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Behavior pattern of marine organism by using Acoustical imaging sonar

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1. Introduction

All countries of the world including Korea are developing a new fish luring system that can reduce the greenhouse gas generated by coastal and offshore fisheries and replace the metal halide lamp that accounts for a considerable portion of the oil consumption during fishing operation. LED (Light Emitting Diode), which has strong durability and can effectively produce only the required wavelength, is attracting attention as a light source suitable for such a fish luring system, and studies carried out around Japan and Korea to investigate the radiation and underwater transmission characteristics of an LED fish luring lamp and to develop diverse types of fish luring lamps and determine their effects on fish catching[1-2)].

Until recently, many studies have been carried out on the reaction of retinal cells of marine animals to an external stimulus such as light, and the Underwater Acoustic Camera (Dual frequency IDentificationSONar; DIDSON), which can analyze the behavioral characteristics of an organism without applying an external stimulus to the organism, is being used increasingly[3-4)].

To develop an efficient underwater fish luring system, this study confirmed the fish luring effect of each wavelength on chub mackerel (*Scomber japonicus*), the main type of study fish at the Korean purse seine fishery, in a circular water tank and investigated its swimming behavior characteristics at each wavelength of the fish luring system.

2. Materials and Methods

For the water tank experiment of this study, 5 types of LED fish luring modules (white lamp; 454nm+560nm, blue lamp; 454nm, red lamp; 634nm, yellow lamp; 596nm, and green lamp; 523nm) were installed in the circular water tank (Ø6.0m×1.5m) holding 50 chub mackerels at the Species Conservation Research Center, Jeju Fisheries Laboratory (located in Wimi-ry, Jeju-si) of National Fisheries Research and Development Institute, and an underwater camera was installed below each LED fish luring module to check the appearance frequency at each wavelength, and the behavioral reaction data of the study fish were collected using an acoustic camera, which allowed fish behavior experiments without stimulating the fishes (**Fig. 1, 2**).

The acoustic camera used in this experiment can store maximum 21 frames of precise ultrasonic images using 1.8MHz and 1.1MHz ultrasonic waves. The 1.8MHz module radiates 96 beams of 0.3° width horizontally and the 1.1MHz module radiates 48 beams of 0.6° width horizontally to detect an area covering a horizontal angle of about 29° and a vertical angle of about 12°. Also, the detectable ranges that can be observed are maximum 12m and 40m for high resolution (18MHz) and low resolution (1.1MHz) respectively. During the fish behavior experiment carried out in the circular water tank cutoff from external light stimulus, we analyzed the instantaneous swimming speed of chub mackerel group resulting from instantaneous reaction and the time it took them to swim in a stable state when the LED fish luring modules was operated at each wavelength.

Fig. 1. Water Tank used for the Experiment and LED Fish Luring Modules installed.

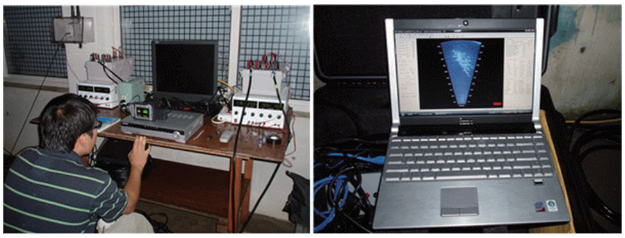

Fig. 2. LED Fish Luring Modules and Synchronization of the Underwater Cameras (Left) and Fish Behavior Monitoring with Underwater Acoustic Cameras (Right).

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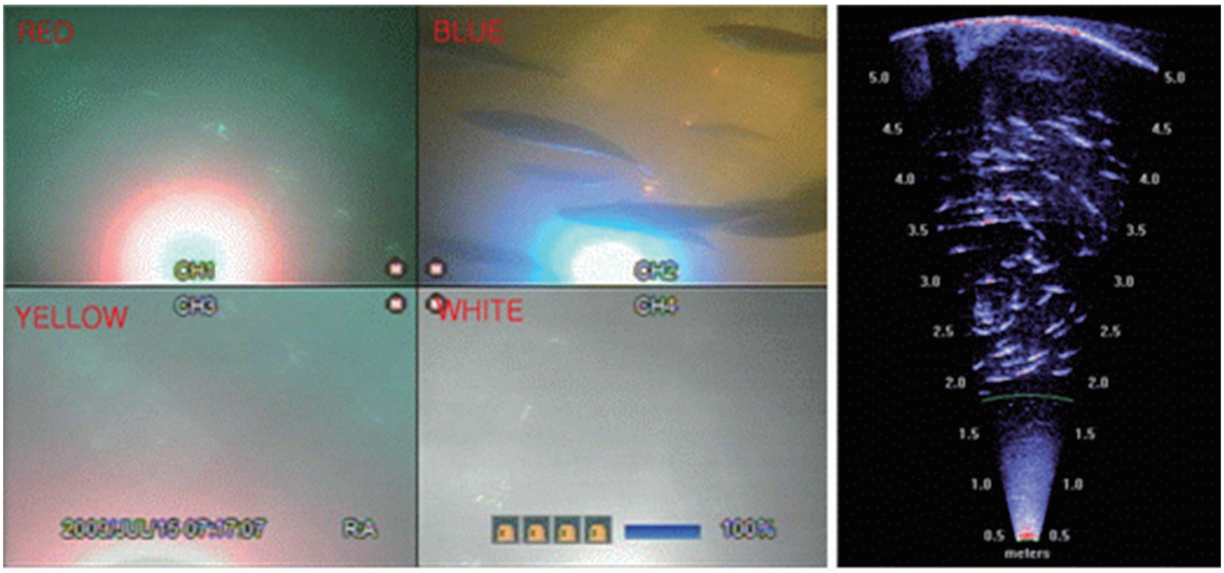

Fig. 3. Image of the Mackerels appearing in the Water Tank (Left), Observation of the Swimming Behavior of Chub Mackerels in Nighttime (Right).

3. Result and Discussion

The analysis of the fish luring effect and fish group behavior at each wavelength in a circular water tank showed that in the experiment of behavioral reaction carried out for chub mackerels at each wavelength in the daytime and nighttime, the mackerels freely swam maintaining a certain distance from the internal wall of the water tank in the daytime under sunlight and that the appearance frequency at each wavelength showed a similar pattern (**Fig. 3**), where the chub mackerels swam inside of the water tank at a constant speed in the daytime and the swimming time needed for the chub mackerels to appear again at each wavelength was 64 seconds on average (max: 7 sec, Min: 3 sec). That is, the average swimming speed of the chub mackerel group in the circular water tank (average body length; 26.5cm) was shown to be 24.5cm/s (0.92BL/s), and the maximum and minimum swimming speeds were shown to be 49.1cm/s (1.85BL/s) and 21.2cm/s (0.8BL/s) respectively. Although the swimming speed of chub mackerel, an anadromous species, is known to be 3 to 4 times the body length in general, the measured swimming speed of the chub mackerels used in this experiment was low because these mackerels were bred for the purpose of collecting fertilized eggs and left in the water tank for a certain period of time.

Table 2. Frequency of the Mackerels in the Water Tank appearing in Front of the Fish Luring Modules

Type Appearance		RED (634nm)	BLUE (454nm)	YELLOW (596nm)	WHITE (454+560nm)
Daytime	Ratio	91.8%	100.0%	95.2%	72.6%
	counts	57	62	59	45
Nighttime	Ratio	0.0%	100.0%	88.1%	72.0%
	counts	0	268	236	193

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At nighttime, the initial swimming speed increased for the 5 types of LED fish luring modules but reached steady state with time, and the appearance frequency was high in the order of blue lamp (454nm), green lamp (523nm), white lamp (454nm+560nm), yellow lamp (596nm), and red lamp (634nm). And, in the experiment of fish luring effect on and preference of chub mackerel at each wavelength by installing 4 types of LED fish luring modules (red lamp, blue lamp, yellow lamp and white lamp) to develop an LED underwater fish luring system for purse seine, the yellow lamp, white lamp and red lamp showed preferences of 88.1%, 72.0% and 0% respectively when the appearance frequency of blue lamp was set to 100% (**Table 1**).

Acknowledgment

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