An Analysis of Sea Ice Hazard Factors and Their Influence on Seaports Operation in Ice Region of Bohai Sea

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ABSTRACT

Floating ice is one of the potential hazards threatening the safety of sea ports operation in winter. In this study, the monitoring data of the ice conditions around Yingkou Port in ice zone in China was analyzed. The analysis results showed that there was a significant negative correlation between cargo throughput change and the magnitude level of sea ice. When the ice thickness is more than 15 cm, it can cause serious impacts on port operations unless tugboats and icebreakers are deployed to remove sea ice from the channel. When the ice thickness is more than 30 cm, it would require icebreaker to operate 24 hours to break the ice. According to ten years of monitoring, the maximum ice thickness in this sea area exceeded 30 cm almost every year.

KEY WORDS: Sea ice disaster; seaport operation; ice region; ice condition.

INTRODUCTION

Ports play an important role in a nation’s economic system. Sea port is an important node of the transportation network, an important gateway of domestic and international trade. According to data released by the Ministry of Transport of the People’s Republic of China in 2021, seven of China’s top 20 seaports in terms of throughput are located in seasonally frozen seas and need to cope with the impact of sea ice in winter. About one-fifth of China’s continental coastline is in seasonally icy seas. Bohai Sea in northern China is a seasonal ice-covered sea with the lowest latitude in the northern hemisphere. In fact, sea ice disaster is considered to be one of the most serious natural disasters in northern China (Eicken et al., 2015; Xu et al., 2018; Liu et al., 2016). This is because it can affect the implementation of human activities on the coast and the safe operation of projects, such as damaging coastal engineering buildings and offshore facilities, crushing and damaging ships, and blocking ports and waterways (Yuan et al., 2015; Liu et al., 2019). The prevention of sea ice disasters in coastal engineering has always been the focus of attention in the north of China. The ice period in the Bohai Sea usually lasts 3 – 4 months in the winter season, which has a certain impact on port operations in the ice area almost every winter.

Due to the rapid development of the regional economy, the throughput of the ports in the ice region has increased significantly. Although these ports play pivotal roles in facilitating growth in the Northeast Asian Economic Circle through international freight shipment, the systems also face increasing risks from seasonal ice disasters, which can cause damage to port infrastructure and major disruptions to port operations. Pierre and Olivier (2015) assessed the relevance of the Northern Sea Route (NSR) for bulk shipping. Aksenov et al. (2017) analyzed the change of sea ice in the Arctic Ocean and the navigability of Arctic sea routes on the future. Nair et al. (2010) established a framework to evaluate port resilience under five disruption scenarios (including earthquake and flooding). As a result, how to ensure the safety of port infrastructure and operations in ice areas and minimize the negative impact of sea ice disasters has always been the most concerned issue for port authorities and disaster management agencies.

Specifically, Port of Yingkou, which is located in Liaodong Bay in the northern of Bohai Sea in China, was selected as the research object. Although its cargo throughput volume has increased substantially due to a rapid regional economic development, the port has also experienced rising challenges due to the uncertainty of severe sea ice disaster events (Liu et al., 2020). From 2010 to 2020, our team conducted ice condition monitoring around Yingkou Port for 10 consecutive years. In this study, based on the monitoring data, the characteristics of ice conditions near the sea port were analyzed in order to provide the basis for early warning, risk management, and safe operation of port in the ice zone in winter.

STUDY AREA AND DATA SOURCES

Study Area

Our investigation focuses on the characteristics of sea ice conditions near Yingkou Port (Fig. 1). The port is considered as one of the largest seaports in the Bohai Sea area with an annual throughput of 362 million tons and 6 million TEUs (twenty-foot equivalent unit). It also serves as a major gateway for freight transportation in northern China, as it provides regular vessel shipping services with connections to more than 140 seaports in 50 countries. The sea area where Yingkou Port is located generally begins to freeze in mid-November and ends in March of the following year. The average freezing period for many years is 95