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RESEARCH ARTICLE

The effectiveness of alternative bait in blue swimming crab trap fishing – green mussel as the main ingredient

Adi Susanto, Petri Suuronen, Mochammad Riyanto, Hendrawan Syafrie, Hery Sutrawan Nurdin, Erik Munandar, Afifah Pebrianti

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Abstract. Blue swimming crab (*Portunus pelagicus*) fishing in the Java Sea is mainly conducted using bottom gillnets, but traps are increasingly being used. Crabs caught in traps are generally larger, remain alive, and have fewer injuries, resulting in a higher selling price than those caught using gillnets. Trap fishing, however, requires suitable bait to be economically viable. The availability of commonly used natural bait, primarily ponyfish, is highly influenced by the season, and its fluctuating price is a major obstacle faced by fishers. This study evaluated the potential of alternative bait made from a mixture of green mussel and tapioca flour. The baits consisted of green mussel meat and tapioca flour at ratios of 2:1 (GM1) and 3:1 (GM2). Their effectiveness was compared with that of ponyfish bait (G0) in fishing trials conducted in September 2024 in Banten Bay over 20 days using 30 traps for each bait type. The difference in capture efficiency among bait types was not significant ($p = 0.1581$), although traps with ponyfish bait caught more crabs than those with alternative baits. However, crabs caught with GM2 bait were dominated by larger individuals than those caught with ponyfish bait. Our study suggests that alternative bait made from green mussel has the potential to substitute ponyfish bait in crab fishing. Green mussel is an easily obtainable and available year-round, with a low production cost, attractive aroma, durable texture, and relatively high effectiveness.

Keywords: bait efficiency, trap selectivity, *Portunus pelagicus*, bycatch, crustacean fisheries

A. Susanto [✉], H.S. Nurdin, A. Pebrianti
Department of Fisheries Science, Faculty of Agriculture, University of Sultan Ageng Tirtayasa, Jl. Raya Palka Km. 4 Sindangsari, Pabuaran, Serang Banten Indonesia, 42163
E-mail: adisusanto@untirta.ac.id

A. Susanto, H.S. Nurdin
Center of Excellence Local Food Innovation, University of Sultan Ageng Tirtayasa, Jalan Raya Raya Palka Km. 4 Sindangsari, Pabuaran, Serang Banten Indonesia, 42163.

P. Suuronen
International Seafood Consulting Group (ISCG), Dagmarinkatu 13, 00100 Helsinki, Finland.

M. Riyanto
Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, Jl. Agathis Kampus IPB Dramaga Bogor West Java, Indonesia 16680.

H. Syafrie, E. Munandar
Department of Marine Science, Faculty of Agriculture, University of Sultan Ageng Tirtayasa, Jl. Raya Palka Km. 4 Sindangsari, Pabuaran, Serang Banten Indonesia, 42163

Introduction

Crustaceans are among the most popular seafood products, have high economic value globally, and are widely traded worldwide (Stevens 2021, Boenish et al. 2022). Blue swimming crab (*Portunus pelagicus*) is a commercially important species, particularly in the western Indian and eastern Pacific regions (Pathak et al. 2021, Oniam and Akronat 2022). Indonesia is an important producer of blue swimming crabs, with total landings of approximately 108,000 metric tons in 2022 (Setioko et al. 2024). The annual export value of Indonesian blue swimming crabs is approximately US$300 million, supporting the livelihoods of more than 90,000 fishers and 185,000 women working in the crab processing industry (MSC 2024).

Globally, traps are important gear for catching crustaceans, with several advantages over bottom gillnets, including reduced bycatch and improved catch quality (He et al. 2021, Stevens 2021, Bacheler 2023). Blue swimming crabs caught with traps usually remain alive and do not experience much physical damage (Susanto et al. 2024). Therefore, the price is often markedly higher than that of crabs caught with gillnets. In addition, small crabs and other bycatch can usually be released alive (e.g., Susanto et al. 2025). Currently, blue swimming crab fishing in Indonesia is mainly conducted using bottom gillnets, although collapsible traps are increasingly being used. A faster transition from gillnet fishing to trap fishing would be desirable, as long as the number of traps remains at a sustainable level.

The right bait is one of the most important factors that determine the catching efficiency of traps in crustacean fishing (Anraku et al. 2001, Archdale et al. 2006, Broadhurst et al. 2018). Fishers in Indonesia commonly use fresh ponyfish (*Leiognathus* sp.) as bait because of its optimal protein (17-19%) and water (73-76%) content (Supriya et al. 2019, Saruga et al. 2023). Ponyfish are silvery white (Kimura et al. 2005) and have a distinctive odor, making them effective at attracting crabs (Budi et al. 2023). However, their availability is greatly influenced by the season. The supply of ponyfish is high during the rainy season (Akter et al. 2020). However, fishers experience serious difficulties obtaining ponyfish at a reasonable price during the dry season. An affordable and readily available alternative bait that is effective at attracting crabs is needed to overcome this problem.

The ideal bait has high freshness and protein content, an attractive odor, and a durable texture (Aksa et al. 2020, Vu et al. 2025). Mussel gonads are highly attractive to many crustaceans because of their high content of amino acids, especially glycine, which stimulates food-search behaviour in many crustaceans (Carr et al. 1996, Williams et al. 2005). In Norway, blue mussel (*Mytilus edulis*) bait had a significantly higher capture efficiency for edible crab (*Cancer pagurus* L.) than saithe (*Pollachius virens*) (Dale et al. 2007). Green mussels (*Perna viridis*) are cultivated in coastal areas of Indonesia and are available year-round. Green mussels have a protein content of 10-15% and a water content of 75-82% (Chakraborty et al. 2016). In addition, green mussels contain volatile compounds (free amino acids, taurine, and glycine) which are well-known attractants for crabs (Wu et al. 2020).

Our study aimed to determine the effectiveness of baits made from green mussels as the main ingredient in blue-swimming crab trap fisheries. The goal was to find an effective alternative bait for ponyfish with year-round availability and an affordable price to overcome dependence on ponyfish bait. It is worth noting that the population of ponyfish in Banten Bay is overexploited (Yusfiandayani et al. 2023). Hence, the availability of ponyfish is likely to become poorer if the decline in the population continues. This highlights the need to find alternative baits.

Materials and Methods

The formulation of alternative bait with green mussels as the main ingredient was carried out at the Capture Fisheries Technology and Management Laboratory, Sultan Ageng Tirtayasa University. The bait consisted of green mussel meat and tapioca flour with weight ratios of 2:1 (GM1) and 3:1 (GM2) (Fig. 1). These ratios are based on the studies of Lee and Meyers (1996), Dale et al. (2007), and Lee et al. (2024). GM1 bait contained 150 g of green mussel meat and 75 g of tapioca flour, while GM2 bait

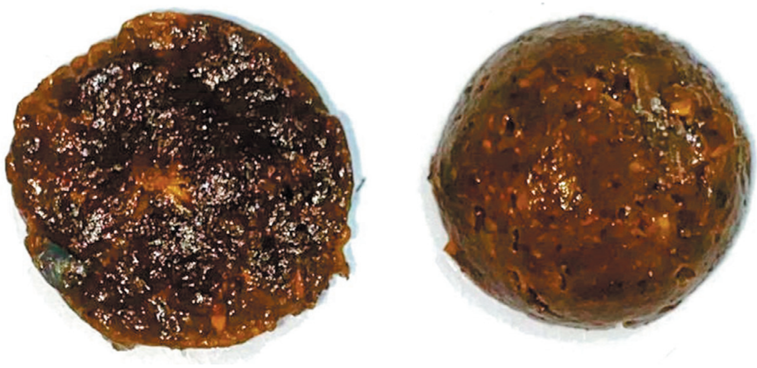

Figure 1. The baits were made of green mussel and tapioca flour (GM1 and GM2).

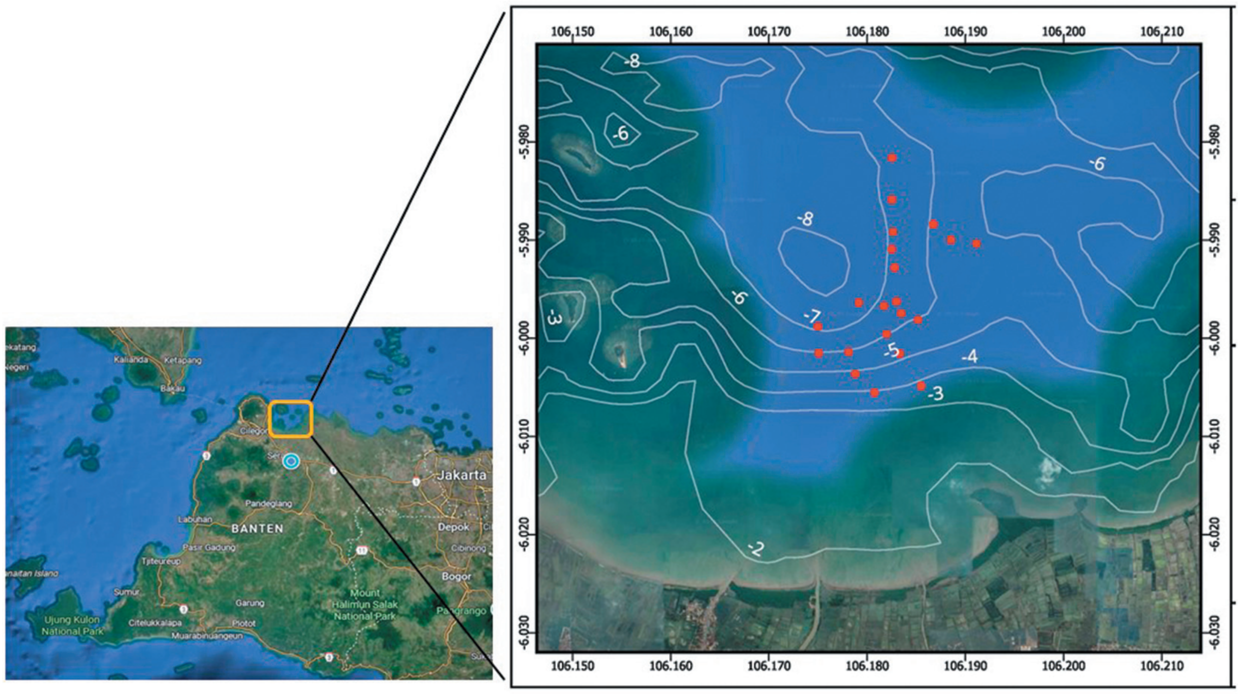

Figure 2. Tracks of the trap-fishing grounds where the trials were conducted.

contained 225 g of green mussel meat and 75 g of tapioca flour.

Green mussel meat, weighed according to each bait formulation, was minced using a blender. Tapioca flour was then added while stirring until the mixture became homogeneous. The dough was molded into portions of approximately 30 g and then steamed for 45 min. After cooling, it was used directly as bait or stored in a freezer. The effectiveness of the alternative baits was compared to fresh ponyfish in fishing trials conducted in September 2024 in Banten Bay (Fig. 2). In total, 20 fishing trips were conducted using 30 traps for each of the three bait types (a total of 90 traps). The traps used in the experiments were 41 cm in length, 29 cm in width, and 18 cm in height, with walls made of polyethylene (PE) netting with a mesh size of 1.25 inches. Traps were arranged in lines consisting of five traps with control bait (G0), followed by five traps with GM1 and GM2 baits. During the fishing trials, bait in all traps was replaced with fresh bait every morning. Each fishing trial was conducted as a one-day trip using a commercial fishing boat of 10.5 m in length. The position of the fishing ground was recorded using a GPS logger, and fishing operations were documented using a digital camera.

The legal minimum carapace width of blue swimming crabs (*Portunus* sp.) in Indonesia is 100 mm (Number 07/Permen-KP/2024). Crabs smaller than this size should be released. To analyse the effectiveness of the bait for all size classes, all crabs caught during the study were retained. The carapace width and total length of the crabs were measured

Table 1
One-way ANOVA of crab catches (in weight) with various baits. The overall weight of the crabs caught with each bait did not differ significantly

Source of Variation	SS	df	MS	F	P-value	F crit
Between groups	617775,6	2	308887.8	1.9054	0.1581	3.1588
Within groups	9241806	57	162136.9			
Total	9859582	59				

Table 2
Summary of the results of fishing trials. The total catch weight included all crabs and bycatch

Criteria	G0	GM1	GM2
Total catch weight (g)	27,760	20,953	21,989
Total crab weight (g)	16,690	11,722	14,356
Average crab weight (g)	110.5	123.4	115.8
SD of weight (g)	25.3	26.1	26.2
Total number of crabs	151	98	124
Number of legal-sized crabs	110	78	91
Number of crabs below legal-size	41	20	33
Share of legal-sized crabs (%)	72	80	73
Bycatch weight proportion (%)	40	44	35
ISU	0.60	0.56	0.65

using a caliper. The weight of crabs caught and bycatch from each trap was measured using a digital scale.

The data were analysed to determine the effect of bait type on the weight of blue swimming crab catch (all sizes). One-way analysis of variance (ANOVA), with normality and homogeneity checked using the Shapiro–Wilk and Levene tests, was applied to determine the effect of different bait types on crab catch weight (Table 1). A Tukey HSD post hoc test was used to determine how crab catch weight differed among bait types. The bait selectivity index (ISU), defined as the relationship between target catch weight and total catch weight, was determined for each bait type. A higher ISU value indicates that the bait is more selective for catching crabs.

Results

Traps baited with ponyfish (G0) caught a higher number and total weight of crabs than the alternative baits; however, the differences were not statistically significant (ANOVA, $F = 1.9054$, $p = 0.1581$). A total of 151 crabs (16.7 kg) were caught with G0, 98 crabs (11.7 kg) with GM1, and 124 crabs (14.4 kg) with GM2.

The highest number of legal-sized crabs was recorded for G0 (110 individuals), followed by GM2 (91) and GM1 (78) (Table 2). Differences among bait types were not significant ($p = 0.4165$). Crabs caught with G0 and GM1 were mainly within the 101-114 mm size class, whereas GM2 catches were dominated by larger individuals (115-129 mm) (Fig. 3). The average weight of crabs was 110.5 g (G0), 123.4 g (GM1), and 115.8 g (GM2). The highest selectivity index (ISU) was observed for GM2 (0.65), followed by G0 (0.60) and GM1 (0.56). Bycatch consisted mainly of mantis shrimp (*Harpiosquilla raphidea*), gastropods (*Babylonia spirata*), and octopus (*Octopus* sp.). GM2 had the highest number of bycatch individuals, while GM1 had the lowest (Fig. 4).

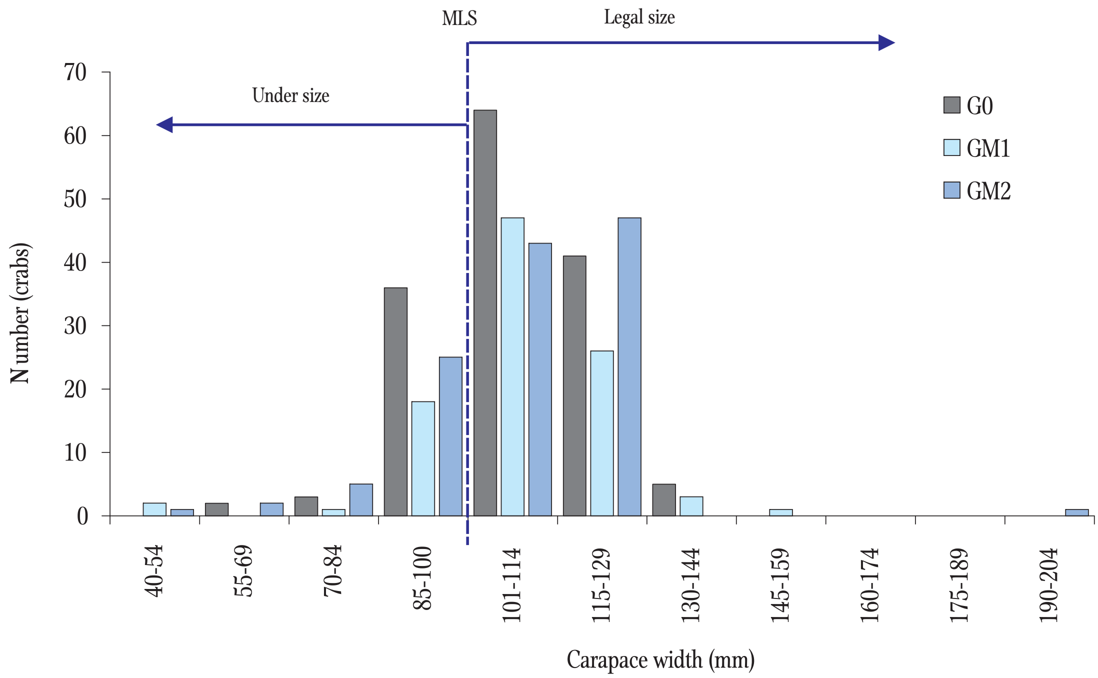

Figure 3. Distribution of carapace width (a) and weight (b) of crabs using different baits.

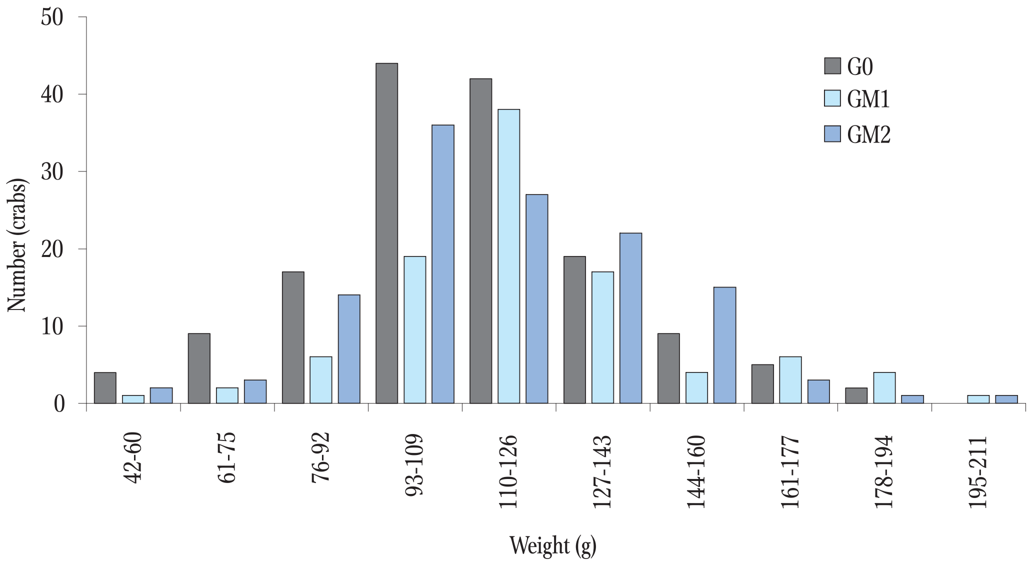

Figure 4. Number (a) and weight (b) of bycatch in fishing trials with various baits. Traps with alternative baits (GM1 and GM2) caught fewer bycatch with lower weight than ponyfish bait (G0).

Discussion

The effectiveness of GM1 and GM2 baits in attracting legal-sized crabs was promising, although traps baited with ponyfish (G0) caught the highest number of crabs (not significant). It is notable that crabs caught with GM2 bait were dominated by larger individuals than those caught with ponyfish bait. Aquatic animals, including blue swimming crabs, can detect and adaptively respond to chemical cues in water (Derby 2020, Kishida 2021). The GM2 bait had a higher lipid content (5.1%) than ponyfish (3.9%). Although lipids are not water-soluble and do not directly contribute to odor dispersion, they may enhance bait attractiveness by acting as carriers of chemical cues and by producing volatile compounds through lipid oxidation. Marine organisms, such as crustaceans, rely on dissolved chemical cues, including amino acids and other metabolites, to locate food sources. Variations in these chemical signals can affect feeding behaviour and attraction responses (Kamio et al. 2022, Lim et al. 2025). These findings suggest that GM2 bait may preferentially attract larger crabs, possibly due to differences in sensitivity to chemical attractants among size classes. Such selectivity is advantageous in fisheries, as larger crabs typically have greater economic value.

The presence of larger crabs in traps with GM2 bait indicates a difference in attraction based on size; however, this study does not demonstrate the sensory or behavioural mechanisms underlying this pattern. Chemical attraction in crustaceans relies on water-borne signals that activate olfactory and gustatory receptors. Low-molecular-weight compounds, such as amino acids, nucleotides, and organic acids, are known to be effective attractants for crustaceans (Lee and Meyers 1996, Dellinger et al. 2016). Behavioural tests with crustaceans have shown that specific amino acids can trigger movement and feeding responses, indicating a strong sensitivity to dissolved attractant molecules (Teoh et al. 2023). It is possible that chemical cues from GM2 bait produce a more persistent or complex signal, which may attract larger individuals with greater sensitivity to these cues. However, without analysing the chemical composition of bait leachates and conducting controlled behavioural experiments, this explanation remains uncertain. Future research should include chemical analyses of bait-derived cues and a direct evaluation of behavioural responses to better investigate this hypothesis.

The cost required to produce GM2 bait for 100 traps is approximately US$1.10, whereas the cost of purchasing ponyfish bait for 100 traps is on average US$1.53 during the peak season. Outside the ponyfish fishing season, fishers may need up to US$3.10 to purchase ponyfish for 100 traps. Although the protein content of GM2 is slightly lower than that of ponyfish, green mussels have a higher water content. Moist bait materials, which contain more water, have been shown to release greater amounts of soluble proteins and attractant compounds into the surrounding water than drier bait materials, resulting in higher diffusion rates of water-soluble chemoattractants (e.g., protein leaching rates measured in fish silage baits) and potentially enhancing the initial odor plume available to foraging crustaceans (Chanes-Miranda and Viana 2000, Lim et al. 2022). Experimental studies have shown that protein hydrolysates and other water-soluble bait components can leach from bait matrices into the water, making attractant molecules available for chemosensory detection by target species (Karunanithi et al. 2018). Moreover, the effectiveness of bait in attracting aquatic animals is closely linked to the diffusion and persistence of these attractant compounds, which depend on their solubility and release dynamics in seawater (Goldstein et al. 2026). Therefore, the relatively higher water content of green mussel bait may facilitate a more rapid release and dispersion of water-soluble attractant molecules compared to drier bait types, potentially contributing to its effectiveness in attracting crabs into traps, particularly during the early stages of bait deployment.

There is no doubt that the odor of ponyfish is effective in attracting blue swimming crabs of all sizes. In our trials, however, it also effectively attracted various bycatch species into traps. In contrast, alternative bait made from green mussels (particularly GM2) attracted fewer bycatch species. This is important from both sustainability and practical perspective, as releasing bycatch from traps is time-consuming for fishers.

It is worth noting that high fishing effort and low selectivity of gillnet fishing have contributed to recruitment overfishing of the blue swimming crab population in the northern part of the Java Sea (Widiastuti and Tirtadanu 2024). The current fishing mortality exceeds the optimum level by 37%, and large quantities of undersized crabs are caught. Trap fishing would allow for more selective fishing and more effective management of the overall fishing effort.

In conclusion, our study suggests that an alternative bait made from green mussels has the potential to replace ponyfish bait, at least outside the peak ponyfish fishing season. Green mussels are easily obtainable raw materials available year-round and have low production costs, an attractive aroma, and a long-lasting texture. Further investigation is required to evaluate the performance of green mussel-based baits across different seasons and fishing grounds. As the present study was conducted at a single fishing location within a limited temporal window (September 2024), this represents a key limitation. Future validation through fishing trials conducted in multiple fishing areas and across different months would allow for a more comprehensive assessment of bait performance under varying environmental and operational conditions. Such trials should be further strengthened by complementary measurements of artificial bait aroma degradation under both laboratory and field conditions. Collectively, these additional data would substantially improve the robustness of the conclusions regarding the effectiveness of green mussel-based artificial baits.

Author contributions. A.S.: Conceptualization, methodology, formal analysis, and writing the original draft. P.S.: Conceptualization, writing – review, and editing. M.R.: Writing – review and editing. H.S.: Resources and validation. H.S.N.: Resources and validation. E.M.: Resources, mapping, and validation. A.P.: Data curation.

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Data availability statement. The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Conflict of interest disclosure. The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this study.

Ethics approval statement. Approval from a research ethics committee was not required for this study, as the experimental work was conducted on blue swimming crabs (*Portunus pelagicus*) as the target species in trap fishing.

ORCID iD
Adi Susanto https://orcid.org/0000-0001-5004-1570
Petri Suuronen https://orcid.org/0000-0001-7743-4091
Mochammad Riyanto https://orcid.org/0000-0001-7089-7894
Hendrawan Syafrie https://orcid.org/0000-0002-4098-2032
Hery Sutrawan Nurdin https://orcid.org/0000-0001-8072-8437
Erik Munandar https://orcid.org/0000-0003-2812-0007

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