Application of LEDs to Fishing Lights for Pacific Saury

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ABSTRACT

We attempted the development of highly efficient fishing lights using LEDs for saury fishing. Considering the spectral luminous efficacy characteristic of a Pacific saury, LED fishing lights were fabricated. Transmission properties in sea water in LED fishing lights were investigated, and it was found that the fabricated LED fishing lights sufficiently can be utilized even in sea water. Furthermore, we attempted the saury-fishing experiments by using the LED fishing lights, and comparable catch of Pacific saury was achieved by approximately 55% electric power by using both LED poles and incandescent lamp poles.

KEYWORDS: light emitting diode, fishing light, Pacific saury, Cololabis saira

1. Introduction

In the saury fishing, incandescent lamps are usually used for a fishing light. However, there are problems of the conventional fishing lights using incandescent lamps. First, electric power consumption is large. And the incandescent lamps are very inefficient, because much infrared light is included. Furthermore, life time is short and there is a problem of a lot of heat generation. Therefore, we proposed LED fishing lights.

In this work, we attempted the development of highly efficient fishing lights using LEDs for saury fishing in order to reduce the environmental impact and to strengthen fishery management by energy saving. We fabricated LED fishing lights, considering the spectral luminous efficacy characteristic of a Pacific saury. Furthermore, we attempted the saury-fishing experiments by using the LED fishing lights.

2. Results and discussion

2.1 Fabrication and characterization of LED panels

Figure 1 shows the reported relative absorbance of visual pigment of a round herring (Etrumeus teres)\(^1\). Relative absorbance of visual pigment corresponds to spectral luminous efficacy. The peak wavelength in a round herring is approximately 500 nm. The spectral luminous efficacy varies with the kind of fish, and the reported peak wavelength of a Pacific saury (Cololabis saira) is approximately 509 nm\(^1\). However, relative absorbance of visual pigment of a Pacific saury is not reported. Therefore, we presumed the spectral luminous efficacy of a Pacific saury from Figure 1 and the peak wavelength of a Pacific saury.

Figure 2 shows the presumed spectral luminous efficacy of a Pacific saury. The spectral luminous efficacy of a human being is also shown for comparison. The presumed spectral luminous efficacy of a Pacific saury is in the shorter wavelength region as compared with that of a human being. We designed the combination of various LEDs for a fishing light, based on the presumed spectral luminous efficacy of a Pacific saury.

![Figure 1: The reported relative absorbance of visual pigment of a round herring](image-url)
Figure 3 shows a picture of the fabricated LED fishing light pole. Considering the presumed spectral luminous efficacy of a Pacific saury, we used two bluish green, two green and one white LEDs (NSP6510S, NSPG510S, NSPW500CS; Nichia, Japan). One LED panel consists of 600 LEDs, and the LED fishing light pole consists of 12 LED panels.

Figure 4 shows the spectrum of the LED panel and incandescent lamp. The presumed spectral luminous efficacy of a Pacific saury is also shown in this figure. We estimated the effective energy ratio of the wavelength region of 460 nm to 560 nm. The effective energy ratios of the LED panel and the incandescent lamp are approximately 81% and 10%, respectively. Therefore, the LED panel is extremely efficient light source for saury fishing light as compared with the incandescent lamp.

2.2 Illuminance distribution of LED fishing light pole

We performed illuminance distribution measurements of the fabricated LED fishing light pole and the conventional fishing light pole. The conventional fishing light pole consists of 18 incandescent lamps of 500 W. The fishing light poles set at the height of 3.5 m, and an array of illuminance meters (T-10: KONICA MINOLTA, Japan) was used.

Figure 5 shows the illuminance distributions of the LED fishing light pole and the conventional fishing light pole. As compared with the distribution of the conventional fishing light pole, the LED fishing light pole has a sharp distribution, because the incandescent lamp is a point light source.

Furthermore, we estimated the effective illuminance for a Pacific saury using the presumed spectral luminous efficacy. The effective illuminance for a Pacific saury was calculated by using eq. (1):

$$L = K_m \int_{580 \text{ nm}}^{780 \text{ nm}} V_s(\lambda)P(\lambda)d\lambda \quad \cdots \quad (1)$$

where $K_m$ is the maximum spectral luminous efficacy (683 [lm/W]), $V_s(\lambda)$ is the spectral luminous efficacy of a Pacific saury as shown in Figure 2, and $P(\lambda)$ [W/m²/µm] is the spectral energy distribution. The average effective illuminances of the LED fishing light and the conventional fishing light were estimated at 87.1 and 73.6 [lx/s] in the area of 300 m², respectively. This result indicates that the LED fishing light has comparable intensity as the conventional fishing light. Therefore, considering the effective illuminance for a Pacific saury, LED fishing light has sufficient performance.
90 properties in sea water is important. However, it is difficult to perform an optical measurement by using actual sea, because of a sea surface fluctuation. Therefore, we measured the transmission properties using a sea water pool. In this experiment, the depth of water was 30 m optical fiber (USB2000; Ocean Optics, USA). The length of the pool is 25 m.

2.3 Transmission properties in sea water

In the fishing light, characterization of the transmission properties in sea water is important. However, it is difficult to perform an optical measurement by using actual sea, because of a sea surface fluctuation. Therefore, we measured the transmission properties using a sea water pool. In this experiment, the depth of water was changed into the horizontal direction of the pool using the mirror. The illuminance was measured by using an underwater illuminance meter (T-10WS: KONICA MINOLTA, Japan), and the distribution of spectrum was measured by using a multichannel monochromator with 30 m optical fiber (USB2000: Ocean Optics, USA). The length of the pool is 25 m.

Figure 6 shows the dependence of illuminance on the depth of water; y and x correspond to the depth and the horizontal distance of sea water, respectively. The illuminance decreases with increasing the depth of water. It is said that Pacific saury inhabits the depth of approximately 15 m. Figure 6 indicates that LED light arrives enough at 15 m.

Figure 7 shows the illuminance distribution in the sea water pool. This result suggests that there is no extreme illuminance unevenness in this range.

Figure 8 shows the distribution of the spectrum in the sea water pool. The illuminance at each point is also shown in this figure. It is found that there is no extreme change in a spectrum in the measured range.

Furthermore, from the distribution of the spectrum, we estimated the absorption coefficient of the sea water used in this measurement. Figure 9 shows the wavelength
dependence of absorption coefficient. It is found that the absorption coefficient increases at the short wavelength region and the long wavelength region. The increase at the short wavelength region is due to the absorption by phytoplankton, and the increase at the long wavelength region is due to the absorption by water and phytoplankton. Furthermore, the transmission property of the sea water used in this work is similar to that of coastal water with low transmittance due to much phytoplankton. Therefore, we concluded that the fabricated LED panels were usable even if those were used in coastal water with much phytoplankton.

2.4 Saury-fishing experiments by using LED fishing lights

Furthermore, we attempted the saury-fishing experiments by using the LED fishing lights. Figure 10 shows the arrangement of the fishing lights in the saury-fishing experiments. In these experiments, 6 LED fishing light poles and 8 conventional light poles were used.

Figure 11 shows the vessel used in this work. This vessel is Bosomaru, the research vessel (110 t) of Chiba Prefectural Fisheries Research Center, Japan.

Table 1 shows the results of the saury-fishing experiments performed in 2005. The results by using the conventional fishing light were also shown for comparison.

The electric power and the fuel consumption in the case...
using both LEDs and incandescent lamps were lower than that in the conventional fishing lights. We achieved approximately 55% electric power and fuel consumption. The average fish catch by using both LED poles and incandescent lamp poles was almost the same as that by the conventional fishing lights. Therefore, it was found that comparable catch of Pacific saury was achieved by approximately 55% electric power by using both LED poles and incandescent lamp poles as compared with the conventional method.

3. Conclusions

We attempted the development of saury fishing lights using LEDs. Considering the spectral luminous efficacy characteristic of a Pacific saury, LED fishing lights were fabricated. From the comparison between the effective illuminance for a Pacific saury of the LED fishing light and the conventional incandescent lamp fishing light, it was found that fabricated LED fishing light had sufficient performance. Transmission properties in sea water in LED fishing lights were investigated, and it was found that there was no extreme unevenness of illuminance and spectrum. Therefore, it is considered that the fabricated LED fishing lights sufficiently can be utilized even in sea water. Finally, we attempted the saury-fishing experiments by using the LED fishing lights, and comparable catch of Pacific saury was achieved by approximately 55% electric power by using both LED poles and incandescent lamp poles as compared with the conventional method.

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References


Table 1 The results of the saury-fishing experiments performed in 2005

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<th>method</th>
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<th>fish catch</th>
<th>electric power</th>
<th>fuel consumption</th>
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<td>conventional fishing lights</td>
<td>off Kushiro</td>
<td>Aug. 21</td>
<td>7 t</td>
<td>182 kW</td>
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<td>(incandescent lamps)</td>
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<td>10 t</td>
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<tr>
<td></td>
<td></td>
<td>Aug. 24</td>
<td>3 t</td>
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<td>Aug. 26</td>
<td>13 t</td>
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<td></td>
<td>Sept. 19</td>
<td>14 t</td>
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<td>LED panels + incandescent lamps</td>
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<td>7.5 t</td>
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<td>29.6 kg/h</td>
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<td>Oct. 21-22</td>
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