Analysis of tropical cyclone data over China's coastal waters and the Northwest Pacific Ocean for Marine Fisheries

Xiaotian Guo[1,2], Weifeng Zhou[1,*] and Huijuan Hu[1,3]

[1] East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, China
[2] School of Information Engineering, Zhejiang Ocean University, Zhoushan, China
[3] College of Fisheries and Life Science, Shanghai Ocean University, Shanghai, China
[*] Author to whom any correspondence should be addressed
E-mail: zhwfzhwf@163.com

Abstract. Tropical cyclones (TCs) have a serious impact on marine fisheries. More than 80% of marine disasters are caused by TCs. Based on the data of the best track of TCs in the Northwest Pacific Ocean, this paper analyzes the spatial distribution of TC influence duration. The analysis shows that: (1) In the Northwest Pacific, Tropical depressions have the most extensive influence; The influence range of tropical storms is similar to that of severe tropical storms; Typhoons gradually decrease around the southeast side of Taiwan Island; From severe typhoon level, the influence of TCs is moving away from the mainland; Super typhoons have obvious influence only in the east of Malaysia archipelago. (2) In terms of marine fisheries, severe tropical storm and typhoon level of wind resistant marine fishery facilities should try to avoid the waters on both sides of the line between Taiwan Island and Malaysia islands; Severe typhoon and super typhoon level of wind resistant marine fishery facilities are only at risk in the east of Taiwan Island and Malaysia islands, and are basically safe in other waters.

Keywords： Tropical cyclone; China's coastal waters; Northwest Pacific Ocean; Marine Fisheries

1. Introduction

Tropical cyclone (TC) is an important part of marine natural environment and one of the major natural disasters. According to the bulletin on marine disasters issued on the Ministry of Natural Resources website (http://gi.mnr.gov.cn), among all kinds of marine disasters in 2019, the most serious direct economic loss caused by a single disaster process is 1909 'Lekima', with a direct economic loss of 10.288 billion yuan. In addition, 1918 'Mitag' and 1907 'Wipha' caused direct economic losses of 1.104 billion yuan and 225 million yuan respectively. The ocean is known as the 'blue granary', which has great fishery potential and is an important source of protein for people. However, tropical cyclones are easy to make marine fisheries suffer losses. According to China Fisheries Statistical Yearbook [1], typhoon and flood caused 50000 damaged net cages, 868 sunken ships, 2354 damaged ships and nearly 380000 tons of aquatic products loss in 2018.

In order to understand the environmental background of typhoon disasters over China's coastal waters and the Northwest Pacific (NWP), based on the data of the best track of TCs in the Northwest Pacific Ocean, this paper makes statistics on the influence duration of TCs in the Northwest Pacific from 1950 to 2020. Divide the coastal waters of China into three parts: Yellow Sea and Bohai Sea,the East China Sea and the South China Sea. The statistical results of TC influence duration are analyzed from

these three areas respectively, so as to grasp the spatial distribution characteristics of influence duration of TCs and the potential typhoon risk in offshore of China.

2. Research Method

2.1. Data

This paper uses the best track dataset [2-3] from 1950 to 2020 provided by China Meteorological Administration Tropical Cyclone Data Center (tcdata.typhoon.org.cn). The data set contains time series, intensity level markers, TC center latitude, TC center longitude and other information, and its sampling interval is 6 hours. Since 2017, the sampling interval within 24 hours before tropical cyclone landing has been adjusted to 3 hours.

Table 1. Tropical Cyclone Category (GB/T 19201-2006)

Tropical Cyclone Category	Maximum Sustained Wind Near the TC Center (m/s)	Beaufort scale
Tropical Depression	10.8–17.1	6–7
Tropical Storm	17.2–24.4	8–9
Severe Tropical Storm	24.5–32.6	10–11
Typhoon	32.7–41.4	12–13
Severe Typhoon	10.8–17.1	14–15
Super Typhoon	≥51.0	≥16

Eliminating additional records with a sampling interval of 3 hours, The sampling interval of records used for data analysis is 6 hours. Eliminate the records that are weaker than the tropical depression level (Table 1 shows the tropical cyclone category). The records with unknown level and the records of denaturated TC centers are excluded. Modern marine facilities can basically resist tropical depression level TCs, therefore, except used in analysis of influence duration of TCs in the Northwest Pacific Ocean, TC records of this intensity level need to be eliminated in other analysis.

2.2. Processing Method

2.2.1. Gridding. Most of the central points of tropical cyclones in the data set are in the region of 0°N~50°N, 100°E~180°E, so the study area is defined as this region. Divide this area by 1°×1° grid to form a warp and weft net with 50 rows and 80 columns.

2.2.2. Distribution of TC Influence Duration. Since the sampling interval of TC records is 6 hours, it can be assumed that each TC center has a 6-hour influence on the grid it falls. Count the TC center frequency f_{TC} of each grid. Calculate the TC influence duration $duration_{TC}$ by $duration_{TC} = 6 * f_{TC}$. Although the correlation between them is simple linear, the specific hourly unit is far more practical than the abstract frequency for marine fishery application scenarios.

The TC data set is processed by Python language, the obtained data is conneted with the study area grids, and then visualized by ArcGIS software. Classify TC influence duration values by Natural Breaks (Jenks) which is commonly used in geographic data classification, and achieve the maximum variance between groups and the minimum variance within groups [4]. The experiment shows that there is a good visual effect in 5 levels.

3. Results and Analysis

3.1. Distribution of TC Influence Duration in NWP
Distribution of TC influence duration in Northwest Pacific is shown in Figure 1.

In the Northwest Pacific Ocean: Tropical depressions have the most extensive impact, and modern marine facilities can resist it; When tropical storm occurs, general fishing boats should actively avoid danger, and common net cages will be affected; The influence range of severe tropical storms is similar to that of tropical storms yet the influence duration of severe tropical storms is shorter, and current-resistence submerged cages can resist this level of TC; Typhoons gradually decrease around the southeast side of Taiwan Island, in which level culture platforms such as abalone culture platform 'Fubao 1' can stay safe; From severe typhoon level, the influence of TCs is moving away from the mainland, and only a small number of sea area grids are affected in China seas; Super typhoons are very destructive and have obvious influence only in the east of Malaysia archipelago, and due to difficult construction and high cost, few fishing facilities will be invested for this safety level. Generally speaking, only a few coastal land buildings need to reach the security level of Super typhoon, such as Hong Kong-Zhuhai-Macao Bridge.
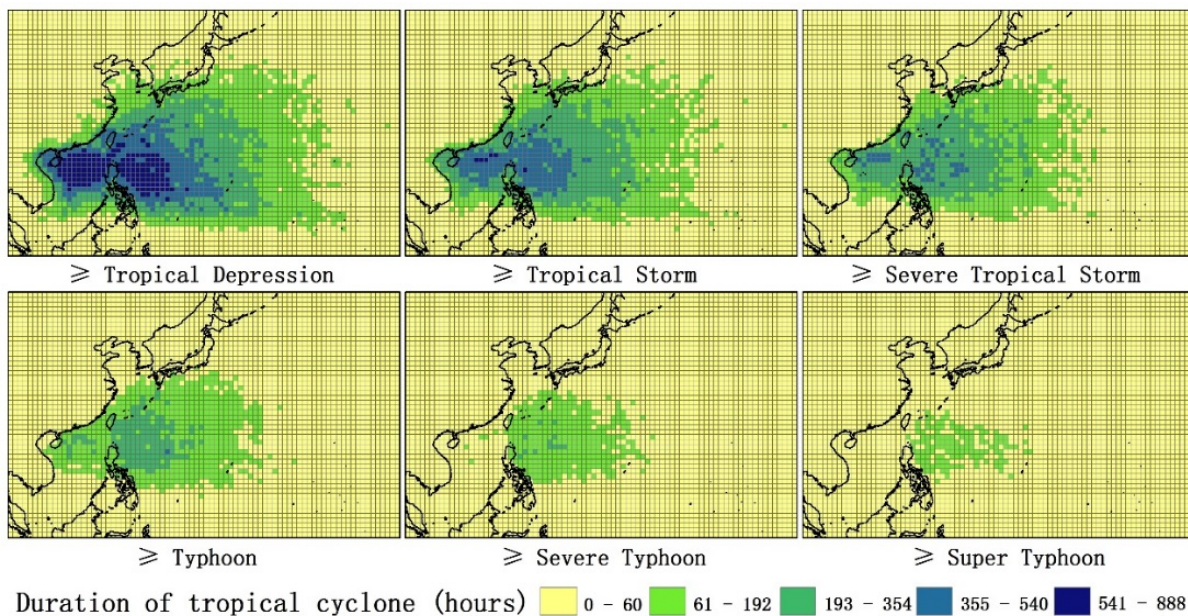
Figure1. Distribution of tropical cyclone influence duration in NWP

For China's maritime space: Except in Yellow Sea, Bohai Sea and southern the South China Sea, Tropical depression and tropical storm level fishery facilities should have the ability of timely risk avoiding; Severe tropical storm and typhoon level marine fishery facilities should try to avoid the waters on both sides of the line between Taiwan Island and Malaysia islands; Severe typhoon and super typhoon level marine fishery facilities are only at risk in the east of Taiwan Island and Malaysia islands, and are basically safe in other waters.
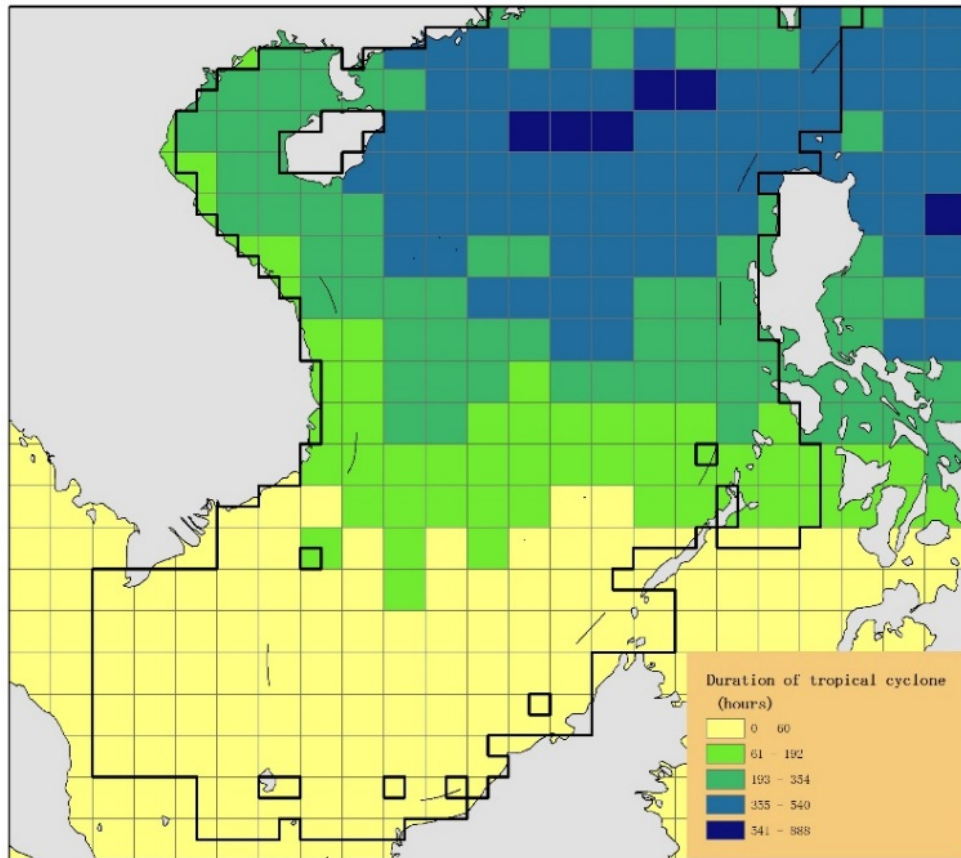
3.2. Distribution of TC Influence Duration in the South China Sea
The distribution of TC influence duration in the South China Sea is shown in Figure 2. The TC influence duration in the northern part of the South China Sea is longer than that in the southern part. The influence duration in the coastal area near the mainland is less than that in the central and northern of the South China Sea. Fishing ground Dongsha, Southeast of Hainan Island, and Western Yue and Northeast

Hainan Island have the greatest risk, while fishing ground Southern Nansha, South Central Nansha, and Eastern Nansha have the least risk.

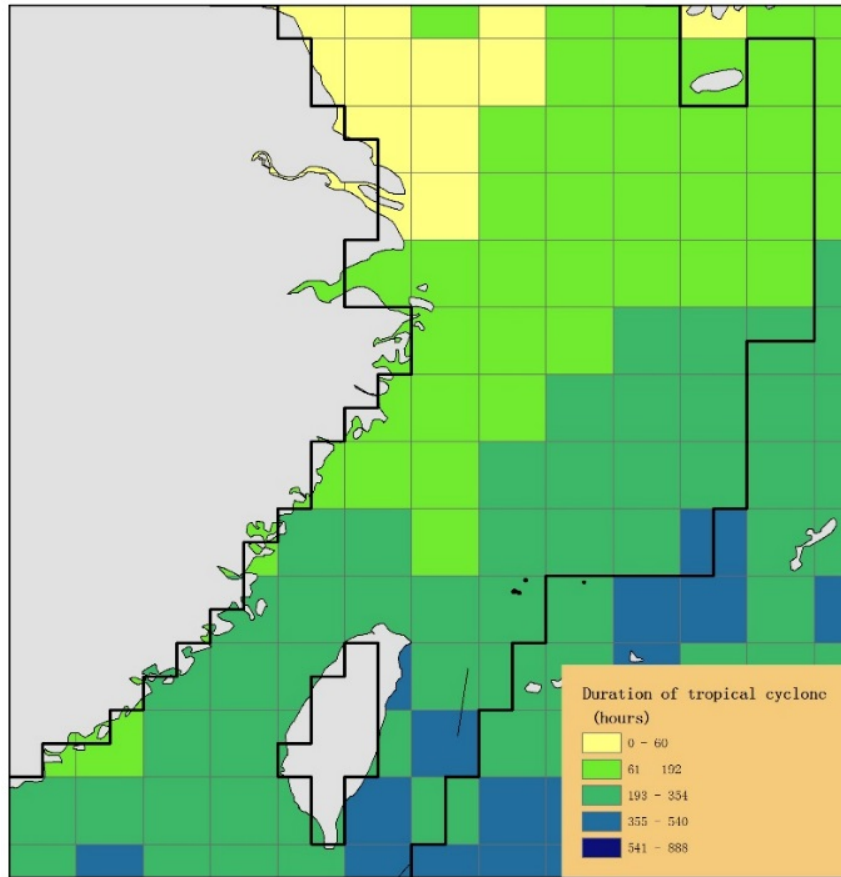*3.3. Distribution of TC Influence Duration in the East China Sea*

The distribution of TC influence duration in the East China Sea is shown in Figure 3. TC influence duration in the southern part of the East China Sea is longer than that in the northern part. Fishing ground Outside Min, Taitung, and Outside Wen have the greatest risk, while fishing ground Lusi, Changjiang River Estuary, and Dasha have the least risk.
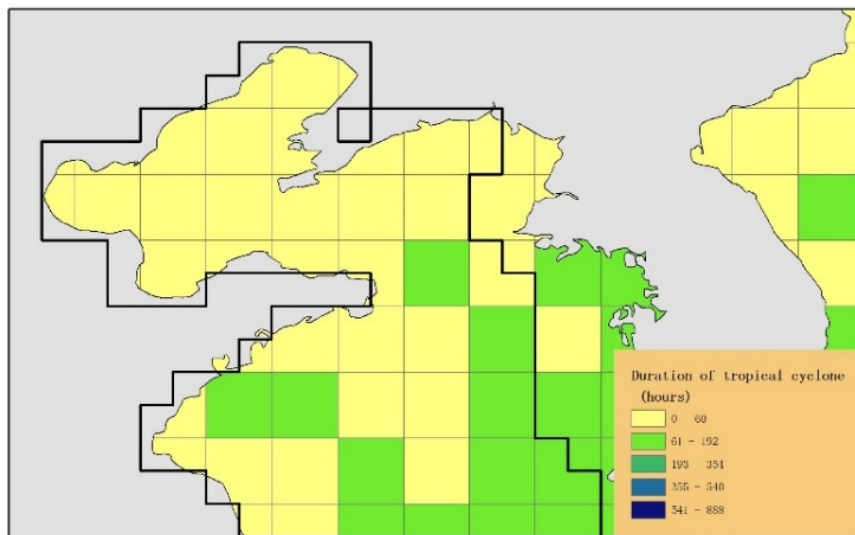

Figure 2. TC influence duration of tropical storm and above in the South China Sea

3.4. Distribution of TC influence duration in Yellow Sea and Bohai Sea

The distribution of TC influence duration in Yellow Sea and Bohai Sea is shown in Figure 4. Compared with the South China Sea and the East China Sea, the risk of tropical cyclones in Yellow Sea and Bohai Sea is significantly lower. Except fishing ground Liandong and Lianqingshi, other fishing grounds are safe.

Figure 3. TC influence duration of tropical storm and above in the East China Sea

Figure 4. TC influence duration of tropical storm and above in Yellow Sea & Bo Hai Sea

4. Conclusions

Based on the data processing of the best track dataset of tropical cyclone in the Northwest Pacific Ocean, this paper analyzes the spatial distribution of the TC influence duration. The results are as follows:

In the Northwest Pacific: Tropical depressions have the most extensive impact; The influence range of severe tropical storms is similar to that of tropical storms; Typhoons gradually decrease around the southeast side of Taiwan Island; From severe typhoon level, the influence of TCs is moving away from the mainland; Super typhoons have obvious influence only in the east of Malaysia archipelago.

For marine fisheries: Severe tropical storm and typhoon level marine fishery facilities should try to avoid the waters on both sides of the line between Taiwan Island and Malaysia islands; Severe typhoon and super typhoon level marine fishery facilities are only at risk in the east of Taiwan Island and Malaysia islands, and are basically safe in other waters.

5. References

[1]   Zhang X L 2019 *China Fishery Statistical Yearbook* (Beijing: China Agricultural Press) pp 127–132

[2]   Lu X Q, Yu H, Ying M, Zhao B K, Zhang S, Lin L M, Bai L N, and Wan R J 2021 Western North Pacific tropical cyclone database created by the China Meteorological Administration *Adv. Atmos. Sci.* **38**(4) 690−699

[3]   Ying M, Zhang W, Yu H, Lu X, Feng J, Fan J Y, Zhu Y, and Chen D 2014 An overview of the China Meteorological Administration tropical cyclone database *J. Atmos. Oceanic Technol* **31** 287−301

[4]   Hou J, Zhou W F, Wang L M, Fan W and Yuan Z H 2020 Spatial analysis of the potential of deep-sea aquaculture in China *Res. Sci.* **42**(7) 1325–1337