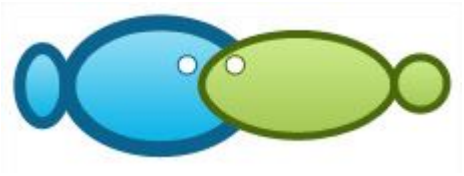

Effect of two different LED lights on catches composition of the stationary lift net from Banyuasin estuarine, South Sumatra, Indonesia

Fauziyah, Vivi L. Manalu, Anna I. S. Purwiyanto, Fitri Agustriani, Wike A. E. Putri, Rozirwan

Marine Science Department, Faculty of Mathematics and Natural Sciences, Sriwijaya University, Ogan Ilir Regency, Province of South Sumatra, Indonesia.
Corresponding author: A. I. S. Purwiyanto, anna_is_purwiyanto@unsri.ac.id

Abstract. This stud aimed to select a light intensity of the LED lamp introduced in the stationary lift net for targeting anchovies and squids. Two light intensities of the LED lamps were introduced and a kerosene lamp was used as a control treatment. The target and non-target catch for the LED-P1 (315 lux), LED-P2 (378 lux), and a kerosene lamp (261 lux) was recorded. Non-parametric analysis was used for selecting the optimal lamp type. The results indicated that the target catch for the LED-P1, LED-P2, and control lamp was 94.20 kg, 20.12 kg, and 76.23 kg, respectively. While the non-target catch using LED-P1, LED-P2, and control lamp was 21.55 kg, 17.90 kg, and 21.92 kg, respectively. There was a significant difference in the weight of target catch between the experimented lamp types (Kruskal–Wallis test, $p = 0.012 < 0.05$); however, there was no significant difference in the weight of non-target catch (Kruskal–Wallis test, $p = 0.513 > 0.05$). Statistical differences in anchovies or squid catch among the treatments were discussed more detailed based on the Mann-Whitney U test. The yellow light LED lamp with 315 lux light intensity (LED-P1) was the optimal light intensity to replace the kerosene lamp in the stationary lift net fishery. These results could provide useful recommendations for adopting selective light fishing.
Key Words: lamp type, light intensity, non-target catch, target catch.

Introduction. An artificial light device (ALD) has been used a thousand years ago in the world of fishing and it has even been applied in commercial industrialized fishing (Nguyen & Winger 2019). This technology development ranged from the use of traditional illumination systems (torches and kerosene lamps) to modern illumination systems (gas, chemical, and electrical lamps). The ALD is essential to attract small pelagic fish which then accumulates in the catchable area of the fishing gear. Generally, a fish's reaction to the light is schooling and moving forward to the light source. Fishing with the ALD is one of the successful methods and most advanced for increasing the catch rate of pelagic fish and squid (Yamashita et al 2012; Nguyen & Winger 2019). Further, light fishing (underwater or over the net) also has successfully attracted some targeted catch (Sokimi & Beverly 2010; Okpala et al 2017).

In Indonesia, the light fishing methods have been employed on the lift net, traps, purse seine, and other fishing gear. During recent decades, the light fishing studies on the lift net have addressed issues such as light fishing intensity (Puspito et al 2015; Sumardi et al 2019), the light types (Sulaiman et al 2015; Susanto et al 2017; Fuad et al 2019), the LED light color (Sugandi et al 2019; Sudirman et al 2020), and fish behavior on the light fishing process (Angreni et al 2020). Light intensity is one of the lamp's physical characteristics that affect the attraction level of catch species (Marchesan et al 2005), but the types of light sources have no significant influence on catch composition (Mgana et al 2019). In the stationary lift net, the use of LED lights harvested in a higher total catch than the kerosene lights (Fuad et al 2019). In the millennium lighting, shifting the traditional systems to LED light systems influence the use of light sources in the ALD

systems. The main challenge in light fishing is how it successfully attracts the target catch and possibly reduces non-target catch.

In Banyuasin of South Sumatra, the stationary lift net is the major fishing gear using the ALD for targeting anchovies and squids. All these gears are equipped with kerosene lamps as the ALD, and optimizing the techniques of this light fishing is a new challenge in these waters. The main issues are inefficient light production, particularly the fuel consumption, and CO_2 emissions of the kerosene lamps. Therefore, comparing the use of kerosene lamps and LED lamps on this fishing gear is essential. In this study, the target species is hypothesized to have a light intensity preference. This study aims to select a light intensity of the LED lamp introduced in the stationary lift net for targeting anchovies and squids. This study is expected to provide a better acknowledgment for the optimum light fishing on stationary lift net fishing.

Material and Method

Sampling. A total of 40 trips on three stationary lift nets were surveyed in Banyuasin estuarine of South Sumatra (Indonesia) in November 2019 (Figure 1). Three similar stationary lift nets at these waters were used to establish the lamp type effect on catches. The first LED system (LED-P1) was designed using two yellow light LED (315 lux) and the second LED (LED-P2) was designed using three yellow light LED (378 lux) whereas the traditional kerosene lamp (261 lux) was used as a control treatment (Figure 2). The daily catch data (during 12 to 14 days per fishing unit) was weighed using digital scales. The catch was categorized into a target (anchovy and squid) and a non-target catch (others fish). These categories were following the fishermen's decisions about the catch. All observations and measurements were carried out at the night after hauling.

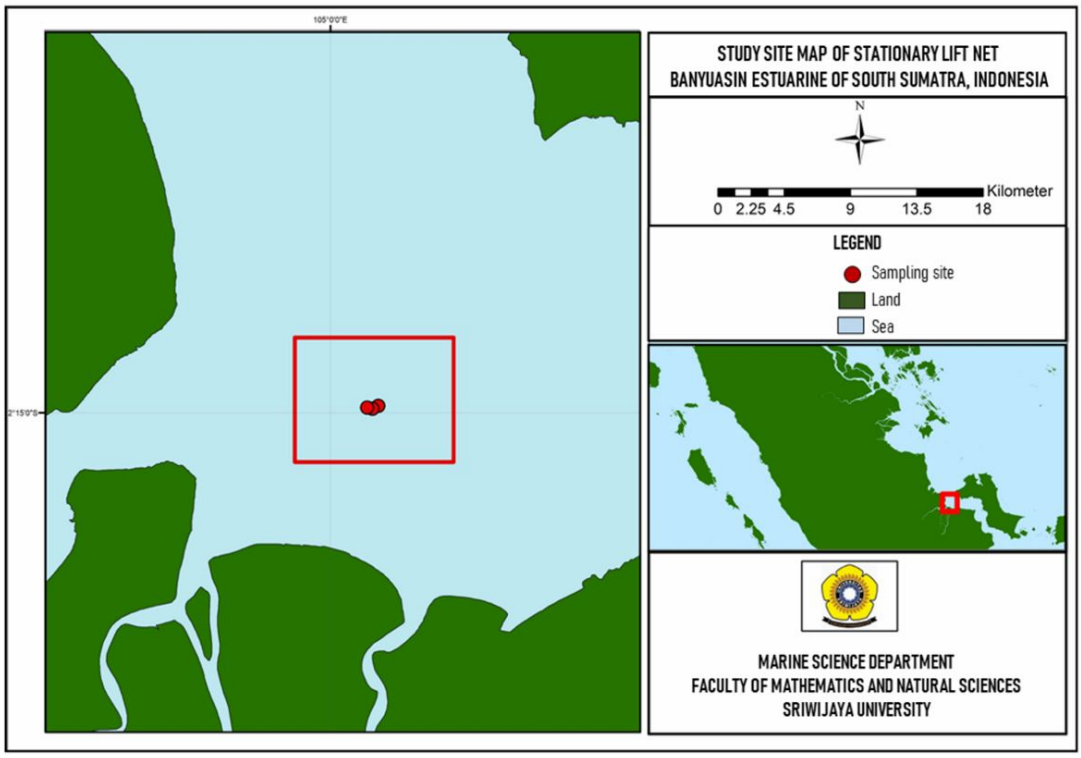

Figure 1. Map of the study location in Banyuasin estuarine of South Sumatra, Indonesia. The distance between the control treatment and LED-P1, control treatment and LEP-P2 as well as LED-P1 and LED P2 treatments are 394 m, 755 m, and 361 m, respectively.

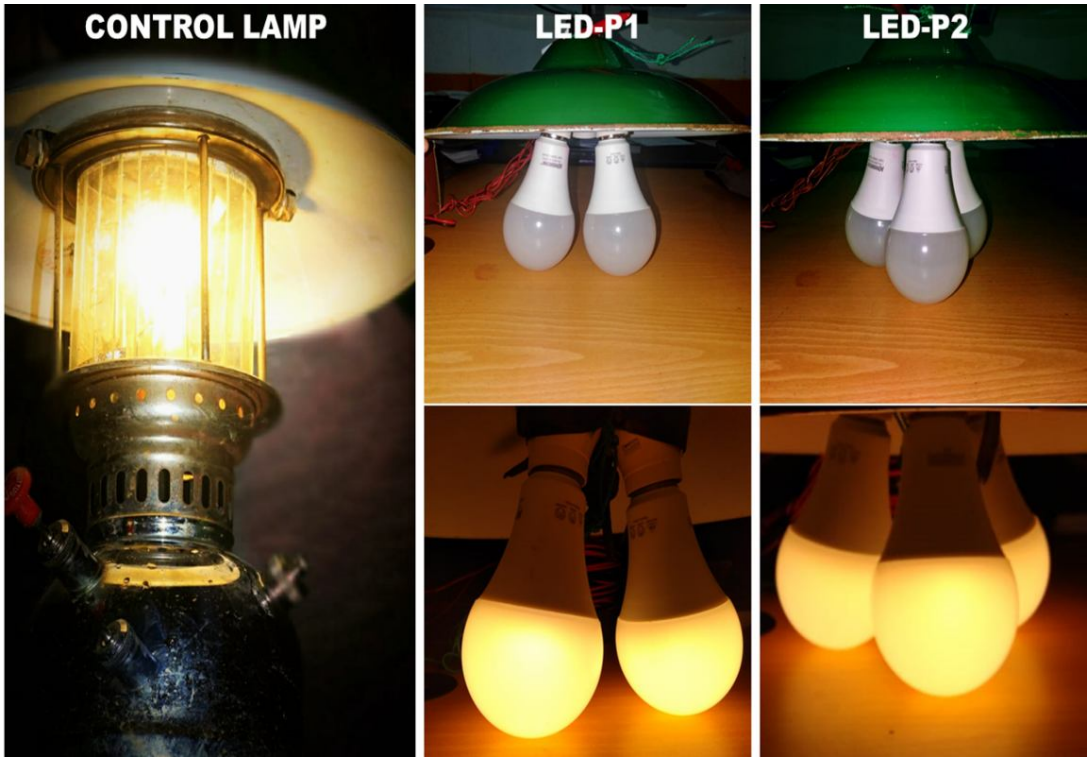

Figure 2. Designing lamp types of stationary lift net used in this experiment. The traditional kerosene lamps were used as a control treatment (left), and two LED types (center and right) as LED treatments.

Data analysis. For estimating the effect of lamp types on target and non-target catch, we have used non-parametric analysis based on the Kruskal-Wallis test (Ostertagová et al 2014; Vieira et al 2017). This test was applied to check the statistical differences between the experimented lamp types on the target and non-target catch. Additionally, the Mann-Whitney U-test was adopted for comparing statistical differences between two groups of experiments and selected the optimal experiments (Thurstan et al 2017; Vieira et al 2017). A significance level of 0.05 and two-tailed distributions were applied for both tests. Both tests were performed by using SPSS 21 software.

Results. During the study, the total catches for all treatments were recorded at 251.92 kg (Table 1). The total catches for the control, LED-P1, and LED-P2 treatments were 98.15 kg, 115.75 kg, and 38.01 kg respectively. The daily catch of control treatment ranged from 0.82 to 22.38 kg (mean 7.01 kg), and LED-P1 treatment varied from 0.47 to 25.03 kg (mean 8.27 kg), whereas LED-P2 treatment ranged from 0.53 to 7.05 kg (mean 3.17 kg).

For catch composition (Figure 3), the LED-P1 treatment yielded the highest in weight than other treatments for both anchovies (63.24 kg or 55%) and squids (30.96 kg or 27%). The LED-P2 treatment harvested quantities of anchovies and squids were 6.43 kg (17%) and 13.69 kg (36%) respectively. While control treatment obtained 56.87 kg (58%) of anchovies and 19.36 kg (20%) of squids respectively. The total catches of non-target species for the control lamp, LED-P1, and LED-P2 treatment were 21.92 kg (22%), 21.54 kg (17%), and 17.89 kg (47%) respectively.

The Kruskal-Wallis test (Table 2) indicated that there was statistically significant difference between the target catch in weight for all treatments ($p = 0.012 < 0.05$), but there was no significant difference in weight for non-target catches ($p = 0.513 > 0.05$). The Mann-Whitney U-test (Table 3) revealed that the control lamp and LED-P2 had a significant difference in weight of target catches ($p = 0.021 < 0.05$) but conversely for the LED-P1 treatment ($p = 0.358 > 0.05$). A significant difference also was revealed between LED-P1 and LED-P2 treatment ($p = 0.007 < 0.05$). Between the control lamp and LED-P2 there was a significant difference in weight of the anchovies catches ($p =$

0.031 < 0.05) but conversely for the LED-P1 treatment (p = 0.890 > 0.05). No statistically significant difference in the anchovies catches weight was revealed between LED-P1 and LED-P2 treatments (p = 0.072 > 0.05). In term of the squids catches weight, there was no significant difference between the control lamp and LED-P2 treatment (p = 0.959 > 0.05) but conversely for LED-P1 treatment (p = 0.048 < 0.05), while between the LED-P1 and LED-P2 treatment there was a significant difference (p = 0.031 < 0.05).

Table 1

Summary details of the fishing experiment on stationary lift net with different lamp types

Trip	*Catches with control lamp (kg)*			*Catches with LED-P1 (kg)*			*Catches with LED-P2 (kg)*			*Total*
	Target	*Non-target*	*Total catch*	*Target*	*Non-target*	*Total catch*	*Target*	*Non-target*	*Total catch*	
1	1.33	0.19	1.52	1.05	0.94	1.99	1.28	0.62	1.90	5.41
2	21.75	0.63	22.38	23.91	1.12	25.03	1.45	0.27	1.72	49.13
3	4.68	1.15	5.83	7.26	1.26	8.52	0.84	0.94	1.79	16.13
4	2.05	0.38	2.43	7.96	0.84	8.80	NA	NA	NA	11.23
5	1.93	0.05	1.98	1.56	0.37	1.93	1.94	2.39	4.32	8.24
6	0.29	0.53	0.82	0.42	0.25	0.67	0.55	0.00	0.55	2.04
7	1.35	0.25	1.60	2.87	0.64	3.51	0.43	0.10	0.53	5.64
8	2.12	0.52	2.64	5.42	0.56	5.98	1.02	0.00	1.02	9.64
9	5.24	0.50	5.74	3.71	1.07	4.78	NA	NA	NA	10.52
10	2.42	6.82	9.24	2.52	0.21	2.74	1.82	5.23	7.05	19.02
11	10.75	1.32	12.07	3.77	2.23	6.00	4.34	0.00	4.34	22.41
12	8.67	2.61	11.28	8.33	3.27	11.60	1.70	0.42	2.12	25.00
13	12.28	6.84	19.12	12.59	6.49	19.08	3.97	2.68	6.65	44.85
14	1.37	0.13	1.50	12.83	2.30	15.13	0.78	5.25	6.02	22.66
Total	76.23	21.92	98.15	94.20	21.55	115.75	20.12	17.90	38.01	251.92
Mean	5.45	1.57	7.01	6.73	1.54	8.27	1.68	1.49	3.17	6.30

NA = no available data.

Table 2

Summary details of Kruskal Wallis Test for checking the statistical differences between the experimented lamps types on the target and non-target catch

Statistics[a]	*Target catch*	*Not-target catch*
Chi-Square	8.773	1.337
df	2	2
Asymp. Sig.	0.012^{S}	0.513^{NS}

a = Kruskal Wallis Test; S = significant difference; NS = no significant difference.

Table 3

Summary details of the Mann-Whitney U test for checking the statistical differences between two groups of experiments

Composition	*CL vs LED-P1*	*CL vs LED-P2*	*LED-P1 vs LED-P2*
Target catch	0.358^{NS}	0.021^{S}	0.007^{S}
Anchovies	0.890^{NS}	0.031^{S}	0.072^{NS}
Squids	0.048^{S}	0.959^{NS}	0.031^{S}

CL = kerosene lamps with the mean light intensity of 261 lux.

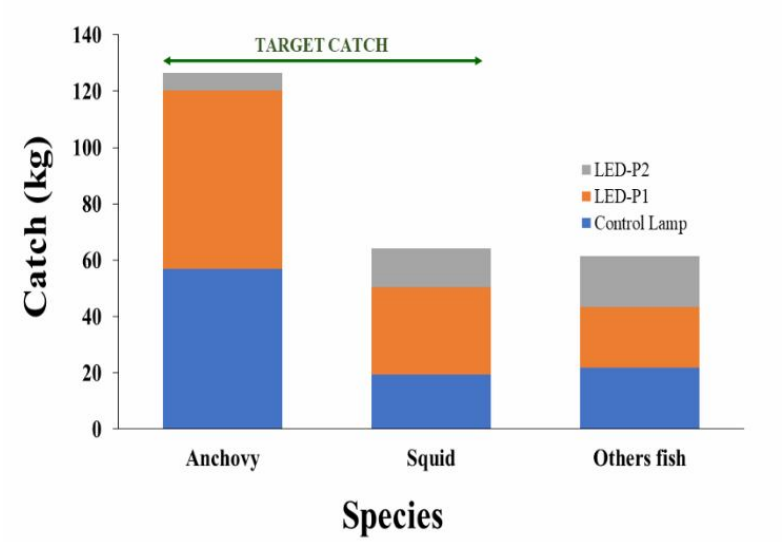

Figure 3. Species composition from the stationary lift net with different lamp types. Anchovies and squids were target catch while others fish as non-target catch. Target catches with LED-P1 were highest in weight of anchovies and squids.

Discussion. This experimental fishing addressed the problems of stationary lift net with traditional kerosene lamps and high kerosene prices that plagued the anchovy fishery in Banyuasin estuarine. Some fishermen have adapted to replace kerosene with diesel fuel. The LED lamps adoption on the stationary lift net in this study location required concrete evidence about the advantage of LED lamps compared to kerosene lamps and this replacement would be beneficial for fishermen. This adoption is encouraged by economic and technical considerations. The key factors that fishers consider in adopting LED technology for their light fishing are suitable design, easier to obtain, low prices, easier to use, as well as lightness, brightness, and durability of LED lamps (Susanto et al 2017; Mgana et al 2019). The performance of LED lamps is more compatible with bad weather conditions comparing to the kerosene lamps (Mgana et al 2019). This study was also intended to introduce the optimal LED light intensity for application in stationary lift nets.

The stationary lift net using LED-P1 had slightly higher target catches (no significant difference) compared to the stationary lift net using a kerosene lamp. But on the contrary, the use of LED-P1 lamps could capture higher target catches (statistically significant difference) compared to the stationary lift net equipped with LED-P2. The LED-P1 with slightly higher intensity (315 lux) compared to the kerosene lamp (261 lux) was a possible reason for this difference in target catches. The LED-P2 with higher intensity (378 lux) had captured much less in target catches compared to both kerosene lamps and LED-P1. This result indicated that there was a significant difference in the target catches between the different light intensities on the lamp types. On the contrary, the similar light intensity of the different lamp types had no significant effect on the target catches. These results revealed that the light intensity affected schooling. The schooling dissipation among fish species varies by light intensities (Higgs & Fuiman 1996). Besides, light possible either repel or attract fish due to its intensity (Okpala et al 2017). Exploiting strong lights intensity would not certainly be the most effective method to concentrate fish in the catchable area (Marchesan et al 2005). Besides, the catch per unit effort (CPUE) on light fishing fully possible be influenced by the predator presence (Liao et al 2007).

Anchovies and squids had prey-predator interactions, and these interactions possibly affected the target catches. In term of catches composition, the catches-weight comparison between anchovies and squid on the kerosene lamp, LED-P1, and LED-P2 treatments were 3:1, 3:2, and 1:3, respectively. Based on the anchovy catches, there was a significant difference between the kerosene lamp and LED-P2 but on the contrary, no significant difference between the kerosene lamp and LED-P1 as well as between the LED-P1 and LED-P2 treatments. In the term of squid catches, there was no significant

difference between the kerosene lamp and LED-P2 but on the contrary, there was a significant difference between the kerosene lamp and LED-P1 as well as between the LED-P1 and LED-P2 treatments. These results indicated that the squid abundance affected the anchovy abundance. Increasing the lamp light intensity would be increasing the relative abundance of squids (predators) and non-target catches.

The yellow LED-P1 light with 315 lux light intensity can be introduced on the stationary lift net with traditional kerosene lights. The stationary lift net with the LED-P1 light showed a higher result in the squid's catch than the stationary lift net with a kerosene light. The squids are more economically valuable than the anchovies. A study on the stationary lift nets in Banten Bay indicated similar results that the LED lights had a significant effect on the anchovy catch (Susanto et al 2017). Research in Lake Tanganyika of East Africa revealed that the LED lights application for light fishing resulted in only a slight increase in the catch (Mgana et al 2019). But research on several coastal areas in Indonesia indicated that LED lights application resulted in a more effective catch on the lift net fishing (Puspito et al 2015; Sudirman et al 2020).

Conclusions. The LED lights were the recommended artificial light device for substituting the traditional kerosene lights. This LED design was possible for developing on the stationary lift net in Banyuasin estuarine. Since catch species depend on the fish's interaction with light, further knowledge about the visual capabilities of target species is essential so that the by-catch can be minimized. Besides, variation in the artificial light positions on fishing gear and its influence on target catch under varying intensities is crucial for further investigation.

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Authors:
Fauziyah, Sriwijaya University, Faculty of Mathematics and Natural Sciences, Marine Science Department, Jl. Raya Palembang-Prabumulih KM. 32, Indralaya, Ogan Ilir Regency, Province of South Sumatra, Indonesia, e-mail: siti_fauziyah@yahoo.com
Vivi Lestari Manalu, Sriwijaya University, Faculty of Mathematics and Natural Sciences, Marine Science Department, Jl. Raya Palembang-Prabumulih KM. 32, Indralaya, Ogan Ilir Regency, Province of South Sumatra, Indonesia, e-mail: manaluvivi@gmail.com
Anna Ida Sunaryo Purwiyanto, Sriwijaya University, Faculty of Mathematics and Natural Sciences, Marine Science Department, Jl. Raya Palembang-Prabumulih KM. 32, Indralaya, Ogan Ilir Regency, Province of South Sumatra, Indonesia, e-mail: anna_is_purwiyanto@unsri.ac.id
Fitri Agustriani, Sriwijaya University, Faculty of Mathematics and Natural Sciences, Marine Science Department, Jl. Raya Palembang-Prabumulih KM. 32, Indralaya, Ogan Ilir Regency, Province of South Sumatra, Indonesia, e-mail: agustrianifitri@gmail.com
Wike Ayu Eka Putri, Sriwijaya University, Faculty of Mathematics and Natural Sciences, Marine Science Department, Jl. Raya Palembang-Prabumulih KM. 32, Indralaya, Ogan Ilir Regency, Province of South Sumatra, Indonesia, e-mail: wike.aep@gmail.com
Rozirwan, Sriwijaya University, Faculty of Mathematics and Natural Sciences, Marine Science Department, Jl. Raya Palembang-Prabumulih KM. 32, Indralaya, Ogan Ilir Regency, Province of South Sumatra, Indonesia, e-mail: rozirwan@gmail.com

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