Study on the Relationship between Maritime Accidents and Bad Weather in Shanghai Coast

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Abstract: By introducing the concept of daily average accident index, this paper discusses the relationship between maritime accidents and bad weather in Shanghai coast, and puts forward some measures and suggestions to reduce the number of maritime accidents.

1. Introduction
The coast of Shanghai is an important sea area for trade and maritime operation in China. Once a disaster happens, it will cause serious economic losses. In recent years, global warming, the increase of extreme weather events and other objective reasons increase the probability of maritime safety accidents[1]. Sea gale, fog and short-term severe convection weather are the main objective causes of maritime accidents. According to the statistics provided by relevant departments, the maritime accidents caused by weather in Shanghai coastal area account for about 60% of all maritime accidents, with an average of 30 accidents per year.

2. Accident data
In this paper, 250 accidents caused by bad weather are selected as examples based on the data of maritime disasters and accidents in 2003-2009 provided by Shanghai Maritime Bureau. The relationship between maritime accidents and weather is discussed through daily average accident index[2], and measures and suggestions for reducing the number of maritime accidents are put forward.

In this paper, the coastal area of Shanghai is set as follows: north to the north of the Yangtze River Estuary (32 °N), east to 125.1 ° E, south to the South Bank of Hangzhou Bay (29.6 ° N), west to Wusongkou, including the whole Hangzhou Bay.

3. General situation of maritime accidents

3.1 Monthly average accident status
From the perspective of monthly average number of accidents, March is the most, with an average of nine. January is the second. August is the least, with an average of one.
3.2 Accident conditions under different environmental factors
Based on the analysis of the sea conditions before the accident, it is found that wind, wave and sea fog are the main causes of the maritime accidents[3]. In this kind of accidents, wind and wave accidents are the most, accounting for 62%, followed by sea fog, accounting for 33%.

3.3 Accidents under different weather conditions
By comparing the weather conditions before the accident, it is found that cold air is the main weather system that causes maritime accidents frequently, accounting for 69%, followed by typhoon, accounting for 12.5%. Extratropical cyclone and high-in-east & low-in-west situation account for 9%, respectively.

4. Research method
Through the above discussion, we have a preliminary understanding of the maritime accidents along the coast of Shanghai. Next, we introduce the concept of daily average accident index for in-depth study. The index represents the daily state of maritime accidents, including three items: the number of accidents, the number of deaths, and the direct material damage, the units of which are different, and the data range is very different. In order to avoid the calculation inaccuracy caused by the above, we use the graded weighting method. First, grade each item, then give each item a weight coefficient, and then calculate the daily accident index [1]. We use the average value to grade. First, we get the highest, lowest and average value of each item. Then, we take the average value as the lowest value for this
time and find the average value between the highest value and this lowest value. Next, we take the average value as the highest value for this time and find the average value between the lowest value and this highest value. Then the average value can be calculated by analogy in this way. According to the change range of data, seven average values are calculated for each item. Finally, the seven average values and the highest and lowest values of each item are divided into 8 levels. According to this method, there are more days involved in the middle levels and less in the two sides, which reflects the objective laws of data.

Then we consider the weight coefficients: the number of accidents reflects the operation state of maritime safety, so the weight coefficient is 0.3; although the number of death accidents only accounts for 24% of the total number of accidents, its social impact is large, and the weight coefficient should be the largest, so it is 0.4; from the perspective of the accident situation under the influence of bad weather, the proportion of shipwreck accidents is relatively high, and the weight coefficient of direct material damage should not be too small, also given 0.3. The calculation formula of daily accident index = level of the number of daily accidents × 0.3 + level of the number of daily deaths × 0.4 + level of daily direct material damage × 0.3. A high accident index on a certain day indicates a serious maritime accident situation on that day, while a low accident index indicates a minor accident.

5. Research results
According to the daily maritime accident index, we calculate the annual average daily accident index as 1.5, and the quarterly average daily accident index as 1.15-1.67 (see Figure 3). The daily average accident index in winter (December to February) is the highest, followed by spring and autumn and the lowest in summer. This is different from the seasonal distribution of accident frequency. Although the accident frequency in spring is the highest, the daily accident index in spring is not the highest while the accident frequency and daily accident index in summer are both the lowest because the accident index also contains other items.

Next, we calculate and analyze the daily average accident index under the conditions of wind, wave and fog based on the daily meteorological data.

![index](image)

**Figure 3. Daily average accident index of Shanghai coastal areas in each quarter**

5.1 The relationship between wind and maritime accidents
It can be seen from Figure 4 that under the wind scale nine, the offshore wind force is directly proportional to the daily accident index, and the accidents in the strong windy days are more serious than those in the light windy days. Although wind scale eight is only one level higher than wind scale seven, the accident index is 0.5 higher. It can be seen that when there is a gale of wind scale eight at sea, ships are more likely to have malignant accidents. When the wind scale reaches nine or above, the daily accident index decreases. The gale above wind scale nine is mainly caused by typhoon. Although it has strong intensity, it has short influence time and gets high attention and long forecast time. Once
typhoon comes, ships can often return to harbor in time to avoid the wind. Therefore, the daily accident index is lower than that of light windy days.

5.2 The relationship between wave and maritime accidents
The strong wind will produce big waves, so the relationship between wave and daily accident index is similar to the relationship between wind and index mentioned above. As can be seen from Figure 5 below, the wave height is directly proportional to the daily accident index. The higher the wave height is, the higher the daily accident index is.

5.3 The relationship between fog and maritime accidents
Sea fog is another important factor affecting navigation. When the visibility is less than or equal to 200 m, accidents are very easy to occur (48% of the total accidents). Most of the accidents in fog weather are collision accidents, 31% of which are shipwrecks. Spring and winter are the seasons that sea fog appears most frequently in Shanghai coastal areas[4]. For example, the monthly average sea fog days in March and April are about 6 days, while the sea fog rarely occurs from August to October. According to statistics: as far as the time period of sea fog accident is concerned, the early morning (24 to 5 o’clock) is a period of high accident incidence, with almost one accident occurring every hour.
on average. It can be seen from Figure 6 that the visibility is inversely proportional to the daily accident index. The lower the visibility is, the higher the accident index is.

![Graph showing daily average maritime accident index under different visibility in Shanghai Coast](image)

**Figure 6. Daily average maritime accident index under different visibility in Shanghai Coast**

### 5.4 The relationship between various weather situations and maritime accidents

According to the analysis (Figure 7), the daily accident index under the influence of cold air is much higher than that of other weather systems. The reason is closely related to the highest number of accidents in such weather. At the same time, we can see that the index of high-in-east & low-in-west is also higher than that of typhoons and extratropical cyclones. It can be seen that people often pay less attention to this weather situation, leading to higher death toll and economic loss.

![Graph showing daily average maritime accident index under various weather systems along the coast of Shanghai](image)

**Figure 7. Daily average maritime accident index under various weather systems along the coast of Shanghai**

Under bad weather conditions, the index is also related to the ship's own conditions, navigation environment, safety management and human factors. According to the statistics provided by relevant departments: in the strong wind and waves, due to the improper operation of the drivers or the defects of the ship itself, the accidents with water in the cabin and the sinking of the ship account for 27%; due to the underestimation of wind and waves, the accidents with grounding due to the loss of control of the main engine or sinking after grounding account for 18%; the accidents with entering the breeding area by mistake due to anchoring for strong wind account for 36%. The above figures fully show that the storm is a major cause of accidents, but the technical quality and sense of responsibility of ship operators are also one of the important factors that cannot be ignored.
6. Conclusionsandsuggestions

• Generally speaking, the daily accident index of wind and wave is proportional to the intensity of wind and wave. However, when the wind force reaches wind scale nine or above and the wave height reaches 3 meters or above, the daily accident index decreases.

• At present, our research on some weather systems is relatively weak, such as sea fog. The degree of accidents caused by sea fog increases with the decrease of visibility. Once it is not reported, it often leads to serious consequences. Therefore, we should strengthen the research of maritime weather system and improve the level of disaster warning and prediction.

• Pay attention to sudden weather changes and the systems that are easy to be ignored. When the typhoon comes, due to the high degree of concern, the long forecast time and the sufficient preparation, the degree of accident and disaster caused by the typhoon is low. However, the southerly gales and extratropical cyclones under the situation of high-in-east & low-in-west have the unpredictable disaster causing ability, but they will be neglected. So, the forecast department, fishery department and government department should pay more attention to this kind of weather system.

• In view of bad sea conditions, the weather conditions at sea shall be broadcast through television, radio and other channels in a timely manner to ensure that ships can return to harbor in time and avoid the occurrence of maritime accidents.

• Improve the emergency rescue level in the sea area. In addition to keeping in touch with professional search and rescue institutions, we should actively collect accident information, further improve the accuracy of search and rescue mode, and reduce the death rate of people falling into water.

• The fishery department should strengthen the crew's safety awareness and sense of responsibility, organize more maritime safety awareness education and maritime safety skills training, and reduce the number of accidents caused by human factors[5].

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