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THE SELECTIVITY AND EFFICIENCY OF TWO DIFFERENT TYPES OF BLUE CRAB POT IN CUBA

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ABSTRACT

Two different crab pot types, Creole pot (CP) and Escape panel pot (EPP) were measured for selectivity and catch efficiency in the blue crab fisheries in Cuba. Though the difference between mean catch rates by pot was relatively small, they were statistically different. The Creole pot caught more crabs than the Escape panel pot. However, when the catch rate between pots for animals larger than 90 mm carapace width were compared, the Escape panel pot caught more crabs. The average catch weight (g) between pots were not statistically different. Both pots showed the same pattern in the catch rates by stations with catch rates in the western station lower than in the central and east stations. Both sexes were represented in the catches with high bias towards males in both pots. A higher percentage of females were caught in the Creole pot but the mean carapace width of both sexes were lower in the Creole pot. The Creole pot retains sizes from 50 mm carapace width, while the Escape panel pot begins to exploit the blue crab stock from 75 mm carapace width. The 50 % retention length (L_{50}) in the Escape panel pot was 84.4 mm carapace width with selection range (SR) of 6.02 mm. The Escape panel pot has proven to be more efficient trap than Creole Pot in terms of maximizing the catch of legal size crabs and minimizing sublegal catch.

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1 INTRODUCTION

Cuba is an archipelago that includes thousands of smaller cays with an insular shelf of 61,525 km^2 and Exclusive Economic Zone (EEZ) of 350,751 km^2 (Carrillo and Contrera, 1998). Fishing has been an important source of revenue in Cuba and with the objective to make fisheries sustainable, the Cuban fisheries management regime has carried out some important changes in the last decade in response to stock size decreases that indicate non-sustainable utilization (Baisre, 2004).

The blue crab (*Callinectes sapidus*) fishery, like most fisheries in Cuba had a boom period in the late 1980s and early 1990s when it reached about 1500t, followed by a subsequent decline in catches until 2005 as seen in Figure 1. Since then, annual blue crab catches have been around 200t. More than 90% of the blue crab catch in the last years has come from in Buena Vista Bay (Sabana-Camaguey Ecosystem), in the northern part of Cuba which operates two landing ports. It is essential that a regular monitoring of this fishing ground is carried out.

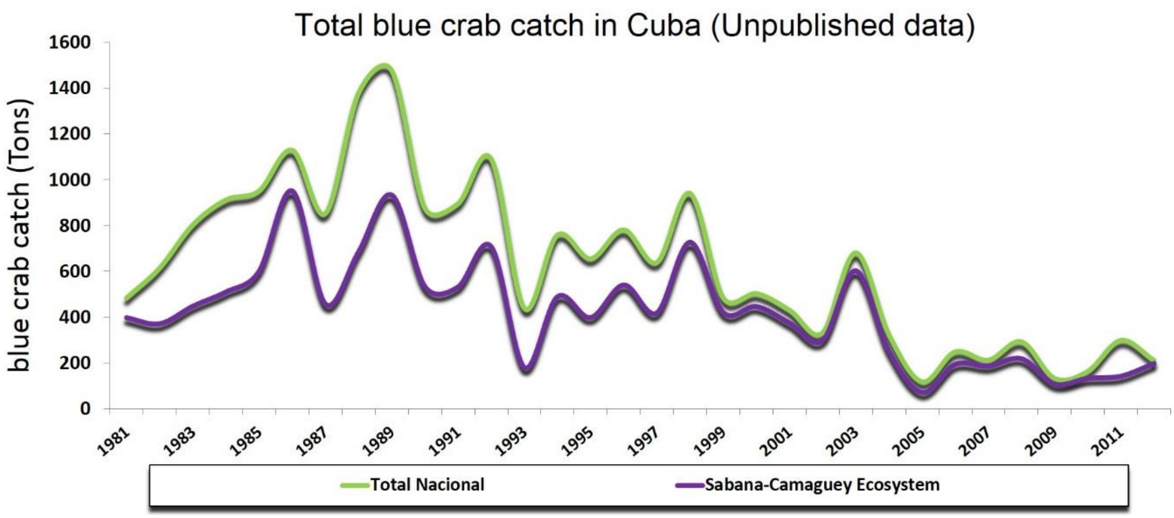

Figure 1. Blue crab catch in Cuba 1985-2012 (Fisheries Research Center, Unpublished data)

The blue crab catch in Cuba is mainly by direct fisheries in shallow water. The crab catch is exclusively by pots like in many other countries of the Caribbean region (Guillory *et al*., 2001a). The pot fisheries are considered an easy fishing method and have been widely used in many regions of the world. Pot fisheries make selective harvesting possible as individual can be released alive, so it is therefore considered from the environment point of view as a fishing method superior to other less selective gears (He and Inoue, 2010). Less energy is required for its fishing operation than for active gears and it has become an important gear for crab fisheries (Thomsen *et al*., 2010).

Recently in pot construction in Cuba, the square plastic mesh of 25 mm (1 inch), used for its durability has replaced the hexagonal wire mesh to cover the pot frame. Also, this plastic mesh has proven efficient in catching crabs (Guimenez and Delgado, 2010). Even though some authors have found that square escape vents can reduce the number of immature crab caught from 80-7.7% in some months, the square mesh size of 25 mm can retain between 32-42% of the immature blue crab (Boutson *et al*., 2009). These pots have no selective device and the fishermen operate manual selection when they discard the illegal size back to the sea.

At present no pots with escape devices or appropriate mesh sizes are used in the Cuban blue crab fisheries that permit escape of small or undersize crab. The percentage of illegal size (<90 mm carapace width) in the catch may reach 22% of the specimens and may be higher in some months and recruitment areas (Medina, 2012). Furthermore, even though this percentage is returned to water, the selectivity process is by hand and the fisherman use harpoon to remove or discard undersized specimen often causing serious damages or mortality which can otherwise be prevented. It is therefore important to use pots that have higher selectivity. The objective of this study is to measure the selectivity and catch efficiency of two different crab pot types in Cuban fishing grounds.

2 LITERATURE REVIEW

2.1 Development of pot fisheries

Traps and pots are among the oldest forms of fishing gear used and seem to have developed independently in many parts of the world. People in different parts of the world are not always referring to exactly the same things when they refer to traps and pots. According to the FAO (2001) traps are considered a passive fishing gear that allow fish to enter easily and then make escape difficult. In general traps are large structures fixed to the shore. Pots are smaller, movable traps, enclosed boxes that can be used from a boat or by hand.

Pots can be rectangular, hexagonal, conical, semi-cylindrical, or circular in shape depending on the traditional design which is often strongly related to the availability of materials for its construction. Even when modern mesh is available (wire mesh or plastic mesh) some areas have maintained their traditional design from natural materials (Thomsen *et al*., 2010).

2.2 Pot fishing in the context of world fisheries

Pots are important fishing gear for targeting crustaceans though they are not commonly used for catching fishes. In some areas of the Caribbean region where the Antillean pot (Figure 2) has been one of the most important fishing gear used, fish can account for more than 50% of the total catch (Munro *et al*., 1971).

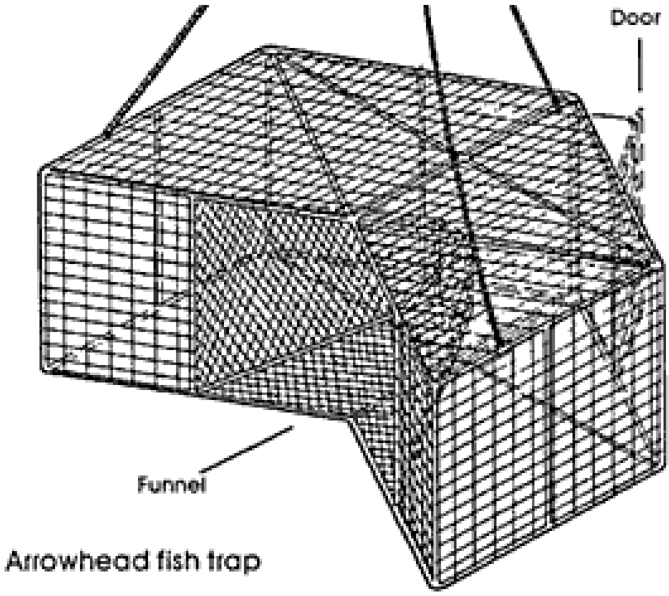

Figure 2. Antillean pot (FAO, 2001)

Shepherd *et al*., 2008 reported that 45% of the total sea bass landing are captured by pots on the eastern seaboard of the United States, and studies have shown that pots in the Caribbean have been effective in catching fish on coral reefs where the use of other fishing gears is restricted (Munro, 1972). Uncontrolled fishing effort of pot fisheries can lead to collapse of fisheries as was witnessed in the Bermuda and Jamaican coral reef fisheries (Munro, 1983; Butler *et al*., 1993).

For many researchers and fishermen, trap and pot fisheries are considered as an efficient catching method. The traps permit both the catch of the animal alive and make escape difficult once they enter the gear. Despite this consideration, in the most cases the gear selectivity which is defined as the probability that a fish or individual of given species is caught when they make contact with a specified gear is poor (Tokait and Kitahara 1989). The selection is manual and depends most often on the fishermen's ability to release live animals.

Different investigations have been carried out to improve pot selectivity and catch efficiency. They have usually focused on designs that seek to prevent the entry or facilitate undersize escape either through mesh size modification, escape vents or increased number of funnels entrance. In the Gulf of Mexico, Turkey and Thailand where there are blue crab fisheries, several experiments on pot selectivity have been done (Guillory and Prejean, 1997; Guillory and Hein, 1998; Guillory, 1998; Guillory, *et al*., 2001b; Huseyin et al., 2002; Boutson *et al*., 2009). All this research shows the need to reduce catch of undersize crabs that in most cases is higher than 50% of total catch.

2.3 Mortality rate of crab by-catch

During handling on board small sized individuals without commercial value and non-target species are discarded, but they may suffer physical injuries or physiological stress that accelerate death, on deck or after release. Discard mortality rates are poorly known and although efforts to improve the gear selectivity are ongoing, unobserved discard mortality continues to be an important source of uncertainty in fishery management (Coggins *et al*., 2007). On the other hand research on discard mortality in some species of crab, have shown mortality rates of 91%, 82.7% and 79.5 % (Stoner et al., 2008). However, in the same type of fishing gears (bottom trawls) the mortality rate reported for the tanner and red king crabs in Saint Paul Island, only reached 32% (Rose *et al*., 2012).

2.4 Fishing gear development in blue crab fisheries

Probably more types of commercial gear have been used to harvest blue crabs (*Calinectes sapidus*) than any other crab species. The primary post-1950 gear used to harvest blue crabs were traps, trotlines, drop nets and otter trawls. Other miscellaneous gears include gill nets, pound nets, beam trawls, brush traps, dredge and wind nets. Blue Crab is currently harvested almost exclusively with pot in most areas that support fisheries of this species (Guillory *et al*., 2001a).

2.5 Distribution of blue crab in the world

The genus *Callinecte* belongs to the family Portunidae which contains approximately 300 species. *Callinectes* is a warm water genus whose distribution appears to be limited by summer temperature (Millikin and Willians, 1984). The species of this genus occur regularly in water where peak temperature is above 20°C. Currently there are 15 species recognized in the genus, three in the Pacific and 12 in the Atlantic and adjacent seas (Norse, 1977).

The blue crab *Callinectes sapidus* (Rathbun, 1896) is found in tropical and subtropical areas from Nova Scotia to Uruguay, occurring in rivers, estuarine and near-shore waters of the Western Atlantic, include Bermuda, the West Indies and Caribbean Sea (Milliken and Williams, 1984). This species has been introduced into several parts of Europe; the Netherlands and adjacent North Sea, southwest France; Gulf of Genoa; northern Adriatic; Aegean, western Black and eastern Mediterranean (FAO, 2014). This species has also been reported in Japan as seen in Figure 3.

Figure 3. Distribution map of *Callinectes sapidus* in the world (FAO, 2014)

2.6 Economic and ecological importance of blue crab

Even though there are 12 species of the *Callinectes* genus in the Atlantic and adjacent seas, the blue crab, *Callinectes sapidus* support one of the most significant commercial fisheries in the USA as well as in many other countries around Atlantic, both in terms of value and weight (Mizerek, 2012).The global catch fluctuated between 80,000 to 120,000 t in 1980-2010 as seen in Figure 4.

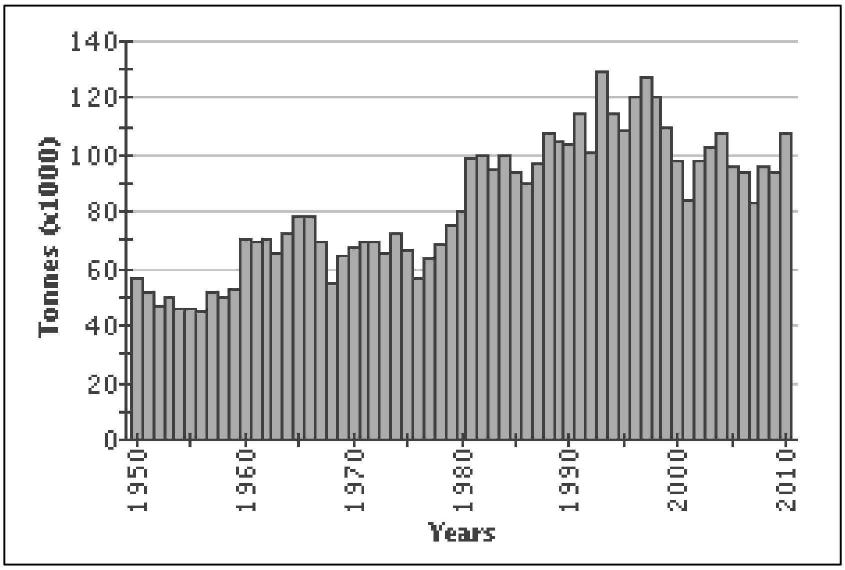

Figure 4: Global catch of blue crabs during 1950-2010 (FAO, 2011).

In addition to its fisheries importance, the blue crab is an important ecological species which may control the abundance of other species within its range, especially juvenile populations of clams, mussels and oysters, its preferred food items (Millikin and Willians, 1984).

3 METHODOLOGY

The experiments were carried out in three different fishing grounds at Buena Vista Bay, North-Coast of Cuba as illustrated in Figure 5.

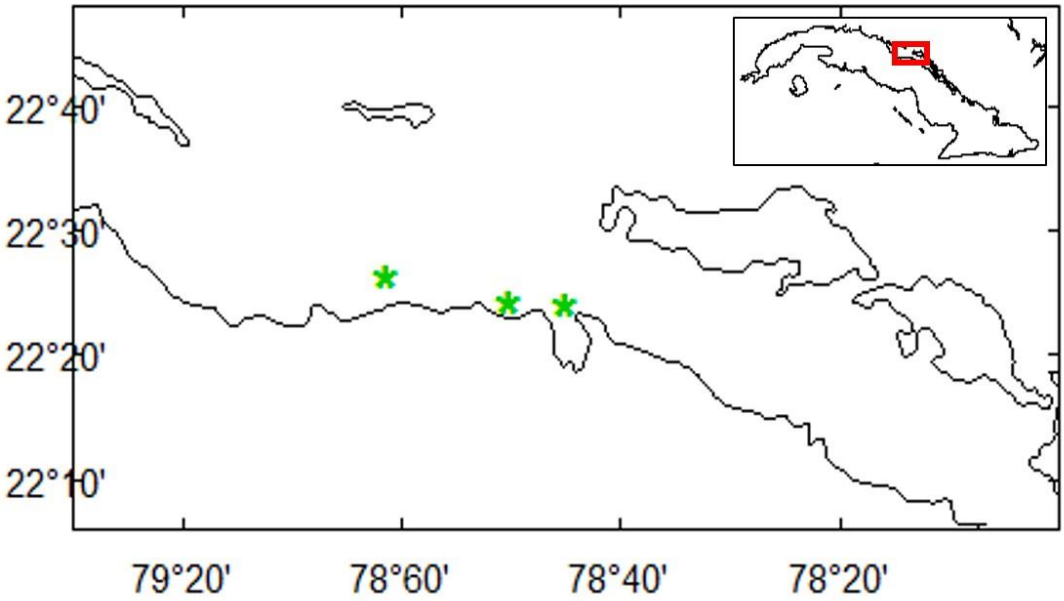

Figure 5: The points show where the experiments were carried out.

Two different types of pots were used. The Creole pot (CP) and the Escape panel pot (EPP) of rectangular shape and with the same dimension; length (100.0 cm), width (50.0 cm) and height (30.0 cm), also with three funnel each. The framework of iron (0.5 cm diameter) and plastic square mesh 2.5 cm to cover it. In the EPP pot type the posterior panel was replaced by a larger mesh size of 3.81 cm which serve as an escape window Diagrams of these pots can be seen in Figure 6.

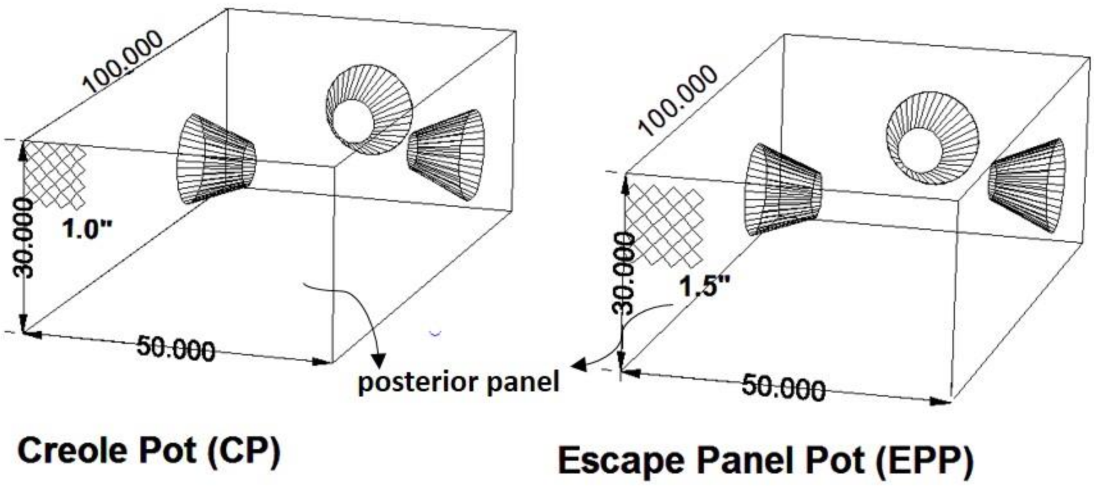

Figure 6: Two different pots, Creole pot (CP) and Escape panel pot (EPP) used in the experiment. Mesh size indicated in inches.

Each area was sampled once, between September and November 2012. In the east and central areas 24 pots of each type were deployed, while 48 pots of each type were in the western area. The experimental design is illustrated in Table 1. The pots were baited with equal portion of fresh fish before placed into water and hauled approximately 24 hours later. All blue crab were measured, weighted and, grouped by size group in 2 mm carapace width (CW) for efficiency comparison between pots.

Table 1. Experimental setup, the location of stations and number of pots.

Station name	date	latitude	longitude	pot number by type EPP	CP	Total
East	22 Sep. 2012	22°24'17.43	78°45'05.96	24	24	48
Center	23 Oct. 2012	22°24'48.11	78°50'07.88	24	24	48
West	18 Nov. 2012	22°26'41.98	79°01'35.00	48	48	96
						192

All data summaries and statistical analyses were conducted using the R statistical software program (Crawley, 2007). The mean weight, carapace width and number of crab by pots were examined for significant difference ($p< 0.05$) using t-test or Two-sample Kolmogorov-Smirnov test if the normality test failed. The variance analysis (One-Way-Anova) was used to compare the mean crab catch rate by stations and by pots.

The selectivity pots analysis were conducted using an indirect method as explained by Millar and Fryer (1999), where the selectivity of a pot is determined by the ability of animals (crabs) escaping from one pot (EPP) while retained by the other (CP as control pot). The selectivity parameters L_{50} and SR $L_{25} – L_{75}$ (Selection Range) were estimated from a logistic curve of expected catch ratio using R within the SELECT functions.

4 RESULTS

4.1 Catch efficiency by pot types

A total of 1,146 blue crabs were caught in the two different pot types at the three sampling stations. The Escape panel pot recorded a catch of 549 blue crabs, while the Creole pot caught 597 blue crabs. The Escape panel pot recorded an average catch of 5.8 blue crabs per pot while Creole pot caught 6.3 blue crabs per pot. A summary of the different catches is below in Table 2.

Table 2. Summary table of catch efficiency (catch weight and numbers) by pot types, where N is sample size and SD standard deviation.

		Crab Weight by pot (g)	Catch rate (#)
Pot type	N	Mean ± SD	Mean ± SD
EPP	549	749.5 ± 243.9	5.8 ± 1.7
CP	597	700.2 ± 264.2	6.3 ± 2.1

Though the difference between mean catch rates by pot was relatively small, it was statistically significant (t= -2.1; p=0.03). The Creole pot caught more crabs than Escape panel pot however, when the catch rate between pots for animals larger than 90 mm of carapace width (CW) were compared, the Escape panel pot caught more crabs than the Creole pot (t=3.27; p=0.001). Figure 7a shows that the average catch rate median between pots are similar but when the sublegal crabs are removed, the escape panel pot median is higher than the 75th percentile of the catches in the creole pot, as seen in Figure 7b, suggesting a large difference.

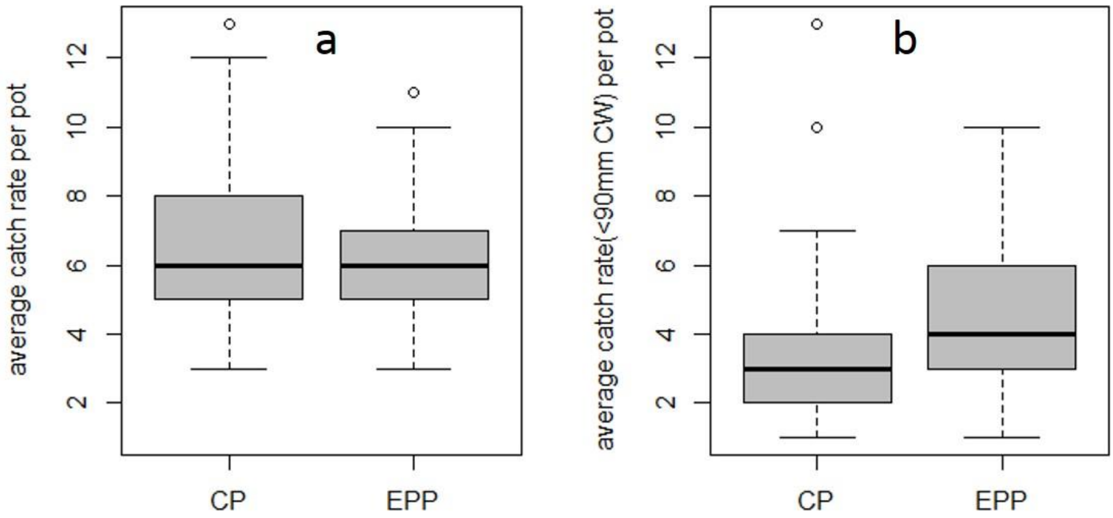

Figure 7: Boxplot chart of blue crab average catch rate per pot (a) and average catch rate by pots for animal larger than 90mm of carapace width (b). Where the grey box (50% of data distribution), the median (black line inside the box), error lines (95% of data distribution), CP (Creole pot) and EPP (Escape panel pot).

Despite the average crab catch weight median was slightly higher in the escape panel pot compared to the creole pot, illustrated in Figure 8, they were not statistically different (D= 0.16; p=0.19).

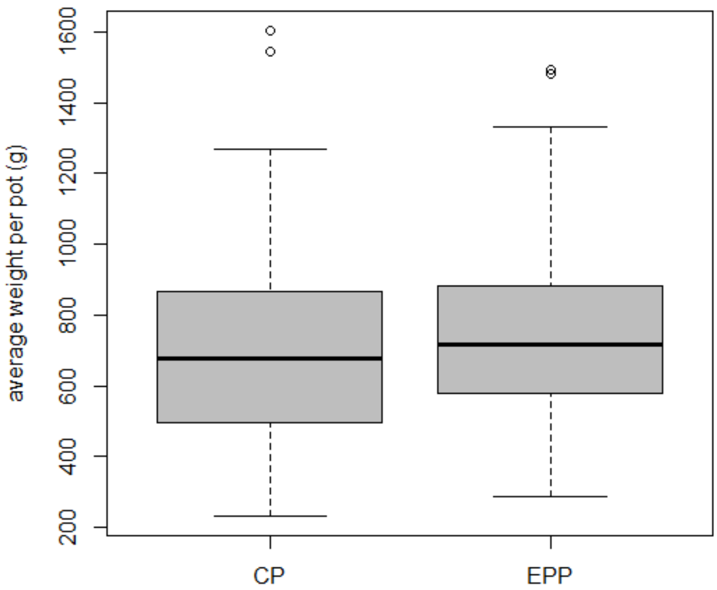

Figure 8. Boxplot chart of blue crab average carapace weight per pot. Where the grey box (50% of data distribution), the median (black line inside the box), error lines (95% of data distribution), CP (Creole pot) and EPP (Escape panel pot).

4.2 Catch rates by stations

Center station had the highest catch rate where Creole pot caught the highest average catch rate (7.2 crab/pot). The catch rate in the West station were lowest where the Creole pot also caught the fewest crabs (5.4 crab/pot) as shown in Table 3.

Table 3. Catch rate in EPP and CP and catch by sex of blue crab at three different fishing ground in Buena Vista Bay

Station	N	Catch rate		Catch by sex (%)	
		Mean ± SD (EPP)	Mean ± SD (CP)	Male	Female
West	48	5.8±1.1	5.4±1.5	80.2	19.8
Center	24	6.4±1.7	7.2±1.8	91.2	8.8
East	24	6.3±2.1	7.0±2.3	98.2	1.8

When the blue crab catch rates for Escape panel pot between stations are compared, as illustrated in Figure 9, the EPP pot caught significantly less blue crab in West station than in Center and East stations respectively (F=7.2; p=0.001).

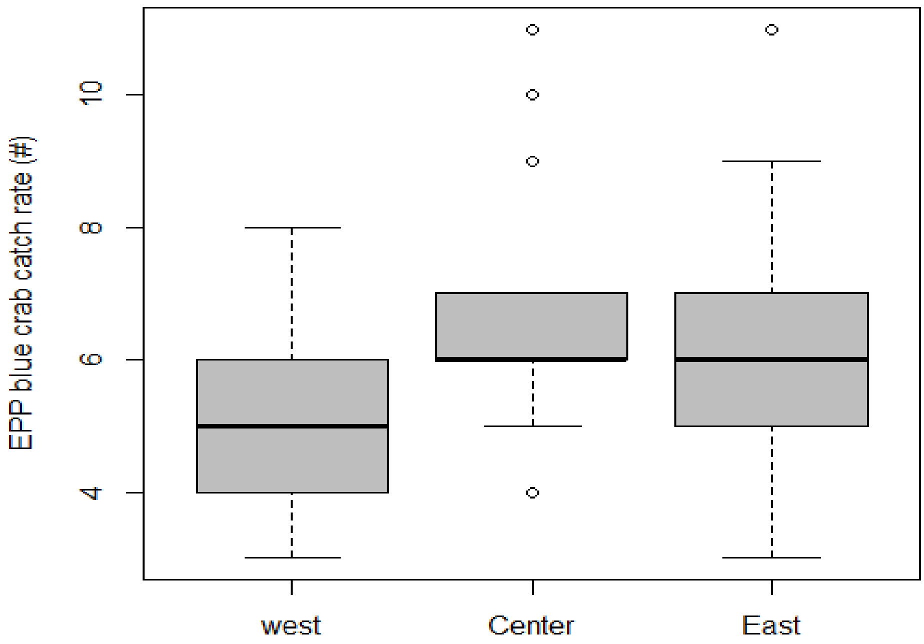

Figure 9. Boxplot chart of blue crab catch rates in escape panel pot (EPP) by station. Where the grey box (50% of data distribution), the median (black line inside the box), error lines (95% of data distribution).

Although the Creole pot has higher catch rate than the Escape panel pot at the Center and East stations, as illustrated in Figure 10, it shows the same catch pattern where the catch rate at West station were lower than at the Center and the East stations ($F=15.1$; $p<0.001$).

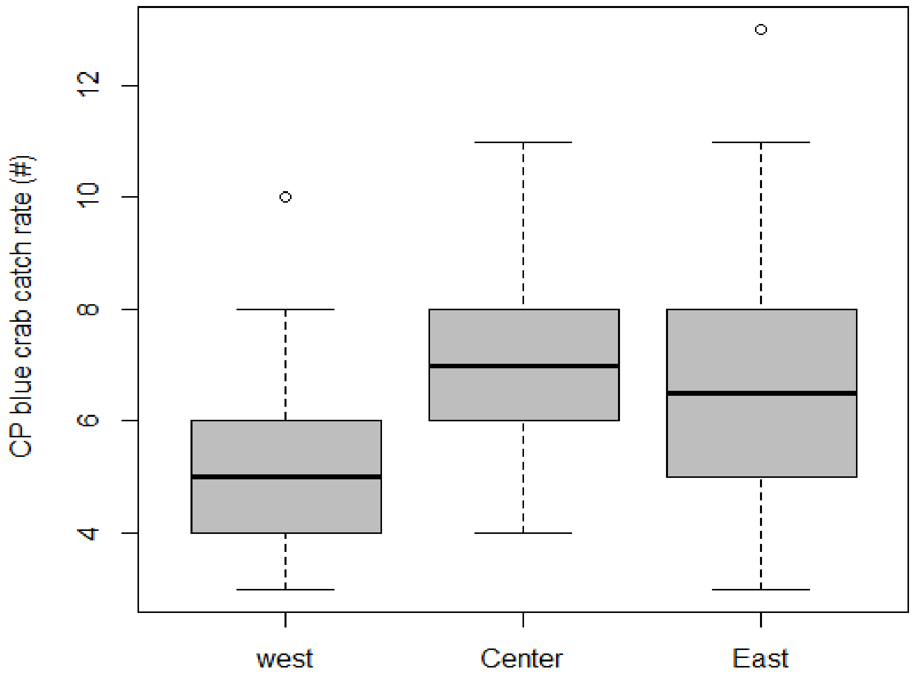

Figure 10: Boxplot chart of blue crab catch rates in creole pot (CP) by stations. Where the grey box (50% of data distribution), the median (black line inside the box), error lines (95% of data distribution).

4.3 Size selectivity analysis

The mean width of blue crab carapace was statistically higher in the Escape panel pot ($t=5.3$; $p<0.001$), although the biggest blue crab (13.9) were caught in the Creole pot, as illustrated in Figure 11. The Creole pot also caught a higher proportion of sublegal size than the Escape panel pot, as seen in Table 4.

Table 4: Average blue crab carapace width and sublegal size percent in the two different pots, where EPP (Escape panel pot), CP (Creole pot), Max (maximum), Min (minimum) and SD (standard deviation).

	Carapace Width				Sublegal size
	N	Mean±SD	Max	Min	
EPP	549	9.6±0.8	12.5	7.5	24.7 (%)
CP	597	9.0±1.3	13.9	5.0	34.7(%)
Total	1146				

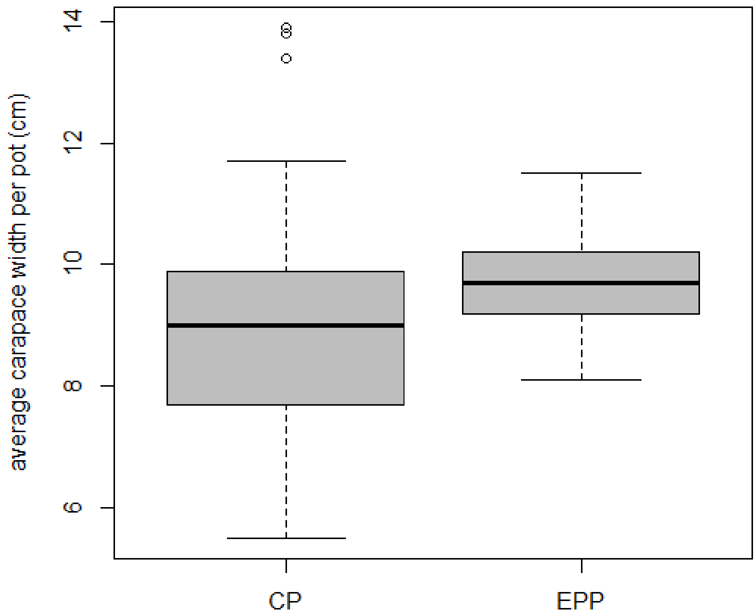

Figure 11: Boxplot chart of blue crab average carapace width per pot. Where the grey box (50% of data distribution), the median (black line inside the box), error lines (95% of data distribution), CP (Creole pot) and EPP (Escape panel pot).

Both sexes were represented in the blue crab catch. However, there were more males in both types of pots, but higher percent of females (15.4 %) were caught in the Creole pot, as illustrated in Table 5. Escape panel pot and Creole pot recorded the same average catch rate of males while the Creole pot caught twice the number of females. Both males and females where larger in the escape panel pot compared to the individuals caught in the Creole pot.

Table 5: Blue crab average catch rate and carapace width (C. Width) by sex in two different pots Escape panel pot (EPP) and Creole pot (CP). With standard deviation.

	Male			Female		
	N (%)	Catch Rate	C. Width	N (%)	Catch Rate	C. Width
		Mean±SD	Mean±SD		Mean±SD	Mean±SD
EPP	506 (92.2)	5.3±1.8	9.5±0.8	43 (7.8)	0.5±0.7	9.5±0.8
CP	505 (84.6)	5.3±2.3	9.1±1.3	92 (15.4)	1.0±1.1	8.9±1.2
Total	1011(88.2)			135 (21.8)		

The size frequencies (carapace width) differed between the two pot types, where the highest frequencies was between 90 and 110 mm carapace width in the Escape panel pot, as seen in Figure 12. The individuals caught in the Creole pot had a wider size distribution and were more representative of smaller sizes.

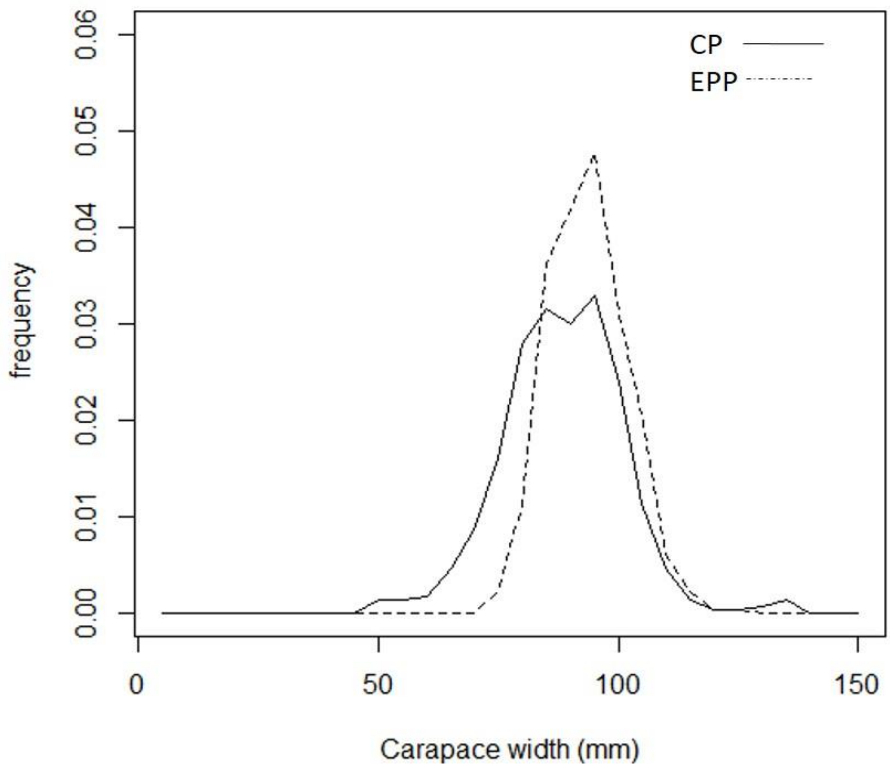

Figure 12. Size frequency distribution (carapace width) caught in the two different blue crab pot CP (Creole pot) and EPP (Escape panel pot).

The Creole pot with 25 mm mesh size begins to retain size from 50 mm carapace width, while the Escape panel pot which has 38mm mesh size begins to exploit the blue crab stock from 75 mm carapace width as illustrated in Figure 13. These sizes are below the minimum legal landing size (90 mm carapace width).

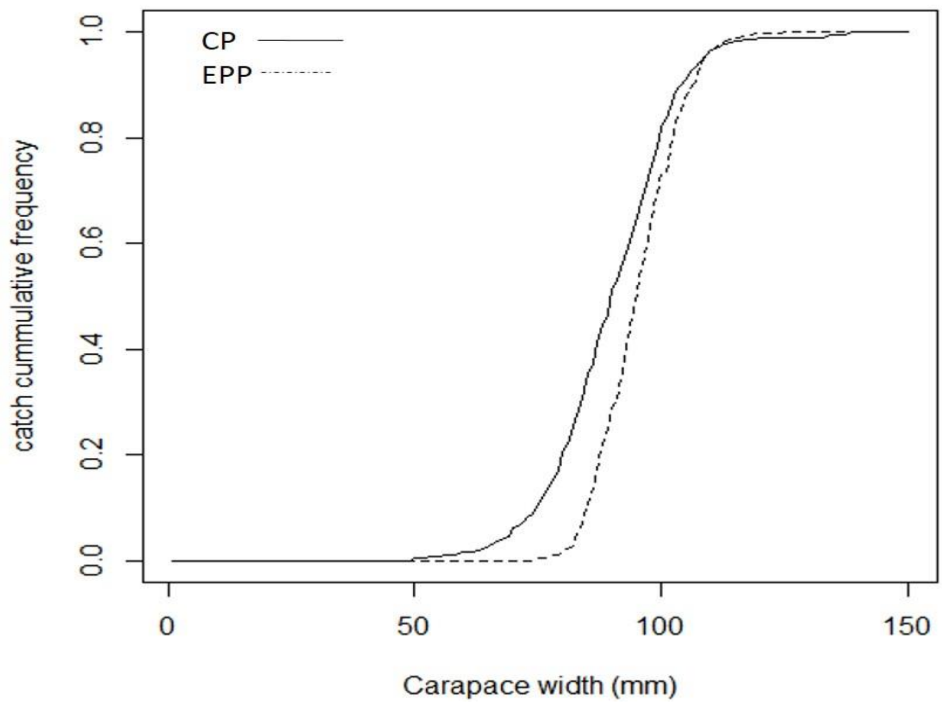

Figure 13: Accumulative size frequency of individuals caught in the Escape panel pot (EPP) and the Creole pot (CP).

On the other hand Escape panel pot (EPP) begins to exploit the blue crab stock from 75 mm carapace width. Even this size are below minimum legal size (90 mm carapace width).

The L_{50} for blue crab in Escape panel pot was estimated to be 84.4 mm carapace width and the selection range (L_{25}- L_{75}) was 6.02 mm, from the comparative study (indirect method) between Creole pot (CP) and Escape panel pot (EPP). The L_{50} is also the smallest size where individuals are caught in higher ratio in the Escape panel pot compared to the Creole pot.

Figure 14 shows the catch ratio of Escape panel pot respect to the total catch where outside the 84.4 mm carapace width (L_{50}) the Escape panel pot begins to catch more than 50 % of total catch of blue crab as compared to Creole Pot.

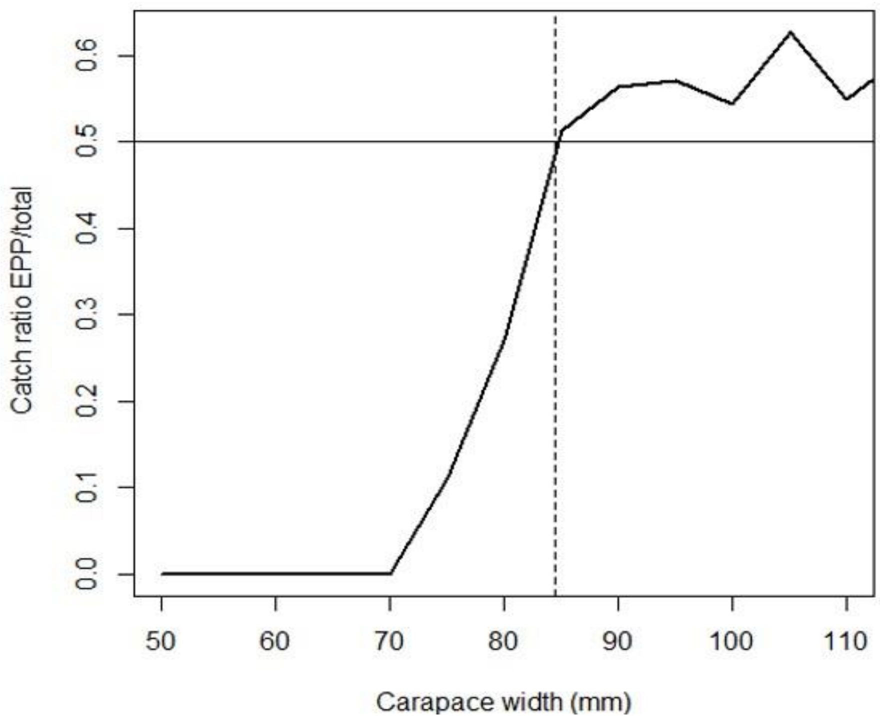

Figure 14: Escape panel pot (EPP) catch ratio in respect to the total catch (EPP + CP). Values above the horizontal line mark where higher percent is caught in the EPP pot and the vertical line is the calculated L_{50} of the EPP.

5 DISCUSSIONS

Although average catch rates of blue crab per pot were relatively higher in the Creole pot than the Escape panel pot, the average weights of blue crab per pot recorded in the latter were significantly higher. The average carapace width of blue crab was also significantly larger in escape panel pot than in the Creole pot. However, Guillory and Prejean (1997) found no significant difference in the catch rate of blue crab caught in pots with 1.0 and 1.5 inches mesh size, so the effect may be attributed to the post design rather than the mesh.

From the economic and ecological point of view, the Escape panel pot is more efficient than Creole pot in terms of maximizing the catch of legal size crabs and minimizing sublegal catch with an average of 5.8 crabs per pot and 749 (g) in weight per pot which represents an advantage for the stock with the incomes of the fishermen also getting a boost. These catch rates (number of crab/pot) and (crab weight/pot) caught by the Escape panel pot in the Cuban fishing ground were similar to that obtained by in South Australia commercial blue crab fisheries (GSA, 2009).

The sex ratio of crabs in this experiment were highly skewed towards males (88%). With the highest male catch for both pots taking place in east and central stations where the salinity levels are lower at the west station (Medina, 2012). Males are known to remain in lower-saline waters or freshwater flowing from one of the largest reservoir aquifer in Cuba (Laguna de la Leche) while females migrate to higher saline waters to spawn. These findings are supported by Hines *et al*., (1987) that confirmed significant habitat portioning by size and sex with movements of both sexes in reproduction season.

Even though sublegal catch rates were lower in escape panel pot (24.7%) than the Creole pot (34.7%), these values are well above the 10% tolerance of sublegal catch allowed in some blue crab fisheries in the Caribbean region (Guillory *et al*., 2001a). However Guillory and Prejean (1997) and Guillory *et al*., (1998) recorded sublegal catch rate over 60% for the same mesh size as used in this study which may be connected to setting pots in areas where juvenile crabs feed and grow (Hines *el al*., 1987).

It is expected that once captured, the blue crab looks for a way to escape from the pot and it is considered that the crabs move laterally (Millikin and Willians, 1984), so the crab length plays an important role in their escape behaviours. Blue crab length-width ratio (CL = 0.52 + 3.20 CW not considering lateral spines in mm) was estimated by Moncada and Gomez, (1980). Carapace width of 90 mm corresponds to 50 mm carapace length which explains why the escape panel pot with 38.1 mm square mesh (a diagonal of 50 mm) allows crabs of less than 50 mm in CL to escape from the pot.

The catch size composition indicates that blue crabs move into the fishing ground from around 50 mm carapace width, so it is necessary to avoid their catch as to reduce poor handling on board, operating times, damages and mortality of individuals with no commercial value. Van Engel (1958) reported that damage and loss of appendages on the crab, can substantially reduce individual growth in the molting process.

It is necessary to consider both future research and commercial fishing, escape ability of individuals, the soak time of the traps and the number of escape windows, as suggested by (Zhou and Kruse, 2000; Nishiuchi, 2003). These authors noted that increasing the soak time of the trap in the water increases the probability of escape of small size individuals, which can be increased too by placing a larger number of windows (Aguilar and Pizarro, 2006).

Moreover in most research, the designation of commercial netting only mentions the dimensions of the pot without giving detail description of the mesh sizes without which comparison between meshes retention results from several studies cannot not be properly ascertained

Despite the L_{50} (84.4 mm) calculated for the mesh size (38 mm) in escape panel pot is below the minimum legal size (90 mm) of carapace width, this mesh size is an improvement from the 25 mm mesh size which retains higher number of sublegal individuals.

6 CONCLUSIONS

The escape panel pot was shown to be more efficient pot than the Creole pot in terms of maximizing the catch of legal size crabs and minimizing sublegal catch.

The escape panel pot was shown more efficient; the sublegal catch rate in this pot was above the 10% tolerance allowed in some blue crab fisheries in the Caribbean region.

7 RECOMMENDATIONS

Carry out a comparative study between pots with larger mesh size than used in this study. The results suggest that changing the mesh size from 1 to 1.5 inch would be a step towards more profitable fisheries.

Input escape devices or appropriate mesh sizes in pot construction to allow the escape of undersize catches in the Cuban blue crab fisheries.

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