Optimizing fishing time with Underwater Fish Lamp Plus (UFLPlus) technology: a strategy to enhance productivity and sustainability of boat lift net fisheries

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Abstract. The UFLPlus technology is an innovative underwater fish lamp equipped with Closed Circut Television (CCTV). UFLPlus can enhance catch productivity by 41% and reduce fishing time, achieving an operational efficiency improvement of up to 33% in a single night. This innovation provides an effective and sustainable solution for lift net fisheries operating from boats. Boat lift net fishing methods often face challenges related to long fishing times, even when using submerged lamps as auxiliary tools. UFLPlus technology, with its optimal lighting system and integrated CCTV or image sensing. This study aims to evaluates the effectiveness of UFLPlus in improving the productivity of boat lift net fisheries by focusing on two key aspects: fishing time and productivity. It also compares UFLPlus with traditional underwater lamps without CCTV. Furthermore, it demonstrates that UFLPlus can significantly improve fishing time efficiency. The research was conducted in August 2024 in the boat lift net fishing grounds around Hari Island, South Konawe Regency, utilizing an experimental fishing method.

1 Introduction

Fishing practices worldwide are continuously improving with technological advancements aimed at increasing efficiency and sustainability [1]. Boat lift net fisheries are a traditional fishing method in Indonesia that significantly supports the economy of coastal communities [2]. This method uses underwater lamps to attract fish [3,4,5]. However, fishermen often face challenges such as prolonged fishing times and unpredictable catches due to the lack of real-time information on fish presence around the gear.

To address these issues, new technologies have been developed to enhance fishing efficiency. One such innovation is the UFLPlus, which combines underwater lamps with a CCTV system to provide real-time visual data on fish presence near the lift net [1]. This

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system helps fishermen monitor fish movements and determine the best timing for hauling, making fishing operations more effective and efficient. With better timing, fishermen can perform more hauls in a single night, increasing their total catch. Thus, the addition of CCTV not only speeds up the fishing process but also improves productivity.

Previous studies have highlighted the benefits of using CCTV in fishing. For example, research by [6] showed that CCTV on trawlers can monitor and measure discarded catches, reducing bycatch, a major issue in commercial fisheries [7, 8]. This makes the technology suitable for boat lift net fisheries, which operate in coastal waters with dynamic fish populations. This study evaluates the effectiveness of UFLPlus in improving the productivity of boat lift net fisheries by focusing on two key aspects: fishing time and productivity. It also compares UFLPlus with traditional underwater lamps without CCTV, hypothesizing that UFLPlus can shorten fishing time and increase catches. This research aims to support the development of more efficient and sustainable fishing technologies in Indonesia and promote their adoption among local fishing communities.

2 Material and methods

This research was carried out directly in the field by following boat fishing operations owned by fishermen in Tondonggeu Village, Kendari City, and was carried out throughout August 2024. The location of the boat fishing ground is around Hari Island, South Konawe Regency. This location is a boat fishing base located north of Staring Bay which is famous for its potential for small pelagic fish that are found throughout the year [9], with a geographic position of 04°15'69.2”S and 122°73'60”E to 04°15'69.2”S and 122°73 '60”E as in Figure 1. The research location was determined deliberately (purposive sampling) with the consideration that this location is a body of water in Southeast Sulawesi where there are quite a lot of boats actively operating throughout the year compared to several other water areas which also have boats, so this is the basis that operation or testing of UFLPlus technology on boat charts is suitable in these waters. This is mainly due to the supportive environment and water conditions.

The research design uses the Action Research method [10], this is a research approach aimed at solving specific practical problems while generating new knowledge or better understanding. This method involves collaboration between researchers and participants to design, implement, evaluate, and reflect on the actions taken. The application of this approach in this study involves testing the UFLPlus technology and underwater lights without CCTV on a single boat lift net unit for 24 nights per month (one trip). For each use, the light trials were carried out for 12 nights, with the first 3 nights using UFLPlus, the next 3 nights using underwater dipping lights without CCTV, then the next 3 nights again using UFLPlus until both types of lights were each tested for 12 nights. Determining the number of repetitions (n=12 for each lamp) increases statistical power, namely the ability to detect real differences between the two technologies if they exist, to avoid type errors or errors in failing to detect differences when differences actually exist, and to provide higher confidence in results of statistical analysis (e.g., t-test). In Table 1 below is a design for a replicated trial using UFL Plus technology and underwater dipping lights without CCTV for 24 nights.

Table 1. Repetitive trial design using UFLPlus and underwater immersion lights without CCTV for 24 nights

Treatment	Night to																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
UFLPLUS	v	v	v				v	v	v				v	v	v				v	v	v			
Underwater diving lights without CCTV				v	v	v				v	v	v				v	v	v				v	v	v

Note: v = night of treatment or use of lights

From the repetition formula above, every night with the use of lights, both UFLPlus lamps and dipped lights without CCTV, the number of repetition frequencies for hauling nets depends on the effectiveness of the use of time for each haul. The more effective the use of time, the greater the number of hauls which will then influence the total number of catches in one night. Data analysis techniques are used to analyze research objectives using a descriptive quantitative research method approach. Productivity analysis is expressed in equation 1:

$$Prd = c/t \quad (1)$$

Where, Prd = Productivity of the boat (kg/minute-1), c = Number of catches (kg), t = effective fishing time (minutes) which is calculated starting from lowering the net followed by turning on the lights [11], as for the different test (t test) through independent sample t-test analysis to analyze differences in boat chart productivity using submersible lights without CCTV and using UFLPLus, and regression analysis to analyze the effect of the amount of hauling on productivity, to obtain a model of the relationship between the amount of hauling and productivity.

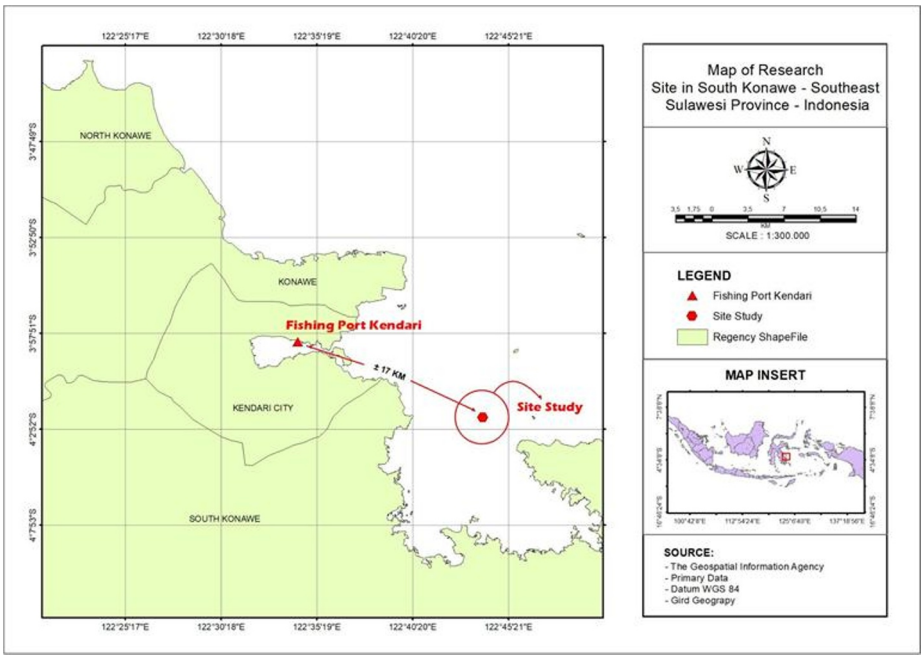


Fig. 1. Test location for using UFLPlus and underwater submersible lights without CCTV.

3 Results and discussion

3.1 Use of UFLPlus Technology to Increase the Productivity of the Boat Lift Net Fishery Business

The use of UFLPlus technology in chartreuse fishing gear is in principle the same as using underwater dipping lights without CCTV, namely the use of lights in the water to attract the attention of fish. The difference lies in the additional functions. The addition of CCTV to the design and construction of underwater dipping lights as in Figure 2, aims to make it easier for fishermen to detect the arrival of fish directly via video, find out the condition of fish in the fishing area or around the net at a depth of 10-20 m, this is in accordance with the expression [12], that fish in water up to a depth of 2 m can still be observed clearly visually from the top of the chart, however at depths of more than 3 m visual observations are difficult so whether there are schools of fish under the chart platform are usually indicated by many whether or not bubbles appear on the surface of the water. Therefore, the use of CCTV to detect the presence of fish schools around the fishing boat lift net or in the catchable area is crucial. According to [13], visual monitoring systems, such as CCTV, enable direct observation of fish movement patterns, thereby supporting the optimization of fishing times. Additionally, the incorporation of CCTV is expected to determine the right timing for lifting the nets or hauling, making fishing operations more effective and efficient. With more effective fishing operations, the chances for fishermen to conduct more haulings will increase, as supported by [14], who noted that light and visual-based technologies contribute to increasing the number of fishing cycle operations. Previous studies have shown that visual monitoring in fishing operations can improve operational efficiency, as fishermen can make more accurate decisions about when and where fish gather, avoiding wasted time in searching for fish [13, 15]. The application of technologies like CCTV is expected to drive improvements in catch yields and promote the sustainability of fish resources [16].

So the amount of production caught in one night of fishing tends to be greater [17, 18]. Information regarding fish behavior can be obtained either directly on the boat via monitors or from CCTV recordings. This information includes the condition of fish under the sea.

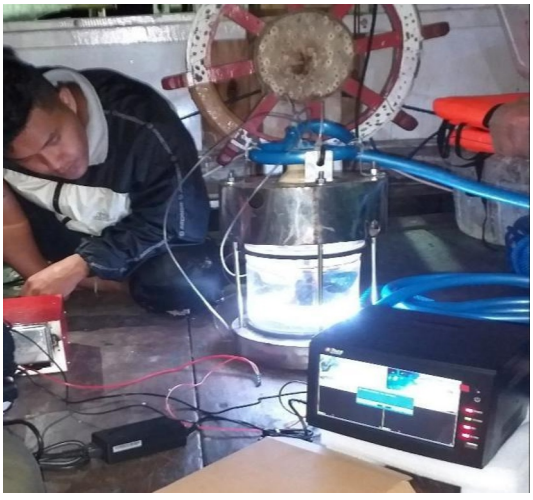


Fig. 2. UFLPlus circuit ready for operation along with CCTV video recording components on board the ship.

The working process of UFLPlus in sea waters or on a boat can be seen in Figure 3a. The results of the CCTV camera catch (Fig 3b) when viewed directly via video, clearly show the condition of the fish in the catchable area of the boat chart, both the type and density of the scaling. From the monitor screen on the boat, you can observe the movements of the fish and the types of fish that are coming, by directly seeing the arrival of the fish so that you can estimate the range of fish that have gathered and the types of fish clearly, whether they include main catch, side fish or even discarded fish. From the initial information obtained, we can know the right time to start lifting the net so that it is no longer based on the fishermen's estimates or guesses. If it appears that there are many target fish, the UFLPlus lamp is slowly pulled towards the surface while the light begins to dim slowly until the lamp completely goes out. This is done to avoid the fish's response to changes in light (light stimuli) so that the fish concentrate on the cathable area. At the same time, the lifting of the net can be done immediately, this of course makes the operational time of the boat more effective, and also reduces the arrival of predatory fish [12].

(a) UFLPlus in sea waters (b) Video display by CCTV

Fig. 3. The working process of UFLPlus in the boat fishing fishery.

3.2 Differences in productivity of bagan boat fishing gear using underwater diving lights without CCTV and using UFLPlus

Fishing productivity is a measure of the production capacity of a fishing gear in units of fishing effort. Fishing research using underwater dipping lights is measured based on the comparison of the number of catches with the length of time of the fishing operation. The length of fishing time that is calculated is the actual fishing time [11]. The actual fishing time calculated is from turning on the lights above the chart, lowering the dipping lights underwater without CCTV or UFLPlus, lowering the net, turning off the lights above the chart to pulling the net until the net frame is visible on the surface. The process of these activity stages is the process of fishing operations on a boat lift net.

Mathematically, the difference in boat chart productivity using underwater dipping lights without CCTV and using UFLPlus was tested using the t test. The hypothesis test used is the independent sample T test, using SPSS 20. The source of this data comes from the use of underwater dipping lights without CCTV and the use of UFLPlus on productivity and the length of time required for 1 night of fishing operations, as in Table 2.

Table 2. Average Productivity Value required in 1 night using underwater immersion lights without CCTV and using UFLPlus.

Night to-	Productivity (kg/min)		Productivity Difference
	Underwater submersible lights without CCTV	UFLPlus	
1	0.67	1.05	0.38
2	0.66	0.98	0.32
3	0.64	0.94	0.3
4	1.15	1.08	-0.07
5	1.10	1.10	0
6	1.62	1.08	-0.54
7	2.20	3.94	1.74
8	2.07	4.03	1.96
9	2.00	4.44	2.44
10	1.68	3.85	2.17
11	1.64	3.65	2.01
12	1.44	2.93	1.49

Table 2. above shows the productivity value of the boat fishing business using underwater dipping lights without CCTV and using UFLPlus. There is a difference in the productivity value of using the two types of lights on each night of fishing operations. Even though there is a night where the productivity value is the same (night 5), namely 1.10 kg/minute, other nights show quite large differences in value. As on the 9th night which shows a greater difference in UFLPlus productivity values of 2.44 kg/minute, however on the 4th and 6th nights it shows a difference in UFLPlus productivity values which is lower than underwater dipping lights without CCTV, namely -0 .07 and -0.54.

The difference in the productivity value of the boat lift net business using the two types of lights is thought to be due to the greater number of hauls that can be carried out on the night of fishing operations using UFLPlus. The large number of hauls that can be carried out using UFLPlus is thought to be because the time required for one haul is shorter than the time required for one haul using underwater dipping lights without CCTV. The higher number of hauling operations possible with the use of UFLPlus is likely due to the shorter time required for a single hauling operation compared to the time needed for hauling using underwater lamps without CCTV. This finding aligns with the results of [15], which stated that the number of hauling operations that can be performed in one night using lift nets is higher when the aggregation patterns of fish are understood. This knowledge enables the determination of the optimal soaking time for the nets and the hauling time, which ranges from 17 to 32 minutes. This phenomenon is closely related to the attraction of fish to underwater light during the initial phase of light deployment, lasting for a few minutes. Over time, however, the fish may become desensitized to the light, causing them to disperse from the fishing area. Meanwhile, on the 4th and 6th nights, the productivity value of using underwater dipping lights without CCTV compared to UFLPlus was greater due to the influence of lunar conditions at that time, where the maximum number of hauls that could be carried out on both lights was only 3 hauls. The difference in the average productivity value of using UFLPlus and underwater dipping lights without CCTV every night of fishing during the study was 1.02 kg/minute with a percentage increase in productivity value from using underwater dipping lights without CCTV to UFLPLus 41%.

The integration of underwater dipping lights and CCTV can increase the number of catches and shorten the duration of actual fishing time. Reducing the duration of hauling or

increasing the number of hauls per night of fishing is the main factor influencing differences in boat chart productivity. In terms of differences in productivity values, researchers tend to focus more on the number of hauls and the time needed to carry out each haul, as these factors also influence the number of catches that can be produced through the use of underwater dipping lights. This is because, in principle, the difference between the two types of underwater dipping lights lies in the addition of CCTV and monitors, which function to streamline hauling time. Through onboard monitors, the condition of fish in the sea can still be properly monitored even at depths of up to 10 meters or more above sea level. As a result, fishermen can make more informed decisions about when to lift nets or haul, no longer relying solely on estimates [17, 18]. Meanwhile, the increase in productivity obtained based on the ability of underwater submersible lights to attract the attention of fish, thus influencing the number of catches, has been carried out by many previous researchers and the average research results show that by using underwater submersible lights the number of catches is greater than by using surface lights. or a combination of both [19,20]. Research conducted by [21] shows that the effectiveness of fishing gear that uses underwater LED lights is 132.09% greater than the effectiveness of fishing gear that uses fishing lights (mercury lamps on the surface), where the number of catches is used as a benchmark comparison. Additionally, the use of CCTV in underwater fish lamps has been explored in previous studies [4], demonstrating that the application of CCTV can significantly reduce fishing time and minimize the bycatch and discarded catch. In general, fishing yield and productivity are influenced by various factors, including the lunar phase, water clarity, and seasonal patterns of specific fish species. These factors are known to be limiting elements in fishing efforts, preventing fishermen from achieving optimal catches year-round. According to research conducted by [18], the peak fishing season for anchovies in the Madura Waters occurs in January, February, March, October, November, and December. The differences in the use of underwater dipping lights without CCTV and UFLPlus based on the productivity of boat fishing gear can be seen from the results of the independent sample test (T-test) using SPSS 20 in Table 2.

Table 2. Results of the Independent Sample Test (T-test) of the use of underwater dipping lights without CCTV and UFLPlus Based on the Productivity of the Bagan Boat Fishing Equipment.

		t-test for Equality of Means						
		t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
							Lower	**Upper**
Produk-tifitas	Equal variances assumed	-2,219	22	,037	-1,01667	,45826	-1,96704	-,06629
	Equal variances not assumed	-2,219	14,061	,043	-1,01667	,45826	-1,99914	-,03419

Based on Table 2, the results obtained are Pvalue < α, so H0 is rejected and it can be concluded that there is a significant difference in the productivity of the boat chart business using underwater dipping lights without CCTV and using UFLPlus. The highest value can be seen in the mean or average section, where productivity using UFLPlus is higher than using underwater dipping lights without CCTV as in Table 3. According to [2], the high productivity value achieved with UFLPlus is partly attributed to the intensity and distribution pattern of light, which aligns with the light adaptation level of fish retinas. Specifically, the illumination value of the white UFLPlus lamps ranges from 28 to 117 lux in horizontal measurements and from 10 to 132 lux in vertical measurements.

Table 3. Statistical Value (Mean) of Dependent Variable (Productivity) With underwater dipping lights without CCTV and UFLPlus.

	UFL	N	*Mean*	*Std. Deviation*	*Std. Error Mean*
Productivity	Underwater diving lights without CCTV	12	1,4058	,55963	,16155
	UFLPLus	12	2,4225	1,48554	,42884

Table 3 shows the average value of productivity using immersion lights without CCTV of 1.40 kg/minute with a standard deviation of 0.55 and the average value of productivity using UFLPlus is 2.42 kg/minute with a standard deviation of 1.48. This shows that the productivity value is greater by using UFLPlus compared to using underwater dipping lights without CCTV. This increase in productivity reflects the efficiency of UFLPlus technology in attracting fish to the fishing area. According to [22], underwater light-based devices can significantly influence fish behavior, particularly in species that are responsive to light. The addition of features such as an underwater camera [23] and real-time monitoring via CCTV, as integrated into UFLPlus, provides more accurate information about the presence and movement patterns of fish.

3.3 Effect of long hauling time required using underwater diving lights without CCTV and UFLPlus on one night of fishing operations

One of the efforts made to increase the productivity of boat fishing gear is to make the actual fishing or hauling time more effective in fishing operations and produce a greater number of catches [24, 25, 26]. This effort was made by using underwater dipping lights equipped with CCTV or Under water Fish Lamp Plus (UFLPlus). The length of time required for one night of fishing operations is a combination of several hauls carried out in one night. Based on the results of calculations in the field, data was obtained on the length of hauling time required using underwater submersible lights without CCTV and the length of hauling time required using UFLPlus as shown in Table 4 below:

Table 4. Length of Hauling Time Using underwater dipping lights without CCTV and UFLPlus on 1 Night Arrest Operation.

Nigth to-	**Underwater dipping lights without CCTV (Minute)**	**UFL+ (Minute)**
1	400	290
2	410	458
3	660	435
4	661	443
5	678	435
6	685	430
7	600	420
8	625	420
9	645	525
10	638	540
11	668	470
12	450	475

Based on Table 4, it is known how long it takes to catch one night. The productivity values obtained tend to fluctuate whether using underwater dipping lights without CCTV or using UFLPlus. On the 1st and 2nd nights there was an increase in productivity, although

the difference was small, then on the 3rd night there was a fairly large increase, increasing by one point on the 4th night and continuing to increase on the 5th and 6th nights, however on the 7th night there was a fairly large decrease and on the 8th and 9th nights it increased again. Furthermore, on the 10th night there was a decrease, but on the 11th night there was an increase again and on the 12th night there was a decrease.

Based on the data obtained, the rise and fall in productivity values is thought to be due to the amount of hauling that can be done on those nights. The number of hauls in one night is influenced by the length of time needed to carry out one haul [27, 28]. To see the effect of the productivity value on the length of time required for one night of fishing operations, the T-test statistical analysis was used. The results of calculating the effect of using UFLPlus on time statistically using independent sample T-test analysis with the help of SPSS 25 are in Table 5.

Table 5. Effect of using Underwater dipping lights without and UFLPLus Regarding the length of hauling time

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Hauling time duration	Equal variances assumed	4,66	0,042	4,12	22	0,000	148,2500	35,91210	73,7728	222,7271
	Equal variances not assumed			4,12	17,64	0,001	148,2500	35,91210	72,6920	223,8079

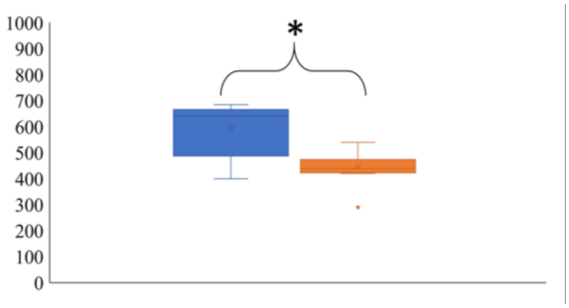
Based on Table 5 above, the results obtained are Pvalue < α, so H0 is rejected and it can be concluded that there is a significant difference in the use of underwater dipping lights without CCTV and the use of UFLPLus in the length of time required for one night of fishing/one night hauling duration. The highest value can be seen in the mean section, where the hauling time required using UFLPlus is higher than using underwater dipping lights without CCTV as in Table 6.

Table 6. Statistical value (Mean) Length of Time Required with Using underwater dipping lights without CCTV and using UFLPlus

Group Statistics

Penggunaan Lampu		N	*Mean*	*Std. Deviation*	*Std. Error Mean*
Hauling time duration	Underwater dipping lights without CCTV	12	593,3333	107,62505	31,06868
	UFLPlus	12	445,0833	62,39385	18,01155

From Table 6 above shows the statistical value of the variable length of time needed to use an underwater dipping light without CCTV and with UFLPlus, with an average value using an underwater dipping light without CCTV of 593.3 with a standard deviation value of 107.6 and a value The average using UFLPlus is 445.08 with a standard deviation value of 62.39. This shows that there is a difference in terms of time use, where using underwater dipping lights without CCTV takes longer than using UFLPlus for all hauling carried out in one night. A comparison of the average length of time required to use submersible lights without CCTV and UFLPlus in one night of fishing operations can be seen graphically in Figure 4 below:



Information :
Blue : using underwater dipping lights without CCTV
Orange: using UFLPLus

Fig. 4. Comparison of the average length of time required (minutes) between the use of underwater immersion lights without CCTV and the use of UFLPlus

Fig 4 above shows the difference in the length of time required for one night of fishing operations between the use of underwater dipping lights without CCTV and the use of UFLPlus. The average time required for hauling using underwater lights without CCTV is 593 minutes for one night of fishing operations, while the average time required for hauling using UFLPlus is 445 minutes. From the difference in the length of time used for the two types of lights, it can be said that using UFLPlus is able to reduce fishing time by up to 33% in 1 night of operation. This demonstrates the potential of UFLPlus as an innovative solution to enhance the efficiency of lift nets on fishing boats. The reduction in fishing time not only leads to energy savings and lower operational costs but also supports sustainable fisheries by reducing pressure on fish resources. According to research [29], the use of auxiliary devices such as underwater lamps has been proven to improve fishing efficiency by attracting fish to specific areas through the influence of light on fish behavior.

4 Conclusion

The application of UFLPlus technology in the boat chart fishery offers significant advantages over underwater light methods without CCTV. The findings of this study show that UFLPlus can increase catch productivity by 41% and reduce fishing time by 33%, making it an effective tool to improve the efficiency and sustainability of boat fishing operations. From an economic perspective, it can reduce operational costs for fishermen and the sustainability of the boat fishing business. Given these promising results, further research needs to be conducted to explore the long-term economic benefits and environmental impacts of UFLPlus technology in different types of fisheries. Additionally, efforts should be made to promote the adoption of this technology among local fishing communities to improve their productivity and livelihoods.

Acknowledgments

Author would like to thank the Ministry of Education, Culture, Research and Technology of the Republic of Indonesia for funding the implementation of this research through a prototype external assistance grant for Fiscal Year 2024 and also all parties who have assisted in carrying out this research.

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