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Desain of Multilevel Wall Trap for Selectivity of the Capture Spiny Lobster

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Abstract

The challenge faced by fishermen involved in lobster fishing is the decline in population due to overfishing and unsustainable practices. Intensive lobster fishing can disrupt the balance of the ecosystem, especially if the fishing gear used is not environmentally friendly. Lost fishing gear can continue to catch lobsters and other species unintentionally, a phenomenon known as ghost fishing. The methods applied in this research include literature review and experimental design. The literature review was conducted by examining data and the development of lobster traps from research publications and various books related to fishing. The analysis of the development of existing trap designs before the modification process is a key factor in selecting the standard trap design. This aims to develop lobster traps that are selective for legal sizes. The tiered wall trap has two entrances, one at the top in the shape of a cylinder with a width of 15 cm and a length of 20 cm, cylindrical in shape and without any hole patterns. It is expected that the trapped lobsters will not be able to escape because the length of the entrance itself is longer than the leg size of the catchable lobsters, where lobsters with a carapace length of 8.3 cm have a front leg length of 8 cm, making it impossible for the caught lobsters to climb out. The design of the tiered wall trap with a perforated pattern on the base of the trap at 8 cm is expected to allow catchable lobsters to climb into the trap's mouth. The tiered walls help lobsters to easily climb up to the mouth, thereby increasing the effectiveness and selectivity of the trap for catchable-sized lobsters. However, this design still needs to be tested in lobster catching areas or in laboratory scale.

Introduction

Lobster fishing by fishermen falls into the category of small-scale capture fisheries, where the techniques and equipment used are generally traditional and simple (Jerry & Razanoelisoa, 2024; Mafuca et al., 2024; Elstner et al., 2025). This activity mostly takes place in coastal waters, utilizing fishing gear such as monofilament bottom gillnets and traps as the primary methods for catching lobsters (Rahayu et al., 2024; Franco et al., 2022; Krishnankutty et al., 2025).

One of the challenges faced by fishermen involved in lobster fishing is population decline due to overfishing and unsustainable practices. Intensive lobster fishing can disrupt the balance of the ecosystem, especially if the fishing gear used is not environmentally friendly. For example, lost fishing gear can continue to catch lobsters and other species accidentally, a phenomenon known as ghost fishing (Sukhsangchan et al., 2020; Pandey et al., 2025; Satria et al., 2023).

Selectivity in lobster fishing is not only crucial for the sustainability of marine resources but also for the economic well-being of fishermen (Tripathy, 2025; Vigo et al., 2024; Grati et al.,

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2025). Through training and education on the use of more selective fishing gear, it is hoped that fishermen throughout Indonesia can increase their catches while maintaining the sustainability of marine ecosystems (Kopp et al., 2020; Dao et al., 2024; Latief & Wijaya, 2025; Yulisti et al., 2024).

The current perspective on fishing should no longer solely focus on large catches, but should also shift toward a new paradigm that emphasizes legal size (Fernando et al., 2025; Montefalcone et al., 2025). This will allow for the continued development of more environmentally friendly and selective fishing methods (Nababan et al., 2022; Lodhi et al., 2024; Bastardie et al., 2024).

Based on Ministerial Regulation No. 7 of 2024, lobsters that may be caught are not laying eggs, and the carapace length of sand lobsters (Panulirus homarus), rock lobsters (Panulirus penicillatus), batik lobsters (Panulirus longipes), and Pakistani lobsters (Panulirus polyphagus) must be at least 6 cm long or each lobster must weigh at least 150 grams. Furthermore, other lobster species (Panulirus spp.) that are permitted to be caught are those that are not laying eggs and have a carapace length greater than 8 cm or a weight greater than 200 grams per lobster.

High-Density Polyethylene (HDPE) is a highly potential material choice for making lobster traps. HDPE has superior mechanical properties, including high tensile strength, impact resistance, and good thermal stability. These properties result from its dense and regular crystalline structure, giving HDPE advantages in terms of stiffness and resistance to deformation in dynamic environments such as coastal waters (Zulbakri et al., 2024; Cruz et al., 2024; dos Santos et al., 2025).

This research aims to design and construct a multi-walled HDPE trap specifically designed to increase selectivity in catching legal-sized lobsters. The selective trap design prevents undersized lobsters from being caught, thus minimizing the impact on lobster populations while ensuring ecosystem sustainability (Christabel, 2021; Leiva et al., 2024; Bacheler, 2024). A good design is also expected to increase the efficiency of fishing operations (Wardiatno et al., 2020; Sun et al., 2024; Xing et al., 20024). Experimental-scale research on this design is expected to develop effective and selective lobster fishing gear to support the implementation of Ministerial Regulation of Maritime Affairs and Fisheries No. 27 of 2024, specifically for the development of sustainable lobster fishing businesses.

Methods

The methods applied in this research include a literature review and an experimental design approach. The literature review was conducted by examining previous studies, technical reports, and reference books related to fishing gear technology, with a particular focus on the evolution of lobster trap designs. This stage allowed the researchers to identify common structural patterns, functional weaknesses, and proven design principles used in earlier models. A careful analysis of these existing trap designs before implementing any modifications was essential, as it ensured that the selected standard design was grounded in established practices while still offering clear opportunities for meaningful improvement. Through this combined methodological approach, the study positioned its experimental design on a strong conceptual and empirical foundation. (Zulkarnain et al., 2011).

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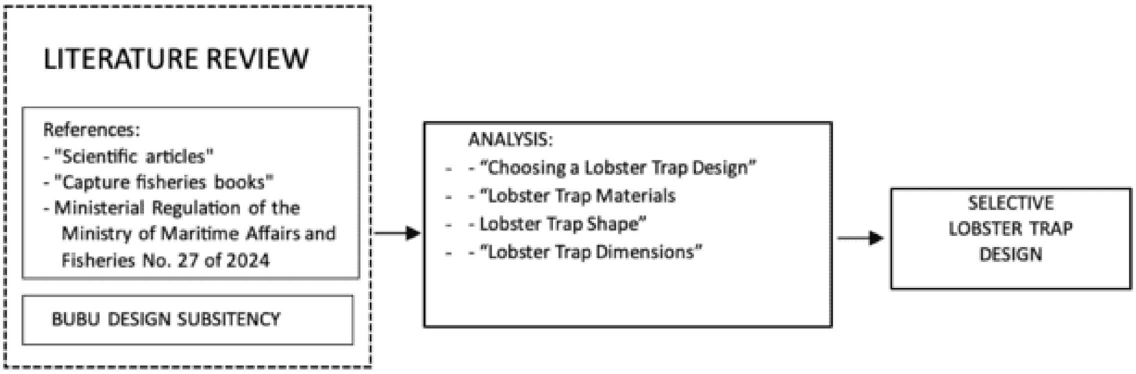

Figure 1. Research framework

Research Tools and Materials

The tools used in this study can be seen in Table 1.

Table 1. Research Tools

Tools	Total	Function
Hand grinder	1	Cutting HDPE steel and drums
Welder machine	1	Connecting steel frames
Welder helmet	1	Wearing eye protection when welding
Digital scale	1	Measuring lobster weight
Meter meter	1	Measuring trap size
Vernier caliper	1	Measuring lobster carapace length
Cutting grinder blade	4	Cutting HDPE steel or drums
Polishing grinder blade	1	Tidying and smoothing
Cable ties	1	Tightening the camera to the trap
Underwater camera	1	Observing the trap's sinking function test
Hand drill	1	Tightening the HDPE walls to the frame using steel screws

The materials used in this study can be seen in Table 2.

Table 2. Research Materials

Tools	Total	Function
2mm strip iron	2 sticks	As a trap frame
Used HDPE drums	1 piece	As a trap wall
Steel screws	1 pack	As a fastener for HDPE walls to iron frames

Time and Place of Research

The initial design for a multi-tiered wall trap made of HDPE began in Jakarta in October 2024 in the fishing gear laboratory at the Jakarta Fisheries Polytechnic. Construction of the trap based on the design is scheduled for February 2025.

Lobster Trap Design Study

The design of the lobster trap was carried out using a systematic approach that included in-depth information gathering related to lobster fishing. This process involved studying the history and development of lobster fishing gear, as well as identifying the problems faced by

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existing lobster fishing gear. Furthermore, observations of lobster behavior obtained from various scientific literature were crucial in designing this tool. To gain a more realistic perspective on the conditions and problems associated with the use of lobster fishing gear in the field, interviews were conducted with fishermen with more than five years of experience in lobster fishing. The respondents provided valuable insights into the effectiveness of existing gear and the challenges they faced, which served as the primary basis for developing a more efficient lobster trap design. The resulting trap designs were discussed descriptively, providing an overview of the design and materials used.

Development of Lobster Traps

The development of lobster traps worldwide has undergone various innovations and adaptations to increase effectiveness and maintain the sustainability of lobster resources. Traps, a traditional fishing gear, have been used by fishermen for a long time and continue to evolve along with the need for and knowledge of environmentally friendly fishing techniques.

Traps are fishing gear used by fishermen to catch various types of marine life, including lobsters and other crustaceans. Traps are environmentally friendly, allowing catches that do not reach economic size to be released back into the water without causing significant injury to the fish (Paillin et al., 2023). In other words, traps are selective fishing gear with minimal bycatch, making them a good choice for maintaining aquatic ecosystems..

The trap shown in Figure 2 is a common type of lobster trap used in Australia. It is made of 51 x 51 mm galvanized wire and is equipped with a 10 mm diameter iron frame. This trap is highly recommended for vessels with a length of 6 to 24 meters, a gross tonnage of 20 to 80 tons, and engines with a power of 30 to 200 hp. The dimensions of this trap are 183 cm long, 152.5 cm wide, and 106.5 cm high (FAO, 1972). This relatively large size makes it less effective for use by lobster fishermen in Indonesia.

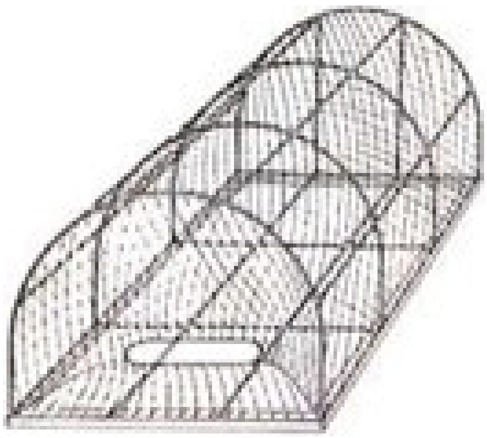

Figure 2. Spiny lobster pots design in east coast of Australia (FAO, 1972)

In the context of European lobster fishing, trap use remains the dominant method, albeit with differences in design and technological application. While both face challenges related to sustainability and environmental impact (Fulmer et al., 2022), with prudent management and innovation in gear design, the lobster fishing industry can continue to grow in a more sustainable manner. The development of traps in Europe can be seen in Figure 3.

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(a) **(b)**

Figure 3. (a) Trap with two entrances side by side and (b) trap with two entrances in opposite directions (Catalogue of fishing gear in the Mediterranean, n.d.)

Determining the location of the lobster trap mouth is a crucial aspect in fishing gear design, based on research by Anwar (2001) entitled "Preliminary Study of Trap Mouths and the Behavior of Green Crayfish (Panulirus homarus)." This study showed that more lobsters entered the trap through the side entrance than the top entrance, although many managed to escape through the side entrance. Conversely, lobsters that entered through the top entrance were unable to escape, thus confirming that trap mouth design must consider this aspect to improve fishing efficiency. These results form the basis for developing more effective trap designs to maximize catch opportunities while reducing lobster escape. Furthermore, Permatasari's (2006) research, "Selection of Plastic Trap Wall Patterns for Catching Green Sand Lobsters," provides additional insight into determining trap wall patterns. This study identified two wall patterns with specific applications; a vertical hole pattern facilitates the ascent of large lobsters (150–300 grams), while a horizontal hole pattern is more suitable for small or illegal lobsters (10–20 grams). Selecting the right wall pattern not only improves fishing efficiency but also supports sustainable fisheries practices and marine resource conservation

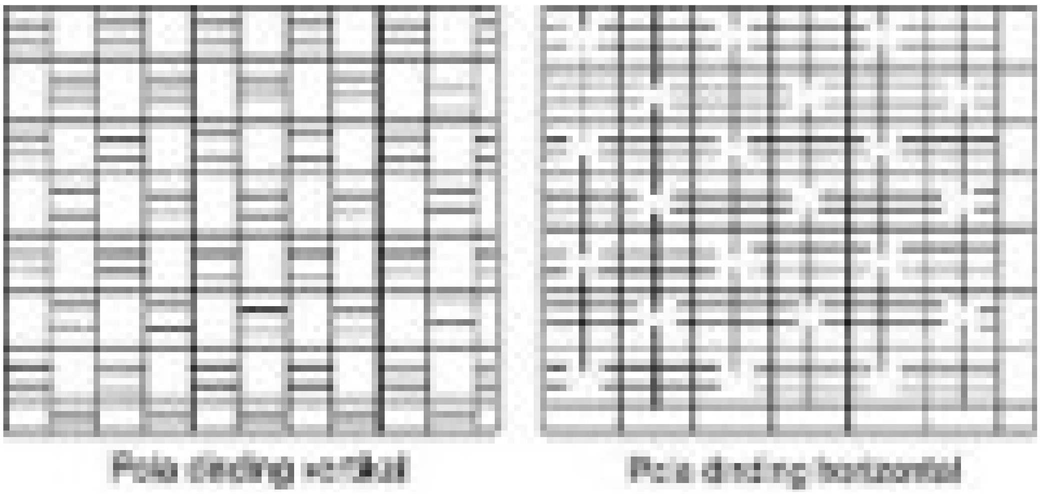

Figure 4. Hole pattern on the plastic trap wall.

Lobster fishing, particularly for spiny lobsters (Panulirus spp.), requires innovation in gear design to increase efficiency and reduce environmental impact. Zulkarnain's (2012) study, "Design and Construction of Modified Folding Traps and the Use of Earthworms (Lumbricus rubellus) as Alternative Bait for Spiny Lobster Fishing," showed that standard folding traps had a higher success rate than traps with plastic lattice doors, which could potentially hinder lobster access. This study emphasized the importance of trap door design in maximizing catch

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opportunities. Furthermore, a study by Khikmawati et al. (2015), "The Effect of Differences in Operational Duration and Trap Wall Slope on Lobster Catch Position in the Argopeni Coastal Area, Kebumen Regency," found no significant difference in the number of lobsters caught between 45° and 60° wall slopes (Figure 5).

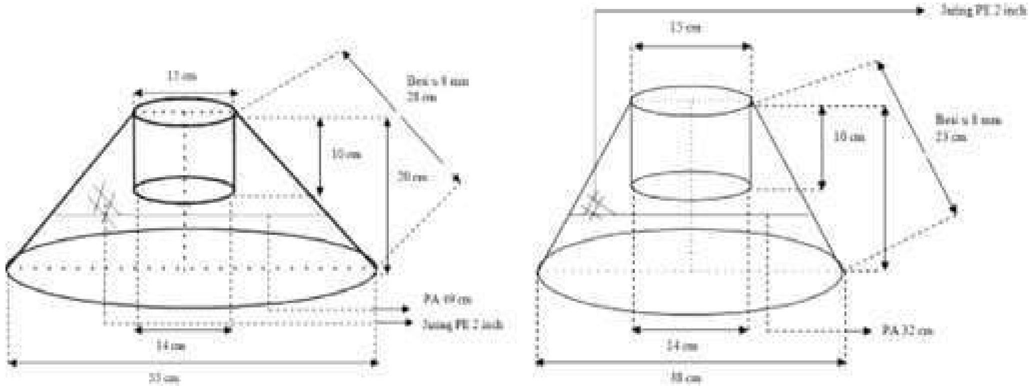

Figure 5. Truncated cone trap with wall slopes of 60° and 45°

Lobster Trap Materials

Lobster trap installation locations typically have choppy waters, surrounding coral and rocks, and highly salty water, which is highly corrosive to metal objects. The choice of material must be based on the best possible characteristics. After researching various materials for lobster traps, based on experience in several countries, HDPE plastic is a good choice because it is strong, has a certain degree of elasticity to resist deformation when struck, and is easy to shape. Furthermore, lobsters dislike movement in the net; they sense it from the movement that typically occurs on the walls of a net trap (Meenakumari & Rajan, 1985).

HDPE plastic can be manufactured in various shapes and sizes, allowing flexibility in lobster trap design. This is particularly useful for tailoring trap designs to suit specific lobster species or sizes and fishing methods. This material has a long service life in marine applications, reducing the frequency of trap replacements and the long-term costs associated with maintenance and procurement of fishing gear (Shen et al., 2023). Overall, these advantages make HDPE an excellent material choice for efficient and effective lobster traps for marine fishing. The traps in this study were made using HDPE from used drums, which are widely available on the market.

Lobster Trap Design

When assessing the design of a lobster trap, one of the primary considerations is a thorough understanding of the life cycle and behavior of spiny lobsters. The growth of marine lobsters is divided into four phases: the larval stage (nauplisoma and phyllosoma), the postlarval stage (puerulus), the juvenile stage, and finally, the adult stage. Upon reaching the juvenile stage, the shell of marine lobsters contains a calcareous substance that hardens their shells and allows them to adapt to a variety of dietary patterns. Marine lobsters have the ability to molt. This process allows them to continue growing throughout their lives, although at a slower rate with age.

Lobsters also have the ability to move on surfaces with varying slopes. They can crawl across rocky or sandy seabeds and even climb coral reef walls, as seen in Figure 6. This ability allows them to explore wider areas in search of food. During the foraging process, lobsters use their

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long antennae to sense their surroundings. They look for food such as mollusks, small fish, and even the remains of other organisms. By understanding the lobster movement pattern, the trap design that will be made is in the form of a truncated cone with tiered walls and a horizontal perforated pattern which can create a wall structure that allows lobsters to easily access the bait placed in the trap. The design of a tiered wall trap made of HDPE can be seen in Figure 7.

Figure 6. Lobsters on the sea surface and on coral reefs

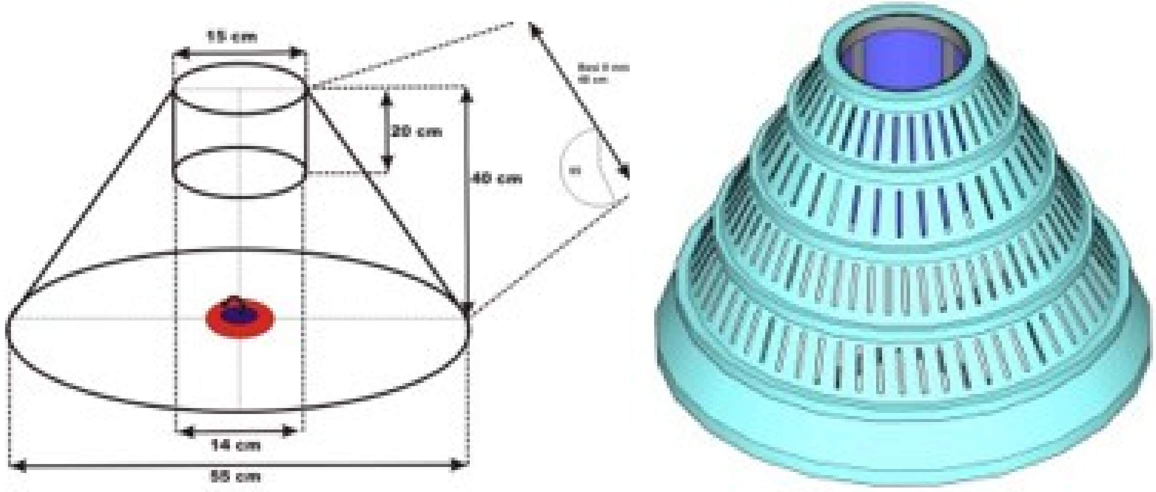

Figure 7. multi-level wall trap design

This design is made by considering the cone shape to reduce the possibility of getting caught in coral reefs and the HDPE trap wall is more stable when climbed by lobsters so that lobsters do not feel any movement on the trap wall unlike traps that use net material, they will experience movement if they are hit by currents and waves that trigger lobsters to move away from the trap if they notice movement such as research conducted by Bharathiamma & Rajan, 1985. The operation of the trap is assisted by using bait to attract lobsters to approach the trap and with a tiered wall pattern and horizontal holes on the trap wall it is hoped that lobsters can easily climb into the mouth of the trap. The creation of the hole pattern and tiered walls is based on the length of the front lobster leg where the length of the sand lobster leg can be seen in figures 8 and 9.

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Figure 8. Length of the front legs of the sand lobster (Carapace length 8.3 cm)

Figure 9. Length of the front legs of the sand lobster (Carapace length 5.3 cm)

The walls of the trap are made with vertical holes above 8 cm from the bottom of the trap (figure 10) with the hope that the lobsters that can climb up are lobsters of a suitable size to catch with a carapace length above 6 cm where this size has an average of front legs above 7 cm and lobsters of a size not suitable to catch such as figure 9 with a carapace length of 5.3 cm with a front leg length of 5 cm are expected to be unable to climb up the trap walls because the surface of the trap is slippery from the bottom of the trap to the first level wall, this has the aim of selectivity.

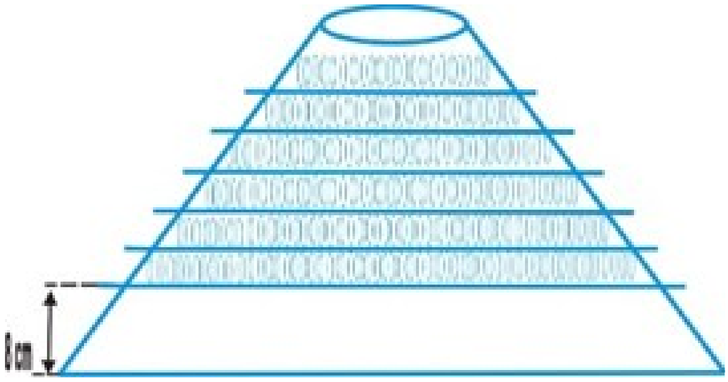

Figure 10. placement of multilevel walls and vertical holes on the trap wall

The combination of vertical hole patterns and tiered walls aims to increase the effectiveness and selectivity of the trap fishing gear, where the vertical hole pattern in Permatasari's research (2006) shows that the vertical pattern is easier for lobsters of a suitable catch size of 100-110 grams to climb, while lobsters of 10-90 grams have difficulty climbing the walls of the trap with a vertical pattern.

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Making a Fish Trap

Making a fish trap consists of five stages.

Stage 1: Make the fish trap frame from 3 cm strip iron.

The trap frame is made from 3 cm strip iron using an electric welding process, made in the shape of a truncated cone with a trap height of 40 cm, a base width of 55 cm, a mouth width of 15 cm and a trap slope of 65º, as can be seen in Figure 11.

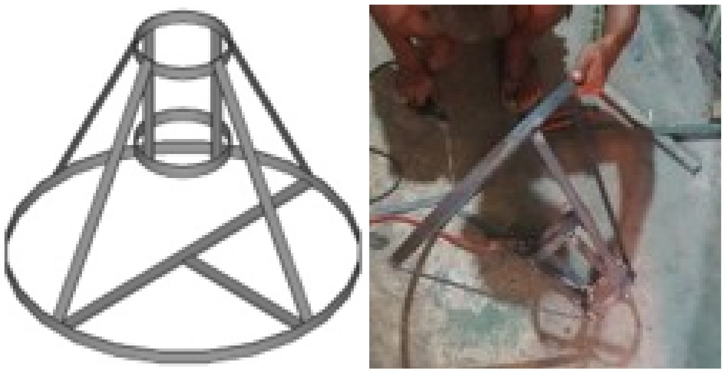

Figure 11. trap frame

Stage 2 is making the trap entrance, exit and bottom of the trap

The next stage of making the trap entrance, trap exit and trap base using HDPE material can be seen in Figure 12, the entrance is made in a cylindrical shape with a width of 15 cm and a height of 20 cm, the entrance is made smooth without holes so that lobsters that enter cannot climb out of the trap while the exit door is 25 cm wide in the middle to make it easier to get out of the caught lobsters, the bottom of the trap is made with a hole pattern to make it easier for trapped water to escape from the trap.

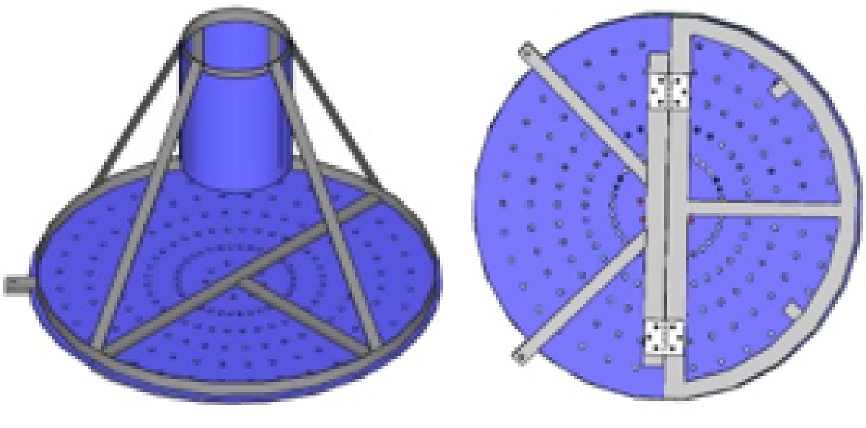

Figure 12: base of the trap, entrance and exit of the trap

The 3rd stage is placing the weights

The weight on the trap is made from tin which has a higher density than iron. The weight is placed in the middle position at the bottom of the trap to maintain balance when submerged in the water. The entrance to the trap remains at the top due to the influence of the weight in the middle position at the bottom of the trap, which can be seen in Figure 13.

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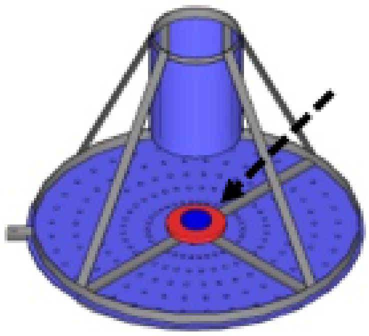

Figure 13. Placement of weights on the trap

Stage 4 of making multi-storey walls

The trap walls are made from HDPE material from used drums which are cut to follow the shape of the trap frame and then made into levels on the trap walls in the hope of making it easier for lobsters to climb to the trap entrance, as can be seen in figure 14

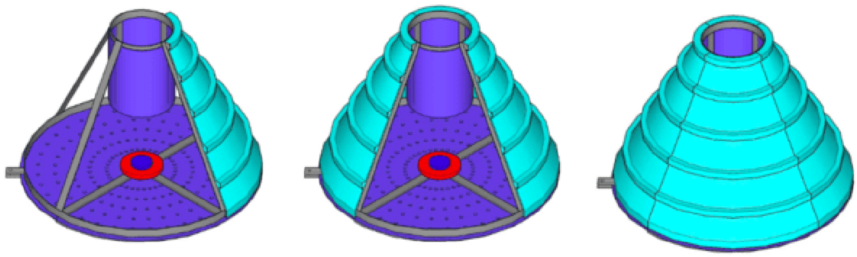

Figure 14. Making multilevel walls on a frame

Step 5: Creating a Vertical Hole Pattern on the Multi-Level Fish Trap Wall

The holes are made by drawing a vertical pattern on the fish trap wall, followed by making holes in the drawn pattern, and then cutting the holes into a vertical shape with a width of 0.5 cm and a length of 2 cm (as seen in Figure 15).

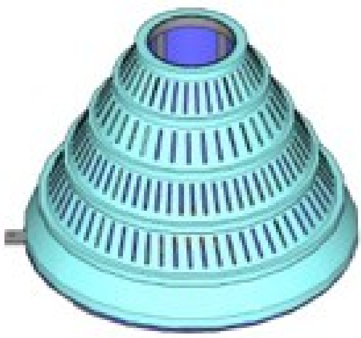

Figure 15. vertical hole pattern on the trap wall

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Results and Discussion

Design Results for a Multi-Level HDPE Wall-Mounted Trap

The multi-level wall trap has two doors: a cylindrical entrance at the top, 15 cm wide and 20 cm long. The cylindrical shape and no hole pattern are expected to prevent lobsters trapped inside from escaping, as the entrance itself is longer than the size of a lobster's legs fit for capture. A lobster with a carapace length of 8.3 cm has front legs that are 8 cm long, preventing them from climbing out.

The trap wall is made with two forms, namely a tiered wall and a vertical pattern where the vertical pattern is made above the base of the trap 8 cm so that only lobsters of a suitable size can reach up and the combination of the tiered wall shape and the vertical pattern is expected to make it easier for lobsters to climb up with the tiered wall and vertical hole pattern so that the lobsters can enter the trap more quickly. The results of the design of a tiered wall trap made of HDPE can be seen in Figure 16.

Figure 16. Design results of HDPE multilevel wall traps

Table 3. Hydrostatic Analysis of HDPE Multilevel Wall Trap

Component	Material	Total	Weight (kg)	Buoyancy (kgf)	Total Buoyancy (kgf)
Bubu Wall	HDPE Plastic	5	0.5	-0.04405	-0.22025
Bubu Skeleton	Iron Strip	1	3.5	3.0432	3.0432
Ballast	Tin	1	5	4.5505	4.5505

Hydrostatic Force Analysis on HDPE Multi-Wall Traps

Hydrostatic pressure is the buoyancy or sinking force exerted by an object's material in water. Buoyancy refers to an object's ability to float in a liquid. Gravity refers to an object's ability to sink. If the buoyancy value of an object or material is negative, it is said to float; if the buoyancy value of an object is positive, it will sink. According to Firdman (1988), the following equations are used to calculate buoyancy and sinking forces:

Information :

Q = weight of an object floating or sinking in water (kgf)

Ey = coefficient of sinking force or buoyant force

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W = weight of object in air (kgf)

ɣw = specific gravity of sea water (1.025kgf/m3)

ɣ = specific gravity of the object (kgf/m3)

The hydrostatic analysis yielded results for each component of the multi-tiered wall trap. The total buoyancy force was then calculated. The part that provided the buoyancy force was the HDPE plastic body of the trap. The parts that provided the sinking force were the trap frame and weights. The prism trap had a total buoyancy force of -0.22 kgf and a total sinking force of 7.59 kgf, causing the multi-tiered wall trap to sink to the bottom.

After calculating the hydrostatic force, the trap was tested in a 7-meter-deep test pool, observing three different trap entrance positions: the first facing upward, the second facing 90 degrees from the first position, and the third facing downward. All three positions landed on the bottom of the water with the trap entrance facing upward, as expected. This was due to the hydrostatic force of sinking and the weight position at the bottom of the trap, which served as the center of gravity. This shows that the trap design ensures the trap's descent from the surface to the seabed, positioning the trap door facing upwards as desired.

The next process of testing the lobster trap to see if it cannot escape from the trap is by placing the lobster in the trap and immersing it in a test pool filled with seawater for 12 hours. After immersion for 12 hours, the lobster is still trapped in the trap. This shows that the trap functions as expected where the entrance is designed in a cylinder with smooth walls without a perforated pattern to ensure that the lobster cannot climb the trap entrance to escape.

Conclusion

The multi-tiered wall trap design, with a perforated pattern 8 cm above the base, is expected to attract viable lobsters to the mouth of the trap. The multi-tiered walls facilitate their ascent, increasing the gear's effectiveness and selectivity for viable lobsters. The HDPE material used is expected to be more resistant to corrosion and temperature changes. Its hard yet elastic properties increase the trap's strength in the event of impacts, extending its lifespan. The entrance design makes it difficult for lobsters to escape.

Acknowledgment

Further research is needed in lobster fishing areas to determine resistance to waves and currents, as well as to test effectiveness and selectivity in the lobster fishing area or on a laboratory scale.

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