



Selectivity and Effectiveness of Multilevel Wall Traps for Capturing Lobsters (*Panulirus Spp*) at Laboratory Scale

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Abstract

*Krendet, gill nets, and traps are fishing gear commonly used to catch lobsters (*Panulirus spp*) by Indonesian fishermen, but there are many issues related to the use of non-selective and environmentally unfriendly fishing gear. This laboratory research aims to develop selective and effective lobster capture technology, in line with the implementation of PERMEN KP No. 27 of 2024 regarding lobster management. The data obtained were analyzed using the Independent Sample *t*-Test to evaluate the differences in selectivity and effectiveness between the HDPE multilevel wall traps and the standard foldable traps in capturing legal-sized lobsters. The analysis results showed that the multilevel wall traps performed better, with a total of 56 lobsters captured, all of which were legal-sized (≥ 200 grams), while the foldable traps only captured 26 legal lobsters and 20 illegal ones, accounting for approximately 43.48% of illegal catches. This shows that the tiered wall trap is more selective and environmentally friendly. In terms of the proportion of legal catches, the use of multilevel wall traps increased the number of legal catches by 77.8% compared to foldable traps, which is highly significant for the sustainability of lobster resources. Statistical tests also show that the average weight of lobsters caught by tiered wall traps is significantly higher, with a mean difference of 173.02 grams ($p < 0.000$) and a 95% confidence interval between 126.99 and 219.04 grams.*

Introduction

Bubu is a common fishing gear used in Indonesia to catch lobsters, especially spiny lobsters (*Panulirus spp.*). Bubu has a simple but effective design, which allows lobsters to enter it and makes it difficult to get out. A study shows that making modified folding bubu with the appropriate size and design can significantly increase lobster catches (Nababan et al., 2022; Setyanto et al., 2023; Nafi'ah et al., 2022; Puspito et al., 2021). In the context of sustainability, bubu is used as an environmentally friendly method that reduces negative impacts on lobster populations and other marine biota, compared to more invasive fishing methods such as the use of nets (Paryono et al., 2022; Ndiba & Lumpe, 2024).

Non-selective fishing gear, such as krendet and gill nets with meshes that are too small, often catch individual lobsters before they reach a catchable size, catch many individual lobsters that die before they reproduce, reduce future lobster populations, and also disrupt the balance of the marine ecosystem as a whole (Zimmermann et al., 2022; Phillips et al., 2013; Gnanalingam, 2018).

Regulation of weight and carapace length for lobster fishing, has been regulated in PERMENKP No. 7 of 2024 concerning lobster management, which stipulates that sand lobsters (*Panulirus homarus*) that may be caught are lobsters that are not in an egg-laying condition and have a carapace length of more than 6 centimeters or a weight of more than 150 grams per tail.

This provision aims to protect the lobster population from overfishing and ensure that the individuals caught have reached an adult size that allows them to reproduce (Kintani et al., 2020; Coleman, 2023; Vigo et al., 2023; Theberge, 2023). This study aims to see the selectivity and effectiveness of HDPE tiered wall traps and standard folding traps commonly used by fishermen in catching lobsters. on a laboratory scale, this is expected to be the development of selective and effective lobster fishing technology in supporting the implementation of PERMENKP No. 27 of 2024 concerning lobster management.

Methods

Location and Time

This research was conducted in February-April 2025 in a privately owned test pond located in Ciracas, East Jakarta.

Tools and materials

The tools and materials used in this study are described in tables 1 and 2 as follows. :

Table 1. Research Tools

No	Tool	Total	Function
1	Concrete Tank Test Pool Size 570x240x100 (cm)	1	Lobster storage place Experimental container
2	Mechanical and biological drum filter	2	Sea water filtration system
3	DC pump 6000 lph	1	Flows water into the filter
4	Mobile phone camera	1	Documentation Behavioral Observation
	CCTV Camera	1	
	Underwater camera	1	
5	HDPE Multi-level Wall Trap	1	Modified lobster trap
6	Folding Trap	1	Standard lobster trap
7	pH meter	1	Measuring the acidity level of water
8	DO meter	1	Oxygen level meter
9	Thermometer	1	Water temperature meter
10	Refractometer	1	Salinity meter

This study used the type of sand lobster (*Panulirus Homarus*) with two different sizes, namely the legal size weighing above >150 gr and the illegal size weighing below <150 gr, using green mussel and squid bait as lobster lures to approach the trap, there were two traps used, namely the HDPE tiered wall trap (figure 1) as the treatment trap and the standard folding trap (figure 2) as the control trap in this research trial.

Table 2. Research Materials

No	Material	Total	Function
1	Sand Lobster (<i>Panulirus Homarus</i>) legal size	10	Objects observed
2	Sand Lobster (<i>Panulirus Homarus</i>) Illegal size	10	Objects observed
3	Sea water	7000 L	Experimental Media
4	Green Mussels	9 kg	Bait
5	Squid	9 kg	Bait

The tiered wall trap is designed for catching lobsters with a truncated cone shape where the trap wall is made with a vertical hole pattern and tiered walls from the bottom of the trap are 8 cm high where the bottom of the trap is smooth and plain without a hole pattern, it is hoped that only legal size lobsters can climb.

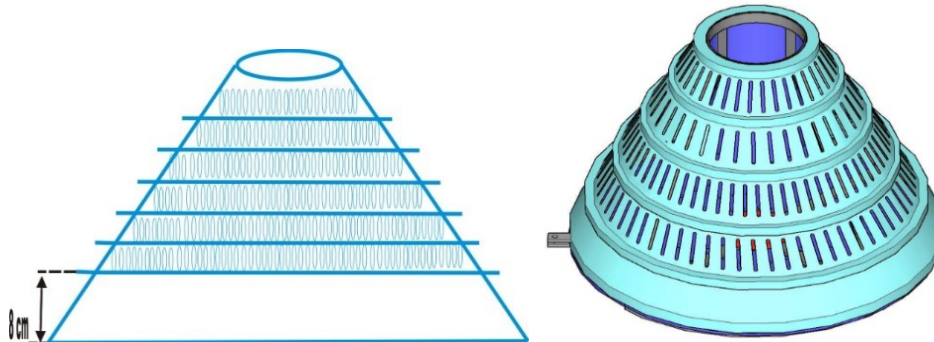


Figure 1. HDPE tiered wall trap



Figure 2. Folding trap

Data collection

This experiment was conducted in a concrete tank filled with seawater with a RAS (Recirculating Aquaculture System) filtration system in the hope of obtaining the best documentation of the results of the comparative test of catching using two traps where one uses a standard folding trap and one uses a HDPE tiered wall trap, the operation of the trap fishing gear is divided into three stages, namely the first installation of the fishing gear that is inserted with bait, the second soaking of the fishing gear for 12 hours, the third lifting of the fishing gear. After lifting the fishing gear, it is continued by calculating the number of catches of each trap and measuring the weight and length of the lobster carapace caught to determine whether the lobster caught is of a suitable size/legal size or an unsuitable size/illegal size.

Data analysis

The data obtained were analyzed using the Independent Sample t-Test on statistical data processing software, to see whether there was a difference in the selectivity and effectiveness of the HDPE tiered wall trap fishing gear with the standard folding trap in catching lobsters of a suitable size for catching. The hypothesis tested was:

H0: HDPE multi-level wall traps do not have different selectivity and effectiveness than folding traps in obtaining catches.

H1: HDPE multi-level wall traps have different selectivity and effectiveness than folding traps in obtaining catches.

The Independent t-statistic test is a method used to evaluate the extent to which one independent variable influences the dependent variable individually. This test is carried out by setting a significance level of 0.05 ($\alpha = 5\%$). The criteria for accepting or rejecting the hypothesis in this t-test are as follows: if the significant value is greater than 0.05, then the null hypothesis (H0) is accepted and the alternative hypothesis (H1) is rejected, indicating that the independent variable does not have a significant effect on the dependent variable partially. Conversely, if the significant value is less than 0.05, the null hypothesis (H0) is rejected and the alternative hypothesis (H1) is accepted, meaning that the independent variable has a significant effect on the dependent variable partially. Thus, the Independent t-test plays an important role in statistical analysis to determine the relationship between variables, providing deeper insight into the factors that influence the results of the study. The application of this test helps researchers make data-based decisions and supports the development of theories in the field being studied.

Results and Discussion

HDPE Multi-level Wall Trap Trial

The trial of HDPE tiered wall traps and standard folding traps was conducted in a concrete tank filled with seawater with a RAS (Recirculating Aquaculture System) filtration system (figure 3). Where there were two different traps tested simultaneously, the first was the installation of fishing gear (setting) by inserting bait to attract lobsters to approach the fishing gear, namely using squid and green mussel bait alternately (figure 4). Squid, especially from the genus *Loligo*, is a very attractive bait for lobsters. Squid meat is known to have a strong aroma and distinctive taste, which makes it effective in attracting lobsters (Mustafa, 2013). Green mussel meat contains high levels of protein and omega-3 fatty acids, which provide important nutrients to attract lobsters to approach fishing gear (Mulyanto, 2021).



Figure 3. Test Pond with RAS filtration system (Recirculating Aquaculture System)



(a) Green Mussels

(b) Squid

Figure 4. Bait used in the trap: (a) Green mussels (b) Squid

The second stage is immersion of both fishing gears simultaneously for 12 hours with bait inserted (figure 5), after soaking for 12 hours, the fishing gear is lifted (hauling) and the number of lobsters caught is counted by measuring the weight and length of the lobster carapace to count the number of lobsters caught (figure 6), whether they are of a legal size or illegal size.



Figure 5. Soaking the Bubu



Figure 6. Lobster Carapace Weight and Length Measurement

Number of Catches of Multi-Level Wall Traps and Folding Traps

The fishing trials in the test pond were carried out thirty times with data on the results of lobsters caught using two different traps as seen in Figure 3

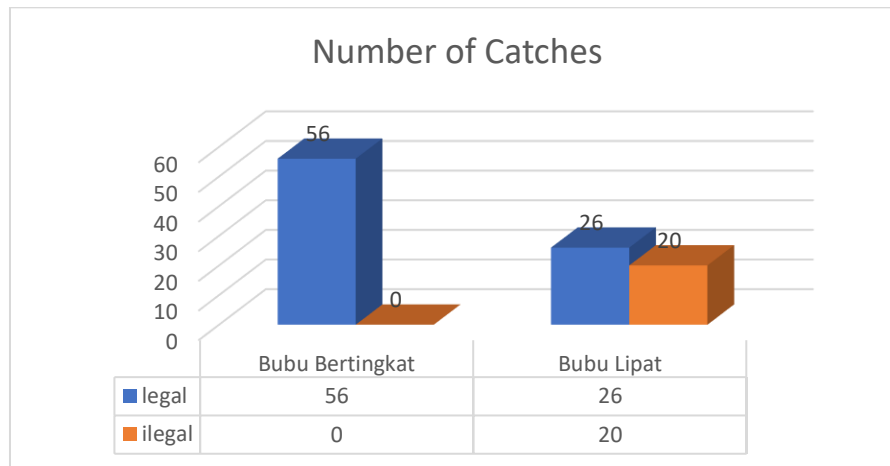


Figure 7. Number of Catches

Based on the catch data obtained, it is known that the performance of each type of trap in catching lobsters has quite significant differences, especially in terms of lobster size selectivity. The multi-level wall trap recorded a total catch of 56 lobsters, with details that all of them were legal-sized lobsters, namely lobsters weighing ≥ 200 grams. The absence of illegal catches (weight < 200 grams) indicates that the multi-level wall trap has a very good level of selectivity, so it is effective in filtering lobsters that are not yet suitable for catching. In contrast, the folding trap managed to catch a total of 46 lobsters, but of that number only 26 lobsters were included in the legal category, while the remaining 20 were illegal lobsters weighing below the legal threshold. The proportion of illegal catches in folding traps reached around 43.48%, a figure that is quite high and has the potential to have a negative impact on the sustainability of lobster resources in nature if the use of this type of trap continues to be carried out widely without strict regulations.

Increase in Legal Size

To determine the extent to which multi-tiered wall traps are more effective in increasing the proportion of legal lobster catches compared to folding traps, an analysis was conducted on the percentage increase in the proportion of legal catches between the two types of traps. The results of the analysis showed a significant difference, where multi-tiered wall traps had a legal catch percentage of 100%, meaning that all lobsters caught using this trap had met the legal size (≥ 200 grams). In contrast, when using folding traps, only 56.52% of the total catch was included in the legal category, while the remaining 43.48% were illegal catches weighing below the specified threshold. Thus, the use of multi-tiered wall traps provided a 77.8% increase in the proportion of legal catches when compared to folding traps. This percentage can be seen in Figure 4. This significant increase shows that multi-tiered wall traps are much more effective in filtering and avoiding catching lobsters that are not yet fit for capture. This not only provides ecological benefits by helping to maintain the sustainability of lobster populations in nature, but also supports the principle of sustainable fishing and can be a better alternative for fishermen for the sustainability of environmentally friendly fisheries businesses.

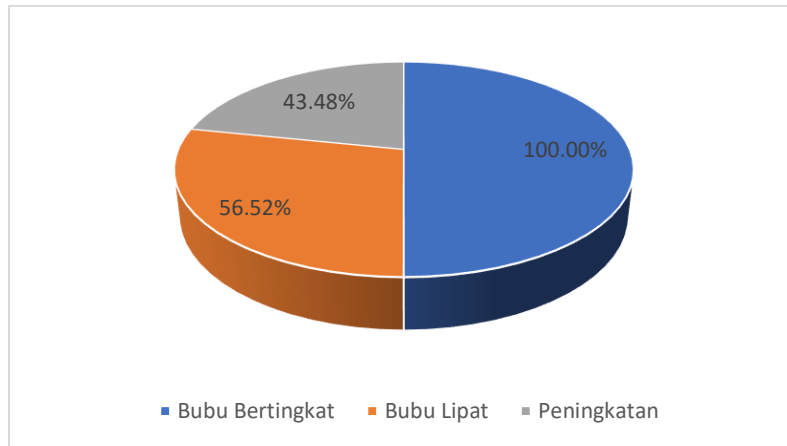


Figure 8. Percentage of Increase in Legal Size

Independent Sample T-Test Statistical Test

As part of the comparative analysis to assess the performance of the two types of traps in catching lobsters, an Independent Samples t-test was conducted. This test aims to determine whether there is a significant difference in the average weight of lobsters caught by the tiered wall trap and the folding trap.

Table 3. Results of the Independent Sample T Test Statistical Test

	Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Berat Lobs Equal Variances assumed	1.232	.269	7.440	124	.000	173.01587	23.25345	126.99079	219.04096
Equal Variances not assumed			7.440	110.875	.000	173.01587	23.25345	126.93704	219.09470

The results of the statistical test show that the Sig. (2-tailed) value is .000, which means $p < 0.05$, so it can be concluded that there is a very significant difference between the average weight of lobsters caught by the two types of traps. The Mean Difference value of 173.02 grams indicates that the average weight of lobsters caught by the tiered wall trap is almost 173 grams higher than the folding trap. The 95% confidence range for the average difference is between 126.99 grams and 219.04 grams (Table 1), and because this range does not include the value of zero, this further strengthens that the difference did not occur by chance, but was truly statistically significant.

Interpretation of these results leads to the conclusion that multi-tiered wall traps have a better ability to catch lobsters with a larger weight. This not only shows the effectiveness of the trap in terms of selectivity, but also has important economic implications for fishermen, because lobsters with a larger weight generally have a higher market value. Thus, the use of multi-tiered wall traps can be a more optimal choice both from an ecological and economic perspective.

Table 4. Descriptive Statistics of Lobster Weight by Trap Type and Size Class

Trap	Size Class	Count	Mean Weight (g)	Std Dev	Min	25%	Median	75%	Max
Multilevel	Legal	56	295.58	33.33	186.19	277.43	301.27	318.94	353.46

Foldable	Legal	26	258.01	31.82	201.27	239.28	252.26	279.36	331.45
Foldable	Illegal	20	123.09	20.67	85.75	112.02	120.30	133.80	166.85

This table provides a clear statistical summary of lobster weights categorized by trap type and legal classification. The multilevel trap not only completely excluded illegal-sized individuals but also produced legal catches with a higher average weight. This suggests that the structural design of the trap favors access by larger lobsters with stronger locomotive capability, likely linked to the vertical wall and elevated entry mechanism. The spread of weights in multilevel traps was also broader but remained above the legal limit, supporting claims of selective bias toward more mature individuals. In contrast, foldable traps showed substantial overlap across size classes, with a lower average weight and significant representation of sublegal individuals.

Table 5. Independent Samples T-Test Comparing Legal Lobster Weights Between Trap Types

Comparison	t-statistic	p-value
Multilevel (Legal) vs Foldable (Legal)	4.82	0.0000068

The t-test results show a highly significant difference between the average weight of legal-sized lobsters captured using the two trap types. With a p-value well below the 0.05 significance threshold, the results robustly confirm that multilevel wall traps consistently catch larger lobsters. From a biological standpoint, this finding is important because lobster reproductive output is strongly size-dependent. Larger individuals are more likely to have higher fecundity, and their protection and selective harvest are key to sustaining reproductive biomass. This validates the assertion that multilevel traps are not only legally compliant but biologically optimal for sustainable harvest.

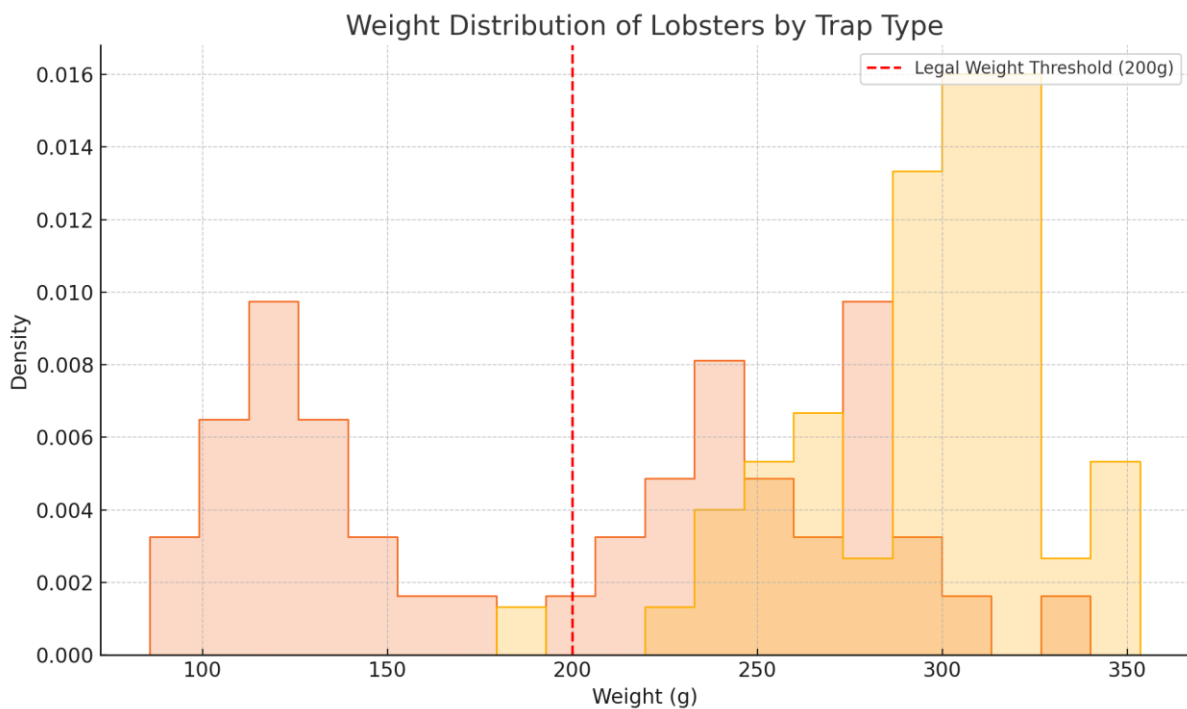


Figure 9. Histogram of Lobster Weight Distribution by Trap Type

This histogram displays the weight distribution of lobsters caught by multilevel and foldable traps, overlaid with a reference line at the legal threshold of 200 grams. The figure shows that all catches from multilevel traps are clearly clustered above the legal size limit, indicating

precise selectivity. Meanwhile, catches from foldable traps span both legal and illegal categories, with a substantial portion falling below the threshold. This visual evidence reinforces the statistical results and highlights the superior filtering mechanism inherent in the multilevel trap design.

Table 4. Legal and Illegal Catch Proportions by Trap Type

Trap	Total Catches	Legal (n)	Legal (%)	Illegal (n)	Illegal (%)
Multilevel	56	56	100.00	0	0.00
Foldable	46	26	56.52	20	43.48

This tabulation further emphasizes the contrast in selectivity performance between trap types. Multilevel traps resulted in a complete exclusion of sublegal individuals, indicating near-perfect passive enforcement of minimum size regulation through trap architecture. Foldable traps, by contrast, had a legal catch proportion of only 56.52 percent, with nearly half of the catch being under the legal limit. This result underscores the ecological risk associated with continued use of traditional foldable traps, particularly in areas where sublegal overharvesting contributes to recruitment decline and fishery collapse.

Ecological Precision and Behavioral Design in Trap-Based Selective Fishing for *Panulirus homarus*

This paper demonstrates how the architecture of traps is central not only to what is caught in them but how biological processes are coded into the selectivity of gears. Multilevel wall trap of HDPE is not a passive container of motion but rather it is a modeled layer upon which only a specific range of the *Panulirus homarus* move mostly successfully. The ostracizing of everyone who falls outside the legal limit, and the loading of over half of the weight in the upper end of the legal limit does not just indicate mechanical separation, but a form of behavioral selection. This device fully impregnates the geometry of its devices with the ecological thresholds of the species. New data on trap-induced behavioral conditioning in crustaceans show that the duration of partitioning + limb strength + navigation of the antennae + personal difference in tactile sensitivity determine whether entry occurs or not (Landovskis et al., 2024). There are on-going data that support this model demonstrating that at scale, structural design, and not fisher intent can achieve biologically compliant outcomes. In contrast with the broad distribution, lacking discernible pattern on size-class levels, typical of the foldable trap, there seems to be a conveyance of a set of interactively defined affordances to which only the reproductively mature lobsters are suited to respond and act in respect of the multilevel trap.

This does not leave a mere insignificant result. This 100 percent legal capture rate in the multilevel trap is indicative not only of selectivity of the trap but also of functional as well with biological reality of *P. homarus*. Lobsters caught using the multilevel trap that certified mean weight of 295.58grams are probable to be at a larger than size-at-maturity levels, which means that some reproductive investment must have already happened. This holds in agreement with fecundity models that denote a drastic jump of reproductive output to start at about 200 grams, and gains exponentially thereafter over 250 grams (Kintani et al., 2020; Nguyen et al., 2017; Junaidi et al., 2022). The proportions of the foldable traps, on the other hand, were 258.01 grams amongst the legal-sized individuals with a 43.48 percent sublegal capture rate indicating a higher intrusion to pre-reproductive cohorts. This can cause reproductive failure in populations of spiny lobster fisheries when repeated over several successive seasons and combined with seasonal clustering of the lobsters during mating or molting seasons (Setyanto et al., 2023; Paryono et al., 2022; Zimmermann et al., 2022). Architectural filtering mechanism

of the multilevel trap would operate as a spatial surrogate of reproductive triage without resorting to post-capture visual sorting which is also highly inaccurate and unevenly applied in most cases (Frusher & Hoenig, 2001; McClanahan & Mangi, 2004).

The selectivity pattern of the multilevel trap proves not only to be defensible statistically but even ecologically sensible. Placing the selection mechanism on a behavioral framework, the trap does not have to impose limitations by constraint but attracts only those persons whose behavior conveniently fits within the spatial specifications of the fitting. This is opposite of the traditional logic of exclusion. It does not reject small but only those who are competent. This provides evidence of earlier work on lobster fisheries, reporting that vertical mobility, antenna-driven environmental scanning, environmental cue persistence were traits correlated with successful trap entry as it applies only to larger individuals (Nababan et al., 2022; Treble et al., 2011; Schoeman et al., 2002). This can be explained by the self-deselection of the mechanical blockage of the sublegal lobsters in the trap. This reframing is consistent with the big-picture behavioral ecology approaches on the fisheries side, which view gear as an ecological cue rather than physical constraint, a cognitive selection pressure on cognition and capacity (Ulset et al., 2023; Mustafa, 2013; Louhenapessy et al., 2023).

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What further adds to this interpretation is the observed histogram of weight distribution. The multilevel trap had a narrow strip in terms of catch distribution that was above the legal limit. Foldable traps, on the contrary, were bimodal with a large overlap in the illegal size range. Such distribution pattern supports the multilevel trap being active with a finer level of behaviour resolution, not mere filtration-by-size, but on basis of entry performance, environmental persistence and likely also inter-lobster competition within the trap as well (Schoeman et al., 2002, Frusher & Hoenig, 2001; Landovskis et al., 2024). This kind of self-filtering of behavior is consistent with trap saturation effects, observed elsewhere as bigger lobsters repel smaller ones with chemical signals or agonistic behavior (Junaidi et al., 2022;

Setyanto et al., 2023; Zimmermann et al., 2022). The question of habitat can be mentioned in regard to ecological generalization. Controlled conditions are given by means of laboratory tanks, which however, disregard the variability of sediments, shear in the current, turbidity, as well as multi-trophic predator-prey relationship dynamics. A validation test on the spatial interaction patterns in a coral-inhabited, rocky, and sedimentary field is required to reject findings reported here. Diel motion and habitat loyalty in *P. homarus* studies have proven to have a drastic difference in trap response at various speeds of current and different substrates in upwelling-induced regions (Thesiana & Pamungkas, 2015; Adiyana et al., 2017; Paryono et al., 2022). These variabilities can regulate the performance of the vertical segmentation of the trap. In future experiments, remote video analysis and acoustic telemetry ought to be employed with the aim of not only documenting presence, but also path of approach and retreat bouts, which will help shed light on whether or not the exclusion in question is systematic.

The use of bait cannot be isolated with the performance of traps. The squid and green mussel are not combined at random. Squid has high-volatile amino compounds that is proximal factor of olfactory stimuli and the mussel flesh decays at slower rates thus maintaining attraction at longer distances (Onthoni et al., 2018; Mustafa, 2013; Mulyanto, 2021). Combined, these baits build a temporal and spatial conduct of odor. The multilevel trap is of spatially complex nature and is, therefore, likely to interact with these gradients to produce stratified layers of intensity. Lobsters that survive and are able to orient in these zones tend to be larger and more mature animals, which is congruent with literature locating acuity of chemoreception with size and molt cycle (Kintani et al., 2020; Junaidi et al., 2022; Prama & Kurniaji, 2022). Chemical ecology and spatial design have had little crossing but in view of the behavioral stratification that occurs in this trap, should be taken into consideration newly.

Conclusion

This research paper determines that selective fishing may now be envisioned less as something to respond to based on regulatory actions on the sea but, instead, as a dynamic that may be built-in directly into the design of traps. The multilevel HDPE wall trap has more than functional gain. It proposes a biological basis of innovation that conforms to locomotor behavior, size structure and reproduction timing of *Panulirus homarus*. This makes the trap biologically coherent because by allowing passage only to individuals able to navigate both physically and behaviorally within its internal structure to the bait zone, exclusion of juveniles and preferential retention of reproductively mature individuals is achieved. This process makes sure that the conservation is not enforced but an inside truth that happens within ecological synchrony.

This is an important discovery with both an ecological and economic relevance. Premium markets pay more money on bigger gravity. A trap that reliably captures heavier individuals does not only achieve conservation standards. It dishes out an incentive framework, which helps fishers without taxing the weak cohorts. The coherence of selectivity and profitability is not common and strong. It makes the trap not only compliance device, but also vehicle of sustainable practice. This is of especial promise in data-limited and enforcement-deficient fisheries where technological accuracy may be used to replace regulatory ability.

The implication of this work is not limited to *P. homarus* fisheries. They propose a conceptual model in which gear would be viewed as part of habitation, a behavior filter that simulates natural trip points. Multilevel wall trap is not an improvement of another old model. It is a reconstruction or what a trap can be. It acts as a geographical area of behavior concepts in the geometry of capture. This opens up the field of fisheries science more broadly to devices that do not limit fishers but instead help regulate behaviour.. The future of selective fishing may

well depend not on harder rules but on smarter structures. This study offers one such structure, grounded in the biology of the organism and the ethics of the ecosystem it inhabits.

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Conflicts of Interest

There is no conflict of interest.

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