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Comparative analysis of fish pot designs and catch performance in a tropical small-scale fishery:

A case study from Banate Bay, Philippines

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Abstract

This study compares the design features, catch performance, and maintenance requirements of four fish pot types employed by small-scale fishers in Banate Bay, Central Philippines, and evaluates their implications for sustainable tropical fisheries. Data were gathered from 45 fishers through structured interviews, field measurements, and onboard observations conducted between October 2024 and February 2025. The study documented variations in materials, mesh sizes, shapes, bait types, and soak durations across designs. Catch per unit effort (CPUE) served as the primary metric for comparing efficiency. CPUE ranged from 5.5 kg/haul (Design B: cylindrical, 2.5 cm mesh) to 20.5 kg/haul (Design A: square prism, 4 cm mesh). *Nemipterus* spp. occurred in all designs, while species selectivity varied with mesh size and soak duration. Larger mesh designs (7 cm) selectively retained demersal species and minimized crustacean bycatch but required longer soaks. Maintenance intervals ranged from monthly (bamboo-framed) to every three months (plastic-screen). Results underscore how material durability, mesh size, and geometry jointly shape efficiency and selectivity. The findings offer evidence-based guidance for gear standardization—favouring 4cm mesh, 12–24h soak duration, and durable materials—to enhance productivity and ecological sustainability in small-scale tropical fisheries.

Keywords: Fish pot; CPUE; Small-scale fisheries; Banate Bay; Selectivity.

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1. Introduction

Small-scale fisheries underpin coastal livelihoods and food security throughout the tropics, particularly in archipelagic nations such as the Philippines. Under Republic Act 8550 (1998), as amended by RA 10654 (2015), small-scale or municipal fisheries encompass operations within 15 km of the shoreline using vessels of 3 GT or less. These fisheries typically employ passive gears—gillnets, hook-and-line, longlines, and fish pots—that reflect local innovation and resource constraints (Ferrer and Monteclaro, 2023). Among these, fish pots (bubo) have endured for centuries as ecologically efficient and culturally embedded gears (Zayas, 2022). Traditionally made of bamboo, modern designs increasingly incorporate synthetic materials such as polyethylene (PE) or wire mesh, improving durability while maintaining artisanal character (Muallil *et al*., 2014). Their selectivity, fuel efficiency, and low habitat impact make them compatible with the Ecosystem Approach to Fisheries Management (EAFM) (FAO, 2021; Rees *et al*., 2021; Abangan *et al*., 2024).

International studies demonstrate how design innovation enhances sustainability. For example, biodegradable escape panels mitigate ghost fishing (Jhohan *et al*., 2024), while experimental pots in Mediterranean fisheries improve Catch per unit effort (CPUE) and durability without ecological trade-offs (Virgili *et al*., 2024). However, despite widespread use in the Philippines, empirical comparisons of local fish pot designs remain scarce (Macario *et al*., 2022).

Previous local research, such as the study by Eleserio and Fernando (1990), titled "Comparative Catch Efficiency of Different Kinds of Fish Pots" in The Philippine Journal of Fisheries, focused mainly on comparing the catch efficiency of several traditional fish pot designs under uniform fishing conditions. Their work provided early insights into gear performance but was limited to assessing catch quantity and pot geometry. In contrast, the present study examines four distinct fish pot types operated across multiple municipalities within Banate Bay, incorporating variations in mesh size, shape, material, and soak duration. This broader comparative approach not only measures efficiency but also evaluates species selectivity, maintenance intervals, and ecological implications, providing updated knowledge relevant to sustainable small-scale tropical fisheries.

In Banate Bay, fish pot designs vary by municipality, reflecting local materials and preferences. Yet differences in catch efficiency, selectivity, and maintenance demands have not been quantitatively compared. This study therefore aims to: (1) evaluate the performance of four locally used fish pot designs through CPUE analysis; (2) examine how design attributes (mesh, material, shape, soak time) influence selectivity and maintenance; and (3) derive management insights applicable to tropical small-scale demersal fisheries beyond the local context.

By situating Banate Bay's fish pot diversity within broader tropical fisheries discourse, this study contributes to evidence-based gear management, supports Sustainable Development Goal (SDG) 14.4.1 on sustainable fisheries, and strengthens implementation of the Food and Agriculture Organization of the United Nations (FAO) Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries (SSF Guidelines).

2. Materials and methods

2.1. *Study area*

The study was conducted in Banate Bay (10°58′26″ N, 122°48′11″ E), North-eastern Iloilo Province, Philippines, bordered by Barotac Nuevo, Anilao, Banate, and Barotac Viejo (Figure 1). The semi-enclosed bay, linked to the Visayan Sea, features sandy – muddy substrates and coral – seagrass mosaics supporting diverse demersal assemblages. Fishing is predominantly small-scale, with fish pots, gillnets, and hook-and-line as principal gears.

The environmental characteristics of Banate Bay play a crucial role in determining fish pot performance. Its sandy–muddy bottom, mixed coral–seagrass habitats, and abundance of demersal species create favorable conditions for trap-based fishing. These habitat features influence both the species composition and the efficiency of different pot designs, particularly those targeting bottom-dwelling fish such as *Nemipterus spp.* and *Upeneus spp*. If the fishing ground were different—such as rocky or deeper areas—the effectiveness of each pot shape and mesh configuration might also vary. Hence, Banate Bay provides an ideal setting to evaluate how gear design interacts with local habitat and species behavior, offering insights applicable to other tropical demersal fisheries.

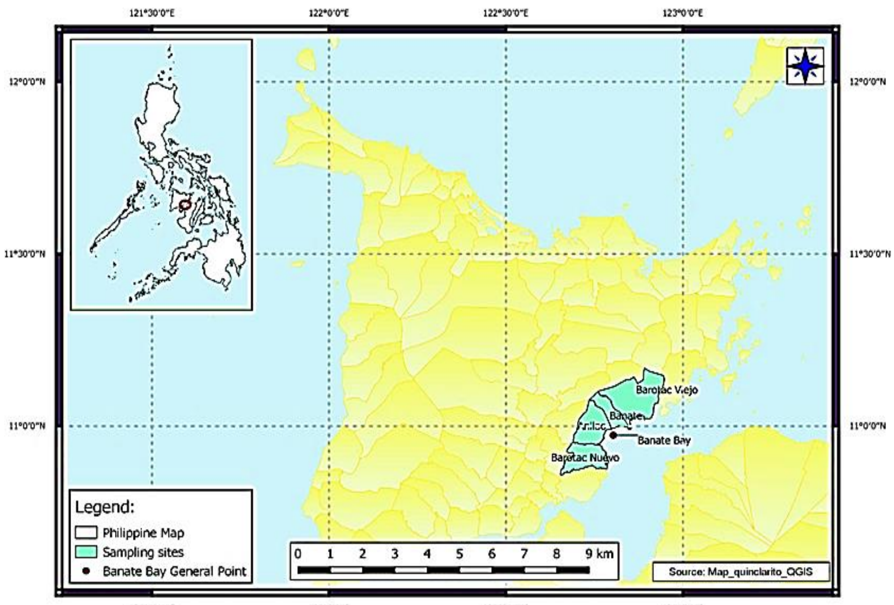

Figure 1. Geographic location of Banate Bay, Iloilo, Philippines, indicating the identified sampling sites within the municipalities of Barotac Viejo, Banate, and Barotac Nuevo. The inset map shows the position of Banate Bay within the Philippine archipelago (Clarito, 2025).

2.2. *Sampling Design*

A purposive sampling approach was used to capture fishers employing four distinct pot designs, as shown in Table 1. Selection criteria included: active operation of fish pots for more than 2 years, regular fishing within Banate Bay, and willingness to participate and share operational data. A total of 45 respondents across four municipalities were interviewed between October 2024 and February 2025. All participants provided informed consent, following ISUFST research ethics guidelines.

2.3. Data Collection

The comprehensive methods used in this study to gather detailed data on fishing practices, gear design, and catch composition are explored. The focus is on how various data collection techniques contribute to understanding fishing operations and their impacts.

(a) Structured Interviews – Collected data on fisher demographics, gear design, bait, soak time, depth, catch composition, and maintenance. Questionnaires were pre-tested and administered in the local dialect.

(b) Field Measurements – Each design was measured for dimensions (cm), mesh size (bar/stretched), number and weight of sinkers, and construction materials. Photos and schematic drawings were recorded.

(c) On-board Observations – Fishing trips were observed to document soak durations, deployment depth, number of units, and haul retrieval procedures.

(d) Catch Sampling – All catch from each haul (retrieval after soak period) was weighed (kg) and species identified using the fish species field guide (Motomura *et al*., 2017).

2.4. Data analysis

The Catch Per Unit Effort (CPUE) was used as an indicator of fishing efficiency and relative fish abundance. It represents the amount of fish caught—either by count or weight—per standardized unit of fishing effort. In this study, the unit of effort was based on one fishing haul or soak operation per fish pot design. CPUE is commonly expressed in various fisheries depending on gear type, such as the number of fish caught per 1,000 hooks for longlines or the weight of fish (in tons) caught per hour of trawling. In trap fisheries, it is typically expressed as kilograms of catch per haul (kg/haul). CPUE is frequently regarded as a proxy for fish biomass or abundance, assuming that higher CPUE values indicate higher stock availability or greater gear efficiency.

Catch per unit effort (CPUE), as shown in Equation (1), was computed as:

$$\text{CPUE}=\frac{\text{Total catch (kg)}}{\text{Number of hauls}} \tag{1}$$

Descriptive statistics summarized design characteristics and mean CPUE. One-way ANOVA tested CPUE differences among designs, followed by Tukey’s HSD ($\alpha = 0.05$). Qualitative analysis identified fisher innovations and perceived performance. In this paper, analyses were conducted using SPSS v21.

Table 1. Design specifications, bait type, soak duration, and fishing locations of four fish pot designs (A–D) operated by small-scale fishers in Banate Bay, Iloilo, Philippines.

	**Design A (Bubo)**: Made with Polyethylene (PE) net No. 10 and bamboo slats, square prism shape, with mesh size of 4 cm (stretched), dimensions 35 × 35 × 16 cm, soaked for 12 hours (4:00 PM to 4:00 AM). Baited with *Modiolus philippinarum* (brown mussels). **Location (Barangay and Municipality)** San Salvador, Banate San Carlos, Anilao Nueva Sevilla, Barotac Viejo
	**Design B (Kiming)**: Constructed from polyethylene plastic screen with a bamboo base frame, cylindrical in shape, 2.5 cm mesh size (bar length), circumference 150 cm (body), 130 cm (base), soaked for 10 hours. Baited with Sardinella spp. **Location (Barangay and Municipality)** San Salvador, Banate Natividad, Barotac Viejo
	**Design C (Bubo)**: Made from 100% polyethylene plastic screen, square prism shape, 1.5 cm mesh size (bar length), dimensions 37 × 37 × 19 cm, soaked for 24 hours. Baited with brown mussels. **Location (Barangay and Municipality)** Natividad, Barotac Viejo
	**Design D (Bubo)**: Constructed with PE net No. 7, rectangular prism (with stones as sinkers), dimensions 122 × 70 × 60 cm, soaked for one week. No bait used. **Location (Barangay and Municipality)** Lanas, Barotac Nuevo

3. Results

3.1. *Gear characteristics, maintenance, and catch composition*

The four fish pot designs varied in shape, materials, mesh size, and cost. Bamboo-framed nets required monthly maintenance, whereas PE plastic-screen pots lasted up to three months without repair. Across all designs, *Nemipterus* spp. dominated catches, as shown in Table 2. Larger mesh traps (Design D) selectively captured *Epinephelus* spp. and *Dasyatis* spp., while smaller meshes retained juveniles and crustaceans.

3.2. *Statistical comparison of CPUE among designs*

The mean catch per unit effort (CPUE) of the four fish pot designs is summarized in Table 3. Results showed that Designs A with 4.0 cm mesh, and D with 7.0 cm mesh obtained the highest mean CPUE values, 20.5 kg/haul and 20.2 kg/haul, respectively, while Design B with 2.5 cm mesh, recorded the lowest CPUE value of 5.5 kg/haul.

Table 2. Species composition by taxonomic group recorded from four fish pot designs in Banate Bay fishing ground.

Taxonomic Group	Species	Design A	Design B	Design C	Design D
Demersal Fish (bony & cartilaginous)	*Nemipterus* spp.	✓	✓	✓	✓
	Epinephelus spp.	–	–	–	✓
	Upeneus spp.	✓	–	–	–
	Pomadasys spp.	✓	–	–	–
	Plotosus spp.	✓	–	–	–
	Pelates quadrilineatus	–	–	✓	–
	Anguilla bicolor	✓	–	–	–
	Dasyatis spp.	–	–	–	✓
	Plectorhinchus sp.	–	–	–	✓
Crustacean	*Charybdis* spp.	✓	✓	✓	–
	Portunus spp.	✓	✓	✓	–
Cephalopod	*Octopus* sp.	✓	–	✓	–

Note: Presence (✓) and absence (–) of each taxon are indicated for Designs A–D.

Table 3. Mean catch per unit effort (CPUE) of four fish pot designs used by small-scale fishers in Banate Bay, Philippines.

Design	Mesh Size (cm)	Mean CPUE (kg/haul)
A	4.0	20.5
B	2.5	5.5
C	1.5	13.5
D	7.0	20.2

Note: CPUE = total catch (kg) ÷ number of hauls; values represent mean catch per haul after specified soak duration.

A one-way ANOVA revealed a significant difference in mean CPUE, as shown in Table 4, among the four designs ($F(3, 12) = 18.62$, $p = 0.0003$) indicating that mesh size and structure significantly influenced fishing efficiency. Actually, a p-value less than 0.05 is typically considered to be statistically important, in which case the null hypothesis should be rejected. A p-value greater than 0.05 means that deviation from the null hypothesis is not statistically significant, and the null hypothesis is not rejected.

Table 4. One-Way ANOVA summary for CPUE among four fish pot designs

Source of Variation	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	694.37	3	231.46	18.62	**0.0003**
Within Groups	149.17	12	12.43		
Total	843.54	15			

Post hoc Tukey's HSD analysis, as shown in Table 5, showed that Design B (2.5 cm mesh; 5.5 kg/haul) had a significantly lower CPUE than all other designs ($p < 0.05$). Designs A (4 cm mesh; 20.5 kg/haul) and D (7 cm mesh; 20.2 kg/haul) did not differ significantly ($p >0.05$), both yielding highest efficiencies. Design C (1.5 cm mesh; 13.5 kg/haul) was significantly higher than Design B ($p < 0.05$) but lower than Design A ($p < 0.05$).

Table 5. Tukey's HSD multiple comparison of mean CPUE among fish pot designs

(I) Design	(J) Design	Mean Difference (I–J)	Std. Error	Sig. (p)	Remark
A	B	15.00*	1.78	0.000	Significant
A	C	7.00*	1.78	0.005	Significant
A	D	0.30	1.78	0.995	Not Significant
B	C	-8.00*	1.78	0.004	Significant
B	D	-14.70*	1.78	0.000	Significant
C	D	-6.70*	1.78	0.006	Significant

Note: The asterisk (*) denotes that the mean difference between groups is statistically significant at the 0.05 probability level ($p < 0.05$).

4. Discussion

The foundation of this study lies in the resourcefulness of small-scale fishers in Banate Bay, whose continued use and innovation of fish pots reflect both tradition and adaptation to changing fishing conditions. The results of the study revealed that the way a fish pot is built, its mesh size, shape, material, and bait, strongly influences its performance in terms of catch efficiency, selectivity, and durability. Among the four designs tested, Design A (4 cm mesh) stood out as the most efficient. Its moderate mesh size and use of brown mussels as bait made it especially effective in attracting demersal species such as *Nemipterus spp.* and *Upeneus spp.*, while minimizing the capture of undersized fish. This finding aligns with Petetta *et al*. (2021) and Herrmann *et al*. (2018), who emphasized that moderate mesh sizes often provide the best balance between retaining target fish and allowing juveniles to escape. Similarly, Santos *et al*. (2019) reported that bait quality and freshness greatly enhance the catch performance of trap gears.

The results further show that moderate to large mesh sizes (4–7 cm) optimize CPUE, consistent with the works of Petetta *et al*. (2021) and Herrmann *et al*. (2018), who investigated trap selectivity in tropical fisheries. Their studies also underscored the role of mesh size in determining which fish sizes are retained or released, reinforcing the ecological importance of properly sized meshes in sustainable fishing practices. The convergence of these results with previous studies strengthens the validity of using 4–7 cm mesh sizes to achieve both high catch efficiency and ecological sustainability.

The findings also build upon earlier Philippine research by Eleserio and Fernando (1990), who examined the catch efficiency of different traditional pot designs. While their study focused mainly on catch quantity and pot geometry, the present work expands this understanding by incorporating ecological selectivity, material durability, and maintenance aspects. In Banate Bay, fishers adapt their gear not only to maximize catch but also to suit local habitats characterized by sandy–muddy bottoms and mixed coral–seagrass substrates. These environmental conditions shape how different fish pot designs perform. This interaction between gear design and habitat demonstrates the adaptive knowledge of local fishers and underscores Banate Bay's role as a natural laboratory for understanding trap performance in tropical demersal fisheries.

Design D with 7 cm mesh also showed remarkable results, particularly for larger and more valuable species such as groupers and stingrays. However, this design required longer soak durations (up to one week), which posed challenges such as ghost fishing and biofouling—issues similarly raised by Jhohan *et al*. (2024). Fishers observed that while longer soak times may increase catch, they also heighten the risk of gear loss and ecological impact, reflecting a delicate trade-off between productivity and sustainability.

In contrast, Designs B (2.5 cm) and C (1.5 cm), with their smaller mesh sizes, captured more juvenile and non-target species, lowering biomass yield and increasing sorting time. This outcome supports Suuronen *et al*. (2016), who noted that fine-mesh gears tend to produce higher bycatch and reduce long-term economic gains. These findings reveal that smaller meshes may not only compromise sustainability but also increase labor effort for fishers.

The choice of material also played a crucial role in the fish pots' performance. Plastic-screen pots lasted longer and required less frequent maintenance compared to bamboo-framed designs, resulting in lower operational costs and improved efficiency. Barnette (2001) likewise observed that material composition affects gear durability and selectivity, with synthetic materials offering better resistance to biofouling and wear. This shows how traditional fishing practices are gradually evolving; fishers now blend indigenous designs with modern materials to improve performance while maintaining cost-effectiveness.

Altogether, the findings of this study form a narrative of adaptation, innovation, and ecological awareness among small-scale fishers in Banate Bay. By understanding how mesh size, shape, material, and local habitat interact, fishers are not merely catching fish—they are refining sustainable practices that can ensure long-term productivity and ecosystem balance.

Conclusion

This study highlights the crucial role of fish pot design in enhancing both the productivity and sustainability of small-scale fisheries in Banate Bay. The findings demonstrate that mesh size, material, and soak duration are key factors shaping the efficiency and selectivity of trap-based fishing. Design A (4 cm mesh), made of plastic screen and baited with brown mussels, yielded the highest CPUE (20.5 kg/haul) while minimizing juvenile bycatch—showing that moderate mesh sizes achieve the best balance between catch performance and ecological responsibility.

Compared with earlier studies such as Eleserio and Fernando (1990), this research offers a more comprehensive perspective by examining multiple pot designs under real fishing conditions and linking gear performance with habitat characteristics and fisher practices. The use of PE plastic-screen materials improved pot durability and reduced maintenance, reflecting both economic practicality and environmental adaptation.

Overall, the results suggest that standardizing a 4 cm mesh size, coupled with durable materials and shorter soak durations (12–24 hours), can enhance both productivity and sustainability in small-scale fisheries. Promoting this design through local ordinances and gear management policies can help align community fishing practices with the Ecosystem Approach to Fisheries Management (EAFM) and the goals of Sustainable Development Goal 14 (Life Below Water).

More than just a technical evaluation, this study captures the ongoing evolution of small-scale fishing in the Visayan region—an interplay between traditional knowledge and modern adaptation that continues to shape the future of sustainable coastal livelihoods.

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