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# Artificial Light Color and Fish Catch Performance in Marine Fisheries: A Review

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**Abstract.** Artificial light is widely used in nocturnal fisheries to aggregate fish, improve encounter probability, and influence capture selectivity. Light-emitting diodes (LEDs) allow precise control of spectral output, yet published evidence does not identify one universally optimal color. This review synthesizes recent studies on the effects of artificial light color on fish attraction, aggregation, catch performance, species composition, and selectivity in marine fisheries. A structured narrative review was conducted using peer-reviewed literature published mainly during 2016–2025, emphasizing field experiments and physiological studies relevant to light-assisted capture. Blue, cyan, and green wavelengths frequently produced strong behavioral or catch responses because they propagate efficiently in seawater and overlap with the visual sensitivity of many marine organisms. However, outcomes were strongly dependent on species, fishing gear, irradiance, depth, water optical properties, and operational context. Indonesian studies on anchovy and lift-net fisheries reported advantages of blue, white, green, or mixed-color LEDs under different experimental conditions, while recent fixed lift-net trials found strong aggregation and catch under green LEDs. International studies similarly reported contrasting responses in trammel nets, pots, squid-related fisheries, and illuminated nets. Light may also increase catch indirectly by attracting prey organisms or improve selectivity by altering bycatch interactions. Therefore, lamp color should be optimized together with irradiance, deployment geometry, exposure duration, lunar phase, and target-species behavior. Future studies should prioritize replicated field trials, spectral measurements, acoustic or video verification, standardized CPUE, and reporting of energy use and bycatch.

*Keywords: fishing light; LED; phototaxis; catch efficiency; fish behavior*

**Abstrak.** Cahaya buatan banyak digunakan dalam perikanan malam untuk mengumpulkan ikan, meningkatkan peluang pertemuan dengan alat tangkap, dan memengaruhi selektivitas penangkapan. Light-emitting diode (LED) memungkinkan pengaturan keluaran spektral secara presisi, tetapi bukti ilmiah belum menunjukkan satu warna yang selalu paling efektif. Artikel ini meninjau pengaruh warna cahaya buatan terhadap ketertarikan, agregasi, hasil tangkapan, komposisi spesies, dan selektivitas pada perikanan laut. Tinjauan naratif terstruktur dilakukan terhadap literatur ilmiah yang terutama diterbitkan pada 2016–2025, dengan penekanan pada eksperimen lapangan dan penelitian fisiologi yang relevan dengan penangkapan berbantuan cahaya. Cahaya biru, sian, dan hijau sering menghasilkan respons perilaku atau tangkapan yang kuat karena dapat merambat dengan baik di air laut dan beririsan dengan sensitivitas visual banyak organisme laut. Namun, hasil sangat bergantung pada spesies, alat tangkap, iradiasi, kedalaman, sifat optik perairan, dan konteks operasi. Penelitian di Indonesia pada ikan teri dan perikanan bagan menunjukkan keunggulan lampu biru, putih, hijau, atau kombinasi warna pada kondisi yang berbeda, sedangkan penelitian bagan tancap terbaru menunjukkan agregasi dan hasil tangkapan yang kuat pada LED hijau. Studi internasional juga menunjukkan respons berbeda pada trammel net, bubu, perikanan cumi, dan jaring bercahaya. Cahaya dapat meningkatkan hasil secara tidak langsung melalui organisme mangsa atau meningkatkan selektivitas dengan mengubah interaksi tangkapan sampingan. Oleh karena itu, warna lampu perlu dioptimalkan bersama iradiasi, geometri pemasangan, lama penyinaran, fase bulan, dan perilaku spesies target. Penelitian berikutnya perlu mengutamakan ulangan lapangan, pengukuran spektral, verifikasi akustik atau video, CPUE yang terstandar, serta pelaporan konsumsi energi dan tangkapan sampingan.

*Kata kunci: lampu penangkapan; LED; fototaksis; efisiensi tangkapan; tingkah laku ikan*

## 1. Pendahuluan

Fishing with artificial light is one of the oldest behavioral techniques used to concentrate aquatic organisms within the effective capture zone of fishing gear. In modern fisheries, light is associated with lift nets, purse seines, squid jigging, handlines, traps and pots, and more recently with illuminated gillnets and trammel nets. The fundamental assumption is behavioral: if a target organism detects a visual stimulus and responds by approaching, remaining near, avoiding, or changing its swimming orientation, the probability of capture can be altered. The development of LEDs has expanded this principle because LEDs allow relatively narrow wavelength bands, low electrical demand, compact underwater installation, and programmable control of intensity and color (Nguyen & Winger, 2019).

Color is particularly important because marine organisms do not perceive the underwater light field in the same way as humans. Wavelengths are attenuated differently by water and suspended materials, while retinal photoreceptors differ among species in spectral sensitivity, dark adaptation, and temporal response. Blue to green wavelengths commonly penetrate farther through clear marine water, whereas long red wavelengths are attenuated more rapidly. At the same time, visual pigments of many fishes and cephalopods show sensitivity peaks in the blue-green region. Laboratory work on Japanese flying squid demonstrated stronger physiological retinal responses under blue, green, and white LEDs than under red light, consistent with the species' visual-pigment sensitivity (Matsui et al., 2016). Similarly, rock bream showed the strongest photoreceptor and behavioral responses near cyan-green wavelengths, with weaker responses toward amber and red (Jang et al., 2019). These mechanisms help explain why blue and green lights are frequently effective, but they do not imply that the same color will maximize catch in every fishery.

The relationship between color and catch is complicated by several interacting processes. First, light can attract the target animal directly through positive phototaxis. Second, it can attract zooplankton or small forage organisms, creating an indirect trophic attraction that subsequently concentrates predators. Experiments on krill and Atlantic cod, for example, found strong attraction of krill to green or broadband white light, while cod itself showed no strong direct positive response; field trials later demonstrated markedly increased cod catches in highly illuminated baited pots, supporting an indirect prey-mediated mechanism (Utne-Palm et al., 2018; Humborstad et al., 2018). Third, light can modify the visibility of gear. Illuminated gillnets may be more detectable to protected species or bycatch while maintaining the catch of target species, thereby changing selectivity rather than simply increasing total catch (Ortiz et al., 2016; Virgili et al., 2018; Gautama et al., 2022).

Evidence from Indonesia is especially relevant because light-assisted fisheries are widespread in the archipelago. Experimental studies have examined anchovy responses to white and blue LEDs, anchovy catches under blue and green underwater LEDs, color combinations on lift nets, RGB lighting around purse-seine operations, and the use of green, blue, yellow, and white LEDs on fixed lift nets (Susanto et al., 2017; Amos et al., 2019; Baswantara et al., 2020; Turnip et al., 2022; Fuad et al., 2025). The results are not uniform. White light may induce a rapid initial response, blue light may retain anchovy for longer periods, and green light may create the strongest aggregation under a different gear and intensity regime. This diversity makes a synthesis necessary so that fishing-light recommendations are based on mechanism and fishery context rather than on the assumption that one color is universally superior.

Accordingly, this review aims to: (1) explain the optical and biological mechanisms linking light color with fish behavior; (2) synthesize recent field evidence on catch performance across fishing gears and target taxa; (3) compare findings from Indonesian fisheries with international studies; (4) identify methodological factors that explain inconsistent results; and (5) propose research and operational recommendations for more efficient, selective, and energy-conscious light-assisted fisheries.

## 2. Review Method

### *2.1 Review design and source selection*

A structured narrative review was used because the available evidence is heterogeneous in target taxa, fishing gears, light sources, wavelengths, intensity units, experimental duration, and catch metrics. Peer-reviewed literature was identified from journal publisher platforms, PubMed/PMC, institutional repositories, and Indonesian scholarly journal portals using combinations of the terms “fishing light”, “LED fishing light”, “light color”, “fish attraction”, “phototaxis”, “catch efficiency”, “lift net”, “purse seine”, “pot fishery”, “trammel net”, “squid”, “anchovy”, and “underwater LED”. Priority was given to studies published between 2016 and 2025, consistent with the journal template's emphasis on recent literature. A small number of review sources were used to frame the field, while the synthesis emphasized primary experimental studies.

Studies were included when they evaluated at least one of the following: (i) behavioral or physiological response to different wavelengths or colors; (ii) catch or CPUE differences associated with colored artificial light; (iii) fish aggregation or retention around light sources; (iv) effects of illumination on catch selectivity or bycatch; or (v) illumination geometry or intensity that materially affected interpretation of color performance. Studies that discussed lighting only as a general fishing practice without color, spectrum, behavioral, or catch information were not used as core evidence.

### *2.2 Analytical framework*

Evidence was compared across five dimensions: target species or taxa, fishing gear, spectral treatment, behavioral response, and catch outcome. Particular attention was given to whether color was tested at comparable irradiance, whether the light was above or below water, whether attraction was measured directly using visual/acoustic methods or inferred only from catch, and whether environmental covariates such as depth, moon phase, turbidity, or soak time were controlled. Because the studies used incompatible response metrics, no pooled meta-analytic effect size was calculated.

Instead, convergence and disagreement among studies were interpreted mechanistically.

## 3. Results and Discussion

### *3.1 Why light color can change catch performance*

The effectiveness of a fishing light begins with photon transmission through water. In relatively clear marine environments, short and intermediate visible wavelengths generally travel farther than long red wavelengths. Suspended sediments, dissolved organic matter, phytoplankton, and depth can substantially shift the underwater spectrum, meaning that the same lamp can produce a different effective stimulus between offshore and turbid coastal waters. Consequently, the nominal color printed on a lamp is less informative than the wavelength distribution and irradiance measured where fish actually encounter the light.

Detection also depends on visual physiology. The rock bream Oplegnathus fasciatus possessed visual pigments with absorption maxima near 425, 520, and 585 nm, while its strongest experimental photoresponse occurred near a 505-nm cyan LED and remained comparatively strong under green and blue light (Jang et al., 2019). Japanese flying squid similarly showed retinal responses that were greater under blue, green, and white LEDs than under red LEDs, matching its known sensitivity near the blue-green region (Matsui et al., 2016). These findings establish a physiological basis for wavelength-specific responses but also show that broad white light can be effective when it includes spectral components close to the visual sensitivity of the target organism.

Behavioral attraction is not equivalent to capture. A fish may enter a lit zone but remain outside the net, approach too quickly and leave, or be attracted at a depth that does not coincide with the effective fishing layer. Conversely, a color that produces slower attraction may maintain a stable aggregation for longer and therefore increase capture probability. Susanto et al. (2017) demonstrated this distinction in anchovy: white LEDs produced a faster response, while fish remained substantially longer in the blue-light zone. The operational question is therefore not simply which color fish detect first, but which color-intensity-duration combination positions and retains a school where the fishing gear can capture it.

### *3.2 General spectral patterns and their limitations*

**Table 1. Generalized interpretation of light-color effects in light-assisted fisheries.**

| Color group | Approx. spectral region | Optical/physiological rationale | Reported fisheries relevance | Important limitation |
|---|---|---|---|---|
| Blue / cyan | ~450–510 nm | Often strong penetration in clear seawater; overlaps visual sensitivity of many pelagic fishes and cephalopods | Strong attraction or retention reported for anchovy, rockfish, rock bream, lumpfish and squid-related applications | Can be less effective than green in turbid/coastal settings; performance changes with irradiance and depth |
| Green | ~500–560 nm | Good underwater propagation in many coastal waters; frequently near rhodopsin/cone sensitivity maxima | High aggregation and catch in recent fixed lift-net trials; strong performance in pots and trammel nets | Not universally best; may act indirectly through prey attraction; spectral peak and intensity matter |
| White | Broad spectrum | Contains multiple wavelengths, often including a strong blue component; high visual contrast | Rapid anchovy response; strong snow-crab and cod-pot responses at appropriate intensity | Broadband output makes "color" difficult to separate from intensity; may increase energy demand |
| Yellow / orange | ~570–620 nm | Moderate to rapid attenuation depending on water type | Can attract some coastal assemblages; orange Petromax treatment produced similar bait-fish catch to green in Ambon | Generally weaker propagation than blue/green and strongly dependent on water optics |

| Color group | Approx. spectral region | Optical/physiological rationale | Reported fisheries relevance | Important limitation |
|---|---|---|---|---|
| Red | >620 nm | Rapid attenuation in seawater; localized stimulus | Useful for some species or mixed-species trammel-net catches; may calm or alter behavior near a light source | Often weak for species adapted to blue-green light; poor long-distance attraction |
| Purple / UV | <450 nm / UV | Short-wavelength visual cue with species-specific sensitivity | Purple improved snow-crab catch in some pot trials; UV/green illumination can reduce protected-species bycatch | Potential non-target and ecological effects; not a universal target-fish attractor |

*Note: Spectral ranges are approximate and overlap between commercial LED products. The effective underwater spectrum should be measured rather than inferred from nominal lamp color.*

### *3.3 Evidence from Indonesian anchovy and lift-net fisheries*

Anchovy provides one of the clearest examples of why different response variables can lead to different recommendations. Susanto et al. (2017) compared anchovy response and retinal adaptation to LEDs and found that fish responded 3.4 times faster to white light than to blue light, yet stayed 1.8 times longer in the blue-light area. White illumination between 42 and 96 lux produced a high cone adaptation index and was interpreted as effective for attracting anchovy. In contrast, field trials by Amos et al. (2019) on boat lift nets in Tateli Weru reported a highly significant catch advantage for blue underwater LEDs over green and combined green-blue treatments. The two results are not contradictory: one study emphasized response and retinal adaptation under controlled observation, while the other measured actual field catch under a specific lift-net operation.

Baswantara et al. (2020) further demonstrated that mixed-color treatments can change aggregation dynamics. A blue-red combination attracted fish somewhat more slowly than a white-red combination but maintained fish beneath the light for longer; the blue-red combination also produced a higher catch, although the difference was not statistically significant. Such results indicate that temporal behavior arrival, stabilization, retention, and vertical positioning can be as important as the initial attraction response.

At Pangkep, Saragih et al. (2021) compared fixed lift-net catches under white-yellow-blue and white-yellow LED combinations. Total catches were similar in magnitude, but the treatment containing blue light produced 359.8 kg compared with 343.8 kg under the white-yellow combination and affected the composition of main catch, bycatch, and discarded catch. The relatively small difference reinforces the idea that adding another color does not automatically generate a large increase in catch; the effect may be expressed instead through species composition or school behavior.

### *3.4 RGB and sequential-color observations around purse-seine operations*

Sequential or programmable RGB systems offer an alternative to a single fixed color. Turnip et al. (2022) used an underwater RGB LED system in Manado Bay and observed that fish approached blue light most rapidly, followed by green. Fish required approximately 10–30 minutes to adjust and remain around the light, while red illumination was associated with a larger and calmer aggregation later in the sequence. The catch included scad, trevally, tuna-like pelagic fishes, moonfish, and squid. Because colors were used within a sequential operational context, the study is particularly useful for showing that different colors may serve different behavioral functions rapid attraction, concentration, or stabilization rather than competing as mutually exclusive choices.

This concept could be valuable in purse-seine operations. A fishing strategy may use a high-penetration blue or green phase to attract fish from a larger volume of water, followed by a lower-penetration or different spectral phase to concentrate fish closer to the vessel before setting or hauling. However, such a sequence should be experimentally tested because the response will vary with species composition, school size, background light, lunar phase, and the spatial geometry of lamps.

### *3.5 Recent fixed lift-net evidence: interaction between color and intensity*

A recent field experiment in Pasuruan provides one of the most quantitatively detailed demonstrations of color effects in Indonesian fixed lift-net fishing. Fuad et al. (2025) tested blue, green, yellow, and white LEDs against a Petromax control during 25 trials and monitored fish distribution with an echosounder. Green LEDs produced the highest mean shoal proportion (75.7 ± 6.3%) and the highest mean catch (28.52 ± 2.41 kg per trip), followed by blue, yellow, white, and the Petromax control. The relationship between underwater intensity and shoal proportion was nonlinear, with stable aggregation occurring within an intermediate irradiance range rather than at the highest possible brightness.

This is a central lesson for fishing-light research: color and intensity cannot be treated as independent labels. Increasing lamp power changes the volume of illuminated water and may move fish vertically or horizontally. Excessive irradiance can also produce avoidance, visual saturation, or a broad diffuse aggregation that is difficult to capture. A meaningful comparison therefore requires either equivalent photon/irradiance exposure among colors or explicit measurement of the underwater light field.

### *3.6 International evidence from passive gears*

Passive gears provide strong evidence that small light sources can change catch probability even without creating a large surface-light field. Nguyen et al. (2017) found that snow crab behavior in laboratory choice tests depended on color and that white and purple LEDs significantly increased field CPUE in baited traps by 77% and 47%, respectively. A subsequent Barents Sea study reported a more modest but significant 12.8% increase for legal-sized snow crab with purple LEDs, while white light did not significantly improve catch (Nguyen et al., 2019). Later experiments using green and white LEDs found increases of up to 76% for green light and approximately 52–53% for white light in commercial snow-crab pots (Cerbule et al., 2021). The variation among these trials shows that even within the same broad target taxon, local abundance, depth, season, lamp intensity, pot geometry, and population behavior can modify the apparent effect of color.

For finfish, Kim et al. (2022) tested colored LEDs in pots targeting bluefin sea robin in Korean waters. Green light produced the largest catch (273 individuals), followed by blue and white, whereas red and unilluminated control pots caught very few fish. In the Yellow Sea, Yu et al. (2022) attached blue, green, red, and white LEDs to trammel nets. Effects were strongly species-specific: green LEDs increased CPUE for several fish and crustacean species by roughly 40–72%, while red LEDs produced large increases for some species but reduced catches of others. The same treatment could therefore improve one commercial component while decreasing another.

An important implication is that fishing-light optimization must be linked to the intended catch portfolio. In a mixed-species small-scale fishery, the 'best' color may be the color that maximizes value per unit effort, not total biomass. Yu et al. (2022) explicitly incorporated economic performance and found that optimal colors varied by fishing area. This approach is more practical than a simple ranking of kilograms caught because it incorporates species value and fishery objectives.

### *3.7 Direct and indirect attraction: the prey-mediated mechanism*

Artificial light can increase catch without directly attracting the target fish. Utne-Palm et al. (2018) found that northern krill responded strongly to green (530 nm) and broadband white light, whereas cod did not show a significant positive direct response to the same stimuli. Field experiments by Humborstad et al. (2018) then showed that intensely illuminated baited pots produced cod catch rates up to 17 times greater than control pots. The authors linked this effect to active krill accumulating around the light and acting as live bait. This mechanism is important because studies that measure only fish abundance or final catch may incorrectly attribute the response to direct phototaxis.

Trophic mediation is likely relevant to tropical light fisheries as well. Small zooplankton and forage fishes may arrive first, followed by larger predatory fishes. Acoustic time-series, underwater video, and species-specific arrival data are therefore useful for distinguishing primary attraction from predator-prey succession. Such information can also inform the optimal waiting period before a purse seine or lift net is deployed.

### *3.8 Color as a selectivity tool rather than only an attractor*

The expanding use of LEDs in fishing technology has shifted attention from increasing catch toward improving selectivity. Ortiz et al. (2016) showed that illuminated gillnets could reduce green turtle bycatch while maintaining target catch, and Virgili et al. (2018) found that ultraviolet illumination prevented turtle catches in a Mediterranean set-net experiment without significantly altering target catch rates. In Indonesia, green LED illumination of coastal gillnets reduced total sea-turtle bycatch by about 61% and green-turtle bycatch by about 60% while total and target fish CPUE remained similar; the market value of catch was not reduced (Gautama et al., 2022).

These results demonstrate that a light stimulus does not need to attract fish to be useful. If target fish tolerate or approach an illuminated net while non-target megafauna detect and avoid it, color becomes a behavioral selectivity device. Conversely, some light colors may increase unwanted catches, as shown by species-specific trammel-net responses. Future studies should therefore report bycatch composition and retained catch value alongside total catch.

### *3.9 Light color in squid and cephalopod-related fisheries*

Cephalopod fisheries have historically been among the most light-intensive fisheries, making spectral efficiency especially important. Physiological work on Japanese flying squid indicates stronger retinal responses to blue, green, and white wavelengths than to red (Matsui et al., 2016). Although conventional squid-jigging fleets have often relied on high-powered broadband metal-halide lamps, LED technology enables spectral targeting with much lower power demand. Recent Indonesian work in Wangi-Wangi tested blue and green mini-LED aids for squid fishing and reported a significant treatment effect, with blue accounting for approximately 35% of the observed catch, slightly above the mixed-color control and green treatment (Hadi et al., 2025).

Lamp geometry also matters in pelagic light fisheries. Li et al. (2025) modeled and evaluated LED fishing-lamp configurations for Pacific saury fisheries and showed that installation angle and device configuration change the underwater illumination field. Thus, two vessels using nominally the same color and electrical power may expose fish to very different irradiance patterns. Spectral recommendations should therefore be paired with lamp orientation, height, submergence, spacing, and vessel geometry.

### *3.10 Behavioral evidence beyond direct commercial fishing*

Behavioral experiments outside conventional capture fisheries can help explain field observations. Foss et al. (2020), for example, tested colored light as an attractant for recapturing juvenile lumpfish from aquaculture systems. Blue LED light produced the highest laboratory recapture, with nearly three-quarters of fish entering the trap, whereas red and yellow lights performed poorly. However, the response did not translate successfully to commercial sea cages. This laboratory-to-field discrepancy is highly relevant to fishing-light research: spectral preference observed under controlled conditions may weaken when natural backgrounds, currents, prey fields, social behavior, and larger spatial scales are introduced.

Likewise, Tomiyasu et al. (2022) conducted in situ observations of white-edged rockfish attraction to LEDs and found substantially more fish under blue light than green or red light. The study supports blue-green sensitivity but also emphasizes that the magnitude of attraction can be species-specific. Together with anchovy and rock-bream experiments, these findings justify measuring the target species' behavior rather than transferring recommendations directly between fisheries.

***3.11 Synthesis of representative studies***

**Table 2. Representative recent evidence on artificial light color and capture-related responses.**

| Study | Target | Gear/context | Color treatment | Key result |
|---|---|---|---|---|
| Susanto et al. (2017) | Anchovy (Stolephorus sp.) | Laboratory/behavioral; fishing-light relevance | White vs blue LED | White induced faster response; blue retained fish longer; white 42–96 lux produced strong retinal adaptation |
| Nguyen et al. (2017) | Snow crab | Baited traps | Blue, white, purple, green, red | White and purple increased field CPUE; laboratory movement differed among colors |

| Study | Target | Gear/context | Color treatment | Key result |
|---|---|---|---|---|
| Utne-Palm et al. (2018) | Krill and Atlantic cod | Laboratory | Green, white and other wavelengths | Green/white strongly attracted krill; cod response weak, supporting indirect attraction |
| Humborstad et al. (2018) | Atlantic cod | Baited pots | White and green at different intensities | High-intensity illuminated pots yielded much higher cod catch, likely via krill attraction |
| Amos et al. (2019) | Anchovy (S. commersonii) | Boat lift net | Blue, green, green-blue underwater LED | Blue produced significantly higher anchovy catch |
| Jang et al. (2019) | Rock bream | Laboratory physiology/behavior | Violet, blue, cyan, green, amber, red | Strongest response near cyan, followed by green/blue; weakest toward red |
| Baswantara et al. (2020) | Mixed lift-net fish | Lift net | Blue-red vs white-red | Blue-red retained fish longer and produced higher, but not significantly different, catch |
| Polhaupessy et al. (2020) | Small pelagic bait fish | Beach seine + Petromax | Green vs orange | Catch differences were not statistically significant; orange had more individuals |

| Study | Target | Gear/context | Color treatment | Key result |
|---|---|---|---|---|
| Saragih et al. (2021) | Mixed coastal assemblage | Fixed lift net | White-yellow-blue vs white-yellow | Similar total catches; blue-containing combination slightly higher and altered composition |
| Cerbule et al. (2021) | Snow crab | Commercial pots | Green, white, control | Green increased catch efficiency up to 76%; white also improved catch |
| Turnip et al. (2022) | Pelagic fish assemblage | Underwater RGB / purse-seine context | Blue, green, red sequence | Blue attracted fish fastest; green followed; red associated with calmer aggregation |
| Kim et al. (2022) | Bluefin sea robin | Pot fishery | Green, blue, white, red, control | Green produced highest catch, followed by blue and white |
| Yu et al. (2022) | Seven commercial species | Trammel net | Blue, green, red, white, control | Effects species-specific; green/red often increased CPUE and economic return |
| Gautama et al. (2022) | Target fish + sea turtles | Coastal gillnet | Green net illumination | Maintained target catch while reducing sea-turtle bycatch by ~60% |

| Study | Target | Gear/context | Color treatment | Key result |
|---|---|---|---|---|
| Hadi et al. (2025) | Squid | Handline/squid fishing aid | Blue, green, mixed control | Blue treatment slightly highest; treatment effect statistically significant |
| Fuad et al. (2025) | Mixed pelagic fish | Fixed lift net | Blue, green, yellow, white, Petromax | Green produced highest shoal proportion and mean catch; intensity showed nonlinear optimum |

### *3.12 Why published results differ*

The literature does not produce a stable universal ranking such as green > blue > white > red. At least seven factors explain this heterogeneity. First, species possess different visual pigments and ecological histories. Second, the same color can be delivered at very different photon fluxes, creating an intensity rather than a wavelength effect. Third, water optical properties alter the effective spectrum and illuminated volume. Fourth, lamp placement above or below the surface changes reflection, refraction, and underwater irradiance. Fifth, gear design determines where fish must aggregate to be captured. Sixth, moon phase, background light, turbidity, current, prey density, and season modify behavioral responses. Seventh, studies measure different endpoints first arrival, number of fish under a lamp, retention time, total biomass, CPUE, value, or bycatch and these outcomes need not rank colors identically.

The snow-crab literature illustrates this clearly: white light performed strongly in one region, purple produced a modest benefit in another trial, and green later generated the largest improvement under a different field experiment (Nguyen et al., 2017, 2019; Cerbule et al., 2021). Indonesian anchovy studies likewise indicate faster response to white light but greater field catch or retention under blue light (Susanto et al., 2017;

Amos et al., 2019). These variations should be interpreted as evidence of context dependence rather than experimental inconsistency.

### *3.13 Methodological standards for future light-color experiments*

**Table 3. Recommended reporting and experimental standards for light-color fisheries research.**

| Component | Recommended practice | Scientific rationale |
|---|---|---|
| Lamp specification | Report peak wavelength, spectral bandwidth, electrical power, irradiance/illuminance, beam angle, number of lamps, and whether lamps are submerged or above water | "Blue LED" alone is not reproducible; commercial lamps differ strongly in spectrum and output |
| Underwater light field | Measure irradiance at multiple depths/distances and record turbidity or water clarity | Fish respond to received light, not nominal lamp wattage |
| Experimental design | Randomize treatment order; use sufficient independent trips/sets; avoid confounding color with vessel, location, or day | Reduces pseudo-replication and weather/abundance bias |
| Environmental covariates | Record moon phase, cloud cover, depth, current, temperature, salinity, water transparency, and time of night | These variables can alter background light and fish availability |
| Behavioral observation | Use echosounder, sonar, underwater video, or fish finder where possible | Separates attraction, vertical distribution, retention, and actual capture |
| Catch metrics | Report number, biomass, CPUE, species composition, length distribution, target/bycatch ratio, and value per unit effort | Total catch alone can hide selectivity or economic trade-offs |
| Energy performance | Report energy use per trip or per kg catch when comparing LED with conventional lighting | Efficiency gains are important to operational sustainability |

| Component | Recommended practice | Scientific rationale |
|---|---|---|
| Statistical analysis | Use treatment replication and models suitable for count/biomass data; include random effects for trip/site where appropriate | Improves inference beyond descriptive differences |
| Transparency | Provide lamp specifications, raw summary data, and analytical code or calculation procedures | Supports replication and comparison across fisheries |

### *3.14 Implications for Indonesian purse-seine and lift-net fisheries*

For Indonesian pelagic fisheries, the present evidence supports testing blue and green as primary candidate wavelengths, but not adopting either color as a universal standard. Blue may be advantageous for long-range attraction and anchovy retention in some lift-net settings, while green may provide strong and stable aggregation under coastal fixed lift-net conditions. White light remains relevant when rapid attraction or broad species coverage is desired. A practical experimental design for purse seines would compare blue, green, and white lights at controlled underwater irradiance, use identical lamp geometry and total electrical power, and record school formation with acoustic instruments before each set.

For student or small-scale field experiments, three response layers should be separated: (1) fish arrival time after lighting; (2) aggregation density and vertical distribution; and (3) final catch biomass and composition. This separation allows the researcher to determine whether a color attracts fish quickly but fails to retain them, or retains a dense school that produces a higher catch. If the aim is to compare white, green, and blue lamps, the number of settings should be balanced across colors and fishing nights, and treatment order should be rotated to reduce effects of lunar phase and daily fish abundance.

Environmental and operational sustainability should also be included. LEDs can reduce energy demand compared with high-power conventional lamps, but brighter or more numerous LEDs can offset this advantage. Catch efficiency should therefore be interpreted together with energy consumed per fishing operation, catch value, and changes in bycatch. This combined approach is consistent with the current transition from simple fishing-power maximization toward selective and lower-impact fishing technology.

### *3.15 Research gaps*

Several important gaps remain. First, many studies report lamp color without spectroradiometric verification, making cross-study comparison difficult. Second, field experiments often have few independent nights or sets, which limits statistical power. Third, tropical multi-species fisheries are underrepresented compared with single-target pot fisheries. Fourth, behavioral observations are frequently absent, so it remains unclear whether color changes attraction distance, residence time, vertical distribution, or vulnerability to gear. Fifth, the ecological footprint of intense or persistent artificial light particularly effects on non-target species, predator-prey interactions, and nocturnal behavior requires greater attention.

Future studies should combine controlled spectral experiments with field-scale operational trials. Portable spectrometers, echosounders, low-light cameras, programmable RGB LEDs, and low-cost environmental sensors make this increasingly feasible. A valuable research direction for Indonesia is the development of species- and gear-specific spectral response curves that link underwater irradiance to arrival time, school density, CPUE, and energy consumption. Such evidence would allow fishing-light recommendations to be based on measurable performance rather than customary lamp preferences.

## 4. Conclusion

Artificial light color can substantially influence fish behavior, aggregation, catch efficiency, species composition, and fishing selectivity, but the effect is not governed by a single universally superior color. Blue, cyan, and green wavelengths frequently perform well because they propagate effectively through marine water and overlap with the visual sensitivity of many fishes and cephalopods. Nevertheless, white, red, yellow, purple, or combined spectra can be more effective in particular species, gears, or environmental settings. Indonesian evidence illustrates this context dependence: anchovy may respond rapidly to white light but remain longer or be caught more effectively under blue light, mixed-color lift-net treatments alter retention and species composition, and recent fixed lift-net trials show strong aggregation and catch under green LEDs. International evidence from trammel nets and pots likewise demonstrates species-specific responses and indirect prey-mediated attraction. Therefore, fishing-light optimization should integrate wavelength with irradiance, exposure duration, lamp depth and geometry, water optical properties, moon phase, target behavior, and gear design. Future studies should use replicated field trials, measure the underwater light field, verify aggregation acoustically or visually, standardize CPUE and bycatch reporting, and evaluate energy use. Applied in this way, spectral control with LED technology can support more efficient, selective, and potentially lower-impact marine fisheries.

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## Conflict of Interest

The author declares no conflict of interest.

## References

Amos, C. T., Pamikiran, R. D. C., Kalangi, P. N. I., & Kumajas, H. J. (2019). Pengaruh warna lampu light emitting diode dalam air terhadap hasil tangkapan ikan teri (Stolephorus commersonii) dengan bagan. Jurnal Ilmu dan Teknologi Perikanan Tangkap, 4(2), 45–51. https://doi.org/10.35800/jitpt.4.2.2019.24225

Baswantara, A., Firdaus, A. N., Astiyani, W. P., Jaya, I., & Yusfiandayani, R. (2020). Respon ikan dan hasil tangkapan berdasarkan perbedaan kombinasi warna cahaya LED sebagai atraktor. Jurnal Penelitian Perikanan Indonesia, 26(3), 181–188. https://doi.org/10.15578/jppi.26.3.2020.181-188

Berlianmastan, A. M., Aponno, A. J., Arundaa, R., Ali, I. U. I. S., & Patty, W. (2019). Automatic underwater LED light and fish behavior observations. Jurnal Ilmiah PLATAX, 7(2), 437–443. https://doi.org/10.35800/jip.7.2.2019.24897

Cerbule, K., Herrmann, B., Grimaldo, E., Grimsmo, L., & Vollstad, J. (2021). The effect of white and green LED-lights on the catch efficiency of the Barents Sea snow crab

(Chionoecetes opilio) pot fishery. PLOS ONE, 16(10), e0258272. https://doi.org/10.1371/journal.pone.0258272

Foss, A., Imsland, A. K. D., Roth, B., & Nytrø, A. V. (2020). Catch me if you can: How to recapture lumpfish using light as an attractant. Aquacultural Engineering, 90, 102074. https://doi.org/10.1016/j.aquaeng.2020.102074

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. https://doi.org/10.18280/ijdne.200912

Gautama, D. A., Susanto, H., Riyanto, M., Wahju, R. I., Osmond, M., & Wang, J. H. (2022). Reducing sea turtle bycatch with net illumination in an Indonesian small-scale coastal gillnet fishery. Frontiers in Marine Science, 9, 1036158. https://doi.org/10.3389/fmars.2022.1036158

Hadi, A. P., Jabbar, M. A., & Yusrizal. (2025). Effect of using polyethylene teraplahate as squid fishing aids in Wangi-Wangi waters, Southeast Sulawesi. ALBACORE Jurnal Penelitian Perikanan Laut, 9(1), 51–62. https://doi.org/10.29244/core.9.1.051-062

Hasly, I. R. J., Yusfiandayani, R., & Mawardi, W. (2019). Respons rajungan (Portunus pelagicus) terhadap warna cahaya yang berbeda pada uji laboratorium. Jurnal Penelitian Perikanan Indonesia, 25(4), 215–224. https://doi.org/10.15578/jppi.25.4.2019.215-224

Humborstad, O.-B., Utne-Palm, A. C., Breen, M., & Løkkeborg, S. (2018). 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

Jang, J.-C., Noh, G. E., Kim, Y.-R., Yu, Y.-M., & Kim, J.-M. (2019). Spectral sensitivity and photoresponse in the rock bream Oplegnathus fasciatus and their relationships with the absorption maximum of the photoreceptor. Fish Physiology and Biochemistry, 45(5), 1759–1769. https://doi.org/10.1007/s10695-019-00672-z

Kim, P., Kim, H., & Kim, S. (2022). Application of light-emitting diode lights to bluefin sea robin (Chelidonichthys spinosus) catch in pot fishery in the South Sea, Korea. Applied Sciences, 12(9), 4149. https://doi.org/10.3390/app12094149

Li, F., Hua, C., & Zhu, Q. (2025). Evaluating the illumination performance of LED fishing lamps with different configurations in Pacific saury fishery. PLOS ONE, 20(8), e0328676. https://doi.org/10.1371/journal.pone.0328676

Lomeli, M. J. M., Groth, S. D., Blume, M. T. O., Herrmann, B., & Wakefield, W. W. (2018). Effects on the bycatch of eulachon and juvenile groundfish by altering the level of artificial illumination along an ocean shrimp trawl fishing line. ICES Journal of Marine Science, 75(6), 2224–2234. https://doi.org/10.1093/icesjms/fsy105

Matsui, H., Takayama, G., & Sakurai, Y. (2016). Physiological response of the eye to different colored light-emitting diodes in Japanese flying squid Todarodes pacificus. Fisheries Science, 82(2), 303–309. https://doi.org/10.1007/s12562-015-0965-5

Melli, V., Krag, L. A., Herrmann, B., & Karlsen, J. D. (2018). Investigating fish behavioural responses to LED lights in trawls and potential applications for bycatch reduction in the Nephrops-directed fishery. ICES Journal of Marine Science, 75(5), 1682–1692. https://doi.org/10.1093/icesjms/fsy048

Nguyen, K. Q., & Winger, P. D. (2019). Artificial light in commercial industrialized fishing applications: A review. Reviews in Fisheries Science & Aquaculture, 27(1), 106–126. https://doi.org/10.1080/23308249.2018.1496065

Nguyen, K. Q., Humborstad, O.-B., Løkkeborg, S., Winger, P. D., & Bayse, S. M. (2019). Effect of light-emitting diodes (LEDs) on snow crab catch rates in the Barents Sea pot fishery. ICES Journal of Marine Science, 76(6), 1893–1901. https://doi.org/10.1093/icesjms/fsz062

Nguyen, K. Q., Winger, P. D., Morris, C., & Grant, S. M. (2017). Artificial lights improve the catchability of snow crab (Chionoecetes opilio) traps. Aquaculture and Fisheries, 2(3), 124–133. https://doi.org/10.1016/j.aaf.2017.05.001

Ortiz, N., Mangel, J. C., Wang, J., Alfaro-Shigueto, J., Pingo, S., Jimenez, A., Suarez, T., Swimmer, Y., Carvalho, F., & Godley, B. J. (2016). Reducing green turtle bycatch in small-scale fisheries using illuminated gillnets: The cost of saving a sea turtle. Marine Ecology Progress Series, 545, 251–259. https://doi.org/10.3354/meps11610

Polhaupessy, R., La Nuhu, H., & Syamsuddin, M. (2020). Pengaruh perbedaan warna cahaya lampu petromaks terhadap hasil tangkapan ikan umpan dengan alat tangkap pukat pantai (beach seine) di Teluk Ambon Bagian Dalam. Jurnal Perikanan Tropis, 7(2), 175–184. https://doi.org/10.35308/jpt.v7i2.2485

Saragih, P., Kurnia, M., & Amir, F. (2021). Catch composition of fix-liftnet based-on the light color combination in Pangkep waters. Torani Journal of Fisheries and Marine Science, 4(2), 100–109. https://doi.org/10.35911/torani.v4i2.14106

Susanto, A., Fitri, A. D. P., Putra, Y., Susanto, H., & Alawiyah, T. (2017). 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

Tomiyasu, M., Tanouchi, Y., Fujimori, Y., Kaji, M., Hayashi, T., Matsubara, N., Yasuma, H., Shimizu, S., & Katakura, S. (2022). In situ observations of fish attraction to light-emitting diodes on an undersea observation deck. Journal of Marine Science and Technology–Taiwan, 30(2), Article 7. https://doi.org/10.51400/2709-6998.2574

Turnip, L. I., Patty, W., Kalangi, P., & Pangalila, F. (2022). Pengamatan ketertarikan ikan pada lampu LED RGB bawah air di Perairan Teluk Manado. Journal of Capture Fisheries Science and Technology, 7(1), 15–21. https://doi.org/10.35800/jitpt.v7i1.36873

Utne-Palm, A. C., Breen, M., Løkkeborg, S., & Humborstad, O.-B. (2018). Behavioural responses of krill and cod to artificial light in laboratory experiments. PLOS ONE, 13(1), e0190918. https://doi.org/10.1371/journal.pone.0190918

Virgili, M., Vasapollo, C., & Lucchetti, A. (2018). Can ultraviolet illumination reduce sea turtle bycatch in Mediterranean set net fisheries? Fisheries Research, 199, 1–7. https://doi.org/10.1016/j.fishres.2017.11.012

Yu, M., Liu, C., Zhang, L., & Tang, Y. (2022). Application of light-emitting diodes (LEDs) fishing lights to improve catch rates of small-scale trammel net fishery in the Yellow Sea, China. Frontiers in Marine Science, 9, 1036979. https://doi.org/10.3389/fmars.2022.1036979