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Effectiveness of the Combination of Raffia Rope Attractors and Lighting on Fish Aggregating Devices (FADs) for Positive Phototactic Fish

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ABSTRACT

Fish Aggregating Devices (FADs) are widely used to improve fishing efficiency, and their effectiveness depends largely on attractor design and visual stimuli such as light. This study aimed to evaluate the effectiveness of combining raffia rope attractors and LED lighting on surface FADs in attracting positive phototactic fish (*Poecilia reticulata*), and to assess their vertical distribution and behavioral responses. A laboratory experiment was conducted using a factorial Completely Randomized Design (position × light presence) with four treatments: bottom without light, bottom with light, surface without light, and surface with light. The primary parameter measured was the number of fish within a 10 cm attraction zone, recorded every 10 minutes for 60 minutes. Data were analyzed using Two-Way ANOVA at a 5% significance level. The results showed that FAD position significantly affected the number of fish approaching the attraction zone ($p < 0.05$), whereas light presence alone had no significant effect ($p > 0.05$). However, a significant interaction between position and light was detected ($p < 0.05$). The highest effectiveness was observed in the surface FAD without light (77%), suggesting that the visual structure of raffia attractors at the surface was sufficient to induce strong aggregation. These findings indicate that the effectiveness of raffia attractors is primarily driven by placement position rather than additional lighting, although their interaction still contributes to fish aggregation behavior. This study provides a practical basis for prioritizing surface FAD placement with raffia attractors over the use of additional lighting in small-scale fisheries.

INTRODUCTION

Fishery resources are a crucial component in supporting food security, the maritime economy, and the sustainability of Indonesia's marine ecosystems. One effort to increase fishing efficiency, widely implemented by both traditional and modern fishermen, is the use of fish aggregating devices (FADs) as fish collection aids. FADs attract and gather fish in a single location, facilitating the fishing process and saving time and operational fuel. This has been supported by several studies, including: Afrisal et al., (2024); Bahtiar Hamar, (2023); Soghirun et al., (2024), which states that FADs such as fish aggregating devices are effective in gathering fish around the structure and helping fishermen in fishing activities more efficiently, so that time and operational costs can be saved.

Fish aggregating devices (FADs) have long been used as fish aggregating aids, and their effectiveness depends largely on the design and materials of the attractor used.Yusfiandayani, (2010)states that fish aggregating devices (FADs) have long been used in Indonesia, and the choice of attractor material influences the number of pelagic fish species that congregate around them. One important component that determines the success of FADs is their visual appeal to fish, especially species that are positively phototactic or attracted to light. Positive phototactic variables towards light sources are an important basis in the design of fish attractors, as evidenced by the development of fishing aids that utilize light as a stimulus to attract fish (Fuad et al., 2025; Tamrin et al., 2025)

The success of fish aggregating devices (FADs) in attracting fish is greatly influenced by the type of attractor used. Attractors are the primary components of FADs, providing visual and sensory stimuli that trigger fish aggregation responses to floating objects, light, and specific structural characteristics (Forget et al., 2020; Humborstad et al., 2018; Rumpa et al., 2022; Zada et al., 2024). One type of attractor widely used is raffia, a synthetic material with visual advantages such as bright colors, surface shine, and high flexibility. These advantages allow the attractor to move with the current and provide additional visual stimuli that are attractive to fish with positive phototactic properties. When this attractor is attached to a lighted surface fish aggregating device (FAD), the combination creates a highly attractive visual effect for fish. Research Fauziyanto et al., (2024) in Ambon Bay showed that materials such as raffia rope can influence the composition and presence of fish in fish houses. In addition, the study Patty et al., (2023) Studies have shown that the use of underwater lights increases pelagic catches by attracting fish to specific areas compared to no light. In surface FADs, light tends to spread laterally, creating a wider illumination zone at the top of the water column. Conversely, in bottom FADs, some light energy can be reduced by absorption and scattering from the water, thus limiting the visual range. This difference in position has the potential to affect the effectiveness of visual attractants for phototactic fish. Light penetration in the water column decreases due to absorption and scattering, so light intensity decreases with depth; this phenomenon significantly affects the visibility and visual behavior of organisms (Bunnell et al., 2021; Li & Hua, 2025).

Positive phototactic fish such as guppies (*Poecilia reticulata*) and anchovies (Stolephorus spp.) are naturally attracted to light sources. Therefore, the use of lights as a complement to fish aggregating devices (FADs) can be a supporting factor in increasing the attractiveness of attractors. The combination of raffia rope and white lights on FADs placed on the water surface is believed to create a strong attraction zone for fish, especially at night or in waters with low light levels. Meanwhile, attractors combined with light sources, especially white lights or other types of LEDs, have been shown to accelerate fish attraction to the FAD area. For example, in a study Susanto et al., (2020) In Banten Bay, green LED lights were able to stimulate fish concentration responses faster than other types of lights. Furthermore, light sensors on fish aggregating devices (AUTOLION prototypes) also showed that the combination of fish aggregating devices and lights significantly increased the number of fish approaching in the laboratory (Chairunnisa et al., 2018). However, the effectiveness of this combination needs to be scientifically proven through a controlled experimental approach.

Although various studies have reported the effectiveness of synthetic material attractors and LED lighting in increasing fish aggregation, most of these studies were conducted separately between material and light factors. Studies that simultaneously tested the combination of FAD positions (surface and bottom) with the presence of lighting in controlled experimental systems are still limited, especially at the laboratory scale that allows detailed behavioral observations. Furthermore, information on how these combinations affect the vertical distribution and behavioral responses of positively phototactic fish is still scarce. This study aims to test the effectiveness of the combination of raffia rope attractors and LED lighting on surface FADs in increasing visual attractiveness to positively phototactic fish (*Poecilia reticulata*), evaluate the vertical distribution and behavioral responses of fish as indicators of the strength of the resulting visual stimulus and The research results are expected to serve as a reference for both traditional and modern fishermen in choosing an efficient FAD design.

METHOD

Location and Time of Research

This research was conducted at the Fisheries Department Laboratory, Faculty of Animal Husbandry, Jambi University from April to June 2024. The laboratory was selected to control environmental variables and allow for controlled observation of fish behavior.

Research Tools and Materials

The tools used in this study were a fish aggregating device (FAD) measuring 20x20x15cm (Figure 1) with a raffia rope attractor. 4 aquariums measuring 60x40x40cm, 5-watt white LED lights, a ruler, and a stopwatch to measure the observation time. The materials used in this study were 72 liters of freshwater and 180 guppy fish (*Poecilia reticulate*) (45 fish/Aquarium) with a length of around 2-3 cm that had been acclimatized for 2 days. Guppy fish were chosen to test the fish's behavior in response to light. This freshwater fish was chosen because it has the same characteristics as anchovies (as the main target in the sea), namely positive phototaxis. Guppy fish (*Poecilia reticulate*) are positive phototaxis fish, meaning they approach light. This is evidenced by the fact that in various light color treatments, guppy fish showed a positive phototaxis response in all treatments tested (Almaas & Harlita, 2023). The guppy's behavioral response to light exposure is also seen in changes in feeding activity under different lighting conditions, indicating sensitivity and attraction to light (MacAulay & Cable, 2024).

The miniature fish aggregating device (FAD) is made from bamboo coated with an attractor. It is equipped with a weight, a float, and a marker float. The construction of each FAD can be seen in Figure 1.

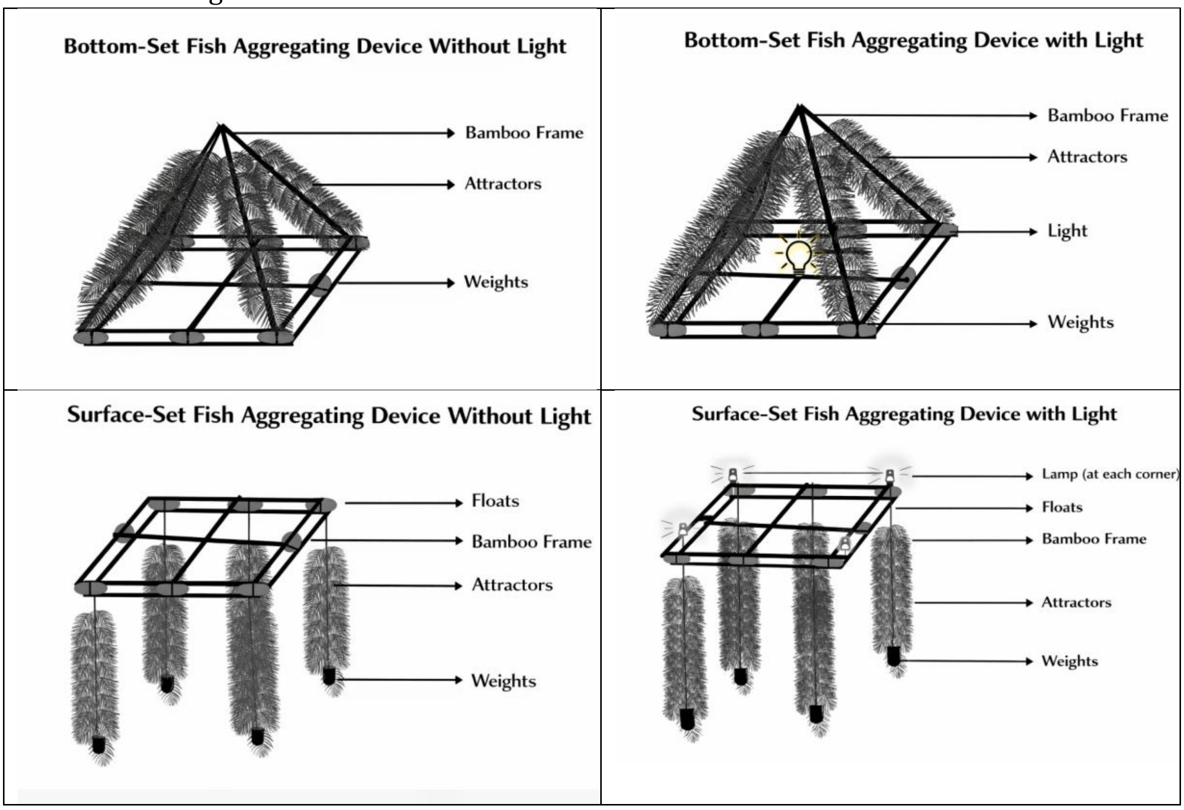

Figure 1. Construction of the Research Fish Aggregating Device

Types and Design of Research

This type of research is a laboratory experiment using a quantitative approach to analyze the response of positively phototactic fish (*Poecilia reticulata*) to the combination of FAD position and lighting. The research design used a Completely Randomized Design (CRD) Factorial (FAD position × presence of light) with repeated observations (repeated measures) in the same aquarium unit.

The first factor was the position of the fish aggregating device (bottom and surface), and the second factor was the presence of light (unlit and lit), resulting in four treatment combinations. Each treatment was placed in a separate aquarium unit with controlled environmental conditions to ensure homogeneity. Observations were conducted repeatedly at specific time intervals to observe the dynamics of fish responses. The experimental design can be seen in Table 1.

Table 1. Experimental Design of Fish Aggregating Devices with Raffia Rope Attractor

Factor A	Factor B	Treatment	Test	Time
Bottom	Without Lights	P1: Bottom Without Light	10 minutes	1 x 60 minutes
Bottom	Lighted	P2: Lighted Bottom	10 minutes	1 x 60 minutes
Surface	Without Lights	P3: Surface Without Light	10 minutes	1 x 60 minutes
Surface	Lighted	P4: Lighted Surface	10 minutes	1 x 60 minutes

The experimental unit in this study was an aquarium containing test fish under homogenous environmental conditions. Each treatment was applied in a separate aquarium as an experimental unit. A total of four experimental units (one aquarium per treatment) were used in this study. Observations were conducted repeatedly over time within each unit, and these repeated measurements were treated as temporal observations rather than independent biological replicates. Therefore, the statistical analysis was based on repeated observations within each treatment, assuming homogeneity of conditions within the experimental units.

Research Procedures

The initial procedure in this study involved preparing an aquarium filled with freshwater and fish. The fish were then slowly guided away from the zone of attraction using a transparent acrylic divider to ensure the fish were initially positioned on the opposite side of the fish aggregating device (FAD). This process was carried out without direct contact with the fish to minimize stress and behavioral disturbances. Once the fish were in a uniform starting position, the divider was slowly removed and observation began. This procedure was applied consistently across all treatments to maintain uniform initial conditions.

The first step is to place the fish aggregating device (FAD) in the aquarium for approximately half an hour, then observe the behavior of fish approaching the FAD for 1 hour (1 x 60 minutes), divided into 10-minute observations. Repeated observations are carried out to achieve accurate results. Then, observe the fish's behavior, position, response to feeding, response to vibration, and schooling behavior for 8 hours (1 x 8 hours), divided into 1-hour observations.

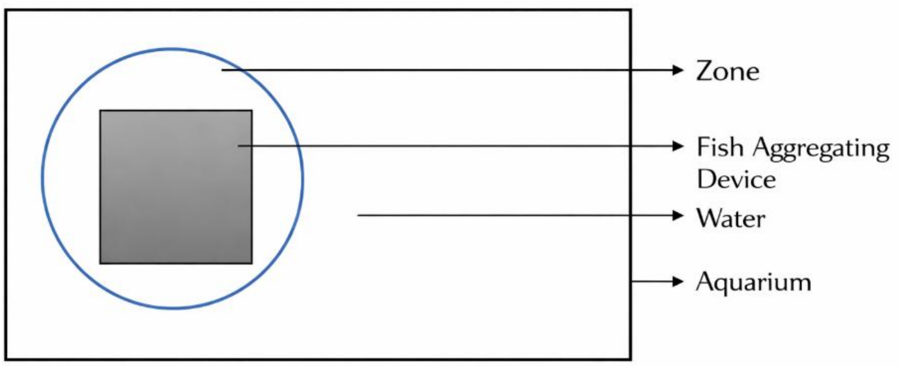

Figure 2. Top View of Fish Attraction Zone

An indicator that fish are attracted to the fish aggregating device (FAD) is their approach to it. In this study, the zone of attraction was determined at a distance of 10 cm from the FAD. The determination of the 10 cm distance from the FAD refers to the results of the study Susanto et al., (2017), Chairunnisa et al., (2018), where the highest light illumination occurs at a depth of 0-10 cm with white light. Fish aggregating devices (FADs) are fish aggregating devices that can help attract fish (Setiawan et al., 2015;Urbasa et al., 2015). The fish attraction zone is shown in Figure 2.

Data collection technique

Data was collected through direct observation and manual recording of fish behavior indicators, namely: Data collection was carried out through direct observation of fish behavior in each treatment.

1. The number of fish in the zone of interest, i.e., the number of fish within a 10 cm radius of the fish aggregating device (FAD), was recorded every 10 minutes for 60 minutes.
2. Vertical fish distribution, namely the number of fish in the surface, middle, and bottom zones of the aquarium. Observations were made every hour for 8 hours.
3. Response to feeding, observed based on the speed of the fish responding to the feed given around the fish aggregating device.
4. Response to light vibrations, observed based on changes in position or movement of fish after being given a vibration stimulus in the aquarium.
5. Social behavior patterns (grouping or dispersing) were observed visually at each observation time interval.

Data analysis

Data obtained from observations of the number of fish in the zone of interest (10 cm radius from the FAD) were analyzed quantitatively using a statistical approach and data on fish vertical distribution were analyzed descriptive. Data analysis in this study used the data were analyzed using Repeated Measures Two-Way ANOVA, where FAD position and light presence were treated as between-subject factors, and observation time was treated as a within-subject (repeated) factor with the IBM SPSS application to examine the effect of FAD position, the effect of light presence, and the interaction between FAD position and light. The statistical model used:

$$Y = \mu + A + B + (AxB) + \varepsilon$$

Where:
Y = response variable (number of fish in the zone of interest or vertical distribution)
μ = general mean value
A = influence of the position of the fish aggregating device
B = influence of the presence of light
A×B = interaction between position and light
ε = experimental error

Each treatment was applied to a single experimental unit (n = 1 per treatment), and repeated observations over time were used to assess temporal dynamics. Therefore, the analysis reflects repeated measurements within treatments rather than true biological replication. The test decision is based on a 5% significance level (α = 0.05). The test decision is determined as follows: If the p-value < 0.05 then the null hypothesis (H0) is rejected, which means there is a significant influence of the tested factor and if the p-value ≥ 0.05 then the null hypothesis (H0) is accepted, which means there is no significant influence.

The statistical hypothesis tested is:

$H0_1$: There is no influence of the position of the fish aggregating device on the number of fish approaching.
$H0_2$: There is no effect of the presence of light on the number of fish that approach.
$H0_3$: There is no interaction between the position of the fish aggregating device and light on the number of fish approaching.

The effectiveness of fish attraction to fish aggregating devices is calculated using the equation:

$$Efektivitas\ (\%) = \frac{Jumlah\ Ikan\ di\ zona\ ketertarikan}{Total\ Ikan\ Percobaan} \times\ 100\%$$

Data on responses to feeding, responses to light vibrations, and social behavior patterns (grouping or dispersing) were analyzed descriptively to describe the behavioral tendencies of fish in each treatment.

RESULT AND DISCUSSION

Fish Attraction to Fish Aggregating Devices

Fish attraction in this study was measured based on the number of fish within the attraction zone (a 10 cm radius from the fish aggregating device). Based on the research results, fish attraction to the fish aggregating device was influenced by the type of attractant, treatment (bottom or surface), and the presence of light (Hamka et al., 2025; Patty et al., 2023; Prihantoko et al., 2025). This parameter is used as the main indicator to evaluate the effectiveness of the combination of FAD position and light presence in attracting positively phototactic fish. The average number of fish for each combination of FAD position and light presence is presented in Table 2.

Table 2. Average Number of Fish Attracted to the Fish Aggregating Device (Individuals)

Fish Aggregating Device Treatment	**Number of Fish (Individuals)**	**Minutes To**						**Average**	**SD**	***Effectiveness (%)***
		10	**20**	**30**	**40**	**50**	**60**			
P1 : Bottom Without Light	45	22	21	26	23	21	26	23	2.32	51
P2 : Lighted Bottom	45	22	26	26	27	22	19	24	3.14	53
P3 : Surface Without Light	45	31	30	34	38	39	37	35	3.76	77
P4 : Lighted Surface	45	22	25	30	36	30	30	29	4.83	64

Based on Table 2, the highest average number of fish was found in the surface FAD treatment without lights (35 ± 3.76 fish), followed by the surface FAD with lights (29 ± 4.83 fish). Meanwhile, in the bottom FAD, the number of fish was relatively lower both without lights (23 ± 2.32 fish) and with lights (24 ± 3.14 fish). In general, the position of the FAD in the water column showed a clearer difference than the presence of light alone.

This pattern indicates that the position of FADs in the water column has a more pronounced visual impact on fish aggregation responses than the presence of light alone. The deeper-protruding structure of FADs has been shown to accelerate the aggregation process, suggesting that the depth and vertical distribution of the devices play a significant role in fish grouping dynamics (Orue et al., 2019; Sinopoli et al., 2023). The quite contrasting differences between bottom and surface fish aggregating devices indicate that positively phototactic fish tend to be more responsive to structures located in the Surface zone of the water (Silooy et al., 2024; Xu et al., 2022; Suchocki & Sepulveda-Villet, 2019).

Treatment P3 (surface FADs without lights) demonstrated the highest effectiveness rate of 77%, compared to other treatments. This indicates that the position of the FADs on the water surface is more capable of attracting fish aggregations than bottom FADs, both with and without lights. Meanwhile, treatments with the addition of lights did not always result in a significant increase in effectiveness, indicating that the vertical distribution of fish in the water column is a more dominant factor in attraction than the artificial light stimulus. Thus, at this laboratory scale, FAD effectiveness is determined more by placement position than by the presence of lights.

Furthermore, the standard deviation value for the illuminated surface treatment (± 4.83) was higher than for the other treatments, indicating greater variation in individual fish responses to this combination. This variation may reflect visual adaptation or differences in individual sensitivity to additional light intensity. High light intensity is known to more dynamically influence fish aggregation patterns and vertical distribution (Sugandi et al., 2019). This variation may reflect the retina's visual adaptation to differences in light intensity (Nabiu et al., 2018; Susanto et al., 2018), as well as differences in individual sensitivity to additional light spectrum and intensity (Riyanto et al., 2023). Although the pattern of differences in fish numbers between treatments has been seen descriptively, statistical analysis is needed to determine whether these variations truly reflect the influence of factors such as the position of the fish aggregating device (FAD), the presence of light, or the interaction between the two. Therefore, a Two-Way ANOVA analysis was conducted (Table 3) to test the effect of each factor and their combination on the number of fish in the zone of interest.

Table 3. Two-Way ANOVA results on the number of fish in the zone of interest

Sources of Diversity	**df**	**F**	**p-value**
Fish Aggregating Device Position	1	32,220	<0.001
Light	1	3,440	0.078
Position × Light	1	4,804	0.040
Error	20	–	–

The results of the homogeneity of variance test (Levene's Test) showed a significance value of 0.425 ($p = 0.425 > 0.05$), so the homogeneity assumption was met and a Two-Way ANOVA analysis could be performed. The results of the analysis (Table 3) showed that the FAD position factor had a significant effect on the number of approaching fish ($F = 32.220$; $p = 0.000$). In contrast, the presence of light factor independently did not show a significant effect ($F = 3.440$; $p = 0.078$). However, there was a significant interaction between FAD position and light ($F = 4.804$; $p = 0.040$). The coefficient of determination (R^2) value of 0.669 indicated that the model was able to explain 66.9% of the variation in fish responses to the treatment. The remaining variation (33.1%) may be influenced by other factors not included in the model, such as ambient light conditions, individual behavioral variability, or minor environmental fluctuations within the experimental setup.

Based on the results of statistical analysis, the first null hypothesis ($H0_1$) which states that there is no effect of the position of the fish aggregating device on the number of fish is rejected ($p = 0.000$). The second null hypothesis ($H0_2$) which states that there is no effect of the presence of light on the number of fish cannot be rejected ($p = 0.078$). Meanwhile, the third null hypothesis ($H0_3$) which states that there is no interaction between position and light is rejected ($p = 0.040$). Thus, the effectiveness of the combination of raffia rope attractor and lighting in attracting positively phototactic fish is more influenced by the interaction between the two factors than by the light factor alone.

The Influence of the Position of Fish Aggregating Devices

The difference in fish numbers between bottom and surface fish aggregating devices is visualized in Figure 3.

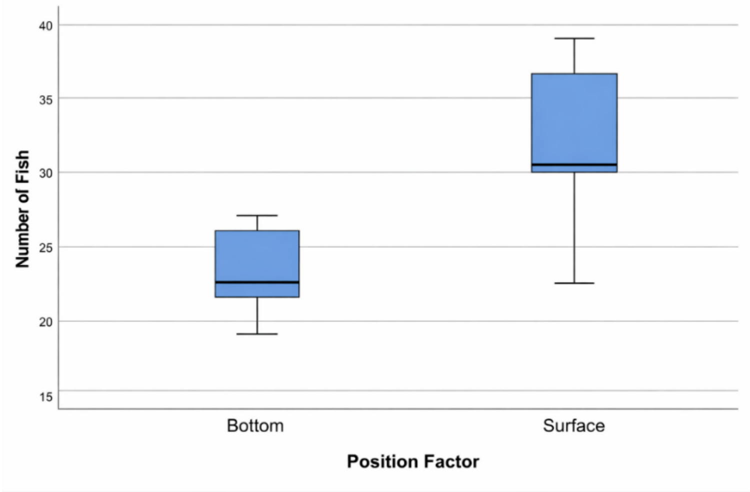

Figure 3. Distribution of the number of fish based on position factors

The boxplot (Figure 3) graph shows a higher median fish count on surface fish aggregating devices (FADs) than on bottom fish aggregating devices (FADs), with a wider distribution range. This pattern reinforces the statistical analysis that FAD position is a dominant factor in determining fish attraction. The surface position allows the raffia rope attractor to be in a more optimal illumination zone because the highest light intensity is in the Surface layer of the water column and decreases with increasing depth (Darondo et al., 2024; Yullita et al., 2025). The distribution of light in the water column plays a significant role in enhancing the effectiveness of visual stimuli in fish. Light distribution in the water column has also been shown to influence the vertical distribution and behavioral responses of fish to visual stimuli (Emam et al., 2018; Moss et al., 2025; Sawada et al., 2025). In addition, variations in light intensity have been shown to alter the motor responses of fish to visual stimuli (Saputra et al., 2025), shows that light plays a direct role in the visual interaction process.

Apart from the illumination factor, the vertical orientation of positively phototactic fish also plays a role in increasing the response to structures located in the Surface part of the water (Moss et al., 2025). Fish with a tendency to move towards light sources will more easily detect and approach objects located in zones with relatively higher light intensity. This is in line with the results of research Sulaiman et al., (2015) that positively phototactic fish are more attracted to illuminated surfaces and also positive phototaxis makes fish orientate towards the light source, the optimum light intensity for foraging and other activities. Thus, the effectiveness of surface position in this study indicates that the spatial distribution of attractors has a dominant role in the process of fish aggregation.

The Influence of the Presence of Light

The distribution of the number of fish based on the presence of light is visualized through a boxplot in Figure 4. Descriptively, the treatment without lights showed a higher median number of fish than the treatment with lights. In addition, the interquartile range in the treatment without lights appeared wider, indicating greater variation in fish responses compared to the light conditions.

The boxplot in Figure 4 shows that the range of variation in fish numbers in the unlit treatment tended to be wider than in the lit treatment, indicating heterogeneity in response under conditions without supplemental lighting. Although the distribution differences are visually apparent, statistically, the presence of light alone did not have a strong enough effect on increasing fish numbers in the zone of attraction.

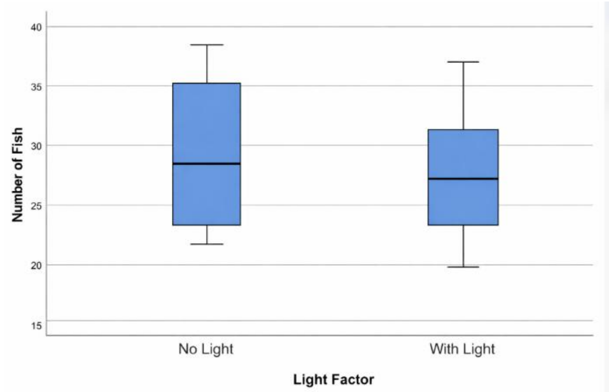

Figure 4. Distribution of the number of fish based on light factors

Descriptively, the unlit treatment showed a slightly higher median fish count than the lit treatment. However, ANOVA results showed that this difference was not statistically significant ($p > 0.05$). This indicates that LED lighting has not consistently increased fish aggregation. Biologically, this can be explained by several possibilities. First, the relatively bright laboratory conditions during the day may reduce the additional contrast produced by the LED lights, so the light stimulus does not produce a significant increase in response. Second, guppies, as a positively phototactic species, may have already been sufficiently stimulated by the ambient light and the reflectance of the raffia attractor, so the addition of artificial light does not produce a linear increase in response.

Light is a major factor in attracting fish, in line with the characteristics of guppies which are positively phototaxis. This is in accordance with the opinion of Sulaiman et al., (2015) who stated that fish with positive phototaxis are more responsive to bright light sources. Light illumination creates a zone of attraction within a certain radius, as reported by Susanto et al. (2017), where the highest light intensity was found at a radius of 0-10 cm from the light source, which is in line with the design of this study. The response variations seen in the boxplot indicate that the presence of light produces a more homogeneous distribution than without light. However, the effectiveness of light appears to depend on the position of the FADs in the water column.

The Interaction of Position and Light as a Form of Combination Effectiveness

The significant interaction between FAD position and light availability indicates that fish aggregation responses are not determined by a single factor, but rather by a combination of both. At the bottom of the FAD, the addition of lights did not result in a significant increase in fish numbers, whereas at the surface FAD, fish responses showed a different pattern. This finding indicates that lighting effectiveness depends on the spatial context of FAD placement within the water column.

The distribution of light in the surface layer of water tends to be more homogeneous and spreads laterally before experiencing vertical attenuation, thus increasing the visual contrast between floating structures such as fish aggregating devices (FADs) and their surrounding environment (Latuconsina et al., 2020; Rumpa, 2023). Optimal light intensity in the surface zone has also been shown to influence the horizontal distribution of fish and visual responses to artificial structures (Pramono & Saraswati, 2021; Tirtana et al., 2025). Therefore, the presence of light is only effective when combined with a position that supports maximum illumination distribution.

These findings align with the theory of positive phototaxis, which is the tendency of fish such as guppies and anchovies to migrate toward illuminated areas. Raffia-shaped visual attractors increase the effectiveness of the visual field and enlarge the reflective stimulus on the water surface, making it a major attraction for fish. Barki et al. (2013) showed that white light can direct guppy larvae to safe areas, reducing cannibalism and increasing the number of larvae collected. This supports the hypothesis that light (especially white) is effective in attracting fish to certain areas. Meanwhile, Almaas & Harlita (2023) proved that variations in light color significantly affect the behavioral responses of guppies, which generally exhibit positive phototaxis towards certain spectrums, including white light.

Interestingly, the average number of fish on unlit surface FADs was higher than on lit surfaces. This indicates that the visual structure of the FADs at the surface is already strong enough to attract positively phototactic fish, so the addition of light does not always increase the response linearly. This phenomenon indicates that the effectiveness of the combination is not simply additive, but rather influenced by the dynamics of the fish's visual perception of their surroundings.

Vertical Distribution of Fish as a Phototactic Response

Fish positional behavior in this study was observed based on their distribution across three zones: surface, middle, and bottom. This data provides an overview of how attractor type, light availability, and treatment influence fish position selection within the aquarium. The number of fish positions in each treatment is shown in Table 4.

Table 4. Average vertical distribution of fish in each treatment combination during the observation period

Treatment	Surface	Middle	Bottom
P1 (Basic Without Light)	29	5	7
P2 (Lighted Bottom)	23	8	10
P3 (Unlit Surface)	29	6	5
P4 (Lighted Surface)	32	8	2

Table 4 shows that the fish are in the surface zone, especially in the light treatment. In the lighted surface treatment, the number of fish in the surface zone reached an average of 32 fish. In the lighted bottom treatment, fish also tended to gather at the surface, although the average was lower, namely around 23 fish. Raffia rope has a light and flexible structure so that this attractor can easily move with the water current and attract the attention of fish in the Surface zone. This movement becomes more clearly visible with the addition of light. The addition of a 5 watt white lamp increases the light intensity in the surface zone, which takes advantage of the positive phototactic properties of guppy fish. Almaas & Harlita, (2023) stated that guppies exhibit a positive phototactic response to various light spectrums, including white, which triggers their movement towards the light source. The raffia rope showed a consistent distribution of fish in the surface zone, with low fluctuation compared to other zones.

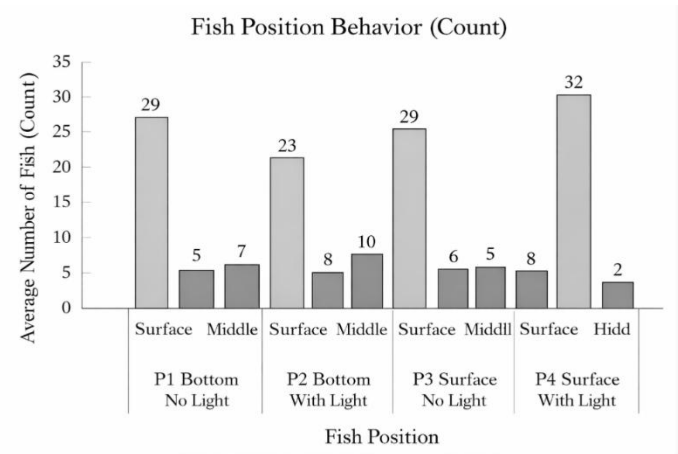

Figure 5. Average vertical distribution of fish in each treatment combination

In the Distribution Diagram (Figure 5), in general, all treatments show a dominance of fish in the surface zone compared to the middle and bottom zones. The highest proportion of the surface zone was found in the lighted surface FAD treatment (P4), while the lowest proportion in the bottom zone also occurred in the same treatment. In the lighted bottom FAD (P2), the distribution of fish appeared more spread out to the middle and bottom zones compared to the other treatments. This indicates that when the FAD is placed on the bottom, the vertical orientation of the fish is not completely concentrated on the surface.

The dominance of the surface zone in all treatments reinforced the positive phototaxis characteristics of the test fish. Guppies tend to move towards areas with higher light intensity, which is naturally found at the top of the water column. Furthermore, the placement of FADs on the surface allows the raffia line attractors to receive more optimal illumination, thus increasing visibility and visual appeal. A study from MacAulay & Cable, (2024) Studies on artificial light at night (ALAN) in guppies have shown that light intensity affects orientation, feeding behavior, and stress generation. This suggests that illuminated surface areas provide more stimulation than the Bottom areas.

Supportive Behavioral Responses to Treatment Combinations

Fish response to feeding is a crucial aspect in assessing the effectiveness of FADs. This behavior indicates the extent to which the attractant on the FAD is able to influence fish concentration and maintain their focus around the FAD when food is provided. The research results showed that fish response to feeding was influenced by the type of attractant, the presence of light, and the fish's location zone. Observations of feeding responses showed that all treatments, both on bottom and surface FADs with or without lighting, produced a fast and consistent feeding response throughout the observation period. No differences in response time were found between treatments, indicating that the combination of attractant and lighting did not cause physiological disturbances or stress in the test fish.

The high concentration of fish in the surface zone makes it easier for fish to detect and respond to the food provided. The white lighted raffia rope attractor creates a visual effect that attracts fish, increasing their focus on their surroundings, including food. The light increases the positive phototaxis activity of fish, allowing them to detect food more quickly (Efendy & Hafiludin, 2024; Gustiron et al., 2024; Tanjaya et al., 2024). Besides that,Kimbell et al., (2019) In his research, he stated that guppies can adjust their foraging strategies during low-light conditions. In this study, despite the lack of light, the results showed that guppies still sought food without any problems, indicating that they also rely on other responses (e.g., lateral line or olfactory senses) when visual conditions are not optimal. Irsandi & Kantun, (2025); Susanto et al., (2017) showed that light increases fish responses to food stimuli, especially in positively phototactic species.

Fish response to vibration is a crucial aspect in understanding how they react to physical stimuli in their environment. In the context of this study, observing fish responses to vibration provides insight into the ability of fish aggregating devices (FADs) to attract fish beyond light or visual attractants. Fish movement responses during observation also demonstrate rapid and responsive activity to environmental stimuli. Mild vibrations in the aquarium produce direct stimulation of the neuromasts, causing the fish to immediately perceive environmental changes, as evidenced by a shift in position when the stimulus is applied. Butler & Maruska, (2016) explained that the lateral line also plays a role in social coordination, such as schooling when water disturbances occur. The primary mechanism of mechanosensory response in fish is through the lateral line system, which consists of neuromasts along the fish's body. This system is capable of detecting changes in water pressure and vibrations over short distances. Grassel A, (2023) explains that the lateral line is sensitive to mechanosensory sources such as water movement due to vibrations or light currents.

In the context of FAD use, schooling patterns indicate the level of fish interest in the attractant used and how they interact with each other around the FAD. Meanwhile, observations of schooling behavior indicate that fish tend to disperse during most of the observation period across all treatments. Only at certain intervals in the lighted bottom FAD treatment did temporary schooling occur. This pattern suggests that aggregation around FADs is more individualistic than social.

CONCLUSION

Based on the results of the study, it can be concluded that the position of FADs significantly influenced the number of positively phototactic fish (Poecilia reticulata) approaching the attraction zone, while the presence of light did not have a significant effect. FADs placed at the surface showed the highest effectiveness in attracting fish, especially in the treatment without lights, with an effectiveness level reaching 77%. The results of the Two-Way ANOVA analysis showed that there was a significant interaction between FAD position and the presence of light, indicating that the effectiveness of the combination of raffia rope attractors and LED lighting depended on their placement in the water column. The vertical distribution of fish was dominated by the surface zone in all treatments, reinforcing the positive phototactic characteristics of the test fish. Overall, this study indicates that at the laboratory scale, the effectiveness of FAD visual attraction is more determined by placement position than by the addition of light alone, although the combination of both still contributes through an interactive effect on fish aggregation responses. and further field-based research is required to evaluate the effectiveness of this approach under varying environmental conditions, particularly in waters with different natural light intensities.

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REFERENCES

Afrisal, M., Ismail, M., & Yani, A. (2024). A Review Of The Effectiveness Of Fish Aggregating Devices (Fads) In Indonesian Waters. *Jurnal Ipteks Psp*, *11*(1), 22–45. Https://Doi.Org/10.20956/Jipsp.V11i1.34312

Almaas, A. F., & Harlita, H. (2023). Guppy Fish (Poecilia Reticulata) Behavior And Growth Are Affected By Variations In Light Color. *Jurnal Perikanan Universitas Gadjah Mada*, *25*(2), 131. Https://Doi.Org/10.22146/Jfs.85836

Bahtiar Hamar. (2023). Strategi Pengelolaan Rumpon Sebagai Alat Bantu Penangkapan Ikan Di Kabupaten Buton Selatan. *Jurnal Cakrawala Ilmiah*, *2*(6), 2781–2796. Https://Doi.Org/10.53625/Jcijurnalcakrawalailmiah.V2i6.5139

Bunnell, D. B., Ludsin, S. A., Knight, R. L., Rudstam, L. G., Williamson, C. E., Höök, T. O., Collingsworth, P. D., Lesht, B. M., Barbiero, R. P., Scofield, A. E., Rutherford, E. S., Gaynor, L., Vanderploeg, H. A., & Koops, M. A. (2021). Consequences Of Changing Water Clarity On The Fi Sh And Fi Sheries Of The Laurentian Great Lakes. *Canadian Science Publishing*, *78*, 1524–1542.

Butler, J. M., & Maruska, K. P. (2016). Mechanosensory Signaling As A Potential Mode Of Communication During Social Interactions In Fishes. *Journal Of Experimental Biology*, *219*(18), 2781–2789. Https://Doi.Org/10.1242/Jeb.133801

Chairunnisa, S., Setiawan, N., Irkham, `, Ekawati, K., Anwar, A., & Fitri, A. D. P. (2018). Studi

Tingkah Laku Ikan Terhadap Prototype Auto-Lion (Skala Laboratorium) Study Of Fish Behavior With Auto-Lion Prototype, (Laboratorium Scale). *Marine Fisheries : Journal Of Marine Fisheries Technology And Management*, *9*(1), 55–63. Https://Doi.Org/10.29244/Jmf.9.1.53-62

Darondo, F. A., Putri, E. T., Manohas, J., Santoso, H., Karyanto, Katili, L., Manengkey, J. I., Saranga, R., Simau, S., & Hamel, S. (2024). Technical Analysis Of Floating Bagan Operation In The Waters Of Batu Putih Village, Bitung City, North Sulawesi. *Saintek Perikanan: Indonesian Journal Of Fisheries Science And Technology*, *20*(4), 188–196.

Efendy, E. N., & Hafiludin. (2024). Produktivitas Alat Tangkap Purse Seine Di Pelabuhan Upt Ppp Pasongsongan. *Juvenil Jurnal*, *5*(2), 116–124.

Emam, W., Lambert, H., & Brown, C. (2018). The Welfare Of Farmed Nile Tilapia : A Review. *Frontiers In Veterinary Science*, *2*(7).

Fauziyanto, R., Haruna, H., Hehanussa, K. G., & Tuhumury, J. (2024). Pengaruh Atraktor Tali Rafia Dan Pita Polypropylene Terhadap Komposisi Jenis Dan Kehadiran Ikan Pada Rumah Ikan Di Teluk Ambon. *Amanisal: Jurnal Teknologi Dan Manajemen Perikanan Tangkap*, *13*(2), 25–39. Https://Doi.Org/10.30598/Amanisal.V13i2.14978

Forget, F., Cowley, P., Capello, M., Filmalter, J. D., & Dagorn, L. (2020). Drifting Along In The Open-Ocean: The Associative Behaviour Of Oceanic Triggerfish And Rainbow Runner With Floating Objects. *Elsevier*, 1–26.

Fuad, Aji, B. P., Isroni, W., Riyanto, M., Mamat, N. B., & Bahri, A. S. (2025). Effects Of Led Light Color And Intensity On Fish Behavior And Shoal Distribution For Fixed Lift-Net Fishing. *International Journal Of Design & Nature And Ecodynamics*, *20*(9), 2069–2079.

Grassel A. (2023). Lateral Line System Of A Juvenile Guppy: Poecilia Reticulata. *Eukaryon*, *19*(March), 1–2. Https://Doi.Org/10.1111/J.1749-4877.2008.00131.Breden

Gustiron, I., Aida, G. R., Noor, M. T., & Yusrudin, Y. (2024). Pengaruh Perbedaan Warna Lampu Pada Hasil Tangkapan Ikan Teri (Stolephorus Sp) Pada Alat Tangkap Bagan Perahu Di Perairan Karangantu Serang Banten. *Manfish: Jurnal Ilmiah Perikanan Dan Peternakan*, *2*(1).

Hamka, E., Nuryadi, A. M., Husain, H., & Said, A. (2025). Penerapan Teknologi Rumpon Dasar , Atraktor Cumi Dan Lampu Bawah Air Bagi Peningkatan Ekonomi Nelayan Kecil Di Sulawesi Tenggara The Implementation Of Bottom-Set Fish Aggregating Devices , Squid Attractors , And Underwater Lights To Improve The Economy Of. *Jurnal Sains Dan Inovasi Perikanan*, *9*(2), 164–173. Https://Doi.Org/10.33772/Jsipi.V9i2.1235

Humborstad, O., Utne-Palm, A. C., Breen, M., & Løkkeborg, S. (2018). Original Article Artificial Light In Baited Pots Substantially Increases The Catch Of Cod (Gadus Morhua) By Attracting Active Bait , Krill (Thysanoessa Inermis). *Ices Journal Of Marine Science*, *75*(6), 2257–2264. Https://Doi.Org/10.1093/Icesjms/Fsy099

Irsandi, & Kantun, W. (2025). Variation In Growth Patterns And Condition Factors Of Fringe Scale Sardinella (Sardinella Fimbriata) Based On The Moon Phase In Takalar Waters, Makassar Strait. *Agrikan - Jurnal Agribisnis Perikanan*, *18*(1), 289–295.

Kimbell, H. S., Chapman, B. B., Dobbinson, K. E., & Morrell, L. J. (2019). Foraging Guppies Can Compensate For Low-Light Conditions, But Not Via A Sensory Switch. *Behavioral Ecology And Sociobiology*, *73*(3). Https://Doi.Org/10.1007/S00265-019-2640-9

Latuconsina, H., Affandi, R., Kamal, M. M., & Butet, N. A. (2020). Distribusi Spasial Ikan Baronang Siganus Canaliculatus Park, 1797 Pada Habitat Padang Lamun Berbeda Di Teluk Ambon Dalam. *Jurnal Ilmu Dan Teknologi Kelautan Tropis*, *12*(1), 89–106.

Li, F., & Hua, C. (2025). Evaluating The Illumination Performance Of Led Fishing Lamps With Different Configurations In Pacific Saury Fishery. *Plos One*, 1–20.

Https://Doi.Org/10.1371/Journal.Pone.0328676

Macaulay, S., & Cable, J. (2024). Gyrodactylus In The Spotlight: How Exposure To Light Impacts Disease And The Feeding Behavior Of The Freshwater Tropical Guppy (Poecilia Reticulata). *Journal Of Fish Biology*, *May*, 682–690. Https://Doi.Org/10.1111/Jfb.15816

Moss, A., Peh, J. Hui, Segaran, T. C., Lananan, F., Kari, Z. A., & Wei, L. S. (2025). Bioactive Compounds In Aquaculture. *Aquaculture International*, *33*(414), 1–35. Https://Doi.Org/10.1007/S10499-025-01985-Y

Nabiu, N. L. M., Baskoro, M. S., Zulkarnain, & Yusfiandayani, R. (2018). Adaptasi Retina Ikan Selar (Selaroides Leptolepsis) Terhadap Intensitas Cahaya Lampu Light Adaptation Process Of Retinal Yellowstripe Scad. *Jurnal Teknologi Perikanan Dan Kelautan*, *9*(1), 97–102.

Orue, B., Lopez, J., Moreno, G., Santiago, J., Soto, M., & Murua, H. (2019). Aggregation Process Of Drifting Fish Aggregating Devices (Dfads) In The Western Indian Ocean : Who Arrives First , Tuna Or Non- Tuna Species ? *Plos One*, *14*(1), 1–24. Https://Doi.Org/Https://Doi.Org/10.1371/Journal.Pone.0210435

Patty, W., Kalangi, P. N. I., & Laian, N. (2023). Application Of Fish-Attracting Lights , At Surface And Underwater , In Raft Fishing In Manado Bay , North Sulawesi , Indonesia. *Aacl Bioflux*, *16*(4), 1901–1907.

Pramono, T. A., & Saraswati, E. (2021). Perbedaan Jenis Alat Bantu Penangkapan Perairan Samudera Hindia. *Journal Of Sustainable Agriculture And Fisheries (Josaf) Perbedaan*, *1*(2), 85–95.

Prihantoko, K. E., Suherman, A., & Setiyanto, I. (2025). Tipe Atraktor Pada Berbagai Alat Penangkapan Ikan. *Jurnal Penelitian Perikanan Indonesia*, *29*(4), 1–15.

Riyanto, M., Aminah, A. S., Mawardi, W., & Wahju, R. I. (2023). Response Of Anguilla Bicolor Glass Eel To Different Light Colors. *Omni-Akuatika*, *19*(1), 61–68.

Rumpa, A. (2023). *Tingkah Laku Ikan Pada Areal Rumpon Dalam Hubungannya Terhadap Proses Penangkapan Ikan Dengan Purse Seine Di Perairan Teluk Bone*.

Rumpa, A., Najamuddin, Safruddin, & Hajar, M. A. I. (2022). Studying The Relationship Of Immersion Duration And Characteristics Of Natural Materials Fad To Fish Aggregation In The Sea. *Biodiversitas*, *23*(10), 5481–5490. Https://Doi.Org/10.13057/Biodiv/D231060

Saputra, F., Pramata, A. D., & Soegianto, A. (2025). Vitamin E Mitigates Polystyrene-Nanoplastic-Induced Visual Dysfunction In Zebrafish Larvae. *International Journal Of Molecular Sciences*, *26*(1216).

Sawada, Y., Nuruki, L., Izumi, M., Miyashima, A., & Agawa, Y. (2025). Ontogenetic Development Of Phototaxis And Countermeasures Against Walling And Surface-Pecking Behaviors In Mottled Spinefoot Larvae. *Ssrn*.

Setiawan, F., Sulistiyanti, R., & Sadnowo, A. (2015). Analisis Pengaruh Medium Perambatan Terhadap Intensitas Cahaya Lacuba (Lampu Celup Bawah Air). *Jurnal Rekayasa Dan Teknologi Elektro*, *9*(1), 21–29.

Silooy, F. D., Noija, D., & Hehanussa, K. G. (2024). Analisis Fase Bulan Terhadap Hasil Tangkapan Purse Seine Di Perairan Amahai, Pulau Seram Analysis Of Moon Phases On Purse Seine Catch Results In Amahai Waters, Seram Island. *Marine And Fisheries Tropical Applied Journal*, *2*(2), 90–102. Https://Doi.Org/10.25181/Marshela.V2i2.3690

Sinopoli, M., Badalamenti, F., Bottaro, M., & Anna, G. D. (2023). The Role Of Fish Aggregating Devices (Fads) In Juvenile Fish Dispersal Along The North-Western Coast Of Sicily. *Journal Of Marine Science And Engineering*, *11*(756).

Soghirun, M., Rumpa, A., Kasim, N., Ohorella, R., Pontoh, P., Baroqi, A. R., Putra S, T., Runtukahu, M. I. Z., & Wulandari, N. A. (2024). Dynamics Of Fish Catch Results From Handline Fishing Gear And Sustainable Solutions For Tuna Fisheries In A Rumpon Area. *Aquatic Science &*

Management, *12*(2), 19–29.

Suchocki, C. R., & Sepulveda-Villet, O. J. (2019). The Role Of Phototaxis In The Initial Swim Bladder Inflation Of Larval Yellow Perch (Perca Flavescens). *International Aquatic Research*, *11*(1), 33–42. Https://Doi.Org/10.1007/S40071-019-0217-X

Sugandi, Wahju, R. I., Riyanto, M., & Sumardi. (2019). Fish Aggregation Pattern On Red-Blue-Green Light Emitting Diode (Rgb-Led) Light In Static Lift Net. *Omni-Akuatika*, *15*(1), 103–109.

Susanto, A., Baskoro, M. S., Wisudo, S. H., & Riyanto, M. (2018). Optimum Light Colour And Intensity Defining Of Light Emitting Diode (Led) In Yellowstripe Scad (Selaroides Leptolepis) Fishing For Fixed Liftnet Fisheries. *Marine Fisheries*, *9*(2), 145–155.

Susanto, A., Fitri, A. D. P., Putra, Y., Susanto, H., & Alawiyah, T. (2017). Respons Dan Adaptasi Ikan Teri (Stolephorus Sp.) Terhadap Lampu Light Emitting Diode (Led) (Response And Adaptation Of Anchovy (Stolephorus Sp.) To Light Emitting Diode (Led) Lamp). *Marine Fisheries : Journal Of Marine Fisheries Technology And Management*, *8*(1), 39–49. Https://Doi.Org/10.29244/Jmf.8.1.39-49

Susanto, A., Wisudo, S. H., Baskoro, M. S., Riyanto, M., & Purwangka, F. (2020). Efektivitas Low Light Emitting Diode Sebagai Lampu Pengumpul Ikan Untuk Perikanan Bagan Tancap. *Depik Jurnal Ilmu-Ilmu Perairan, Pesisir Dan Perikanan*, *9*(2), 365–376. Https://Doi.Org/10.13170/Depik.9.2.15582

Tamrin, T., Rumpa, A., Maskur, M., Kusmedy, B., Yusuf, A., & Tamrin, D. R. (2025). System Development Of Fish Attractor (Sound And Light Combination) In Fixed Lift Net Fisheries. *Fisheries And Aquatic Sciences*, *28*(10), 709–716.

Tanjaya, E., Almodar, E., Notanubun, J., & Hukubun, W. G. (2024). Analisa Hasil Tangkapan Ikan Pada Bagan Perahu Berdasarkan Waktu Hauling Di Perairan Ohoi Selayar Kepulauan Kei. *Jurnal Sumberdaya Akuatik Indopasifik*, *8*(1), 79–90.

Tirtana, D., Kencana, A. K. D., Syahputra, F., Rosalia, A. A., & Fatoni, K. (2025). Ikan Pada Rumpon Dengan Atraktor Semi Sintetis Di Perairan Teluk Hurun, Lampung. *Jurnal Penelitian Perikanan Indonesia*, *31*(2), 63–72.

Urbasa, F., Kaparang, F. E., & Kumajas, H. J. (2015). Studi Ketertarikan Ikan Di Keramba Jaring Apung Terhadap Warna Cahaya Lampu Di Perairan Sindulang I, Kecamatan Tuminting, Kota Manado. *Jurnal Ilmu Dan Teknologi Perikanan Tangkap*, *2*, 39–43. Https://Doi.Org/10.35800/Jitpt.2.0.2015.7020

Xu, J., Sang, W., Dai, H., Lin, C., Ke, S., Mao, J., Wang, G., & Shi, X. (2022). A Detailed Analysis Of The Effect Of Different Environmental And Expelling Technique. *Behavioral Ecology Of Aquatic Animals*, *12*(3), 1–18.

Yullita, I., Hartoko, A., & Haeruddin. (2025). Analisis Spasial Daerah Penangkapan Ikan Dengan Trammel Net Di Perairan Morodemak Kecamatan Bonang, Kabupaten Demak, Jawa Tengah. *Jurnal Pasir Laut*, *9*(1), 59–65.

Yusfiandayani, R. (2010). Pelagis Dengan Menggunakan Payang Bugis Di Perairan Pasauran , Provinsi Banten (The Effect Of Attractor Material On Pelagic Fish Captured Using Payang Bugis In Pasauran Waters , Province Of Banten). *Jurnal Teknologi Perikanan Dan Kelautan*, *1*(2), 47–60. Https://Doi.Org/Https://Doi.Org/10.24319/Jtpk.1.47-60

Zada, D., Schulze, L., Yu, J., Tarabishi, P., Napoli, J. L., Milan, J., & Lovett-Barron, M. (2024). Development Of Neural Circuits For Social Motion Perception In Schooling Fish. *Curr Biol*, *34*(15), 3380–3391. Https://Doi.Org/10.1016/J.Cub.2024.06.049.Development