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Optimization of catch by phosphor coating of artificial baits

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Abstract
Artificial baits are necessary to get an ample amount of catches. Fishing rod requires a bait that is attractive to fish so they can be caught easily. Other than colors, fish are also attracted to light that comes from planktons or other fish (bioluminescence), and tend to move toward the light sources (positive phototaxis). Based on this phenomenon, a research of phosphorization of artificial baits in relation to the catch numbers has been conducted. Phosphor is a substance that can absorb and reflect light, so it's an ideal substance to be used for layering of fish baits. This research has been conducted in Marine Nature Park of Kupang Bay, East Nusa Tenggara from April to June 2021. The method being used is experimental fishing, with increasing amount of phosphor being used in every 60 grams of bait. There are four levels of treatment; without phosphor, 10 grams, 30 grams, and 50 grams of phosphor. The amount of fishing trips being repeated are 16. Data analysis is using analysis of variance with further testing of mean for each variable. Result of the research shows that there are nine type of caught fish, which are *Sphyraena sp.*, Lutjau ruselli, Caranx sexfasciatus, Plectropomus leopardus, *Rastrelliger sp.*, *Trichiurus lepturus*, *Lutjanus*, *Lutjanus jocu*, and *Epinephelus coioides*. Based on the result of analysis of variance, increasing amount of phosphor contributed significantly to the number of catches (F-test 4.91 > F-table 1%). From further testing, treatment 2, 3, and 4 are significantly different than treatment 1 (without phosphor), meanwhile each treatment with increasing amount of phosphor shows least significant difference in result.

Keywords: Biolomminescence, fishing rods, photo taxis, addition of phosphorus

1. Introduction
Recreational fishing is one of the activities in the fisheries sector, which is currently rapidly developing. An important fishing gear used in such activities is fishing rods. Fishing techniques, including use of fishing rods, have remained relatively the same since ancient times, which are based on the use of the fish's own behavior of being attracted to other fish and/or aquatic invertebrate species as preys (Yuda *et al*., 2012; Lokkeborg *et al*., 2014) [25, 13]. Referring to this behaviour, the whole body and/or parts of fish or other aquatic invertebrates (squids), or land animals, such as earthworms, are used as bait in fishing activities (Fitriana *et al.*, 2018) [9].

The next development about bait is the discovery of artificial bait that can be used as an alternative to natural bait. It is certainly designed specifically to attract fish for fishing purposes. The development of artificial bait is based on the fact that the population fish commonly used as bait is starting to decline (Dewi dan Juanda, 2014) [6]. In addition, the development of artificial bait in fishing activities is also aimed at minimizing operational costs because of the lower cost, ability of being used more than once, and ability to withstand damage during storage (Dewi dan Juanda, 2014) [6].

Various studies on effect artificial bait on fish catches have been carried out. Such studies include the effect of artificial bait color and material, e.g. patchwork yarn (Dewi & Juanda, 2014; Farikha *et al*., 2014; Moraga *et al*., 2015) [6, 8, 14] and poultry feathers. Colour significantly affected catches. The effect of bait color is actually related to color reflection caught by the retina of fish (Niam *et al*., 2013; Puspito, 2010) [15, 17]. This is due to the presence of rod and cone cells in the fish retina that allow fish retinas of being able to absorb light well (Subani & Barus, 1989) [22].

In addition to being attracted to colors of artificial bait, fish is also attracted to light (Notanubun *et al*., 2010; Sulaiman *et al*., 2015) [16, 23].

Attraction to light is indicated by fish moving toward and flocking around the light source. The movement of fish towards a light source is known as positive phototaxis (Ben-Yami, 1976) [3]. In nature, light sources include various species of aquatic animals capable of absorbing and then emitting light from their bodies, a phenomenon known as bioluminescence (Dunlap, 2009; Haddock *et al*., 2010; Bolelli *et al*., 2016) [7, 11, 4].

Based on the the above research results, making artificial baits glowing is a means of increasing catches. The technique being tested in this study is phosphor coating, hereinafter referred to as the phosphorization technique, intended to allow artificial baits function as light sources by emitting light after absorbing a certain amount of light. The use of phosphorus as a compound that can produce light began with its use in the fashion world. Phosphorus powder is added to cloth or other objects to produce glowing effects in the dark (Baskoro & Kahdar, 2010).

Phosphor coating makes artificial baits glowing when used for fishing and hence attracts photo-positive fish to approach and take the artificial bait. To date, most artificial bait available in the markets have not been given this touch. Therefore, this study was designed to investigate levels of phosphorization of artificial baits with the purpose of determining the level most capable of improving catches.

Materials and Methods

This study was conducted at Kupang Bay Marine Recreational Park (Taman Wisata Alam Laut Teluk Kupang or TWAL Teluk Kupang). TWAL Teluk Kupang is a nature conservation area with an area of 50,000 ha covering most areas of Kupang Bay in front of the City of Kupang, the capital city of the Provinve of East Nusa Tenggara, Indonesia. Data collection was conducted from April to June 2021.

The study employed experimental fishing method. According to (Andaloro *et al*., 2011) [2], experimental fishing method is an experimental method in which replication or blocking cannot applied at random. As in normal experimental method, measurement is carried out under artificial conditions, meaning that conditions that affect the measumenet are created and regulated by the researcher by creating levels of treatment and control (Subagyo, 2014). In this study, the experiment was designed according to the randomized complete block design, in which fishing trips were used as non-random blocks and all levels of phosphor coating of artificial baits were tested in each site. Levels of phosphor coating tested are as follows:

1. 0 g of phosphor coating as control (emitted no light)
2. 10 g of phosphor coating (emitted 2 lumen of light)
3. 30 g of phosphor coating (emitted 4 lumen of light)
4. 50 g of phosphor coating (emitted 5 lumen of light)

Each of the above treatmen levels was replicated 16 times, each at different fishing trip at 16 fishing sites.

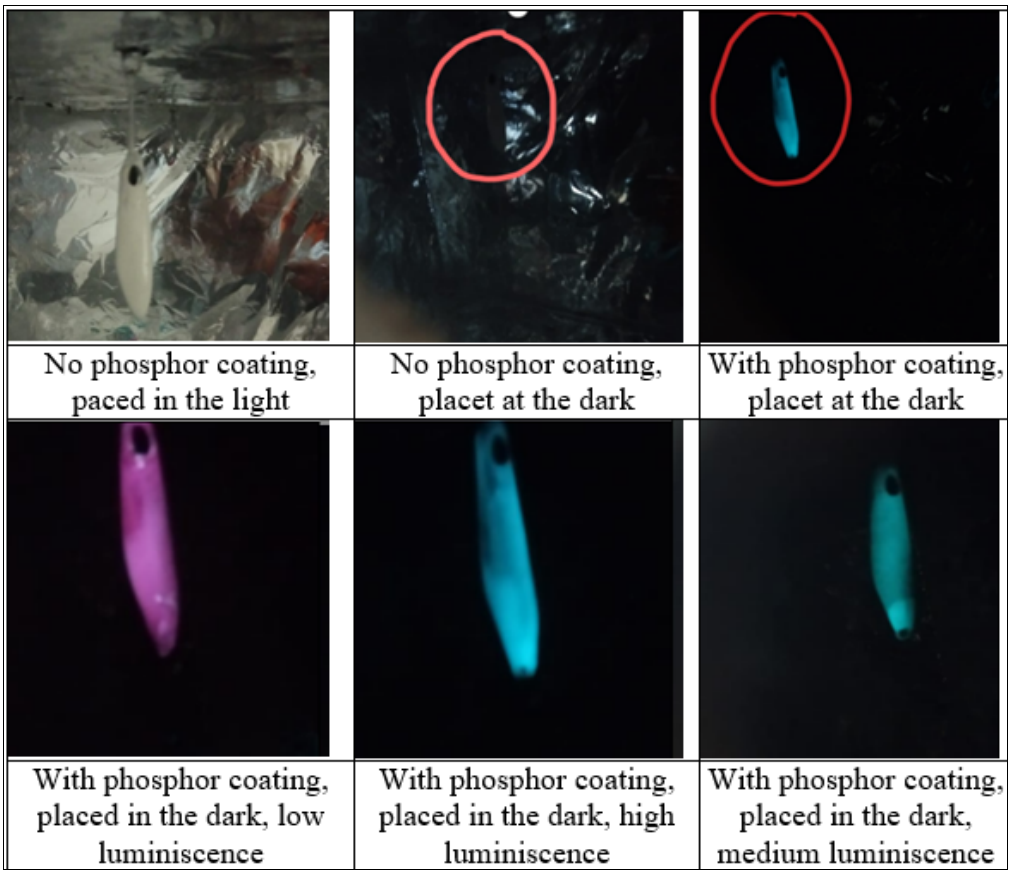

Fig 1: Gambar 1 Visualisasi fosforisasi pada umpan buatan sebagai perlakuan.

Catching for each treatment level was carried out at 16 fishing locations determined intentionally as replicates. Determination of the location is done by using bathymetry overlay. The catch obtained during the study was calculated as the number of fish species caught within the allowed size range. Within all fishing locations, the study was designed using a randomized complete block design. In accordance with the number of treatment levels and the number of points of capture location, 64 units of observation were obtained (4 treatment levels x 16 replications). Catching was carried out at each location by involving 5 professional anglers with more than 5 years of fishing experience. Catching was carried out at

night until the early hours of the morning, with an average fishing time of 9 hours (18:00-03:00 local time). The study was conducted on a full moon at a depth of 30-50 m above sea level.

Each species of fish caught was sorted and separated for further observation of the characteristics needed for identification. Species identification was then carried out by matching the characteristics of each fish species with the description of fish species available online on the Fish Base website (https://www.fishbase.de/). The data on fish species and the number of each species are presented in tabular form. The data on the number of each type of fish were later subjected to analysis of variance followed with Least Significant Difference test (5 and 1% level of significance).

Result and Discussion

Based on the results of the study, nine species of fish were successfully caught using phosphorized bait. The list of species and the treatment level succeded in catching the species are presented in Table 1.

Table 1: List of species of fish caught for each artificial bait treatment

Common Name	Local Name	Scientific Name	Treatment Level (g of phosphor coating)			
			0	10	30	50
Barracuda	Alu-Alu	*Sphyraena sp.*	-	-	√	√
Russell's snapper	Kakap tompel	*Lutjanus russellii* (Bleeker, 1849)	-	√	-	-
Bigeye trevally	Kuwe mata besar	*Caranx sexfasciatus* Quoy & Gaimard, 1825	-	√	√	√
Leopard coralgrouper	Kerapu sunu	*Plectropomus leopardus* (Lacepède, 1802)	√	√	-	-
Mackerel	Kembung	*Rastrelliger sp.*	√	√	√	√
Largehead hairtail	Layur	*Trichiurus lepturus* Linnaeus, 1758	-	-	√	√
Bigeye snapper	Kakap kuning	*Lutjanus lutjanus* Bloch, 1790	-	√	-	-
Dog snapper	Lencam kuning	*Lutjanus jocu* (Bloch & Schneider, 1801)	√	-	-	-
Orange-spotted grouper	Kerapu lumpur	*Epinephelus coioides* (Hamilton, 1822)	-	√	-	-
		Total	3	6	4	4

Source: Field Data (2021)

Table 1 shows that the species of fish caught for each treatment listed from the treatment with the hghest number of species to the lowests number of species caught are treatment 2 (6 species of fish), treatment 3 and 4 (4 species of fish each), and treatment 1 (3 type of fish each). The number of fish caught for each treatment is related to internal and external stimuli. Internal stimuli involve the attraction of each type of fish to eat, while external stimuli involve the attraction of fish to the color, smell, shape and movement of the bait used (Takapaha *et al*., 2010) [24].

The number of individual's count for each species for each treatment level and block is presented in Table 2

Table 2: Number of individual's couht for each species for each treatment level and block

Block	Common Name	Scientific Name	Treatment Level (g of phosphor coating)			
			0	10 g	30 g	50
1	Barracuda	*Sphyraena sp.*	0	0	0	3
	Russell's snapper	*Lutjanus ruselli*	0	3	0	0
2	Bigeye trevally	*Caranx sexfasciatus*	0	2	0	0
	Barracuda	*Sphyraena sp.*	0	0	1	1
3	Bigeye trevally	*Caranx sexfasciatus*	0	4	1	0
	Leopard coralgrouper	*Plectropomus leopardus*	1	6	0	0
	Barracuda	*Sphyraena sp.*	0	0	0	1
4	Mackerel	*Rastrelliger sp.*	1	1	3	0
	Bigeye trevally	*Caranx sexfasciatus*	0	2	7	1
5	Mackerel	*Rastrelliger sp.*	0	3	6	1
	Barracuda	*Sphyraena sp.*	0	0	1	1
	Bigeye trevally	*Caranx sexfasciatus*	0	5	1	0
	Largehead hairtail	*Trichiurus lepturus*	0	0	1	1
6	Bigeye trevally	*Caranx sexfasciatus*	0	4	1	0
	Mackerel	*Rastrelliger sp.*	0	3	0	0
7	Bigeye snapper	*Lutjanus lutjanus*	0	10	0	0
	Barracuda	*Sphyraena sp.*	0	0	1	5
	Mackerel	*Rastrelliger*	0	0	2	0
	Largehead hairtail	*Trichiurus lepturus*	0	0	0	4
8	Barracuda	*Sphyraena sp.*	0	0	1	9
	Bigeye trevally	*Caranx sexfasciatus*	0	6	1	7
9	Mackerel	*Rastrelliger sp.*	0	0	2	6
	Barracuda	*Sphyraena sp.*	0	0	3	10
10	Bigeye trevally	*Caranx sexfasciatus*	0	0	0	1
	Barracuda	*Sphyraena sp.*	0	0	0	3
11	Bigeye trevally	*Caranx sexfasciatus*	0	0	8	0
12	Bigeye trevally	*Caranx sexfasciatus*	0	2	10	0
	Dog snapper	*Lutjanus jocu*	1	0	0	0
	Orange-spotted grouper	*Epinephelus coioides*	0	3	0	0
	Mackerel	*Rastrelliger sp.*	0	1	6	1

13	Bigeye trevally	*Caranx sexfasciatus*	0	11	1	1
	Largehead hairtail	*Trichiurus lepturus*	0	0	0	4
	Barracuda	*Sphyraena sp.*	0	0	0	1
	Mackerel	*Rastrelliger sp.*	0	2	0	0
14	Bigeye trevally	*Caranx sexfasciatus*	0	3	3	2
	Mackerel	*Rastrelliger sp.*	1	4	1	0
15	Barracuda	*Sphyraena sp.*	0	0	1	1
	Dog snapper	*Lutjanus jocu*	1	0	0	0
	Largehead hairtail	*Trichiurus lepturus*	0	0	0	1
16	Bigeye trevally	*Caranx sexfasciatus*	0	5	0	1
	Orange-spotted grouper	*Epinephelus coioides*	0	4	0	0
Total			5	84	62	66

Source: Field Data (2021)

As presented in Table 2, the total number of fish individuals caught in succession for each treatment was treatment 2 (84 individuals), treatment 4 (62 individuals), treatment 3 (66 individuals), and treatment 1 (5 individuals), respectively. The intensity of light cought by the retina of fish eyes triggers the movement of the fish towards the light source. However, not all fish species react in the same way in response to the same intensity of light emitted by an artificial bait. This condition caused at the number of fish individual caought in this study vsries among treatments and block.

The catch data as presented in Table 2 were then subject to analysis of variance to determine the effect of treatment. The results of the analysis showed that the phosphorylation technique through coatings of artificial bait with different amount of phosphor had a very significant effect on the number of fish individuals caught as presented in Table 3.

Table 3: Results of the analysis of variance of the number of fish individual cought for each treatment level

Source of variation	df	Sums of Square	Mean Square	F calculated		F table	
						5%	1%
Treatment	3	242.3392857	80.7797619	4.91	**	2.86	4.36
Block	15	178.0488281	11.86992188	0.72	ns	1.95	2.56
Error	37	609.2544643	16.46633687				
Total	55	1029.642578	18.72077415				
kk =	120.79	%					

Source: Results of data analysis (2021)

Table 3 shows that the application of phosphorus to artificial baits affected fishing catches significantly. This is because phosphor coating caused the bait to be able to adsorb and emit light. The emited light is then caught by the retina of the fish so that the fish are attracted and approach the light source (positive photo taxis). Phosphorus is a substance that has the ability to emit light when certain rays of light hit it as an object. Phosphor coating to give artificial bait a luminous effect is an idea that is based on the habit of fish of being attracted to light emitted by some plankton in water bodies (bioluminescence). The phenomenon of bioluminescence by a collection of plankton in the waters at night is caught as light points by fish. Bioluminescence requires a chemical reaction involving the photoprotein luciferin contained in the plankton body. In this case, it is the compound luciferin that produces light (Haddock *et al*., 2010; Schrope, 2007 in Dewi *et al*., 2018; Stelle *et al*., 2001) [11, 19].

To determine the difference within each pair of treatment levels, the number of fish individual fish cought was further subjected to Least Significant Difference (LSD) Test. The results of further analysis are presented in Table 4.

Table 4: Comparison of treatment pairs based on results of LSD Test

Treatment Level (g of phosphor coating)	Number of fish individual cought	LSD (5%)	LSD (1%)
1	0.36	a	a
2	5.86	b	b
3	4.43	b	b
4	4.71	b	b

Note:
The number of individuals for each species of fish caught followed by the same letter showed no significant difference according to 5 and 1% LSD Test.
Source: Results of data analysis (2021)

As shown in Table 4, treatment 2, 3, and 4 were each significantly different from treatment 1. However, treatment 2 was not significantly different from treatment 3 and 4, as well as treatment 3 was not significantly different from treatment 2 and 4, and treatment 4 was also not so from treatments 2 and 3. The light emitted by the phosphor used to coat the artificial bait did not seem to be sufficiently different in intensity among the three levels of phosphor coating treatment. This resulted in the number of individuals of each fish species caught for each pair of phosphor coating treatment was not significantly different.

Conclusions

Phosphorus coating of artificial bait was able to attract certain types of fish so that it could significantly increase the number of fish individuals caught. Thus, phosphorus coating, which is based on the eating habits of fish attracted to light (positive photo taxis), has the potential to be developed as a new

technology in the development of artificial baits that have not been carried out so far. Therefore, the results of this study will be followed up by proposing it to obtain a simple patent by referring to the provisions of IPR in Indonesia before being mass-produced.

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