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Multi-Exciter†

1. Introduction

Measurements of the species composition of phytoplankton in seawater and freshwater need to be performed periodically in order to preserve ecosystems and reducing damages to the fishing industry caused by Red Tide. For example, in coastal waters with active fish and shellfish farming industries, designated harmful algae are monitored and Red Tide warnings are issued when an increasing growth tendency is observed. Observation by optical microscopy is an effective general method of measuring species composition, but this observation results depend on the skill of the observer, and it is difficult to quickly cover a large area due to the long time required from water sampling to the end of this kind of analysis. Commercial chlorophyll fluorometers are *in situ* devices that enable rapid measurement. These devices measure chlorophyll-a fluorescence (Chl-a), which all phytoplankton possess, and thus can measure phytoplankton biomass. However, they cannot measure species composition. Therefore, the development of an *in situ* observation technology that enables objective measurements of the species composition of phytoplankton in a wide area within a short period of time had been demanded[1].

The multi-wavelength excitation fluorometer, Multi-Exciter (**Photo 1**), which was developed by JFE Advantech Co., Ltd., is a submersible, *in situ* device to measure fluorescence excitation spectra of phytoplankton in order to estimate phytoplankton species composition. This report introduces the features of the Multi-Exciter and an example of its measurements.

2. Product Features

2.1 Product Outline

The Multi-Exciter is a device to measure multiple parameters; in addition to a fluorescence excitation spectrum sensor, it is equipped with a depth sensor, water temperature sensor and turbidity sensor (**Photo 2**). Depth data can be used in observations using the instrument as a vertical profiler. Water temperature and turbidity measurement values can be used to confirm the quality (effect of temperature and/or effect of turbidity) of the fluorescence excitation spectrum results. A mechanical wiper is also provided to prevent biofouling, enabling stable and accurate data measurements in long-term deployments extending over several months.

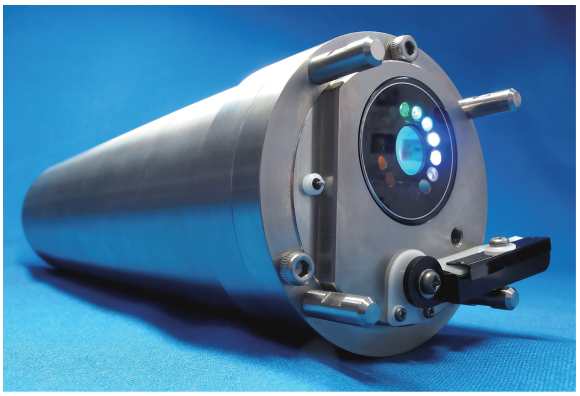

Photo 1 Appearance of Multi-Exciter

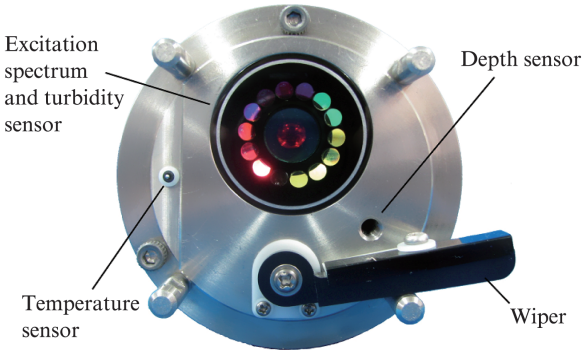

Photo 2 Arrangement of sensors and biofouling protection wiper[5]

This product is available as a memory type and as a cable type. The memory type, which records data internally in the device and realizes long-term automatic observation, while the cable type, which transmits data via a submerged cable, is easily incorporated in real-time monitoring and also in other platforms. Since measurements can be performed to a maximum depth of 500 m, observations in a wide range of environments and measurement modes are possible.

2.2 Measurement Principle

The optical characteristics (absorption spectrum, fluorescence excitation spectrum) of phytoplankton generally depend on the pigments contained in their cells. Moreover, each species of phytoplankton has a different pigment composition. Accordingly, it is known that phy-

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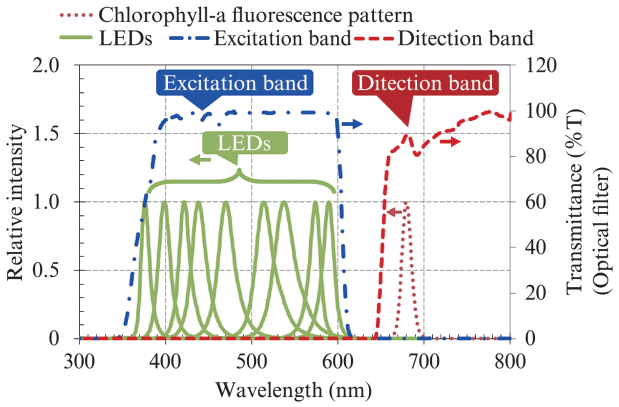

Fig. 1 Spectral distributions of the nine light emitting diodes (LEDs) and characteristics of the optical filters [5)]

toplankton species can be estimated from the results of indirect measurements of their pigments by measuring their optical characteristics[2,3)].

In phytoplankton, fluorescence due to chlorophyll-a appears around the wavelength of 680 nm. The Multi-Exciter measures the fluorescence excitation spectra of phytoplankton by detecting fluorescence from 640 nm to 1100 nm, which is excited by multi-excitation light sources having wavelengths shorter than 610 nm. As excitation light sources, nine light emitting diodes (LEDs) with different peak wavelengths are used; the peak wavelengths in these LEDs are 375, 400, 420, 435, 470, 505, 525, 570 and 590 nm. These wavelengths were selected considering the maximum absorption of the phytoplankton pigments. **Figure 1** shows the spectral distributions of the LEDs, the optical characteristics of the optical filters and the detection band of the fluorescence spectrum of chlorophyll-a.

3. Product Performance

3.1 Measurement Sensitivity and Influence of Turbidity

Phytoplankton observations are performed in a variety of environments, including open ocean, coastal waters, lakes and marshes, waterworks and sewage treatment plants, etc. Therefore, an observation device must support observations in open ocean, which have an extremely low concentration of phytoplankton, and in coastal waters, lakes and marshes, where turbidity due to suspended solids, etc. is high. In order to respond to both of these issues, the Multi-Exciter has high sensitivity performance for chlorophyll-a, enabling detection at concentrations of 0.1 μg/l or less, together with low sensitivity to turbidity, having a detection error of 0.6% FS or less at 109 FTU (Formazin turbidity unit) of turbidity[4,5)].

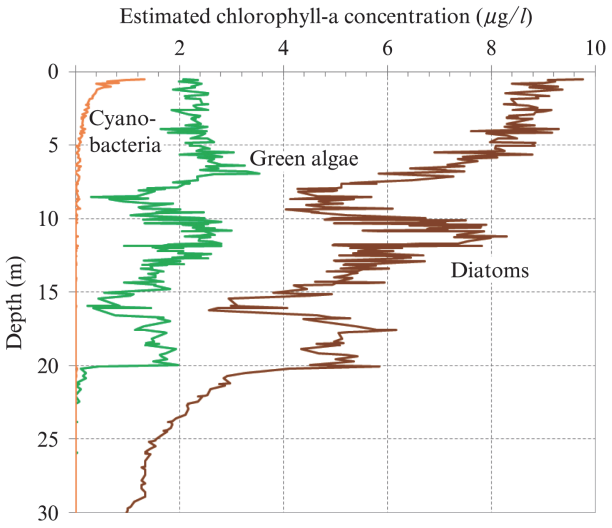

Fig. 2 Example of estimated vertical class distribution in a coastal region

3.2 Example of Measurement

The fluorescence excitation spectrum of a single species of phytoplankton measured by the Multi-Exciter shows a distinctive spectral signature for each phytoplankton species[4,5)]. By using the differences in the shapes of these signatures, it is possible to estimate the species composition by multiple regression analysis, etc[4,5)]. **Figure 2** shows an example of the estimation of the species composition of diatoms, green algae and cyanobacteria based on the results of continuous vertical measurements in the water column in a coastal region.

4. Conclusion

The Multi-Exciter is a chlorophyll fluorometer that enables rapid, wide-range measurements of fluorescence excitation spectra of phytoplankton, which depends on the pigment composition of each phytoplankton species. The measured fluorescence excitation spectra can be applied to estimate phytoplankton species composition by multiple regression analysis, etc. As key features, the Multi-Exciter has high sensitivity to chlorophyll, enabling use in open ocean with extremely low densities of phytoplankton, as well as low sensitivity to turbidity, making it possible to perform measurements in coastal waters, lakes and marshes, which have relatively high turbidity. As result, the Multi-Exciter can contribute to estimations of the phytoplankton species composition in a wide range of applications and environments.

References

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