Catch characteristics on stationary lift net using light emitting diode (LED) and kerosene lights in Pasuruan waters

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Abstract. Light in stationary lift nets (SLN) is important to the extent that it can determine the composition of species, size and number of fish caught. Different types of light are often used in aggregating certain types of fish. This study aims to find the best type of light for SLN and to determine the characteristics of the catch between light emitting diode (LED) and kerosene lights. The results showed that there were no significant differences in species composition of fish caught in both LED and kerosene lights. These types of lights do not affect the composition of fish species, but have a significant effect on the amount of catch. The most caught fish (target species) were short mackerel (*Rastrelliger brachysoma*) and yellowstripe scad (*Selaroides leptolepis*). The SLN operated with kerosene lights caught short mackerel (*R. brachysoma*) and yellowstripe scad (*S. leptolepis*) of bigger size compared to SLN with LED lights. The average length and weight of short mackerel caught with kerosene lights were 146.3 mm and 37.17 grams, respectively. The average length and weight of yellowstripe scad (*S. leptolepis*) caught with kerosene lights were 117.04 mm and 21.5 grams, respectively. However, only a small portion of catch, 4.5%, had already reached its mature size (Lm), while the rest of the catch (95.5%) had not reached its mature size. Similarly, only 11% of yellowstipe scad had reached its mature size (>Lm). Underwater LED lights seemed to be better than kerosene lights due to the amount of catch acquired, however the size of the catch was smaller compared to kerosene lights.
Key Words: length-weight, light, short mackerel, stationary lift net, yellowstripe scad.

Introduction. Stationary lift nets (SLN) in Indonesia utilize lights as fishing tools. Light plays an important role in fishing operations (Fuad et al 2016; Sulaiman et al 2015a) by attracting fish around the fishing area (Rudin et al 2017; Sukandar & Fuad 2015). The lights that are often used by fishermen are kerosene, fluorescent, filament and LED lights. These lights are operated above the water and some can be operated underwater (Kumajas 2015; Yulianto et al 2014). Both ways of operating the lights have their own advantages and disadvantages. The design of the lights that are operated underwater tends to be more complicated but no light intensity is lost. All the light intensity of the underwater lights is absorbed and not reflected. The lights operated above the water have a more simple design. However, most of the light intensity is reflected by the surface of the water (Yulianto et al 2014).

There are many studies focusing on different types of light. Lights which are able to produce bright light with small electrical power are the basis for selecting the type of lights for fishing tools (Ibrahim & Hajisamae 2015; Nguyen & Paul 2018). One type of light that meets this criterion is the light emiting diode (LED). LED lights are more efficient than compact fluorescent lights (CFL) (Susanto et al 2017; Cahyadi & Xing You 2017; Sufijanto et al 2017; Thenu et al 2013). In addition, the operation method of the lights is very important. Underwater lights are more effective than the lights operated above water (Yulianto et al 2014; Taufiq et al 2015). The intensity of the light operated underwater is mostly flat and not reflected by the surface of the water (Anggawangsa et al 2014; Chen et al 2013).

Despite the many studies focusing on the type and color of light (Cahyadi & Xing You 2017), the intensity of light (Anongponyoskun et al 2012; Guntur et al 2015) and how to operate it (Sulaiman et al 2015b; Setiawan et al 2015), few focus on the

biological aspects of fish caught using lights. Fish responses to light are different in each species (Kehayias et al 2018; Kumajas 2015; Marchesan et al 2010). The response also differs for each wavelength of light (Bryrhn et al 2014; Solomon et al 2016; Nguyen & Paul 2018). Many fishermen utilize white light to catch anchovy and green light for squid. Different fish responses toward each type of light are used as a basis for fishermen to determine the target species. Lift net fishermen always customize their lights to catch fish with high economic value.

Biological factors such as fish species, size and gonad maturity stage are very important for determining the type of lights and fish response in SLN. Information related to the size of fish caught by SLN with certain types of lights are very useful to support the sustainability of fish resources. This study aims to find the best types of lights between LED and kerosene lights for short mackerel and yellowstripe scad (target species) in Pasuruan waters. The parameters determined are length and weight of catch and gonad maturity stage. This research was conducted on SLN in Pasuruan waters, Madura Strait, Indonesia.

Material and Method

Research Location. The research was conducted in Pasuruan waters, Madura Strait, in three months, from March 05 to May 26, 2018. The research was conducted in two SLN, which had the same the aquatic environment conditions. Water depth around SLN was approximately 20 m, the average current speed was 0.13 m/s, the water salinity ranged between 27-29 ppt and the temperature was between 29 and 30 ^{0}C. The dimensions of the SLN used in this research were 12 x 12 m^2 (L x W).

Fishing operations were carried out 32 times for each type of lights, simultaneously on two different SLN, only in new moon phase. The species captured and their length and weight in each fishing operation were recorded. Fishing operations were carried out between 7:30 PM - 05.00 AM. Fishing operations were conducted after midnight, for a better catch, as indicated by other studies (Kurnia et al 2015). The lights were on for 3-4 hours in each setting process to attract fish that gathered around the SLN. The catch was grouped by species and weighed. Target fish yellowstripe scad (*Selaroides leptolepis*) and short mackerel (*Rastreliger brachysoma*) from each fishing operation were sampled to measure the length, weight and gonad maturity stage. There were 400 individuals collected in total, consisting of 200 samples of yellowstripe scad (*S. leptolepis*) and 200 samples of short mackerel (*R. brachysoma*).

Figure 1. The location of Pasuruan waters, Java Island, Indonesia (Source: Map of the Earth, Indonesian Geospatial Agency).

Light Emitting Diode (LED) and Kerosene Lights. LED and kerosene lights were operated in two different SLN at the same time (Figure 2). Three units of kerosene lights were set at the first SLN. These lights were fueled by Liquid Petroleum Gas (LPG) 3 kg. LPG was equipped with valves in its cylinders to adjust the pressure and light intensity. The second SLN was operated by three underwater LED lights. These LED lights were submerged underwater. Both LED lights and kerosene lights have the same light intensity of 422 lux. LED lights use batteries as a direct current (DC) source. The type of LED lights used in this research were SMD (surface mounted diodes) strips 5050 33 in-door IP, with 120^0 lighting angles and temperatures of 20-50°C. LED lights were designed in the shape of cylinders, with a length of 56 cm and a diameter of 6 cm. LED lights were equipped with an iron sinker at the center of the cylinder.

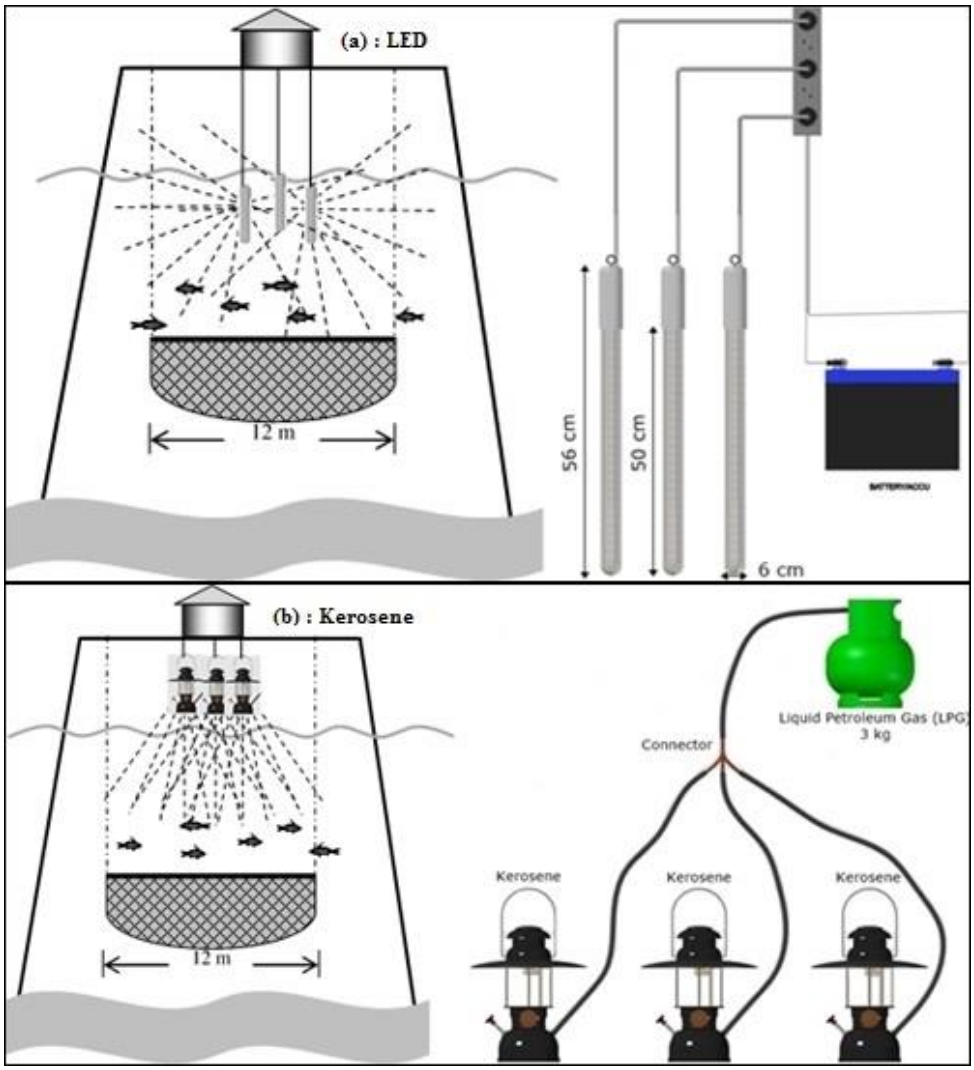

Figure 2. Design of LED lights (a) and kerosene lights (b).

Data Analysis. The catch in each fishing trip was grouped according to species and weighed for total weight (Anggraini et al 2017). Data from fish catches of both lights was analyzed. Paired T-test analysis determined whether there are differences in the number of fish caught between LED and kerosene lights. Paired T-test analysis was performed using linear univariate model with confidence interval $p < 0.05$, by using SPSS software.

Samples were collected in each fishing operation to measure the total length, weight and gonad maturity stage. The length and weight of the fish were used to determine the distribution size of the fish caught in LED and kerosene lights. The length of fish was measured by a ruler and the weight of fish was weighed by a digital scale. Observation of the gonad maturity stage was done by dissecting the fish. The formula of

length and weight relationship is $W = aL^b$, where: *W* - Weight (gram), *L* - Length (cm), *a* - coefficient related to body form, *b* - exponent indicating isometric growth.

Results and Discussion. The total catch during the study (32 trips) amounted to 1,243.9 Kg. The catches of SLN with kerosene lights amounted to 504.7 Kg (mean 15.772 ± 6.05 SD), while the catch from SLN with LED lights was 742.5 Kg (mean 23.20 ± 6.07 SD) of fish. This value indicates that SLN with LED lights caught more fish than SLN with kerosene lights. The result of statistical analysis showed that the catch from SLN with LED lights was significantly different than the catch from SLN with kerosene lights ($p < 0.05$). The catch for each fishing trip is presented in Figure 3.

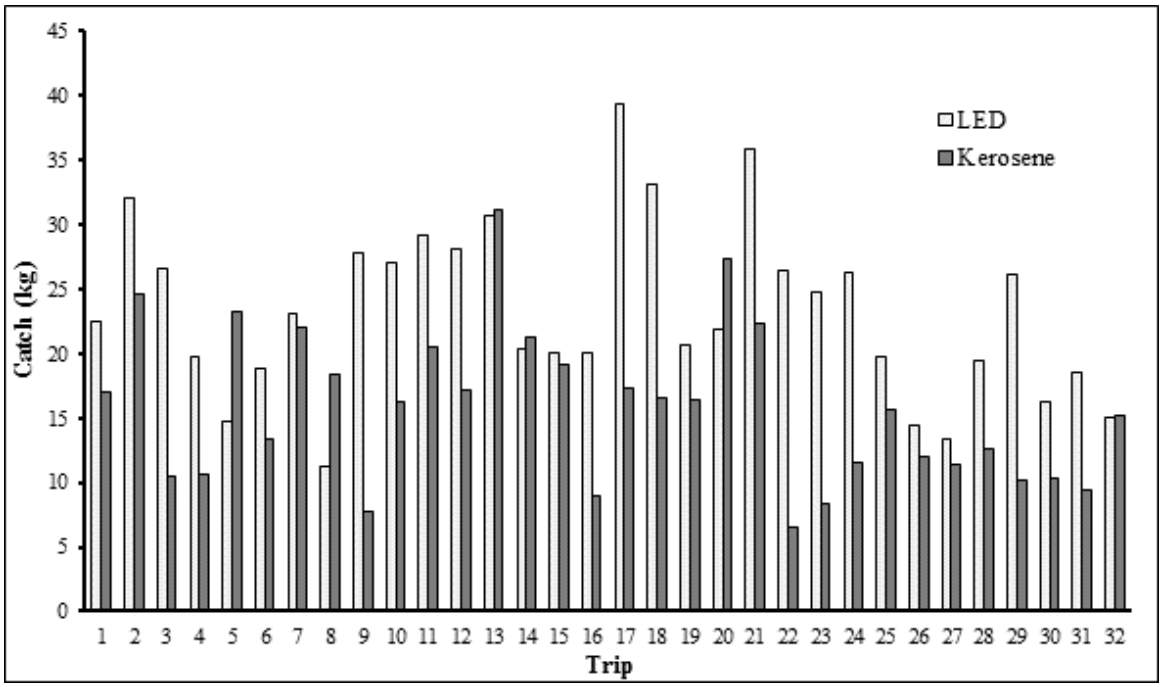

Figure 3. The catch for each fishing trip using LED and kerosene lights.

The average catch from SLN using kerosene lights was 15.772±1.193 kg/trip, while the average catch for SLN using LED lights was 23.20±1.070 kg/trip (Figure 4).

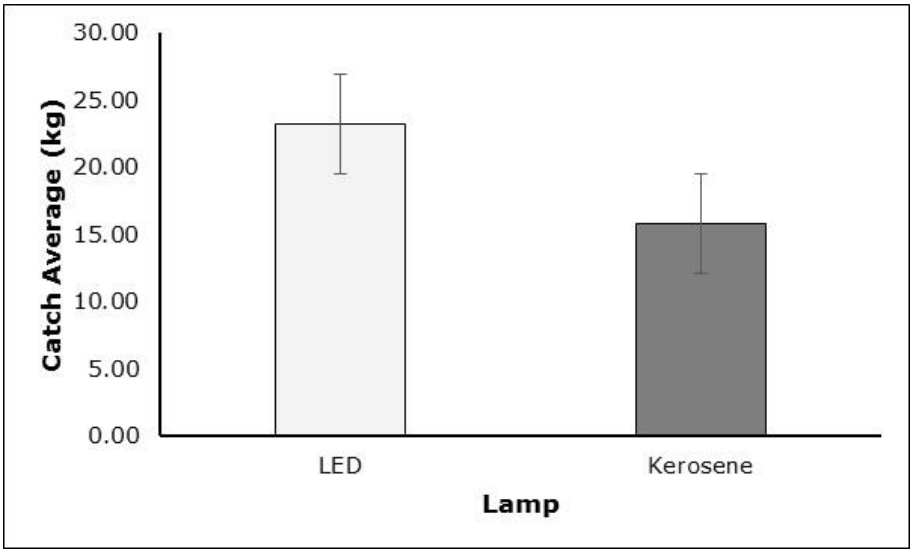

Figure 4. The average catch on stationary lift nets using LED and kerosene lights.

Catch composition. The catch from the SLN consisted in small pelagic fish such as short mackerel (*R. brachysoma*), yellowstripe scad (*S. leptolepis*), Squid (*Loligo* sp.), anchovies (*S. commersonnii*) and ponyfish (*Leiognathus* sp.). The total quantities of pelagic fish caught with LED and kerosene lights were 739.7 kg and 504.2 kg, respectively. The catch composition of fish caught by SLN using LED lights was dominated by *S. leptolepis,* with 169.3 Kg (22.8%), followed by *R. Brachysoma,* with 205.2 kg (27.7%), *Loligo* sp. with 50.5 kg (6.8%), *S. commersonnii* with 66 kg (8.9%), *Leiognathus* sp. with 55.7 kg (7.5%) and others with 193 kg (26.1%). The catch composition of SLN with kerosene lights consisted of *S. leptolepis*, with 142.7 kg (28.3%), *R. brachysoma* with 154.5 kg (30.6%), *Loligo* sp. with 38.2 kg (7.5%), *S. commersonnii* with 25.4 kg (5%), *Leiognathus* sp. with 37.8 kg (7.5%) and others with 105.5 kg (20.9%) (Figure 5). The catch compositions of fish caught with SLN using LED lights and kerosene lights were not significantly different (p> 0.05).

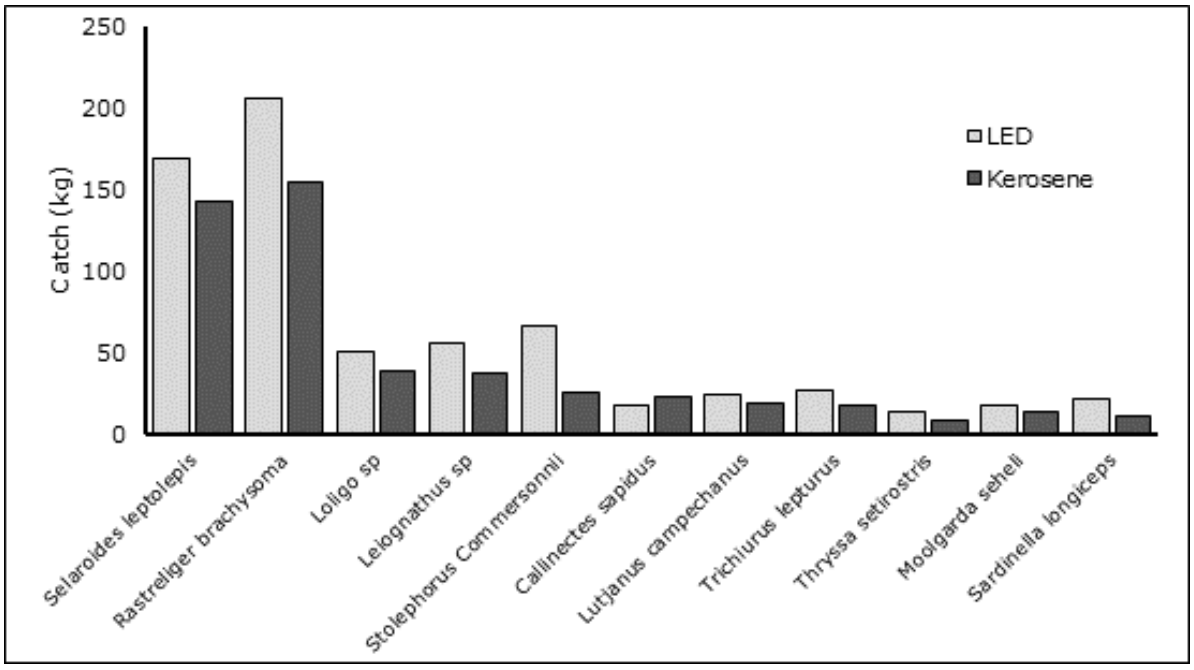

Figure 5. The catch compositions of stationary lift nets with LED and kerosene lights.

Length and weight of the target species. The target species of SLN are short mackerel (*R. brachysoma*) and yellowstripe scad (*S. leptolepis*). *R brachysoma* and *S. leptolepis* were mostly caught by SLN at 15-20 m below water. Both *R. brachysoma* and *S. leptolepis* caught in SLN during this research were mostly female.

The percentages of female short mackerel caught with SLN with LED and kerosene lights were 63% and 60%, respectively. *R. brachysoma* caught with SLN with kerosene lights had a larger size than short mackerel in SLN with LED lights. *R. brachysoma* caught with SLN with kerosene lights presented a length distribution of 130-160 mm (87%), whereas in LED lights it was between 120-150 mm (79%). The percentage of *R. brachysoma* which already reached maturity (legal size>Lm) was only 4.5%, while the rest of 95.5% had not reached maturity level (undersized) (Figure 6).

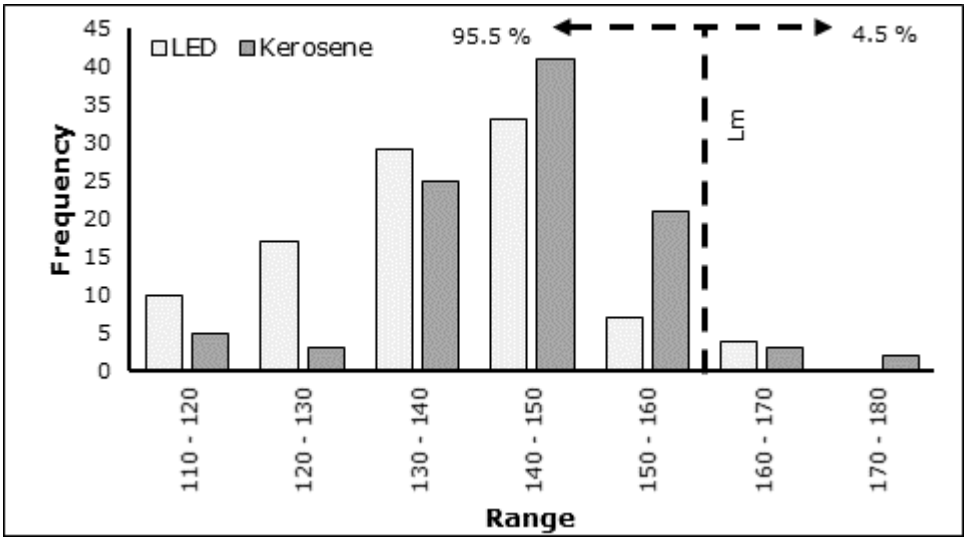

Figure 6. Length distribution of short mackerel (*Rastrelliger brachysoma*) caught in stationary lift nets with LED and kerosene lights.

The percentages of female *S. leptolepis* caught in SLN with LED and kerosene lights were 50% and 59%, respectively. However, *S. leptolepis* caught in SLN using kerosene lights were bigger in size compared to the catch on SLN with LED lights. Most *S. leptolepis* (82%) caught by SLN with kerosene lights presented a total length of 100-140 mm. Meanwhile, most *S. leptolepis* (90%) caught by SLN with LED lights had 90-130 mm total length. By comparing both length distributions, it can be seen that the fish caught by SLN with LED lights were smaller than the fish caught by SLN with kerosene lights. The percentage of *S. leptolepis* of legal size (>Lm) amounted to 11% and the rest, 89%, were still undersized (Figure 7).

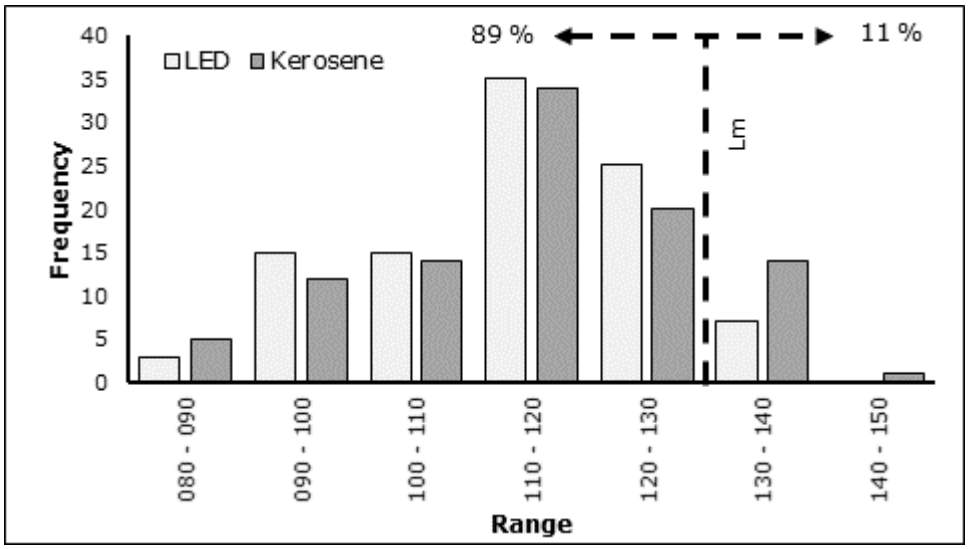

Figure 7. Length distribution of yellowstripe scad in stationary lift nets with LED and kerosene lights.

Gonad maturity stage (GMS) of short mackerel and yellowstripe scad. Short mackerel (*R. brachysoma*) and yellowstripe scad (*S. leptolepis*) caught by SLN with LED and kerosene lights were mostly undersized and had not reached gonadal maturity. The gonad maturity stages (GMS) of *R. brachysoma* caught by SLN with kerosene lights amounted to 23% at GMS 1, 50% at GMS 2, 24% at GMS 3 and 4% at GMS IV. Meanwhile, the gonad maturity stages of *R. brachysoma* caught by SLN with LED lights amounted to 52% at GMS 1, 36% at GMS 2, 11% at GMS 3 and 1% at GMS IV. Based on

gonad maturity stage, *R. brachysoma* caught by SLN with kerosene lights were bigger in size compared to *R. brachysoma* caught on SLN with LED lights (Figure 8).

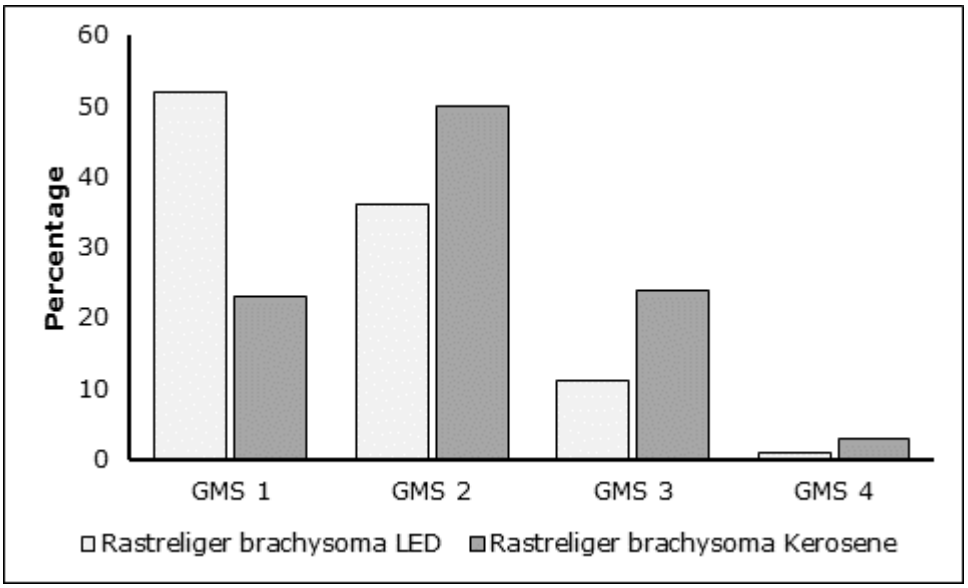

Figure 8. Gonad maturity stage of short mackerel (*Rastrelliger brachysoma*) caught in stationary lift nets with LED and kerosene lights.

R. brachysoma caught in this research was grouped into GMS 1 with gonad size of 25–30 mm, GMS 2 with gonad size of 30-40 mm, GMS 3 with gonad size of 40–47 mm and GMS 4 with gonad size of 50-60 mm (Figure 9).

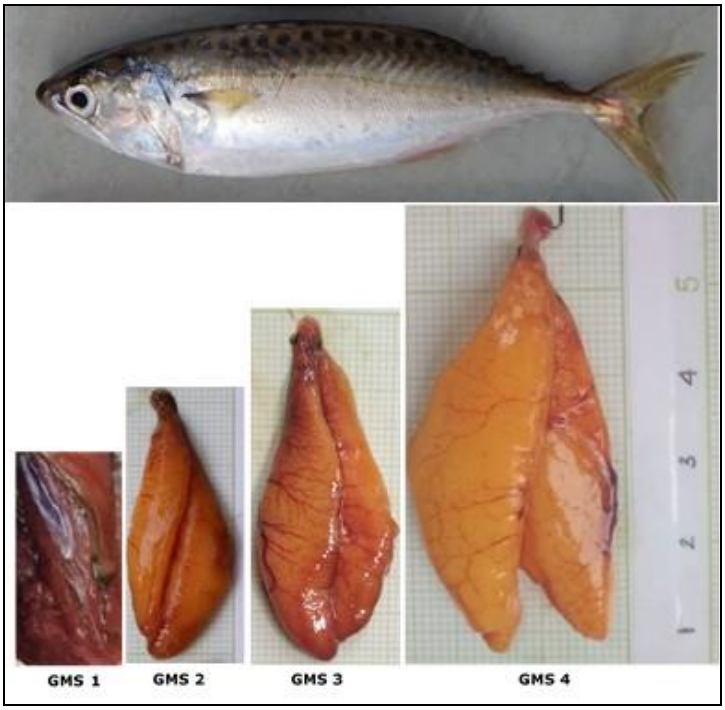

Figure 9. The size of gonad in short mackerel (*Rastrelliger brachysoma*).

The gonad maturity stages of *S. leptolepis* caught by SLN with kerosene lights amounted to 34% at GMS 1, 20% at GMS 2, 31% at GMS 3 and 15% at GMS 4. Meanwhile, the gonad maturity stages of *S. leptolepis* caught in SLN with LED lights amounted to 41% at

GMS 1, 24% at GMS 2, 30% at GMS 3 and 5% at GMS 4. Therefore, most *S. leptolepis* caught in SLN with kerosene lights were bigger in size than the fish caught in SLN with LED lights (Figure 10).

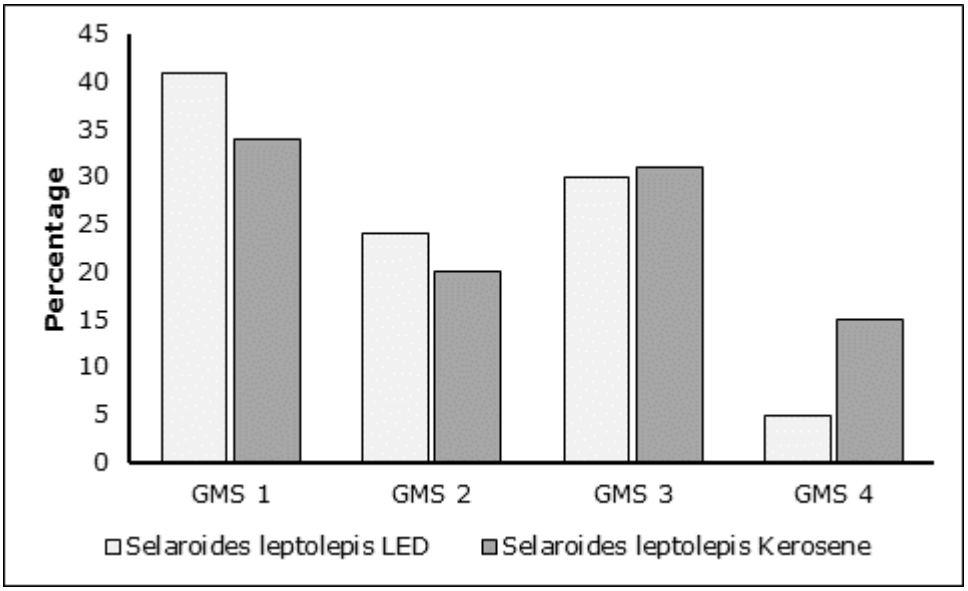

Figure 10. Gonad maturity stages of yellowstripe scad (*Selaroides leptolepis*) caught by stationary lift nets with LED and kerosene lights.

Yellowstripe scad caught in this research had smaller gonad size compared to short mackerel. The size of gonads in *S. leptolepis* ranged from 10 to 13 mm for GMS 1, 12-16 mm for GMS 2, 16-20 mm for GMS 3 and 20-22 mm for GMS 4 (Figure 11).

Figure 11. Gonad maturity stages of yellowstripe scad (*Selaroides leptolepis*).

Catch compositions from SLN with LED and kerosene lights were almost the same. However, the number of captured fish in SLN with LED lights was higher compared to kerosene lights. The results of the analysis showed that the number of catches in SLN with LED lights was significantly different from kerosene lights, but the species composition was not significantly different. There were 18 species of fish caught by SLN

with LED lights and 16 species of fish caught by SLN with kerosene lights. Many giant trevally (*Caranx ignobilis*), halfbeak (*Hemiramphidae* sp.), anchovy (*Stolephorus Commersonnii*) and squid (*Loligo* sp.) were caught by SLN with LED lights, while fewer were caught by SLN with kerosene lights. These fish were presumably attracted toward the light. *S. Commersonnii* tended to move around LED lights. Meanwhile, *S. leptolepis, R. brachyoma* and *C. Ignobilis* were circling the lights while preying on *S. commersonnii*. LED lights have more diverse wavelengths and are able to attract pelagic fish (Mills et al 2014; An & Jeong 2012). Information on the number and composition of the catches in this study can be used for determining target species based on the type and different wavelengths of lights.

Target species (*S. leptolepis* and *R. brachysoma*) caught by SLN with LED and kerosene lights were different in size. *S. leptolepis and R. brachysoma* caught by SLN with kerosene lights were bigger in size than those caught by SLN with LED lights. Most of *R. brachysoma* caught by SLN with kerosene lights had a total length from 130 to 160 mm. This range of size is still categorized as undersized or immature (GMS 2 and GMS 3). The length corresponding to the first stage of maturity of *R. brachysoma* in this research was 162 mm. According to Zamroni et al (2017) and Suwarso et al (2015), *R. brachysoma* in the Java Sea reach gonad maturity at 164 mm length. *R. brachysoma* with a length longer than maturity length are not usually caught by SLN, but by purse seines and gillnets. Most *S. leptolepis* caught by SLN with both LED and kerosene lights ranged from 90 to 130 mm length. However, these catches were still considered immature (GML 1, 2 and 3). The length at first maturity of *S. leptolepis* was 130 mm. According to Sharfina et al (2014), *S. leptolepis* in Sunda straits has a Lm of 134.9 mm. Therefore, based on the size of the fish caught, SLN with LED and kerosene lights were categorized as non selective fishing gear, due to the small size of caught fish. Large-sized *S. leptolepis* and *R. brachysoma* are actively moving and prey on small fish surrounding the lights (Hamidi et al 2017). This fish escape when the net is hauled. According to Bryrhn et al (2014), large fish are more difficult to catch than small fish.

Based on the level of interest for light, the nature of fish is divided in two categories: positive phototaxis and negative phototaxis (Chairunnisa et al 2018). Fish of positive phototaxis will approach the light and will circle the light for a long time. The positive phototaxis type is dominated by pelagic fish that actively forage during day and night. However, the level of interest of pelagic fish also varies by species (Arimoto 2013). Plankton-eating fish, such as anchovy and mullet, are very interested in light and will continuously swarm around the light (Guntur et al 2015). Predatory fish, such as yellowstripe scad, short mackerel, squid and sardines, are very interested in light due to the availability of small fish around the light. These predatory fish will leave the area when small fish leave. Pelagic fish also have different interests in the color of lights (Yulianto et al 2014; Hamidi et al 2017). *S. leptolepis* and *R. brachysoma* were very interested in green (Hilman et al 2018) and blue lights (Khairul et al 2017; Hamidi et al 2017). The wavelength of lights also affects the level of fish attraction to the light (Siebeck et al 2008; Risner et al 2007). Fish are able to capture light wavelengths from 340 to 640 nm (Risner et al 2007).

Conclusions. Underwater LED lights performed better in comparison to kerosene lights in stationary lift nets catches. The average number of fish caught with LED lights was higher compared to kerosene lights. The average catch of LED light SLN was 23.20 kg/trip while for kerosene lights SLN was 15.77 kg/trip. The size and composition of fish caught by LED lights SLN was almost the same as kerosene lights. There were 18 species of fish caught with LED lights and 16 species of fish at kerosene lights.

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