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Fish Aggregation Pattern on Red-Blue-Green Light Emitting Diode (RGB-LED) Light in Static Lift Net

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ABSTRACT

The Red-Blue-Green Light Emitting Diode (RGB-LED) light used in the static lift net can manipulate fish behavior to attract, approach and be concentrated in the lighting area. The purpose of this study is to determine the use of the RGB-LED light intensity with pulse width modulation, value for gathering fish and changing patterns of schooling fish's movement. Seven treatments with changes in PWM values were the initial conditions, 250, 195, 145, 95 20 and 5 PWM. The methods were by using Hydro-acoustic sonar 360^{o} and ImageJ analysis used to determine the schooling fish's area in horizontal and vertical by dividing the center zone, main zone, influence zone, and shadow zone. Results of the visualization image of schooling fish as the target fish group visualized by horizontally and vertically. It has the longest duration of 90 ' and 250 PWM has a time duration of 10' shows the difference in the area of schooling fish in four zones. 195, 145 and 95 PWM with each time duration of 10' dominant schooling fish were in the main zone and influence zone, the lowest two light intensities of PWM values were 5 and 20, there are three zones namely center zone, main zone, and shadow zone, schooling fish were increasing with movement pattern by revolving the light source at shadow zone. The approached fish were forming schooling fish because they were attracted to light, with changes in the PWM value that can model the movement patterns of schooling fish.

Keywords: *Hydro-acoustic, sonar 360^{o}, gather, zone, PWM.*

1. Introduction

RGB-LED light is an innovation of technology development of fish attractor lamp in static lift net (SLN), using a combination of different colors light of Red, Green, and Blue of High Power Led (HPL) with special designed become RGB-LED. Blue, green and red light, are easily stimulated by target catch of lift net and tend to move by approaching the light source (Takahasi *et al.* 2018; Flare *et al.* 2016; Bao 2014). According to Brown *et al*. (2014); Loupatty. (2012), revealed that by using the colors of blue, yellow, green, red and white from the LEDs produces a difference in fish catch. Fish in lighting areas tend to form school formations and normal feeding interactions (Mekdara *et al,* 2018; Im *et al.,* 2018; Pena *et al.,* 2018).

SLN using light to manipulate fish behavior in movement patterns, migration, and fish interactions (Pulgar *et al.,* 2019; Chairunnisa *et al.,* 2017). The approaching fish and concentrated to light sources have a spatial and temporal distribution patterns (Fujaya 2002; Urbasa *et al.* 2015). The success of fishing in SLN is determine from the use of the light intensity level, oceanographic factors and the hauling time (Brown *et al.,* 2016; Ramadan *et al.,* 2018; Palawe *et al.,* 2019).

The observations of fish behavior that occurs in the RGB LED lighting area is very

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difficult to detect visually. The hydro-acoustic approach is can be used to detect objects includes schooling fish in real-time and in-situ (Penggabean, 2011), without disturbing the fish habitat (Dufour *et al.,* 2018). The hydro-acoustic method is widely used to monitor fish, the distribution of fish movements and the fish abundance in the waters (Parra *et al.,* 2017; Fore, *et al.,* 2017). The hydro-acoustic method is able to distinguish objects other than fish such as seaweed, and base substrate by developing the value of the algorithm (Manik *et al.,* 2014; 2015).

The response of fish attraction to LED light is influenced by light intensity, irradiation time and water conditions. Use of RGB-LED light with control of light intensity using a Pulse Width Modulation (PWM) value system as the main fishing tools in lift net fishing. RGB-LED lighting still has problems in utilizing changes in PWM values to pay attention to the fish behavior of approaching, gathering and concentrated in light. The setting of RGB-LED light on the presence of fish needs to be analyzed with the hydro-acoustic method approach so that it can determine the model of fish movement, presence and effective hauling time. The purpose of this assessment is to determine the use of RGB-LED light intensity based on fish behavior such as changes in fish movement patterns, presence, and fish gathering.

2. Materials and Methods

2.1. Time and locations

The research was conducted in October 2018 during the dark phase of the moon, in the waters of the Bokor Island with the coordinate position of (05^{0}56'593'S - 106^{0}37'557'E), Seribu Islands, North Jakarta **(Figure 1)**.

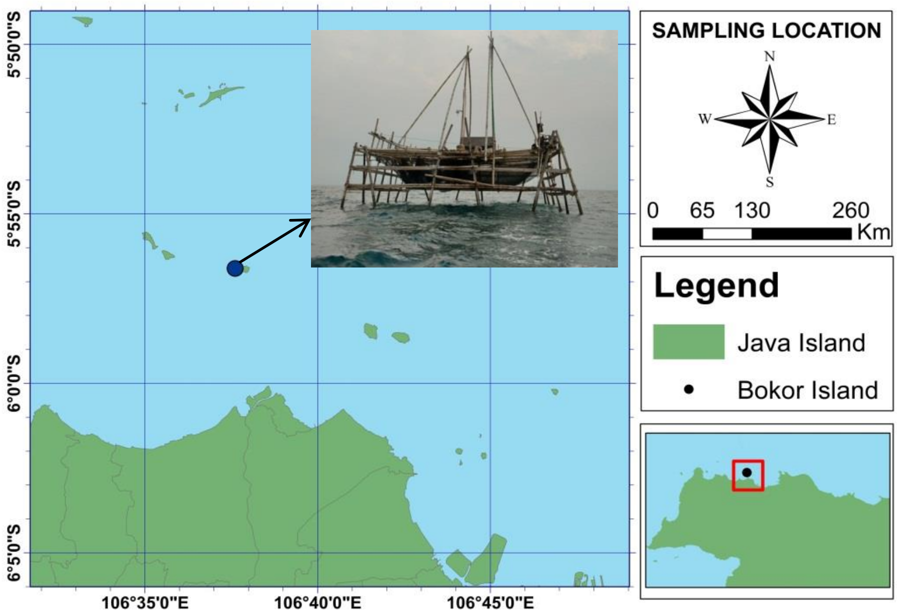


Figure 1. Map of research location in Seribu Island, North Jakarta

2.2. Data analysis method

Observations was started at 6:15 p.m., setting until hauling has duration of 140 minutes divided into initial conditions (IC) of 90', 250 PWM of 10', 195 PWM of 10', 145 PWM of 10', 95 PWM of 10', 20 PWM 10' and 5 PWM of 10'. The research method was conducted by experimental fishing on the lift net using RGB-LED light.

Observation of fish behavior with sonar hydro-acoustic devices (360^o imaging sonar and side imaging sonar) mounted on the center of lift net. The working principle of sonar 360^o detects the movement of schooling fish which are approaching to the light source horizontally with an area within 12 m while side imaging sonar (fish finder) has a two-way system (dual beam) to detect the depth of schooling fish movement vertically with a distance of 21 m depth by frequency of 800kHz.

The collected data were the image of schooling fish including the presence of schooling fish by zones consisting of the center zone (CZ), main zone (MZ), influence zone (IZ) and shadow zone (SZ) and fish movement patterns under RGB-LED lighting. The schooling fish image from the hydro-acoustic device was produced vertically and horizontally. Image data of schooling fish were tabulated based on time and light intensity by using a different PWM value.

2.3. Data analysis of schooling fish estimation from hydro-acoustic devices

The tabulated image data of schooling fish then analyzed descriptively with processing image techniques. Image-J is an open source software analysis that has macro-tools that are used to process the data and analyzing a patterned digital image (Dey *et al.,* 2011). The analysis parameters were using the fish presence by vertical and horizontal preference.

Image data of schooling fish were distributed at each depth and then the technique of measuring area was carried out on the light distribution vertically and horizontally. Characterization of proportions, in general, can be known by Image-J analysis (Zielkea *et al.* 2016). Measure the estimated proportions of schooling fish from digital images, by marking areas of proportion and object points (Alhosseini *et al.,* 2011):

$$P = \left(\frac{n}{N}\right) \times 100\% \quad \text{....................................(1)}$$

Descriptions:

n = represents the white image
N = total image in the image
P = total area of proportion

2.4. Analysis of RGB-LED light distribution patterns in the water medium

The light intensity of RGB LED with PWM is a way to manipulate pulse signal width in a period through the provision of measurement signal waves using radians meters (ILT500) and modeled with Surfer 13 software. Measuring the light intensity was performed vertically and horizontally based on the light intensity of different RGB-LED lights.

3. Results and Discussion

RGB-LED light intensity changes from the maximum to minimum intensity by reducing the PWM value that consists of 250 PWM, 195 PWM, 95 PWM, 20 PWM, and 5 PWM. The results of the compilation of the estimated images of schooling fish by light distribution with different PWM.

Hydro-acoustic fish identification is an analysis to identify fish with sound waves in the area and time **(Figure 2)**. The hydro-acoustic device is consists of sonar 360^{o} and side imaging sonar.

Acoustic power radiated to detect fish (Celi, *et al.,* 2016). The noise of the generator engine on lift net influences the cleanliness of the scanning display in estimating the schooling fish in the form of an image on the hydro-acoustic device display. The noise from the ship reduces its sensitivity for detecting fish (Smott el al., 2018).

The appearance of schooling fish images **(Figure 2)** generally has histograms that tend to be around dark. Processing image by thresholding image is to distinguish between objects and background (Faizah K., 2017). The image provides a mean to measure membrane proportions in a faster and more accurate way.

The abundance of schooling fish images was determined based on the observation time interval with PWM value changes. Maximum light intensity conditions with a value of 250 PWM has the image of schooling fish spreading by keeping a distance, but at minimum conditions indicate changes in the formation of schooling fish image by near to the light source. The temporal abundance of fish will increase fish swimming movements consistently (Rand, *et al.,* 2014). According to Rieucau *et al.,* (2016) the dynamics of schooling fish spread rapidly in environmental conditions when predatory fish came.

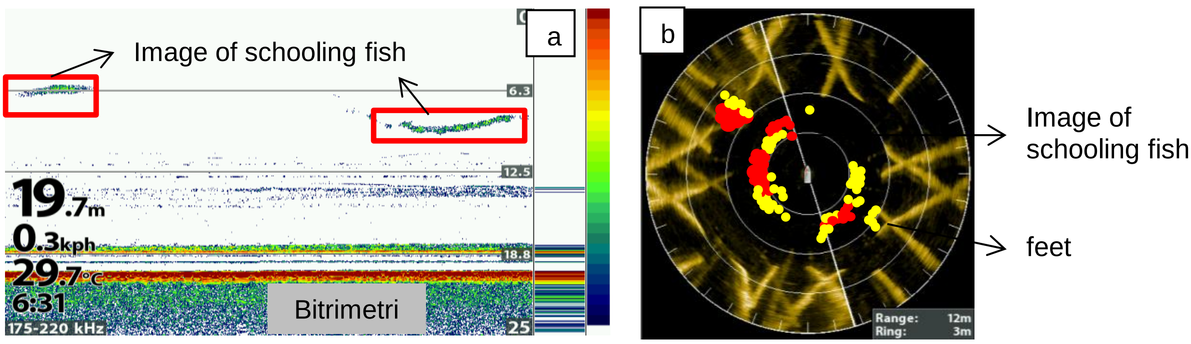


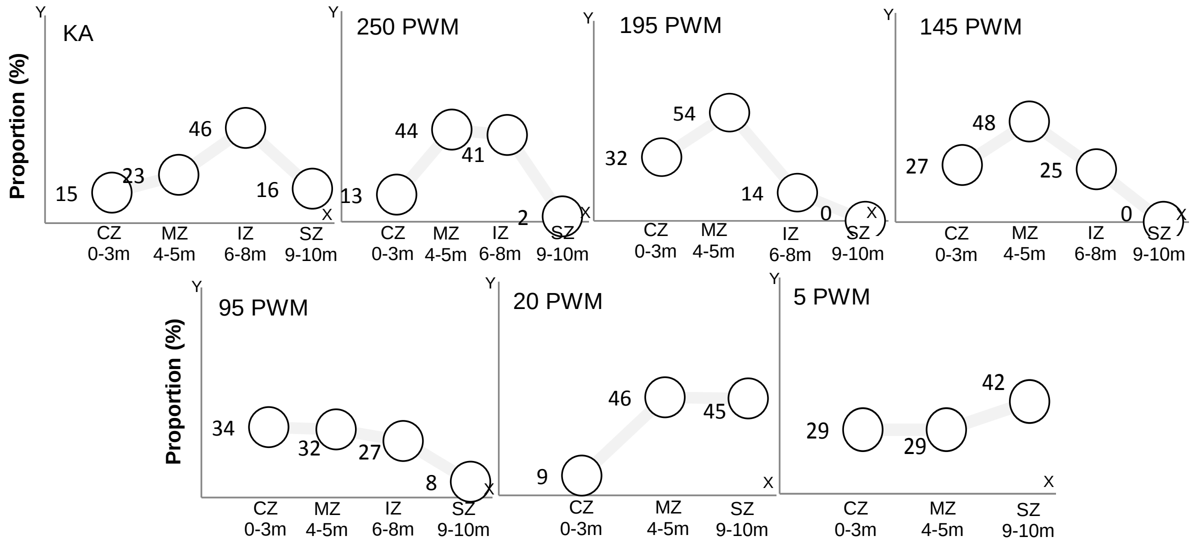
Figure 2. Image of schooling fish from Sonar 360^{o} hydro-acoustic device. (a). Side imaging sonar (b). Imaging sonar

Hydro-acoustic sonar 360^o device observes differences in the presence and pattern of schooling fish horizontally and vertically. An interesting phenomenon of light intensity changes using PWM value system where fish behavior that always maintains a distance, gather and move around by rotating pattern on the light source (Cahyadi and You., 2016), strategies for using light can affect fish density and fish biomass in certain areas (Gou *et al.,* 2019)

Horizontally, the movement pattern of schooling fish revolves around the center of light with a certain distance and certain time will increase the fish. Whereas vertically, the movement pattern of schooling fish with high light intensity of 250 PWM resulting the fish at 14 - 18 m depth in the influence zone which was a wide-spread light, at medium light intensity the pattern of schooling fish moves up to the surface, at low light intensity with a value of 20 PWM was the optimum intensity of fish, because the movement pattern of schooling fish was close to the center of light and the number is increasing, so when the hauling process the percentage of escaped fish was very small. External factors other than light intensity changes is the movement pattern change of schooling fish in the presence of predatory fish which attacking the targeted fish catch of lift net (Williamson *et al.,* 2019).

The presence of schooling fish was closely related to its optimum light intensity. The difference in light intensity horizontally with an area of 12 x 12 m of lift net by the initial conditions, 250, 195, 145, 95, 20 and 5 PWM will affect the proportion of schooling fish area. Differences in different light intensities resulting fish species which sensitive to the light color (Nabiu *et al.,* 2018).

The result of sonar 360^o shows the proportion of the schooling fish presence in each zone horizontally with light intensity using different PWM values. In the CZ, one of seven treatment shows a proportion of dominant schooling fish at 95 PWM value of 34%. MZ at 195 PWM value of 54%. In IZ the initial conditions of 46%, the initial condition is a stage to gather the fish with the longest duration in the lift net operation (Himan *et al.,* 2018), but at 20 and 5 PWM there was no influence zone because of the generated light was out of the net width. SZ at 5 PWM was equal to 42%. **(Figure 3)**.



Figur 3. The presence of schooling fish based on light intensity horizontally

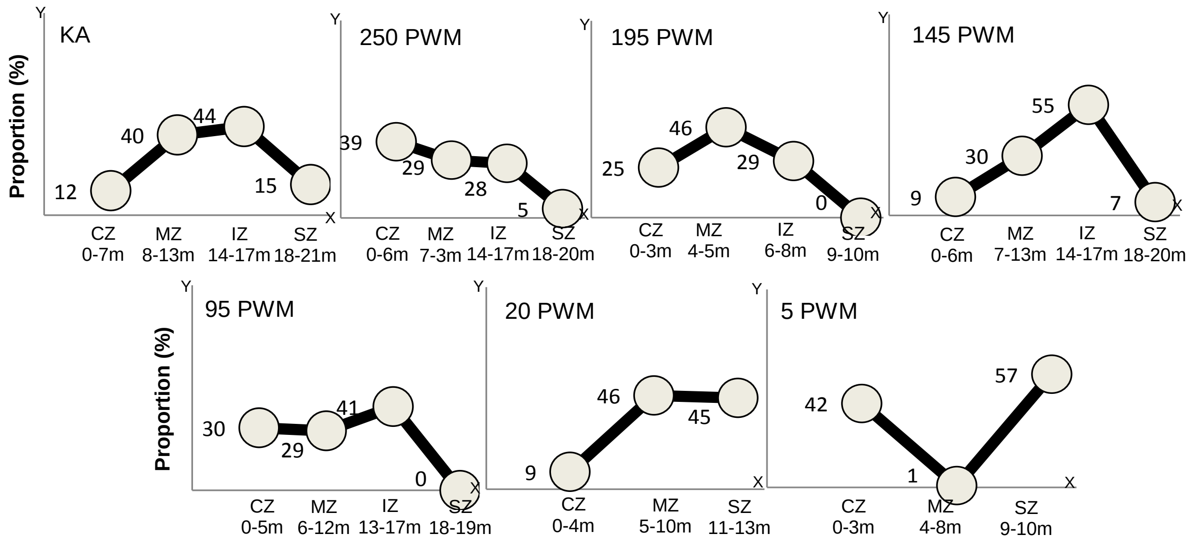


Figure 4. Presence of schooling fish based on light intensity vertically

The emergence of schooling fish vertically around the fishing area is attracted to light. According to Sajdlov et al., (2018), migratory is part of fish behavior. Vertically there are four zones, each zone has different proportions. **(Figure 4)**.

High light intensity tends to make schooling fish spread (Syahputra *et al.,* 2016), as evidenced by the high intensity, the schooling fish spreading out of the catchable area characterized by zones namely influence zone (IZ) and shadow zone (SZ) with 44% of IZ proportion in initial conditions, 15% of SZ, at 250 PWM value 28% of IZ, 5% of SZ, when schooling fish outside the catchable area it is needed to reduce the light intensity (Dwipayana *et al.,* 2018), while moderate intensity values 195, 145 and 95 PWM produce proportions like high intensity. Fish that have the good visual ability are also has good resolution to light space (Purbayanto *et al.,* 2010).

The gathering fish in a catchable area can be caused by one of the light intensities (Kardi et al., 2019). Catchable area zone of which CZ and MZ with a proportion of 39%, 30% and 42% CZ at 250, 95 and 5 PWM; while MZ with proportion of 40%, 46% and 46% at initial condition, 195 and 20 PWM **(Figure 5)**. The light intensity with different PWM values can modify fish behavior patterns by migration (Barranco and Hughes, 2015).

The existence of schooling fish is important to be known as basic information for the application of the use of light intensity with the appropriate PWM value in the fishing technique of static lift net fisheries. In Figure 4 and 5, it shows the area of schooling fish with the different proportion value of schooling fish based on changes of the PWM value by horizontally and vertically.

4. Conclusion

The RGB-LED can change the light intensity by the PWM value, each light intensity has a zone with different radium vertically and horizontally. Intensity changes directly affected the changes in fish behavior to approach, gather and fish movement. By knowing changes in fish behavior based on the light intensity, it can be modeled and developed to be used in fishing activities on SLN.

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