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# USE OF BLUE LED LIGHTS AS AN ATTRACTANT IN A COLLAPSIBLE POT ON BLUE SWIMMING CRAB CATCHES

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## ABSTRACT

*Blue light-emitting diode (LED) lights have been tested as a potential tool in a blue swimming crab collapsible pot at the laboratory level. However, field-scale trials have not yet been conducted to confirm their effects on pot catches. This study aims to determine the effects of blue LEDs on catch composition and the effectiveness of catching the main target of crab (Portunus pelagicus). A fishing trial was conducted in Brondong, Lamongan waters to examine the influence of blue LED lights on crab catches. A total of 54 pots were deployed, consisting of 18 pots with fish bait (U) as control, 18 pots with blue LED light (L), and 18 pots with a combination of fish bait and blue LED (LU). The results showed that the LU treatment yielded the highest number of species, with a total of 13 species, followed by the U treatment, with 10 species, and the L treatment, with 9 species. The LU treatment had the highest catch of 48 fish (3,718 g), followed by U with 43 fish (3,448 g) and L with 5 fish (208 g). Statistical analysis revealed no significant differences between the LU and U (control) treatments in terms of both catch number and weight. The highest catchable width distribution in treatment U was 88%, while the highest catchable weight distribution in treatment LU was 75%. The analysis of crab-catching effectiveness analysis showed that the LU treatment had the highest average effectiveness of 13%, followed by the U treatment at 11%, and the lowest was the L treatment at 1%. In conclusion, LED lights do not affect the catch, however, adding LED lights to the bait can increase the number of species caught, the number of individuals, the weight of the catch, and the effectiveness of catching kingfish (P. pelagicus).*

***Keywords:*** *Blue light, catchable distribution, effectiveness, bait*

## INTRODUCTION

Crab (*Portunus pelagicus*) is one of Indonesia's leading export commodities. According to statistical data (KKP 2022 a), crab exports amounted to 29,177 tons, worth US$ 484 million in 2022. The high demand for fresh and processed crab products results in high selling prices for fresh and processed crab products. This condition increased crab exploitation (Adam *et al.,* 2016; Istrianto *et al*., 2021). Blue swimming crabs (BSC) are usually caught by fishermen using pots. The pot is operated passively by using bait to trap the trapped crabs (Zulkarnain *et al.,* 2019). Generally, fishers use fish as natural bait to attract BSC (Tallo, 2015). Commonly used baits are sardines (*Sardinella sp.*) and horsefish (*Leiognathus spp.*) (Widowati *et al.,* 2015)

However, due to the decline in production, fishers need help finding fish for bait. This scarcity occurred in several areas, such as Banten Bay, Cirebon, and Lamongan. The availability of sardines in Lamongan and Gebang Mekar, Cirebon, and the productivity of tuna in Banten Bay have decreased (KKP, 2022b; Yusfiandayani *et al.*, 2023). Fishers in Sedayulawas Village, Lamongan Regency, experience this situation. Under certain conditions, fisher need help to get fish as bait. This is due to the fishing season, declining fish production, and high demand for fish processing in Lamongan. According to data from Lamongan District Fisheries Office (2022), the production of sardines and scads has decreased over the last 2-3 years. The fish processing industry in Lamongan Regency, with products such as frozen fish, surimi, and fishmeal, requires a total average production capacity of 15,413 tons per year (Hidayah *et al.,* 2022). This will lead to scarcity, and collapsible pot fishers will need to help find fish to meet bait needs.

Meanwhile, light-emitting diode (LED) technology has been utilized and developed to attract potted mud crabs (Susanto *et al.,* 2022; Nguyen & Winger, 2019). LED lights on crabs can increase the effectiveness of catches with a faster duration of immersion time and can substitute natural bait (Nguyen *et al.,* 2017; Nguyen *et al.,* 2019). Similar research has been conducted in Indonesia, namely by Hasly *et al.* (2019) and Susanto *et al.* (2022), who tested the attractiveness and response speed of BSC to different LED colors (blue, green, white, orange, purple, and red) and natural bait, which resulted in that BSC had the highest attractiveness and response speed to blue LEDs. In this case, using blue LED lights effectively attracts BSCs. However, the study was only conducted on a laboratory scale, where the research was conducted under highly controlled conditions, without the influence of currents, waves, or water turbidity.

The problem in this study was that LEDs developed from laboratory research provided recommendations that blue LEDs could be used as attractants to attract BSC. However, the research was only conducted in the laboratory and not on a field scale. Therefore, this study implements the research conducted in the laboratory to confirm whether LEDs affect catch. This study aims to identify the composition of the catch and determine the effectiveness of blue LED lights on the catch of BSC (*P. pelagicus*). This study is expected to provide benefits in the form of information on the effect of LED lights on BSC catch. It can be a reference for academics, researchers, and stakeholders in developing BSC fishing technology.

## METHODS

The research was conducted from December 2023 to January 2024 at Brondong Fishing Port, Sedayulawas Village, Brondong Subdistrict, Lamongan Regency (Indonesia) as a fish landing base, and the northern waters of Brondong Subdistrict as a fishing area (Figure1).

### Data collection

This study used an experimental fishing method that followed fishermen's fishing operations for one day. Experimental fishing was conducted using pots with three treatments: lights and natural bait (LU), lights only (L), and natural bait only (U) as the control.

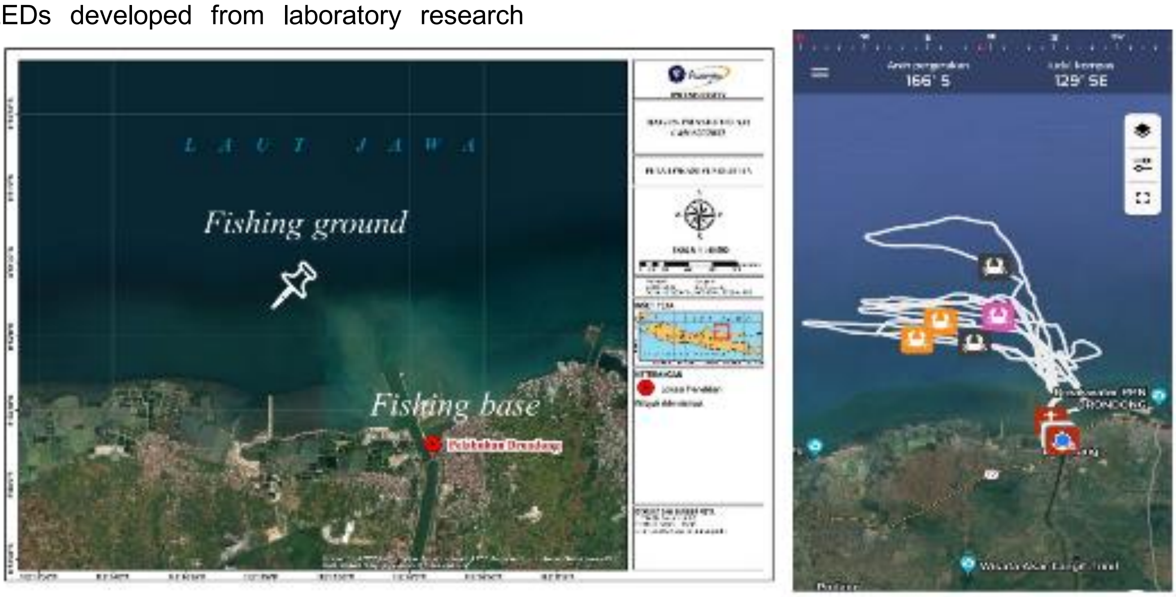


Figure1 Experimental site of BSC fishing operation using collapsible pots with the fishing base at Brondong Fishing Port, Lamongan, East Java, Indonesia

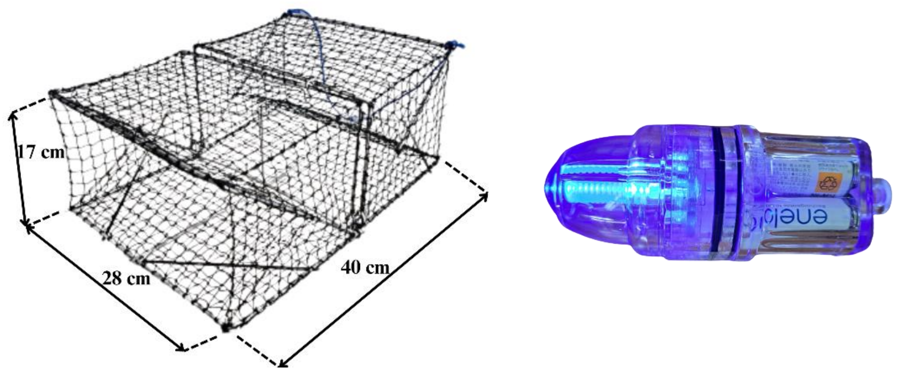


Figure 2 Shape and Dimension of the pots and LED lights used in the fishing experiment

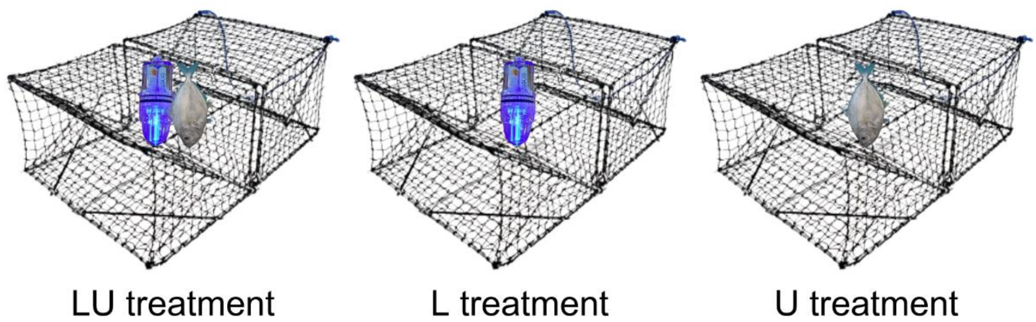


Figure 3 Placement of LED lights and natural bait in pots, light and bait (LU treatment), Light (L treatment), and bait (U treatment)

The pots used were fisherman pots made of stainless steel wire (mesh size 2 cm, 40× 28× 17 cm), with a total of 54 units consisting of 18 units per treatment. Blue LED lamp brand Jiohong model 204, specifications: IP67 waterproof level, 0.5 A current, 2.4 V voltage, 110 mm length, 460 nm peak wavelength, and 2.0 µW intensity $^{(-2)}$ (Figure 2). The LED Light has two rechargeable AA-type batteries for each capture operation. The batteries used are Doublepow, 3,000 mAh capacity, and 1.2 V voltage. The fishermen own the natural bait in the form of seahorse fish measuring 5.5 - 7.0 cm with a weight of 30 - 58 g. The LED lights are mounted on a bait mounting frame. The LED lights are mounted on a natural bait mounting frame, as shown inFigure 3.

**Field experiment procedure**

Field operations and data collection were conducted at ±5 nautical miles from the fishing ground to the fishing base with a travel time of ±1 hour. Data were collected at the setting, soaking, and transportation stages. The setting time of the treatment pots was 12:00 - 12:30 pm, soaking for ± 12 hours, and transportation of the treatment pots at 01:00 - 01:30 pm. Setting, soaking, and transportation were done once on each fishing trip. All treatments were set up, soaked, and transported simultaneously. A practice strictly followed to maintain uniform environmental conditions and minimize external variables that could affect results. The time uniformity of each process is critical as this ensures that light treatments can be accurately compared to other treatments under the same conditions. This scientific rigor guarantees that any differences in catch are solely due to the treatment, not variations in fishing time.

Treatment pots were installed in the last set of fisherman pots. The distance between treatment pots was 13-15 m, with a set length of 3.4 mFigure 4). Data were collected during 20 fishing trips according to the minimum number of repetitions, based on Federer's formula:

$(r-1)(n-1) \geq 15$ .......................................... (1)

With:
$r$ = number of treatments
$n$ = number of replications

Table 1 Experimental design and setting coordination points during experimental fishing

| Observation Time (days/travel) | Randomization | Setting Coordinate Point | |
|---|---|---|---|
| | | Latitude | Longitude |
| 1 | $B_1$ - $B_2$ - $B_3$ | -6,835426 | 112,223419 |
| 2 | $B_1$ - $B_2$ - $B_3$ | -6,827136 | 112,221456 |
| 3 | $B_2$ - $B_3$ - $B_1$ | -6,828013 | 112,235005 |
| 4 | $B_2$ - $B_3$ - $B_1$ | -6,829935 | 112,228687 |
| 5 | $B_3$ - $B_1$ - $B_{(2)}$ | -6,828027 | 112,232117 |
| 6 | $B_3$ - $B_1$ - $B_{(2)}$ | -6,829384 | 112,227921 |
| 7 | $B_1$ - $B_3$ - $B_2$ | -6,833841 | 112,225842 |
| 8 | $B_1$ - $B_3$ - $B_2$ | -6,842021 | 112,22315 |
| 9 | $B_2$ - $B_1$ - $B_3$ | -6,841473 | 112,222941 |
| 10 | $B_2$ - $B_1$ - $B_3$ | -6,841196 | 112,221924 |
| 11 | $B_3$ - $B_2$ - $B_{(1)}$ | -6,839497 | 112,216196 |
| 12 | $B_3$ - $B_2$ - $B_{(1)}$ | -6,81139 | 112,22846 |
| 13 | $B_1$ - $B_2$ - $B_3$ | -6,832251 | 112,224474 |
| 14 | $B_1$ - $B_2$ - $B_3$ | -6,837422 | 112,228078 |
| 15 | $B_2$ - $B_3$ - $B_1$ | -6,843964 | 112,227961 |
| 16 | $B_2$ - $B_3$ - $B_1$ | -6,837758 | 112,220591 |
| 17 | $B_3$ - $B_1$ - $B_{(2)}$ | -6,840928 | 112,22198 |
| 18 | $B_3$ - $B_1$ - $B_{(2)}$ | -6,833265 | 112,219194 |
| 19 | $B_1$ - $B_3$ - $B_2$ | -6,834724 | 112,219513 |
| 20 | $B_1$ - $B_3$ - $B_2$ | -6,826169 | 112,19726 |

Description: $B_1$: LU treatment; $B_{(2)}$, L treatment; $B_3$, U treatment.

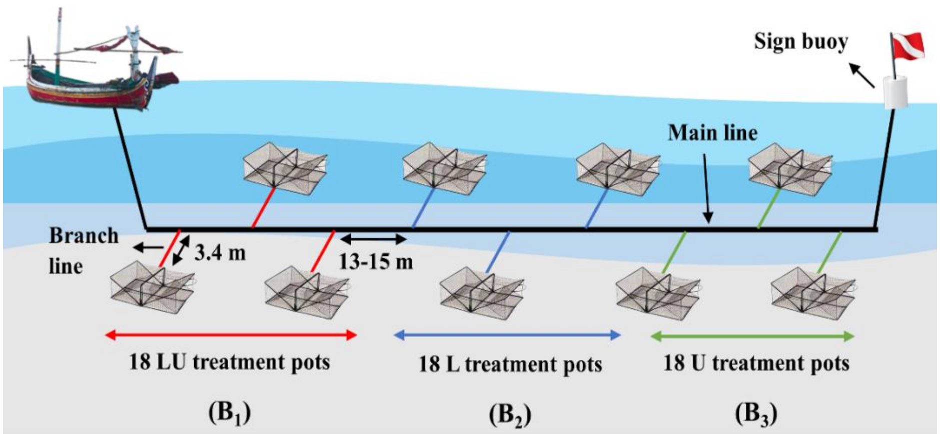


Figure 4 Number of treatment pots and randomization of treatment pots

The experimental design was a one-factor, completely randomized design (CRD) consisting of three treatment levels: lights and natural bait, lights only, and bait only (control). Randomization was done systematically per 2x trips at different locations to provide equal opportunity in 20 replicatesTable 1) and (Figure 4

Table 2 Catch size and weight composition

| Common Name | Species | Total catch (individuals) | | | Catchweight (g) | | |
|---|---|---|---|---|---|---|---|
| | | LU | L | U | LU | L | U |
| Blue swimming crab | *Portunus pelagicus* | 48 | 5 | 43 | 3,718 | 208 | 3,448 |
| Guardian crab | *Podophthalmus vigil* | 12 | 0 | 15 | 728 | 0 | 852 |
| Crab cross | *Charybdis feriatus* | 3 | 1 | 1 | 279 | 65 | 36 |
| Oceanic rowing crab | *Charybdis anisodon* | 119 | 41 | 52 | 2,429 | 649 | 932 |
| Spider crab | *Libinia emarginata* | 0 | 0 | 1 | 0 | 0 | 100 |
| Square-shelled crab | *Galene bispinosa* | 5 | 1 | 15 | 433 | 46 | 907 |
| Praying mantis Shrimp | *Harpiosquilla harpax* | 4 | 1 | 5 | 114 | 17 | 193 |
| Shells | *Tonna galea* | 1 | 0 | 0 | 44 | 0 | 0 |
| Squid | *Sepia officinalis* | 1 | 2 | 0 | 172 | 34 | 0 |
| Grouper | *Epinephelus sexfasciatus* | 4 | 11 | 4 | 73 | 214 | 74 |
| Marble star Binoculars | *Batrachoides pacifici* | 0 | 0 | 2 | 0 | 0 | 191 |
| Croaker Fish | *Johnius carouna* | 2 | 0 | 0 | 211 | 0 | 0 |
| Large-scale grunter | *Therapon Therapy* | 8 | 43 | 6 | 118 | 675 | 82 |
| Ariid catfish | *Netuma thalassina* | 1 | 0 | 0 | 285 | 0 | 0 |
| Sharks | *Chiloscyllium punctatum* | 1 | 0 | 0 | 52 | 0 | 0 |
| Pufferfish | *Lagocephalus spadiceus* | 0 | 1 | 0 | 0 | 123 | 0 |
| **Total** | | **209** | **106** | **106** | **8,656** | **2,031** | **6,815** |

Description: LU (lamp and natural bait) L, (lamp); U (natural bait)

**Data analysis**

The first data analysis was used to determine the composition of the catch by using quantitative descriptive analysis to analyze the composition of the catch, the distribution of the length and weight of the main catch of mackerel (*P. pelagicus*), and the relationship between the length and weight of mackerel (*P. pelagicus*). Statistical analysis in this study used the Kruskal-Wallis test and the Wilcoxon paired test to determine differences in the number and weight of the main catch of mackerel (*P. pelagicus*) between treatments using the Statistical Analysis System (SAS) program.

The second data analysis was used to determine the effectiveness of catching kite fish (*P. pelagicus*) by using the average fishing effectiveness formula with the equation (Saputra *et al.,* 2023)

$$Ef = \frac{Ku}{TB} \times 100\% \quad \text{.......................................} \quad (2)$$

with:

*Ef* : Effectiveness of deployment
*Ku* : Number of traps that caught crabs/trip
*TB* : Number of traps used/trip

## RESULTS

**Composition of catch**

The catch composition (Table 1 2) included 16 species. The LU, L, and L treatments had the highest catches of 13, 9, and 10 species, respectively. In the LU treatment, the most caught species was the mangrove crab (*Charybdis anisodon*) with 119 individuals, while by weight, BSC (*Portunus pelagicus*) was the highest with a weight of 3,718g.

Figure 5 compares the primary catch of BSC (*P. pelagicus*) in each treatment, totalling 96 individuals weighing 7,374g. The LU treatment had the highest catch compared to the other two treatments regarding number and weight. The LU treatment produced 48 individuals (50%), the U treatment 43 individuals (45%), and the L treatment five individuals (5%). In terms of weight, the LU treatment produced 3,718 g (50%), the U treatment produced 3,448 g (47%), and the L treatment was only 208 g (3%).

Based on the Kruskal-Wallis statistical test with the number and body weight variables in each treatment, the sig. value was P<0.05. There was a significant difference between the three treatments based on the number and body weight variables. Furthermore, further tests were carried out.

The Wilcoxon paired test on the number and weight variablesFigure 5 5) showed that the relationship between the LU treatment and the L treatment and between the L treatment and the U treatment was P<0.05, indicating that the relationship between the treatments was significantly different. The relationship between the LU treatment and the U treatment was P>0.05, indicating that the relationship between the two treatments was not significantly different.

Figure 6 compares the bycatch of each treatment with a total of 363 individuals and a weight of 10,128 g. The LU treatment obtained the highest number and weight compared to the other two treatments. Regarding numbers, the LU treatment obtained 44% (161 individuals), while the U and L treatments each obtained 28% (101 individuals). In terms of weight, the LU treatment obtained 49% (4,938 g), the U treatment obtained 33% (3,367 g), and the L treatment only obtained 18% (1,823 g).

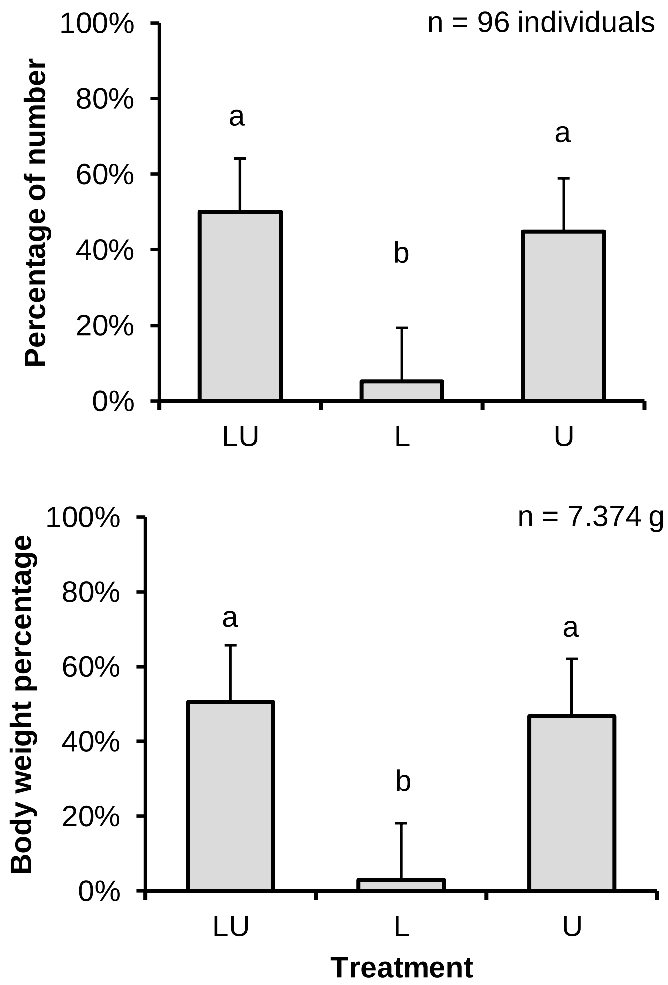


Figure 5 Comparison of the number and weight of BSC (*P. pelagicus*) main catches. LU (lights and natural bait); L (lights only); U (natural bait only). Different superscript letters (a, b) in the graph indicate significantly different results (P<0.05).

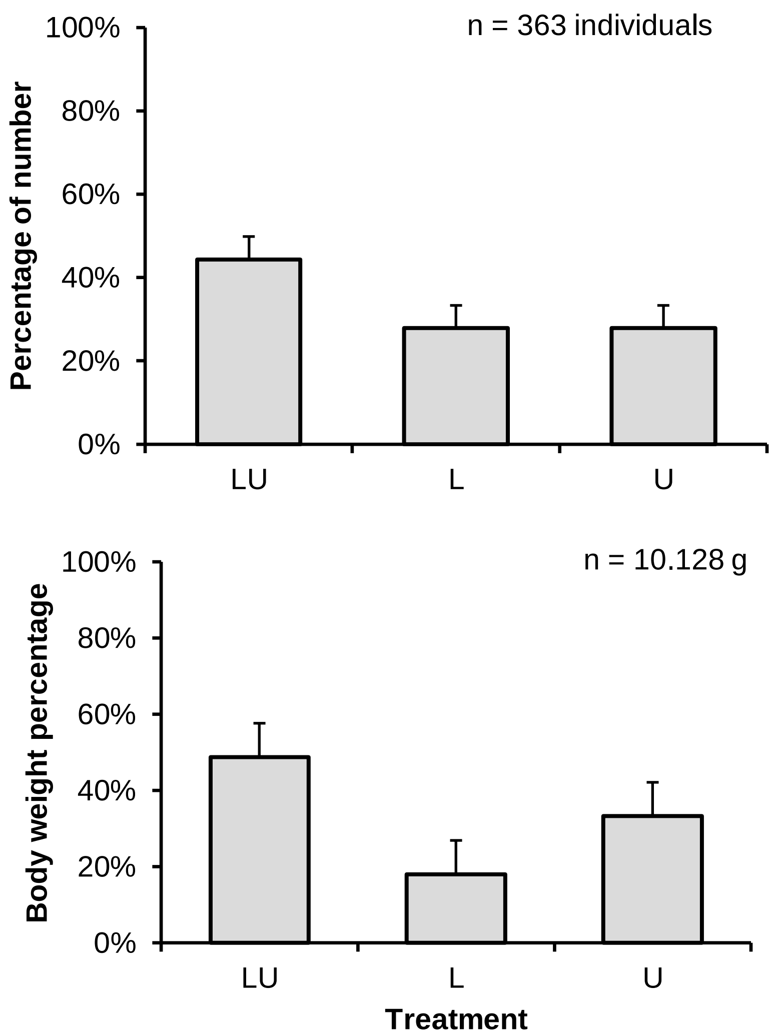


Figure 6 Comparison of bycatch number and weight. LU (lights and natural bait); L (lights only); U (natural bait only)

**Width and weight distribution of BSC (*P. pelagicus*)**

The frequency of carapace width distribution was highest in treatment LU, with an average width of 118 mm (11 individuals); treatment L, with an average width of 88 mm and 98 mm (2 individuals); and treatment U, with an average width of 128 mm (13 individuals) (Figure 7 a). The highest weight distribution frequency was found in treatment LU, with an average weight of 75 g (14 individuals); treatment L, with an average weight of 35 g and 55 g (2 individuals); and treatment U, with an average weight of 55 g (13 individuals) (Figure 7 b).

According to Regulation No. 7 (2024) of the Ministry of Maritime Affairs and Fisheries, the management of lobsters (*Panulirus spp.*), crabs (*Scylla spp.*), and crabs (*Portunus spp.*) allow the capture of crabs under certain conditions. These conditions include catching crabs that are not in spawning condition and are more significant than 10 cm (100 mm) or weigh more than 60 g. Data showed that the natural bait treatment resulted in the highest percentage of captured carapace width at 88% (38 out of 43 individuals). This was followed by the lamp and bait treatment with 79% (38 out of 48 individuals) and the lamp treatment with 20% (1 out of 5 individuals). Similarly, in terms of weight, the lamp and natural bait treatment produced the highest catch weight at 75% (36 out of 48 individuals). This was followed by the natural bait treatment at 70% (30 out of 43 individuals) and the lamp treatment at 20% (1 out of 5 individuals).

**The average effectiveness of the capture**

The average capture effectiveness value was calculated by dividing the number

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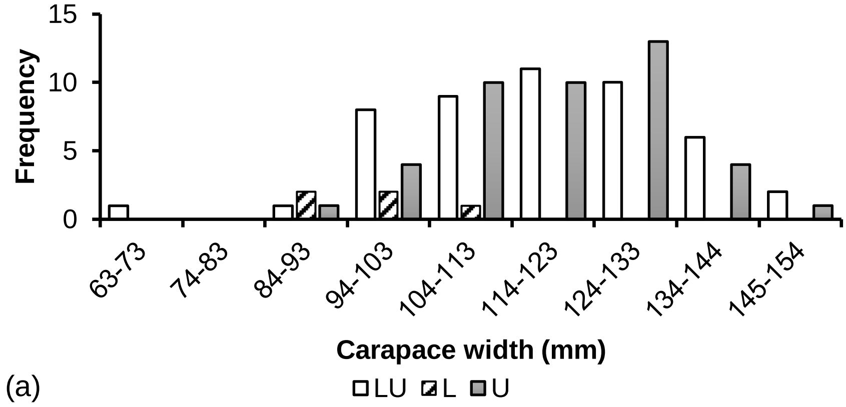
of traps that captured BSC in each treatment/trip by the total number of traps used in each treatment/trip, expressed as a percentage, over 20 trips. Figure *8* shows the average percentage of effectiveness of the traps for each treatment. Treatment LU outperformed treatments U and L, with an average effectiveness of 13%, compared to 11% and 1%, respectively.



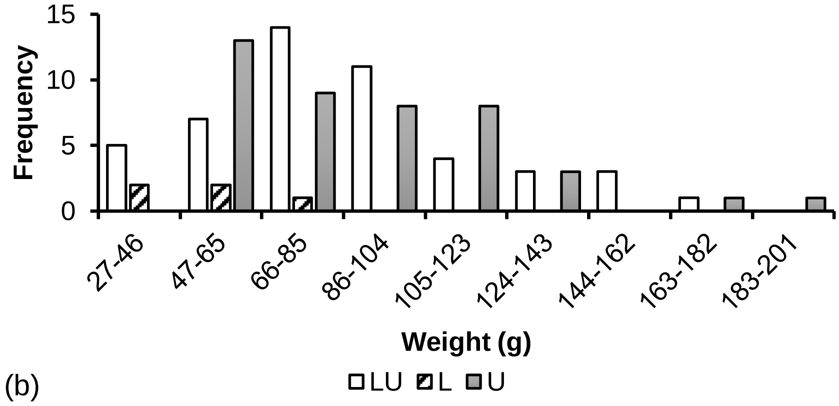




Figure 7 (a) Carapace width distribution and (b) weight distribution of BSC (*P. pelagicus*). LU (lamp and natural bait); L (lamp); U (natural bait)

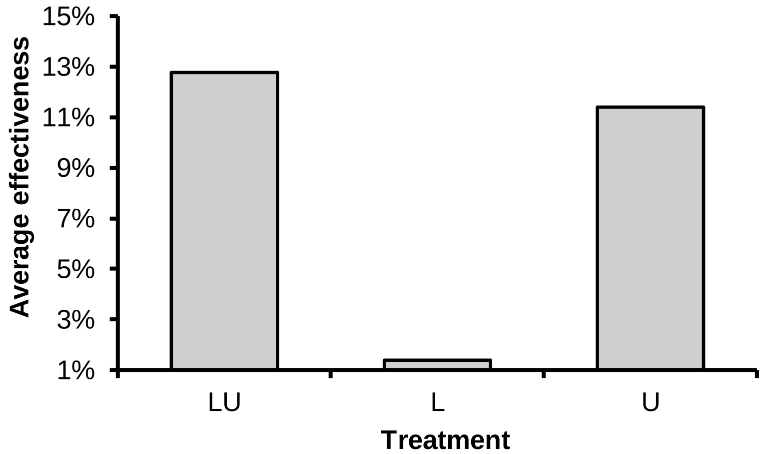



Figure 8 Mean capture effectiveness of BSC (*P. pelagicus*). LU (lights and natural bait); L (lights); U (natural bait)

## DISCUSSION

The higher catch in the Light and natural bait treatment (LU treatment) was because this treatment utilized the response of the senses of sight and smell. Most fish respond to objects that move and have shapes, smells, and colors around their environment through the senses of smell and sight. (Bleckmann 2024) . LED lights, as attractants, increase the diversity of species caught because fish are attracted to Light with varying or specific intensities and wavelengths. (Alwi *et al.* 2014; Koten *et al.* 2024) . This is because most reef and demersal fishes are predators and are attracted to Light. They use their sense of sight and smell to forage and adapt to their environment (Reppie *et al.*, 2016). Crustaceans have different abilities to receive Light depending on the class and species, which is related to the receptor function of each crustacean (Waters & Angreni, 2023). LED Light can affect crab behavior when approaching and trapped in pots (Nguyen *et al.*, 2017)

The main catch was BSC (*P. pelagicus*), while the bycatch was caught other than BSC (*P. pelagicus*). The main catch of BSC (*P. pelagicus*) obtained from each treatment was less than the bycatch. However, the main catch of BSC (*P. pelagicus*) had the highest weight. Lower catches with high weights are better than higher catches with low weights. This is related to the economic value of the catch, which is calculated by weight. It also indicates that the catch is already large or fishable. The fishing season for BSC in Indonesia usually occurs in the western season (Ekawati *et al.*, 2019). At the time of data collection, December-January was a long transition season (October- January), causing a decline in BSC production in Lamongan. BSC production decreases annually from October to March (Ihsan *et al.*, 2014)

Combining LED lights with natural bait increased the number and weight of BSC caught, but not significantly compared to using natural bait. In contrast, LED lights did not affect BSC catch compared to combining LED lights with natural bait and natural bait alone. At the beginning of immersion (in this case, at noon), the natural bait effectively dispersed odor to attract BSC. However, the effectiveness of the natural bait odor decreased as time passed. The amino acid content of the natural bait decreases with the length of time the bait is immersed, which causes the stimulus to the BSCs to decrease, thus causing the BSCs to become disinterested (Rahman *et al.* (Rahman *et al.*, 2015). Adding LED lights to the natural bait can be an additional attractant to stimulate BSCs through their sense of sight during nighttime immersion. Histologically, BSC eyes are sensitive to blue LED light in the dark (Susanto *et al.*, 2022). Baited traps resulted in higher catches than unbaited traps when the immersion duration was short, whereas light-baited traps performed better when the immersion duration was more prolonged (Nguyen *et al.*, 2017).

In this study, the short duration of nighttime immersion attracted only a few BSCs. In addition, new activity patterns have not been established in the crab environment in response to pot changes (Zulkarnain *et al.*, 2019); in this case, LED lights affect crab attraction. This finding aligns with the study of *Ibaad et al.* (2022), who concluded that flickering blue LED lights did not significantly affect the catch of BSC. However, this contradicts the findings of Nguyen *et al.* (2017), who found that adding Light to bait can increase the catch.

All treatments were dominated by oceanic paddle crabs (*C. anisodon*). Oceanic paddle crabs are small, with a maximum carapace width of 8 cm. Paddle crabs have little economic value but will still be used for sale to collectors if there are many. However, if only a small amount is obtained, these crabs will be thrown back into the sea (Hamid and Wardiyatno, 2018).

According to Regulation No. 7 (2024) of the Ministry of Maritime Affairs and Fisheries, the management of lobsters (*Panulirus spp*.), crabs (*Scylla spp*.), and mangrove crabs (*Portunus spp*.) allow the capture of crabs under certain conditions. These conditions include catching crabs that are not spawning and are more than 10 cm (100 mm) in size or weigh more than 60g. Overall, the results showed that the BSC caught were not in spawning condition. The BSC spawning season occurs between May and September, peaking in August (Ihsan *et al.*, 2014). Based on carapace width, the percentage caught in the LU treatment (79%) was lower than the U treatment (88%), but based on weight, the percentage caught in the LU treatment (75%) was higher than the U treatment (70%). These results indicate that adding LED lights to the bait is classified as having a high percentage of catchability in carapace width and weight. Blue LED lights can increase the catch of heavier crabs when combined with bait. This suggests that adding blue LED lights to bait is more efficient for catching adult crabs that meet the catchable criteria.

The lamp and natural bait treatments obtained an average effectiveness of 13% and the natural bait treatment of 11%, while the lamp treatment only amounted to 1%. The lamp and bait treatments had higher capture effectiveness than the other treatments. During the long transitional season (October-January), when there is a decline in BSC production, the effectiveness of the traps used by fishermen can only reach an average effectiveness of 12-15% for each set of traps (one set totalling 70-100 units of traps). In this case, the light and bait treatments had the same effectiveness as the fishermen's pots. The effectiveness of pot fishing gear can be influenced by bait as an attractant to attract targets to enter and be trapped in the pot (Kurniadi *et al.*, 2022). In addition, it is affected by several factors, such as behavioral patterns, population abundance, and environmental conditions (Nihe *et al.*, 2017).

The results showed that BSC catches were low because the study was conducted during the transitional season. This resulted in decreased BSC production and the relatively short immersion time and duration at night. Immersion refers to when the fishing gear is left in the water, and this short immersion time resulted in the low effectiveness of the LED lights in attracting BSC. Therefore, further research must be conducted during the BSC fishing season to ensure higher catches. In addition, fishing operations at the time of setting and hauling were carried out at night with a soaking time of ± 24 hours to compare more night time than daytime because LED lights are more effective at night.

## CONCLUSION

The lamp and natural bait treatment had more species than the lamp and natural bait treatment, with 13 species. The highest main catch ratios in the lamp and natural bait treatments were 50% by number and 50% by weight, while the highest bycatch ratios in the lamp and natural bait treatments were 44% and 49%, respectively. According to Minister of Marine Affairs and Fisheries Regulation No. 7 (2024), the highest catch width distribution was in the natural bait (U) treatment at 88%, while the highest catch weight distribution was in the lamp and natural bait (LU) treatments at 75%. The highest capture effectiveness of 13%% was observed in the lamp and natural bait (LU) treatments. LED lights did not affect the catch, but adding LED lights to the bait can increase the number of species caught, the number of individuals, the weight of the catch, and the effectiveness of catching kite fish (*P. pelagicus*).

## SUGGESTION

Further research is needed to improve catches during the BSC fishing season. Deployment and transportation operations should be conducted at night as Light is more effective, allowing a better comparison between night and daytime catches.

## ACKNOWLEDGMENTS

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