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Utilization of light-emitting diode lamp on lift net fishery

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Abstract. The research aimed to prove the LED (light emitting diode) lamp efficiency in lift net fishing and to find out the optimum time for lift net fishing operation. In this study, 2 lift net operated simultaneously for 15 nights. Each lift net has attached 4 LED lamps and 4 fluorescent lamps. Result showed that composition of lift net catches consist of anchovies (*Stolephorus* spp.) weighing 107 kg, pony fish (*Leiognathus dussumieri*) 68 kg, trasi shrimp (*Mysis* sp.) 45 kg, yellowstripe scad (*Selaroides leptolepis*) 16 kg, indian mackerel (*Rastrelliger* spp.) 8 kg, squid (*Loligo* sp.) 34 kg, and hairtail (*Trichiurus* sp.) 12 kg. Lift net operated with LED lamp was able to capture water organism weighing 159 kg. It is more effective compared to fluorescent lamp which caught only 131 kg. Meanwhile, time operation between 6 PM – 9 PM produced organisms weighing 56 kg, higher than the interval time of 9 PM – 12 AM (41 kg), 12 AM – 3 AM (32 kg) and 03 AM – 06 AM (30 kg).
Key Words: Fishing, fluorescent lamp, lift net, plankton feeder, predator organisms.

Introduction. One of the factors that determine lift net fishing operation's advance is light. It functioned as attractant to various types of plankton-eating organisms, such as anchovies, trasi shrimp, pony fish, yellowstripe scad and indian mackerel, to come closer to lift net so they could be captured easily. As the small organisms exist, automatically draw predators to approach lift net.

Types of light being used in lift net are varied. At the beginning fishermen used torch, then turned into petromax. The expensive price of kerosene forced fishermen switch into incandescent bulb, then fluorescent lamp in the end. Furthermore, by government policy that raised the price of gasoline and diesel resulted in difficulties in the operation. Most fishermen forced to stop lift net operation, while the one who still operates often suffer losses as the price of the catch is much lower compared to the operation costs. One of the solutions that could be done is the use of other types of light sources which are energy-efficient and requires no fuel (gasoline or diesel).

This research tried to introduce LED (light emitting diode) lamp as one of the alternative source in lift net fishing tools. LED lamp chosen for its benefits over other types of lamps, which are more cost efficient, more durable, with dry and rechargeable battery as energy source which using direct current for it won't harm and easier to fishermen to operate. LED circuits where placed on cheap and accessible container to make it easier for fishermen to replicate. Goals of this research are to prove LED lamp could be used as fishing tools and to determine the best time to operate lift nets. Fluorescent lamp is used as comparison in this study since it is commonly used by fishermen. Indicators of this research are amount of types and weight of caught organisms, either based on lamp of time of catch.

Publications related to LED lamp on lift nets usage above sea level are still hard to find. Thenu et al (2013) examines of sunken LED lamp in the sea. Several other researches discuss lamp reflector modification to improve lift net's catch (Puspito 2008), trial of incandescent bulbs usage dipped under sea water (Hasan & Widipangestu 2000),

and the use of conical reflectors on fluorescent lamp (Puspito & Suherman 2012). Those publications were used as reference to analyze results of this research.

Material and Method

The research was divided into 3 stages. First stage, 4 units of LED lamp constructed. Second stage, determining illumination and directions of light distribution on LED lamp (Figure 1) and fluorescent lamp 24 Watts (Hannochs brand) with plastic cover that commonly used by fishermen (Figure 2). As for the third stage was the test of LED lamp in Sangrawayang coastal waters, Palabuhanratu Village, Sukabumi district, West Java, Indonesia (Figure 3). All stages on the research were using experimental fishing method. The research took place in July-August 2013.

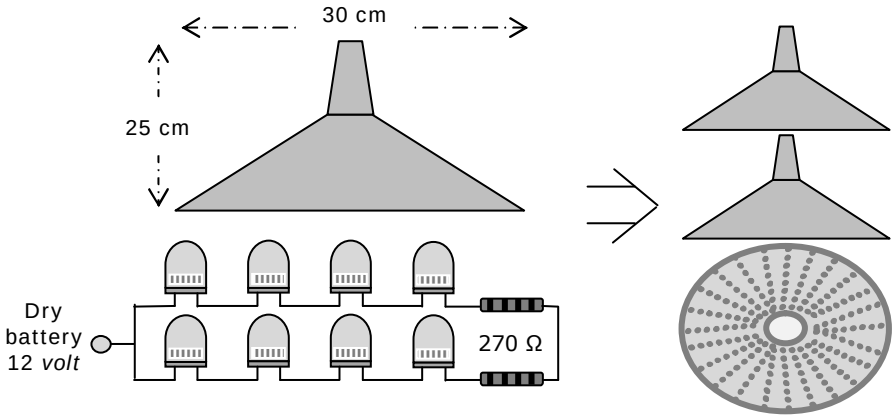

Figure 1. LED lamp.

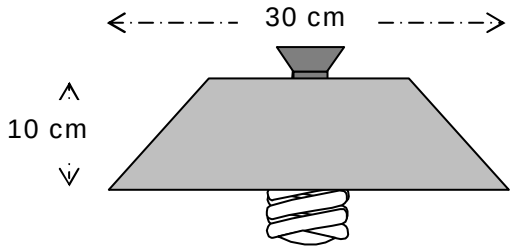

Figure 2. Fluorescent lamp with plastic cover.

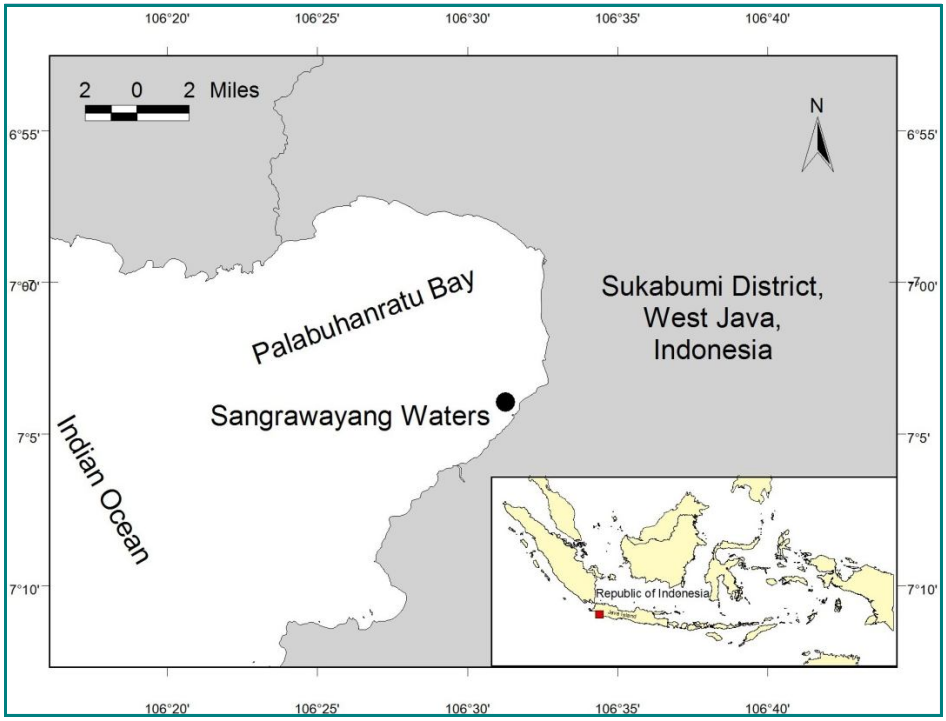

Figure 3. Research locations map.

Design of LED lamp. Construction 1 unit LED lamp begun by making 408 holes Ø 5 mm on a plastic funnel as a medium for putting 408 LED 5 mm of *ultra bright*. Four LED lamps arranged in series with one resistor 270 Ω as electric current resistor. Furthermore, circuits arranged parallel with 99 other series. One more funnel stacked on top of the funnel with LED. Its function is to protect the LED circuit from water to prevent the occurrence of short circuit. One unit of LED lamp shown on Figure 1.

Determination of lamp's direction distribution and light illumination. Measurement of direction of light distribution and illumination of covered fluorescent lamp and LED lamp was performed inside a dark room. Measurement was performed at the distance of 1 m from the center of the light source. Position started from angle of $\alpha = 0^o$ and multiplied every 30^o to $\alpha = 360^o$. Illumination measurement was done using digital luxmeter LX1010B model.

Field research. Two lift nets, attached with 4 units of LED lamp and 4 fluorescent lamps, operated simultaneously at 11 m depth (Figure 4). Distance between lift nets was set at approximately 25 m. The operation processes were following steps:

1. Four lamps hung below the lift net 1 m from the sea surface to form a rectangular area of 1 × 1 (m);
2. Net was drowned 9 m under the sea, and then lights were turned on for 2.5 hours;
3. Net lifted once schools of fish gathered under the lift net;
4. Fishes caught were scooped and put into the basket container;
5. The light switched back on and the net drowned for next fishing operation;
6. The catch were being sorted, identified and weighed by type;
7. Lift nets operated for 15 nights, and the net lifted 4 times during 6 PM to 9 PM, 9 PM to 12 AM, 12 AM to 3 AM, and 03 AM to 06 AM on each night.
8. Light illumination at the depth of 0, 1, 2, 3, 4, 5, 6, 7 and 8 m below the lift net was measured using underwater OSK 16648 Marine Luxmeter every night.

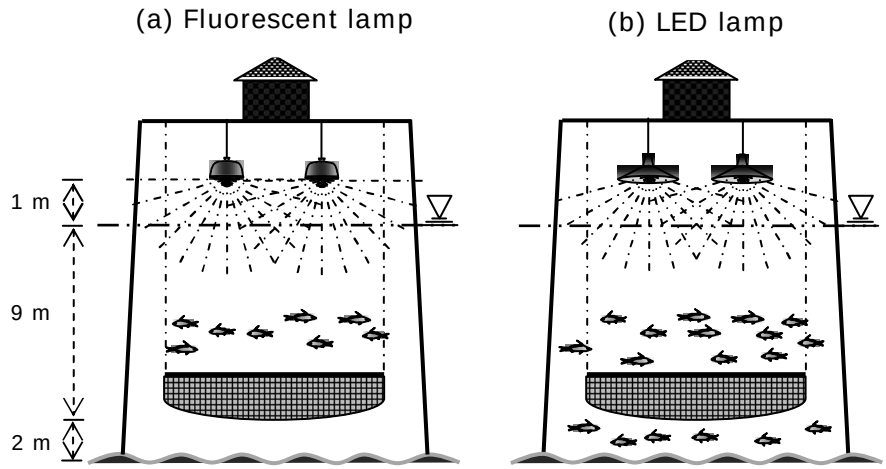

Figure 4. Position of (a) flourescent lamp and (b) LED lamp set under lift net.

Light illumination from both fluorescent and LED lamp in air medium being projected into radar diagram. Light illumination on water medium, weight of lift net catch based on light type and time operation were plotted in the form of graphic. Furthermore, four types of data were analyzed using descriptive comparative analysis. Catch data analysis based on time operation only focused on the type of lamp which gives the highest number of species and weight.

Electrical calculations were based on Kirchoff's Law by determining the resistance R (*ohm*) of each LED lamp based on the amount of LED *N* pieces arranged in series with the equation of:

$$R = [V_S - (N \times V_L)] / I$$ (Syahbana 2012).

Where: V_S is the voltage source (*volts*), V_L voltage law (*volt*) and *I* is electric current (*ampere*).

Furthermore, the voltage *V* (*voltage*) which passes through the LED circuit was calculated by the equation of:

$$V = R \times I$$

While the electric power *P (watt)* determined by the formula:

$$P = V \times I$$ (Sutrisno 1989).

Results and Discussion

Electricity of LED lamp. Calculation using Kirchoff equation resulted that 1 unit of LED lamp, composed from 400 pieces of LED, only takes electrical power equal to 12 Watts. Endurance test on 4 LED lamps that will be used in lift net brought suitable result. LED lamp could be lit for more than 12 hours, though it is only powered by a DC electric current of 1 dry battery 10 *A* 12 *V*. It means that the LED lamp is much more energy-efficient than the fluorescent lamp. The use of direct current electricity to the LED lamp provides many benefits. Two of them are not causing a short circuit and wildfire (Sutrisno 1989).

Light distributions and illuminations. Result of light distribution and illumination measurement are shown on Figure 5.

Light emitted by fluorescent lamp was more outspread compared to LED lamp. Furthermore, fluorescent lamp has higher illumination for the similar light direction. This result happened due to the difference of characteristics of each light. LED lamp is lit by

direct current electric voltage 12 V, or much lower than the fluorescent lamp which electrified with alternating current of 230 V.

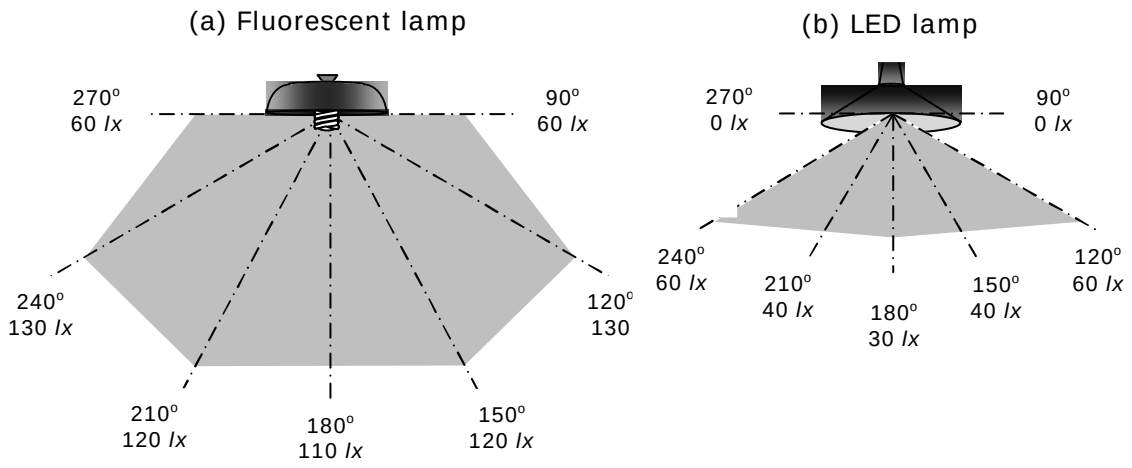

Figure 5. Distribution and light illumination on air media (a) fluorescent lamp and (b) LED lamp.

Fluorescent lamp initially was designed as indoor lighting. Its spiral shaped construction cause the light to spread to every direction. With plastic cover, the light distribution could be narrowed between angle of $\alpha = 90^o - 270^o$.

Based on Figure 5 (a), fluorescent illumination light reach its maximum point at $\alpha = 240^o$ (120^o) that is 130 lx. Light emitted by the lamp on this angle comes from inner and outer side of lamp through the gap on spiral tube. It means that the illumination decreased as the directions of light beam getting flatter. Light illumination should also be decreased if the directions of light beam are more upright, because the light that only comes from the bottom side of spiral has the most limited area to reach. The light reflection from plastic cover cause the illumination light becomes slightly higher than $\alpha = 90^o$ and 270^o. The use of plastic cover still cannot optimize the use of fluorescent lamp. The light still spreads around lift net, while plastic cover is actually functioned to focus the light under lift net to gather fish.

LED light designed to be used on various purposes. Based on literature review, it is known that one LED part only has light beam angle of 15^o. Thus, to make a wide angle light beam lamp, some LED needs to be mounted in different positions. In this study, all LEDs are positioned perpendicular to funnel with angle of 60^o. This made the angle of light beam emitted only as much as 120^o or between $120^o < \alpha < 240^o$ (Figure 5b). It is also resulted that the highest LED light illumination located on $\alpha = 120^o$ (240^o) that is 60 lx. The illumination gets lower to 30 lx on $\alpha = 180^o$.

The result of light illumination measurement on both LED and fluorescent lamp is shown in Figure 6. Illumination on both lamps was declining with the increasing of water depth. This is according with the opinion of Cayless & Marsden (1983) which stated that light illumination is the ratio between light intensity and squared distance from the light source. Light illumination will be declined with increasing distance. Very high difference between two kinds of light at a depth of 0-3 m is shown by the light illumination.

Light penetration on both fluorescent and LED lamp was only able to reach within 7 m depth. It caused by high refractive index and water turbidity that the light penetration was greatly reduced (Hutabarat & Evans 2006). Highest depletion of illumination happened at 2 m depth. It is presumably due to high water density in depths of 2 m.

Light illumination on both fluorescent and LED light was not relatively different at depth of 4-7 m. It indicated that both lights have the same capabilities to attract fish. However, LED lamp is more effective than the fluorescent lamp. Its light directions are

more concentrated to the net, impacted to distribution of fish schooling which also concentrated at the center of the net drowned at 9 m depth.

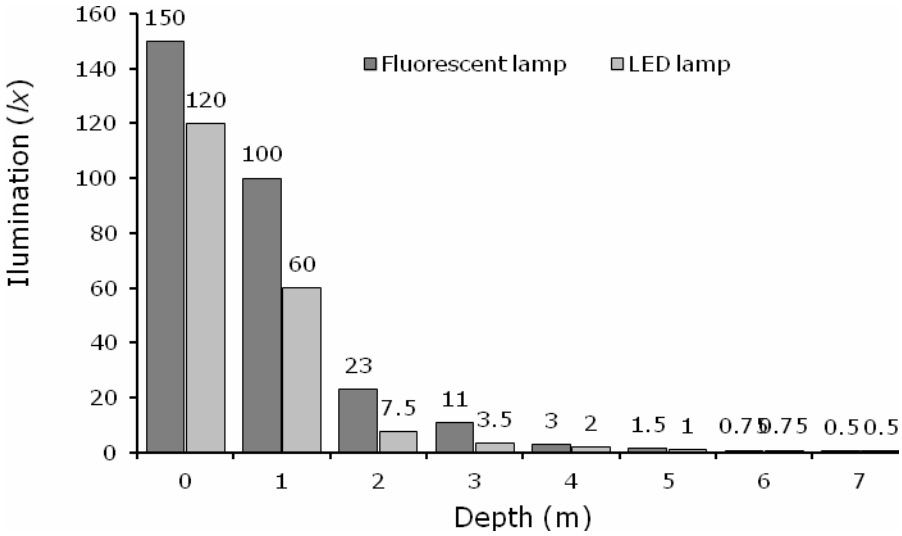

Figure 6. Light illumination of fluorescent and LED lamp at 0-7 m water depth.

Types and weight composition of lift net catch. Lift net has a very small mesh size so that various sizes of organisms can be caught. Its operation area which is not far from beach and performed at night indicates that the main targets are plankton feeders which inhabit coastal waters. Basmi (1995) stated that plankton constantly needs to be on water that gets enough light to be able to live and breed well. The existence of plankton, according to Gunarso (1988) and Hutomo et al (1987), will attract plankton feeder to come to the light for their feeding activity. Species of predator organisms that are hunting for food likely also be caught during lift net fishing operation.

Lift net catch grouped into two types of organisms, i.e. plankton feeder and predators. Plankton feeder consist of anchovies (*Stolephorus* spp.) weighing 107 kg or 36.69% of lift nets total weight catch, pony fish (*Leiognathus* spp.) 68 kg (23.45%), trasi shrimp (*Mysis* sp.) 45 kg (15.52%), yellowstripe scad (*Selaroides* spp.) 16 kg (5.52%), and indian mackerel (*Rastrelliger* spp.) 8 kg (2.76%). While predator organisms consist of squid (*Loligo* sp.) and hairtail (*Trichiurus* sp.) with a weight of 34 kg (11.72%) and 12 kg (4.14%) each. Detail of weight composition of lift net catch based on organism type is shown in Figure 7.

All plankton feeders inhabit coastal waters. Hutomo et al (1987) explains that anchovy is a pelagic fish that lives in schools, inhabit coastal waters and estuaries. Pony fish lives in shallow coastal waters, forming a large school and sometimes goes to estuaries (Genisa 1999). Trasi shrimp, according to Gunarso (1988), lives in coastal waters, estuaries and bays. Yellowstripe scad is one of small pelagic fish which lives in school and inhabits coastal waters up to 80 m depth.

Anchovy is a plankton feeder which dominates lift net total weight catch. Its percentage reached 43.85% of plankton-feeders total weight catch. It is obvious because fishing operation was done on anchovys fishing season, which is between April to October. Other plankton feeders caught by lift net are pony fish 27.87%, trasi shrimp 18.44%, yellowstripe scad 6.56% and indian mackerel 3.28%.

Pony fish is classified as plankton eater organism. Its existence under lift net was possible because they are attracted by plankton. While trasi shrimp, also feed on plankton which is hugely available under lift net. Yellowstripe scad can be found from open seas to coastal waters and bays in almost all Indonesian waters area. Its food are zooplankton, benthos, juvenile, and small fish. The existence of yellowstripe scad caught in lift net catch is closely related to its activity to search for food under lift net. While

indian mackerel is also classified as pelagic fish that feed on plankton. It can be found in shallow coastal waters area from 20-90 m depth (Bal & Rao 1984).

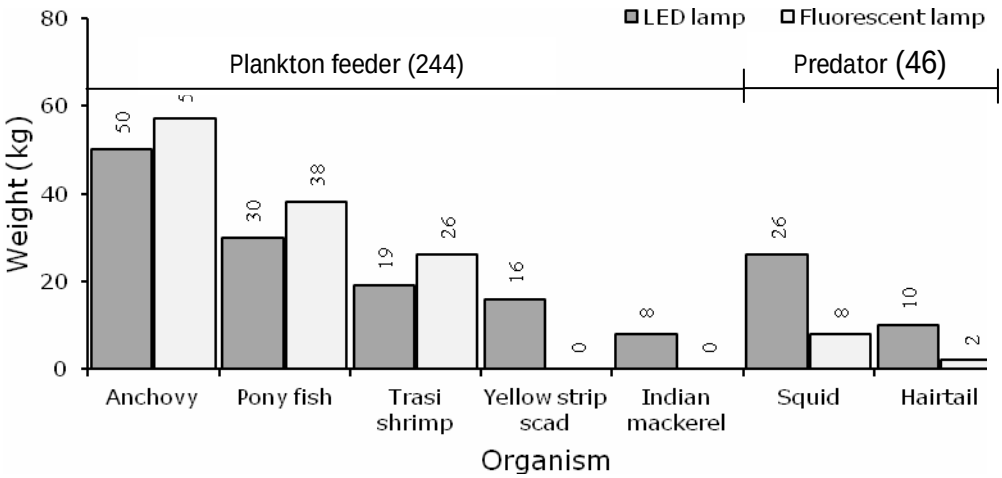

Figure 7. Weight composition of lift net catch by organism type.

Squid and hairtails as predators feed on zooplankton, shrimp and small fish, such as anchovies. Squid spreads in coastal waters to depth of 400 m which rich in zooplankton and small fish. Lift net fishing operation to catch small fish causes squid to be caught. While hairtail is not lift net target catch, but just demersal fish that occasionally come to the surface or water column to search for its prey. Hairtail existence around lift net caused by its activity to search for food that hugely available under lift net.

Lift net catch based on types of lamp. Both lift nets using fluorescent lamp and LED lamp gave different result on amount of types and weight of captured organisms. Figure 7 shown details of catches weight composition based on organism types. LED lamp usage caught 8 species of plankton feeders and 2 predators with total weight 159 kg. Plankton feeders catch consist of anchovies weighing 50 kg, pony fish 30 kg, trasi shrimp 19 kg, yellowstripe scad 16 kg and indian mackerel 8 kg. Predators caught were squid 26 kg and hairtail 10 kg. Meanwhile, fluorescent lamp usage on lift net only caught 3 kinds of plankton feeder (anchovy 57 kg, pony fish 38 kg and trasi shrimp 26 kg) and 2 kinds predator organism (squid 8 kg and hairtail 2 kg). Total weight of the catch was just 131 kg. Thus, lift net with LED lamp caught more species and higher total weight of catch compared to fluorescent lamp usage.

Direct observations in field found that number of organisms concentrated under LED lamp was higher compared to those under fluorescent lamp. This indicates that LED lamp is preferred by plankton feeder against fluorescent lamp. Based on Figure 6, light illumination on both LED and fluorescent are relatively similar at depth of >2 m. Huge difference only occurred from 0-2 m depth. However, narrowed light beam on LED light caused plankton feeder to be more concentrated over the net (Figure 5b). Due to this situation to the quantum of captured organisms becomes higher. Dimmer LED lamp seems to be preferred by predators. Hairtail and squid feeding activity made plankton feeders which stay above the net scattered and hard to caught. Hairtail migrates to surface to seek food such as small fishes that was close to lift net. This is proven on Figure 7. Weight of predator organisms caught by lift net with LED lamp was higher than fluorescent lamp but the opposite happened to the plankton feeder catch. Fluorescent light that spread around lift net caused plankton feeder and predator feeding activity to scattered (not focused in one point). This caused the number of plankton feeder under lift net not as many as LED's, resulting in plankton feeder not likely disturbed by predators. The result is lift net with fluorescent lamp will produce more plankton feeder and less predator compared to LED lamp.

Predator organisms were not the main target of lift net. Their existence under lift net was to search food, plankton feeder. From field observation, predator always seemed to hunt and eat plankton feeder. Hairtail and squid rise to water surface to hunt for small fishes. Adult hairtail will be more active migrating to water column to search for food. Small fishes that are close to lift net lights will attract demersal organism to rise to the surface.

Total weight of plankton feeder organisms caught by lift net using both fluorescent and LED lamps is not significantly different. However, lift net with LED lamp showed better result because the weight of predator organism catch was far more superior compared to fluorescent lamp result. Besides, predator organisms have higher economic value than plankton feeder organisms.

The catch of lift net based on fishing operation time. Lift net fishing operation will provide optimal results when is adjusted to fish feeding time. Therefore, fish feeding time should be known beforehand so the operation not necessarily should be conducted the whole night. Hungry fish, according to Gunarso (1988) will come to the light to seek food.

It can be seen in Figure 8, the weight composition of lift net catch. Highest catch weight occurred on fishing operation at time interval of 6 PM to 9 PM weighing 56 kg or 35,22% of total weight, followed by time interval of 9 PM to 12 AM (41 kg; 25.79%), at 12 AM to 3 AM (32 kg; 20.13%) and 3 AM to 6 AM (30 kg; 18.87%).

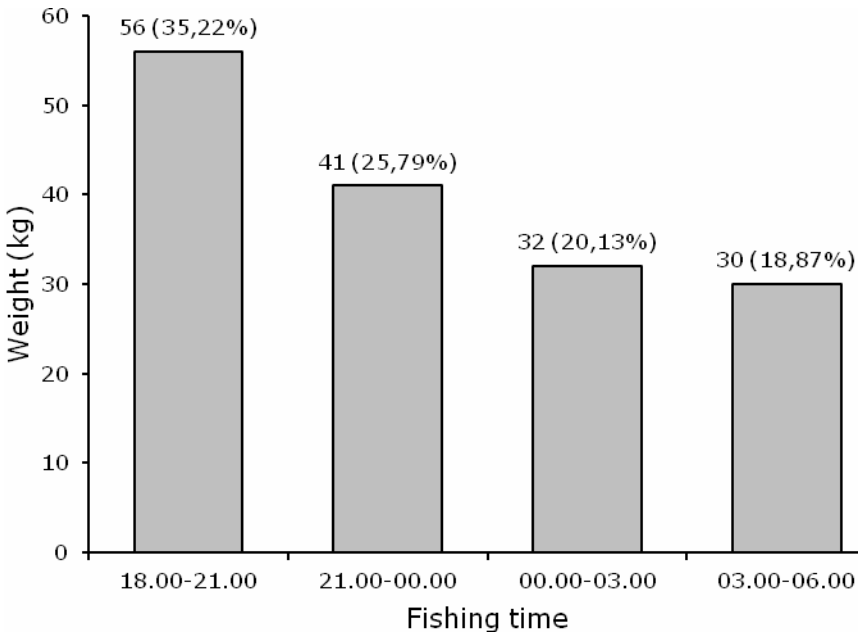

Figure 8. Organism weight based on fishing operation time.

The highest weight of catch at interval of 06 PM to 09 PM is strongly influenced by feeding behavior of marine organisms. The availability of food under the light is very abundant at that time intervals. This condition caused marine organisms, both plankton feeder and predators, to come near lift nets to get food. Plankton-feeder reached its peak feeding activity before midnight. The same goes to predator (hairtail and squid). Matsuda et al (1975) said that predators appear to surface water at dusk to search for their prey. Thus, lift net fishing operations should be conducted between the hours of 6 PM to 12 AM. In that interval, fishing operations should be optimized to increase the number of catches.

Conclusions. The conclusions of this research are:

1. The use of the LED lamp on lift net resulted in catch of 7 types of organisms weighing 159 kg, which is higher compared to the fluorescent lamp method (5 organisms weighing 131 kg);
2. Best lift net fishing operation time is between 6 PM – 9 PM due to catch weighing of 56 kg, followed by 9 PM – 12 AM (41 kg), 12 AM – 3 AM (32 kg) and 3 AM - 6 AM (18.8 kg).

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