

Assessment of the environmental friendliness of accordion-shaped shrimp traps (Bubu Naga) in Tambak Lorok waters, Semarang City

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Abstract. The accordion-shaped shrimp trap, locally called Bubu Naga, is increasingly used by fishermen in Tambak Lorok to catch white shrimp (*Penaeus merguensis*). Although the trap yields high catches, its effect on marine resources and the environment must be examined. This study evaluated the environmental friendliness of Bubu Naga using nine criteria from the FAO Code of Conduct for Responsible Fisheries (CCRF). Data were collected during six fishing trips in November 2024 and analyzed with descriptive statistics. The total catch was 32.04 kg, of which 13.43 kg (42%) were target shrimp and 18.61 kg (58%) were bycatch. Because the by-catch proportion exceeded that of the target species, the gear does not meet the CCRF requirement for high selectivity. However, when all nine criteria were scored, Bubu Naga obtained a total score of 32 out of 36, placing it in the “very environmentally friendly” category. In summary, while the catch composition suggests limited environmental friendliness, the overall assessment indicates that Bubu Naga is highly acceptable from an ecological perspective. Managers should focus on improving species selectivity of the trap, so that its overall environmental performance can be fully realized.

Keywords: bycatch, catch composition, Code of Conduct for Responsible Fisheries, passive fishing gear, *Penaeus merguensis*.

Introduction. The accordion-shaped shrimp trap, locally called Bubu Naga, is a traditional fishing gear widely employed by Indonesian fishermen to capture fish, crabs, lobsters, shrimp, and other marine organisms. Bubu Naga are also known as dome traps and guiding barriers (Von Brandt, 1964; Gani et al., 2025). It is designed to attract marine animals so they enter and cannot escape. The use of traps as fishing gear has been known for a long time because they are environmentally friendly, selective regarding the type of catch, and cause minimal damage to underwater habitats such as coral reefs (Dirja & Sutarjo, 2019). Traps are generally made from natural materials like bamboo or rattan, although in modern times, some fishermen also use synthetic materials like wire or plastic netting (Meintzer et al., 2018; Todd et al., 2024). The simple yet effective design of traps uses bait inside to attract the target catch, which then gets trapped when trying to leave (Slack-Smith, 2001; Bergshoeff et al., 2018; Bacheler, 2024).

The waters of Tambak Lorok, located on the northern coast of Java Island in Tanjungmas Village, North Semarang District, Semarang City, are rich in marine resources (Nugroho et al., 2021). In this area, dome traps play a crucial role in supporting the coastal community's economy (Ramadhan et al., 2024; Kuncoro & Fitriani, 2025). Dome traps are generally used to catch shrimp, crabs, and various demersal fish with relatively high economic value (Putsa et al., 2016; Hapsari et al., 2020). The operating area for dome traps is in rocky areas at depths of 2-10 meters.

The Code of Conduct for Responsible Fisheries (CCRF) is a FAO guideline that promotes responsible fisheries practices. This guideline provides completeness for each country to ensure sustainable and long-term utilization of marine resources (Rofiqo et al., 2019; Rasal et al., 2025; Kurniawati et al., 2026). In this research we evaluated the environmental friendliness level of the Bubu Naga operated in Tambak Lorok waters based on catch composition and CCRF criteria. According to Firdaus et al. (2017), Yu et al. (2023),

and Qiao et al. (2026), using environmentally friendly fishing gear that complies with CCRF must adhere to nine criteria. The criteria for environmentally friendly fishing gear include high selectivity, not damaging fish habitats, not harming fishermen, producing high-quality fish, products that do not harm consumers, minimal catch results, the fishing gear used should have a minimum impact on biodiversity, not catching protected or endangered fish species, and being socially accepted by the community. This study therefore aimed to assess the environmental friendliness of the Bubu Naga (accordion-shaped trap) operated in Tambak Lorok waters, Semarang, with a focus on white shrimp (*Penaeus merguensis*) as the main target species, by evaluating its catch composition, catch-size suitability, and CCRF-based selectivity criteria.

Material and Method. This study was conducted from September to October 2025 in the waters of Tambak Lorok. A descriptive analysis method was employed, utilizing purposive sampling to determine the deployment sites for Bubu Naga. Purposive sampling was used to select locations with sandy or sandy-muddy substrates, which serve as fishing grounds for the target species, *P. merguensis*. Fishing operations using Bubu Naga in Tambak Lorok followed a one-day fishing pattern. Data collection also involved interviewing 31 Bubu Naga fishermen. Data analysis focused on the composition and weight of the catch obtained from each trap unit. A map of the study area is presented in Figure 1.

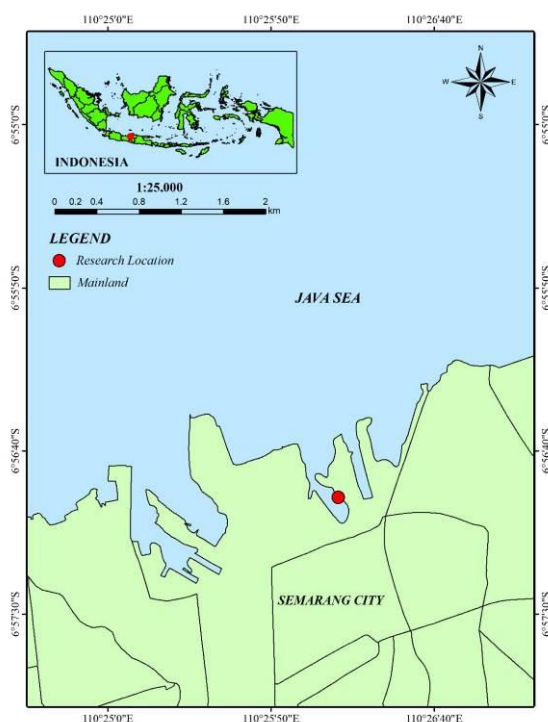


Figure 1. Map of Tambak Lorok, Semarang (study area).

Comparison of the main catch and bycatch composition. Data analysis covers catch composition and catch weight from each fishing trip: main catch and bycatch. To determine whether the fishing gear is sufficiently selective or not, the formula for comparing main catch and bycatch according to Dewanti et al. (2019) can be used as follows:

$$\text{Main catch (\%)} = \frac{\sum \text{main catch}}{\sum \text{total catch}} \times 100$$

$$\text{Bycatch (\%)} = \frac{\sum \text{bycatch}}{\sum \text{total catch}} \times 100$$

A fishing gear is classified as having a high level of selectivity if the weight of the target catch constitutes $\geq 60\%$ of the total catch weight.

Catch size suitability. The size suitability of the catch reflects the selectivity of the fishing gear. The main catch of the Bubu Naga is *P. merguensis* (Hadi et al., 2022). The carapace length of *P. merguensis* was recorded and compared with the length at first sexual maturity (Lm). The Lm for *P. merguensis* is 9 cm (Yuniarta et al., 2014). According to Boesono et al. (2017), the biological suitability of a catch obtained by specific fishing gear can be determined by measuring carapace length and comparing it with Lm. The measurement results of the catch will be grouped into two calculations as follows:

$$\text{Worth catching (percentage)} = \frac{\text{lenght} > \text{Lm}}{\text{Total main catch}} \times 100$$

$$\text{Not worth catching (percentage)} = \frac{\text{lenght} < \text{Lm}}{\text{Total main catch}} \times 100$$

CCRF assessment. The environmental friendliness of a fishing gear can be determined by calculating its score based on nine criteria for environmentally friendly fishing gear established by the Ministry of Marine Affairs and Fisheries in 2006, as outlined in the fisheries management guide module in Abdulaziz et al. (2018). The criteria for environmentally friendly fishing gear based on the CCRF, along with their descriptions and scores, are presented in Table 1.

Table 1

Criteria for environmentally friendly fishing gear

No.	Criteria	Description	Score
1.	High selectivity	The gear catches more than three species with significantly different sizes;	1
		The gear catches three species with significantly different sizes;	2
		The gear catches fewer than three species of similar sizes;	3
		The gear catches only one species of roughly the same size.	4
2.	Does not damage habitat	Causes habitat damage in a wide area;	1
		Causes habitat damage in a moderate area;	2
		Causes partial habitat damage in a narrow area;	3
		Safe for habitat (does not damage habitat).	4
3.	Does not endanger fishermen	Fishing gear and its use can cause fishermen's deaths;	1
		Fishing gear and its use can cause permanent (lasting) disabilities in fishermen;	2
		Fishing gear and its use can cause temporary health issues;	3
		Fishing gear that is safe for fishermen.	4
4.	Produces high-quality fish	Dead and rotten fish;	1
		Dead, fresh, and physically flawed fish;	2
		Dead but fresh fish;	3
		Live fish.	4
5.	Products do not harm consumers	Likely to cause death;	1
		Potential to cause consumer health issues;	2
		Small chance of causing consumer health issues;	3
		Safe for consumers.	4
6.	Low bycatch	Non-target catch consists of several species that are not marketable;	1
		Non-target catch consists of several species that are sold in the market;	2
		Non-target catch consists of fewer than three species and is sold in the market;	3
		Non-target catch consists of fewer than three species and has high market value.	4
7.	Low impact on biodiversity	Fishing gear and its operation cause death and habitat damage;	1
		Fishing gear and its operation cause the death of some species and habitat damage;	2
		Fishing gear and its operation cause the death of some species, but do not damage the habitat;	3
		Safe for living creatures and their habitats.	4

8.	Does not endanger protected fish	Legally protected fish are often caught with fishing gear;	1
		Legally protected fish have been caught several times by fishing gear;	2
		Legally protected fish have been caught by fishing gear;	3
		Legally protected fish will never be caught by fishing gear.	4
9.	Socially accepted	a. Low investment cost	
		b. Economically beneficial	
		c. Not contrary to local culture	
		d. Not contrary to applicable regulations	
		Fishing gear meets one of the four criteria above;	1
		Fishing gear meets two of the four criteria above;	2
		Fishing gear meets three of the four criteria above;	3
		Fishing gear meets all criteria above.	4

To determine the score obtained for a fishing gear based on interviews, the most appropriate weight must be determined for the fishing gear from the nine criteria. According to Pramesthy et al. (2020), the weighted criteria for environmental friendliness are obtained from the following formula:

$$\% X = \frac{\sum X + X_2 \dots X_n}{n}$$

$$= \frac{\sum X_n}{n}$$

where: % X = environmental friendliness value;
Xn = total weighted score;
n = number of respondents.

The weighting of fishing gear will produce a maximum score of 36. The weighted score indicates whether the fishing gear is environmentally friendly or not. According to Abdulaziz et al. (2018), the weighting categories are divided into four. The weighting criteria for fishing gear based on scores are presented in Table 2:

Table 2

Weighting criteria for environmentally friendly fishing gear

Score	Criteria
1-9	Not very environmentally friendly
10-18	Somewhat environmentally friendly
19-27	Environmentally friendly
28-36	Very environmentally friendly

Profile of the Bubu Naga. The Bubu Naga, based on PERMEN KP No. 36 Year 2023 with code 08.2.3, is a gear that falls into the passive trap category and is located at the seabed. The Bubu Naga is widely used by fishermen in Tambak Lorok, Semarang, starting with 2022. This is indicated by an increasing number of fishermen using this trap as a shrimp-catching tool. The Bubu Naga used in this research consists of a trap body (net cover) 8 meters long, a trap entrance door, a trap frame consisting of a body frame, and a trap bag. Generally, the total length of the Bubu Naga fishing gear is 12 meters. A diagram of the dragon trap can be seen in Figure 2.

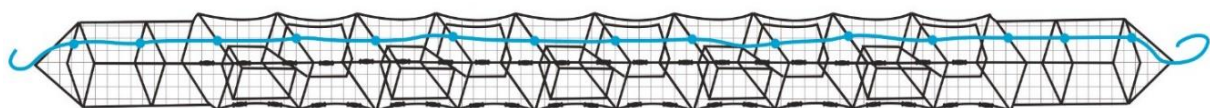


Figure 2. The shape of Bubu Naga.

Results

Fish catch analysis. The environmental friendliness criteria of fishing gear can be seen from the comparison between the main catch and bycatch results (Zucchetta et al., 2026). One of the environmentally friendly fishing gear criteria according to the CCRF is minimal

bycatch, which can be observed from non-target catch results consisting of fewer than three fish species that can be sold in the market. In addition, the environmental friendliness of fishing gear, seen from its good selectivity, can be determined by comparing the main catch length with L_m . Fish size larger than L_m can indicate that the fish in those waters have spawned at least once before being caught. The main target catch of the Bubu Naga operated in Tambak Lorok waters, Semarang, is white shrimp (*P. merguensis*) with bycatch consisting of crabs, lobsters, and fish species.

The main catch from the Bubu Naga had a total weight of 13.43 kg or 42%. The total bycatch weight from the Bubu Naga was 18.61 kg or 58% (Figure 3). This is due to the diversity of the Bubu Naga catch results. The diversity of catch types is caused because the fishing area is a river estuary that serves as a food source for shrimp, crabs, fish, and others. This is supported by the statement of Rupawan (2017) that estuaries are habitats, shelter, and food providers (feeding grounds) for several species of shrimp and fish. Based on the research comparing main catch 42% and Bubu Naga bycatch 58%, it can be said that the Bubu Naga operated in Tambak Lorok waters is not environmentally friendly based on its catch composition. According to Dewanti et al. (2019), the selectivity level of fishing gear is considered high if the percentage weight of the main catch is $\geq 60\%$ of the percentage weight of the bycatch, whether utilized or not. This is consistent with other studies showing that trap shape and design strongly influence catch composition and selectivity in similar passive gear (Dirja & Sutarjo, 2019).

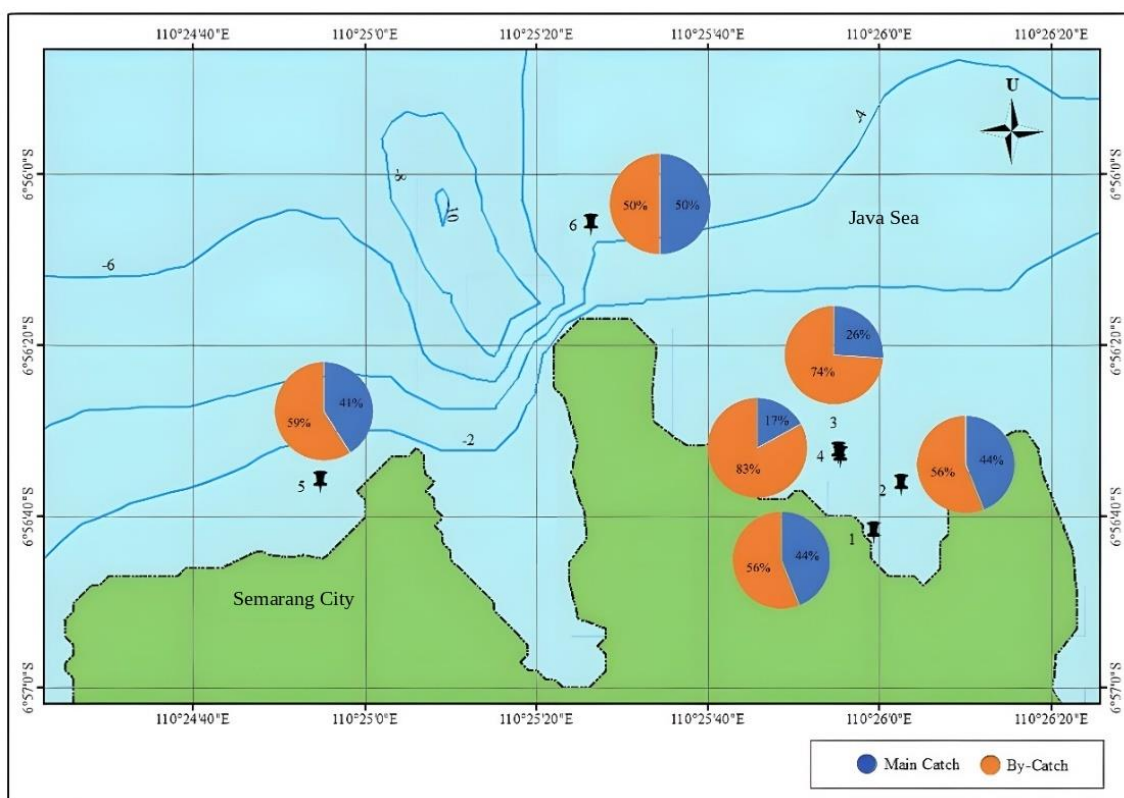


Figure 3. Map of fish catch points and percentage of main catch and bycatch.

Main-catch size suitability. The Bubu Naga captures a variety of species, but generally it catches the main target, which is shrimp. According to Yuniarta et al. (2014), the L_m of *P. merguensis* ranges from 9 to 20 cm consistent with reported spawning-size ranges for the species in other Indonesian waters (Pane & Ali, 2020). Based on the research conducted, the number of shrimp caught varied in size. The sizes ranged from 3 to 14 cm. Shrimp smaller than L_m numbered 1,616 individuals (68%) and weighed 5,574 kg. In contrast, the number that met the catch-size suitability criterion was 756 individuals (32%), with a total weight of 7,416 kg. These results suggest that the Bubu Naga is not sufficiently selective by catch-size suitability. The average first-catch size (L_c) of *P.*

merguiensis over six fishing trips was 6 cm. This indicates that the Bubu Naga used in Tambak Lorok waters is not environmentally friendly, based on catch-size suitability. When L_c is lower than L_m , most caught shrimp have not reached gonad maturity or spawned (Tang et al., 2019; Griselda et al., 2024). Because $L_c < L_m$, most of the shrimp caught in Tambak Lorok waters have likely not achieved gonad maturity.

Catch size suitability of bycatch. The bycatch from the Bubu Naga consisted of 13 species: nine finfish and four crab species, with a total of 390 individual bycatch. The sizes of the bycatch varied. The number of individuals with a body length (finfish) or carapace width (crustaceans) greater than L_m was 94 individuals (24%), whereas the number of individuals with a body length (finfish) or carapace width (crab) less than L_m was 296 individuals (76%). This indicates that various types of biota (finfish and crabs) are likely to be caught in the Bubu Naga; furthermore, body length measurements suggest that the captured organisms fall into the "undersized" category, meaning they are not of a size suitable for harvesting. This study was conducted in November 2025, and most finfish and crabs were below market size. The difference between sizes that meet versus did not meet the suitability threshold can be attributed to variations in research location, timing, and fishing season. Naimullah et al. (2022) and Xu et al. (2026) noted that seasonal, locational, and temporal factors influence whether bycatch meet catch-size suitability. These findings suggest that the Bubu Naga operated in Tambak Lorok waters may not be environmentally sustainable when evaluated by bycatch catch-size suitability.

Criterion for high selectivity. According to FAO (1995) in CCRF Article 8, Paragraph 5, countries must require that fishing gear, methods, and practices minimize non-target catch, waste, discarded fish, and impacts on related biota. The Bubu Naga traps operating in Tambak Lorok waters have a selectivity criterion with a weight of 1 and an average score of 1.39. In this criterion, the traps do not meet the requirement because they catch more than three species with significantly different sizes. Based on the research, the main target of the Bubu Naga traps is white shrimp (*P. merguensis*). However, these traps also capture more than three species. According to Khikmawati et al. (2015), Zhao et al. (2016), Putsa et al. (2016), Mahiswara et al. (2018), and Dewanti et al. (2023), selectivity refers to a gear's ability to reduce or eliminate unwanted catch of a certain size. Selectivity depends on the fishing principles used and design parameters such as mesh size, thread elasticity, material type and thread size, hanging ratio, speed, and duration of operation. Apprilliani et al. (2001) noted that bycatch reduces selectivity and is characteristic of multi-species fishing grounds. Full scoring results for all nine CCRF criteria are presented in Table 3.

Table 3

Results of scoring analysis for environmental friendliness level of fishing gear

No.	Criteria	Sub-criteria	Score
1.	High selectivity	The gear catches more than three species with significantly different sizes.	1.39
2.	Does not damage habitat	Safe for habitat (does not damage habitat).	4.00
3.	Does not endanger fishermen	Fishing gear that is safe for fishermen.	4.00
4.	Produces high-quality fish	Dead but fresh fish.	3.81
5.	Products do not harm consumers	Safe for consumers.	4.00
6.	Low bycatch	Non-target catch consists of several species that are sold in the market.	2.81
7.	Low impact on biodiversity	Safe for living creatures and their habitats.	4.00
8.	Does not endanger protected fish	Legally protected fish will never be caught by fishing gear.	4.00
9.	Socially accepted	Fishing gear meets all criteria above.	4.00
Total			32

Criterion for not damaging habitat. FAO (1995) in CCRF Article 8, Paragraph 4.2 states that fishing should prohibit dynamiting, poisoning and other comparable destructive fishing practices. The Bubu Naga traps scored an average of 4 points on the “not damaging habitat” indicator. They operate at depths of 1-4 m on a sandy-muddy seabed to prevent entanglement with coral. Partadisastra (2015) argued that environmentally friendly fishing practices can be assessed by operating methods, gear materials and construction, fishing areas, and fish resource availability while maintaining environmental sustainability. The CCRF assessment also considers the safety of gear users or fishermen. Banurea et al. (2024) emphasized that improving fishermen’s living standards involves increasing catch production through productive, efficient units suited to local conditions without harming fishery resource sustainability.

Criterion for not endangering fishermen. FAO (1995) in CCRF Article 6, Paragraph 17 requires gear used by fishermen to meet international safety standards. The Bubu Naga traps scored an average of 4 points on the “not endangering fishermen” indicator. They operate at depths of 1-4 m near shore with relatively calm waves, making them safe for fishermen. Firdaus et al. (2017) found that traps do not damage habitats or aquatic organism dwellings and are safe for users. The traps are passive gear deployed on the seabed. They operate in sandy-muddy substrates, posing no danger to fishermen.

Criterion for producing high-quality fish. FAO (1995) in CCRF Article 6, Paragraph 7 requires that capture, handling, processing, and distribution consider nutrition, quality, and safety. The indicator scored an average of 3.81 points. Shrimp caught are usually alive. However, fishermen sometimes kill the catch before selling it to middlemen, even when it remains fresh with minimal physical flaws. *P. merguensis* are typically sold dead, but are occasionally requested alive as bait. Firdaus et al. (2017), noted that fish caught in traps are of high quality and safe for consumption. The catches remain alive and fresh, with intact body parts, making them highly marketable (Kartiningtyas et al., 2018). The trap is designed to minimize physical damage to the catch, maintaining its resale value. Pramesthy et al. (2020) observed that fishing methods influence catch results, requiring alignment between methods, gear types, and target species.

Criterion for products not harming consumers. FAO (1995) in CCRF Article 11, Paragraph 1 requires policies ensuring consumers’ rights to safe, healthy, and non-expired fish. The indicator scored an average of 4 points. *P. merguensis* is the primary catch and does not harm consumers when consumed. While most shrimp are killed before sale, bycatch includes stingrays containing toxins. Sahubawa (2017) emphasized that post-capture handling plays a crucial role in maximizing value, as this stage determines market price, further processing, and product quality.

Criterion for low bycatch. FAO (1995) in CCRF Article 7, Paragraph 2 recommends developing selective, environmentally safe, low-cost gear to minimize discarded catch and non-target species. The indicator scored an average of 2.81 points. With a 12-hour soaking time (trips 1 and 2), the traps were relatively selective, catching only three bycatch species. Lower diversity was due to shallow operating depths (< 1.5 m) near shore. However, with a 24-hour soaking time (trips 3-6), the traps caught more than three species of varying sizes, indicating low selectivity. Dewanti et al. (2019) noted that gear selectivity depends on catch diversity and size range. High selectivity means catching fewer than three similarly sized species. The difference in bycatch diversity between 12- and 24-hour soaking times was influenced by water depth and fishing location.

Criterion for low impact on biodiversity. FAO (1995) in CCRF Article 6, Paragraph 6 requires safe gear and operating methods to protect aquatic biodiversity and ecosystems. The indicator scored an average of 4 points. Trips 1-2 (12-hour soaking) and trips 3-6 (24-hour soaking) were categorized as safe for biodiversity. The Bubu Naga passive traps do not cause species mortality when retrieved after operation, supporting biodiversity

safety. Melianti et al. (2023) confirmed that trap fishing is a one-day operation where gear is retrieved post-operation, ensuring biodiversity safety.

Criterion for not endangering protected fish. FAO (1995) in CCRF Article 7, Paragraph 2 states that aquatic habitats and endangered species must be preserved and protected. Fisheries should consider the sustainability of long-regenerating or declining species. The Bubu Naga traps scored an average of 4 points on this indicator. They have never caught protected species because their seabed operation with entrance sizes tailored to target catches minimizes non-target entanglement. Septiani et al. (2024) noted that Bubu Naga catches primarily consist of crustaceans, as the traps operate in river estuaries bordering seawater, which are habitats suitable for crustaceans.

Criterion for social acceptability. FAO (1995) in CCRF Article 6, Paragraph 15 requires countries to collaborate to prevent social conflicts among fishermen. Article 7, Paragraph 2 also states that cost-effective, highly selective gear should be prioritized for economic benefits. The indicator scored an average of 4 points (100%). Since 2022, fishermen in Tambak Lorok have considered these traps highly profitable due to low investment costs and significant earnings potential. They also align with local culture and comply with regulations. Sari et al. (2021) and Hadi et al. (2022) noted that while Bubu Naga traps are economically advantageous, their catch composition classifies them as less environmentally friendly.

Conclusions. The research found that the total main catch (main target) was white shrimp (*Penaeus merguensis*), accounting for 42% by weight, with bycatch (bycatch) comprising 13 species at 58%. Based on the main target and bycatch comparison, Bubu Naga traps are not environmentally friendly due to their catch composition. Only 32% of the main catch met suitable size criteria, while 68% did not. For bycatch, 24% met suitable size criteria, whereas 76% did not. The environmental friendliness score for Bubu Naga traps based on nine CCRF criteria was 32, indicating high environmental friendliness. However, there are certain criteria that do not yet meet eco-friendly standards, namely the level of selectivity and the amount of bycatch. The findings of this study can serve as a source of information for government policymakers involved in resource management, particularly concerning *P. merguensis*. Further assessment and evaluation of fishing gear modifications are required, focusing on effectiveness, fishing efficiency, and aquatic resource conservation.

Authors Contributions. Data collection: ADPF and SS; Research framework: ADPF, SS, and FK; Data analysis: DED; Writing: ADPF, SS, FK, and DED.

Conflict of Interest. The authors declare that there is no conflict of interest.

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