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Time and Space Analysis of Pirate Attacks in Southeast Asia

Wanglai Kuang
Merchant Marine College, Shanghai Maritime University, Shanghai, China

Abstract

The Southeast Asia sea area is the busiest sea area in Asia. However, due to the attack of pirates on ships, the navigation safety of ships on the sea is seriously endangered. It can provide reference for shipping related parties to prevent pirate attacks or to develop response mechanism. Based on the data of pirate attacks in Southeast Asia from 2007 to 2019, this paper analyzes the time and space distribution of pirate attacks in this region by using descriptive statistics and kernel density estimation methods. The results show that there are about 65 pirate attacks in Southeast Asia every year, less in January March, and the three kinds of ships that are attacked most are bulk carriers, oil tankers and tugboats. In space, the Singapore Strait and the waters near benawaa are the high incidence areas of piracy.

Keywords

Southeast Asia sea area, pirate attack, kernel density estimation.

1. Introduction

Southeast Asia is the most important sea area for maritime trade in Southeast Asian countries. It is an important maritime transportation channel connecting Southeast Asian countries to major ports in the world. The threats to maritime transport not only come from bad weather conditions, narrow waterways and ship collisions, but also pirate attacks [1]. Since 2017, there have been 172 cases of piracy and armed robbery against ships in Southeast Asian waters, accounting for about 30.3% of the global total. Relevant research shows that the degree of activity of pirates will affect the number of ships passing through the region to a certain extent, and affect the trade between the two countries [2].

The causes of piracy are related to socio-economic conditions [3], human trafficking, arms smuggling and military power [4] [5]. Domestic experts' research on piracy is mostly for the establishment of early warning models to respond to pirate attacks [6], the formulation of emergency plans [7], naval escort site selection methods [8] and the game between escorts and pirates [9]. Based on the Bayesian network, Jiang Meizhi analyzed the pirate attack and found that the external environment, ship's own risk and time were the main factors affecting the pirate attack [10]. Although the macro analysis analyzes the relevant factors and the degree of correlation of piracy risks from various angles, they rarely determine the detailed characteristics of pirate attacks. These characteristics are of great significance for the crew to take preventive measures or policy responses. Therefore, many studies have carried out micro-level factor analysis, including ship characteristics and natural environment. The research by Psarros et al. [11] Shows that bulk carriers, tankers and ordinary cargo ships have suffered the most attacks. Ships with lower freeboards and lower speeds are particularly vulnerable to pirate attacks. Shane and Magnuson [12] believe that environmental factors such as night time, vessel mooring status, and ships in ports or territorial waters close to the port significantly increase the chances of successful attacks. Effective wave height (sea conditions), sea surface wind speed, sea surface velocity and sea surface temperature are related [13]. Huang Daozheng et al. [14] Calculated the probability of encountering a pirate by combining the average pirate probability and the adjustment coefficient derived from the

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geographic information system (GIS). Cao and others conducted an annual review of the global piracy and armed hijacking of ships in 2018, including the pirate's weaponry and crew damage, the success rate of pirate attacks and the status of the attacked ship, ship type and flag state characteristics, etc. [15]. Although the microscopic analysis has been very detailed, there are few spatiotemporal analyses on piracy incidents. Distributing pirate attack incidents in time and space can better obtain the true situation of pirate attacks, and only then can we make more reasonable anti-piracy recommendations [16] .

In this study, the pirate attack data in Southeast Asia from 2007 to 2019 was used to analyze the increase and decrease of pirate events from the time dimension, and the spatial distribution of pirate attack events was analyzed using kernel density estimation. Analyze the GIS data of piracy attacks in Southeast Asian waters in order to provide reference for the industry to formulate piracy prevention measures, so as to raise the vigilance of crews sailing in areas where piracy incidents are common, because the discovery of piracy is the prerequisite and key to all preventive measures [17].

2. Data and Methods

This article conducts research based on the report of pirate attacks and armed robbery in the Global Integrated Shipping Information System (GISIS) developed by the International Maritime Organization (IMO) in 1982. According to the regulations of the International Maritime Organization, the data is provided voluntarily by shipowners, captains, international organizations and member states, including the date of attack, ship type, geographical coordinates (after 2006), details of the incident, and the authorities and coastal areas to which the incident was reported. The country 's actions, etc., the database has been widely used in previous academic research [18]. Based on the latitude and longitude geographic information (92 ° E ~ 140 ° E, 10 ° S ~ 28 ° 26N) of Southeast Asia, this paper selected a total of 1260 pirate attack data points from January 2007 to December 2019 Pcs. The following first uses basic descriptive statistical methods to analyze the basic characteristics of pirate incidents, then uses the kernel density estimation method to explore the spatial distribution of pirate incidents, and finally summarizes the spatial and temporal distribution of pirate incidents.

3. Time Distribution of Pirate Attacks in Southeast Asian Waters

According to the statistics of 13 years of pirate attacks, the annual distribution of the number of pirate attacks in Southeast Asia is shown in Figure 1. The number of pirate attacks reached a peak of 198 in 2015, and the number of attacks in 2016 after a joint cruise operation was carried out in relevant countries in Southeast Asia. The number of pirate attacks is about 65 per year, and the lowest number in the past five years was 54 in 2018. Monthly statistics on the attack data found that the number of pirate incidents occurred in January-March and July was relatively small, and the number in other months was more than 100. It is worth mentioning that since the joint cruise operation, the average number of pirate attacks per month has dropped to 21, with the worst month being November-December.

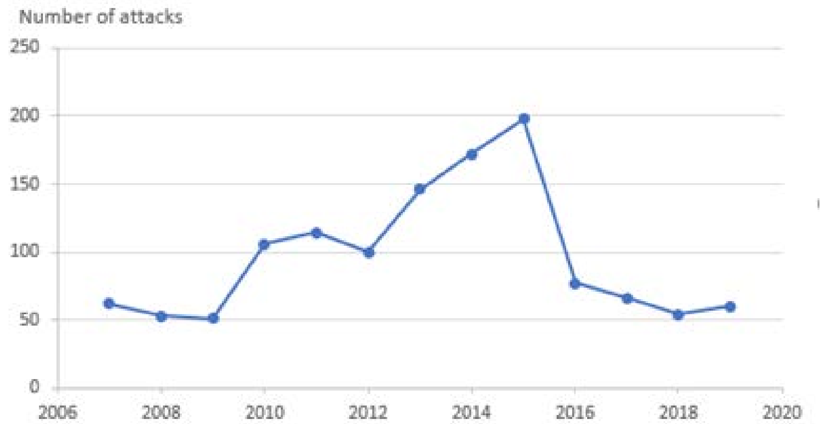

Figure 1: 2007-2019 annual distribution of pirate attacks in Southeast Asian waters.

The targets of pirate attacks in Southeast Asian waters have significant characteristics in terms of ship type. Bulk carriers and oil tankers are the most attacked by pirates in the region, with a cumulative proportion of 53.17%, which is consistent with the results of Psarros research. The number of attacks on bulk carriers, oil tankers, tugboats / towboats, chemical tankers and container ships in this sea area accounted for more than 80% of the total number of pirate attacks in the sea area over the past 13 years, as shown in Figure 2.

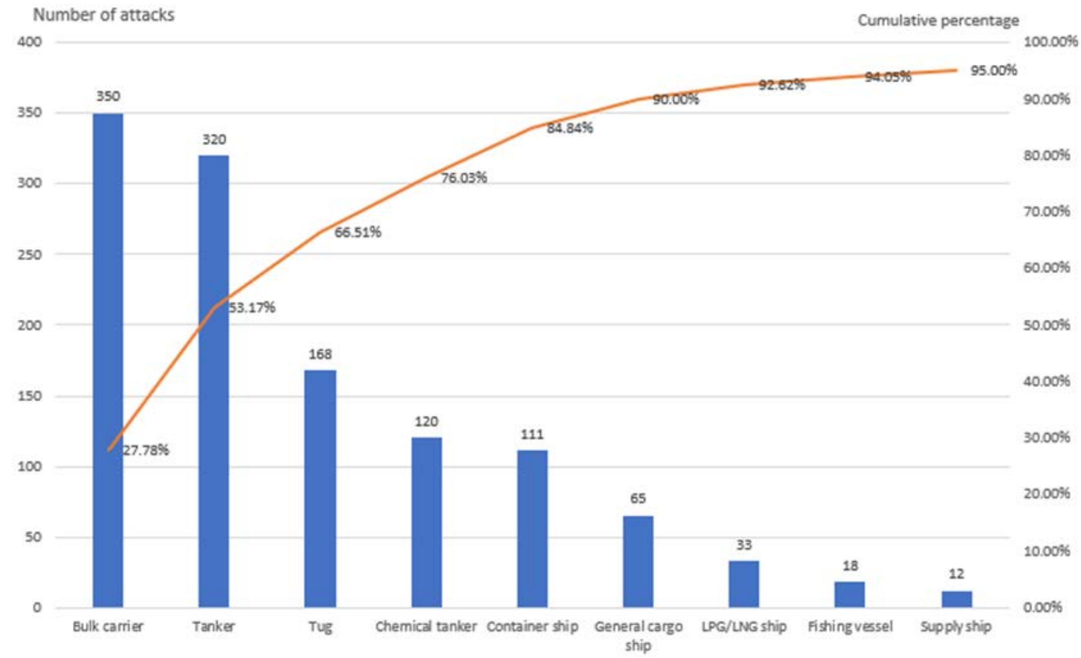

Figure 2: Distribution of ship types attacked by pirates in Southeast Asian waters from 2007 to 2019.

4. Kernel Density Estimation and Analysis of Pirate Attacks in Southeast Asia

4.1. Kernel Density Estimation

The kernel density estimation is used to calculate the concentration of pirate attacks in Southeast Asia, focusing on the impact of pirate attacks on the surrounding areas. The kernel density estimation method uses a moving cell to estimate the pattern density of points or lines. Given sample points x1, x2, ..., xn, use kernel density estimation to simulate the detailed

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distribution of attribute variable data. The kernel density estimation function used in ArcMap can be defined as follows:

$$f_n(x) = \frac{1}{R^2}\sum_{i=1}^{n}[\frac{3}{\pi} \bullet pop_i(1-(\frac{d_i}{R})^2)^2] \quad (1)$$

in which: i = 1, ..., n are input points; if they are within the radius distance of (x, y), only the points in the sum are included; popi is the population field value of point i, which is an optional parameter ; Di is the distance between the point i and the position of (x, y).

In kernel density estimation, bandwidth is a free parameter that defines the amount of smoothing. Too large or too small bandwidth will affect the result of kernel density. For the kernel density analysis of spatial data, the bandwidth needs to be reasonably determined according to the actual spatial distribution of the points and the research problem. The smaller bandwidth is suitable for reflecting local changes in density distribution, and the larger bandwidth can effectively reflect the spatial changes in global scale. The bandwidth calculation formula we chose is as follows:

$$R=0.9*\min(SD,\sqrt{\frac{1}{\ln(2)}}*D_m)*n^{-0.2} \quad (2)$$

in which: SD is the standard distance; Dm is the median distance; n is the number of points.

4.2. Result Analysis

Considering the sea area with a history of piracy, it is more likely to have another pirate attack. In this paper, we use kernel density tool in ArcMap to estimate the kernel density of 1260 pirate attacks data points in 13 years, and generate the kernel density map of pirate attacks in Southeast Asia in 2007-2019. As shown in Figure 3, the kernel density distribution of pirate attacks in Southeast Asia sea generates nine cores. The Singapore Strait and the waters near benawaa are the high incidence areas of piracy, followed by the Malacca Strait; the southeast of Kalimantan island in Indonesia is also an active area of piracy, mainly distributed along the coast of Samarinda, Balikpapan and Banjarmasin; the other three cores are located in the Sunda Strait, along the coast of Nantou in Vietnam and in the waters of Halong Bay in Vietnam.

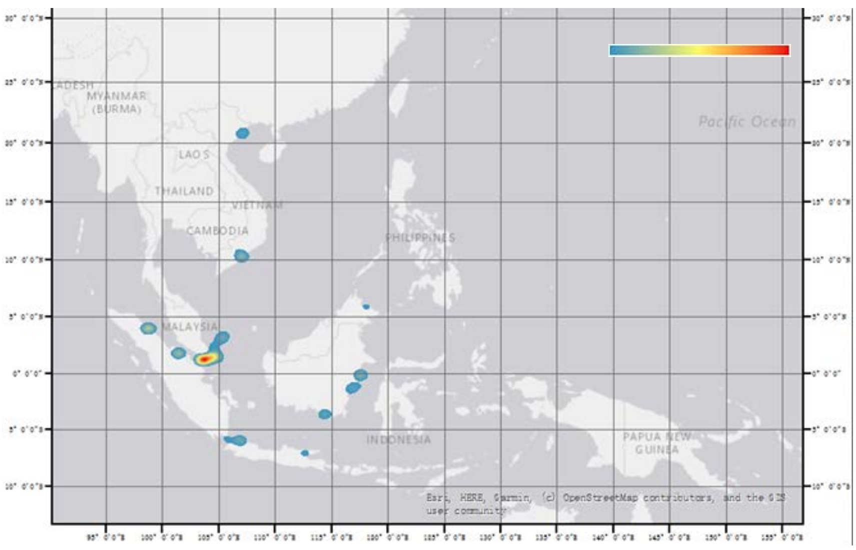

Figure 3: Kernel density estimation of piracy attacks in Southeast Asia in 2007-2019.

As a result of the Southeast Asian countries to take joint cruise operations, pirate attacks significantly reduced. The author further analyzes the data since 2016, and finds that Singapore Strait is still a sea area with frequent pirate attacks, and the pirate attacks in the

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Sulu Celebes Sea and the eastern sea of Sabah are more active. There are many ships in the channel of Singapore Strait and Malacca Strait, and pirates have more targets. Since the implementation of the maritime Silk Road strategy, the number of ships passing through the Straits of Malacca and Singapore has increased. However, piracy is the main reason affecting safety and efficiency. As Malaysia and the Philippines have territorial disputes in the Sabah sea area, pirates are more active in the Sulu Celebes Sea area, and the risk of kidnapping crew is high.

5. Conclusion

This paper analyzes the time distribution of pirate attacks in Southeast Asia, and finds that since 2016, the pirate activity in this area has declined, but bulk carriers, oil tankers and tugboats / tugboats are still the main targets of their attacks; spatial analysis shows that the main areas of pirate activity in this year are in the Singapore Strait and the southeast coast of Kalimantan island, Indonesia. This information is very important for the captain, shipowner, convoy and insurance company. It can provide reference for them to take preventive measures or formulate response mechanism, which has practical significance. However, due to the lack of some detailed data in many records of gisis database (such as the number of pirates, current sea conditions, etc.), this paper does not carry out a detailed analysis of these factors. In the future, we will further expand the research database, analyze the situational factors of pirate attacks one by one, and evaluate the probability of pirate attacks based on the AIS data of ships in the sea area at that time.

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