At-sea testing of the Hills Nets BRD onboard the *FV Dolphin Pearl* for approval in Australia's Northern Prawn Fishery

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Executive summary

Square mesh codends have been successful in reducing bycatch in a number of fisheries globally. This report documents the trialling of a modified square mesh codend and TED developed by Queensland netmaker Hills Nets P/L in the NPF during the 2009 tiger prawn season against the NPF Bycatch Subcommittee's performance requirements.

The primary objective of this trial was to determine if the gear can produce more efficient catches of prawn by reducing the amount of bycatch being caught and therefore be approved as a bycatch reduction tool for the NPF.

Design and operational problems hindered the effective testing of the gear. A number of modifications were required to address deployment and retrieval issues and to control prawn loss. Commercially unacceptable prawn loss (22% reduction in kg.trawl hour^{-1}) required the trials to be halted after two separate trials and 13 trawls (48.35 trawl hours). The design significantly reduced bycatch weight by 46%, attributable to reduced retention of ponyfishes (family Leiognathidae) and whiting (family Sillaginidae).

The complexity of the gear design prevented the observers and crew identifying and correcting the source of prawn loss. A simplified design which limits the number of variations from standard commercial trawl systems is required if future testing is to be conducted. Specifically, a standard TED configuration should be used so that tests on mesh size and orientation can be conducted. Future work could also incorporate covered codend trials to determine the size selectivity of specific mesh sizes to reduce the loss of marketable size classes of prawns.

Due to the unacceptable prawn loss and incomplete trialing against the NORMAC *TED and BRD testing protocol* this proposed Hills Nets design is not recommended for use by industry.

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Introduction

There is existing literature that supports the use of square mesh codends as bycatch reduction measures. The design proposed by Hills Nets P/L brings together a number of individual modifications from the literature into a single device, specifically an increase in meshes round the codend and using square mesh for the codend. Mesh count significantly effects water flow in and around the codend (Broadhurst et al 1999), while square mesh codend (instead of diamond mesh) can improve size selectivity and survival of escapees (Macbeth et al 2005, 2007). However Farmer et al (1998) showed an increase in mesh size (38 – 45 mm) reduced escapee damage regardless of mesh orientation. Square mesh codends are recommended for use in Queensland's deepwater eastern king prawn fishery where experiments showed a 29% reduction in bycatch with no loss of targeted prawns (Courtney et al 2007), and square mesh codends are considered a plausible management tool to improve the state of deep water crustacean resources and to reduce ecosystem effects of fishing (Guijarro & Massuti 2006).

Square mesh codends are permitted to be used in the NPF (Direction No NPFD 107), however the proposed codend has an increased nominal mesh size and mesh count.

The objective of these trials was to determine if the Hills Nets design can produce more efficient catches of prawn by reducing the amount of bycatch being caught, and therefore be approved as a bycatch reduction tool for the NPF. Here we report on changes in catch weight and composition using the Hills Nets square mesh codend configuration in the NPF.

Methods

Two trials were conducted testing two gear configurations of the proposed codend (see below for codend designs). For both trials industry standard quad rigged prawn trawls were used (4 x 7.5 fathom nets, #8 Bison boards). Trawl shots were towed on a circular path in trial 1 and a straight path in trial 2, at approximately 4 knots for 3 – 3.8 hours.

Trial 1

Two codends were constructed to the design shown in Figure 1, consisting of 160 meshes x 50 meshes x 63mm (ID) *Euroline Premium Plus* net in the throat (hung on the diamond), housing a 1480 x 1170 mm rota moulded plastic Turtle Excluder Device (TED) set at 55°. The codend was constructed of 50mm (ID) *Euroline* net set on the square (160 bar count round). The draw strings are accommodated by a 160 x 10 x 50 mm mesh section of diamond netting.

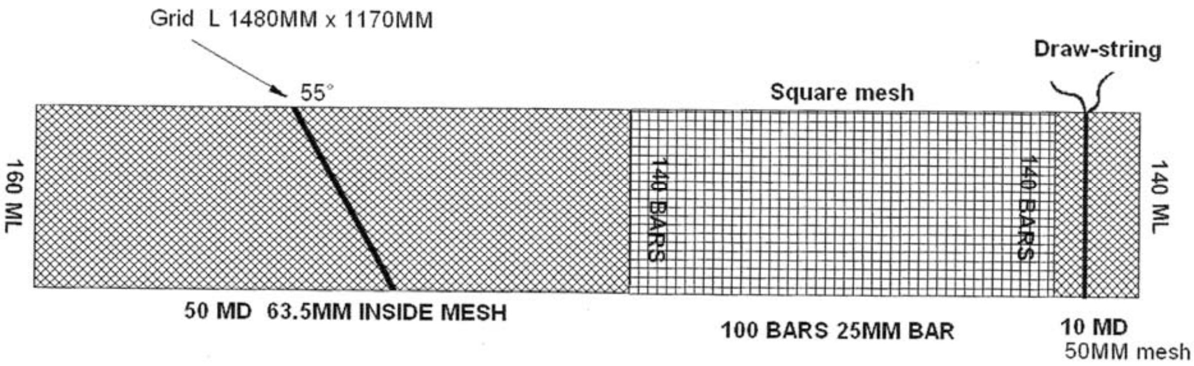

Figure 1: Codend net plan tested in trial 1. Image by Wally Hill. Note the number of meshes in the square mesh section was reduced by approximately 20 meshes during the trials.

A number of adjustments to the design were made during the trial to reduce prawn loss, including sewing up the double TED flap, and the longitudinal mesh count was reduced 8 meshes for operational purposes.

Trial 2

The above described codend design was modified for trial 2. Modifications included skirting the codend with 44mm mesh set on the diamond at 60 meshes, the lifting ears moved down the codend to allow the nets to be lifted above the hopper, TED flap and TED escape to be sewn to regulation dimension and TEDS to be moved further forward of the codend in line with industry standards.

Further modifications were carried out during the trials to improve seabed contact of the trawl system, including extending the length of the throat, removal of float ropes on the codend and ballasting the TEDs.

Data analysis

Subsamples weighing about 10 kg were measured for family composition and family weight for control and experiment codends from each shot. Baseline and experimental CPUE (kg.trawl hr^{-1}) data were analysed using independent sample t tests.

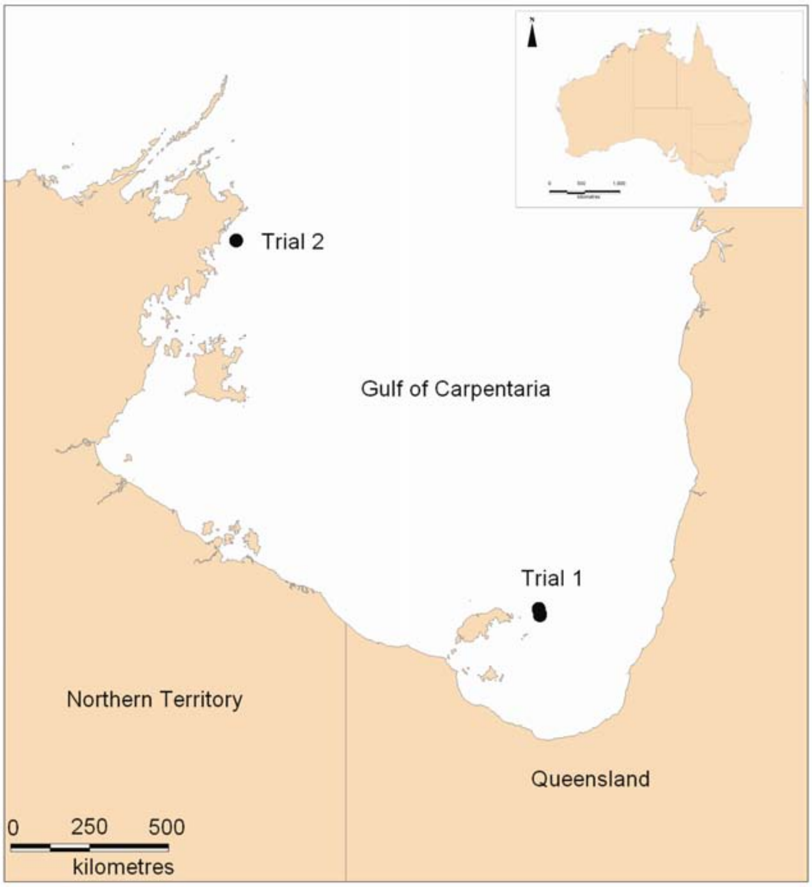

Figure 2: Map show location of Trial 1 and Trial 2.

Results

A total of 13 experimental tows (48.35 hours) over seven nights and two trials were conducted. Eight baseline trawls using standard commercial gear were also conducted in trial 2 to identify standard catch weights and compositions.

Baseline analysis

Two sets of baseline trawls (2 x 4 tows = 24.5 hours tow time) were conducted to measure catch rates of target and bycatch species using *Dolphin Pearl's* existing trawl gear configuration. The first set of four baseline trawls occurred prior to the deployment of the Hills Net configuration. Based on these catch measurements, the crew made a number of rigging modifications to the trawl boards, ground gear and droppers, which in turn made the baseline measurements invalid. A second set of four baseline trawls were conducted after the experimental trawls. The mean CPUE for target species and bycatch for each trial appears in Figure 3. There was no difference in CPUE's between baseline data sets and so the combined baseline measurements were used for subsequent analyses.

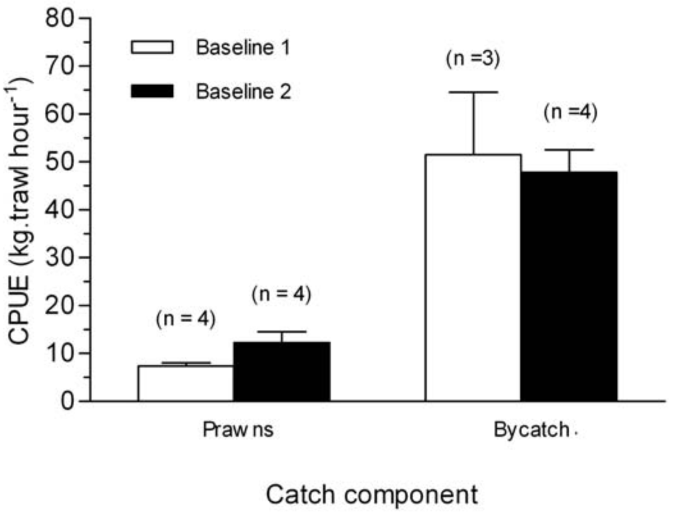

Figure 3: Change in CPUE (kg.trawl hr^{-1} ± SE) for target species and bycatch within baseline trawls (first four trawls v last four trawls).

Combined baseline data

There was no significant difference in target species catch rates between sides of vessel (prawn port: 9.4 ± 2.0 kg/hr; prawn starboard: 10.2 ± 1.8 kg/hr; t=-0.293, df 14, P=0.774). The bycatch catch rate also did not differ significantly between sides (bycatch port 58.7± 8.4 kg/hr; bycatch starboard 54.8 ± 7.2 kg/hr; t=0.357, df 12, P=0.727; Figure 4).

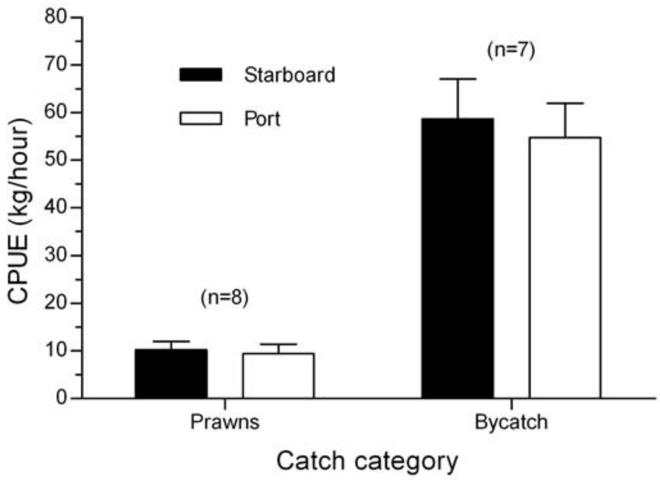

Figure 4: CPUE (kg.trawl hr^{-1} ± SE) for target species and bycatch for control conditions on port and starboard sides of the vessel.

Trial 1 analysis

The trial was halted after 5 trawls (16.85 hours tow time) due to commercially unacceptable prawn loss (21% reduction in CPUE). There was no significant difference in target species catch rates between codend designs (standard codend: 51.8 ± 8.7 kg/hr; modified codend: 41.0 ± 5.2 kg/hr; t=1.067, df 8, P=0.3174). The bycatch catch rate was significantly different (48%) between codend designs (standard codend 64.1± 7.3 kg/hr; modified codend 33.3 ± 1.2 kg/hr; t=4.16, df 6, P=0.006; Figure 5).

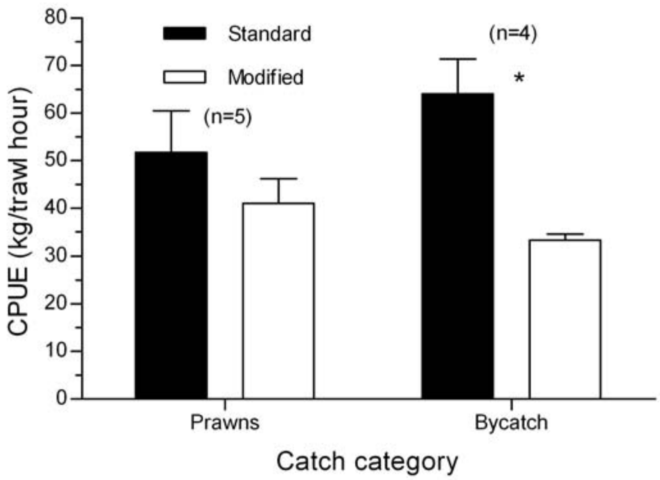

Figure 5: CPUE (kg.trawl hr^{-1} ± SE) for target species and bycatch for comparison of standard and modified codends for trial 1 (* = significant difference).

Trial 2 analysis

The trial was halted after 8 trawls (26.5 hours tow time) due to commercially unacceptable prawn loss (28% reduction in CPUE). There was a no significant difference in target species catch rates between codend designs (standard codend: 13.8 ± 2.0 kg/hr; modified codend: 9.9 ± 1.2 kg/hr; t=1.681, df 14, P=0.115). The bycatch catch rate was significantly different (45%) between codend designs (standard codend 51.7 ± 6.3 kg/hr; modified codend 28.2 ± 4.3 kg/hr; t=3.092, df 14, P=0.008; Figure 6).

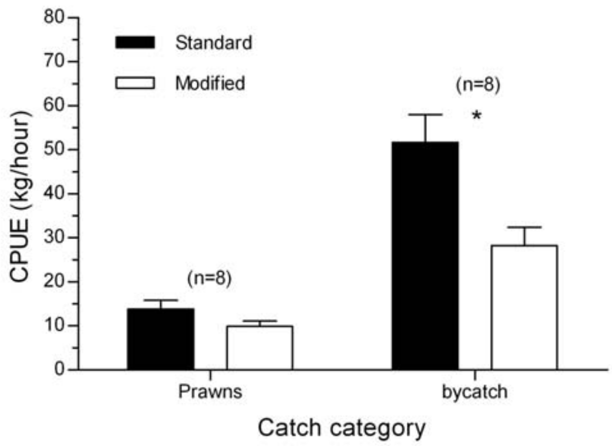

Figure 6: CPUE (kg.trawl hr^{-1} ± SE) for target species and bycatch for comparison of standard and modified codends for trial 2 (* = significant difference).

There was no difference in catch rates between the baseline data and control trawls in trial 2, meaning the gear modifications being tested did not impact of the catching performance of the controls (Figure 7, Table 1).

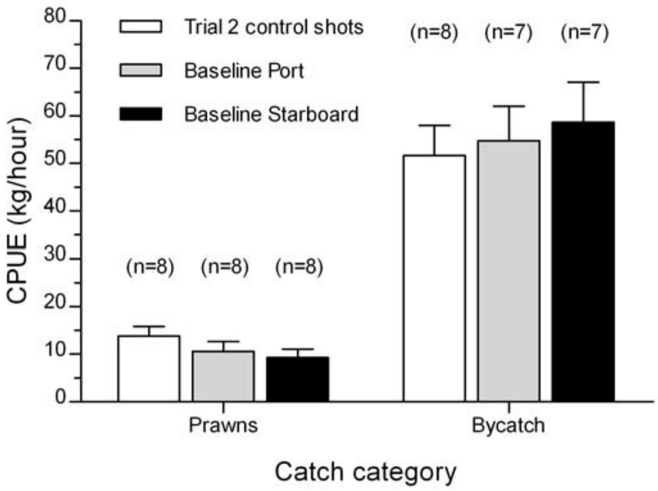

Figure 7: Average catch rates (kg.trawl hr^{-1} ± SE) for target and non-target catches for baseline trawls and control trawls in trial 2.

Table 1: Two-way ANOVA for baseline and control trawls.

Source of variation	df	MS	*F*	*P*
catch component	1	22121.4	110.8	0.000
trial component	2	10.799	0.054	0.947
Catch component*trial component	2	125.5	0.629	0.538
Residual	40	199.6		

Combined experimental data

Experimental catch rate data was combined for all 13 trawls (48.35 hours tow time) from the two trials to identify changes in catch due the Hills Net design. Continual modification of the gear design occurred throughout the trials to tackle prawn loss and improve seabed contact. These specific changes cannot be analysed separately due to the lack of replication. Analysis is based on the comparison of CPUE from the standard trawl codend to the generic modified codend.

There was no statistically significant difference in target species catch rate between codend designs (prawn standard codend: 28.4 ± 6.3 kg/hr; prawn modified codend: 21.9 ± 4.8kg/hr; t=-0.853, df 24, P=0.402) however, the bycatch catch did significantly differ between codend designs (bycatch standard codend 55.8 ± 5.0 kg/hr; bycatch modified codend 29.9 ± 2.9 kg/hr; t=4.354, df 22, P<0.001); Figure 8).

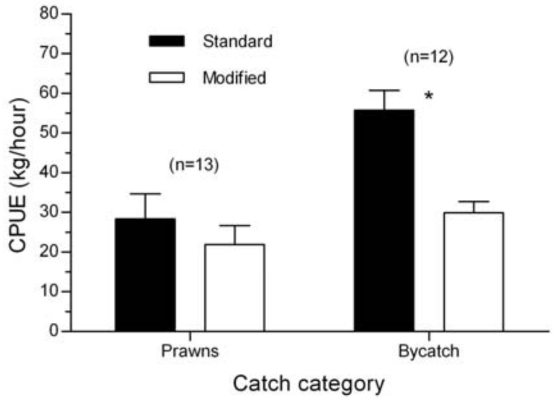

Figure 8: CPUE (kg.trawl hr^{-1} ± SE) for target species and bycatch for comparison of standard and modified codends for combined data sets (* = significant difference).

Subsamples

Target species

The length frequency distribution of retained prawns from trial 1 appears in Figure 9 (note the frequencies are not standardised; ignore the absolute numbers and focus on the shape and location of the curve). Male and female prawns were clearly retained at 30 and 35 mm carapace length, respectively. Using length-weight relationship parameters for tiger prawns (*Penaeus esculentus* & *P. semisulcat*us; Penn & Hall 1974; Farmer 1980) female prawns below about 32 – 35 grams, and male prawns below 22 – 25 grams were not retained by the codend tested in trial 1. This translates into lost prawn production for U 13-15 (30 – 36 g) and U 16-20 (22 – 30 g) grades. Commercial size grades measured by O'Neill et al (1999) support the above findings for females only, with the smaller males (22 – 25 mm) likely to have been discarded or lost through the codend (prawns per pound >26-30).

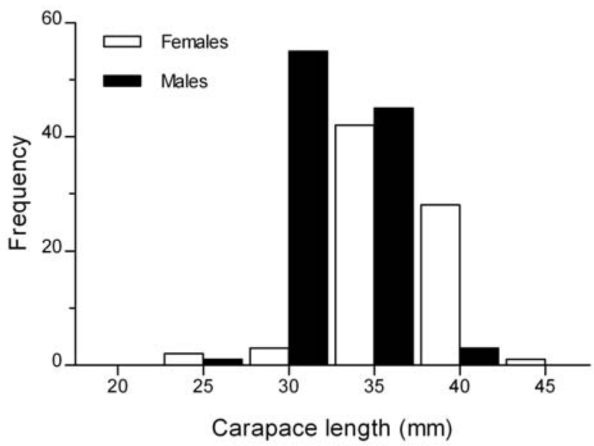

Figure 9: Length frequency distribution for a subsample of prawns landed in trial 1.

Using samples of prawn length frequency data from trial 2, differences in prawn sizes retained in baseline and experimental tows were examined with the Kolmogorov-Smirnov test. The only significant difference in length frequencies was for portside nets between baseline tows and experimental tows (Table 2, Figure 10).

Table 2: Non-parametric tests for differences in length frequencies of target species from baseline and experimental trawls.

Test	D	*P*
Baseline Port v Baseline Starboard	0.921	>0.05
Experiment Port v Experiment Starboard	1.323	>0.05
Port baseline v Port experiment	1.826	**<0.05**
Starboard baseline v Starboard Port	1.323	>0.05

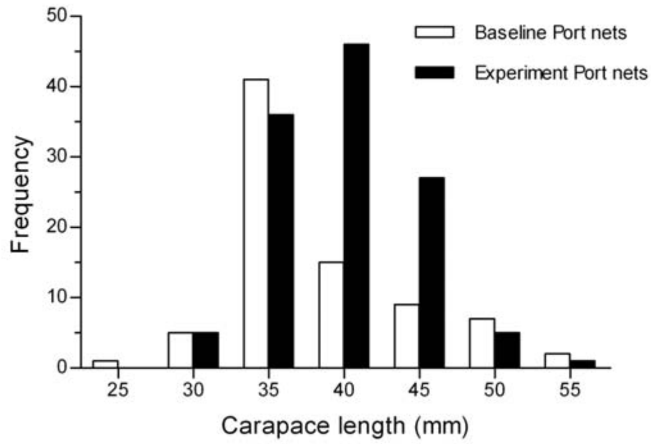

Figure 10: Length frequency distributions for combined targeted prawns from portside nets under control and experimental conditions (note frequencies are not standardised).

The mean carapace lengths of these two distributions were not significantly different (baseline port = 36.1 0.68 mm; experiment port = 37.5 0.46 mm; t = -1.842, df=198, P = 0.067), however the median carapace length increased from 34 mm to 37.5 mm due to the square mesh codend. This loss of smaller prawns partially accounts for the reduction in target species weight.

The length frequencies for all four prawn data sets appears in Figure 11 as smoothed line graphs for ease of interpretation. The length frequency distribution of prawns retained in the square mesh codend shows normal distribution, unlike the other three data sets in which at least two cohorts are evident. The small sample sizes make it difficult to explain this observation, but it couldn't go by without mention.

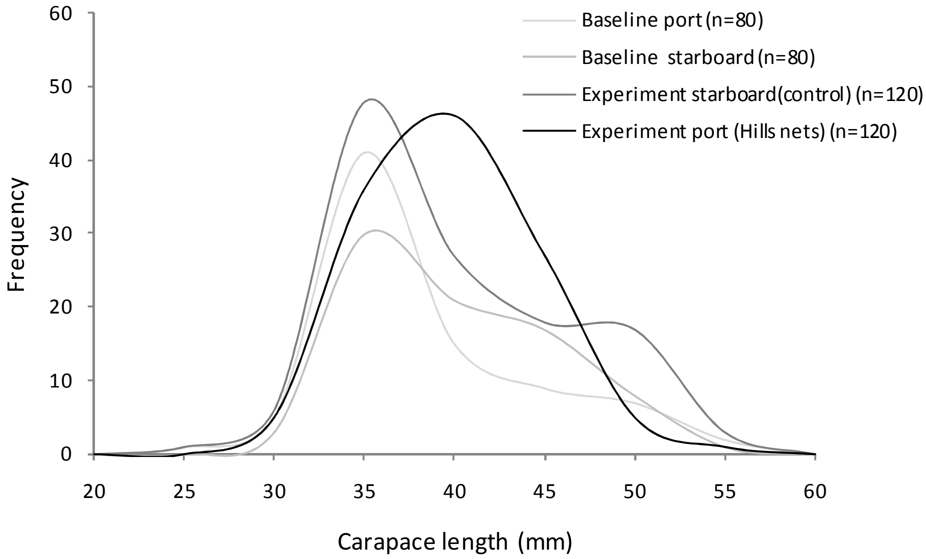

Figure 11: Length frequency distributions for combined targeted prawns under control and experimental conditions (note frequencies are not standardised).

Fish bycatch

Bycatch subsampling during trial 1 identified more than 80% of bycatch weight per trawl hour was comprised of seven finfish families (Figure 12). Ponyfishes (Family Leiognathidae) dominated bycatch (38.8%) with whiting (family Sillaginidae, 16.8% and sweetlips (Family Haemulidae, 6.7%) contributing more than 60% to bycatch weight per trawl hour.

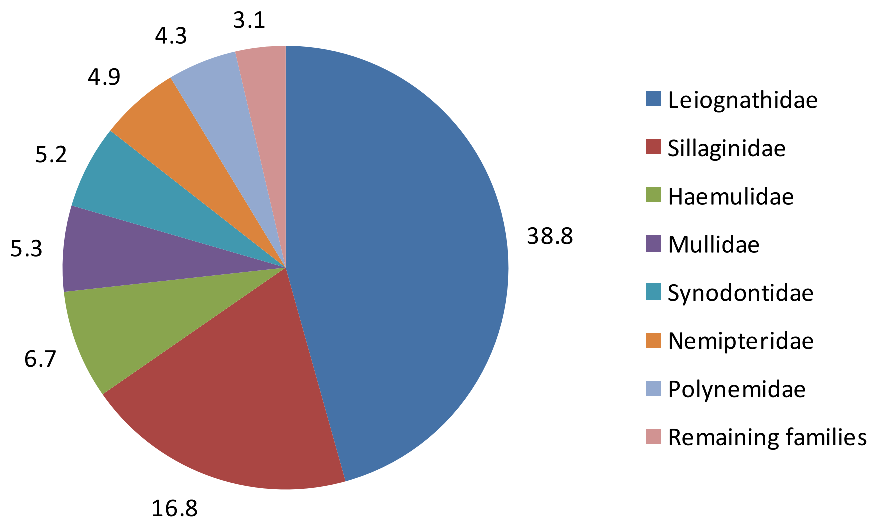

Figure 12: The percentage representation of the dominant bycatch families in CPUE (kg.trawl hr^{-1}) in subsamples from trial 1.

Of the seven dominant families of fish in the control catches, the Hills Net design was successful in significantly reducing the bycatch weight of ponyfishes from 21.2 ± 6.2 to 3.3 ±

1.5 kg.trawl hr^{-1} and whiting from 9.1 ± 0.9 to 2.7 ± 0.4 kg.trawl hr^{-1} (Figure 13, Table 3). There was no change in the remaining dominant families.

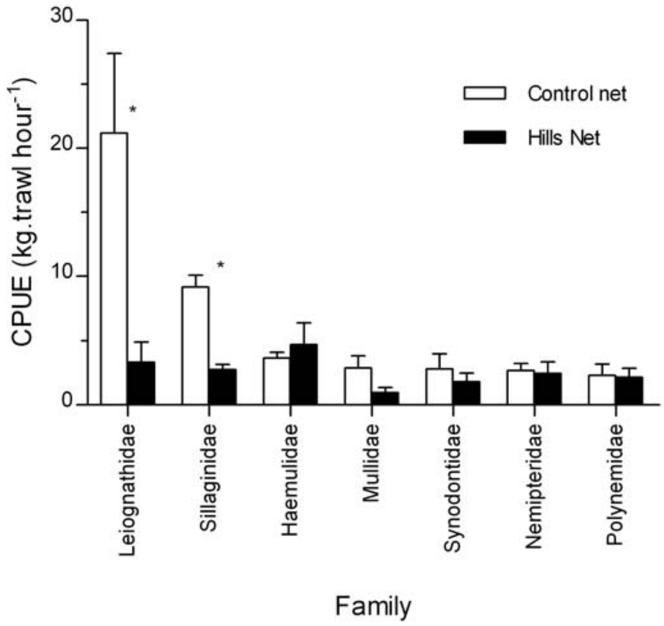

Figure 13: The effect of codend configuration on CPUE (kg.trawl hr^{-1}) of dominant bycatch families.

Table 3: T- test results for the seven most represented families in subsamples from control and experimental codends in trial 1.

Family	t	*P*
Leiognathidae	-2.773	0.032
Sillaginidae	-6.333	0.001
Heamulidae	0.589	0.577
Mullidae	-1.869	0.111
Synodontidae	-0.739	0.488
Nemipteridae	-0.205	0.844
Polynemidae	-0.132	0.899

Discussion

The Hills Nets codend design reduced the bycatch catch rate by 46.6%, however this came at a 22.8% reduction in prawn catch. The catches in both trials were reasonably ‘clean’ with a ratio of prawns to bycatch weight of 1 : 1.9. In terms of gross reductions in bycatch weight the proposed design was very effective with nearly half the bycatch being excluded, however the reductions were limited to two families, ponyfishes and whiting. The corresponding reduction in prawn catch was not statistically different however, in commercial terms the loss of 1/5th of the catch was unacceptable and required the testing to be halted. The prawn to bycatch weight ratio in the Hills Nets was 1 : 1.3.

During both trials the proposed gear configuration was considered unacceptable, requiring a number of modifications between trawls. It is impossible to assess the impact of each modification on catch composition due to lack of replication. Also, the intricate design (e.g., TED construction and location, mesh orientation and size) makes it difficult to attribute the impact of each component on bycatch reduction and prawn loss. For further developments of this or similar gear the observers and crew recommended that the TED and throat configuration be the same as the industry standard and testing of individual modifications (e.g., mesh orientation) are tested in isolation. The significant reduction in bycatch catch rate for the proposed design shows that there is potential application in the NPF, however prawn loss as well as problems with gear handling and in water performance need to be addressed before the gear can be field-tested under the auspices of the NORMAC bycatch subcommittee for potential approval for industry use.

Conclusion

Square mesh codends have been successful in other Australian and overseas prawn fisheries at reducing bycatch without significant loss of target species. The Hills Nets design significantly reduced bycatch catch rate, however with commercially unviable rates of prawn loss. The source of prawn loss could be isolated due to the intricate nature of the proposed BRD (throat, TED, mesh orientation and mesh size). A simplified gear design is required. Future research requires better knowledge of prawn size selectivity for given a mesh size and orientation before going to field testing. This understanding of mesh size and orientation size selectivity may provide fishers with a range of codend options that can be changed to suit the size of the target species at different locations and at different times of the season. Based on the data collected during these trials, the proposed design is not recommended for approval as a BRD in the NPF at this time.

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