JIPK
(JURNAL ILMIAH PERIKANAN DAN KELAUTAN)

Scientific Journal of Fisheries and Marine

Research Article

UFLPlus: An Underwater Fish Lamp Technology as an Innovation of Fish-Luring Aids on Boat Lift Net

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Abstract

The usage of underwater immersion lights outfitted with CCTV is a technological innovation that is expected to solve the inadequacies of the acoustic work system while also improving the existing underwater immersion light work system. Underwater Fish Lamp Plus (UFLPlus) technology can attract attention and directly monitor the condition of fish in the sea from the boat. The purpose of this study was to understand how the UFLPlus was designed and constructed; to test its performance using lamplight, waterproof, and immersion tests; to learn how the light distribution pattern is formed; and to learn the state of the catch. The study was separated into two phases: the design and fabrication of UFLPlus, and numerous laboratory-scale experiments and outdoor trials with boat lift net fishing gear. The results reveal that UFLPlus performed effectively in the field after all of its physical components were tested in the laboratory, and that the values of light intensity and light distribution patterns are still in accordance with the level of adaptation to light reception on the fish retina. During the trial catch, 62 kg of anchovy (*Stolephorus* sp.), 27 kg of ponyfishes (*Leiognathus* sp.), 32.5 kg of fringe-scale sardinella (*Sardinella fimbriata*), and 17.5 kg of yellow-stripe scad (*Selaroides leptolepis*) were caught. UFLPlus was capable of functioning as an underwater immersion lamp that attracts fish attention and directly monitors the arrival of fish in the water in the fishing area.

1. Introduction

Technological developments in the field of capture fisheries continue to develop. Various means, both in the form of main fishing gear and fishing tools, have experienced numerous technological touches that are adapted to current conditions and needs, one of which includes the use of artificial light in the lamp to attract fish that like light and concentrate it on a fishing area (Mills *et al.*, 2014). Underwater submersible lights are designed to solve technical problems and operational costs experienced by Bagan fishermen (Li *et al.*, 2021). The value of the illumination of a light source will decrease with distance and will become smaller due to fading when light enters the water (Yami, 1976; Telemka *et al.*, 2018).

Underwater dip lamp technology has been known for its use since the 1990's, according to the findings of Natiqoh *et al.* (2017), who found that the catch of the boat lift net fishing gear employing underwater submersible light tools outperformed solely utilizing surface lights. Furthermore, the use of underwater submersible light in Bagan fishing gear has developed with the application of light-emitting diode (LED) lights (Hamidi *et al.*, 2017; Taufiq *et al.*, 2016; Thenu *et al.*, 2013; Wahyu *et al.*, 2020). LED lights were selected because it needed lesser energy, therefore saving more operational costs (Shen *et al.*, 2013). In a trial that uses LED lights in capture operations, there was around a 15-17% reduction in fuel consumption (Sulkhani *et al.*, 2014). Furthermore, development continues. Researchers integrated underwater submerged lights using LEDs with closed-circuit television (CCTV), to know the arrival of fish directly and clearly from the boat when fishing and knowing the right time to lift the net on the boat. It is hoped that this technological innovation can provide solutions to major problems of fishermen in Indonesia. This problem according to Baskoro *et al.* (2019) is how fishermen know that the fish in the catchable area are certain types of fish.

Currently, acoustic technology is widely used as a fish detection tool, but it only describes a general school of fish without knowing what kind of fish and how large it is. The use of underwater immersion lights equipped with CCTV that is placed in a transparent acrylic tube is a technological innovation that is expected to overcome the shortcomings of the acoustic work system and at the same time improve the existing underwater immersion light work system; the addition of CCTV to underwater immersion lights provides an added value to fishing tools that use light. Therefore, this study proposes an Underwater Fish Lamp Plus (UFLPlus) technology that serves as a fishing aid that can attract attention and directly monitor the condition of fish in the sea from the boat. Doing this research is important because the design of the UFLPlus model and work system is a novelty of the existing underwater submersible light technology.

This study aimed to determine how the UFLPlus was designed and constructed, estimate the Buoyant and sinking force of the UFLPlus material, measure the amount of illumination and light distribution generated from the lamps contained in the UFLPlus, and provide an overview of the results of fishing trials using UFLPlus on a field scale. From the results of these trials, this research can provide recommendations for a fishing aid technology that is more effective and efficient.

2. Material And Methods

## 2.1 Research Location and Design

This research was conducted in two stages. The first stage was laboratory-scale research in which UFLPlus was designed, constructed, and tested. The design and construction of UFLPlus were carried out from December 2019 to February 2020 at the Shipbuilding Workshop, Nambo Village, Kendari City, Indonesia, and UFLPlus trials were carried out at the Fishing Technology Laboratory, Faculty of Fisheries and Marine Sciences, Haluoleo University, Indonesia. Research activities and laboratory-scale testing include the following: designing and determining the materials to be used, testing the lights on, testing water tightness, and testing light distribution in the air. In the second stage, the research was carried out in the field: UFLPlus was tested by following a boat lift net fishing gear from February to March 2020 in the waters of Pulau Hari, Konawe Selatan Regency, southeast Sulawesi Province (Figure 1). The research and field-scale testing activities carried out include the following: testing the Buoyant and sinking forces of UFLPlus in the sea and testing of UFLPlus during fishing operations.

2.2 Materials

The tools used in the design and manufacture of UFLPlus included welding tools, solders, electric drills, measuring instruments, and hacksaws. The materials used in the manufacture of UFLPlus were 14.5-Watt white LED strip lights with 60 lamp points, 5-mm acrylic tube, acrylic glue, ballast iron, solder tin, lead, drill bits, power supply, resistor, power cable, DC dimmers, CCTV cameras, and 7-inch ATM digital video recorders (DVRs).

2.3 Data Collection Method

The research method used in this study was tool design and experimental fishing. The data were collected using descriptive methods. Primary and secondary data were needed in this study. Primary data were collected by making direct measurements with related parameters, including the construction of immersion lamps in water, measurement of UFLPlus immersion and the Buoyant force measurement of light illumination, and
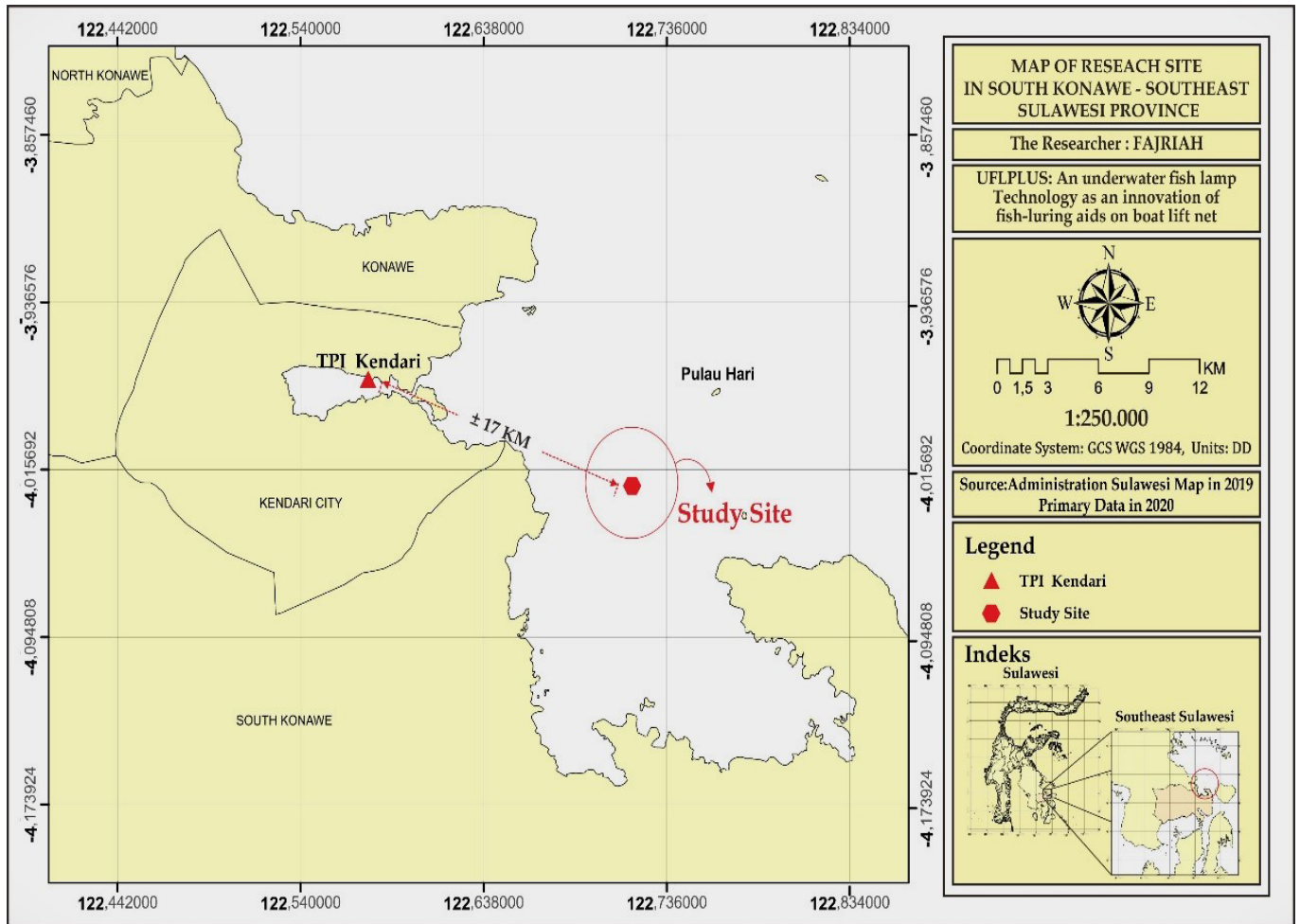
Figure 1. Map of the research location

workability of UFLPlus as an underwater immersion lamp in collecting and concentrating fish in the fishing area of the boat lift net fishing gear. The workability of UFLPlus was determined based on the type and composition of the fish catch and the duration of each dropping and lifting of the net using UFLPlus in the waters of Pulau Hari. Conversely, secondary data were collected through the study of research-related literature.

2.4 Analysis Data

2.4.1 Making UFLPlus

Descriptive analysis that details the design process, material selection, and manufacturing process was used in this study. Furthermore, it has been completed with specifications and references of the UFLPlus parts, including the materials used.

2.4.2 Testing the UFLPlus lamp

To ensure that there is no electrical short circuit during use of UFLPlus in the field, the constructed UFLPlus was tested to light up three times: before, during, and after water immersion. If there is no electrical short circuit or the light goes out, the light test

is complete.

2.4.3 Waterproof test

The UFLPlus series that has been completed and passed its ignition capability was tested for its water tightness by placing it in 1–2 m of water in the water tank to determine whether there was a leak or not. The soaking process took about 1–2 hours; then, the UFLPlus was lifted upward to ensure that no water enters the UFLPlus tube. If no water enters or seeps into the UFLPlus acrylic tube, then the waterproof test is complete.

2.4.4 Test sinking and UFLPlus buoyancy

The immersion and buoyancy test were carried out in two stages: first, through technical calculations of material contained in the UFLPlus, in which the Buoyant and sinking forces of the UFLPlus material were calculated, and, second, directly lowering the UFLPlus from the top of the boat lift net fishing gear into 7-m-deep water. To determine the Buoyant and sinking forces, knowing in advance the volume and weight data of the UFLPlus material were necessary.

Buoyancy (B) is referred to in the formula used in this modification. The buoyant force on the fishing gear demonstrates an object's ability to float on water. The formula for buoyancy and sinking force (Martasuganda, 2008) were shown in Eq 1 and Eq 2.

$$F b = W(\sigma t/\rho - \sigma t) \qquad (Eq\ 1)$$

$$F s = W(\sigma t - \sigma t/\rho) \qquad (Eq\ 1)$$

Note: F b = Buoyant force (N); F s = sinking force (N); W = Gravity force (g); σt = sea water density (kg/m³); ρ = density (kg/m³)

In measuring the Buoyant and sinking forces of a material, the most important thing to know is the density of the material to be measured. Density is the mass of a material substance per unit volume. If the ratio of the value of the buoyancy is less than that of the sinking force, then UFLPlus can be used as a submerged lamp in water.

2.4.5 Light scatter test

The light distribution test is carried out by measuring the illumination of the spread of light or the intensity of light in the air, which is calculated as follows (Singh, 2015):

$$E = I / r^2 \qquad (Eq\ 6)$$

Note: E: illumination of light (lux); I: light intensity (candela); r: distance from the light source (m)

The measurement procedure is carried out in a closed or darkroom in the laboratory to see the light distribution pattern of the LED lights used in the UFLPlus, which are white. The measurement of light illumination is carried out in a dark room. The position of the light intensity measurement is from the right to left and bottom positions using the LX1010B digital lux meter with a range of 2000 lux. The working principle of a lux meter is to measure the level of illumination in a predetermined area and digitally show the measurement results (Hamidi *et al.*, 2017). Measurements were carried out horizontally and vertically at every angle-angle 10° with different distances ranging from 100 to 200, to 300, to 400 cm in the air medium.

2.4.6 UFLPlus testing during fishing operations and data analysis

This trial is carried out at the time of the fishing operation on the boat lift net fishing gear. The aim is to obtain information regarding the ability of UFLPlus lamps to collect and concentrate fish in the fishing area. Observations are made on a boat lift net visually via a monitor screen connected to a CCTV camera attached to the UFLPlus. The variables observed were the type of fish, the amount of catch per hauling, and the recorded duration of how long it takes for one hauling, and how much hauling can be done in one night of fishing operation. The analysis used was descriptive analysis.

3. Results and Discussion
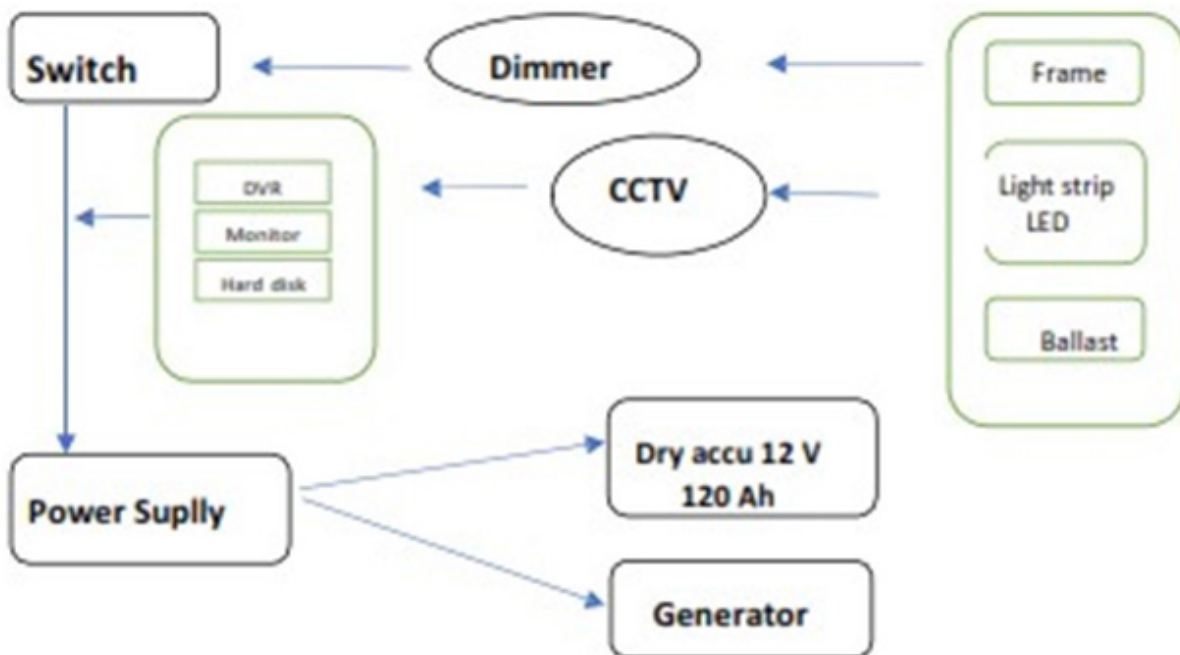
3.1 Results

Figure 2. UFLPlus circuit system

3.1.1 UFLPlus design and construction

The light system is connected to the power supply system using a switch (Figure 2). The components of the UFLPlus technology section along with their functions, are LED lights as call lights or fish attractants, where the light frame functions as an UFLPlus protector (Figure 2). The tin ballast functions so that the UFLPLus can sink appropriately in the water. CCTV as a camera to monitor conditions in the water around the boat chart (CCTV is in the UFLPlus series). The mini monitor and receiver function capture and display images on the screen to see the conditions in the water around the boat, which were caught by CCTV cameras. The adapter or power supply serves to connect a DC or AC voltage source. DC voltage is required for the UFLPLus circuit to function. The switch helps to connect the electric current to the dimmer lamp, and the dimmer serves to adjust the intensity or dimming of the lamplight. A dry Battery serves as an alternative source of electrical energy for UFLPlus, which is operated on a boat lift with a voltage of 12 Volts. The generator acts as a source of electrical power for UFLPlus on the boat chart, and the cable serves as a connector for electric current between components.

The specifications and information in the construction of the UFLPlus technology is composed of (1) An upper frame in which rope hooks measure 2 cm high and 1 cm wide (3 angles and made of stainless steel) and maximum weights measuring 12 cm tall. and 28 cm in diameter (1 in total and made of tin-coated iron). (2) A tube consisting of a tube made of acrylic. with a height of 20 cm, a diameter of 18 cm, a thickness of 55 mm, and a locking rubber or rubber cell that seal the acrylic tube with the top frame. (3) The bottom frame and the bottom weights with a height of 5 cm are made of tin-coated iron. Construction on the top and bottom of the UFLPlus (frame), the primary material is chosen for use is a 10-inch steel stirrup covered with a tin plate. The choice of this material because of its quite heavy and robust mass is very appropriate to be used as ballast and protector of UFLPlus. Tin plate as an iron coating was chosen to protect the iron material inside so it is not easy to rust. (4) CCTV consists of a central lens component with a lens size of 3.6mm, totaling two pieces and made of polycarbonate plastic. (5) The LED strip light consists of 120 chip lamps with a DC power of 12 V, 6 watts. it was made of a combination of plastic and aluminum. (6) Power cord. (7) The hose that protects the lamp power cable and CCTV has a length of 10 m made of silicone plastic (Table 1).

Table 1. Specifications and information in UFLPlus construction

| UFL Plus section	Component	Size	Total	Material
Top Frame	Hose hook	Height: 2 cm; Width: 1 cm	3	Stainless iron
	Upper frame	Height: 12 cm; Diameter: 28 cm	1	Lead plated iron
Tube	Protection tube	Height: 20 cm; Diameter: 18 cm; Thickness: 55 mm	1	Lead plated iron
	Seal rubber	Thickness: 4 mm; Width: 11; Diameter: 16 mm	1	Acrylic
Underframe	Ballast	Height: 5 cm; Diameter: 28 cm	1	Lead plated iron
CCTV	Lens	3.6 mm; DC 12V; IR length 20 m	2	Plastic polycarbonate
Light strip LED	Lamp	DC 12 V; Diameter: 14 mm; 5 watt	60	Plastic and aluminum
Power cable	Isolator	Length: 10 m	1	Thermoplastic
	Conductor	Length: 10 m	1	Copper
Hose	Hose	Length: 10 m	1	Silicone
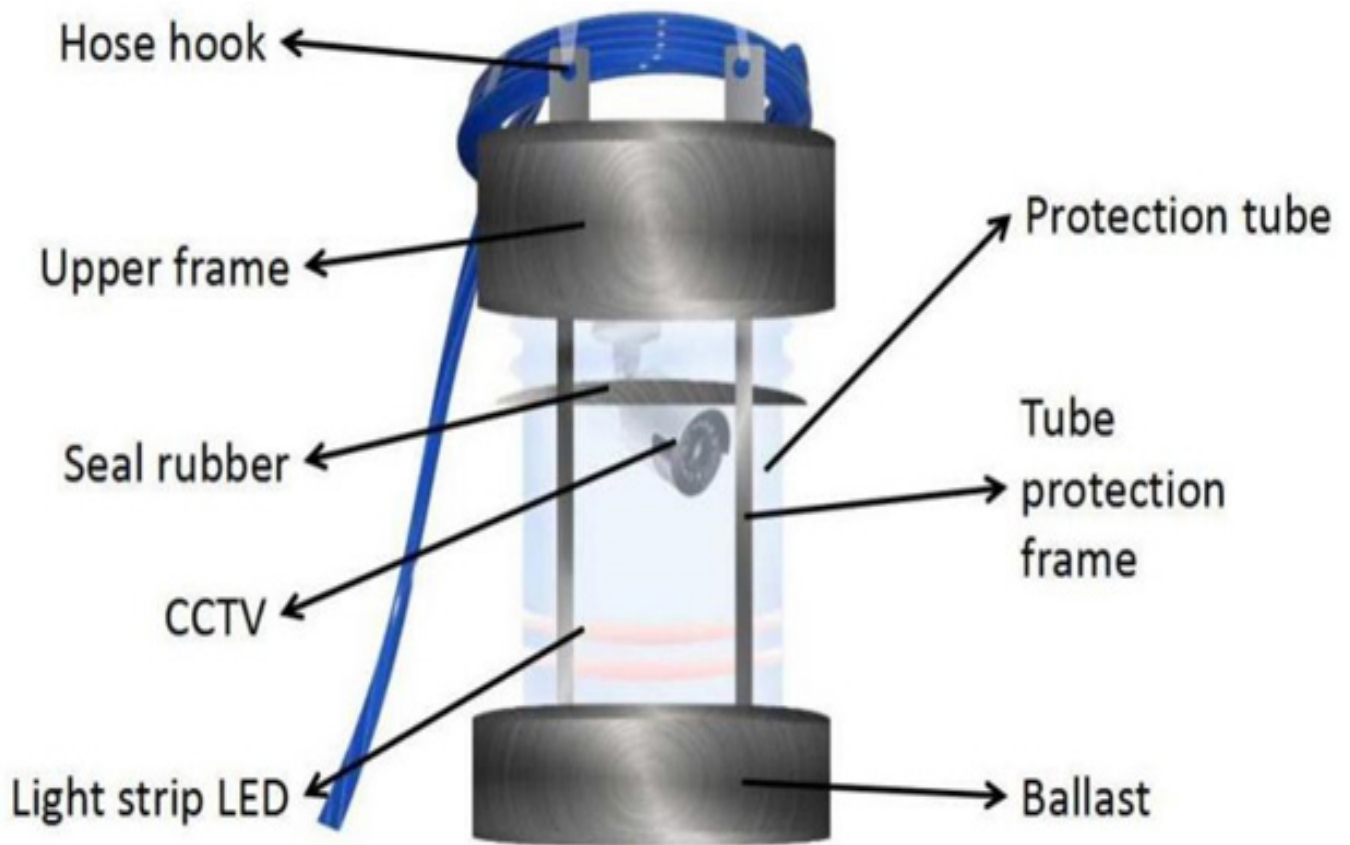
Figure 3. UFLPlus construction design

(a)   (b)

Figure 4. The observation media has been integrated with the light system (a), storage media (DVR), and monitor screen (b).

3.1.2 Light circuit system

The UFLPlus construction design consisting of a hose hook, upper frame, CCTV rubber seal, LED light strip, protection tube, tube protection frame, and ballast (Figure 3).

3.1.3 Recording system (recording)

The UFLPlus unit is integrated with the recording system (Figure 4). The UFLPLus technology consists of CCTV observation media that has been integrated with the lighting system (Figure 4a). CCTV used has a lens size of 3.6 mm, DC 12V, IR length 20 m. For video recording purposes, the system is equipped with storage media with a capacity of 1 TB (terabytes). At the same time, recording storage medium (DVR) is captured from CCTV in a lamp (Figure 4b). This storage media also functions as a monitor screen that can monitor the movement of fish directly on the boat. All CCTV cameras will be recorded in a DVR (Digital Video Recorder) series with a monitor screen (7 inches DVR ATM).

3.1.4 Test turns on the UFLPlus lamp

The test results showed that the lamp contained in the UFLPlus lights up when an electric current is applied in the state before being immersed in water, during water immersion for 30 minutes, and after being immersed in water (Table 2).

Table 2. UFLPlus lamp light test

UFLPlus lamp light test	On	Off
Before immersion	√	
When immersion	√	
After immersion	√	

3.1.5 Waterproof test

Based on the waterproof test, the water did not enter the acrylic tube in the UFLPlus that was soaked for 2 hours (Table 3).

Table 3. Waterproof test

Is there water in the tube?	Yes	No
UFL Plus lamp after soaking for 2 hours		√

3.1.6 Test of UFLPLUS for the Buoyant and sinking forces

Information related to the size and weight of the UFLPlus material is needed to obtain the total value of the Buoyant and sinking forces (Table 4).

3.1.7 Light spread test

Each light distribution pattern has a shape or design that is generated. The form of the horizontal light distribution pattern is around or circle shape (Figure 5a), while in the shape of the vertical light distribution pattern has obtained a shape resembling a butterfly (Figure 5b). The body of this light distribution pattern resembles the light distribution pattern obtained by Taufiq *et al.* (2016) that the dipped LED lamp in the form of a vertical tube or cylinder that he assembled has a round horizontal distribution pattern, and the vertical distribution pattern resembles a butterfly, but the bottom half is a cone. The pattern of light intensity of UFLPlus lamps with a vertical and horizontal position is decreasing (Figure 6). Based on this, it can be seen that the form of the lamp media influences the shape of the light distribution pattern in the air.

3.1.8 UFLPlus testing during fishing operations

The average number of lift net catches obtained using the UFLPlus tool per trip is 139 kg. There were four species that were caught, including *Stolephorus sp.* (62 kg), *Leiognathus sp.* (27 kg), *Selaroides leptolepis* (17.5 kg), and *Sardinella fimbriata* (32.5 kg) (Figure 7). Catches were documented and monitored directly from the boat via a camera (Figure 8).

3.2 Discussion

### 3.2.1 UFLPlus design and construction

The goal of designing and building a CCTV-equipped UFLPlus is to make it easier for fishermen to directly detect the arrival of fish and to know the conditions in the sea in the fishing area or nets and surroundings at a depth of 10–20 m from the boat, and it is hoped that fishermen will be able to determine the right time to lift the net so that fishing operations can be more effective and efficient. The most crucial first stage is to decide on the shape or model and materials that will be utilized in designing and building. A vertical tube or cylinder shape was chosen for the lamp construction for the following reasons: it can accommodate a CCTV camera that will be placed close to the LED strip light; it is formed by two parallel upper and lower circles and a rectangle that surrounds the two circles (Firdawati, 2011); and it is suitable for the construction of the underwater submerged lamp design because there is no angle in the space, resulting in the even distribution of the emitted light on all sides, which then attracts the attention of fish. Furthermore, the tube or cylinder shape may evenly divide the pressure into each area, making the tube more pressure-resistant (Taufiq *et al.*, 2016).

**Table 4.** Total Buoyant and sinking forces of UFLPlus material

Material	W (g)	ρ (kg/m³)	σt (kg/m³)	F b (N)	F s (N)
Acrylic tube	9.8	0.53841	1.025	8.611785721	-8.611785721
Iron-lead frame	9.8	5.825808331	1.025	-8.32077575	8.32077575
Light strip LED	9.8	0.666666667	1.025	5.0225	-5.0225
CCTV	9.8	0.4	1.025	15.0675	-15.0675
Power cable	9.8	2	1.025	-5.0225	5.0225
Hose	9.8	1.578947368	1.025	-3.683166667	3.683166667
PE rope	9.8	1.25	1.025	-2.009	2.009
Total Buoyant force				**9.666343**	
Total sinking force					**-9.666343**
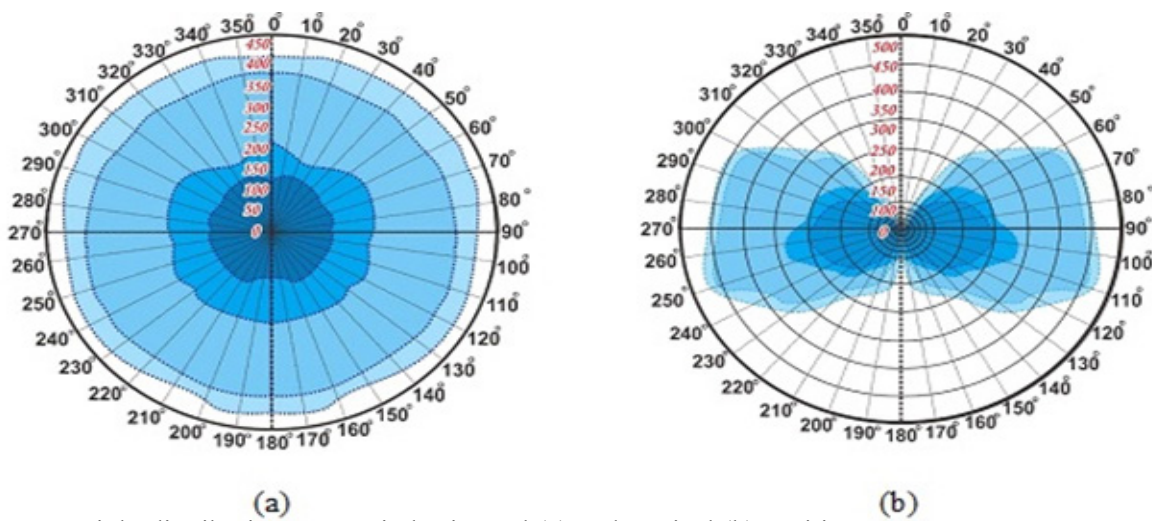
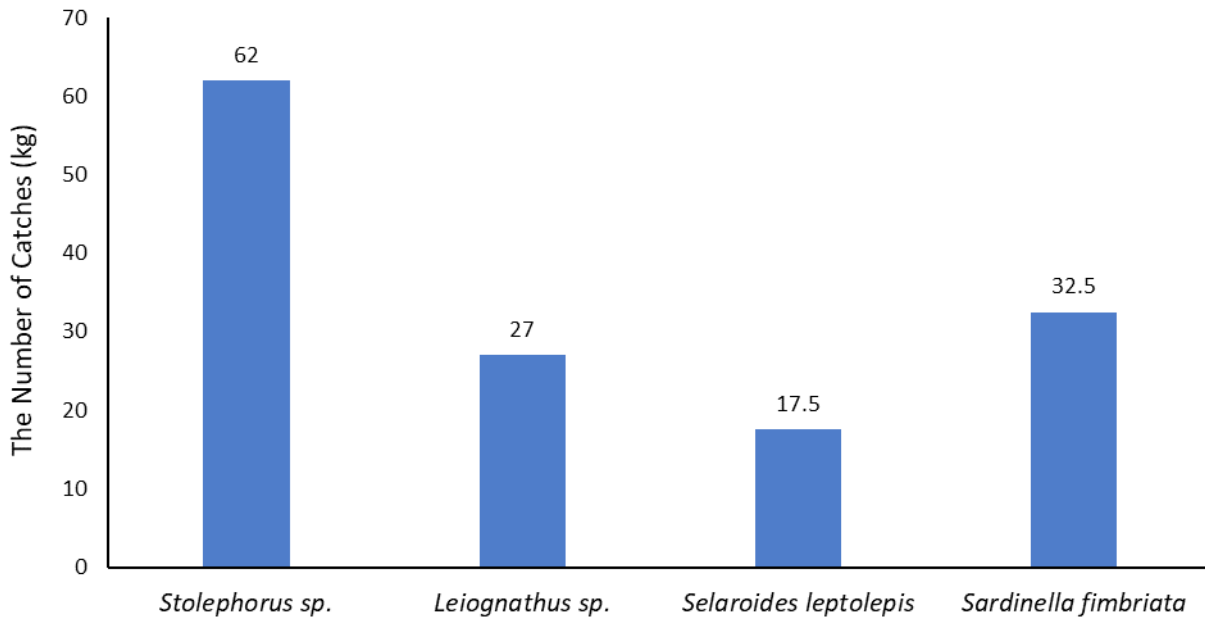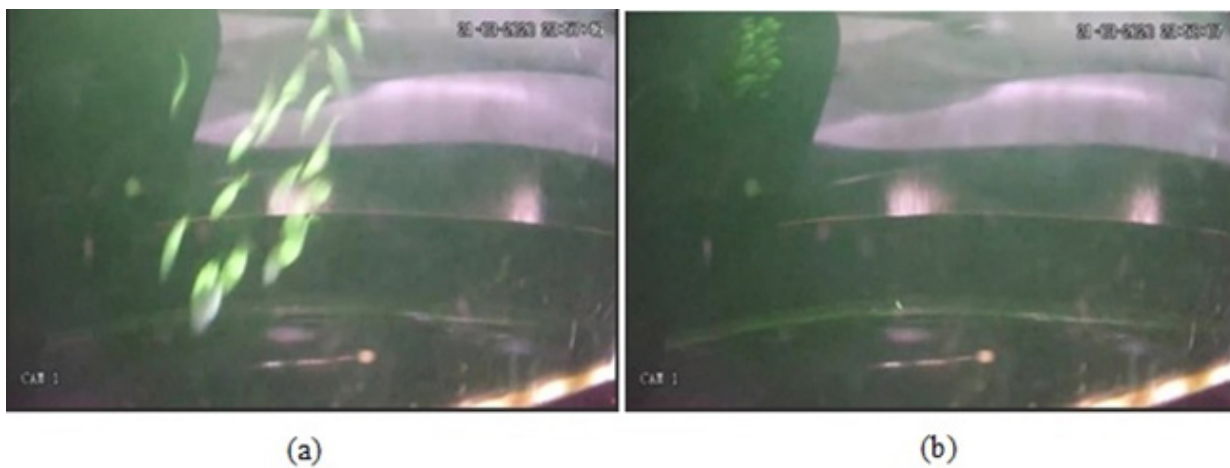**Figure 5.** Light distribution pattern in horizontal (a) and vertical (b) positions
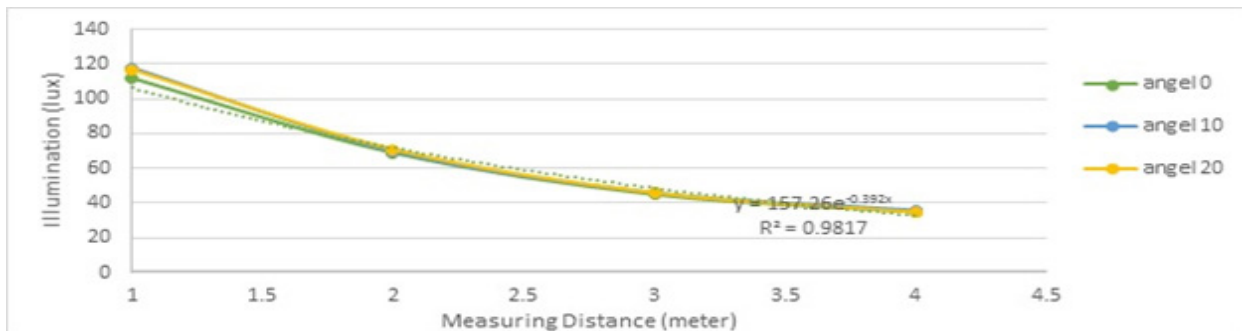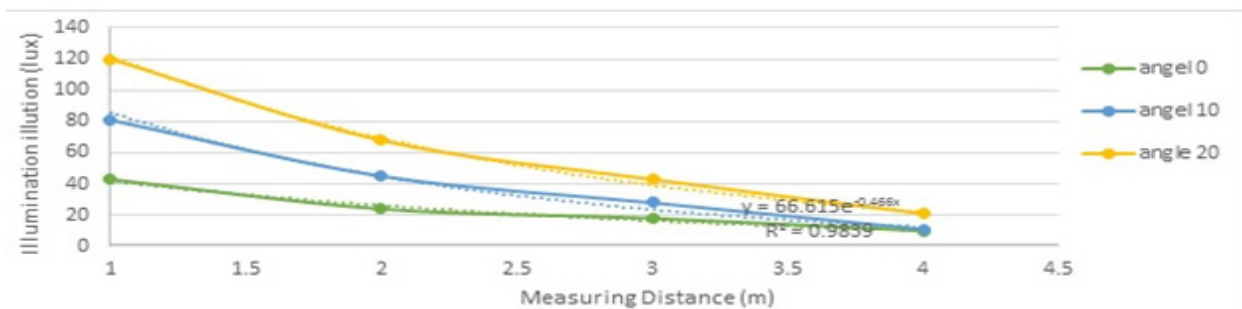
Figure 6. Reduction pattern of UFLPlus light intensity with horizontal (a) and vertical (b) positions

Figure 7. Average number of catch per trip and type of UFLPlus catch during the study.

Figure 8. Results of UFLPlus video camera recording documentation in water (processed): schools of fish that have been close to UFLPlus (a) and schools of fish from afar that come to approach UFLPlus (b).

UFLPlus is built in such a way that the components included within it can be assembled and integrated without interfering with the function and operating mechanism of each component. Each UFLPlus section is designed to perform many duties in order to improve the efficiency of the UFLPlus model and size. The top not only serves as a protector and support for the tube frame, but it also serves as a location to tie ropes, power lines, and hoses. The acrylic tube's middle section serves as a guard for LED and CCTV lights. The bottom, in addition to serving as ballast, also serves as a bottom protector. The arrangement of the main components and the materials used, particularly the capacity of UFLPlus tube materials to protect lamp sections from pressure, leakage, and damage from immersing in the sea, will have a significant impact on the performance and construction of the created UFLPlus. This is consistent with Callister (2004) report. Material selection is critical when creating a product, and functions, restrictions, objectives, and independent variables must all be considered. A side from CCTV, another innovation, such as an integrated dimmer, can be added to the light system to allow for easy adjustment of the light intensity.

The greater the depth of water, as is well known, the greater the hydrostatic pressure. The acrylic tube material was chosen to cover LED lights and CCTV

since it can endure pressure in seawater. Based on the findings of Sulkhani *et al.* (2014), the highest load value that the tested acrylic can with stand is in the range of 1238.65–1539.30 kgf/cm², with the hydrostatic pressure increasing by 1 atm every 10 m depth, which is equivalent to 1.03 kg/cm² or 14.70 1bs/in². This amount is far more than the load or hydrostatic pressure that UFLPlus will experience when operating in the sea. Acrylic material fits the criteria of shielding the lamp and CCTV with the current UFLPlus operational depth of 10–20 m above sea level, or roughly 1.03–2.06 kgf/cm². There is also a rubber lock (a circle around the tube) that secures the acrylic tube to the top frame and allows the tube to be tightened or locked properly so that water does not enter the tube and it can be readily removed for component replacement. The main material used for the top and bottom of the UFLPlus (frame) is a 10-inch steel stirrup coated with a tin plate. This material was chosen for its hefty and sturdy bulk, and it is ideal for use as ballast and UFLPlus protector. As an iron covering, a tin plate was used to protect the iron material and prevent rust. The dimensions of UFLPlus were as follows: The overall height is 35 cm, the diameter is 28 cm, and the total weight is 7.5 kg.

3.2.2 Light circuit system

The lighting circuit system of the UFLPlus, like any other underwater immersion lamp, plays an important role in deciding the effectiveness of a capture operation. As a result, the materials utilized must be carefully chosen. On the 1 m circuit sheet of UFLPlus, which is produced with the LED light strip SMD 5630 IP20/3 and a DC voltage of 12 V, there are 60 SMD LED chip lights with a power rating of 14.5 watt. This sort of LED light strip was chosen as a lamp on the UFLPlus because it is more flexible and easy to modify or remove as needed. The lamp on the UFLPlus was mounted to the tube wall to reduce condensation caused by the lamp's heat. Furthermore, it is simple to turn on and, like all LED lights, is long-lasting. The LED light strip is mounted in parallel circuits around a portion of the surface of the acrylic tube; it does not take up much room for a series of lights. The lamp's color is white; this is based on the findings of Sulkhani *et al.* (2014), who indicated that utilizing white for the light intensity distribution pattern generates a hexagon, which makes the reflector more perfect. This is because light white is diffuse, whereas other hues are straight. The fitted LED light is linked to a resistor, which regulates the current to make it more steady. The resistor used is 47 Ohm and 2 Watts. Dimmer assemblies are intended to be directly linked to the power supply via a switch system.

3.2.3 Recording system (recording)

Another novel feature of UFLPlus is the presence of a video camera or CCTV that can record happenings in the water. This will substantially aid fisherman using passive fishing gear, such as a boat lift net, in their fishing activities. While waiting for the fish to gather, fishermen can directly monitor events in the water around where the underwater submerged lights are located. CCTV has an infrared camera that can capture images or videos, even in dark conditions. All captured CCTV cameras will be recorded on a DVR, which is also in a series with a 7-inch ATM DVR monitor screen. This device was selected to reduce the use of CCTV components to facilitate the use of UFLPlus on a ship or in the middle of the sea. The CCTV used has a lens size of 3.6 mm, DC voltage of 12 V, and IR length of 20 m. For video recording purposes, the system is equipped with storage media with a capacity of 1 terabyte.

3.2.4 Test turns on the UFLPlus lamp

The lamp light test was carried out before, during, and after water immersion to ascertain whether there is a problem with the lamp or a short circuit. The test was conducted with the help of a power supply by attaching the end of the UFLPlus power cord. The lamp is lit in water, and the lamp is left on for 30 minutes.

3.2.5 Waterproof test

The watertight test procedure began by dipping a series of UFLPlus into a media filled with water with a depth of 1 m and then left to soak for ± 2 hours. Furthermore, a thorough inspection of all sides of the UFLPlus was carried out to check if there is water in the protective tube.

3.2.6 Test of UFLPLUS for Buoyant and sinking forces

The measurement of the Buoyant and sinking forces of the UFLPlus is very important as finding the ideal size for a submerged underwater lamp to sink properly is necessary. If Buoyant force is greater than the sinking force, it is certain that the UFLPlus circuit cannot be used as an underwater immersion lamp. The choice of material and size is very important in determining whether UFLPlus can sink in the sea properly or not.

The calculated result of the Buoyant and sinking forces of UFLPlus obtained from the total the Buoyant and sinking forces of each UFLPlus material component shows that the sinking value of 11,893.20 g is far greater than the buoyancy value of 6.80 g. This is as expected in a submerged underwater light, in general, to completely submerge in seawater. Although the UFLPlus material is primarily made of iron, this does not guarantee that a series of objects will easily sink into the sea as there is also a Buoyant force affecting it; therefore, it must be supported by the correct material size (g/cm³), design, and construction. The sinking force value obtained by an object helps the object to remain stable in its place in the water if external effects such as current factors are

present (Wahyu *et al.*, 2009).

3.2.7 Light spread test

The light distribution pattern produced by the main lamp is influenced by the shape of the UFLPlus construction, which has a symmetrical shape and the same type and number of lamps used, resulting in the 180º–360º angle pattern having the same value; thus, measurements are only performed at an angle of 0º–180º. The light intensity of UFLPlus lamps was measured using white color at various measuring distances ranging from 1 to 2, 3 to 4 m. Vertical and horizontal measurements are taken using multiples of 10º angles in an air medium ranging from 0º to 180º.

When creating light using a device like UFLPlus, it is required to do a light scatter test to determine whether the final illumination value is still within the appropriate range or suitable for fish. In terms of movement behavior and light adaptation on floating boat lift net fishing gear, anchovies at a water column depth of 1–10 m are particularly responsive to light, with intensities of 45 (1 m), 35 (5 m), and 14 lux (10 m) (Baskoro *et al.*, 2019; Chairunnisa *et al.*, 2018). The results of measuring light intensity horizontally at various distances (1-m distance, 102–117 lux; 2-m distance, 61–69 lux; 3-m distance, 36–45 lux; and 4-m distance, 28–35 lux) revealed that the greater the measurement distance, the lower the illumination value. Each scattering of light generated a shape or pattern. The light distribution pattern took on a circular shape when placed horizontally. Vertical light intensity was recorded at a distance of 1 meter ranging from 43 to 351 lux, 2 meters ranging from 24 to 264 lux, 3 meters ranging from 18 to 176 lux, and 4 meters ranging from 10 to 132 lux. The light intensity produced by UFLPlus is still within the range that can be captured well by the retina of fish, such as anchovies (*Stolephorus* sp.), which can adapt to light intensities of 35–45 lux (Sudirman *et al.*, 2004b). A butterfly-like shape was obtained in the vertical position. The illumination value is influenced by the measuring distance at each measurement angle, and the effect is given in the form of an exponential equation.

3.2.8 UFLPlus testing during fishing operations

The fishing trial was carried out for four nights or four consecutive trips in the third week of March 2020. Every night, there were three haulings. Therefore, there are 12 replications of lowering the net on the boat using the UFLPlus. The types of fish caught include anchovies (*Stolephorus* sp.), ponyfishes (*Leiognathus* sp.), yellow-stripe scad (*S. leptolepis*), and Fringe-scale sardinella (*S. fimbriata*). Based on the results of the fishing trials, the average catch per trip was dominated by 62 kg of anchovy (*Stolephorus* sp.). This is because of the ability of anchovy to adapt perfectly to light that

occurs every hauling (Baskoro *et al.*, 2019). Conversely, other types of fish are more or less the same: ponyfishes (*Leiognathus* sp.) with as much as 27 kg and Fringe-scale sardinella (*S. fimbriata*) with 32.5 kg. The lowest catch is yellow-stripe scad (*S. leptolepis*), with 17.5 kg.

Based on the results of trials using UFLPlus in the field, it shows that UFLPlus can work well as its function is to collect fish in a fishing area and increase the number of hauling every night of fishing. This is evident from the lack of catches of other boat lift net fishing gear that only use the surface light (without the aid of an underwater immersion lamp) closest to the lift net of the boat used for testing. From the results of interviews with fishermen on the boat lift net, the catch is less, which is only around 20–30 kg per hauling, and the maximum number of hauling was twice in one night; therefore, the estimated total catch, including all types of fish caught, only ranges 50–60 kg per trip.

Catches were documented and monitored directly from the boat via a camera It showed that there are many types of anchovy (*Stolephorus* sp.) that come clustered around the UFLPlus lights. The arrival of fish in the fishing area in the operation of the fishing gear of the boat lift net is influenced by not only the use of underwater submerged light technology but also other factors such as oceanographic factors. The catch of lift net fishing equipment is impacted by the brightness and current speed at a specific depth, particularly during hauling (Lucchetti and Sala, 2012; Sistiaga *et al.*, 2015; Sudirman *et al.*, 2004a).

4. Conclusion

LED light strips with 120 chip lights and 14 watts of power are arranged in a circle around the tube in the UFLPlus structure. Acrylic was chosen as the tube's material because it is lightweight and resistant to pressure in seawater; the tube also serves as a lamp protector and CCTV. The upper section is made up of an upper frame that serves as top protection, a hook for a rope hanger, and a weight; it is composed of tin-plated iron, which does not corrode readily. The lowest section serves as both a weight and bottom protection. The UFLPlus stands 35 cm tall, has a diameter of 28 cm, and weighs 6 kg. The findings of laboratory tests confirm that UFLPlus is safe to use. Several test findings, including the lamp immersion test, the waterproof test, the buoyancy test, and the immersion power test, demonstrate this. The findings of the measurement of the illumination value of the white UFLPlus lamps range from 28 to 117 lux in horizontal measurements and 10 to 132 lux in vertical measurements. This value is still within the completely adapted range of numerous fish, particularly anchovies (Stolephorus sp.); thus, the light illumination fits the standards as a fishing aid. According to the field test results, UFLPlus can work as an underwater immersion lamp that draws fish attention

and directly monitors the arrival of fish in the water in the fishing area.

Several additional studies on the use of UFLPlus will be required in the future to support the perfection of UFLPlus. These studies should include fish behavior research, fish arrival patterns, a comparison of the productivity level of UFLPlus with existing underwater immersion lamps, and an economic analysis calculation relating to the effectiveness and efficiency of UFLPlus lamps in increasing the competitiveness of boat lift net fishing gear.

Acknowledgement

Author's Contribution

The contribution of each author as follow, Fajriah; collected the data, data analysis, drafted the manuscript and designed the figures. Ahmad and Muhammad; devised the main conceptual ideas and critical revision of the article. Kobajashi, La Anadi, and Marsuki; collected data and data analysis. Idrus and Sampunur; data analysis. All authors discussed the results and contributed to the final manuscript.

Conflict of Interest

The authors declare that they have no competing interests.

Funding Information

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