmetic mean value without weighting the experts' professional background, academic background, and other aspects. Whether the final result is scientific enough is still being determined.

3. The suggestions given are only based on the facts and focus on solving the current navigation safety issues during the spring tide period without providing

forward-looking, systematic, and strategic suggestions from a long-term perspective.

5.3 Future work

COVID-19 has gradually faded out of sight, and the world economy is recovering. China is in a critical period of development, from big to vigorous. There are unprecedented contradictions, risks, and challenges. Next, with the rapid development of the economy and the continuous tilt of policies towards the Yangtze River Delta region, the navigation pressure on the Shanghai section of the Yangtze River will also become heavier, and other natural and human factors will change over time. The future navigation safety of the Shanghai section of the Yangtze River has many uncertainties, and the pressure of risk prevention and control is still enormous. How to take precautions and prevention is the focus of future work. As a guidance and service department, the Shanghai MSA should use systematic thought, safety-oriented vision, cooperation attitude to build the Shanghai section of the Yangtze River into a safer, more convenient, and smoother "water expressway."

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Appendices

Appendix 1: List of participants

No.	Pseudonym.	Age(Yrs.)	Sailing Exp. (Yrs.)	Familiar with YRSS
1	Pilot-1	49	20	Yes
2	Pilot-2	40	12	Yes
3	Pilot-3	42	13	Yes
4	Pilot-4	33	7	Yes
5	VTSO-1	26	0	Yes
6	VTSO-2	30	3	Yes
7	VTSO-3	28	3	Yes
8	VTSO-4	43	9	Yes
9	Navigator-1	52	23	Yes
10	Navigator-2	47	22	Yes
11	Navigator-3	50	25	Yes
12	Navigator-4	37	11	Yes
13	Manager-1	55	10	Yes
14	Manager-2	49	15	Yes
15	Manager-3	50	13	Yes
16	Manager-4	42	8	Yes

Appendix 2: Sample of questionnaire

<u>Yangtze River Shanghai Section Spring Tide Risk Factor Weight Survey</u>

First part.

1. The evaluation system of the risk factor during spring tide in Yangtze River Shanghai section.

Goal Level (A)	Standard Level (B)	Index Level I (C)	Index Level II (D)
Safety risks of ships in YRSS during spring tide	Spring tide characteristicfactors(B1)	High Traffic Density(C11)	Complex situation in precaution area(D111)
			Difficulty to cross the channel(D112)
			Difficulty to berth and leave(D113)
		Big Tide Difference(C12)	Groundingin anchorage(D121)
			Groundingin channel(D122)
		High Current Speed(C13)	Easy to dragging (D131)
			Difficulty in maneuverability(D132)
			Below or over required speed(D133)
	Navigation Environment factors (B2)	Meteorological condition(C21)	Strong wind or typhoon season(D211)
			Poor visibility(D212)
			Storm surge(D213)
		Channel condition (C22)	Width (D221)
			Depth (D222)
			Navigation Obstruction (D223)
			Navigation aids (D224)
	The factors from ship,crew and cargo (B3)	Ship factor(C31)	Type (D311)
			Tonnage (D312)
			Age (D313)
		Crew factor(C32)	Knowledge of spring tide(D321)
			Familiarwithnavigation environmentin YRSS(D322)
			Experience(D323)
		Cargo factor(C33)	Cargo type(D331)
			Cargo density(D332)
	Safety management factors (B4)	Maritime safety supervision(C41)	Relative regulation or countermeasures(D411)
			VTS monitoring ability(D412)
			Emergency response force(C423)
		Shipping company management (C42)	Rules,regulations,implementation (D421)
			Relative training(D422)
			Proceduresor checklists on spring tide(D423)

2. The nine grade AHP table.

Number	Meaning
1	Equally important
3	Slightly important
5	Obviously important
7	Significantly important
9	Extreme important
1/3	Slightly not important
1/5	Obvious not important
1/7	Significantly not important
1/9	Extreme not important

3. Evaluation description

For the relative importance of each behavioral indicator in the questionnaire, please select the relative importance relationship you consider to be two-by-two.

Second part.

1. Your current job position [single choice question] *
○Pilot
○VTS operator
○Navigator
○Shipping company management personnel

2. What types of ships do you mostly work with or manage? [multiple choice question] *
□Bulk carrier
□Container ship
□Hazardous goods ship
□Ro-ro ship
□Passenger ship
□Other

3. What is the approximate tonnage (per vessel) of the ships you work with or manage? [single choice question] *
○500 gross tons and below
○500~3000 gross tons
○3000~10000 gross tons
○10000 gross tons and above

4. How well do you understand the tidal flood characteristics of the Yangtze River Shanghai section? [single choice question] *
○Very well
○Somewhat understand
○Not very familiar

5. How old are you? [filling question] *

6. How many years have you worked on sea? [filling question] *

Third part.

1. In the Yangtze River Shanghai section tidal flood risk weight analysis, evaluations need to be made from four perspectives.

- Spring tide characteristics
- Navigational Environment
- Ship,crew and cargo
- Safety management

Please compare the the relatively importance two by two with nine grade AHP table.

2. From the “spring tide characteristics” part, compare the factors two by two

- High traffic density

- Big tide difference
- High current speed

Please compare the the relatively importance two by two with nine grade AHP table.

3. From the “High traffic density” part, compare the factors two by two

- Complex situation in precaution area
- Difficulty to cross channel
- Difficulty to berth and leave

Please compare the the relatively importance two by two with nine grade AHP table.

4. From the “Big tide difference” part, compare the factors two by two

- Grounding in anchorage
- Grounding in channel

Please compare the the relatively importance two by two with nine grade AHP table.

5. From the “High current speed” part, compare the factors two by two

- Easy to dragging
- Difficulty in maneuverability
- Below or over required speed

Please compare the the relatively importance two by two with nine grade AHP table.

Fourth part.

1. From the “navigational environment” part, compare the factors two by two

- Meteorological condition
- Channel condition

Please compare the the relatively importance two by two with nine grade AHP table.

2. From the “Meteorological condition” part, compare the factors two by two

- Strong wind or typhoon season
- Poor visibility
- Storm surge

Please compare the the relatively importance two by two with nine grade AHP table.

3. From the “Channel condition” part, compare the factors two by two

- Width
- Depth
- Obstruction
- Aids

Please compare the the relatively importance two by two with nine grade AHP table.

Fifth Part.

1. From the “ factors from ship,crew and cargo ” part, compare the factors two by two

- Ship
- Crew
- Cargo

Please compare the the relatively importance two by two with nine grade AHP table.

2. From the " ship " part, compare the factors two by two

- Type
- Tonnage
- Age

Please compare the the relatively importance two by two with nine grade AHP table.

3. From the " crew " part, compare the factors two by two

- Knowledge of spring tide
- Familiar with navigation environment in YRSS
- Experience

Please compare the the relatively importance two by two with nine grade AHP table.

4. From the " cargo " part, compare the factors two by two

- Cargo type
- Cargo density

Please compare the the relatively importance two by two with nine grade AHP table.

Sixth part.

1. From the " Safety management " part, compare the factors two by two

- Maritime safety supervision
- Shipping company management

Please compare the the relatively importance two by two with nine grade AHP table.

2. From the " Maritime safety supervision " part, compare the factors two by two

- Relative regulation or countermeasures
- VTS monitoring ability
- Emergency response force

Please compare the the relatively importance two by two with nine grade AHP table.

3. From the " Shipping company management " part, compare the factors two by two

- Rules,regulations,implementation
- Relative training
- Procedures or checklists on spring tide

Please compare the the relatively importance two by two with nine grade AHP table.

Appendix 3: Detailed Matlab process

3.1 Basic definition and concept

- A is the matrix, balanced with arithmetic mean method. According to the numerical scale of AHP, the final result will be adjusted.
- RI is the consistency check reference value.
- V, D is to find the eigenvalues and eigenvectors of the judgment matrix A, V is eigenvalues, and D is eigenvectors.
- B is the maximum eigenvalues, C is the corresponding eigenvectors.
- CI is consistency check index.

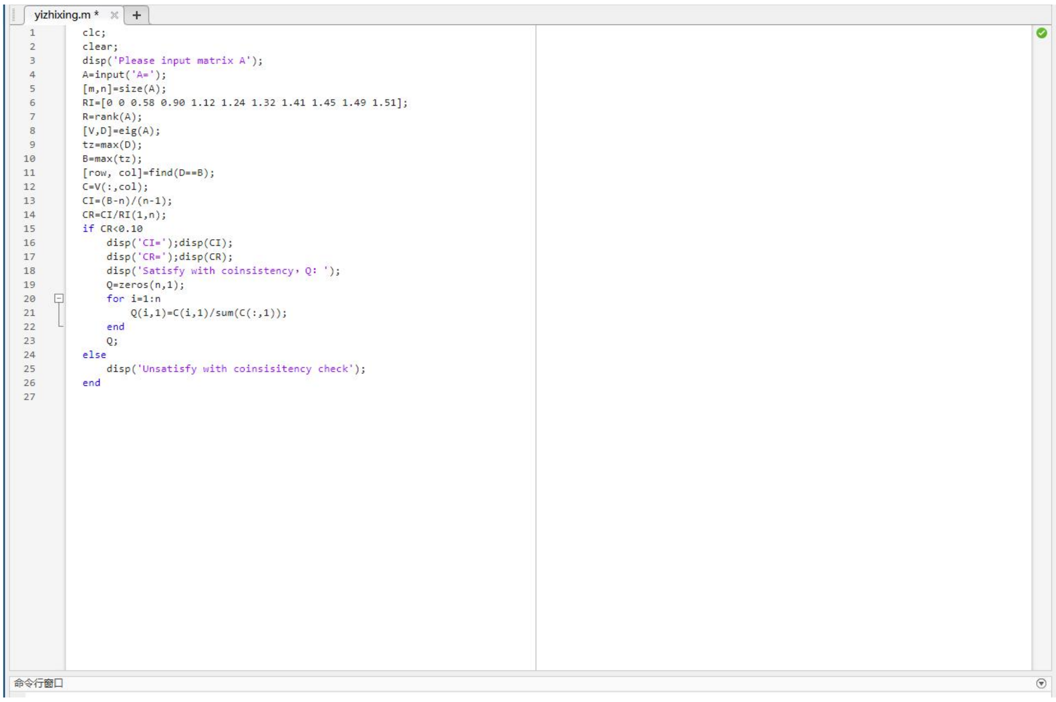

Figure 1: Main Matlab program. Source: author.

3.2 Participants demographic details

Table 1~4. Demographic details of participants. Source: author

3.3 Calculating results of consistency check.

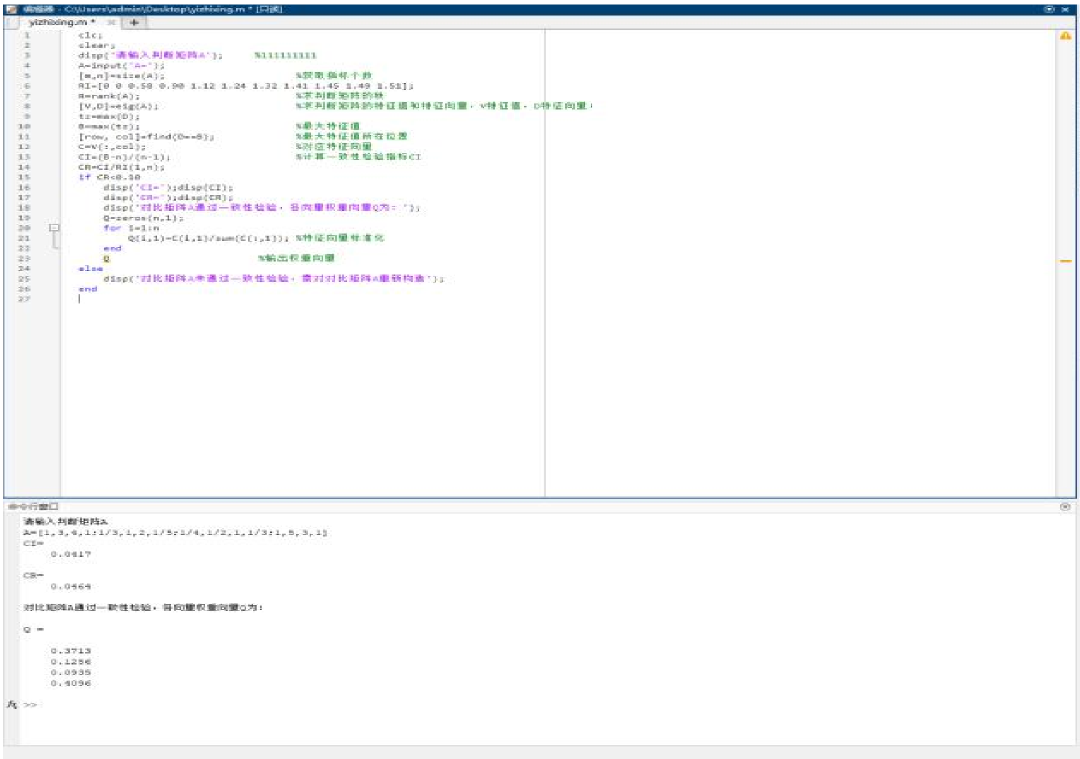

Figure 2. Consistency check of criterion level. Source: author.

Figure 3. Consistency check of spring tide characteristics. Source: author.

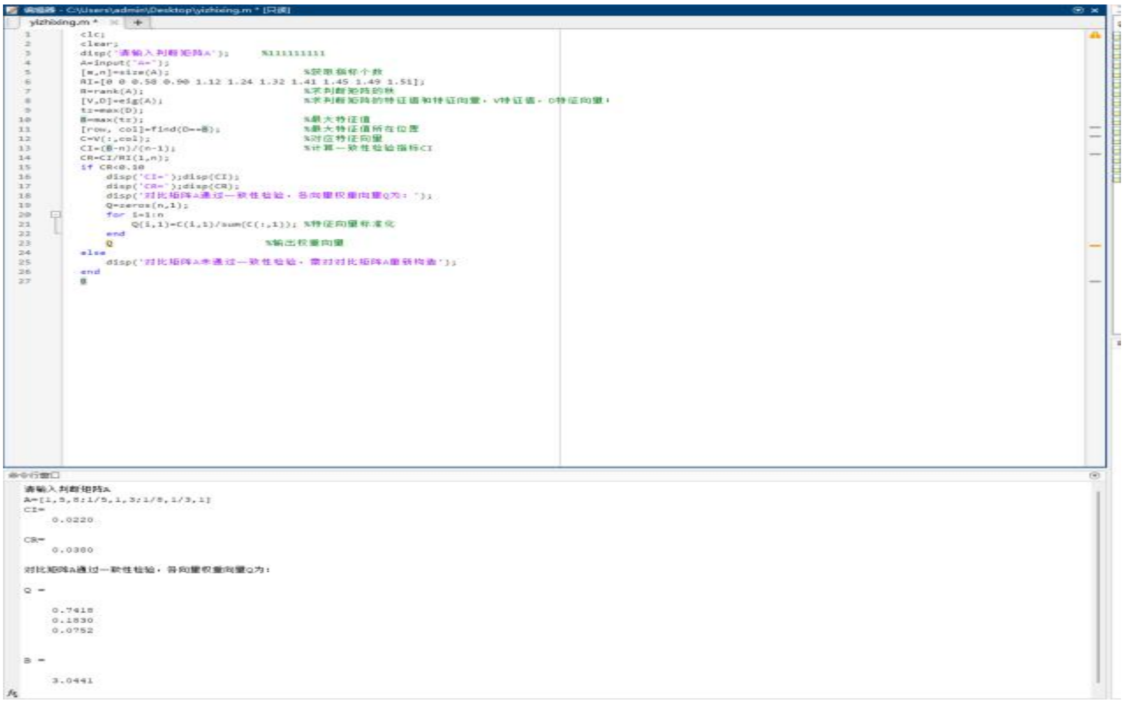

Figure 4. Consistency check of navigation environment. Source: author.

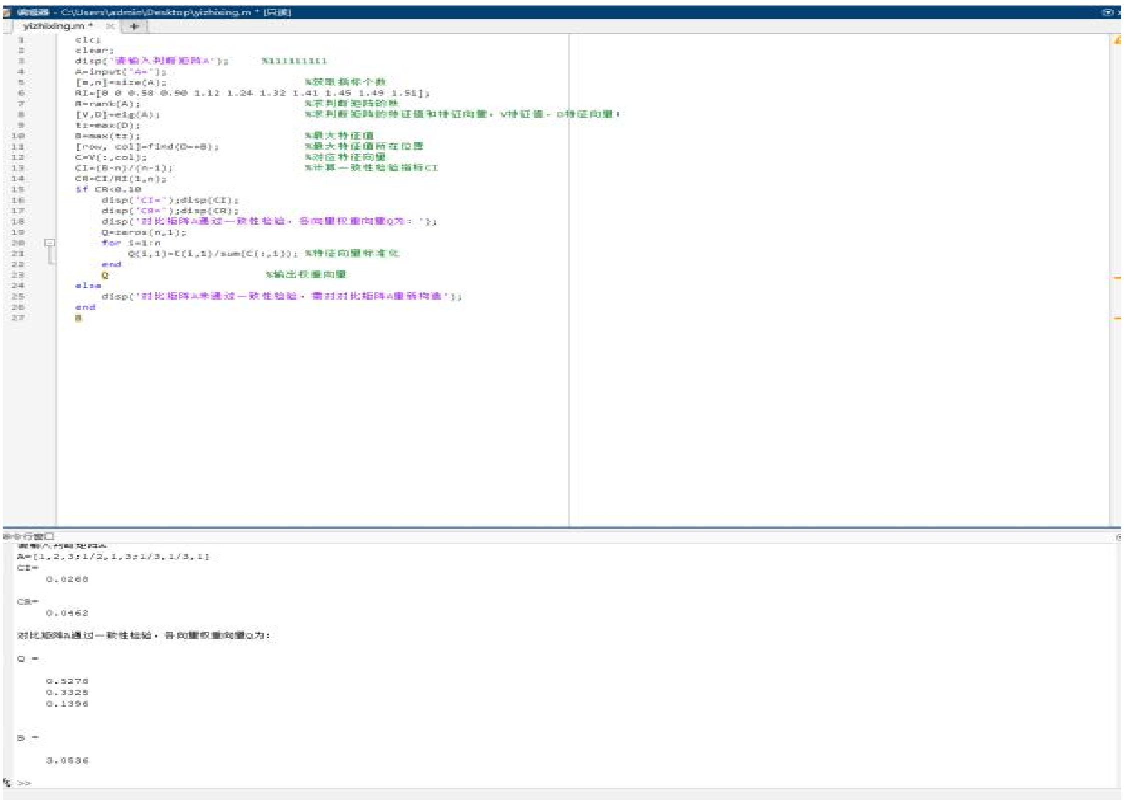

Figure 5. Consistency check of ship, crew and cargo. Source: author.

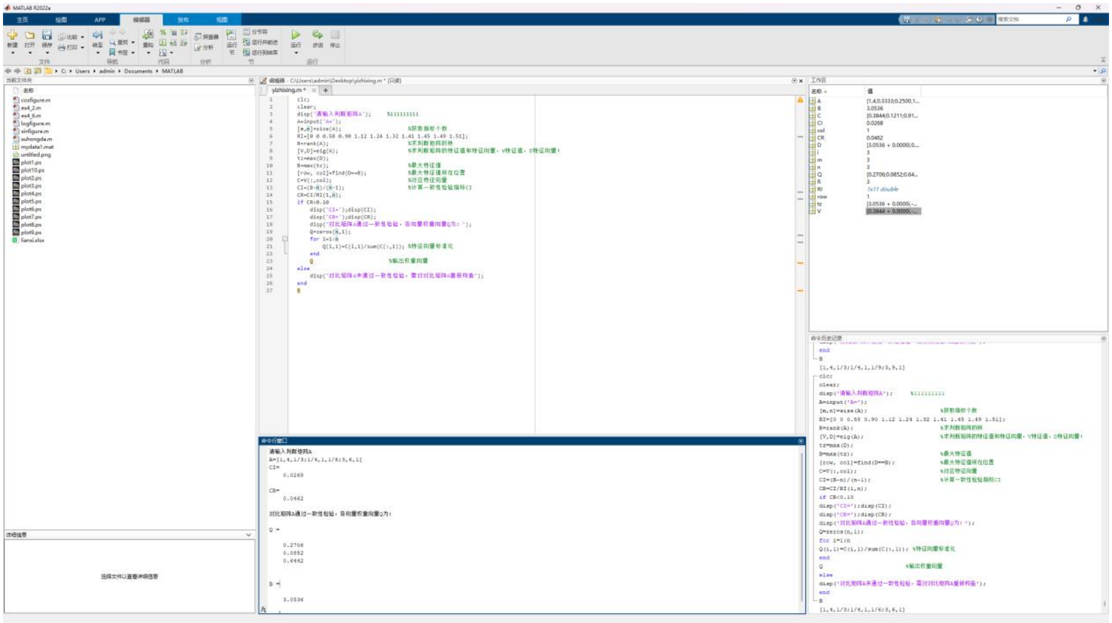

Figure 6. Consistency check of safety management. Source: author.

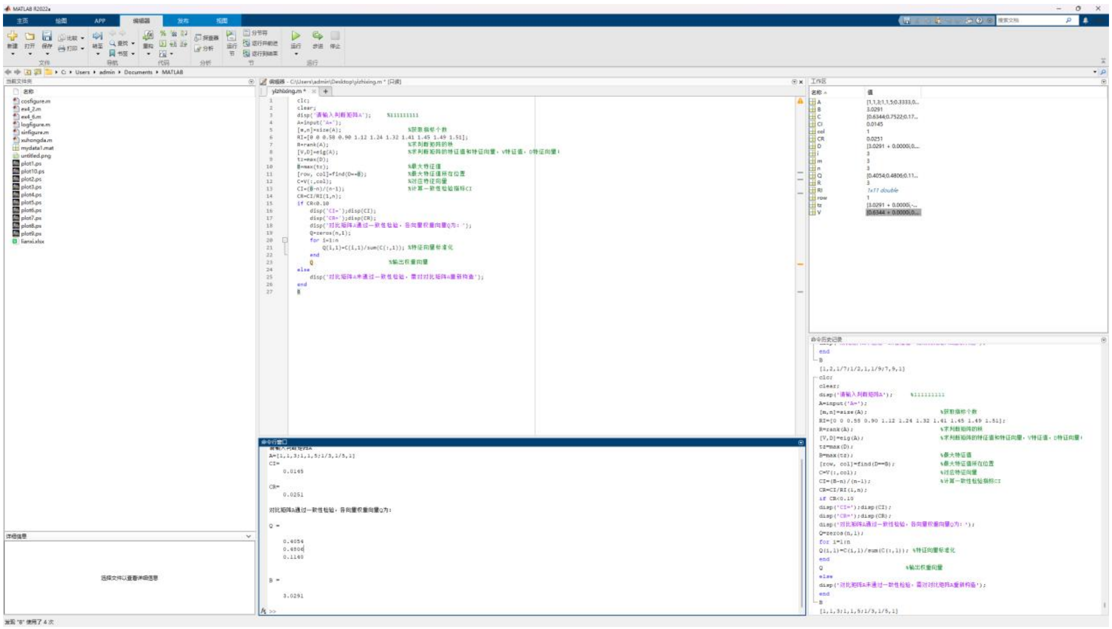

Figure 7. Consistency check of high current speed. Source: author.

Appendix 4: Ethics consideration

4.1 Sample of consent form

Dear Participant,

Thank you for agreeing to participate in this research survey, which is carried out in connection with a Dissertation which will be written by the interviewer, in partial fulfilment of the requirements for the degree of Master of Science in Maritime Safety and Environment Management delivered in Dalian, China, by World Maritime University in collaboration with Dalian Maritime University.

The topic of the Dissertation is Risk Management During Spring Tide in Yangtze River Shanghai Sector

The information provided by you in this interview will be used for research purposes and the results will form part of a dissertation, which will later be published online in WMU's digital repository (maritime commons) subject to final approval of the University and made available to the public. Your personal information will not be published. You may withdraw from the research at any time, and your personal data will be immediately deleted.

Anonymised research data will be archived on a secure virtual drive linked to a World Maritime University email address. All the data will be deleted as soon as the degree is awarded.

Your participation in the interview is highly appreciated.

Student's name	Xu Hongda
Specialization	Maritime Safety and Environment Management
Email address	wmuxuhongda@163.com

* * *

Whether or not you consent to the use of personal data, as outlined above, being used for this study. Do you understand that all personal data relating to the participant is held and processed in the strictest confidence and will be deleted at the end of the researcher's enrolment?

☐ Yes ☐No

Name:
....
....

4.2 WMU REC Protocol

WORLD MARITIME UNIVERSITY

WMU Research Ethics Committee Protocol

Name of principal researcher:	Xu Hongda
Name(s) of any co-researcher(s):	NA
If applicable, for which degree is each researcher registered?	Master of Science in Maritime Safety and Environment Management
Name of supervisor, if any:	LV Hongguang
Title of project:	Risk Management in Yangtze River Shanghai Sector during Spring Tide
Is the research funded externally?	No
If so, by which agency?	No
Where will the research be carried out?	Dalian Maritime University
How will the participants be recruited?	To be confirmed
How many participants will take part?	To be confirmed
Will they be paid?	NA
If so, please supply details:	NA
How will the research data be collected (by interview, by questionnaires, etc.)?	Questioinnaires
How will the research data be stored?	In my personal laptop with strong password
How and when will the research data be disposed of?	Data will be deleted upon completion MSc Studies by Jul 2023
Is a risk assessment necessary? If so, please attach	Yes

Signature(s) of Researcher(s): Date: 17th April 2023

Signature of Supervisor: Date:17th April 2023

Please attach:

- A copy of the research proposal
- A copy of any risk assessment
- A copy of the consent form to be given to participants
- A copy of the information sheet to be given to participants
- A copy of any item used to recruit participants

4.3 WMU REC Approval

consent form.pdf 等5个附件

phd@wmu.se 4月17日
Dear Xu Hongda, Many thanks for your submissi...

phd@wmu.se 4月26日
发给 徐洪达

Dear Xu Hongda,

I am pleased to let you know that the members of the WMU Research Ethics Committee (REC) have now unanimously **approved** the research related documents that you submitted to this office on 17 April 2023, concerning your research study involving human participation.

You are now free to start your data collection work in consultation with your supervisor(s).

With kind regards,

Carla Fischer
REC Secretary
Faculty Support Officer
Research Projects and Doctoral Programs
World Maritime University

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