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# Liftnets Compare Favorably with Pots as Harvesting Fishing Gear for Invasive Swimming Crabs

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**Abstract:** The aim of this study is to assess the efficiency of liftnets as a harvesting gear for invasive crustaceans. Fishing trials targeting swimming crabs took place in a pond using liftnets and collapsible pots. The liftnet consisted of 2 metal rings and a 6 cm mesh net and the dome-shaped pot (6 cm mesh size) had two open entrances at opposite ends. Trials (100 hauls/gear type) were done using a 1 h soaking time and 50 g of mackerel as bait for the liftnet and 24 h and 100 g of mackerel for the pot, which are the usual fishing practices for these gear types. The liftnets caught 99 swimming crabs consisting mainly of *Thalamita sima*, while the pots caught only 28 crabs composed mainly of *Portunus pelagicus* and *Charybdis japonica*. The non-target catch was only 7.5% in liftnets compared to 18% in pots. The difference in the catch rate of the liftnets is attributed to the daytime setting and their crab tangling ability. Liftnets entangled 99 crabs/hour versus only 1.17 in pots and bait returns were also higher, 19.8 crabs $kg^{-1}$ of bait in liftnets versus only 2.8 in pots. We recommend liftnets for harvesting purposes of invasive swimming crabs.

**Key words:** Invasive, *Charybdis japonica*, *Portunus pelagicus*, eradication, fishing gear

## INTRODUCTION

The introduction of several species of invasive crabs around the world requires the development of more effective harvesting gear and methods for their removal (Ahmadi *et al*., 2008; Ahmadi and Vazquez Archdale, 2008; Jones *et al*., 2009; Roche *et al*., 2009; Griffen and Byers, 2009; Roudez *et al*., 2008). The first researcher has examined the behavior of several species of swimming crab around commercial pots (Vazquez Archdale *et al*., 2003, 2006a, 2006b, 2007; Vazquez Archdale and Kuwahara, 2005) and made recommendations for improving existing trapping gear and adapting it for eradication purposes, such as installing smaller meshes to retain smaller crabs and using open funnel entrances to minimize the impact of ghost fishing.

Liftnets have many advantages over pots; they are cheaper, lighter, simpler to construct, more easily stacked and occupy less space on deck. They can also be fished with much shorter soaking times, so they can be used more frequently and require a smaller quantity of bait. Their deployment can be easily done from land, small dinghies or canoes. Liftnets have a long history as gear for harvesting lobsters and crabs (Thomas, 1953; Miller, 1980; Von Brandt, 1984) and because they are fished more quickly, they have been the gear of choice for sport fishermen and poachers; consequently, their use is even prohibited in some countries (Miller, 1980). However, research on liftnets is scarce.

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During the trials we targeted swimming crabs present in an experimental pond assuming that they could represented a potential alien invasive crab species and would serve as a model to determine which fishing gear would be more effective at removing all sizes of swimming crab. The crabs targeted in our study were the shore swimming crab *Charybdis japonica,* blue swimming crab *Portunus pelagicus* and four-lobed swimming crab *Thalamita sima*. The former two are commercial species in Japan, but also considered invasive (Takeda, 1983; Smith *et al*., 2003). Crabs may damage aquaculture and fisheries industries by spreading diseases, such as white-spot syndrome (Maeda *et al*., 1988), as well as competing for habitat and resources with local fauna. The objective of the current study was to assess the potential of liftnets as a harvesting gear for crabs and to obtain evidence on their fishing performance when compared to pots.

## MATERIALS AND METHODS

The fishing trials were conducted in a 70×1000 m pond located in Kagoshima City's Marine Park, southern Japan, from 3 July 29 August 2007 (Vazquez Archdale and Kuwahara, 2005) for pond details. This pond is connected through concrete pipes to a bay, thus allowing the entry of local marine organisms and has a variable depth ranging from 2.5 to 4.5 m depending on the tide. The surface water temperature ranged from 26.0-31.8°C. *T. sima, C. japonica* and *P. pelagicus* are the predominant crab species found there.

The liftnets were made from multifilament nylon 9 strand twine net (6 cm mesh size), which was fastened around two galvanized steel ring frames (3 mm diameter): the larger one of 210 cm perimeter was placed on the top and the smaller one of 105 cm in the middle (Fig. 1a). The net panels used had a 45 mesh width and a 9 mesh height. The larger ring was fastened to the top of the panel with nylon line, the smaller one at a height of 4.5 meshes and

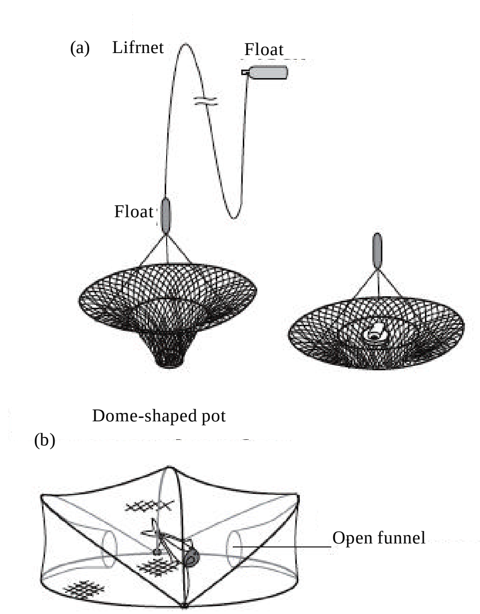


Fig. 1: (a) Liftnet suspended in the water (left) and flat on the sea bottom (right); dimensions of two galvanized steel ring frames (3 mm diameter) are 210 and 105 cm perimeter. (b) Collapsible dome-shaped pot

on the bottom a plastic baiting plate was attached. Bait was wired to the plate to prevent crabs from reaching it from under the net. A 19 g lead weight was attached to the bottom of the plate to ensure that it sank and reached the sea bottom before any other part of the liftnet. The dome-shaped collapsible pots (Kagotoku Shiroyama Kenmousha, Ise, Japan) used in the trials are used in Japan to catch commercial swimming crabs (Fig. 1b). This pot consists of an iron rod frame and polyethylene netting (6 cm mesh size) and it has two open funnel entrances at opposite ends that are kept open by a rigid metal-frame (15 cm width, 8 cm height).

Frozen mackerel *Scomber japonicus* was used for bait and each fish was either cut into four pieces (approx. 50 g) and one was skewered on the baiting wire of each liftnet, or cut in half and a piece was placed in each pot (approx. 100 g) (Fig. 1).

During the trials 100 hauls were completed for each gear type, at a rate of five per day for each type, making a total of 10 hauls day$^{-1}$. Trials took place over 20 days. Liftnets and pots were placed in a line running along the Eastern length of the pond and their locations were randomly assigned for each day's treatment. The fishing gear was set at about 15 m intervals, the distance commonly used by fishermen targeting swimming crabs (Kaneda, 1977). Divers placed the liftnets and pots on the bottom of the pond around 16: 30. The liftnets were hauled after one hour, which is approximately the soaking time employed for the tangle nets used to catch *R. ranina* (Sumpton *et al*., 1995) when it was daytime and the visibility underwater was sufficient to see the organisms on the liftnets. Pots remained in the water overnight and were retrieved the next day, as done by the local pot fishers. The catch was released after identification and measurement not to deplete the animal populations in the pond.

The t-test was used to check for significant differences in the total number of catches depending on the type of gear used. The normal approximation to the binomial test was employed to examine if the catch in the liftnets and the pots for total crabs, by-catch and individual swimming crab species were significantly different. All tests were evaluated at 0.05 level of significance and the t-test statistic computed using SPSS 10.0 software.

## RESULTS AND DISCUSSION

Observations on the underwater conditions around the gear and the behavior of the organisms were made by diving during the setting and hauling of the pots. After deploying the gear, numerous damselfish *Chromis notata* and gobies *Chasmichthys gulosus* were observed crowding around the bait; after several minutes the arrival of the crabs *T. sima* and a few *P. pelagicus* were observed; no *C. japonica* were seen until the following day, when some specimens were found inside a few pots. Crabs of all sizes were caught in the liftnets when they became entangled in the net by the spines present in their carapace and chelipeds and a few egg-bearing female crabs by the abdomen. Rockfish *Sebasticus marmoratus*, damselfish and moray eels *Echidna nebulosa* became enmeshed, but ivory shell *Babylonia japonica* and gobies were found in the baiting plate after hauling the liftnets. Animals caught in the pots were not entangled.

Quantitative results of the fishing trials for both gear types showed that liftnets caught more than three times the number of crabs than pots (Table 1). Normal approximation to the binomial test results showed that the crab catch in the liftnets and the pots were significantly different. Thirty times more small-sized four-lobed swimming crab *T. sima* were caught in the liftnets than in the pots ($Z_{0.05(2)} = 1.960$, $Z_c = 8.298$, $p<0.0001$) while, the catch of blue swimming crab *P. pelagicus* was only one third of that found in the pots ($Z_{0.05(2)} = 1.960$, $Z_c = 6.135$,

Table 1: Number of trapped organisms and by-catch using liftnets and dome shaped pots

| | Liftnet | | | | Dome-shaped pot | | | |
|---|---|---|---|---|---|---|---|---|
| Organisms | No. | Proportion | Ave. size (cm) | Range (cm) | No. | Proportion | Ave. size (cm) | Range (cm) |
| Four-lobed swimming crab | 93 | 0.869** | 5.6 | 4.4-7.6 | 3 | 0.088 | 6.8 | 6.7-6.9 |
| Blue swimming crab | 6 | 0.056 | 14.2 | 13.0-15.3 | 18 | 0.529** | 13.6 | 10.7-16.7 |
| Shore swimming crab | | | | | 7 | 0.206** | 9.1 | 7.4-10.8 |
| Total swimming crab catch | 99 | 0.925 | 6.1 | | 28 | 0.824 | 9.8 | |
| Non-target organisms | | | | | | | | |
| Marbled rockfish | 1 | | 19 | | 1 | | 25.8 | |
| Moray eel | 1 | | 40 | | | | | |
| Damselfish | 1 | | 9.5 | | | | | |
| Goby | 2 | | 7.1 | 6.3-7.9 | | | | |
| Ivory shell | 1 | | 4.5 | | | | | |
| Hermit crab | 2 | | 4.0 | 3.5-4.4 | | | | |
| Octopus | | | | | 2 | | 2.55 kg | 2.3-2.8 kg |
| Sea cucumber | | | | | 3 | | | |
| Total by-catch | 8 | 0.075 | | | 6 | 0.176 | | |
| No. of gear | 100 | | | | 100 | | | |
| Total catch | 107* | | | | 34 | | | |
| By-catch/pot | 0.08 | | | | 0.06 | | | |

Statistical tests used were the normal approximation to the binomial test and t-test; value with asterisks indicate significant difference (**p<0.001, **p<0.05)

Table 2: Time and bait efficiencies of 100 liftnets and collapsible pots

| | Gear type | | |
|---|---|---|---|
| Efficiency parameters | Liftnet | Collapsible pot | Liftnet/pot |
| Crab catch per hour | 99 crabs/hour | 1.17 crabs/hour (28 crabs/24 h) | 84.6 |
| Amount of bait used | 5 kg (100 nets×50 g) | 10 kg (100net×100 g) | |
| Crab catch-kg of bait | 19.8 crabs/kg (99 crabs/5 kg bait) | 2.8 crabs/kg (28 crabs/10 kg bait) | 7.1 |

p<0.0001). The catch of shore swimming crabs *C. japonica* also showed significant differences between gear types ($Z_{0.05(2)} = 1.960$, $Z_c = 4.361$, $p<0.0001$).

The total number of by-catch in both gear types was small and no significant difference could be detected. Significant differences were found for total catch between liftnets and pots (t-test, $t_{0.05(2),261} = 1.969$, $t_c = 3.046$, $p = 0.003$) (Table 1).

Crab size was affected depending on the gear used. Liftnets caught both small *T. sima* (size range 4-8 cm carapace width, CW) and large *P. pelagicus* (12-16 cm CW) (Fig. 2a). Crabs found in the pots were all larger than 6 cm CW (Fig. 2b), because smaller crabs could escape through the netting. As a consequence only a few *T. sima* (size range 6-8 cm CW) remained in the pots and the catch consisted mainly of the larger *C. japonica* (6-12 cm CW) and *P. pelagicus* (10-18 cm CW).

Records on the condition of the bait at the time of hauling showed that the bait quantity was enough in the liftnets, with remains ranging from 0-90%, but most of the bait was consumed in the pots as a result of the long 24 h soaking (Fig. 3).

In relation to the time efficiency of the gear employed, liftnets were almost 85 times more efficient at catching crabs than pots. They entangled 99 crabs/hour versus only 1.17 in pots (Table 2). Liftnets also outperformed pots when considering the amount of bait consumed by catching 19.8 crabs $kg^{-1}$ of mackerel, which is a catch seven times larger than the 2.8 crabs $kg^{-1}$ in the pots.

From the results of the trials it was found that liftnets compare favorably with pots when used to catch swimming crabs. They caught 85 times more crabs per hour than pots and seven times more crabs $kg^{-1}$ of bait. The greater efficiency of the liftnets can be attributed to the way they lay flat on the sea bottom; this allows crabs to crawl over them from any direction while they follow the bait odor trail. Pots, on the other hand, have entrances

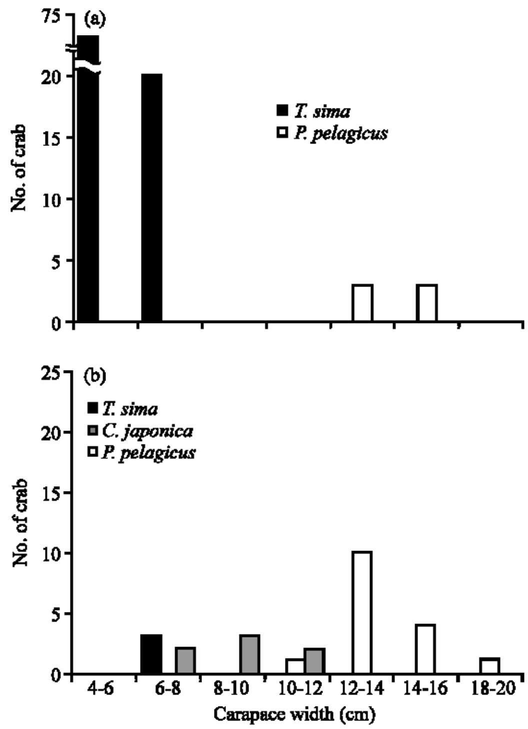


Fig. 2: Crab size distributions according to species in (a) liftnets and (b) pots

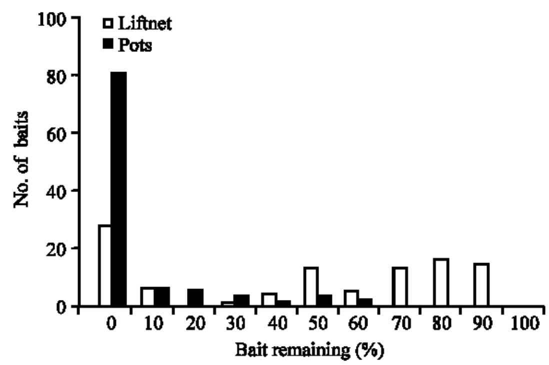


Fig. 3: Percentage of bait remains distributions according to gear

through which the crabs must enter to reach the bait and in many cases their location does not coincide with the direction of the water current and bait odor trail. Many crabs are misguided in this way and remain around the pots trying to get in and fighting until they give up (Miller, 1979, 1990).

The capture mechanism of the liftnets and pots is different even though they both have the same mesh size. Liftnets work by entangling crabs from spines and appendages, while pots do not. Similar results were observed in tangle nets targeting the spanner crab *R. ranina*, a crab that is susceptible to entanglement because their dactyls are flattened and have narrow joints (Bourne, 1922).

Our trials showed that liftnets outperformed pots when fished in the same fishing ground. Field trials targeting *R. ranina* using tangle nets and different pot designs in Australia agree with our results, with tangle nets catching five times more crabs per hour than the most efficient pot design (Sumpton *et al*., 1995).

Liftnets have many advantages over pots. They are easily constructed, require less material and cost less, occupy less space on deck so more can be carried onboard, they are easy to handle and can be operated by a single fisher. Furthermore, liftnets are operated quickly, like tangle nets and interfere less with other gear operating in the same fishing ground (Sumpton *et al*., 1995).

In our study 6 cm mesh size netting was fitted on the liftnets because it was the same size as that found in the commercial crab pot. Further, trials should examine which mesh sizes and twine thickness are the most effective for catching swimming crabs. Looking at mesh size results from tangle nets (2.5, 8.5 and 12 cm mesh size), the most effective mesh size was 8.5 cm, which is closest to the 6 cm used in our liftnets (Kennelly and Craig, 1989).

Our trials showed that liftnets are a simple and powerful gear that can be used to catch several species of swimming crabs and that they are probably much more efficient than the pots that are currently used in eradication studies and research (Gust and Inglis, 2006). Their use should be further tested for sampling and removal purposes and countries suffering from alien crab infestations should consider them as a better alternative to pots.

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