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Simple fix: The potential of escape gaps in enhancing the capture performance of crab pots used in the fishery of blue swimming crab, *Portunus pelagicus* (Crustacea, Decapoda, Portunidae), in the Philippines

Rizalyn M. PICOY-GONZALES[1,2], Nathaniel C. AÑASCO[1], Joy C. LIZADA[3], Kazuhiko ANRAKU[4], Harold M. MONTECLARO[1]

1 *College of Fisheries and Ocean Sciences, University of the Philippines Visayas, Miagao, Iloilo, Philippines*
2 *College of Fisheries and Aquatic Sciences, Visayas State University Tolosa, Tolosa, Leyte, Philippines*
3 *College of Management, University of the Philippines Visayas, Miagao, Iloilo, Philippines*
4 *Faculty of Fisheries, Kagoshima University, Kagoshima, Japan*

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Corresponding author: Harold M. Monteclaro (hmmonteclaro@up.edu.ph)

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Abstract

This study investigated the capture performance of two types of Philippine crab pots, a dome-type (DCP) and a box-type (BCP) installed with a pair of laboratory-tested escape gaps with flap through actual fishing operations. A total of 30 units of DCP and 30 units of BCP, of which 15 were gapped and 15 were conventional, were deployed in each fishing trial. Over the sampling period, 12 fishing trials were conducted resulting in a total of 180 hauls per pot type per design. The results showed the potential of 48 × 25 mm escape gaps with flaps in improving the selectivity and efficiency of crab pot gears used in catching blue swimming crab *Portunus pelagicus* (Linnaeus, 1758). The gapped crab pots significantly reduced the catch of undersized *P. pelagicus* by 48% in DCP and by 79% in BCP. The non-target catch was also reduced in the gapped pots by 67% in DCP and 72% in BCP. In addition, the capture of legal-sized *P. pelagicus* was not affected by the presence of the escape gaps in both DCP and BCP. Further, catch species richness was reduced in gapped DCP. The catch retrieval and sorting time was also reduced in both gapped DCP and BCP.

Keywords

Bycatch, catch composition, catch per unit effort, escape gaps, fishing gear modification

Introduction

The blue swimming crab *Portunus pelagicus* (Linnaeus, 1758) is an important fisheries commodity in many coastal areas around the world. In the Philippines, *P. pelagicus* ranks among the top fisheries commodities with highest volume of production (BFAR 2023). In the period 2019 to 2023, the total production of *P. pelagicus* averaged at 28 089.93 tonnes valued at PhP 4.65 billion, with a range of 22 000.67 to 32 216.86 tonnes valued at PhP 3.89 to PhP 5.69 billion, respectively (Philippine Statistics Authority OpenStat). About 90% of the production came from the marine municipal fisheries. One of the two major fishing gears preferred by municipal fishers in catching *P. pelagicus* is the crab pot gears.

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The viability of pot fishing gears such as crab pot is influenced by several factors including efficiency, selectivity, usability, safety of use, and ease of procurement. Each affects the biological and environmental impacts of the gear, its profitability, as well as the likelihood of adoption among fishers (Meintzer et al. 2018). Compared to other gear types, pots interchangeably termed as traps, are considered more advantageous in terms of reduced bycatch rates and premium catch quality since the catch generally remains alive after retrieval. The use of pots also results to minimized rate of ghost fishing and reduced impacts to the marine environment (Ljungberg et al. 2016; Meintzer et al. 2018). Pot fishing is classified as "low impact and fuel-efficient", wherein, fuel requirement for the fishing operations is lesser compared to many active gears such as trawls and dredges (Meintzer et al. 2018). On the other hand, catch of juveniles and bycatch in pots are undeniably of major concern for fisheries management especially in highly biodiverse regions such as in the Philippine fishing grounds where many other organisms co-inhabit with the target organism.

According to the Department of Agriculture–Department of the Interior and Local Government Joint Administrative Order (DA-DILG JAO) No. 01, s. 2014, the minimum legal size (MLS) of *P. pelagicus* in the Philippines, which refers to the minimum carapace width (CW) of the species that is allowed for catching, collecting and trading, is 102 mm. Though there are fishers who return the juveniles or undersized crabs (those with less than 102 mm CW) to the sea, there are some who retain this portion of the catch either for household consumption or selling in the local markets or direct buyers, most especially during times when catch is low (de la Cruz et al. 2018). The mortality of juveniles is detrimental to marine fisheries (Winston et al. 2019). This would potentially impact future catches and succeeding recruitment (Najmudeen and Sathiadhas 2008; Winger and Walsh 2011) which would create socio-economic issues to the fishery. Ingles (2004) reported that the crab pot catch is comprised of 8%–27% immature or juvenile *P. pelagicus*. Mesa et al. (2018) reported a higher percentage of immature catches at 62% in the Western Visayan Sea.

Furthermore, all types of fishing gears result to some level of bycatch with possible exemption of highly selective gears such as spear and harpoon (Morgan and Chuenpagdee 2003). Bycatch refers to all non-targeted species that are either retained or discarded (Alverson et al. 1994). In many developed countries, much of the non-targeted species caught are discarded at sea, while in developing countries including the Philippines, those bycatch with either economic or commercial value are brought on land (Najmudeen and Sathiadhas, 2008). Nevertheless, much are being discarded at sea, especially those without economic value (Picoy-Gonzales and Monteclaro 2017). Bycatch may have adverse impacts on biological, ecological and socioeconomic aspects of the fishery. High rates of bycatch may contribute to loss of biodiversity in particular areas and may alter the ecological profile of species in general (Morgan and Chuenpagdee 2003; Ingles 2004; Zimmerhackel et al. 2015). Bycatch could also contribute to overfishing and slow the recovery of overexploited stocks which may negatively impact the economic and social aspects of the concerned fisheries. In the case of pots, an intensive fishing using >200 units would entail a large proportion of bycatch species, in which some, if not many, are of no economic value including shellfish and finfish, that must be discarded onboard after hauling (Naimullah et al. 2022). In San Miguel Bay Philippines, Nieves et al. (2013) reported that the crab pot catch in the area was comprised of only 31.79% *P. pelagicus* with 32.66% *Charybdis feriata* (Linnaeus, 1758), 25.93% *Portunus sanguinolentus* (Herbst, 1783), and the remaining 9.62% of other bycatch species. Bycatch in crab pots used in targeting *P. pelagicus* were also reported in other countries such as Thailand (Boutson 2008) and Indonesia (Hamid and Kamri 2021).

Various studies had reported the effectivity of escape gap as a tool in improving the selectivity without affecting the efficiency of pot fishing gears. Improved selectivity is particularly crucial in addressing biological and ecological issues such as the reduction in the capture of juveniles to effectively ensure the stock's reproductive potential (Watanabe and Sasakawa 1984) and in minimizing the impact of the gear on other non-target species (Bjordal 2002). Broadhurst et al (2020) even recommended the promotion of escape gaps among commercial and recreational pot fisheries targeting portunid species including *P. pelagicus* in many coastal countries. The design of the escape gap appropriate for a specific type of pot used in targeting specific species is crucial, which may be determined through laboratory experiments for easier monitoring. Meanwhile, the conduct of comparative field fishing trials is necessary to validate the capture performance of the modified fishing gear in the real-world setting (Winger and Walsh 2007). Thus, this study aimed to evaluate the capture performance of crab pots installed with escape gaps with flaps through actual fishing operations. Specifically, this study examined the catch composition and catch rates of the gapped and conventional crab pot gears.

Materials and methods

Study location. Comparative field fishing trials were conducted in Cancabato Bay, Tacloban City, Leyte, Philippines (Fig. 1) from August to October 2021. Cancabato Bay is part of the bigger San Pedro Bay situated in between the islands of Leyte and Samar in Eastern Visayas, with a total approximate area of 949 km^2 (Yap-Dejeto et al. 2018). Cancabato Bay is one of the major sources of fish, sea shells, oyster and crabs of the fisherfolk in Tacloban City (Anonymous 2016). For this study, there were four sampling stations where the crab pots were randomly deployed in each fishing trial. These identified stations are where the fishers typically deploy their gears in catching *P. pelagicus*.

Figure 1. Sampling stations in Cancabato Bay, Tacloban City, Leyte, Philippines.

Experimental design. A total of 30 units of dome-type crab pot (DCP) and 30 units of box-type crab pot (BCP) were used in each fishing trial. It is important to note that this study had no intention of comparing the two pot types (DCP and BCP), but instead, to check whether the installation of an escape gap is possible for various pot types commonly used in the Philippines, particularly in Eastern Visayas. The choice of pot type depends on the preference of the fishers and the condition of their fishing grounds.

For each crab pot type (DCP or BCP), 15 gapped and 15 conventional units were attached randomly to a mainline. The overall configuration of the pots was based on what was commonly practiced in the area. The pots were deployed where crab fishers commonly set their units. Fishing operations were conducted during the daytime following the practice of the local fishers. The average soaking time was 8.5 h. All units were baited with pony fish species or similarly cheap small fishes whenever the former was not available at the local fish market. Commissioned local fishers assisted in the conduct of fishing operations. A total of 180 hauls were conducted for each crab pot type (DCP and BCP) per design (gapped and conventional), that is, 15 units per pot type (DCP or BCP), across 12 separate trials or fishing operations. This method was similar to the approach of Archdale et al. (2006) which involved 100 pot hauls/pot type.

The gapped (experimental) crab pot units were installed with a pair of laboratory-tested 48 × 25 mm (L × H) rectangular-shaped escape gaps. The location of the escape gaps varied according to pot type. For DCP, paired escape gaps were installed at the side of one of the two parallel bamboo frames (Fig. 2). For BCP, gaps were situated right below the slit entrance (Fig. 3). Each gap was covered from the outside with a thin (0.20 mm) transparent plastic flap to avoid the probability of entrance of organisms through the gap. A cut sinker was provided in the lower side part of the flap to serve as auto lock via gravitational force. The gaps used in this study were made manually from galvanized iron wire #16 (1.65 mm diameter).

Fishing operations. A typical fishing operation for catching *P. pelagicus* starts with the preparation of the bait (pony fish or other small-sized species) early in the morning at around 06:00 h. The bait is skewered on a bamboo stick and is fixed on the floor of the pots. After about 30 min of bait preparation, fishers depart for fishing and start setting the gears at around 07:00 h. Setting takes about 30 min. At 08:00 h, fishers have already returned to the shore. In the afternoon at around 14:30 h, fishers depart again from the shore to haul the pots. Actual hauling starts at around 15:00 h and takes about 1 h to finish. But for this research, pot gears were brought to the shore for data collection. So, when all the pots were already onboard, the fishers would immediately head back to the shore. The data collection then started right after the boat with the pot gears reached the shore at around 16:30 h. Data collection took about 1 h. In terms of catch retrieval, the time spent varied according to the number and type of catch. Retrieval was more difficult and took a longer time for aggressive organisms such as crabs, while easier and quicker for fish species.

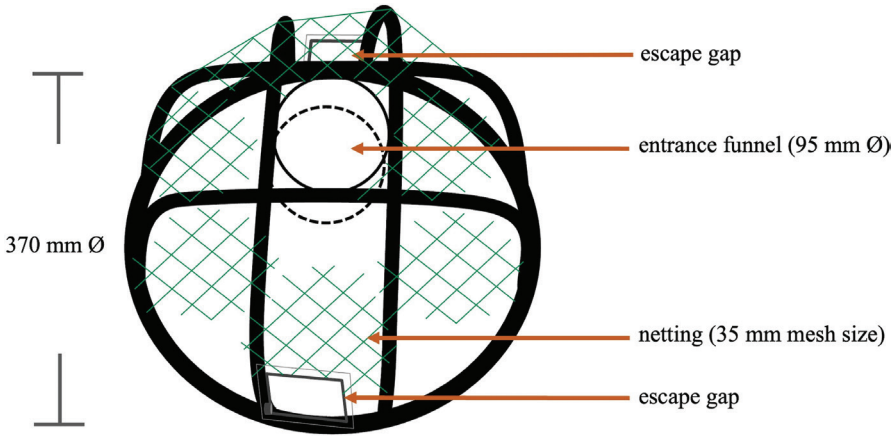

Figure 2. The location of the paired escape gaps in the gapped (experimental) dome-type crab pot units.

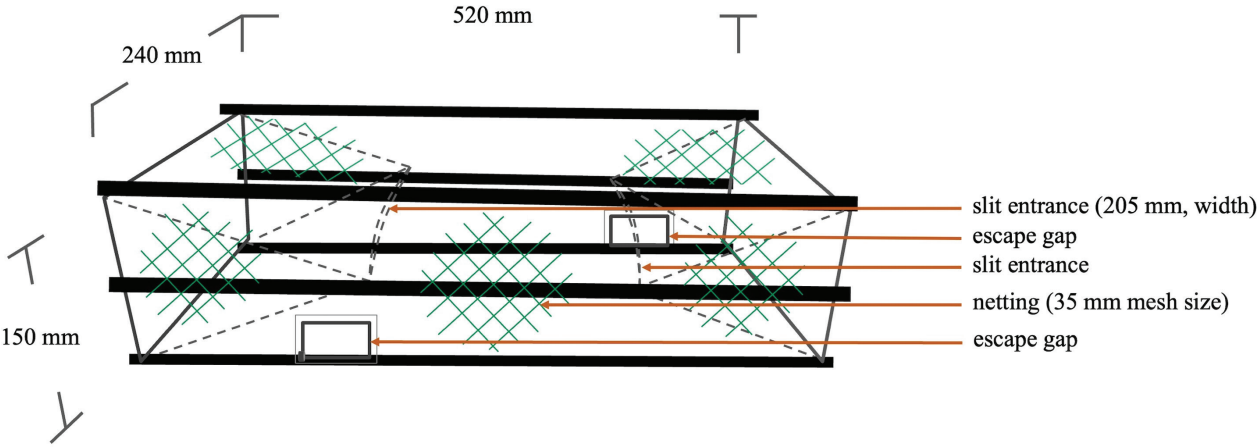

Figure 3. The location of the paired escape gaps in the gapped box-type crab pot units.

Data collection and analysis. Data collected included weight and carapace width (CW) for *P. pelagicus* and other crab species, while weight and total length for other captured species. For *P. pelagicus*, those with ≥102 mm CW were considered legal-sized based on DA-DILG JAO No. 01, s. 2014, while those below 102 mm CW were considered undersized. The CW was measured as the distance between the tips of the posterior most lateral spines using a standard 150-mm Vernier caliper (0.05 mm accuracy). Bigger samples such as grouper were measured using a standard 300-mm ruler (0.5 mm accuracy). Weight of all samples were measured using a digital weighing scale (1 g accuracy). The time spent in catch retrieval and sorting was also recorded. All species containing the catch were identified using Froese and Pauly (2024), Palomares and Pauly (2024), White et al. (2013), and Motoh and Kuronuma (1980).

All data were encoded and processed in Microsoft Excel (MS Excel) 2019. Data analysis using descriptive statistics, tables, and graphs were also done in MS Excel 2019. To examine for significant differences between treatments per test variable (i.e., catch composition, species richness, catch per unit effort, retrieval, and sorting time), the Mann–Whitney test was used. All statistical tests were performed using JASP version 0.16. The catch per unit effort (CPUE) was calculated as the average number of individuals caught per pot (indv./pot) per fishing trial. For *P. pelagicus*, CPUE based on average weight in g per pot (g/pot) per fishing trial was also computed since the catch is commonly sold by weight.

Results

The results of the comparative fishing trials using the gapped and conventional DCP and BCP are shown in Table 1. In this study, only *P. pelagicus* was considered as target species while all other species were considered non-target or bycatch. The gapped DCP caught a total of 10 different species, of which, *P. pelagicus* (35 indv.), *Charybdis anisodon* (De Haan, 1850) (5 indv.), and *Thalamita crenata* Rüppell, 1830 (5 indv.) were the top three. In contrast, the conventional DCP caught a total of 8 species, in which, *P. pelagicus* (40 indv.), *C. anisodon* (42 indv.) and *Charybdis hellerii* (Milne-Edwards, 1867) (6 indv.) were the top three. In the case of BCP, the gapped pots caught a total of 10 while the conventional pots caught a total of 13 different species. The top species caught in BCP were similar to DCP. The three species caught the most in the gapped BCP were *P. pelagicus* (50 indv.), *C. anisodon* (20 indv.), and *T. crenata* (4 indv.). On the other hand, *P. pelagicus* (64 indv.), *C. anisodon* (87 indv.) and *C. hellerii* (9 indv.) were the top three species caught using the BCP conventional design.

Table 1. Species composition and frequency of catch in the gapped and conventional dome-type and box-type crab pots.

Species composition	Number of individuals caught			
	Dome		Box	
	Gapped	Conventional	Gapped	Conventional
Target species				
Portunus pelagicus (Linnaeus, 1758)	35	40	50	64
Legal-sized (≥102 mm CW)	23	17	43	30
Undersized (below 102 mm CW)	12	23	7	34
Other species	19	58	32	114
Crustacean species	14	51	27	105
Charybdis anisodon (De Haan, 1850)	5	42	20	87
Charybdis feriata (Linnaeus, 1758)	1	0	1	0
Charybdis hellerii (Milne-Edwards, 1867)	3	6	0	9
Podophthalmus vigil (Fabricius, 1798)	0	0	1	0
Scylla serrata (Forskål, 1775)	0	0	1	0
Thalamita crenata (Rüppell, 1830)	5	3	4	8
Penaeus semisulcatus (De Haan, 1844)	0	0	0	1
Shell species	2	2	2	1
Conus sp.	1	0	0	1
Nassarius sp.	1	2	2	0
Fish species	3	5	3	8
Acentrogobius sp.	0	0	1	1
Ambassis kopsii (Bleeker, 1858)	1	0	0	0
Apogon sp.	0	1	0	0
Arothron sp.	0	3	1	1
Epinephelus coioides (Hamilton, 1822)	1	0	0	2
Epinephelus quoyanus (Valenciennes, 1830)	0	0	0	1
Lethrinus lentjan (Lacépède, 1802)	0	1	0	0
Monacanthus sp.	0	0	0	1
Paramonacanthus sp.	1	0	1	1
Pelates quadrilineatus (Bloch, 1790)	0	0	0	1
Total	54	98	82	178

Catch compositions. The results of the comparative fishing trials between gapped and conventional designs of crab pots in terms of the mean ($\bar{x}$± SE) number of individuals caught for *P. pelagicus* (target), non-target species, and the total or pooled catch of all *P. pelagicus* and non-targets are shown in Table 2.

The catch of the gapped DCP was composed of only 54 indv. weighing 4.11 kg, of which 65% composed of 35 indv. weighing 3.21 kg were *P. pelagicus* and 35% composed of 19 indv. weighing 0.89 kg were non-target species. Among the captured *P. pelagicus*, 66% were of legal sizes and 34% were undersized. In contrast, the conventional DCP caught a total of 98 indv. weighing a total of 4.63 kg, of which 41% comprised of 40 indv. weighing 2.83 kg were *P. pelagicus* and 59% comprised of 58 indv. weighing 1.80 kg were non-target species. Among the captured *P. pelagicus*, 42% were legal-sized and 58% were undersized. The results of the Mann–Whitney Test showed that the mean catch of the combined *P. pelagicus* (legal-sized + undersized) was not significantly different between gapped and conventional DCP ($P > 0.05$). When the *P. pelagicus* catch was grouped into legal and undersized, Mann–Whitney Test results showed that the catch of both were also not significantly different between treatments ($P > 0.05$). However, in terms of non-target species, the catch in the gapped with 1.58 ± 0.40 indv. was significantly lower than the conventional DCP with 4.83 ± 1.36 indv. ($P < 0.05$). Congruently, the total catch (*P. pelagicus* + other species) was significantly lower in the gapped with 4.50 ± 0.94 indv. compared to the conventional design with 8.17 ± 1.38 indv. ($P < 0.05$).

For BCP, the gapped design caught a total of 82 indv. weighing 6.72 kg, of which, more than half or 61% composed of 50 indv. weighing 5.70 kg were *P. pelagicus* and the remaining 39% composed of 32 indv. weighing 1.65 kg were non-target species. The bulk of the *P. pelagicus* catch (86%) was composed of legal-sized indv. while the rest (14%) were undersized. With the conventional design, the total catch was comprised of 178 indv. weighing 8.18 kg, of which, 36% (64 indv.) weighing 4.74 kg were *P. pelagicus* and 64% (114 indv.) weighing 3.44 kg were non-target species. Of the total *P. pelagicus*, 47% were of legal sizes while more than half (53%) were undersized. The Mann–Whitney Test results showed no significant difference in the combined catch of *P. pelagicus* (legal-sized + undersized) between gapped and conventional BCP ($P > 0.05$). Also, the number of legal-sized *P. pelagicus* was not significantly different between treatments ($P > 0.05$). However, the number of undersized *P. pelagicus* was significantly lower in the gapped with 0.58 ± 0.29 indv. compared to the conventional BCP with 2.83±0.90 indv. ($P < 0.05$). Further, the average number of non-target species was also significantly lower in the gapped with 2.67 ± 0.05 indv. than in conventional design with 9.50 ± 1.25 indv. ($P < 0.01$). As expected, the mean total catch of the gapped with 6.83 ± 0.76 indv. was significantly lower compared to the conventional BCP with 14.83 ± 1.80 indv. ($P < 0.01$).

Size composition of catch. The size composition of *P. pelagicus* caught in the two designs of DCP and BCP are shown in Figs. 4, 5. Sizes of *P. pelagicus* in DCP ranged from 91–133 mm CW in the gapped, while 76–138 mm CW in the conventional design. The class size of undersized catch with most occurrence was 92–96 mm CW with 7 indv. in the gapped (Fig. 4A), while 82–86 mm CW with 10 indv. in the conventional (Fig. 4B) DCP.

For BCP, sizes of *P. pelagicus* ranged from 80–150 mm CW in the gapped, while 74–141 mm CW in the conventional design. The class size with most occurrence in BCP was 97–101 mm CW with 5 indv. in the gapped (Fig. 5A), while 77–81 cm CW with 9 indv. in the conventional (Fig. 5B).

Catch species richness. The catch of the two types of crab pots (DCP and BCP) were basically composed of three major animal groups including crabs, shells and fishes as presented in Table 1. For DCP, the gapped pots caught 5 crab species including *P. pelagicus*, 2 shell species and 3 fish species, while the conventional design caught 4, 1, and 3 species, respectively. Based on the Mann–Whitney Test result, the number of species caught in the gapped with a mean of 2.17 ± 0.21 species was significantly lower ($P < 0.05$) compared to the conventional design with a mean of 3.00 ± 0.28 species (Fig. 6).

For BCP, the gapped design caught 6 crabs, 1 shell and 3 fish species, while the conventional design caught 5, 1, and 7 species, respectively. The Mann–Whitney Test results showed no significant difference in the species richness between gapped and conventional BCP with a mean of 2.75 ± 0.22 and 3.50 ± 0.36 species, respectively (Fig. 7).

Catch rates. In this study, catch rate expressed as catch per unit effort (CPUE) refers to the number of individuals caught per pot (indv./pot). The mean CPUE (indv./pot) of the two designs (gapped and conventional) of DCP and BCP are shown in Table 3. Further, the mean CPUE in terms of weight (g/pot) for *P. pelagicus* in both DCP and BCP are shown in Table 4.

Table 2. Average ($\bar{x}$ ± SE) and total catch (number of individuals) of the gapped and conventional designs of the dome-type and box-type crab pots.

Catch	Dome				Box			
	Gapped		Conventional		Gapped		Conventional	
	$\bar{x}$ ± SE	Total	$\bar{x}$ ± SE	Total	$\bar{x}$ ± SE	Total	$\bar{x}$ ± SE	Total
Portunus pelagicus (target)								
Legal-sized (L)	1.92 ± 0.65^{ns}	23	1.42 ± 0.53^{ns}	17	3.58 ± 0.73^{ns}	43	2.50 ± 0.60^{ns}	30
Undersized (U)	1.00 ± 0.21^{ns}	12	1.92 ± 0.45^{ns}	23	0.58 ± 0.29^{b}	7	2.83 ± 0.90^{a}	34
Total *P. pelagicus* (L + U)	2.92 ± 0.70^{ns}	35	3.33 ± 0.56^{ns}	40	4.17 ± 0.77^{ns}	50	5.33 ± 1.12^{ns}	64
Other species	1.58 ± 0.40^{b}	19	4.83 ± 1.36^{a}	58	2.67 ± 0.05^{b}	32	9.50 ± 1.25^{a}	114
All species	4.50 ± 0.94^{b}	54	8.17 ± 1.38^{a}	98	6.83 ± 0.76^{b}	82	14.83 ± 1.80^{a}	178

Different letter notations indicate significant difference in the catch between gapped and conventional designs.
"ns" indicates no significant difference.

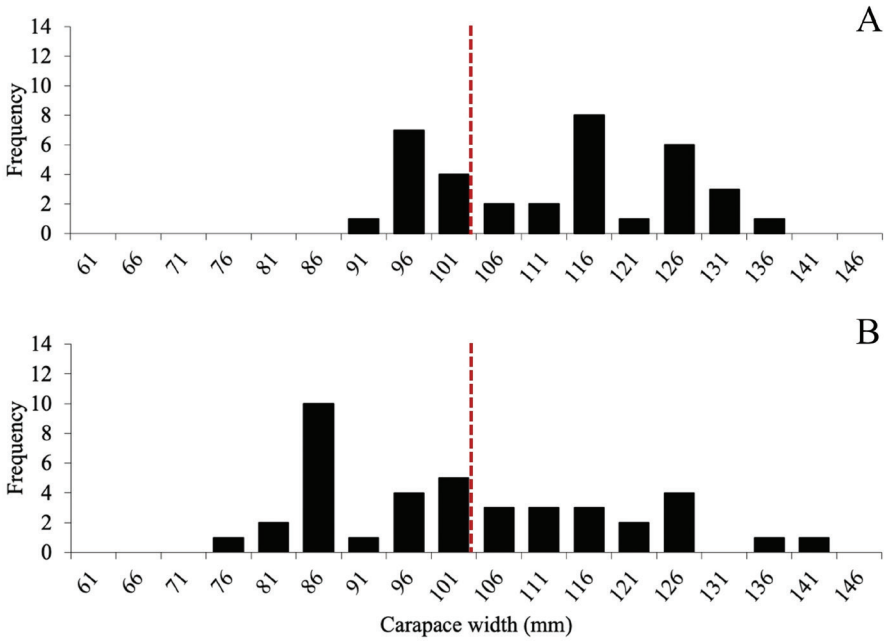

Figure 4. Size frequency distribution of blue swimming crab in gapped (**A**) and conventional (**B**) dome-type crab pot. The red broken line shows the boundary between the undersized (left) and legal-sized (right) crabs.

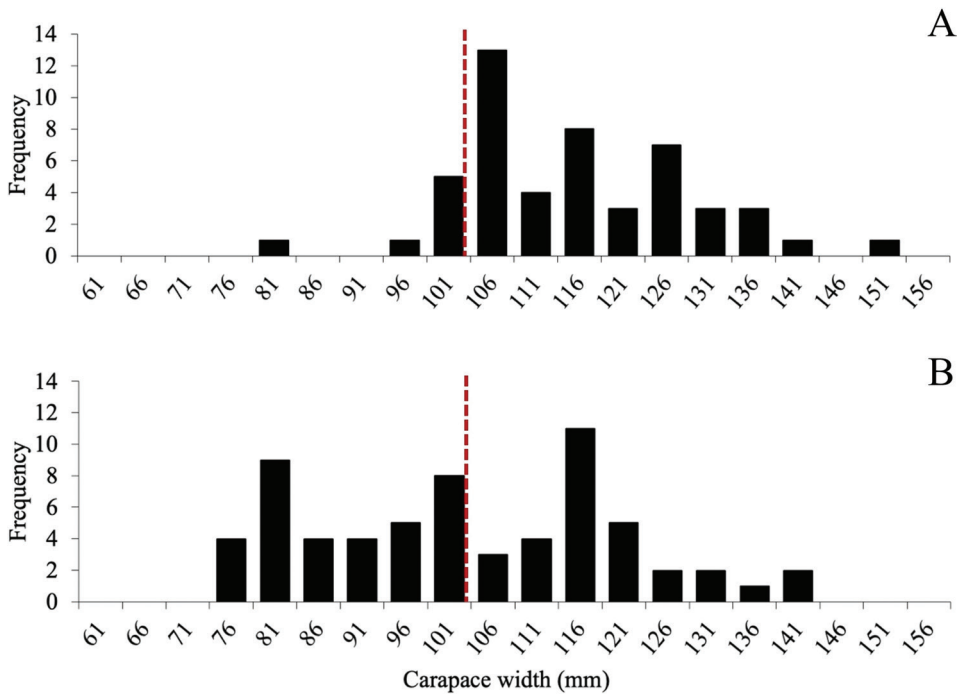

Figure 5. Size frequency distribution of blue swimming crab in gapped (**A**) and conventional (**B**) box-type crab pot. The red broken line shows the boundary between the undersized (left) and legal-sized (right) crabs.

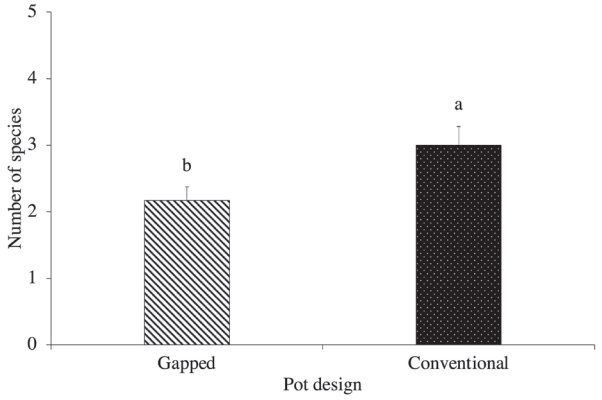

Figure 6. Number of species caught ($\bar{x}$± SE) in the gapped and conventional dome-type crab pot. Different letter notations indicate significant difference in the catch species richness between pot designs ($P < 0.05$) compared by Mann–Whitney test.

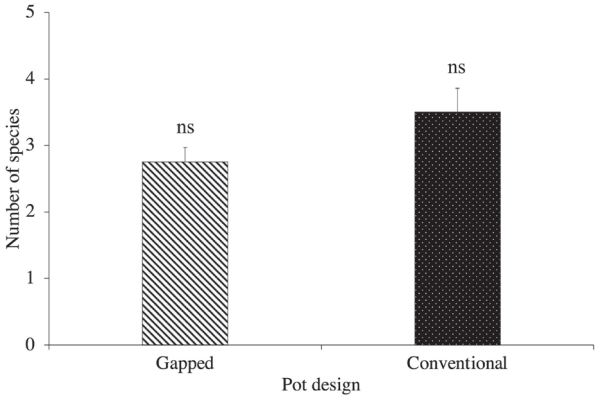

Figure 7. Number of species caught ($\bar{x}$± SE) in the gapped and conventional box-type crab pot. The notation "ns" indicates no significant difference in the catch species richness between pot designs ($P > 0.05$) compared by Mann–Whitney test.

In DCP, the result showed no significant difference in the mean CPUE indv./pot of the *P. pelagicus* catch, whether the legal-sized, undersized or the combined catch ($P > 0.05$). Consistently, the CPUE g/pot for *P. pelagicus* showed no significant difference ($P > 0.05$) between the two DCP designs. In contrast, the CPUE indv./pot of the non-target species was significantly lower in the gapped compared to the conventional design ($P < 0.05$). The CPUE indv./pot of the total catch which included all *P. pelagicus* and non-target species was also significantly lower in the gapped design ($P < 0.05$).

Similar results were recorded in BCP. The mean CPUE indv./pot of the legal-sized and combined catch of *P. pelagicus* were not significantly different between gapped and conventional designs ($P > 0.05$). On the other hand, when considering only the undersized *P. pelagicus*, the CPUE both in terms of indv./pot and g/pot were significantly lower in the gapped compared to the conventional BCP ($P < 0.05$). Similarly, the CPUE indv./pot of the non-target species and the total catch (all *P. pelagicus* and non-target species) were also significantly lower in the gapped BCP ($P < 0.01$).

Catch retrieval and sorting. In this study, the average time spent in the retrieval and sorting of catch are shown in Figs. 8, 9. The Mann–Whitney Test result showed a significant difference in the catch retrieval and sorting time between the gapped and conventional DCP. The average time spent for the retrieval and sorting of catch was lower in the gapped with only 7.81 ± 1.99 min compared

Table 3. Mean catch per unit effort in terms of the number of individuals caught in the gapped and conventional design of dome-type and box-type crab pots.

Catch	CPUE ($\bar{x}$± SE), indv./pot			
	Dome		Box	
	Gapped	Conventional	Gapped	Conventional
Portunus pelagicus (target)				
Legal-sized	0.13 ± 0.04^{ns}	0.09 ± 0.04^{ns}	0.24 ± 0.05^{ns}	0.17 ± 0.04^{ns}
Undersized	0.07 ± 0.01^{ns}	0.13 ± 0.03^{ns}	0.04 ± 0.02^{b}	0.19 ± 0.06^{a}
Total (L+U)	0.19 ± 0.05^{ns}	0.22 ± 0.04^{ns}	0.28 ± 0.05^{ns}	0.36 ± 0.07^{ns}
Non-target species	0.11 ± 0.03^{b}	0.32 ± 0.09^{a}	0.18 ± 0.04^{b}	0.63 ± 0.08^{a}
Total catch	0.30 ± 0.06^{b}	0.54 ± 0.09^{a}	0.46 ± 0.05^{b}	0.99 ± 0.12^{a}

Different letter notations indicate significant difference in the catch between gapped and conventional designs.
"ns" indicates no significant difference.

Table 4. Mean catch per unit effort in terms of weight (g) of blue swimming crab caught in the gapped and conventional design of dome-type and box-type crab pots.

Catch	CPUE ($\bar{x}$± SE), (g/pot)			
	Dome		Box	
	Gapped	Conventional	Gapped	Conventional
Portunus pelagicus catch				
Legal-sized	14.38 ± 5.06^{ns}	10.32 ± 3.67^{ns}	26.03 ± 5.61^{ns}	18.59 ± 4.65^{ns}
Undersized	3.47 ± 0.72^{ns}	5.38 ± 1.05^{ns}	2.14 ± 1.13^{b}	7.72 ± 2.09^{a}
Total (L+U)	17.85 ± 5.21^{ns}	15.70 ± 3.75^{ns}	28.17 ± 5.48^{ns}	26.32 ± 5.14^{ns}

Different letter notations indicate significant difference in the catch between gapped and conventional designs.
"ns" indicates no significant difference.

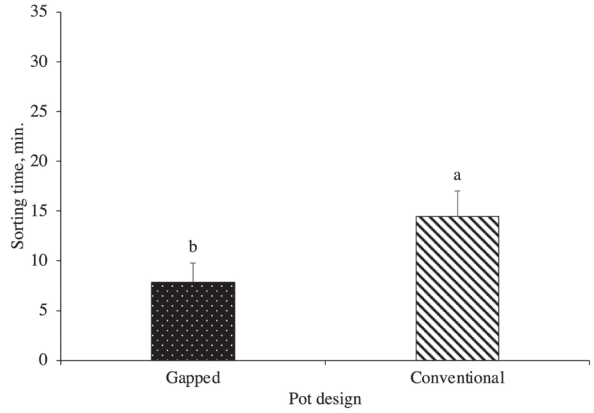

Figure 8. Average time ($\bar{x}$± SE) spent in the retrieval and sorting of catch from the gapped and conventional dome-type crab pot. Different letter notations indicate significant difference in the average time between pot designs (Mann–Whitney test, $P < 0.05$).

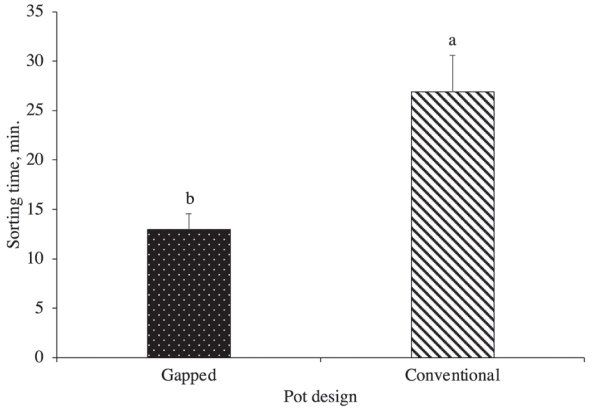

Figure 9. Average time ($\bar{x}$± SE) spent in the retrieval and sorting of catch from gapped and conventional box-type crab pot. Different letter notations indicate significant difference in the average time between pot designs (Mann–Whitney test, $P < 0.01$).

to the conventional design of DCP with 14.45 ± 2.60 min (Fig. 8, $P < 0.05$). A similar result was obtained in the BCP, in which, the average time spent was also significantly lower in the gapped with only 12.94 ± 1.64 min compared to the conventional BCP with 26.92 ± 3.69 min (Fig. 9, $P < 0.01$).

In a typical fishing operation in the area, fishers do the retrieve-bait-set strategy. After retrieval of catch per pot, the stick (where bait is skewered) is placed with a new set of bait and the gear is set again underwater. If catch is good, the gears are set in the same location. If catch is poor, the pots are set in another location. Upon landing at the shore, *P. pelagicus* catch is placed in a cylindrical polyethylene net. The net is then tied to the boat and is left soaked in water at the shore. The collector/middleman comes in the morning of the next day and collects the catch. Other economically-important species that compose the catch are placed in another container or just on the boat's deck and are usually brought home for household consumption. However, it is common that bycatch of economic value per fishing operation is only rare. In such cases, fishers typically choose to discard them especially those with small size such as *C. hellerii* and other juvenile fish like terapon.

Discussion

Effect of escape gap in catch composition of crab pots. Assessing the catch composition of fishing gears is necessary in providing relevant information that could help in identifying the potential impacts of a particular fishery to various marine organisms and the ecosystem as a whole (Cerbule et al. 2022). In this study the catch composition of gapped (experimental) and conventional designs of the two types of crab pots namely: DCP and BCP were examined. Based on the results (Table 1), the trend of the performance of the gapped and conventional designs were similar in DCP and BCP. The proportion of the combined catch of *P. pelagicus* (target species) was generally higher in the gapped with >50% (65% in DCP and 61% in BCP), while lower in the conventional design with <50% (41% in DCP and 36% in BCP). In contrast, the proportion of the non-target catch was generally lower in the gapped (35% in DCP and 39% in BCP) than the conventional design (59% in DCP and 64% in BCP). In the report of Nieves et al. (2013), the crab pot catch in San Miguel Bay was comprised of 31.79% *P. pelagicus*. On the other hand, Abrenica et al. (2021) reported an almost homogeneous *P. pelagicus* catch (reaching to 99.9%) from the crab pots used in Danajon Bank, Bohol. Mesa et al. (2018) also reported a high percentage of *P. pelagicus* catch (93.49%) from crab pots used in the Western Visayan Sea. In San Pedro Bay, Picoy-Gonzales and Monteclaro (2017) reported that *P. pelagicus* comprised only 15%–29% of the total catch of crab entangling nets of different heights. These prove that the catch composition varies from site to site, depending on the status of the stock and the overall condition of the ecosystem in the area as well as the different anthropogenic activities therein which affect the aforementioned factors.

Considering the target species alone, the catch trend of *P. pelagicus* in the gapped and conventional designs in DCP and BCP was similar. The catch of undersized *P. pelagicus* was generally reduced in the gapped (34% in DCP and 14% in BCP) compared to the conventional design (58% in DCP and 53% in BCP). Conversely, the catch of legal-sized *P. pelagicus* was higher in the gapped (66% in DCP and 86% in BCP) than in the conventional design (42% in DCP and 47% in BCP). By examining closely, it was found that the installation of escape gap has no significant effect on the catch of *P. pelagicus* particularly the legal-sized ones for both DCP and BCP. The size profile of *P. pelagicus* where range is generally narrower and that these sizes are somehow inclined to the right side of the "*x*" axis (carapace width) in the gapped design for both DCP and BCP supports that the *P. pelagicus* catch in the gapped was generally of larger sizes compared to the conventional design. This can be attributed to the high capacity of the escape gap in retaining the legal-sized individuals inside the gear owing to its design where only undersized individuals can get through it. For this reason, the undersized crabs were significantly reduced in the gapped design especially in BCP. The catch of undersized *P. pelagicus* was reduced by 48 percentage points and 79 percentage points in gapped DCP and BCP, respectively. The sub-legal or undersized crabs that had escaped from fishing gears would contribute to the future recruitment of the stock (Stearns et al. 2017). These undersized escapees will have a chance to grow bigger and spawn. This reduction in the undersized *P. pelagicus* will be a significant help in achieving sustainable goals for the fishery. In the study of Broadhurst et al. (2017) in the same fishery in Australia, the use of escape gaps of different designs also resulted in a significant reduction of undersized *P. pelagicus* from 51% to 100%, without affecting the legal catch. Similar results were reported in the Dungeness crab *Metacarcinus magister* fishery in Washington with the use of the two modified box-type traps with four additional escape rings, of which, one with standard size of 10.8 cm (4.25 inches) and the other with 11.4 cm (4.5 inches) (Stearns et al. 2017). The rings significantly reduced the catch of sub-legal crabs at 51.2% (in traps with 10.8 cm ring) and 82.2% (in traps with 11.4 cm ring). On the other hand, the study of Zhang et al. (2023) showed that the use of an escape vent of different designs was not able to meet the goal of reducing the sublegal while retaining the legal crabs in relation to the interim minimum legal size (MLS) of *Portunus trituberculatus* (Miers, 1876) set at 49 mm carapace length (CL) in Zhejiang Province in China. But, in reference to the previous MLS that was set at 60 mm CL, the escape vent was able to reduce the sublegal-sized crabs by 52% and 91% with the use of 33 mm rectangular and 40 mm elliptic vents, respectively. At the same time, the respective vents retained 1.05 and 1.10 times of the legal-sized *P. trituberculatus*.

Bycatch of non-target species is one of the major issues in fisheries that has received much attention due to its potential ecological impacts (Rotherham et al. 2013). Bycatch mortality from fishing is considered as a major threat to marine biodiversity, wherein, even those seemingly resilient species could be at risk (e.g., a high proportion of the catch in shrimp trawlers are comprised of juvenile fish) (Lobo 2012). The continuous mortality of juvenile bycatch can hamper the recovery of both the target and non-target species. As such, the reduction of bycatch is presumed to have long-term biological and socio-economic benefits and improves the reputation of a fishery (Suuronen 2022). With the use of escape gap in this study, the catch of the non-target species in the *P. pelagicus* fishery was significantly reduced by 67 percentage points in DCP and by 72 percentage points in BCP. Like the case of the undersized *P. pelagicus*, non-target species can also escape from the gear through the gaps provided, particularly those species of smaller sizes. Similar results were observed in the data presented by Broadhurst et al. (2017) where catch of the non-target species was also reduced in the gapped traps used in Australia. In the fishery of mud crab in New South Wales, the use of escape gaps also lessened the capture of yellowfin bream bycatch by 53 percentage points to 78 percentage points (Rotherham et al. 2013).

As expected, the mean total catch (all *P. pelagicus* and non-target species) in terms of the number of individuals caught was significantly lower in the gapped compared to the conventional design of both DCP and BCP since a significant number of non-target species were able to escape from the gapped pots. On the other hand, looking at the weight attribute, it can be noted that the total weight of the gapped was comparable to that of the conventional. In DCP, the number of individuals caught in the gapped was only 55% of the conventional, but in terms of weight, the gapped weighed 86% of the latter. Similarly, gapped BCP basically caught only 46% of the catch in the conventional in terms of number, but the former weighed 82% of the latter. This can be explained by the fact that more than half of the individuals caught in the conventional were non-target species, in which most were of relatively smaller sizes, especially *Charybdis anisodon* which composed 43% of the total catch in DCP and 49% in BCP.

The results of this study clearly show the potential of escape gap as a simple measure that may help promote the sustainability of *P. pelagicus* fishery in the Philippines by reducing the catch of undersized as well as non-target species in crab pot gears. Aside from the environmental stresses such as barotrauma and increase in temperature, undersized crabs that are retained inside the pot can get injured due to the interaction with larger crabs therein (Stearns et al. 2017). The crab pot fishers in the study area also shared their actual observation in the field where octopus preys on the crab inside the pot. Octopus is considered as the primary predator of *P. pelagicus* (see Ingles unpublished[*]). With the use of escape gap, the survival probability of undersized individuals is increased since they have a high chance of escape right underwater. The onboard sorting time is also decreased given the reduced presence of non-target organisms and undersized *P. pelagicus* in the pots, thus making the catch retrieval and the overall fishing operation generally faster.

Effect of escape gap on catch rate. The escape gaps with flap in DCP and BCP did not significantly affect the CPUE of the target catch *P. pelagicus*. More importantly, the CPUE of the legal-sized *P. pelagicus* was not significantly affected by the installation of the selectivity tool. It can be noted that capture of legal-sized *P. pelagicus* was generally higher in the gapped than the conventional design by 26 percentage points in DCP and by 30 percentage points in BCP. The antagonistic behavior of *P. pelagicus* due to the competition for food and/or space inside the gear may also help in prompting the escape of undersized, while those of legal sizes would not be able to get out through the gap since they will not fit in it, thus increasing the selectivity potential of the escape gap. With the reduction of the smaller-sized crabs inside the gear, the pot saturation phenomenon is minimized, and the capture of larger-sized crabs is increased (Zhang et al. 2023) given that more space become available for them. Thus, a comparable CPUE between the gapped and conventional design in both DCP and BCP was achieved. This finding is important to increase the probability of acceptance among fishers who will be the end users of the measure.

The study of Abrenica et al. (2021) recorded a mean annual CPUE of crab pot operated in Danajon Bank at 4.23 kg · day^{-1}. Though the number of pots used per day was not clearly indicated, the author's report mentioned that there were 3000 units of crab pot used in the area owned by 17 fishers, so roughly, each fisher owned 176 units. This then gives a CPUE of 24 g · pot^{-1}. Mesa et al. (2018) reported that the annual mean CPUE of crab pot in the Western Visayan Sea where *P. pelagicus* composed 93.49% was 4.61 kg · day^{-1} in 2011 and 5.61 kg · day^{-1} in 2012. Though the number of pots used per fishing operation was also not indicated, the study mentioned that the crab pot fishers used 200–300 pots per operation, thus giving a mean CPUE per pot (at 250 units of pot per fishing operation) at 18.44 g and 22.44 g in 2011 and 2012, respectively. The CPUEs obtained in this study were actually close to the CPUEs reported in the previous studies mentioned where the mean CPUE of *P. pelagicus* alone in terms of weight were 17.85 g · pot^{-1} for the gapped and 15.70 g · pot^{-1} for the conventional DCP, while 28.17 g · pot^{-1} for the gapped and 26.32 g · pot^{-1} for the conventional BCP.

Bycatch or non-target species were also caught in the gapped and conventional DCP and BCP. Bycatch in all types of fishing gears are unavoidable with possible exception of highly selective gears such as harpoon and spear (Morgan and Chuenpagdee 2003). In this study, the CPUE of bycatch was also significantly reduced in the gapped design of both DCP and BCP. Though there might be a little loss from the smaller-sized commercially valuable non-target species that had escaped, this might be replaced by larger-sized *P. pelagicus* or other larger-sized species with higher commercial value. Additionally, those that escaped will still have a chance to grow bigger and possess a subsequent higher market value. Thus, the reduction of bycatch may have a little short-term disadvantage, but a long-term economic benefit can be expected. Bycatch has been a major conservation issue in marine fisheries, globally (Zimmerhackel et al. 2015). It is considered as a major threat to biodiversity (Lobo

* Ingles J (1996) The crab fishery off Bantayan, Cebu, Philippines. Report submitted to the Philippine Council for Marine and Aquatic Resources Research and Development. Institute of Marine Fisheries and Oceanology, University of the Philippines-Visayas, Iloilo, Philippines.

2012; Perez Roda et al. 2019). Bycatch that are discarded often die and therefore can no longer reproduce which would eventually impact marine ecosystems. Bycatch may alter the availability of prey and so affect fisheries productivity. Species vary in their capacity to withstand elevated mortality primary caused by fishing (Jennings and Revill 2007). Bycatch of overexploited species will slow the stock's recovery, and put low productive, threatened and endangered species into further peril. Thus, the reduction of bycatch, especially those non-economically important species, would be beneficial to the ecosystem, and would help improve the reputation of fisheries (Suuronen 2022). Those that were able to escape could continue their role in maintaining the biodiversity in the area, and the ecosystem integrity as a whole. Thus, measures that are effective and practical to use for the reduction of bycatch such as the use of an escape gap in crab pots will be helpful in minimizing the biological and ecological impact of the *P. pelagicus* fishery.

Effect of escape gap on catch species richness. Catch species richness refers to the number of species in each sample (Tikadar et al. 2021). It accounts for the total number of species caught including the target and bycatch species. In this study, the catch species richness was measured by the number of species composing the catch in each fishing operation.

The results of this study showed the utility of the escape gap in reducing the catch species richness in crab pots especially in DCP. This means that fewer number of species or bycatch are caught in the gapped compared to the conventional DCP units. In BCP, though the difference in the species richness between the two designs was not significant, catch in the gapped was generally 1–2 species fewer per fishing operation. Most of the non-target species caught in the gapped design for both DCP and BCP were composed only of a single individual—suggesting that the abundance of each bycatch species in the catch is low. In the *P. pelagicus* fishery in Thailand, the same bycatch species were caught in the vented and conventional crab pots. But in terms of the number of individuals, fewer were caught in the vented design (Boutson et al. 2009). In another comparative fishing trial in Montserrat, the use of a 2.5 cm gap in fish traps showed no effect on the catch species richness of the gear. On the other hand, the proportion of smaller-sized and immature fish species were generally lower in the gapped traps (Flower et al. 2021).

In this study, most of the non-target species caught were without value or had only low market value such as *C. anisodon*, *C. hellerii*, and *T. crenata*. As shared by the fishers in the study area, when the catch of the aforementioned smaller crabs is few per fishing operation, which happens often, these are just discarded by them. However, when catch of these species is high, which happens very seldom, these are sold at PhP 100.00 per medium-sized pail with approximate weight of 4 kg. These are also sometimes brought home by the fishers for their own consumption, especially during difficult times. The reduction in the species richness of the catch in crab pots would mean that the impact of the fishery on other species or biodiversity and ultimately to the ecosystem as a whole is also minimized.

Based on the results, the authors suggest the promotion of the use of escape gaps in the crab pot gears used in the blue swimming crab fishery in the Philippines. The results of this study should be disseminated to the fisheries' policy makers, and crab pot fishers to inform them of the potential advantages of using the selectivity tool in the fishery, thus encouraging them to use it. Necessary adjustments of the escape gap design, particularly its size, must be done based on the possible adjusted minimum legal size for *P. pelagicus* in the future, which will depend on the results of monitoring and biological studies of the resource.

Conclusion

This study showed the viability of gapped crab pots for the blue swimming crab *Portunus pelagicus* fishery. Technologically, the construction and installation of the escape gaps with flap is simple and easy. Ecologically, the use of escape gaps with flap in crab pots is shown to be an effective tool for the reduction of undersized *P. pelagicus*, non-target species, and catch species richness. Equally important, the use of the tool does not reduce the catch of the legal-sized *P. pelagicus*. The use of the tool also reduces the sorting and retrieval time of the catch owing to the improved selectivity of the gear, translating to higher efficiency of the fishing operation. Thus, the use of an escape gap in the crab pot gears targeting *P. pelagicus* is a potential practical management measure that may help in promoting the sustainability of the blue swimming crab fishery in Eastern Visayas, Philippines.

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References

Abrenica BT, Fajardo MJM, Paran JS, Ruinata MN, Espino MS, Poquita AL (2021) Stock assessment of the blue swimming crab *Portunus pelagicus* (Linnaeus, 1758) in stock enhancement sites of Danajon Bank, Central Philippines. Philippine Journal of Fisheries 28: 210–227. https://doi.org/10.31398/tpjf/28.2.2020C0014

Alverson DL, Freeberg MH, Murawski SA, Pope JG (1994) A global assessment of fisheries bycatch and discards. FAO Fisheries Technical Paper. FAO, Rome.

Anonymous (2016) A study on the perceived impacts of waste and waste water on aquaculture and capture fisheries at San Juanico Strait. NGOs for Fisheries Reform, the Philippines.

Archdale MV, Añasco CP, Hiromori S (2006) Comparative fishing trials for invasive swimming crabs *Charybdis japonica* and *Portunus pelagicus* using collapsible pots. Fisheries Research 82: 50–55. https://doi.org/10.1016/j.fishres.2006.08.009

Bjordal A (2002) The use of technical measures in responsible fisheries: Regulation of fishing gear. FAO, Rome.

Boutson A (2008) Behavior of blue swimming crab for improving catch selectivity and efficiency of collapsible pot in Thailand. PhD Thesis, Tokyo University of Marine Science and Technology, Tokyo, Japan.

Boutson A, Mahasawasde C, Mahasawasde S, Tunkijjanukij S, Arimoto T (2009) Use of escape vents to improve size and species selectivity of collapsible pot for blue swimming crab *Portunus pelagicus* in Thailand. Fisheries Science 75: 25–33. https://doi.org/10.1007/s12562-008-0010-z

Broadhurst MK, Millar RB, Hughes B (2017) Performance of industry-developed escape gaps in Australian *Portunus pelagicus* traps. Fisheries Research 187: 120–126. https://doi.org/10.1016/j.fishres.2016.11.013

Broadhurst MK, Tolhurst DJ, Hughes B, Raoult V, Smith TM, Gaston TF (2020) Optimising mesh size with escape gaps in a dual-species portunid-trap fishery. Aquaculture and Fisheries 5(6): 308–316. https://doi.org/10.1016/j.aaf.2019.12.007

Bureau of Fisheries and Aquatic Resources (BFAR) (2023) The 2022 Philippine Fisheries Profile. BFAR, Philippines. https://www.bfar.da.gov.ph/wp-content/uploads/2024/02/2022-Philippine-Fisheries-Profile.pdf

Cerbule K, Savina E, Herrmann B, Larsen RB, Feekings JP, Krag LA, Pellegrinelli A (2022) Quantification of catch composition in fisheries: A methodology and its application to compare biodegradable and nylon gillnets. Journal for Nature Conservation 70: 126298. https://doi.org/10.1016/j.jnc.2022.126298

de la Cruz MT, de la Cruz JO, Ruizo EKC, Tan IL (2018) The blue swimming crab fishers and fishing practices in Leyte and Samar, Philippines. Philippine Journal of Fisheries 25(2): 1–15. https://doi.org/10.31398/tpjf/25.2.2018-0001

Flower J, Estep A, James K, Ramdeen R, Runge CA, Thomas L, Lester SE (2021) An experimental evaluation of the effect of escape gaps on the quantity, diversity, and size of fish caught in traps in Montserrat. PLoS ONE 16(12): e0261119. https://doi.org/10.1371/journal.pone.0261119

Froese R, Pauly D [Eds] (2024) FishBase. [Version 06/2024] http://www.fishbase.org

Hamid A, Kamri S (2021) Bycatch biodiversity of blue swimming crab (*Portunus pelagicus*) fisheries in Kolono Bay, Southeast Sulawesi, Indonesia. Aquaculture, Aquarium, Conservation and Legislation 14(3): 1548–1560.

Ingles JA (2004) Status of the blue crab fisheries in the Philippines. In: DA BFAR (Department of Agriculture-Bureau of Fisheries and Aquatic Resources). In turbulent seas: The status of Philippine marine fisheries. Coastal Resource Management Project, Cebu City, Philippines, pp. 47–52.

Jennings S, Revill AS (2007) The role of gear technologists in supporting an ecosystem approach to fisheries. ICES Journal of Marine Science 64(8): 1525–1534. https://doi.org/10.1093/icesjms/fsm104

Ljungberg P, Lunneryd S, Lovgren J, Konigson S (2016) Underwater observations of cod: Including cod (*Gadus morhua*) behavioral analysis to evaluate entrance type dependent pot catch in the Baltic Sea. Journal of Ocean Technology 11(4): 49–63.

Lobo AS (2012) Managing fisheries and ocean bycatch. Coastal Ecology and Marine Resources Centre, Energy and Resources Institute, Goa.

Meintzer P, Walsh P, Favaro B (2018) Comparing catch efficiency of five models of pot for use in a Newfoundland and Labrador cod fishery. PLoS ONE 13(6): e0199702. https://doi.org/10.1371/journal.pone.0199702

Mesa SV, Bayate DEE, Guanco MR (2018) Blue swimming crab stock assessment in the western Visayan Sea. ~~The~~ Philippine Journal of Fisheries 24: 77–94. https://doi.org/10.31398/tpjf/25.1.2017C0008

Morgan LE, Chuenpagdee R (2003) Shifting gears. Addressing the collateral impacts of fishing methods in U.S. Waters. PEW Science Series. https://doi.org/10.2307/3868162

Motoh H, Kuronuma K (1980) Field guide for the edible crustacea of the Philippines. Aquaculture Department, Southeast Asian Fisheries Development Center, Iloilo, Philippines, 96 pp.

Naimullah M, Lee W, Wu Y, Chen Y, Huang Y, Liao C, Lan K (2022) Effect of soaking time on targets and bycatch species catch rates in fish and crab trap fishery in the southern East China Sea. Fisheries Research 250: e106258. https://doi.org/10.1016/j.fishres.2022.106258

Najmudeen TM, Sathiadhas R (2008) Economic impact of juvenile fishing in a tropical multi-gear multi-species fishery. Fisheries Research 92: 322–332. https://doi.org/10.1016/j.fishres.2008.02.001

Nieves PM, de Jesus S, Guiriba MAB, Macale AMB, Belen S, Corral G (2013) Capture fisheries assessment of commercially important marine crabs in Sorsogon Bay and San Miguel Bay. Kuroshio Science 7: 59–67.

Palomares MLD, Pauly D (2024) SeaLifeBase. www.sealifebase.org

Perez Roda MA, Gilman E, Huntington T, Kennelly SJ, Suuronen P, Chaloupka M, Medley P (2019) A third assessment of global marine fisheries discards. FAO Fisheries and Aquaculture Technical Paper No. 633. FAO, Rome.

Picoy-Gonzales RM, Monteclaro HM (2017) Effects of net height of crab entangling nets on the capture of targeted economically important portunid species and non-target species. Fisheries Science 83: 907–915. https://doi.org/10.1007/s12562-017-1126-9

Rotherham D, Johnson DD, Macbeth WG, Gray CA (2013) Escape gaps as a management strategy for reducing bycatch in net-covered traps for the giant mud crab *Scylla serrata.* North American Journal of Fisheries Management 33(2): 307–317. https://doi.org/10.1080/02755947.2012.760502

Stearns G, Conrad R, Winfrey D, Shippentower-Games N, Finley D (2017) Dungeness crab trap catch efficiency related to escape ring location and size. North American Journal of Fisheries Management 37(5): 1039–1044. https://doi.org/10.1080/02755947.2017.1345807

Suuronen P (2022) Understanding perspectives and barriers that affect fishers' responses to bycatch reduction technologies. ICES Journal of Marine Science 79(4): 1015–1023. https://doi.org/10.1093/icesjms/fsac045

Tikadar KK, Kunda M, Mazumder SK (2021) Diversity of fishery resources and catch efficiency of fishing gears in Gorai River, Bangladesh. Heliyon 7(12): 1–13. https://doi.org/10.1016/j.heliyon.2021.e08478

Watanabe Y, Sasakawa Y (1984) A preliminary note on pot selections for the size of the rock crab. Bulletin of the Faculty of Fisheries Hokkaido University 35(4): 225–233.

White WT, Last PR, Dharmadi, Faizah R, Chodrijah U, Prisantoso BI, Pogonoski JJ, Puckridge M, Blaber SJM (2013) Market fishes of Indonesia (Jenisjenisikan di Indonesia). ACIAR Monograph No. 155. Australian Centre for International Agricultural Research, Canberra, 438 pp.

Winger PD, Walsh PJ (2007) The feasibility of escape mechanisms in conical snow crab traps. ICES Journal of Marine Science 64(8): 1587–1591. https://doi.org/10.1093/icesjms/fsm125

Winger PD, Walsh PJ (2011) Selectivity, efficiency, and underwater observations of modified trap designs for the snow crab (*Chionoecetes opilio*) fishery in Newfoundland and Labrador. Fisheries Research 109(1): 107–113. https://doi.org/10.1016/j.fishres.2011.01.025

Winston RB, Phiri TB, Singini W (2019) Assessment of catch composition and economic analysis of monofilament and multifilament under-meshed gears (Ngongongo) at Likoma Island, Lake Malawi. Journal of Fisheries Research 3(1): 7–17. https://doi.org/10.35841/fisheries-research.3.1.7-17

Yap-Dejeto L, Durante CY, Tan IL, Alonzo CO (2018) *Pyrodinium bahamense* and other dinoflagellate cysts in surface sediments of Cancabato Bay, Leyte, Philippines. Philippine Journal of Science 147(2): 209–220.

Zhang J, Shi X, He P, Shi J (2023) Effectiveness of escape vent shape in crab pots for releasing swimming crab *Portunus trituberculatus* in the East China sea. Aquaculture and Fisheries 8(3): 332–340. https://doi.org/10.1016/j.aaf.2021.12.007

Zimmerhackel JS, Schuhbauer AC, Usseglio P, Heel LC, Salinas-de-Leon P (2015) Catch, bycatch and discards of the Galapagos Marine Reserve small-scale handline fishery. PeerJ 3: e995. https://doi.org/10.7717/peerj.995