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Reducing the marine debris of recreational hoop nets in south-eastern Australia

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ABSTRACT

Alternative configurations of Australian recreational portunid hoop nets were investigated to address debris and selectivity issues. Four treatment nets (all comprising 152-mm polyamide–PA mesh) were assessed that differed in their twine (conventional multifilament vs new multi-monofilament) and fishing configuration (conventional conical vs inverted shapes). The conical multifilament design lost means (±SEs) of 130.6 ± 23.1 and 5.3 ± 1.2 mm of twine 3-h soak^{-1} when used to target *Scylla serrata* and *Portunus pelagicus*. Inverting this hoop net significantly reduced legal-sized catches (by up to 70%) and with greater twine loss (×5) when targeting *P. pelagicus*. Conversely, both multi-monofilament configurations maintained legal catches of *S. serrata* and *P. pelagicus*, but lost 78 and 95% less twine than the conical multifilament design. Using multi-monofilament hoop nets could reduce PA debris by thousands of m p.a. in south-eastern Australia, without affecting targeted catches. Further, a lower fishing height of inverted multi-monofilament nets might reduce non-portunid bycatch.

1. Introduction

Portunids form the basis of important recreational fisheries throughout Australia, with >9 million individuals caught each year (Henry and Lyle, 2003). Catches mostly compromise *Scylla serrata* and up to four *Portunus* congenerics (until recently collectively grouped as *P. pelagicus*; Lai et al., 2010), and typically are taken from various baited traps—the regulations describing which vary among states (Campbell and Sumpton, 2009; Butcher et al., 2012; Broadhurst et al., 2015, 2016, 2017).

Like for trap fisheries globally, most of the recreational traps targeting Australian portunids are considered to have benign environmental impacts, including negligible benthic contact and low bycatch (Butcher et al., 2012; Leland et al., 2013; Uhlmann and Broadhurst, 2015). However, one method that has raised ongoing concerns is the conical hoop net (or so-called 'witches hat') which is an inexpensive and popular baited recreational gear fished throughout south-eastern Australia (New South Wales, NSW) (Butcher et al., 2012; Leland et al., 2013; Broadhurst et al., 2015, 2016).

Hoop nets are regulated by a minimum 13 mm stretched mesh opening (SMO), base diameter (<1.25 m) and height (<1 m), with up to four permitted per recreational fisher in >100 estuaries (typically deployed either diurnally for <6 h, or overnight) to catch daily personal quotas of 10 *P. pelagicus* (≥60mm carapace length; CL) and five *S. serrata* (≥85 mm CL) (Butcher et al., 2012; Broadhurst et al., 2015). While the limited technical regulations imply a plethora of designs, virtually all hoop nets comprise a rectangular panel of ~152-mm mesh made from thin (~ <0.9 mm diameter–Ø) multifilament polyamide (PA) twine sewn into a cylinder 30 meshes in circumference and 6 or 7 meshes long (Fig. 1a). One end of the cylinder is attached to a ~750-mm Ø galvanized steel ring, while the other is laced tightly together and secured immediately below a small float, resulting in a conical net that entangles catches as they attempt to access a centrally located bait (Fig. 1b).

Owing to their construction and catching method, there are two key environmental issues associated with hoop nets. First, they often are damaged and with some twine lost as marine debris (and potentially entangled around escaping organism). For example, Leland et al. (2013) observed that hoop nets (~0.7 mm Ø multifilament PA twine) set for up to 24 h to target *P. pelagicus* had between 1 and 11 meshes damaged (i.e. broken bars) per net. Damage rates among the same hoop nets targeting *S. serrata* were worse at 7–12 meshes per net (Butcher et al., 2012). Further, after 24 h, nearly 60% of hoop nets used to target both species had >20 meshes broken and were considered unusable (Broadhurst et al., 2015, 2016). No quantitative data are available describing the amount of twine lost during mesh breakage in hoop nets, but it is widely acknowledged that such debris has pervasive negative consequences for the environment (e.g. Derraik, 2002; Chiappone et al., 2005; Rochman et al., 2015).

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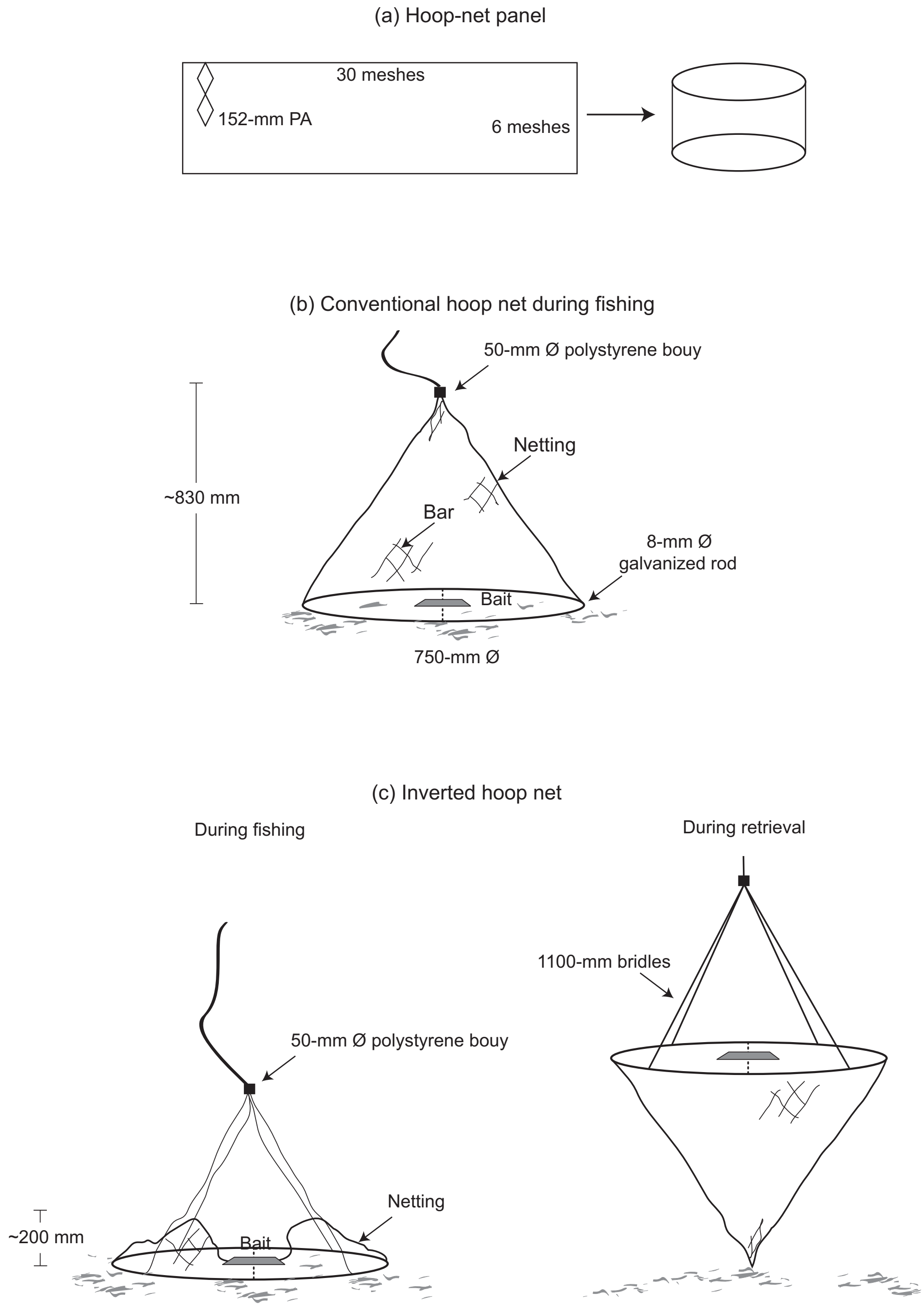

Fig. 1. Diagrammatic representation of (a) the panel used to construct hoop nets, (b) a conventional conical hoop net during fishing, and (c) an inverted hoop net during fishing and retrieval.

A second environmental issue is that hoop nets are neither 100% size nor species selective and so, in addition to undersize or excessive (beyond personal daily quotas) portunids, unwanted fish and, on very rare occasions at some locations, green turtles *Chelonia mydas* are caught. Non-portunid bycatch can asphyxiate, while portunids can lose limbs during disentanglement. Although short-term mortalities to portunids are low (Butcher et al., 2012; Leland et al., 2013), there remain potential negative implications for longer-term survival (Uhlmann et al., 2009).

Beyond prohibiting hoop nets (for which there is considerable resistance by recreational fishers, which typically comprises >800,000 participants), the stated environmental issues might be ameliorated via subtle design changes, and possibly (i) stronger materials and/or (ii) lower vertical orientation in the water column (to spatially limit catches of fish and turtles). Previous studies have shown that these parameters can influence the efficiency and selectivity of other entangling gears (e.g. gill and trammel nets; Gray et al., 2005; Uhlmann and Broadhurst, 2015), but few data are available for hoop nets used in NSW (but see Broadhurst et al., 2015).

In the only relevant published study, Broadhurst et al. (2015) identified a negative relationship between mesh damage and the multifilament PA twine Ø (0.5–0.8 mm), although the thickest conventional twine was still readily damaged and caught fewer *P. pelagicus*—potentially owing to reduced elasticity. An alternative approach might be to assess other, stronger materials that maintain elasticity (and therefore catches), but with less propensity to break. One option is relatively thicker multi-monofilament twine, which is readily available and used by professional gill netters in south-eastern Australia to catch various species, including *P. pelagicus* (Gray et al., 2005).