The use of LED lights in the process of catching *Amblygaster leiogaster* using surface gillnets in Kotania Bay, West Seram, Indonesia

Stany R. Siahainenia, Agustinus Tupamahu, Haruna, Ruslan H. S. Tawari

Faculty of Fisheries and Marine Sciences, Pattimura University, Ambon, Maluku, Indonesia. Corresponding author: S. R. Siahainenia, stanysiahainenia@gmail.com

Abstract. Fisherman in the Kotania Bay area of West Seram have utilized light technology to enhance the effectiveness of catching *Amblygaster leiogaste*r since 1980. This study investigated the effectiveness of using LED lights as an attractant for catching *A. leiogaster* using surface gillnets in Kotania Bay, West Seram, Indonesia. The study involved five fishing trips during the dark moon phase in July and August 2024. The average total length and weight of *A. leiogaster* caught using drift gillnets during the five trips were 20.9-22.0 cm and 90.5-112.7 g, respectively. The mode of the total length class was consistent across trips, but with slight differences between trips. This suggests that the population of *A. leiogaster* in the area may have similar sizes overall, but there might be variations in the distribution of sizes due to factors such as fish migration, spawning periods, and environmental conditions. Future research is needed to investigate these factors in more detail to gain a deeper understanding of the population dynamics of *A. leiogaster* in the area.

Key Words: fishing trips, light intensity, size distribution.

Introduction. Fishing is an important economic activity that supports thousands of coastal communities around the world. In its operations, effective and efficient fishing methods and technologies are continuously developed to improve catch yields and the sustainability of fish resources. One method is the use of surface gillnets, which are employed at the water's surface to catch various types of fish, including *Amblygaster leiogaster*. *A leiogaster*, known as smoothbelly sardinella, is a small pelagic species found in tropical and subtropical waters, primarily in the Indo-Pacific region (Charles 2023). This fish has significant economic value due to high local market demand. It forms schools in coastal waters and is distributed at depths ranging from 0-50 m, with a standard length reaching up to 23.0 cm, generally averaging 18.0 cm (Whitehead 1985).

Since the 1980s, fishermen in the Kotania Bay area of West Seram have utilized light technology to enhance the effectiveness of catching *A. leiogaster*, starting from the use of kerosene pressure lamps to the adoption of LED (Light Emitting Diode) light in surface gillnet fishing. LED lights have proven to be more energy-efficient compared to traditional light sources such as incandescent or halogen lamps. Additionally, LED lights produce high-intensity light powered by dry cell batteries, are small and practical to use, and have a lifespan of up to 30,000 hours (Yu et al 2022; Kim et al 2022; Setiawan et al 2015; Suhardi 2014).

Research related to fish capture using LED light attractors in Indonesia has been extensive, especially in lift net fishing (Fatma et al 2022; Fuad et al 2022; Nuraga et al 2018; Taufiq et al 2016). In principle, gillnets operate passively and are typically used at night. The success of gillnet fishing operations largely depends on the direction of fish swim paths relative to the net position; fish are caught when their movement intersects with the net position, causing them to gilled with the net and subsequently become entangled. One solution to further improve gillnet catch yields is to enhance the capture method by using LED light attractors. Various studies on the use of LED light attractors to improve gillnet catches have been conducted in several locations in Indonesia. Research results indicate that introducing LEDs as an auxiliary tool in gillnet fishing can increase catch yields (Hartono et al 2019; Puspito et al 2020; Muhyun et al 2022; Ginanjar et al 2023).

The species *A. leiogaster*, belonging to the Dorosomatidae family, is attracted to artificial light sources, with an illumination range of 10-100 lux, and exhibits anticlockwise swimming behavior (Tupamahu et al 2001). Due to the behavior of *A. leiogaster*, surface gillnet fishermen in Kotania Bay use LED light attractors, in their fishing process. However, there is an urgent need for more in-depth research on how *A. leiogaster* is caught using surface gillnets by fishermen with LED light attractors. This study is a descriptive research through field observations of the surface gillnet fishing process to capture *A. leiogaster* species with the attractors of LED light by fishermen operating in Kotania Bay, West Seram, Indonesia. Observations focus on the optimal param for LED light usage, such as light intensity and duration, fish behavior in light-illuminated areas during the lighting and the capture process, and the characteristics of the catch. This research is expected to provide practical benefits for fishermen in improving the effectiveness of their fishing operations, positively impacting sustainable fisheries management, and offering fundamental information for future research.

Material and Method

Description of the study sites. The research was conducted in Kotania Bay at the astronomical position 127058’46.978’’E, 304’34.98’’S–128050’50.074’’E, 2059’31.452’’S. Figure 1 shows the fishing location area in Kotania Bay, West Seram. Data collection was carried out during the dark moon phase at the end of July and August 2024 over the course of 5 trips (Figure 1).

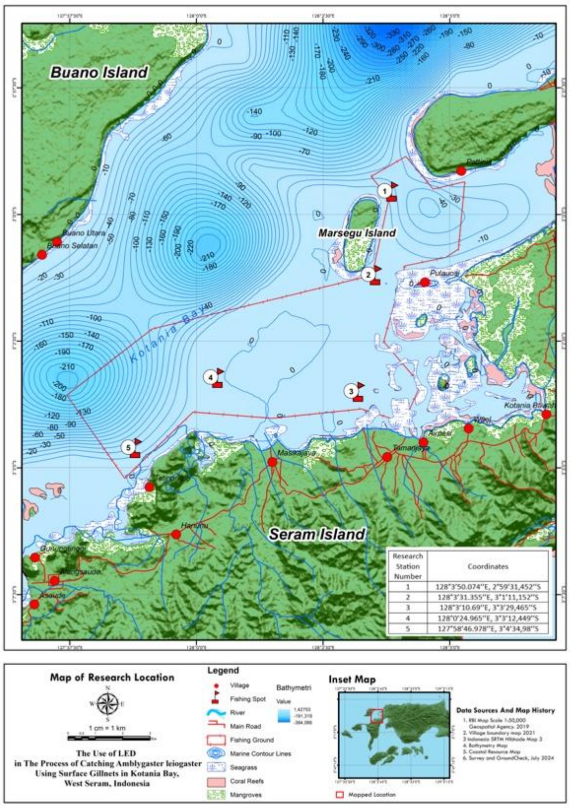

Figure 1. Map of research locations in Kotania Bay, West Seram, Indonesia: comprehensive data collection at five stations.

Data collection. The fishing boat used in this study has dimensions of 7.0 x 1.5 x 0.5 m^3 (length x width x depth). Two 20 Watt LED lights were installed at 2.5 m from the stern, while a 25 Watt LED light is installed 1.5 m from the front of the boat on the right side, and a 3 Watt light on the left side. Figure 2 shows an illustration of the boat used for catching *A. leiogaster* and the LED light positions. The fish finder and underwater camera are positioned near the 20 Watt LED lights, with the fish finder placed at a depth of 0.5 m and the underwater camera at a depth of 2 m. The surface gill net used in this study is made from PA 210 d3 multifilament material, with a mesh size of 1.25 inches. Once assembled, the net, attached to the float line and hanging line, has a length of 12 m. It consists of 283 mesh openings in the vertical direction and has a hanging coefficient of 50%. Five observation trips (Figure 1) were carried on for the experimental purposes, where the lighting conditions of all observation trips were the same.

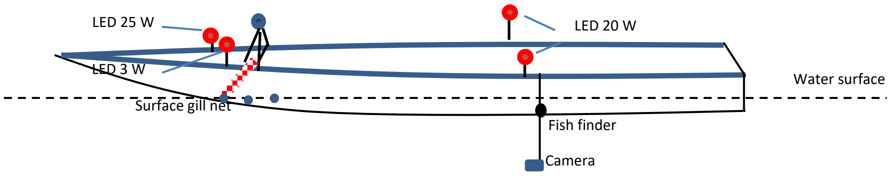

Figure 2. Illustration of a fishing boat used to catch *Amblygaster leiogaster* with surface gill nets, utilizing LED lights during the fishing process.

The underwater light from the LED lamps was measured using a lux meter specifically designed for underwater use. Measurements were taken both vertically and horizontally, starting from the center of the boat, then under the 20 Watt and 3 Watt LED lights. The lighting was measured towards the stern at a distance of 3 m from the center of the boat and towards the bow at the same distance.

Observation of fish behavior in the illuminated area was conducted using the EYOYO 1000TV DVR Recorder Camera. When the fish aggregation lights were turned on, fish behavior was observed, and the behavior of fish around the illuminated area was also monitored using the Garmin 350C fish finder. The observation of fish attracted to the light was carried out for 43 minutes after the LED lights were turned on, before the surface gill net fishing process began (setting and hauling). Individual fish caught with surface gill nets during each observation trip were recorded at their capture positions, and then their total length and girth at the level of gills were measured with an nearest of 0.1 cm.

Data analysis. Descriptive statistics were used to analyze the collected data and presented as percentages in tables and charts using Microsoft Excel. The distribution of underwater light intensity was illustrated using Surfer software, while the underwater video recordings of fish behavior during the lighting period were analyzed with Tracker software. The analyzed fish behaviors included swimming speed.

Results and Discussion

Distribution of underwater LED light intensity. Figure 3 shows the distribution of light intensity underwater from two 20 Watt, one 3 Watt and one 25 Watt LED lights. At the water's surface, right in the middle of the boat, the light intensity is about 70 lux, then decreases exponentially with distance, reaching 5 lux at a depth of 5.5 m, with a shadow area from 5.5 to 10 m. Under the 20 Watt LED lights, the light intensity at the water's surface reaches 100 lux. This intensity then decreases exponentially with the increase of depth, reaching 3 lux at a depth of 6 m, with a dimly lit area down to 10 m.

At a distance of 3 m from the middle of the boat towards the stern, the light intensity at the water's surface is 40 lux and decreases exponentially with the increase of depth, reaching 5 lux at a depth of 4.7 m, with a shadow area extending up to 10 m. Meanwhile, the light intensity at the water's surface at a distance of 3 m from the middle of the boat towards the bow is 25 lux, and this intensity decreases exponentially to 5 lux at a depth of 3.3 m.

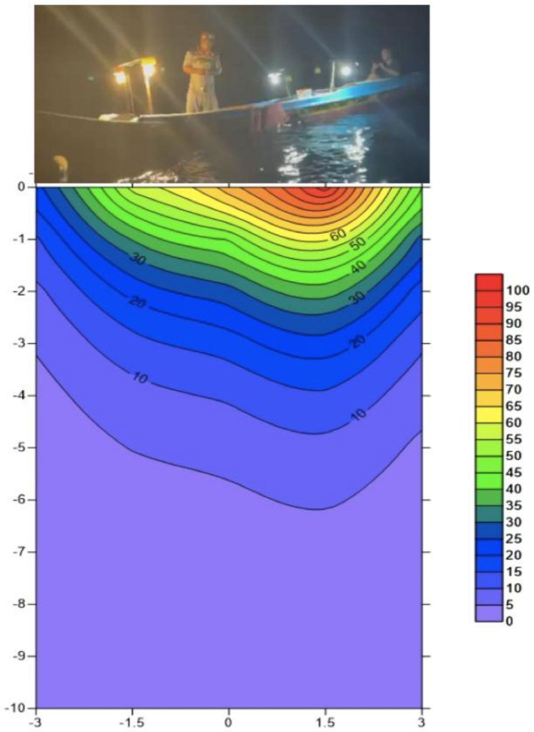

Figure 3. Underwater light intensity distribution: 20 W, 3 W, and 25 W LED lights. Horizontal and vertical measurements relative to boat center: depth 0-10 m, interval 1.5 m.

Behavior of A. leiogaster under LED light. The near field of a transducer refers to the area in front of the transducer where the acoustic wave pattern has not yet fully developed into the parallel and regular pattern found in the far field. In the near field, the behavior of acoustic waves tends to be complex and unpredictable, as the wave components generated by different parts of the transducer's surface interfere with each other (Urick 1975). Therefore, the near field length must be determined based on the transducer's width/diameter (5 cm), the transducer frequency (50 kHz) of the Garmin 350C fish finder, and the speed of sound in water (1500 m s^{-1}), resulting in a near field length of 2.08 cm. Given the near field length of 2.08 cm and the transducer being 50 cm below the water surface, the depth of the fish location shown on the fish finder monitor must be increased by 0.708 m.

The fish finder detection results show the presence of *A. leiogaster* in the area illuminated by two 20 Watt LED lights and one Watt and one 25 Watt LED lights, as displayed in Figure 4. After 11 minutes of the LED lights being turned on, the fish started appearing at depths of 2.7 m to 7.3 m. Twenty-five minutes later, the fish spread out at depths from 2.8 m to 7.4 m, forming schoolings at depths of 2.8 m to 4.1 m and 5.7 m to 7.4 m. This fish schooling formation was maintained until 38 minutes after the lights were switched on. When the two 20 Watt and the 25 Watt LED lights were turned off, the detection at minute 43 showed that only one schooling of fish formed at a depth of 2.1 m to 4.3 m.

Light can affect fish in various ways and can act as a limiting factor for their behavior and activity (Helfman 1993; Anras et al 1997). Most pelagic fish rely on vision as predators, and their activity is heavily influenced by the daily light cycle (Batty et al 1990; Ryder 1990). Pelagic fish tend to school at light intensities around dusk and dawn, with light levels between 0.03 and 59 lux, before dispersing as the light intensity increases (Didrikas & Hansson 2009). This pattern was also seen in this study using artificial light, where during 38 minutes of light exposure, fish were detected at water depths of 2.7 to 7.4 m. At these depths, light intensity ranged from 35 lux to less than 5 lux. After the lights were dimmed at the 41st minute, the fish were detected schooling closer to the water surface at depths of 2.1 to 4.3 m.

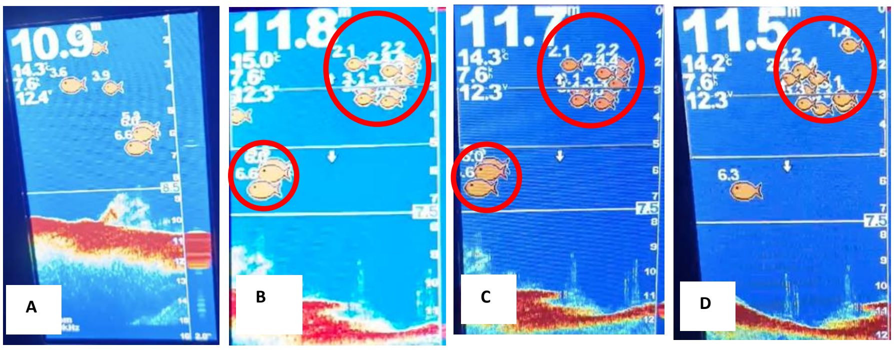

Figure 4. Fish detection timeline using LED lights and Garmin 350 Plus Fish Finder: observations at 11 minutes (a), 25 minutes (b), 38 minutes (c), and 43 minutes (d) before gill net fishing process.

One of the videos analyzed to measure the swimming speed of fish in the illuminated area with 4 LED lights using the Tracker application is shown in Figure 5. The average swimming speed analysis results of *A. leiogaster* over five underwater video recordings are displayed in Figure 6. The calibration of fish size is determined by measuring the average total length of fish caught using drift gillnets with a mesh size of 1.25 inches over five trips. The data from the swimming speed analysis recorded with an underwater video camera during each capture trip is displayed on the right side of the image.

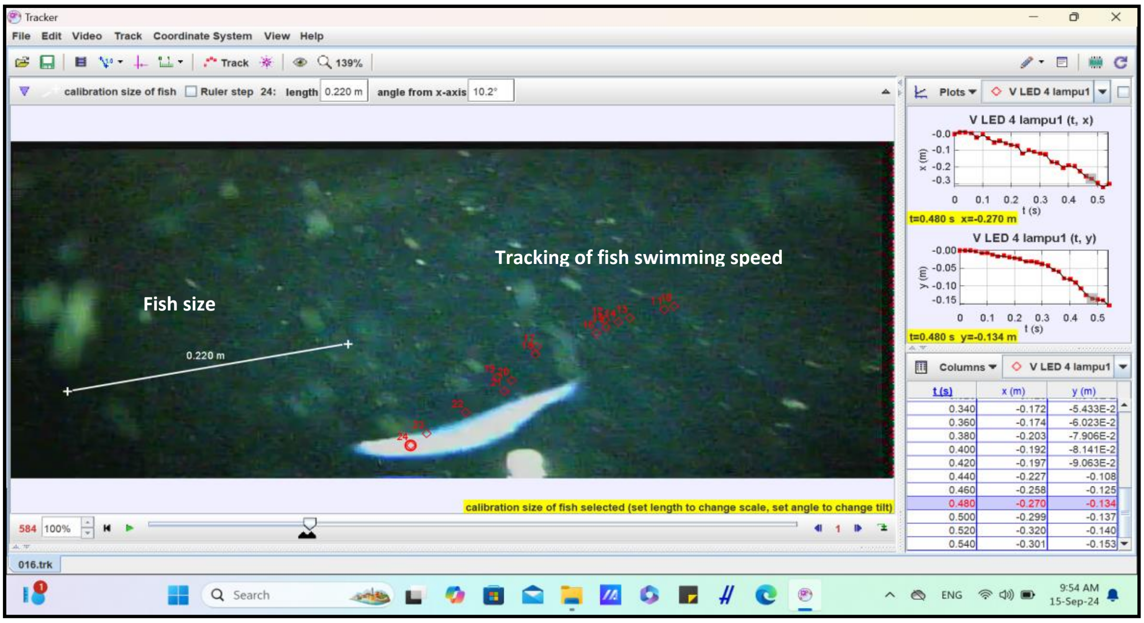

Figure 5. Tracking analysis: *Amblygaster leiogaster* swimming behavior under LED light using tracker application

The analysis shown in Figure 6 indicates a positive linear relationship between the total length of *A. leiogaster* and their swimming speed after being influenced by LED light, within an illumination range of 35 lux to 5 lux. The regression equation (Y=0.9x-4.8672) can be used to project the swimming speed of *A. leiogaster* based on its length, where each 1 cm increase in length is estimated to increase the swimming speed by 0.2857 m s^{-1}. However, it is important to note that other unmeasured factors may also affect swimming speed (Beamish 1978; Brett 1967; Claireaux & Lefrançois 2007; Rubio-Gracia et al 2020), and regression only shows the linear relationship from the available data. According to Gjelland et al (2004), the highest average swimming speed was recorded during illumination periods, and the speed decreased in dark conditions (Gjelland et al 2004). However, unlike this study, when the three LED lights were turned off, *A. leiogaster* showed panic and increased its swimming speed, as shown in Figure 7 and Figure 8.

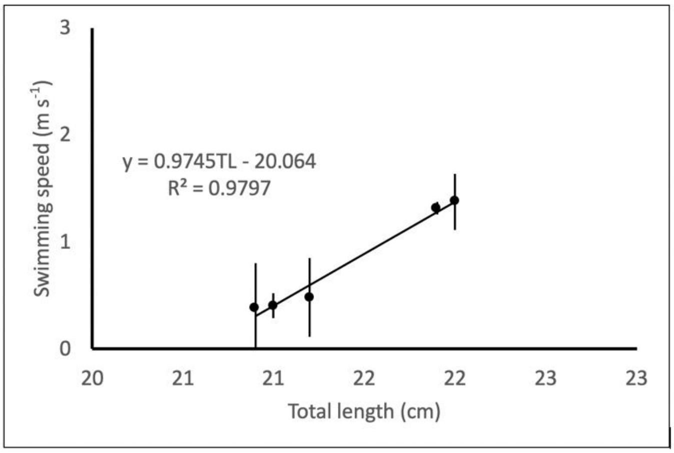

Figure 6. The average length of *Amblygaster leiogaster* caught during five fishing trips and swimming speed analyzed from video recordings using the tracker application when all four LED lights were turned on.

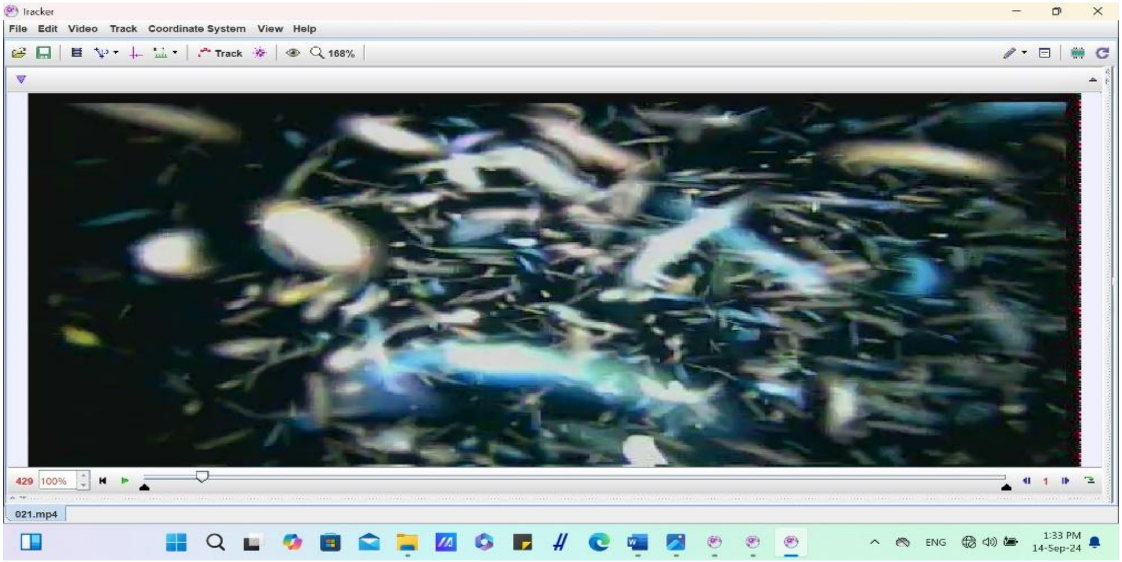

Figure 7. Behavior of *Amblygaster leiogaster*: agitation and dense swimming after 3 LED lights off, 1 remaining (3 Watts), facilitating capture with surface gill nets.

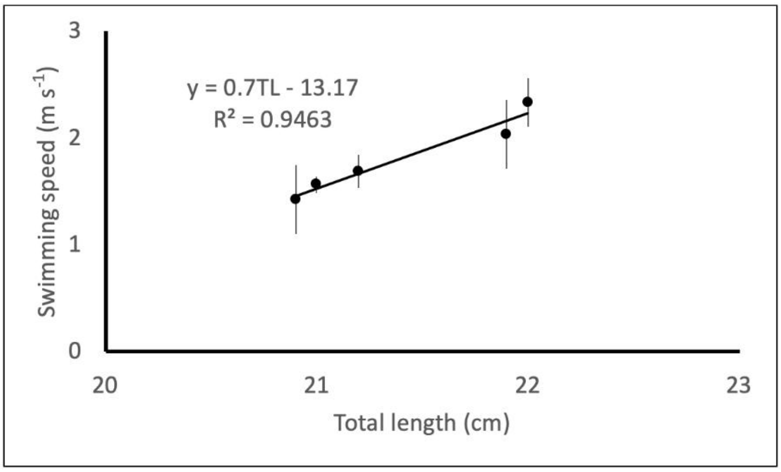

Figure 8. The average length of *Amblygaster leiogaster* caught during five fishing trips and the average swimming speed analyzed from video recordings using the Tracker application when only the 3 Watt LED light was turned on.

Catch characteristics. The composition of catches using surface gill nets over five fishing trips is shown in Table 1. These catches were predominantly composed of *A. leiogaster* (97.7%), with the remaining 2.3% consisting of other fish species, namely *Rastreliger kanagurta* (0.9%), *Decapterus russelli* (0.6%), *Caranx ignobilis* (0.5%), *Selaroides leptolepis* (0.2%), and *Sphyraena barracuda* (0.2%). Fish types attracted by LED lights and caught using surface gill nets in Selayar waters consisted of 20 species, with the dominant catch rate of fish being 31.4%, as reported by Muhyun et al (2022). In comparison, Puspito et al (2020) reported that fish attracted and caught using drifting gill nets involved 10 species, with the dominant fish catch at 76.6%. The differences in catch composition and the percentage of dominant fish caught in this study are due to the capture method employed, where the lights were left on for 38 minutes before the net was set. After that, three LED lights were turned off, leaving only a 3 Watt LED light on. In contrast, in the other two studies, the lights were turned on simultaneously with the net setting, waiting for fish to be attracted by the light and caught (Muhyun et al 2022; Puspito et al 2020).

Table 1 shows that catches on each fishing trip fluctuated, even though the LED lighting conditions remained consistent on each trip. This variation in catch is a complex phenomenon, influenced by various factors, such as the use of artificial light, environmental conditions, seasonal changes, as well as the instability present in fish populations (Anderson et al 2008; Heermann et al 2013; Nguyen et al 2018).

Table 1

The composition of fish caught that were attracted by LED light and captured using surface gill nets with a mesh size of 1.25 inches

Species	*Catch (individual)*						
	Trip 1	*Trip 2*	*Trip 3*	*Trip 4*	*Trip 5*	*Total*	*%*
Abligaster leiogaster	94	83	86	101	265	629	97.70
Ratreliger kanagurta	1	3	0	2	0	6	0.93
Caranx ignobilis	0	2	0	1	0	3	0.47
Decapterus ruseli	0	0	3	1	0	4	0.62
Selaroides leptolepis	0	0	1	0	0	1	0.16
Sphyraena barracuda	0	0	0	0	1	1	0.16
Total	95	88	90	105	266	644	100.00

In this study, the minimum, maximum, and mean total lengths, as well as the weight of *A. leiogaster* captured with surface gill nets after being attracted by LED lights, are presented in Table 2. The distribution of total lengths during five capture trips is shown in Figure 9. The average total length and weight of *A. leiogaster* attracted to LED light and caught using drift gill nets during five trips were 20.9-22.0 cm and 90.5-112.7 g, respectively. The mode of the total length class of *A. leiogaster* in each fishing trip was almost the same, in trip 1 and 3 the mode was 21-22 cm, while in trip 2, 4 and 5 the mode was in the total length class of 22-23 cm.

Table 2

The minimum, maximum and mean length and weight of the *Amblygaster leiogaster* caught in the net after being attracted by LED light, by trip

Trip	*Minimum length (cm)*	*Maximum length (cm)*	*Mean length (cm)*	*Minimum weight (g)*	*Maximum weight (g)*	*Mean weight (g)*
1	18.3	24.4	21.0	62.7	125.1	90.5
2	18.2	24.1	21.2	61.5	145.1	98.3
3	18.5	23.0	20.9	64.7	121.3	92.9
4	19.5	23.2	21.9	77.6	138.4	112.7
5	19.5	23.5	22.0	73.8	137.3	107.4

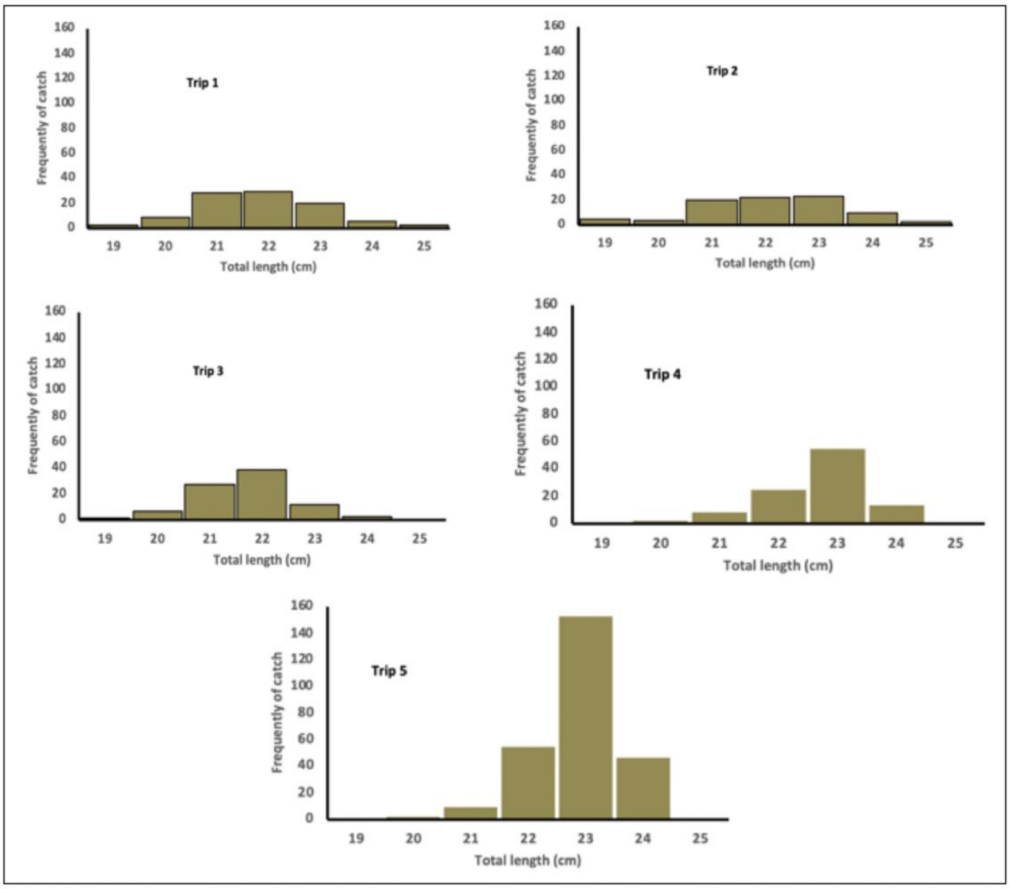

Figure 9. The distribution of total length of *Amblygaster leiogaster* attracted to the LED lamp light and captured using surface gill nets during the five trips.

The research findings show that *A. leiogaster* attracted by LED light and caught using drift gill nets during five trips had a relatively consistent average total length and weight, with little variation between trips. However, there were interesting differences in the mode of the total length between fishing trips. The relatively stable average total length (20.9-22.0 cm) and weight (90.5-112.7 g) indicate that the population of *A. leiogaster* attracted by LED light at the fishing location may have similar sizes during the five trips. While the average total length was consistent, the mode of the total length showed slight differences between fishing trips. These changes may be due to several factors: fish migration and spawning variations. Fish migration with different sizes occurring between fishing trips, and larger fish migrating to spawning locations on specific trips may explain the dominance of smaller length classes on those trips (Ciannelli et al 2015; Peer & Miller 2014). To gain a better understanding of the factors contributing to the differences in mode, further analysis is required, such as: comparing environmental data, information on sex, reproductive stage, and age of the fish will provide a deeper understanding of population dynamics (Surya et al 2024).

Conclusions. The use of LED lights as an attractant for *A. leiogaster* in surface gillnet fishing proved to be an effective strategy and an effective method, as evidenced by the consistent catch sizes observed during the research trips. However, the absence of control samples (catches without LED lights) limits the ability to fully quantify the contribution of the LED lights to the catch efficiency. However, further research is recommended to understand the impact of environmental factors and fish behavior in detail. This study emphasizes the importance of combining observation data with environmental data to gain a comprehensive understanding of the species and its response to fishing practices. The information gathered can be valuable for promoting sustainable fishing practices for *A. leiogaster* in Kotania Bay and similar fishing areas.

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Conflict of interest. The authors declare no conflict of interest.

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Authors:
Stany Rachel Siahainenia, Faculty of Fisheries and Marine Science Pattimura University, Mr CHR Soplanit Street Ambon, 97234 Maluku, Indonesia, e-mail: stanysiahainenia@gmail.com
Agustinus Tupamahu, Faculty of Fisheries and Marine Science Pattimura University, Mr CHR Soplanit Street Ambon, 97234 Maluku, Indonesia, e-mail: agustupamahu02@gmail.com
Haruna, Faculty of Fisheries and Marine Science Pattimura University, Mr CHR Soplanit Street Ambon, 97234 Maluku, Indonesia, e-mail: haruna@lecturer.unpatti.ac.id
Ruslan Husein Saban Tawari, Faculty of Fisheries and Marine Science Pattimura University, Mr CHR Soplanit Street Ambon, 97234 Maluku, Indonesia, e-mail: donbilloland@ymail.com

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