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Short communication

Configuring escape gaps in recreational rectangular traps to improve size selection for eastern rock lobster, *Sagmariasus verreauxi*

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ABSTRACT

The utility of escape gaps in rectangular traps for improving the size selection of eastern rock lobster, *Sagmariasus verreauxi* was assessed during two experiments in an Australian recreational fishery. In experiment one, compared to conventional traps (no escape gaps), those comprising one (57 × 500 mm) or three (each 57 × 200 mm) escape gaps along their sides maintained legal catches of *S. verreauxi*, but did not significantly affect undersized (< 104 mm carapace length; CL) catches; although there were fewer (mean catch reduced by 35%) in the latter traps. In experiment two, three escape gaps all located either on the sides or corners of traps significantly reduced catches of undersized *S. verreauxi* by up to 82%, with no effect on legal catches, and when catches were pooled between treatments, produced a 50% CL at selection of 102 mm with a selection range of 10 mm. Notwithstanding the inter-experimental differences—which possibly reflected relative catches and density-dependent escape rates—escape gaps should be enforced in recreational traps targeting *S. verreauxi* as a means for reducing discarding.

1. Introduction

Spiny lobsters (Palinuridae) are important to Australian recreational fisheries, with > 1.35 million individuals caught each year comprising four species: tropical lobster, *Panulirus ornatus*; western rock lobster, *P. cygnus*, southern rock lobster *Jasus edwardsii*, and eastern rock lobster, *Sagmariasus verreauxi* (Henry and Lyle, 2003). The latter three species dominate catches, and mostly are caught in either baited round ('beehive pots') or rectangular wire-mesh traps fished inshore throughout southern states (Leland et al., 2013). Neither round nor rectangular traps are completely selective for legal-sized lobsters which, combined with daily personal quotas, means up to 50% of the above total catch is released, raising concerns over unaccounted fishing mortality (Uhlmann and Broadhurst, 2015).

A simple method for improving crustacean trap selectivity is to use so-called 'escape gaps'—which are mandated for all Australian recreational lobster traps (Brown and Caputi, 1986; Treble et al., 1998; Linnane et al., 2011). But, while legislation in New South Wales (NSW) prescribes either one, two or three escape gaps trap^{-1} (all 57 mm high and either minimums of 500, 250 or 200 mm long, respectively), historically these have not been enforced owing to a lack of formal data describing utility for the key target, *S. verreauxi*.

Recently, Broadhurst et al. (2017b) sought to address the above shortfall for round traps. Compared to round traps with zero escape gaps, those with one, two and three (as above) similarly reduced undersize catches of *S. verreasuxi* (< 104 mm carapace length; CL) by up to 84%, while retaining 1.6–4.8× more legal-sized conspecifics (attributed to size-specific trap saturation). Although these results are promising, escape gaps have not been tested in rectangular wire-mesh traps targeting *S. verreasuxi*. Such data are important, because various technical parameters, including trap design (Vazquez Archdale et al., 2007), along with escape-gap configuration (Broadhurst et al., 2017a) and location (Jirapunpipat et al., 2008) can affect crustacean selectivity. Considering the above, our aims were to assess the utility of either one or three escape gaps (i.e. the range of existing legislated options) at different locations in rectangular traps for reducing catches of undersized *S. verreauxi*.

2. Methods

Two experiments were done during August–December in 2013 and 2016, respectively off Port Stephens (32.70°S, 152.12°E), NSW using

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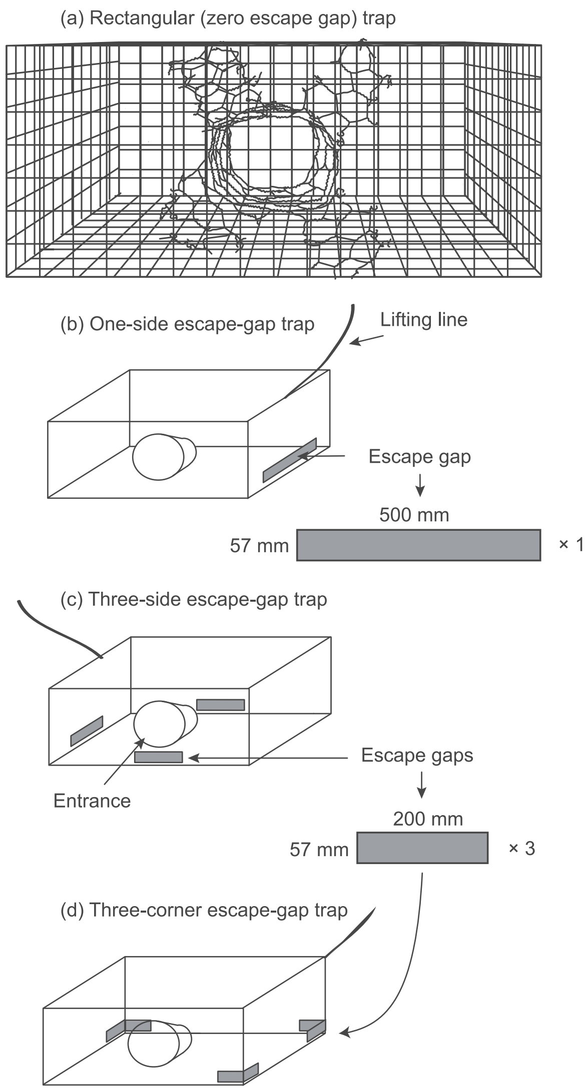

Fig. 1. Diagrammatic representation of (a) a conventional rectangular trap (zero escape-gap trap), with (b) one and (c) three side escape gaps, and (d) three corner escape gaps.

the same rectangular traps ($n = 16$; ~800 × 600 × 360 mm and 18 kg). Each trap was constructed from 4-mm diameter (Ø) square steel mesh (50 × 50 mm) with a single, side entrance (200-mm in Ø and 200 deep; Fig. 1a).

During experiment one, five each of the traps had either no escape gaps, or one (57 × 500 mm) or three (each 57 × 200 mm) located on the sides ('three-side escape-gap trap') and made from 4-mm Ø galvanized rod (Fig. 1a–c). One trap was left as a spare. Based on the results, we then reconfigured the escape-gap traps so that they each had three escape gaps, but either located on the sides (as above) or the corners ('three-corner escape-gap trap') and made from 16-mm Ø rod (to maintain trap strength at the corners; Fig. 1d). Four replicates of each of these two treatment traps and the zero escape-gap trap were then fished in experiment two.

All traps had lifting ropes attached so any escaping *S. verreauxi* had to do so during fishing (and not hauling; Fig. 1) and were baited with sea mullet, *Mugil cephalus* in a central wire-mesh bait bag (10-mm steel mesh). During each experiment, the five or four replicates of each treatment trap were simultaneously deployed at least 50 m apart in ≤10 m depth (a legal spatial requirement) across 16 and 20 days, respectively.

2.1. Data collected and analyses

Temperature loggers (Minilog-II-T – Vemco Ltd., Nova Scotia, Canada) were deployed on some traps, and configured to provide an average datum every 30 min. The deployment and retrieval times were noted for all traps and water visibility recorded using a Secchi disk. After retrieval, traps were emptied and *S. verreauxi* were counted, sexed and measured for CL (to the nearest mm), before being assessed for mortality and any damage to antennae or limbs (defined as either old or new following Uhlmann et al., 2009). Any fish or octopus were counted and released.

Generalized log-linear mixed models (GLMM) were fitted to the numbers of trapped *S. verreauxi* within experiments. Random effects were 'days' and 'traps-within-days', while the considered fixed effects were the type of 'trap' (number of escape gaps), 'legal status' of *S. verreauxi* (legal- or undersized) and 'soak time'. Preferred models were chosen using forward selection, starting with the model having only the random-effect terms and sequentially adding the most significant fixed-effect term at each step until no further terms were significant at the 5% level. Significant effects were subsequently explored using the Benjamini-Hochberg-Yekutieli procedure to control the false discovery rate (FDR; Benjamini and Yekutieli, 2001) of multiple pairwise comparisons.

Where significant differences were detected between the conventional and escape-gap traps and there were sufficient size-frequency data, the symmetric logistic and asymmetric Richards selection curves were fitted using an estimated-split SELECT model (Treble et al., 1998; Millar and Fryer, 1999), with the preferred model chosen using the likelihood ratio test after correction for overdispersion (Millar et al., 2004). Confidence intervals of parameter estimates (50% probability of retention—CL_{50} and selection range—SR) for the best model were obtained using a double bootstrap to incorporate both between- and within-day variabilities. One thousand bootstrap simulations were performed. Pointwise 95% confidence intervals for the selection curve were similarly obtained. All fits were obtained using the R language (R Core Team, 2018).

3. Results

In total, 533 *S. verreauxi* and 35 individuals from 11 other species (mostly the blind shark, *Brachaelurus waddi*) were trapped from 1 to 10 m of water with visibilities of 1–14 m (Table 1). Mean water visibilities and depths trap deployment^{-1} were greater in experiment two than one (Table 1); but temperatures remained similar (mean ± SD of 18.8 ± 0.8 and 18.3 ± 0.7 °C, respectively). Owing to poorer weather (precluding access), soak times were also longer during experiment two (Table 1). Irrespective of experiment, similar numbers of female and male *S. verreauxi* were caught and only one (undersized) was dead (experiment two); providing a total immediate discard mortality of < 1%. Few *S. verreauxi* were damaged, which was typically limited to broken antenna (Table 1). For several other species, there was a trend of fewer catches in the traps with escape gaps (Table 1).

3.1. Experiment one: zero vs one-side vs three-side escape gaps

One trap (a three-side escape-gap) was lost and replaced with the configured spare replicate. A total of 190 *S. verreauxi* were trapped, with similar numbers in each of the three trap types (Table 1). The preferred GLMM included soak time, trap, legal status and an interaction between the latter two effects (Table 2). Significance was limited to the interaction (GLMM, $p < 0.05$; Table 2, Fig. 2a), but subsequent FDR pairwise tests of traps within either legal- or undersized *S. verreauxi* failed to separate the means, although the mean catch of undersized individuals was 35% lower in the three-side escape-gap trap than the zero escape-gap trap ($p > 0.05$; Fig. 2a). Based on these results we restricted the treatments in the second experiment to three