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Research Article

The efficacy of crab condos in capturing small crab species and their use in invasive marine species monitoring

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Abstract

Crab condos are designed to sample for invasive species, which are not specifically targeted using current Australian biosecurity methodologies. Smaller crab species are often excluded, overlooked and damaged to be collected via current trapping or collection methods. An artificial habitat collector such as the 'crab condo' (PVC tubes 25cm long and 50mm diameter arranged in a 3×3 square matrix) aims to provide shelter among an animal's natural environment. Twenty condos were deployed on a weekly basis for 48 hours during the months of April and July 2012 within Hillarys Boat marina, Western Australia. Condos proved to be highly successful, capturing a total of 555 specimens from five different phyla, with over half (n=332) of specimens identified as crabs. The detection of 223 other smaller non-crab individuals, covering four different phyla highlighted the versatility of condos to sample a range of other small species, not only crabs. Given the recognized importance of early detection of marine pests at their early life stages and current lack of methods targeting small and cryptogenic species, the crab condo sampling method may fill an important gap in marine pest surveillance capacity.

Key words: marine pest; monitoring; biosecurity; artificial shelter; crustacean

Introduction

The 'National System for the Prevention and Management of Marine Pest Incursions' (hereafter referred to as the Australian National System) is an Australian biosecurity initiative which aims to prevent, monitor for, respond to, and manage marine pests incursions in Australian waters (National System 2012). This initiative includes biosecurity monitoring strategies that utilise a variety of methodologies essential for the detection of marine pests. Through the use of a variety of different sampling techniques, they allow for the collection of a wide range of species that may pose a threat to our aquatic environments. While the existing gamut of sampling techniques including beam trawls, benthic sleds, crab traps, plankton tows, visual searches and sediment cores are effective, they are still not enough to address the full suite of potential pests. For example, baited crab traps are designed to specifically target introduced invasive decapods such as *Charybdis japonica* (A. Milne Edwards, 1861), *Carcinus maenas* (Linnaeus, 1758) and *Callinectes sapidus* (Rathbun, 1896). Though these traps are successful in capturing larger decapods that cannot escape through the meshing around the trap, they are not suitable for other smaller species (adults or juveniles that are generally <5cm carapace width) that can escape.

Rhithropanopeus harrisii (Gould, 1841) and *Hemigrapsus sanguineus* (De Haan, 1835) are examples of two small marine crab invaders that have been introduced to coastlines around the world. Species such as these are often cryptic, fragile, and too small to be collected via traditional crab traps, and their presence can often go undetected until well established populations are detectable via visual searches (Breton et al. 2002). Smaller crab species are also less likely to be attracted inside baited traps since cannibalism and predation inside traps are common (Guillory 1993; Guillory et al. 2001;

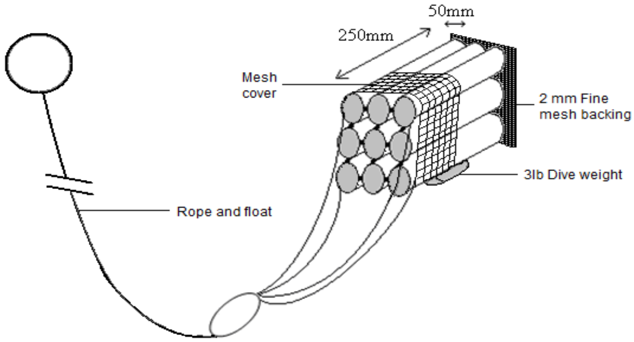

Figure 1. Diagram of the modified crab condo used during the current study.

Kimker 1994). Furthermore, many crab species naturally consume a variety of other food sources, such as alga and detritus, rather than the bait used in baited traps. The combination of these factors suggests the need for an alternative non-baited trapping method to target and monitor for these smaller individuals.

Artificial habitat collectors are a non-baited alternative to baited traps, often specifically built to attract particular organisms. These devices are engineered to attract organisms by providing shelter with an animal's natural habitat. Artificial habitat creates filled with dead oyster shells have been successfully used at capturing *R. harrisii* (Fowler et al. 2013) for monitoring invasive populations in Panama and Europe. Another successful non-baited sampling device used to target the Chinese mitten crab, *Eriocheir sinensis* (H. Milne Edwards, 1853), was the 'crab condo' (Veldhuizen 2000). The condos were designed to imitate the burrows and crevices that mitten crabs typically inhabit. Veldhuizen (2000) compared condos and crab traps while monitoring for mitten crabs and found that baited traps only captured 8 mitten crabs from 1,011 traps (<1% success rate) in contrast to condos, which captured 206 mitten crabs from 278 traps (74% success rate). However, condos have so far only been used for targeting mitten crabs (Morrisey et al. 2009; Veldhuizen 2000).

The concept of using condos as an artificial habitat to capture a range of small crab species was the focus in this study. We assessed if crab condos had the ability to capture small crabs and determined their use as a monitoring tool for introduced marine pest species. As Western Australia has no confirmed invasive pest crab populations, the study used native swimming and walking crab species as surrogates for invasive crab species.

Methods

Study site

Trials for this study were undertaken in the Hillarys Boat Harbour Marina, 18km north west of Perth, Western Australia (31.825058 S, 115.735572 E). The marina is subject to frequent recreational vessel movement and accommodates 473 pens for both yachts and power boats up to 35m in length. This site was chosen as it represents a 'typical marina environment' with a fine sediment benthic substrate and limestone rock walls protecting the marina from the majority of winds and waves.

Crab condo design

The crab condos deployed in this experiment were based on the original 'crab condo' design by Veldhuizen (2000) used to sample *E. sinensis* in San Francisco Bay. To increase structural complexity, and in theory accommodate a broader range of species, the condos were slightly modified from the original design. The modified condos used in this study consisted of PVC tubes 25cm long and 50mm diameter arranged in a 3×3 square matrix (Figure 1). One end of the PVC matrix was covered by a fine (2mm) mesh to prevent specimens falling out upon retrieval, with a mesh cover (10mm) also surrounding the device to provide further structure and habitat. The open end of the matrix was attached to the surface via a rope and float. The entire condo was weighted down with a 1.3kg or 2.7kg dive weight, depending on the environmental conditions in which they were to be deployed. The weight was attached to one of the sides to ensure that the condo deployed horizontally when it reached the target substrate. The approximate costing's

Table 1. CPUE (number of individuals caught per condo) and counts of captured specimens between in the two periods of April and July and their combined totals.

Common name	**Taxon**	**April**	CPUE	**July**	CPUE	**Total**	CPUE
Walking Crabs	Family *Pilumnidae*	1	0.013	0	0	1	0.006
Swimming crabs	Family *Portunidae*	16	0.200	0	0.000	16	0.100
Spider crabs	Family *Hymenosomatidae*	4	0.050	9	0.113	13	0.081
Decorator Crabs	Family *Majidae*	1	0.013	7	0.088	8	0.050
Hermit Crabs	Infraorder *Anomura*	240	3.000	54	0.675	294	1.838
Marine Snails	Superfamily *Muricoidea*	91	1.138	99	1.238	190	1.188
Fish	Class *Actinopterygii*	3	0.038	5	0.063	8	0.050
Seastars	Subphylum *Asterozoa*	1	0.013	6	0.075	7	0.044
Squid	Class *Cephalopoda*	1	0.013	0	0.000	1	0.006
Mussel	Class *Bivalvia*	0	0.000	3	0.038	3	0.019
Shrimps	Family *Palaemonidae*	10	0.125	4	0.050	14	0.088
Total		368	4.600	187	2.338	555	3.469

for the materials per unit would equate to AUD$29.18, including weights, floats and ropes.

Condo deployment

Twenty condos were deployed weekly for four consecutive weeks in both April and July 2012 for a 48hr soak period each time (n = 160 total deployments). Condos were randomly placed along the inside of the marina wall approximately 2 - 4m off the marina rockwall. Upon retrieval, all specimens on or inside the condo were removed and identified. Species compositions are known to change over time however the temporal variation in species abundance or assemblage was not the focus of this study. Deployment over two periods (April and July) (Table 1) was to examine the efficacy of this method under different conditions.

Results

In total, 555 specimens from five different phyla were caught and identified from the crab condos. Over half (n=332) of those individuals caught were crabs (sub-order *Pleocyemata*). The remainder were composed of marine snails (Superfamily *Muricoidea*), fish (Family *Pinguipedidae* and *Monacanthidae*), seastars (Subphylum *Asterozoa*), squid (Class *Cephalopoda*), mussels (Class *Bivalvia*), echinoids (*Ophiuroidea* and *Asteroidea*) and shrimps (Family *Palaemonidae*).

Capture of crabs

A total of 332 crabs were caught during the sampling regime, the majority (n = 294) of which were hermit crabs (Infraorder Anomura) (Table 1). Although there was noticeable diversity among the Anomurans, they were only identified to the infraorder level as they were not the focus of this study. The remaining 'true crabs' (Infraorder Brachyura) were represented by 38 specimens from four different families (Portunidae, Hymenosomatidae, Majidae and Pilumnidae) and ranged in size from 4 – 43mm carapace width.

Within the 38 specimens of Brachyura, 16 individuals of Portunidae were collected, with nine belonging to the genus *Thalimita*, and seven to *Portunus.* Almost all of the 13 Hymenosomatidae 'spider crabs' collected were identified to be *Halicarcinus ovatus* (Stimpson, 1858) whilst the others could not be identified further due to cost, time and staffing restraints. Eight individuals were found to belong to the Majidae family of 'decorator crabs', while only one specimen of 'walking crab' (Family *Pilumnidea*) was found (Table 1).

Capture of other specimens

In addition to crabs, a further 223 other fauna were collected from the crab condos, representing four different phyla (Table 1). Marine snails made up the greatest proportion (85%, n=190) of the non-crab species found to be utlitsing the crab condos. Of the eight fish species collected, two were small leatherjacket species (Family *Monacanthidae*), four were identified to be the small spotted grubfish, *Parapercis ramsayi* (Steindachner, 1883), and two were *Callogobius mucosus* (Günther, 1872). *In-situ* monitoring of the condos (by divers) revealed high numbers of these fish species sheltering in the condos, but most are believed to have escaped on retrieval.

The majority of the Echinoids collected within the condos were small brittle stars (*Ophiuroidea*) although two sea stars (*Asteroidea*) were also found. The mussels found within the condos were identified to the genus *Musculus*. These small mussels (5mm in length) were alive and attached to the fine mesh at the bottom of the condos.

Discussion

The capture of 332 native swimming and walking crab specimens in this study illustrates the condos suitability to capture small crabs and indicates their potential to target similar invasive counterpart species. Introduced 'true crabs' can significantly threaten marine ecosystems and are known to displace native species, disrupt or destroy fisheries, and alter ecosystems (Grosholz and Ruiz 1996; Walton et al. 2002). The ability to detect these species is crucial in marine pest management and we suggest that crab condos would be a useful addition to any invasive marine pest monitoring programme.

Swimming crabs captured during this study, consisting of juvenile *Thalimita sp.* and *Portunus sp.*, comprised the greatest portion of the true crabs caught. These species share similar characteristics in terms of their life history and habitat preference to pests, such as *C. japonica* and *C. sapidus*, listed under the Australian National System. These results indicate that condos have the capacity to detect and capture juveniles of invasive species similar to the native species caught during this study.

While spider, decorator, and walking crabs were all caught in fewer numbers than swimming crabs, their presence still highlights the usefulness of this monitoring tool for other faunal groups. Detection potential of such small and cryptic mobile species is often reduced using methods such as benthic sleds and visual searches due to the volume of material or the likelihood of specimens sustaining damage. Some of the captured species (e.g. *H. ovatus*) are fragile and have a high chance of being crushed easily, underlining the condos value at catching more fragile mobile walking crab species.

While developed for crabs, we observed that the sampling capability of condos can be extended to a range of other species, including gobies and seastars. Both phyla have well known invasive pest representatives (e.g. *Tritentiger barbatus* (Günther, 1861), *Asterias amurensis* (Lutken 1871)). Although dredging and trawling are the current methods used to detect these species, they are highly destructive and cannot be implemented in environments such as rocky outcrops, reefs, or in structurally complex environments (e.g. wharves, near underwater cables, wrecks etc). Condos were used in a sheltered marina environment, with rocky and soft sediment habitats; however they have the ability to sample in almost any environment.

The large number of marine snails (n=190) captured in these devices also indicates that condos may serve as a critical tool for detection of similar non-predatory gastropod species, such as the New Zealand screw shell, *Maoricolpus roseus* (Quoy & Gaimard, 1834). This invasive marine snail acts as an environmental engineer by modifying sediment structure through creating layers of empty shells and is a major invasive species in Tasmania (Probst and Crawford 2008). The ability to detect such invasive species would enhance current biosecurity monitoring strategies.

While the aim of the study was to assess the condos ability to capture small crab species for introduced marine pest purposes, the presence of a variety of small mobile species across a range of phyla was an indication of the condos versatility. The usefulness of the condo is also identified by the absence of suitable sampling methodologies for some invasive crab species under the Australian National System. For example, the Chinese mitten crab *E. sinensis* has a diet consisting of predominantly detritus and vascular plants (Czerniejewski et al. 2010); however, they are currently targeted using fish-baited traps even though condos are a far more effective agent in their capture (Veldhuizen 2000). Currently, baited traps are used to sample for the majority of listed invasive crab species; however, only those species that are attracted to the bait and are larger than the trap mesh size will be caught (e.g. aggressive or active predators and scavengers). This identifies a gap in the current sampling protocol whereby smaller, omnivorous invasive crab species are likely not to be caught by baited traps and are not specifically targeted.

Crab condos also have a range of other advantages in their use for invasive species monitoring. It has been shown that artifical habitat traps have the capacity to sample for a range of crab life stages, from new settleling megalopae up to reproducing adults (Fowler et al. 2013). Likewise, condos are also able to catch crabs at all life stages and could also potentially be used to monitor for an invasive species entire population demography. It is also highlighted that condos are able to detect both pelagic and benthic species, whereas many of the current sampling methodologies only sample one or the other. Given the condos' success and versalitlity in capturing a range of small mobile species, it is highly recommened they are included as part of all invasive marine pest monitoring, especially in marina or port environments.

Typically, populations of introduced species have a lag-period before they reach a point of significant range expansion and establishment (Crooks and Soule 1999); however, once populations have established they are very difficult to eradicate. For that reason, eradication of such introduced species is only practical at the early stages of invasion; therefore regular monitoring for marine pest species in areas at high risk of introductions is paramount. The use of crab condos is aimed at increasing the likelihood of detecting invasive species at an early enough stage to allow a successful response. These devices will be recommended for inclusion in all introduced marine pest monitoring carried out in Western Australia, as well as in the Australian National System. Their role in pest monitoring is to target a range of juvenile and small species, using a non-baited artificial device. These simple, yet effective, devices add to the suite of biosecurity sampling methodologies that in turn aim to prevent the costly economic and environmental damage caused by invasive marine pests.

Conclusion

Juvenile and small species, especially those that are cryptogenic or easily crushed, are often overlooked in many marine pest sampling methodologies or are destroyed in the act of sampling for them. Current methods are aimed at monitoring sessile, planktonic and macrofaunal species but do not specifically target smaller benthic species. As demonstrated by this study, crab condos are recommended to fill this gap due to their utility and efficacy in sampling a wide range of species and their ability to further detect a range of other species. The use of such devices in the future will only improve the detection of invasive species in the marine environment.

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References

Breton G, Faasse M, Noël P, Vincent T (2002) A new alien crab in Europe: *Hemigrapsus sanguineus* (Decapoda: Brachyura: Grapsidae). *Journal of Crustacean Biology* 22: 184–189, http://dx.doi.org/10.1651/0278-0372(2002)022[0184:ANACIE]2.0.CO;2

Crooks JA, Soule ME (1999) Lag times in population explosions of invasive species: causes and implications. In: Sandlund OT, Schei PJ, Viken A (eds), Invasive Species and Biodiversity Management, Kluwer Academic Publishers, Netherlands, pp 103–125

Czerniejewski P, Rybczyk A, Wawrzyniak W (2010) Diet of the Chinese mitten crab, *Eriocheir sinensis* H. Milne Edwards, 1853, and potential effects of the crab on the aquatic community in the River Odra/Oder estuary (N.-W. Poland). *Crustaceana* 83: 195–205, http://dx.doi.org/10.1163/001121609X12591347509202

Fowler AE, Forsström T, von Numers M, Vesakoski O (2013) The North American mud crab *Rhithropanopeus harrisii* (Gould, 1841) in newly colonized Northern Baltic Sea: distribution and ecology. *Aquatic Invasions* 8: 89–96, http://dx.doi.org/10.3391/ai.2013.8.1.10

Grosholz ED, Ruiz G (1996) Predicting the impact of introduced marine species: lessons from the multiple invasions of the European Green Crab, *Carcinus maenas*. *Biological Conservation* 78: 59–66, http://dx.doi.org/10.1016/0006-3207(94)00018-2

Guillory V (1993) Ghost fishing by blue crab traps. *North American Journal of Fisheries Management* 13: 459–466, http://dx.doi.org/10.1577/1548-8675(1993)013<0459:GFBBCT>2.3.CO;2

Guillory V, McMillen-Jackson A, Hartman L, Perry H, Floyd T, Wagner T, Graham G (2001) Blue crab derelict traps and trap removal programs. Gulf States Marine Fisheries Commission, pp 1–10

Kimker A (1994) Tanner crab survival in closed pots. *Alaska Fishery Research Bulletin* 1: 179–183

Morrisey D, Peacock P, Inglis G (2009) Targeted surveillance for non-indigenous marine species in New Zealand: Annual report for the Port of Auckland 2008/2009

National System (2012) National System, Available from the National System for the Prevention and Management of Marine Pest Incursions. http://www.marinepests.gov.au/national_system (Accessed December 12, 2012)

Probst TA, Crawford CM (2008) Population characteristics and planktonic larval stage of the New Zealand screwshell *Maoricolpus roseus*. *Journal of Molluscan Studies* 74: 191–197, http://dx.doi.org/10.1093/mollus/eyn006

Veldhuizen TC (2000) Gear type selection for the Chinese Mitten Crab habitat use study. *IEP Newsletter* 13: 10

Walton WC, MacKinnon C, Rodriguez LF, Proctor C, Ruiz GM (2002) Effect of an invasive crab upon a marine fishery: green crab, *Carcinus maenas*, predation upon a venerid clam, *Katelysia scalarina*, in Tasmania (Australia). *Journal of Experimental Marine Biology and Ecology* 272: 171–189, http://dx.doi.org/10.1016/S0022-0981(02)00127-2