Present situation and prospect of green tide monitoring technology

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Abstract. According to green tide broke out frequently in recent years in Huanghai sea, we analyzed the current technical state and shortage of four kinds of detection methods which were satellite remote sensing, aerial remote sensing, ship monitoring, offshore fixed platform observation, underwater fixed platform and mobile platform observation, in order to promote the construction of green tide observation networks.

1. Introduction
Green tide is a phenomenon that under certain environmental conditions, some large green algae (such as Enteromorpha prolifera) proliferate or gather violently in the ocean, which resulting the abnormal ecological environment. In 2007, the green tide broke out for the first time in the Yellow Sea, which did not cause for concern because of its short duration. [1] However, the great green tide disaster broke out again in 2008, which seriously affected the holding of the Olympic sailing competition, has aroused great attention at home and abroad. The large-scale outbreak of green tide has brought a lot of adverse effects. First, a large number of green tides shade the sun and affect the growth of sea bottom algae. Second, studies have shown that the chemical substances secreted by green tide may have adverse effects on other marine organisms. [2] Third, the outbreak of green tide will seriously affect the landscape and interfere with tourism and water sports. Therefore, the monitoring of green tide is of great significance. At present, the main means of monitoring green tide is Satellite remote sensing, Aerial remote sensing, Ship monitoring, Offshore fixed platform observation. Since 2008, the State Oceanic Administration has carried out operational monitoring of the green tide of Enteromorpha prolifera, including satellite remote sensing monitoring, aviation monitoring, on-site monitoring of ships, serving the salvage of green tide of Enteromorpha prolifera and disaster prevention [3,4]. Through practical application, we find that each method has its own advantages and limitations.

2. Method
Firstly, we collected the academic literature to understand the current situation and monitoring methods of green tide, then compared and analyzed the advantages and disadvantages of them, including their different application scope, and finally summarized the development trend of green tide observation methods.
3. Analysis of current green tide detection methods

3.1. Satellite remote sensing
Satellite remote sensing monitoring, including optical and microwave remote sensing, is an important technical means of green tide operational monitoring [5,6]. It can provide the location, coverage area, distribution and coverage rate of green tide, which is suitable for large-scale green tide monitoring. However, due to the influence of resolution and revisit cycle, it is difficult to realize the early detection of green tide only by using satellite remote sensing technology; the estimated green tide area is seriously affected by resolution, so it needs to be corrected by using mixed pixel decomposition to improve the accuracy. In addition, biomass estimation, algae species identification, physiological state assessment cannot complete with this method.

3.2. Aerial remote sensing
Aerial remote sensing is an important part of green tide operational monitoring system. Aerial remote sensing is mobile and flexible, which is suitable for large-scale patrol and detailed survey of key areas [7]. It can be used to verify satellite monitoring results and make up for the lack of satellite observation resolution and time phase. However, it also has some limitations. The monitoring ability and scope are restricted by weather conditions and air control. In addition, UAV observation technology needs to be explored.

3.3. Ship monitoring
Ship monitoring is mainly carried out by marine surveillance ship and scientific investigation ship. It can provide the location, distribution area, density, species and environmental parameters of green tide[8]. It is suitable for detailed survey of key areas, sample collection and analysis, remote sensing information verification. However, it has some limitations, the observation range is limited to a certain area on both sides of the route; the synchronization and timeliness of the observation data are also insufficient; the observation ability of the volunteer ship or fishing boat needs to be developed; the observation technology of the unmanned ship also needs to be developed, such as using the unmanned ship to track the boundary of the green tide, tracking sporadic green tide, carrying underwater cameras to detect underwater green tide.

3.4. Offshore fixed platform observation
Offshore fixed platform equipped with camera and video equipment. By offshore fixed platform, the distribution of green tide and other marine environmental parameters can be observed continuously and
automatically, and the data can be transmitted in real time. However, due to its small observation range, its monitoring ability is still limited [9,10].

![Diagram of three-dimensional monitoring technology for green tide](image)

**Figure 2.** Diagram of three-dimensional monitoring technology for green tide

### 4. Conclusion

With the development of technology, more and more underwater observation methods will be used in green tide monitoring in the future. For example, the seabed based marine environment automatic monitoring system, which can be placed on the seabed for fixed-point, long-term and continuous measuring the marine environment. It is an important technical means to obtain long-term underwater comprehensive observation data. Glider is a type of underwater platform, which can realize marine environment investigation, monitoring and data acquisition, and it has low power consumption, low cost and long endurance; Autonomous underwater vehicle (AUV) can track underwater targets, and use it to track the growth process, drift trajectory and path of green tide. In addition, according to the acoustic characteristics of the green tide, sonar can be used to detect the settling green tide.

### Table 1. Application of interdisciplinary green tide monitoring technology

| Method                          | Effect                                                                 |
|---------------------------------|------------------------------------------------------------------------|
| Satellite remote sensing        | monitor the floating green tide in a large area and obtain the dynamic factors such as water color, water temperature, wind, wave and current |
| Aerial remote sensing           | monitor the floating green tide in the key sea areas and obtain the data of water color and temperature |
| Ship monitoring                 | Obtain observation photos, videos, wind, temperature, pressure and other meteorological parameters |
| Offshore fixed platform observation | Obtain the wind, temperature, humidity, pressure and other meteorological parameters; ecological environment elements and dynamic environment elements |
| Underwater platform observation | Underwater marine environment survey |


On the basis of the above technologies, interdisciplinary network observation will be carried out through satellite, aviation, offshore sports platform, offshore fixed platform, underwater fixed platform and underwater sports platform. The three-dimensional and real-time monitoring data of green tide can be obtained focusing the early detection of green tide occurrence period, the estimation of green tide coverage area, development trend and biomass in development period, and the observation of sinking green tide suspension depth and spatial distribution in extinction period.

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