

DEVELOPMENT OF FLUORESCENCE IMAGING LIDAR FOR BOAT-BASED CORAL OBSERVATION

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ABSTRACT

A fluorescence imaging lidar system installed in a boat-towable buoy has been developed for the observation of reef-building corals. Long-range fluorescent images of the sea bed can be recorded in the daytime with this system. The viability of corals is clear in these fluorescent images because of the innate fluorescent proteins. In this study, the specifications and performance of the system are shown.

1. INTRODUCTION

Reef-buildings Corals (hereafter corals) are mainly distributed in tropical shallow water (0-30 m in depth) and play a role in primary producers of coral reefs. Despite the importance as a species, it has been reported that coral distribution areas are rapidly diminishing because of various marine environmental factors [1]. In addition, it is predicted that global climate change (such as ocean warming and ocean acidification) will affect decline of corals [2]. Therefore, understanding their current status is important. Coral observation is considered an urgent requirement.

As corals are marine organisms, wide-area observations are technically difficult. In air surveillance, the waves on the sea surface and the absorption and scattering of light in seawater interfere with coral observation. In underwater surveillance, the field of view (FOV) is narrow, and navigation is slow. In this study, a boat-based surveillance technique has been developed as an improved method of coral observation beneath the sea surface.

Ordinary boat-based video observation has several weaknesses:

- The clarity of video images depends on the amount of solar radiation (cloudy conditions) because of passive observation;
- Video image resolution is affected by image blurring due to boat propulsion and motion;
- Sometimes checking coral viability is difficult because of short observation times and insufficient information.

In this study, a new active coral observation method has been developed to address the above mentioned problems.

Most corals have innate fluorescent proteins in the surface of their flesh, and they emit fluorescence with colors ranging from blue to yellow-green by ultraviolet (UV) excitation. Their fluorescence lifetime is approximately 1 to 3 ns. When corals die, the fluorescent proteins are degraded and no longer emit fluorescence. Thus, the detection of UV excited fluorescence is a sign of live corals.

2. METHODOLOGY

Observing UV excited fluorescence of corals is preferred in the nighttime in order to avoid background sunlight. However, surveying in the daytime is necessary because the boat operator must confirm the sea traffic safety and the safety of operating the boat with the shallow sea bottom in the observed coral reef area. Therefore, a fluorescence imaging lidar system has been developed for operating in the daytime.

In this system, the wavelength of the UV pulsed laser is 355 nm, the pulse width is approximately 9 ns, and the exposure time of the ICCD camera is approximately 100 ns. The effect of background

sunlight can be suppressed by setting a very short exposure time. In addition, the image blurring caused by the boat motion does not occur because of the very short duration of the laser irradiation. Thus, clear fluorescent sea bed images would be obtained in the daytime.

Table 1 Specifications of the lidar.

Laser	wavelength	355 nm
	pulse width	9 ns
	power	90mJ / pulse
	spread angle	1~100 mrad (adjustable)
ICCD	gate width	100 ns
	gain	10 ⁹ (max)
DAQ	repetition	5 Hz

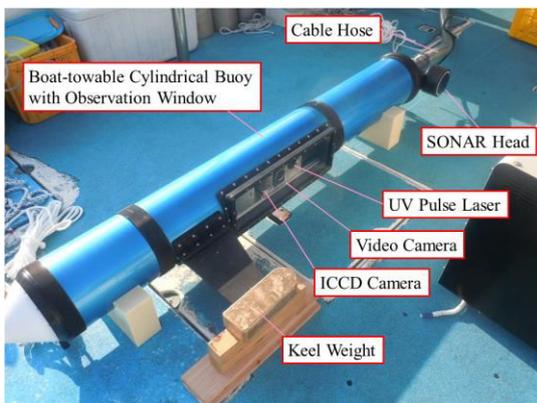


Fig.1 Fluorescence imaging lidar system installed in a boat-towable cylindrical buoy.

3. RESULTS

Coral observations have been operated using this lidar system in Taketomi Island, Okinawa, Japan (24.33N, 124.09E). A large number of fluorescent images of the sea bed in shallow coral reef sea area have been successfully obtained. In addition, passive sea bed images, boat position data with an accuracy of 1 m, and bathymetry data with an accuracy of 0.1 m were also simultaneously recorded using a video camera, DGPS, and SONAR, respectively. Sample images from the video and the lidar are shown in Fig. 2.

Estimating the coral viability is much easier using fluorescent images than video images because of the intensity of the coral fluorescence. The boat-

based lidar surveillance around the Taketomi Island (boat track ~14 km long) was recorded with a repetition of 5 Hz, and the total observation time was approximately 3 h.

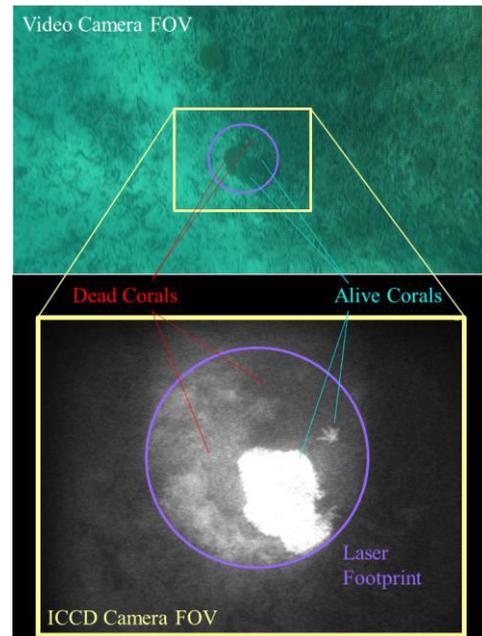


Fig.2 Sample image from recorded video (upper) and fluorescence imaging lidar (lower).

4. CONCLUSIONS

A fluorescence imaging lidar system installed in a boat-towable buoy has been developed, and sea bed fluorescent images were successfully obtained in the daytime. This study indicates that the observed lidar data are useful in surveying coral distributions.

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