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INTRODUKSI LAMPU ATRAKTOR CELUP (LAC) PADA OPERASIONAL GOMBANG (TIDAL TRAP) DI PERAIRAN BENGKALIS, PROVINSI RIAU, INDONESIA

INTRODUCTION OF A SUBMERSIBLE ATTRACTOR LAMP (SAL) IN TIDAL TRAP (GOMBANG) OPERATIONS IN BENGKALIS WATERS, RIAU PROVINCE, INDONESIA

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ABSTRACT

Submersible Attractor Lamp (SAL) *could increase* the efficiency of tidal traps *operation. The current* study aims to evaluate the *introduction* of SAL in *the* trap operations to enhance catch efficiency. The research was conducted in the Bengkalis *Waters*, Riau Province, Indonesia, between May and October 2023. An experimental approach was *applied, comparing the* catch *of a* standard *trap* (control) and *a* modified *trap* equipped with SAL (treatment). Statistical *analyses, paired t tests, were used to* assess the differences in catch weight. *Results indicate* that the *implementation* of SAL *produced higher* catch *weight* by 17.5% *compared to fishing gear without SAL,* with significant *improvements* in the capture of pelagic and demersal species ($p < 0.05$). The use of SAL effectively attracted fish by creating *localized light-induced* plankton *aggregation,* increasing fish density near the trap. *SAL* integration significantly enhanced *the* efficiency *of the trap* and present*ed* a sustainable method for improving small-scale fisheries without increasing fishing effort*s*.

Keywords: Fish aggregating devices; fishing innovation; small-scale fisheries; traditional fisheries

ABSTRAK

Lampu atraktor celup (LAC) dapat meningkatkan efisiensi pengoperasian perangkap pasang surut. Penelitian bertujuan untuk mengevaluasi penerapan LAC dalam pengoperasian perangkap untuk meningkatkan efisiensi tangkapan. Penelitian dilakukan di Perairan Bengkalis, Provinsi Riau, Indonesia, antara bulan Mei dan Oktober 2023. Pendekatan eksperimental diterapkan, dengan membandingkan hasil tangkapan perangkap standar (kontrol) dan perangkap yang dimodifikasi yang dilengkapi dengan LAC (perlakuan). Analisis statistik, uji t berpasangan, digunakan untuk menilai perbedaan berat tangkapan. Hasil penelitian menunjukkan bahwa penerapan LAC menghasilkan tangkapan yang lebih berat sebesar 17.5% dibandingkan alat tangkap tanpa LAC, dengan peningkatan yang signifikan dalam penangkapan spesies pelagis dan demersal ($p < 0.05$). Penggunaan SAL secara efektif menarik ikan dengan menciptakan agregasi plankton yang disebabkan oleh cahaya secara lokal, sehingga meningkatkan kepadatan ikan di dekat perangkap. Integrasi LAC secara signifikan meningkatkan efisiensi perangkap dan menyajikan metode yang berkelanjutan untuk meningkatkan perikanan skala kecil tanpa meningkatkan upaya penangkapan.

Kata Kunci: Alat pengumpul ikan; inovasi penangkapan ikan; perikanan skala kecil; perikanan tradisional

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INTRODUCTION

Tidal trap is a traditional fishing gear widely used by fishermen in Bengkalis Island, Riau Province. In 2018, there were 505 units of trap which were operated in the area (Department of Marine and Fisheries of Bengkalis Regency, 2019). Ministry of Marine and Fisheries Affairs of Republic of Indonesia (2021) classifies the fishing gear as a type of trap due to its passive operation. It is typically operated near river estuaries, where strong tidal currents, about 0.07–1.19 m/s (Amri & Muchlizar, 2018), have a significant influence. Fish or shrimp carried by the tidal currents enter the trap and become trapped in its pocket section.

Field observations revealed that the trap is not equipped with a bag which has a backflow barrier, allowing fish that have entered the bag to escape when the ebbs occur. Additionally, the trap lacks a guiding structure, such as a leader net, which means fish movement in front of the trap is not directed into its main chamber. The two weaknesses prevent the trap from achieving maximum catch efficiency. Another limitation is that the trap is generally operated only during the daytime, even though studies by Forbes and Benfield (1986) and Sanudin *et al.* (2014) have shown that the activity of certain fish and shrimp species increases at night.

Efforts to improve the catch results of the trap have been carried out by Kholis *et al.* (2024a) by adding bags and a leader net. The result showed that the combination of bags and the leader net could increase the catch by 40.16% compared to the control trap catch. Kholis *et al.* (2024b) further tested the trap equipped with bags and a leader net at night. The result showed that operating the trap at night increased the catch weight by 20.94% compared to operating it during the day. Current research is essential to improve the trap operating method by using a light attractor placed in front of the trap's mouth. The light attractor functions to lure and gather fish in front of the trap's mouth. The tidal currents would be able to guide the fish into the body of the trap in large numbers.

The use of submersible attractor lights (SAL) is one of the innovations to optimize the catch results of the trap at night. The SAL has been proven effective in increasing the number of fish caught with various fishing gear, such as squid jigs, floating fish traps, and purse seines. According to Puspito (2022), the waters illuminated by light serve as an indicator of food availability, which attracts fish to approach the light. The introduction of SAL is expected to help increase the trap catch without adding more fishing units, which could potentially lead to overfishing (Alfaro-Shigueto *et al.*, 2010).

The study aims to prove the compatibility of SAL as fish aggregating devices (FADs) of the trap. The model was chosen because it is more feasible to use with passive fishing gear, such as the trap, which relies on tidal currents for its operation. The lighting does not require high intensity, as coastal waters are already abundant in fish resources (Bolton *et al.* 2017). Using light with high intensity would actually cause fish to move away from the light source (Becker *et al.*, 2013). The chosen light colour is warm white, which is capable of penetrating murky waters. The type of light used in the current study is an LED strip. Some of its advantages include low intensity, high efficiency, low power consumption, high reliability (resistant to shocks and vibrations), no ultraviolet (UV) radiation, and ease of construction. The two objectives of the study are (1) to determine the composition of fish species and their weight caught by the trap with and without SAL and (2) to prove that the trap equipped with SAL will increase the catch weight. The hypothesis used in the study is that the use of SAL will increase both the diversity and weight of the trap's catch.

Literature on the introduction of SAL to trap is still limited. Three studies that are somewhat similar consist of the use of FADs in the form of SAL in passive fishing gear, such as set nets (Rudiyanto and Haryasakti, 2020) and gill nets (Hartono *et al.*, 2019; Muhyun *et al.*, 2022). The results show that SAL could increase the catch in passive fishing gear. These three references were used as inputs for analysing the research findings.

MATERIALS AND METHODS

Time and Location

The research was conducted in two stages, namely the setting of SAL and field testing. The setting of the SAL took place at the Fishery Technology Laboratory, Faculty of Fisheries and Marine Sciences, IPB University, from April to July 2023. Subsequently, the SAL was field-tested in the waters of Prapat Tunggal Coastal Area, Bengkalis Sub-District, Riau Province, from May to October 2023. The fishing locations were at two coordinate points, namely 1°34'12.0"N, 102°00'00.9"E (Site 1) and 1°33'43.2"N, 102°00'09.0"E (Site 2). The research location can be seen more clearly in Figure 1.

Equipment and Materials

The equipment used in the research consisted of light-emitting diodes (LED) lights, batteries, iron frames, measuring tapes, calipers, rulers, whiteboards, cameras, current drifters, lux meters, stopwatches, thermometers, buckets, GPS trackers, and two units of tidal trap which consist of one trap as control (T0) and the other one as treatment (T1). The placement of the SAL was in front of the mouth of the trap, attached to the leader net. The materials in the study consisted of fish catch, acrylic materials, and LED strips. The construction of the SAL is shown in Figure 2, and the illustration of the SAL placement during the trap operation is displayed in Figure 3.

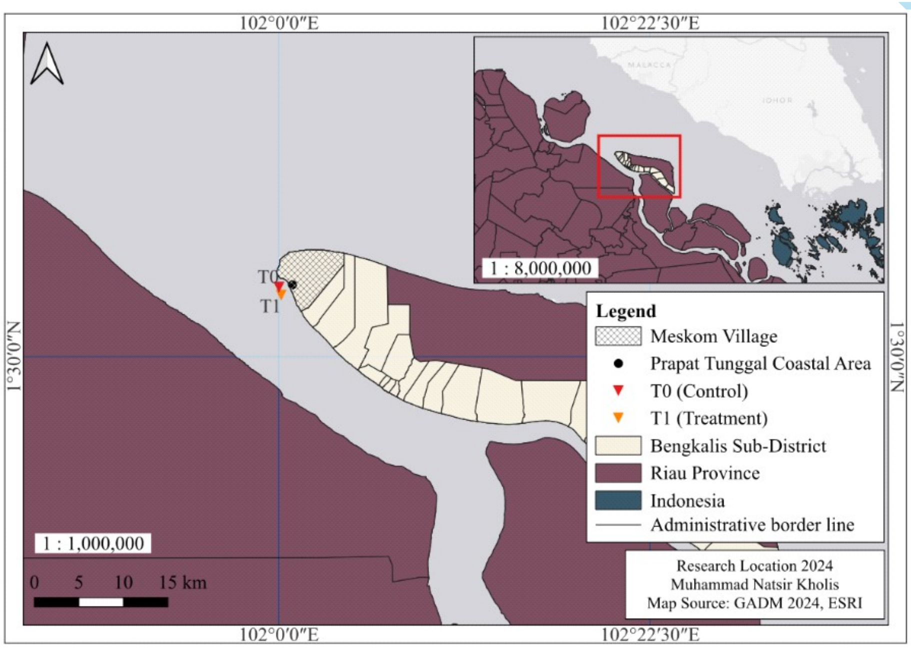

Figure 1. Research location

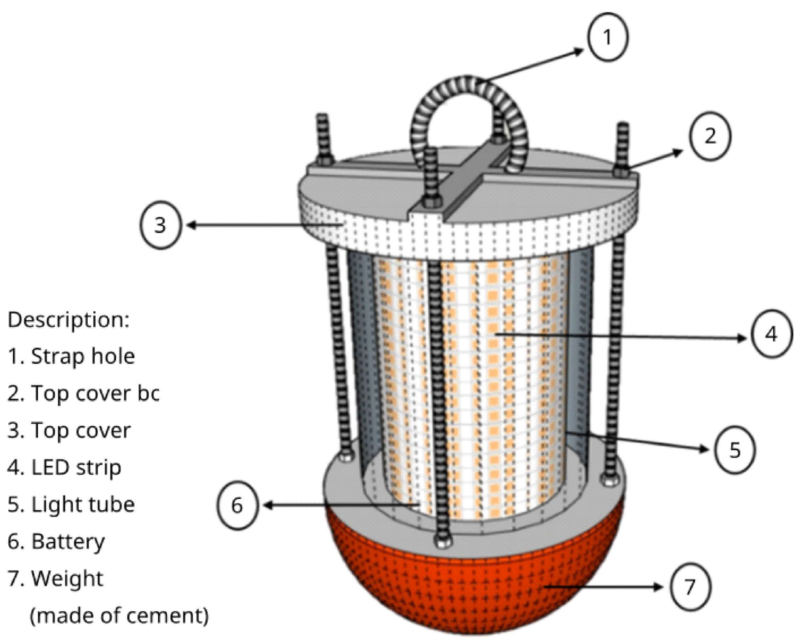

Figure 2. The construction of a Submersible Attractor Lamp (SAL)

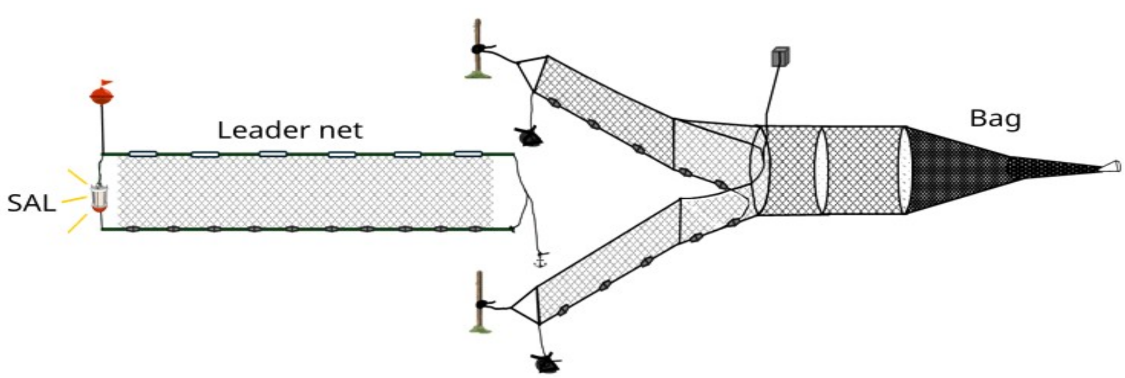

Figure 3. Illustration of SAL placement in trap operation

Design and Specification of SAL

The design of the SAL features a cylindrical shape with a compact and well-structured design, combining various components for optimal functionality. The main tube, made of acrylic, is transparent, giving an elegant look while allowing the LED light inside to spread effectively. At the top of the tube is a round cap with a silicone rubber seal, which helps prevent leakage and protects the LED components and the inner parts. The LED strip is neatly wrapped around the inner walls of the tube, providing uniform lighting.

The specification of the SAL reflects a design focused on efficiency and durability. The LED light uses a 5050 DC 12 V Luxen strip, with 60 LEDs per 5 m, offering lighting with an intensity of 45 w per 5 m and a warm white color (yellowish white), providing soft light. The power source relies on a UPS Gpower 12 V/5 AH battery, with dimensions of 90 × 70 × 101 mm and T2/L terminals, making it an excellent choice for applications requiring long-lasting power and reliability. The SAL tube is made of acrylic material with precise dimensions which the inner tube is Ø 12 cm × H 15 cm, while the outer tube is Ø 15 cm × H 18 cm. The top cap of the tube is made of acrylic, with an inner Ø 15 cm and H 0.5 cm, and the outer Ø 20 cm × H 2 cm, ensuring good protection for the internal components.

Other supporting elements are foam rubber isolators with Ø 14.8 cm, which provide extra protection against vibrations and shocks, enhancing the overall durability of the device. The cables used are Eterna type with dimensions of 1.0 × 2.5 mm, ensuring strength and flexibility in installation. The switch is semi-plastic with a rubber button, offering ease of operation and long-lasting performance even with repeated use. The frame is made of iron with dimensions of Ø 20 × H 19 cm, providing stability and durability to the SAL structure, making it a solid and efficient tool for lighting applications requiring high endurance and reliable operation.

Methods

The research utilized an experimental fishing method. The data collected consisted of both primary and secondary data. Primary data comprised the composition of the catch, including fish species and weight. All data were gathered from two different trap units, a control trap (T0) at Site 1 and a treatment trap (T1) at Site 2. The T0 was equipped with a bag and a leader net (Kholis *et al.* 2024), while the T1 was the same as T0 but with an added SAL. Both trap units were operated simultaneously, with a separation distance of approximately ±750 m to minimize bias.

The operational sequence of both trap units followed the fishing procedures typically practiced by local fishermen, as described by Kholis *et al.* (2024b), namely:

1) Preparation of fishing equipment, such as fish containers (buckets or baskets).
2) Inspection of the boat, including equipment like oars and outboard engines.
3) Travel to the fishing location, covering a distance of 0.5–1 nautical mile (nm).
4) Installation of the trap, positioning its mouth to face the tidal current.
5) Installation of the leader net along with the SAL.
6) Soaking of the trap for 5 hours, from 18:00 to 22:30 (GMT+7).
7) Lifting the trap bag and collecting the catch.
8) Reinstalling the trap for the next 5 hours of soaking period, from 23:00 to 06:00 (GMT+7).
9) Sorting, species identification, counting, and weighing of fish, conducted immediately after the catch is retrieved onto the boat.

The determination of the number of fishing operations was based on Federer's formula (1963), $(t-1)(r-1) \geq 15$. From the two treatments (*t*), the minimum number of replications (*r*) required was calculated to be 8 replications. However, the number of replications in the study was set at 17 times to ensure better data accuracy.

Data Analysis

Data analysis was conducted using descriptive analysis and the t test. The normality test is conducted using The Kolmogorov-Smirnov test. Meanwhile, Levene's test is used to determine the homogeneity. Decision-making is based on the value of significance found in the coefficients table with a significance level of 5% (McDonald, 2014).

The light intensity was measured using a lux meter to test its intensity and distribution. The first measurement was conducted to determine the horizontal light intensity. The second measurement was performed to assess the light distribution pattern between 0° and 180°. The light intensity measurements were recorded every 10 minutes and conducted over a period of 2 hr. Figure 4 illustrates the position of the lux meter sensor and the position of the light in both light intensity measurements.

RESULTS

Catch Composition

The catch composition caught by trap, both with and without SAL, consisted of 12 species divided into three groups, namely crustacean group, pelagic fish, and demersal fish. The crustacean consisted of Sergestid shrimp (*Acetes* sp.), red shrimp (*Solenocera depressa*), and tiger shrimp (*Penaeus monodon*). Furthermore, the pelagic fish consisted of shad fish (*Ilisha* sp.), longjaw thryssa (*Thryssa setirostris*), rainbow sardine (*Dussumieria acuta*), and narrow-barred Spanish mackerel (*Scomberomorus commerson*). The demersal fish consisted of wolf-herring (*Chirocentrus* sp.), leaftail croaker (*Johnius trachycephalus*), largehead hairtail (*Trichiurus lepturus*), Bombay-duck (*Harpadon neherus*), and cuttlefish (*Sepia* sp.).

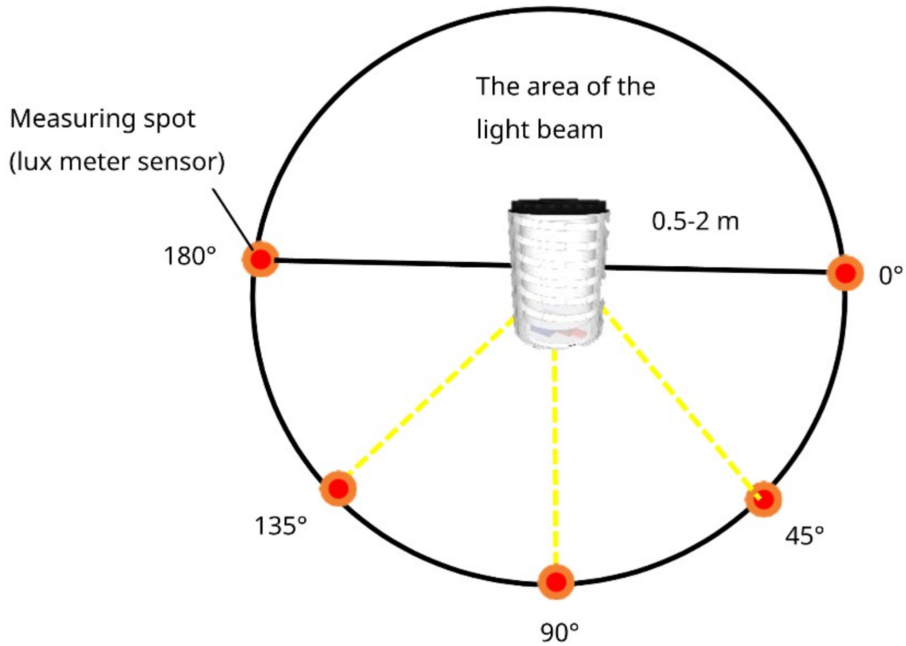

Figure 4. The position of the lux meter sensor relative to the light during the measurement of light distribution direction

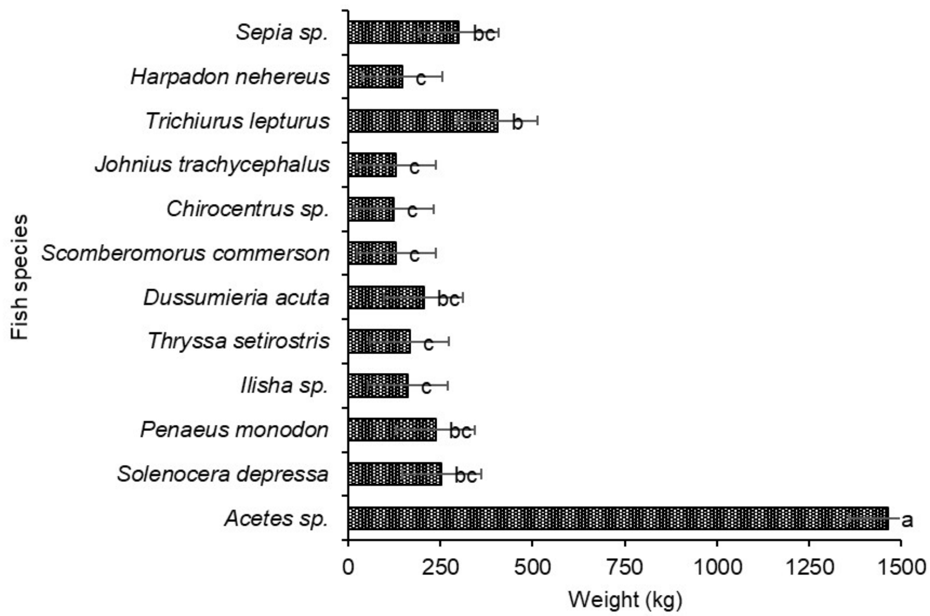

Figure 5. Weight composition of trap catches based on species

The total weight of the catch reached 3721.14 kg. The details are as follows: Sergestid shrimp, 1466.10 kg; largehead hairtail, 405.24 kg; cuttlefish, 300.52 kg; red shrimp, 253.43 kg; tiger shrimp, 236.55 kg; rainbow sardine, 204.25 kg; longjaw thryssa, 165.66 kg; shad fish, 160.92 kg; leaftail croaker, 129.55 kg; narrow-barred Spanish mackerel, 129.50 kg; Bombay-duck, 146.92 kg; and wolf-herring, 122.50 kg (Figure 5). Crustaceans, especially Sergestid shrimp, dominated the trap catch with a total of 1956 kg. The demersal fish group ranks second after crustaceans, with a total weight reaching 1105 kg.

The Effect of SAL on the Catch

The trap with SAL (T1) caught 2010.32 kg, which is 54% of total catch. Meanwhile the trap without SAL (T0) caught 1710.76 kg (Figure 6). The highest catch weight for trap without SAL (T0) was from crustacean group at 956 kg, followed by the demersal group at 475 kg, and the pelagic group at 280 kg. Crustaceans were also the heaviest catch for the trap with SAL, at 1000 kg, followed by demersal at 630 kg, and pelagic at 380 kg.

The increase in the catch of T1 was proven by the t test results ($p < 0.05$). Hypothesis null was rejected due to the significant statistical difference between the catches of trap without SAL (T0) and trap with SAL (T1). The conclusion is that the use of SAL significantly affects the trap catch. Therefore, SAL is considered as effective in increasing the catch.

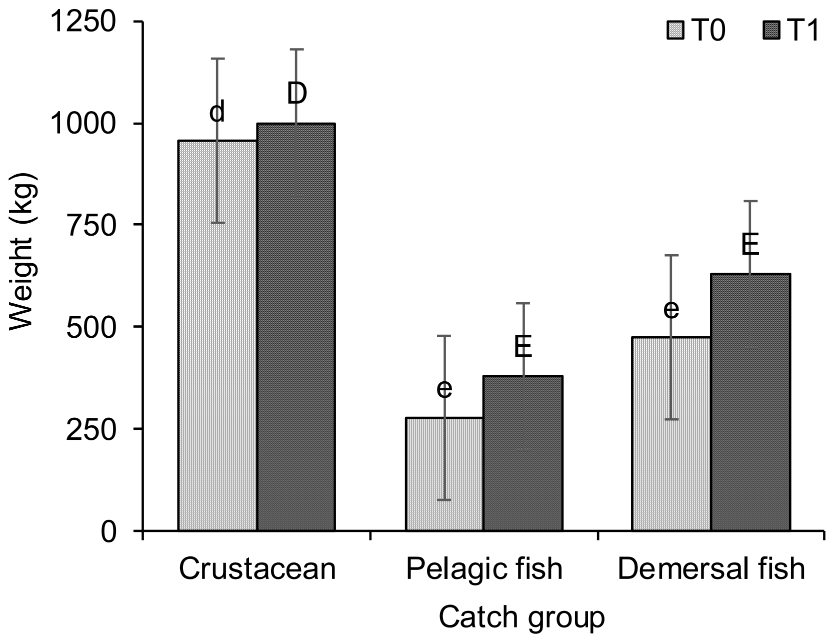

Figure 6. Comparison of the weight of the catch of trap with SAL (T1) and without SAL (T0)

DISCUSSIONS

Catch Composition

Crustaceans were frequently caught because their habitat aligns with the trap operation area—shallow coastal waters or estuary waters with sandy and muddy bottoms. Carpenter and Niem (1999) stated that shrimp are tropical organisms that inhabit turbid waters rich in organic elements. Their life cycle begins in estuary waters near mangrove forests, which serve as nursery areas, and continues in offshore seas as spawning grounds (Subrahmanyam, 1971; Gillanders *et al.*, 2003). The shrimp fishing season usually occurs between April and September (Amron *et al.*, 2009). The trap operation, which starts in May, coincides with the peak of the shrimp fishing season.

The most caught fish are largehead hairtail, followed by cuttlefish, Bombay-duck, leaftail croaker, and wolf-herring. Largehead hairtail were caught in large numbers because their habitat is closely associated with the presence of shrimp, which is their primary food source. Setyobudi *et al.* (2024) stated that largehead hairtail are carnivorous, feeding on shrimp, squid, and small fish. Harjanti *et al.* (2012) and Branenda *et al.* (2019) note that the largehead hairtail fishing season occurs from February to May, coinciding with the peak shrimp fishing season.

Cuttlefish inhabit neritic waters, living in groups and concentrating in shallow areas. Their habitats include offshore waters, mangrove forests, coral reefs, and estuaries (Danna, 2023). Their diet varies depending on their habitat but typically consists of shrimp, snails, and crabs (Jereb *et al.*, 2016). The catch weight of cuttlefish is significant, accounting for 8% of the total catch, as the trap operation coincided with the early cuttlefish fishing season, which runs from September to December (Febrianto *et al.*, 2017).

Bombay-duck, leaftail croaker, and wolf-herring are also classified as carnivorous fish. Their fishing seasons occur around April to May and November to January. Both species are closely associated with benthic marine organisms, such as small fish, shrimp, crabs, and sea eels, which form their primary diet (Sasaki, 2001; Yan *et al.*, 2011; Zhang and Jin, 2014).

Rainbow sardines are the most frequently caught pelagic fish by trap operations. The fishing season for the fish occurs between May and September, aligning with the trap operating period (Simarmata *et al.*, 2014). In contrast, longjaw thryssa and shad fish were caught in smaller quantities. The reason is because their fishing season runs from October to December, while trap operations were conducted from May to October 2023, meaning only the early part of their fishing season overlapped with trap activity (Talwar and Jhingran, 1991; Firdaus, 2010; Zhang *et al.*, 2009).

Narrow-barred Spanish mackerels are pelagic fish known for their fast-swimming abilities and migratory behaviour, often traveling far from coastal habitats (Roa-Ureta *et al.*, 2019). As carnivorous fish, their diet includes zooplankton, crustaceans, molluscs, fish eggs, and small fish (McPherson, 1987; Bakhoum, 2007). The mackerel catch is relatively small because the peak fishing season, which occurs between March and April, did not align with the trap operation period (Situmorang *et al.*, 2018).

The Effect of SAL on the Catch

The weight of the catch from trap with SAL (T1), both in total weight and per species, was higher than that of trap without SAL. The use of SAL lights on the trap attracted fish to gather and forage in front of the trap's mouth. In contrast, the trap without SAL only relied on currents and the migration of fish, which may not certainly be directed toward the trap's mouth.

Crustacean species are the main catch of the trap, both when using SAL and when not using it. SAL is effective in attracting crustaceans, such as Sergestid shrimp, by creating a concentration of plankton as a food source through a 45 w LED light at an optimal intensity of around 300 lux. The effectiveness of using SAL is supported by the mangrove habitat as the natural ecosystem for crustaceans (Barbier *et al.*, 2011; Hutchison *et al.*, 2014). At night, the vertical migration of plankton to the surface further attracts crustaceans to the illuminated area, thereby increasing the catch opportunities (Quirino *et al.*, 2021; Cottingham *et al.*, 2021).

The demersal group became the second-largest catch at current research. As nocturnal predators, they are active in foraging at night (Sofijanto et al.., 2019). The use of SAL increases the catch by up to 57%, not because of the direct light, but because of the increased plankton concentration around the lighting. Like crustaceans, demersal fish rely on plankton in neritic waters as their main food source, so the SAL lighting supports their presence and catch opportunities (Hanlon *et al.*, 1979; Dinisia & Adiwilaga, 2015; Triyanto *et al.*, 2020; Tasak *et al.*, 2015).

On the other hand, the pelagic group also shows a 58% increase in catch with SAL. Small pelagic fish, which feed on plankton, tended to approach the light. However, the presence of demersal predators, which also approach the light, often causes small pelagic fish to migrate away to avoid the threat. The condition creates a unique dynamic where pelagic fish tend to migrate to deeper or shallower waters depending on the need to avoid demersal predators. Nonetheless, pelagic fish still take advantage of the plankton concentrated under the light, which remains their primary food source (Sutton, 2013; Anderson *et al.*, 2017).

The increase in catch with SAL is closely related to the dynamics of the trophic food chain. SAL light attracts plankton, crustaceans, and small fish, which in turn attract larger predators, creating a concentration of species in the illuminated area and increasing catch opportunities (Kadir *et al.*, 2019; Bubun *et al.*, 2014).

The Use of an LED Strip in the SAL

An effort to improve the trap's catch efficiency is accomplished by attracting more fish to concentrate in front of its mouth. This condition can be achieved by using a submerged attraction light (SAL) when operating the trap at night. Kholis *et al.* (2024b) explained that some species caught by the trap are predatory and nocturnal, meaning their feeding activity depends on light to see their prey. Pelagic fish swim horizontally, while demersal fish move vertically, both behaviours being closely related to the food chain process. Hartono *et al.* (2019) and Muhyun *et al.* (2022) have previously proven that the use of submerged lights in passive fishing gear, such as gill nets, can significantly increase the catch yield.

The type of SAL was chosen as a fish aggregating device for the trap because it has many advantages. The SAL is submerged underwater, ensuring that all emitted light propagates efficiently without reflection or refraction. The main material of SAL consists of LED strips, which provide even horizontal light distribution (Fig. 7). LED strips are a new type of LED that is not yet widely known but offers several benefits, including horizontal light distribution, high-intensity illumination, compact size, soft light output, low cost, easy availability, and simple assembly process.

The advantages of LED strips make them highly suitable as a fishing aid for trap operations. Based on Figure 7, the maximum light intensity reaches 300 lux, with a uniform horizontal light distribution around the lamp. The reduction in light intensity also occurs evenly at every angle when the battery power (used as the energy source) starts to decrease.

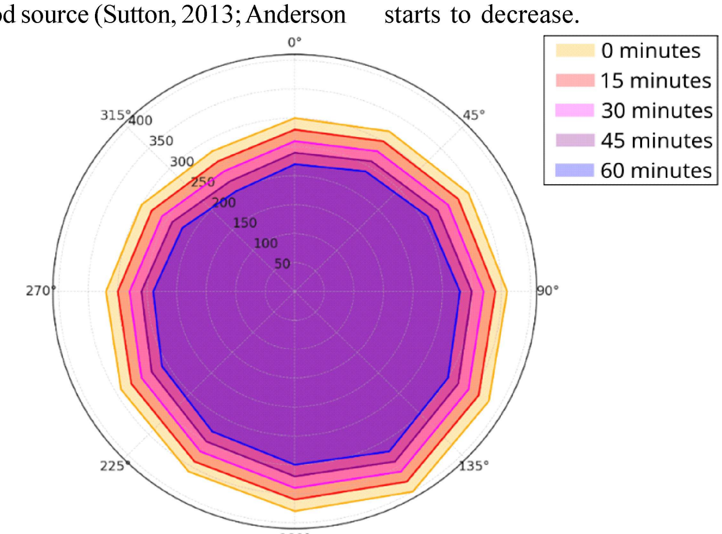

Figure 7. Intensity and distribution of LED strip light

CONCLUSION

The results of the study indicate that the use of SAL in trap operations significantly increases catch weight. The trap equipped with SAL (T1) recorded 17.5% higher in catch weight (2010.32 kg) compared to the trap without SAL (T0) at 1710.76 kg. The effectiveness of SAL was statistically supported by a t-test ($P < 0.05$), confirming that SAL significantly contributes to improving trap catch performance. The increased catch is attributed to the ability of SAL to attract plankton and lower trophic organisms, which in turn draw crustaceans and fish to congregate around the trap's mouth. The trophic interaction creates a favourable condition for capture. Additionally, the light distribution of the LED strip used in SAL enhances its attractiveness in the underwater environment, particularly for nocturnal species during nighttime operations. Its role in aggregating target organisms makes it a suitable innovation for optimizing passive fishing gear, specifically in coastal and estuarine waters.

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