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Ghost fishing in the pot fishery for blue swimmer crabs *Portunus pelagicus* in Queensland, Australia☆

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ABSTRACT

Blue swimmer crabs (*Portunus pelagicus*) are an economically important crab caught in baited traps throughout the Indo-west Pacific and Mediterranean. In Australia they are traditionally caught using rigid wire traps (≈pots) but there has been a recent increase in the use of collapsible pots constructed from polyethylene trawl mesh. Two experiments were conducted in Moreton Bay, Queensland, to determine the ghost fishing potential of lost crab pots on both target and bycatch species and to evaluate the differences between traditional and contemporary pot designs. A lost contemporary, collapsible trawl mesh pot will catch between 3 and 223 *P. pelagicus* per year after the bait has been exhausted, while a traditional wire mesh pot would catch 11–74 crabs per year. As most fishers now use the collapsible trawl mesh pots, ghost fishing mortality could be as high as 111,811–670,866 crabs per year. Bycatch retention was also higher in contemporary designs. Periods of strong winds appeared to increase the ghost fishing potential of lost pots. The use of escape gaps, larger mesh sizes and construction options that allow for the deterioration of entrance funnels to minimise ghost fishing are recommended to reduce environmental impacts.

1. Introduction

The blue swimmer crab *Portunus pelagicus* is the basis of a valuable commercial and recreational fishery in Australia and elsewhere throughout the Indo-west Pacific and Mediterranean Oceans (Kailola et al., 1993). The species is taken as bycatch by trawl fishers but a significant amount is landed by fishers using baited traps (colloquially known as pots in Australia). Total landings of blue swimmer crabs in 2005 from the commercial pot fishery in Queensland was approximately 800 tonnes, worth about $AU6.4 million.

In Queensland, the majority of the effort in the fishery is restricted to the area between Moreton Bay (27°15′ S, 153°15′ E) and Bundaberg (24°45′ S, 152°25′ E), in both inshore and offshore grounds. A mixture of adult and sub-adult animals typifies the inshore fishery (<20 m depth), while large adult males dominate the offshore fishery. Only male crabs greater than 11.5 cm carapace width (measured between the notches just forward of the lateral spines) are allowed to be retained. Fishers generally fish from vessels approximately 8 m in length, up to a maximum of 14 m, with each licence holder limited to 50 pots. Typically, fishers set their pots on individual buoyed lines in the shallower inshore grounds (<20 m). In offshore waters, pots are set in trotlines of about ten pots deployed with buoys at either end of the line. Baited pots are usually left to fish in the water continuously and are commonly cleared and rebaited daily, most commonly with a single ≈500-g sea mullet (*Mugil cephalus*), although inclement weather conditions can prevent fishers from tending pots for up to 10 days. This is particularly the case in the offshore fishery during summer when south-easterly trade winds regularly reach 25 knots or more.

Traditionally, Queensland fishers used rigid pots constructed from a steel rod frame, covered by wire meshing (Smith and Sumpton, 1989). In the late-1980s, however, some fishers began using pots constructed of multi-filament, polyethylene trawl mesh (≈50 mm diamond-shaped mesh) on a steel and/or plastic frame. Approximately 95% of fishers operating in the Moreton Bay area are now using these trawl mesh pots (Wayne Sumpton, unpublished data). This trend occurred for a number of reasons. Firstly, trawl mesh pots are less prone to corrosion, thereby prolonging the effective working life of the gear. Secondly, some trawl mesh pots are collapsible and allow for easy storage aboard small vessels enabling fishers to work more efficiently when fishing further from port. Also, fishers believe that they achieve higher catch rates and are less prone to sea turtle interactions when compared with the traditional wire mesh pots.

A recent survey of Queensland's commercial crab fishers (Sumpton et al., 2003) reported that significant pot loss occurred during a fishing season. Annual pot losses of 35 pots per year per fisher were reported or in excess of 6000 pots for the entire fish-

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ery, about half of which remain in the environment. According to the fishers, pot loss occurred for several reasons including the accidental or intentional removal of marker floats and pots by other vessels, heavy weather moving pots into deeper water and incidental removal of floats by large animals including sharks. Regardless of the reasons for the loss, gear remaining in the environment gives rise to ghost fishing, a phenomenon described by Smolowitz (1978a) as the ability of fishing gear to continue fishing after all control of that gear is lost by the fisherman. Theoretically, ghost fishing occurs when the contents of a lost pot (both target species and bycatch) die and attract more animals into the pot. These animals then die and attract more, with this process continuing until the pot breaks down and can no longer fish.

Historically, a lost traditional wire mesh pot would corrode and cease fishing in a relatively short space of time and fishers commonly replaced the wire mesh at least once per fishing season (Sumpton et al., 2003). However, the more durable nature of a trawl mesh pot is that, if lost, it will remain viable for a longer period of time and may continue to ghost fish for crabs and bycatch species long after the traditional wire designs would have corroded away. Further, the shift toward the use of trawl mesh pots, with smaller mesh sizes, may have resulted in higher retention rates of smaller bycatch species.

The objective of this study was to examine the ghost fishing characteristics of the traditional wire mesh pot compared to the contemporary collapsible and rigid-framed trawl mesh pots, used by commercial crab fishers. Specifically, the rates of entrance, escapement and mortality of the target species are assessed and the bycatch composition of each pot type is described. The overall pot loss in the fishery is quantified and the ecological impacts of ghost fishing are discussed along with mitigation strategies.

2. Materials and methods

Two ghost fishing experiments were conducted in Deception Bay, part of the larger Moreton Bay, Queensland (27°11′ S 153°03′ E). The area is generally shallow (<10 m) with a mud/silt substrate with high turbidity throughout the windy autumn and summer months. This area was chosen for the experiment as it is easily accessible in most weather conditions and there is a substantial *P. pelagicus* population that is fished throughout the year by both recreational and commercial fishers.

Three pot designs that are used by commercial fishers were used in the experiments. The first design tested was the traditional wire-mesh pot (930 mm diameter, 300 mm high). The frame consists of two circular 6 mm galvanised steel hoops, held apart by four evenly spaced 6 mm galvanised steel rod uprights. The frame was covered by hexagonal-shaped 1 mm galvanised steel mesh (mesh size approximately 60 mm). Two diametrically opposed, inclined entrance funnels each had a rigid galvanised steel rod frame (2 mm diameter approximately 250 mm wide and 60 mm high) on the inner margin to ensure the correct opening width was maintained during fishing. A hinged, square-shaped access hatch (approximately 25 cm by 30 cm) on one side of the pot allows access to the contents. This pot was described by Smith and Sumpton (1989) and was similar to that used by Miller (1978).

The second pot tested was a contemporary, rigid-framed trawl mesh pot. This pot utilised a frame constructed in the same manner as the traditional wire mesh pot but was 400 mm high. The frame was covered in #36-ply polyethylene, diamond-shaped trawl mesh with a mesh size of 50 mm. As with the above pot, two slightly inclined, diametrically opposed entrance funnels (inner funnel margin approximately 300 mm wide by 40 mm high) were sewn into the sides of each pot, held open by U-shaped hooks connected through the middle of the pot with rubber shock or "bungy" cord. A drawstring arrangement on the upper side of the pot is utilised to allow access to the pot contents.

The third pot tested was a contemporary, collapsible trawl mesh pot. This pot consisted of two galvanised steel rings (8 mm rod), with a diameter of 1 m, which are threaded through a "tube" of trawl mesh (#36-ply polyethylene mesh with 50 mm mesh size). One end of the tube was drawn together and tied-off with 5 mm multifilament polyethylene twine to form the base (i.e., ventral side) of the pot. A drawstring arrangement is used on the dorsal side of the pot to allow access to the contents. The two rings are held apart using four lengths of plastic (PVC) irrigation pipe, 25 mm in diameter and approximately 400 mm each in length, termed uprights. A small hole is drilled approximately 15 mm from each end of each upright, before a V-shaped notch is cut from the end of each upright to the hole drilled earlier. This allows the uprights to be slipped onto the rings so that the rings fit securely into the pre-drilled holes. The uprights can be removed and the pots collapsed for easy storage. Entrance funnels are the same as those used in the rigid-framed trawl mesh pots described above.

Each pot was attached to a 15-cm diameter spherical float via 5 m of 6 mm polyethylene rope. Five pots of each design were deployed alternately, 50 m apart, in approximately 3 m of water in the study area with funnels in approximately the same orientation to the tidal flow in order to reduce variation in catch rate due to this factor.

The first experiment was conducted over a period of 46 days beginning on the 15 May 2000. Pots were checked daily for the first 4 days, twice weekly during the following 2 weeks and weekly thereafter. The second experiment was conducted over 78 days beginning on 19 October 2001. During this experiment the pots were checked daily for 3 days, twice the following week and weekly for the remainder of the experiment. In both experiments, the pots were baited once only at the beginning of the experiment with a single frozen sea mullet (*Mugil cephalus*) weighing approximately 600 g, using stainless steel (2 mm rod) baiting wires attached in the centre of each pot's base. When pots were checked they were removed from the water and all *P. pelagicus* were measured, sexed and fitted with a tag. The tags consisted of a numbered, 15 mm diameter, stainless steel disc that was attached across the lateral spines of the carapace using stainless steel wire. The tag number and carapace width of each individual was noted, as was bycatch abundance and composition, before all animals were returned to the pots. The pots were then returned to the water, with any remaining bait left *in situ*.

On subsequent lifts, all tagged crabs and bycatch species were noted, while new crabs were tagged, sexed and measured. All captured animals, alive and dead, were left in the pots and records kept of the number of 'new', 'escaped' or 'dead' crabs as well as dead bycatch. The live crabs tagged on previous lifts were classified as 'static'. The crabs were assumed to have entered the pots on the day they were first tagged, while dead crabs were assumed to have died the day they were first discovered dead. Any damage to pots was recorded but was not repaired in order to best replicate the condition of a lost pot.

The condition of the bait was defined as follows. "Fresh" bait was defined as the first 2 days after the pot was first set, "Stale" was from day 2 to day 4 when there was commonly some bait remaining in the pot and "None" referred to day 4 onward when the bait was always exhausted. During the second experiment a further state was described as "None + SE" which was defined as the period after which the bait was exhausted but immediately following an prolonged period of strong (>25 knots) south-easterly winds which occurred during this experiment.

A generalised linear model (GLM) was used to analyse the catch rates of crabs. The catch rate of crabs (in crabs per pot per day)