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RADIATION SYSTEM FOR SIMULATION OF UNDERWATER LIGHT

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MATSUI T., EGUCHI H. and SOEJIMA Y. *Radiation system for simulation of underwater light*. BIOTRONICS **12**, 43–47, 1983. In an attempt to develop the simulation of underwater light for environmental studies of marine organisms in the aquatron, a colour cathode ray tube (CRT) was used as an artificial light source. The light spectrum of CRT depends on outputs of blue, green and red lights from phosphors and can be controlled by manipulating anode voltages of electron guns. In order to facilitate the simulation of underwater light, wavelength region of 400 to 700 nm was divided into 6 bands at an interval of 50 nm, and spectral characteristics were expressed as relative spectral irradiances in respective bands. For adequate simulation, the respective light outputs of blue, green and red were set to minimize differences in relative spectral irradiance between natural underwater light and CRT light. The controlled light of CRT represented sufficiently the spectra of natural underwater light in different depths.

INTRODUCTION

The condition of underwater light varies mainly with optical characteristics of water and incident angle of solar radiation (*1–3*, *6*, *7*). For environmental studies of marine organisms in the aquatron, it is necessary to develop more adequate method of artificial light radiation. The present paper deals with artificial light control for simulation of underwater light by using a colour cathode ray tube (CRT).

RADIATION SYSTEM

The CRT (MV-1620, Tokyo Sibaura Electric Co., Ltd.) was used as an artificial light source. Fluorescent screen of CRT is coated with phosphors emitting blue, green and red lights. Figure 1 shows spectra of CRT light measured with a spectroradiometer (*4*). Blue light distributed from 400 to 530 nm with a peak at 450 nm, and green light distributed from 450 to 650 nm with a peak at 530 nm. Red light consisted of many lines in a region of 540 to 700 nm. Each light output can be changed by manipulating the anode voltage of electron gun. Figure 2 shows distributions of spectral irradiance of the CRT lights manipulated at different set values of respective light outputs of blue, green and red. In these patterns, it was

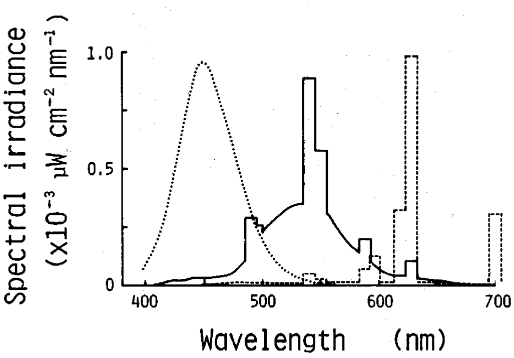

Fig. 1. Emission spectra of blue (·······), green (——) and red (- - - -) lights from phosphors of CRT.

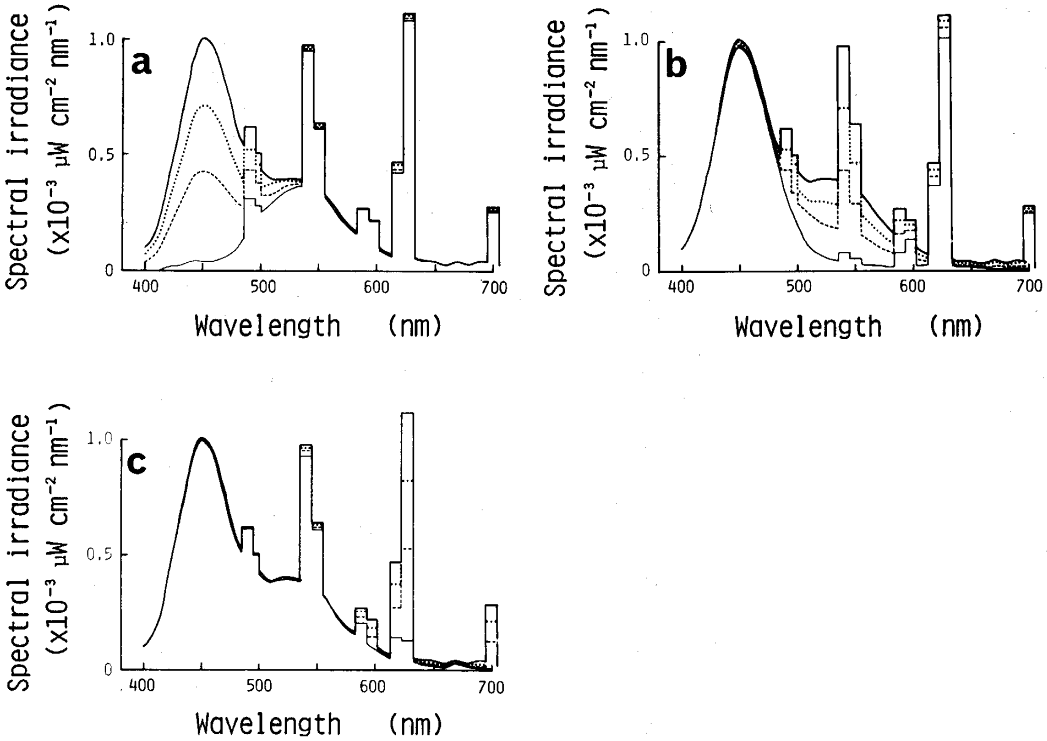

Fig. 2. Distributions of spectral irradiance of CRT lights, where respective light outputs of blue (a), green (b) and red (c) were set at 0 (——), 0.4 (- - - -), 0.7 (·······) and 1.0 (——).

found that spectra of the CRT light can be controlled in the visible light region and can be applied to the simulation of underwater light.

SPECTRUM SIMULATION OF UNDERWATER LIGHT

In order to facilitate the simulation of underwater light, wavelength region of 400 to 700 nm was divided into 6 bands of $400 \leq \lambda_1 < 450$ nm, $450 \leq \lambda_2 < 500$ nm,

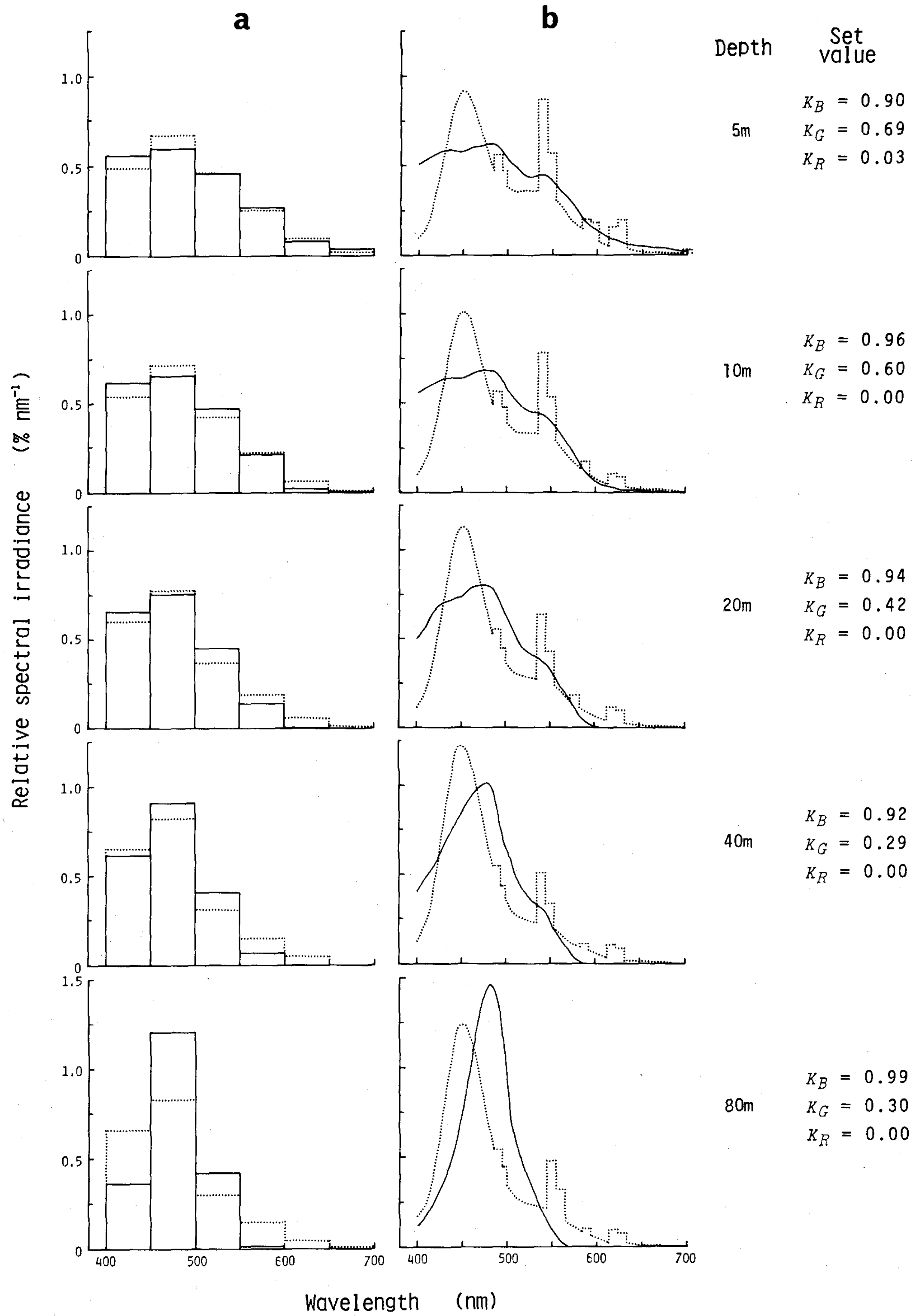

Fig. 3. Distributions of relative spectral irradiances of CRT light (·······) and natural underwater light (——) in wavelength regions divided at intervals of 50 nm (a) and 1 nm (b) at different depths of water; K_B, K_G and K_R were set to obtain the least S (line spectra are expressed as bands of 10 nm).

$500 \leq \lambda_3 < 550$ nm, $550 \leq \lambda_4 < 600$ nm, $600 \leq \lambda_5 < 650$ nm and $650 \leq \lambda_6 \leq 700$ nm, and spectral characteristics were expressed as relative spectral irradiances in respective bands; the relative spectral irradiance in λ_i was given as percentage of total irradiance (E_T). In controlled CRT light, the relative spectral irradiance (Ic_i, %) can be calculated from

$$Ic_i = \frac{(K_B \cdot B_i + K_G \cdot G_i + K_R \cdot R_i)}{E_T} \times 100\%, \qquad i=1, 2, \ldots 6 \tag{1}$$

where B_i, G_i and R_i are respective spectral irradiances in λ_i in blue, green and red lights set at the rated capacity, and K_B, K_G and K_R are set values (dimming rates of 0 to 1.0, defined as 1.0 at rated capacity) of respective light outputs of blue, green and red, which are used for manipulating anode voltages of electron guns. Degree of difference (S) in relative spectral irradiance between CRT light and underwater light was given by

$$S = \left(\sum_{i=1}^{6} (In_i - Ic_i)^2\right)^{1/2} \tag{2}$$

where In_i is relative spectral irradiance in λ_i in natural underwater light. For approximation of CRT light to underwater light, optimal values of K_B, K_G and K_R were set to obtain the least S. Figure 3 shows spectra of controlled lights of CRT and natural underwater light derived from the data reported by Okami et al. (*5*), which were measured at different depths of water in the Sea of Japan (off the Noto Peninsula). Values of the least S at 5, 10, 20, 40, and 80 m in depth were 5.5, 6.0, 6.4, 8.5, and 26.0, respectively. Most of the controlled lights of CRT were found satisfactory to represent the spectra of underwater lights at different depths. At 80 m, however, the controlled light shifted somewhat from the natural underwater light, as the CRT light was not able to follow the decrease of short wavelength light in the natural underwater (*2, 3, 6*). Therefore, a light-green filter (G-555, Hoya Glass Works) was attached in front of the CRT screen to compensate the CRT light. Figure 4 shows improved simulation at 80 m in depth. The controlled light

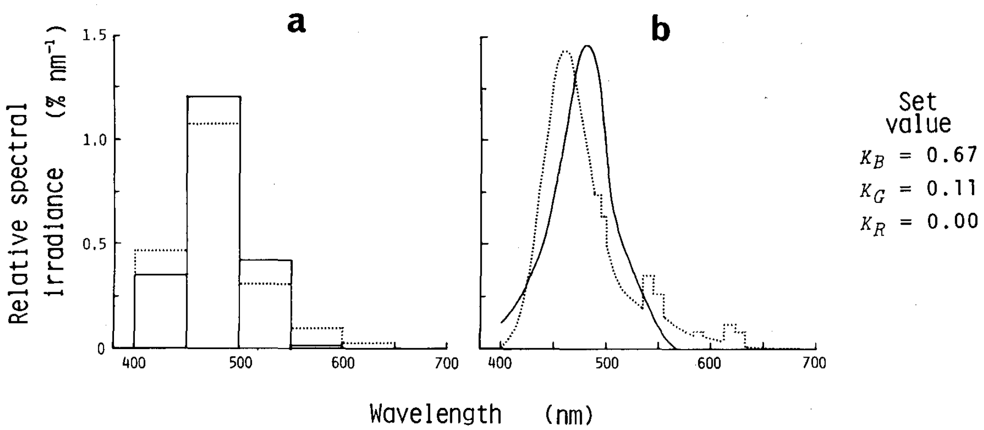

Fig. 4. Distributions of relative spectral irradiances of CRT light (·······) transmitted through the light-green filter and natural underwater light (——) in wavelength regions divided at intervals of 50 nm (a) and 1 nm (b) at 80 m in depth; K_B, K_G and K_R were set to obtain the least S (line spectra are expressed as bands of 10 nm).

became closer to the underwater light even at this depth, where the least S was 11.4. Furthermore in underwater, the light intensity (total irradiance) also varies with depth of water. In the case that higher intensities are necessary, the light outputs can be increased with the use of multiplicate CRTs.

Thus, it was made possible to simulate the condition of underwater light in the aquatron by using the CRT as a light source of artificial radiation for environmental studies of marine organisms.

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