

Application of Remote Sensing Technology in Chinese Marine Pollution Monitoring

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Abstract. The ocean is an important source of food and energy for global ecosystems, so the protection and monitoring of Marine water quality have become extremely important. By introducing the development of remote sensing monitoring methods and the degree of offshore water pollution in China in recent years, this study explains the specific application of Marine remote sensing in China from three aspects of offshore oil pollution, plastic waste and algae. There are three best known Landsat series of satellites: Landsat, spot series of satellites, and high score series of satellites. Remote sensing technology plays a significant role in monitoring offshore oil spills, marine plastic trash, ocean surface water quality, marine ecology, and maritime pollution. Sources of marine pollution in China is mainly from land-based pollutants and pollutants directly discharged into the ocean. This study provides technical also discusses the application field of remote sensing technology in the ocean, which provides a scientific basis for marine protection and marine ecological environment management.

Keywords: Remote sensing technology, marine pollution monitoring, application.

1. Introduction

The ocean serves as a vital source of sustenance for global ecosystems and plays a fundamental role in supporting human existence and progress. The Earth's oceans encompass the most extensive expanse of surface area and are abundant in valuable materials and energy. In recent years, there has been a growing concern regarding the escalating issue of marine pollution. This encompasses several forms of pollution, such as oil pollution, rubbish and plastic pollution, chemical pollution, organic pollutant pollution, and sound pollution. The Japanese government announced on August 24, 2023, regarding the initial stage of releasing 7,788 tons of effluent from the Fukushima nuclear plant [1,2]. The global community has once again directed its collective attention towards the matter of marine pollution. Therefore, to control marine pollution, how to monitor the marine water quality becomes extremely crucial.

Over the past decades, remote sensing technology has been widely used in marine pollution monitoring. For example, remote sensing technology can be used for red tide monitoring and oil spill monitoring [3]. In marine pollution monitoring, remote sensing technology is especially suitable for monitoring parameters such as oil pollution, thermal pollution, ocean water color and turbidity. However, there are still some problems in marine pollution monitoring. First, the precision and accuracy of marine pollution monitoring need to be further improved. Secondly, data processing and analysis methods in marine pollution monitoring also need to be improved. In addition, more field surveys and sample collection work are needed to verify the reliability of remote sensing technology in marine pollution monitoring.

To solve these problems, this study discusses a variety of popular marine pollution in China and corresponding research methods, taking marine oil pollution, marine plastic waste, and marine algae as examples. By processing and analyzing remote sensing data, we can obtain the spatial and temporal distribution information of marine pollution, and then evaluate and monitor the extent and trend of marine pollution.

The significance of the research is to introduce a variety of marine pollution monitoring methods so that readers can choose the most efficient, rapid and comprehensive one, providing scientific basis for protecting the marine environment and maintaining human health. By studying the spatial and

temporal distribution and trends of marine pollution, timely measures can be taken to reduce the impact of marine pollution on the ecological environment. In addition, research can also provide a scientific basis for formulating marine pollution prevention and control policies and management measures, and promote the sustainable development of the marine environment. Therefore, this study has important theoretical and practical significance.

2. Basis of remote sensing technology

2.1. Definition and development of remote sensing technology

Remote sensing technology, also known as telemetry, remote sensing telemetry, is a technology that uses electromagnetic radiation and broad-spectrum data acquisition using satellites, aircraft and others, used to obtain information about the target surface and its surroundings. The development of remote sensing technology has gone through many stages, from the initial space photogrammetry to the present high-resolution image acquisition, making significant progress.

The origin of remote sensing technology can be traced back to the development of space photogrammetry. In the early days, only aerial photogrammetry technology could obtain information on the target surface, but because of the limitation of the low resolution and the limited coverage of the aerial image, it could not meet the need to obtain the information on the larger surface [4]. With the development of technology, satellite remote sensing technology has been applied to the acquisition of surface information, providing higher-resolution images and a wider coverage area. This makes the application of remote sensing technology in marine pollution monitoring possible.

2.2. History and main remote sensing satellite

The 1858 began when French photographer Ronald Rees shot the first ever satellite image, it experienced the transformation from single-band to multi-band, from low-resolution to high-resolution. The initial remote sensing technique can only gather single-band information, such as visible light-band photos. With the advancement of technology, remote sensing technology can acquire information on different bands, such as infrared bands and short-wave infrared bands. Over the past 200 years, more than 1,500 remote sensing satellites have been active in low Earth orbit by the end of 2021.

Today, the three are best known as the Landsat series of satellites:

(1) Landsat is a series of remote sensing satellites that NASA and the U.S. Geological Survey (USGS) have partnered on, the purpose is to capture high-resolution remote sensing photos of the Earth's surface. Some Landsat satellites have been launched, the latest of which is Landsat 8. The Landsat satellite includes sensors in a range of spectral bands, including visible, infrared and thermal infrared. These bands may provide a huge quantity of surface information, including vegetation cover, land use, water distribution and so on, helping the Landsat satellite become a widely utilized tool for Earth observation and environmental study. Landsat's OLI sensor captures data in both the visible and near-infrared spectrum, with a 30-meter spatial resolution and some spectral bands, it includes blue, green, red, near-infrared and two short-wave infrared bands. Take landsat8, which gets at least 400 images per day. The previous series received less than 250 images a day, because the remote sensing device on the Landsat 8 had the ability to obtain information at an angle away from the track, collecting information from the ground below the satellite [5].

(2) Spot series of satellites: Spot is a series of high-resolution commercial remote sensing satellites produced by the French Space Agency (CNES). The SPOT family of satellites offer excellent spatial resolution and large coverage and are frequently utilized in the disciplines of surface coverage analysis, resource management and Environmental monitoring.

(3) High score series of satellites: The high score series of satellites is a series of remote sensing satellites launched by the China National Space Administration (CNSA), such as the high score 1 and high score 2. These satellites have a variety of sensors that can produce high-resolution remote

sensing photos and are commonly employed in fields such as land-use monitoring, agricultural surveys and urban planning.

2.3. Applied areas

Remote sensing technology plays a significant role in monitoring and responding to offshore oil spills. The sea surface temperature data obtained by remote sensing devices can be utilized to monitor the oil spill region, thereby assisting relevant departments to adopt prompt and effective reaction actions [6]. At the same time, remote sensing technology can track and identify the oil leak accident by monitoring the optical features of the oil film, thereby providing critical information for the cause of the disaster.

Remote sensing also plays a significant role in monitoring marine plastic trash. The dispersion of plastic debris in the water may be visible through high-resolution photos collected by remote sensing satellites. With the help of a remote sensing picture feature extraction algorithm, plastic trash can be automatically detected and counted, which gives a scientific basis for the construction of plastic waste treatment program. Remote sensing technology can also actively monitor the diffusion of plastic trash across time and space, helping to comprehend the migration patterns and accumulation locations of plastic garbage [6].

In addition, remote sensing technology can also be utilized for the monitoring of ocean surface water quality. Traditional water quality monitoring methods need to collect a significant number of water samples for experimental analysis, time-consuming and difficult. With the use of remote sensing technologies, we can employ satellite sensors to measure the ocean surface water swiftly and remotely. Remote sensing technology can give essential characteristics, such as optical properties, suspended matter concentration and chlorophyll content, to achieve rapid assessment of ocean water quality and real-time monitoring to some extent.

Remote sensing also has enormous potential in the environmental monitoring of marine ecology. The automatic identification and monitoring of marine biological communities can be realized using image processing and classification algorithms of remote sensing technology. Remote sensing data is feasible to study the spatial distribution and temporal fluctuation of marine ecosystems and their link to environmental conditions in support of scientific conservation and management of living marine resources.

Remote sensing technology has been widely used in maritime pollution monitoring. Remote sensing technology can provide important information on the monitoring, tracking, assessment and early warning of marine pollution in the context of oil spills, plastic waste, water quality and the ecological environment, to provide scientific support for the protection and sustainable use of the marine environment.

3. Analysis of the marine pollution in China

3.1. Sources of marine pollution and its impacts

3.1.1. Land source pollution

The composition of land-based pollutants accounts for almost 85% of the total marine pollutants. The primary contributors to this phenomenon include chemical aerobic compounds, ammonia nitrogen, oil compounds, and phosphate salts. A significant proportion, exceeding 95%, of the aggregate additionally comprises sulfide, zinc, arsenic, lead, chromium, volatile phenol, and cyanide constituents, as well as copper, cadmium, mercury, and other similar elements [7]. Land-based pollutants primarily originate from industrial waste and urban garbage. The topic of discussion pertains to the management of various forms of waste, namely in the context of agricultural practices involving the breeding of animals, the application of fertilizers, and the use of pesticides. Consequently, the nation's Local pollution sources can be categorized into four distinct groups,

including industrial pollution sources, domestic pollution sources, and agricultural pollution sources. Furthermore, it is important to consider the sources of contamination in onshore aquaculture [8].

3.1.2. Point-source pollution

Point-source pollution refers to the pollutants directly discharged into the ocean by clear pollution sources, such as wastewater from chemical plants, sewage discharge from ships, and waste from offshore oil platforms. These emission sources are usually concentrated and traceable, and the pollution caused to the Marine environment is more obvious. Non-point source pollution refers to the pollutants that are difficult to determine specific sources, such as agricultural non-point source pollution, and overflow of urban drainage system. These pollutants will enter the Marine environment through a natural process and have a potential impact on the Marine ecosystem.

3.2. Current situation of environmental pollution in China's offshore waters

By 2022, China's coastal waters will reach 75,530 km², mainly polluted Cloth in the Yalu River estuary, Liaodong Bay, Bohai Bay, Yangtze River Estuary, Hangzhou Bay, Pearl River Estuary and other Bureau Department of Water. The sea area of each sea area that does not meet the cleaning standard is shown in Table 1.

Table 1. Area of water quality area of different grades in China's four major offshore waters in 2022 (km²) (The data are derived from [9])

Area	Class II seawater	Class III seawater	Class IV seawater	Below class IV seawater	Growth
Bohai Sea	10910	3790	2150	7800	11800
Huanghai Sea	9850	1650	1000	1210	4190
East China Sea	11190	4030	2370	11350	-7030
South China Sea	2440	2560	1020	4520	-2120

About 75,000 square meters of China's entire waters do not meet clean water standards. This is an increase of 500,000 km² from 2021, but it has decreased by nearly 20,000 km² compared to 2020 (Table 2). On the whole, the pollution in China's waters has not been alleviated, especially the second-class sea area 3850 km² increased by 12.6%; the area of inferior seawater increased the increase of 3,530 km² reached 16.5% and the pollution level increased significantly.

Table 2. Comparison of pollution in the whole sea area from 2020 to 2022 (km²) (The data are derived from [9-11])

Area	Class II seawater	Class III seawater	Class IV seawater	Below class IV seawater	Sum
2020	30730	20650	13480	30070	94930
2021	30540	10960	7150	21350	70000
2022	34390	9720	6540	24880	75530

In the next few years, the polluted sea area will not increase significantly in the short term but is fluctuating. The condition will remain severe. The burden of foreign ecology is still very heavy to strengthen the marine environment, to ensure the sustainable development of China's Marine ecological environment.

4. Application of remote sensing technology in marine pollution monitoring

4.1. Application of remote sensing technology in marine oil pollution monitoring

China started late in this area, as early as the late 1960s, American scientists used multi-band visible light scanners at sea oil pollution from oil wells was monitored by aviation; European countries jointly used the MSS data of Landsat satellites in 1972-1975. The overall dyeing monitoring has determined the pollution area, pollution speed and diffusion direction; Stumpe et al applied a monitoring test in a 100-km-long oil film in the waters southeast of Asatig Island, Virginia, and estimated the pollution area and inferred the source of oil pollution.

It was only in the late 1980s that the China Oceanic Administration began to use aerial remote sensing in the monitoring of offshore oil pollution, but no progress was made in recent years. Zhang et al. have tested and analyzed the spectral characteristics of the offshore oil spill to monitor kerosene, light diesel oil and run oil with Landsat T M and NOAA AVHRR data [12]. Li et al. used TM and AVHRR data to test the oil leakage accident in the Laotieshan waterway [13]; Zhao also analyzed the spectral characteristic curve of the visible light near-infrared band of oil, diesel oil and lubricating oil. The comparative analysis reveals the spectral characteristics of oil with thickness and the contrast between oil and water Rules and absorption characteristic parameters [14].

4.2. Application of remote sensing technology in marine plastic waste monitoring

There is a large amount of plastic waste in the Marine environment, which poses a great threat to the marine ecosystem and human health. To effectively monitor and manage marine plastic waste, remote sensing technology has become a very useful tool. Remote sensing technology obtains information on distant surfaces or underwater and through various image processing and analysis methods. Remote sensing technology can use multispectral and hyperspectral images to identify and classify marine plastic waste. Through the analysis of spectral features, we can distinguish between different types of plastic waste and further understand their origin and properties. Combined with surface temperature changes, you can also detect nearby hotspots, which could be a gathering site of plastic waste. This information provides an important basis for the monitoring and management of plastic waste.

At present, the mainstream remote sensing technologies applied to marine plastic waste are divided into passive remote sensing and active remote sensing. Passive remote sensing includes collecting high-resolution images in the visible light band (VIS, 400-700 nm) and near-infrared to short imaging high/multispectral remote sensing in NIR (NIR-SWIR, 780-2526 nm). Active remote sensing includes Lidar (LIDAR) or synthetic aperture radar (SAR). The applications of dynamic remote sensing plastic waste include: combining LIDAR system with BP neural network or support vector machine methods. The beach garbage classification is identified as plastic, paper, cloth and metal.

In the emerging field of remote sensing, UAV remote sensing has been relatively hot in recent years. In 2022, the deep learning platform BML, developed a quantitative identification model of plastic waste classification using target detection technology based on a convolutional neural network, to realize the automatic identification and statistics of plastic waste [15].

4.3. Application of remote sensing technology in the monitoring of harmful Marine algae

As a monitoring method without field sampling, it has great potential and advantages in monitoring harmful algae in the ocean. Through remote sensing technology, we can timely and comprehensively obtain information on marine algae, quickly identify the distribution range and density of harmful algae, and provide effective monitoring data, to provide a scientific basis for the management and protection of the marine environment.

Remote sensing technology can obtain the spatial distribution information of harmful marine algae through high-resolution satellite images. Using remote sensing images, we can observe the growth and distribution of algae in the ocean, and we can determine the hot spot area and possible diffusion path of harmful algae. In this way, we can take timely measures to avoid the further spread of harmful algae and reduce the impact on the marine ecological environment.

The algal remote sensing monitoring is divided into optical remote sensing and microwave remote sensing, which mainly aims at the algal floating on the water surface, and the optical remote sensing monitoring method is based on, the spectral difference between normal water and algae in the visible and near-infrared bands is developed. The method of microwave remote sensing monitoring is based on the difference of grey value and backscatter coefficient of echo signal between algae and water body, which is extracted by threshold segmentation, mostly in the trial phase.

In addition to spatial distribution and species identification, remote sensing technology can also predict and simulate the growth trends and changes of harmful marine algae by using big data and

machine learning algorithms. Based on GOCI satellite remote sensing data, Nanjing University of Information Science and Technology builds a deep learning model that can effectively extract the information of large floating algae. Compared with the commonly used NDVI method and AFAI method, the proposed deep learning model has higher accuracy of large floating algae extraction [16].

5. Conclusion

According to the current situation, China's Marine pollution area has controlled, but it is still above the world average level, so the application of remote sensing technology in the marine field is essential. Because China's Marine remote sensing technology started late, most aviation remote sensing satellite data depends on foreign satellite data, such as Landsat, Sentinel future trend must focus on making full use of sensors and computer technology, form a variety of sensors real-time data processing and integration, and use the geographic information system for digital modeling form integrated processing and analysis of reaction system, for marine oil spill accident processing, Marine plastic waste monitoring and harmful algae monitoring and technical support.

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