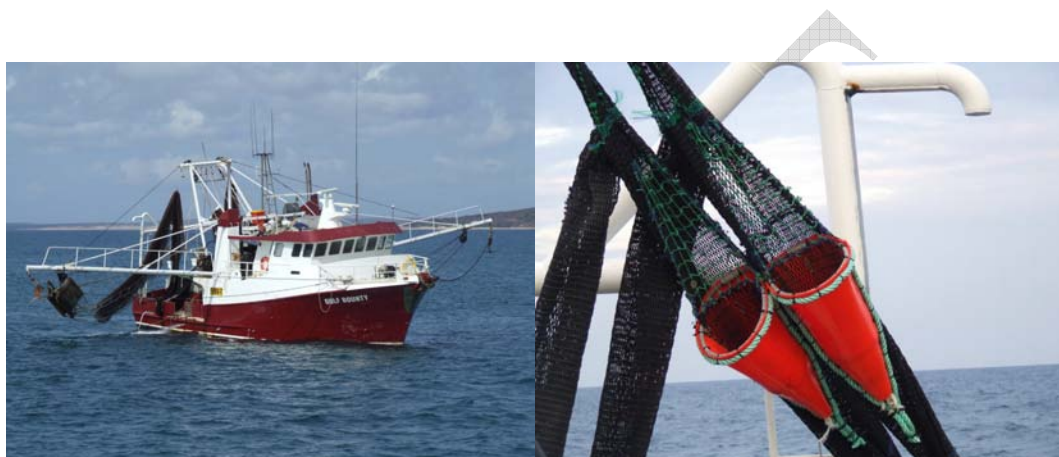# At-sea testing of the witches hat bycatch reduction device enhancer in the Northern Prawn Fishery

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July 2010

AFMA Northern Fisheries
73 Northbourne Ave
Civic ACT 2607

Published by the Australian Fisheries Management Authority

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Acknowledgements

The author and AFMA are appreciative of the many individuals and groups who provided advice and support for the following trial. Particular mention goes to:

Table of Contents

List of Figures

List of Tables

Executive Summary

This report documents the trialling of the witches hat enhancer device in conjunction with an approved square mesh panel bycatch reduction device (BRD) in the Northern Prawn Fishery (NPF) during the 2009 tiger prawn season. The device was designed to complement the effectiveness of the square mesh panel BRD. The BRD enhancer was trialled in line with the NPF Bycatch Subcommittee's performance requirements (Appendix 1).

The aims of this trial were to 1) show that the witches hat can significantly increase small fish bycatch escape through a square mesh panel and 2) measure the impact of the witches hat on the target species catch rate.

 The witches hat is a tool for enhancing the efficacy of some existing BRD designs by creating an area of reduced water velocity in the area of influence of the device. The inclusion of the witches hat device increased the rate of escape of small fish bycatch through a square mesh panel by 34% without changing the prawn catch. No difference in prawn catch was found throughout the trial. There is scope for further work to improve device design, streamline the process of attachment and to identify if the device improves the efficacy of other BRD designs.

Introduction

The Northern Prawn Fishery (NPF) is located off Australia's northern coast, and extends from the low water mark to the outer edge of the Australian fishing zone (AFZ) in the area between Cape York in Queensland and Cape Londonderry in Western Australia. The NPF is a demersal trawl fishery that targets nine species of prawn including tiger (*Penaeus esculentus* and *P. semisulcatus*) and endeavour prawns (*Metapenaeus endeavouri* and *M. ensis*). With operators towing twin or quad-rigged otter trawlers to harvest prawn species. The fishery is categorised by its high biodiversity and bycatch volume.

Bycatch is defined as that part of the catch which is returned to the sea either because it has no commercial value or because regulations preclude it being retained, and that part of the 'catch' that does not reach the deck of the fishing vessel but is affected by interactions with the fishing gear (DAFF 2000). The introduction of compulsory turtle excluder devices (TEDs) and the continual development of bycatch reduction devices (BRDs) in the NPF have improved gear selectivity in recent years (Brewer et al 2006).

With trawling considered to be one of the least selective fishing methods (Alverson 1994), the NPF industry has been working with the Australian Fisheries Management Authority (AFMA), research bodies and gear suppliers to continually develop and improve the effectiveness of BRDs. The Northern Prawn Fishery Management Advisory Committee (NORMAC) estimates that bycatch has been reduced by 50% since 1998, and continues to support research in the area (AFMA *n.d.*). To aid the development and implementation of suitable devices the NORMAC Bycatch Subcommittee developed the *TED and BRD Testing Protocol* which requires a device to reduce bycatch by at least 10%. To date seven TEDs and BRDs have been approved for use in the fishery (AFMA 2009). Testing of the witches hat enhancer was identified in the NPF's workplan as high priority for the fishery (Northern Prawn Bycatch and Discard Work Plan 2009) as early trials had shown the device could effectively and easily improve the rate of small fish bycatch escape (34%) through use with some existing BRDs (Evans 2008). However these early trials also measured a reduction in target species catch weight (6.8%) and the results were confounded by a number of gear modifications during testing (Evans 2008). In 2009, extra funding from AFMA's Bycatch and Discard Program allowed for formal testing of the BRD enhancer. This report presents the results of the trial.

Aims

The aims of this trial were to:

1) show that the witches hat can significantly increase small fish bycatch escape through a square mesh panel; and

2) measure the impact of the witches hat on the target species catch rate.

Methods

Hydrodynamic modelling

The witches hat design used in this trial was originally tested at the Australian Maritime College (AMC) in a circulating water channel (flume tank, figure 1). The device was attached to a commercially representative codend with a 101 mm square mesh panel and water flow profiling conducted around the device. The witches hat creates a region of turbulent, reduced velocity water (wake) in the area of influence of the square mesh panel making it easier for small finfish to escape through the BRD.
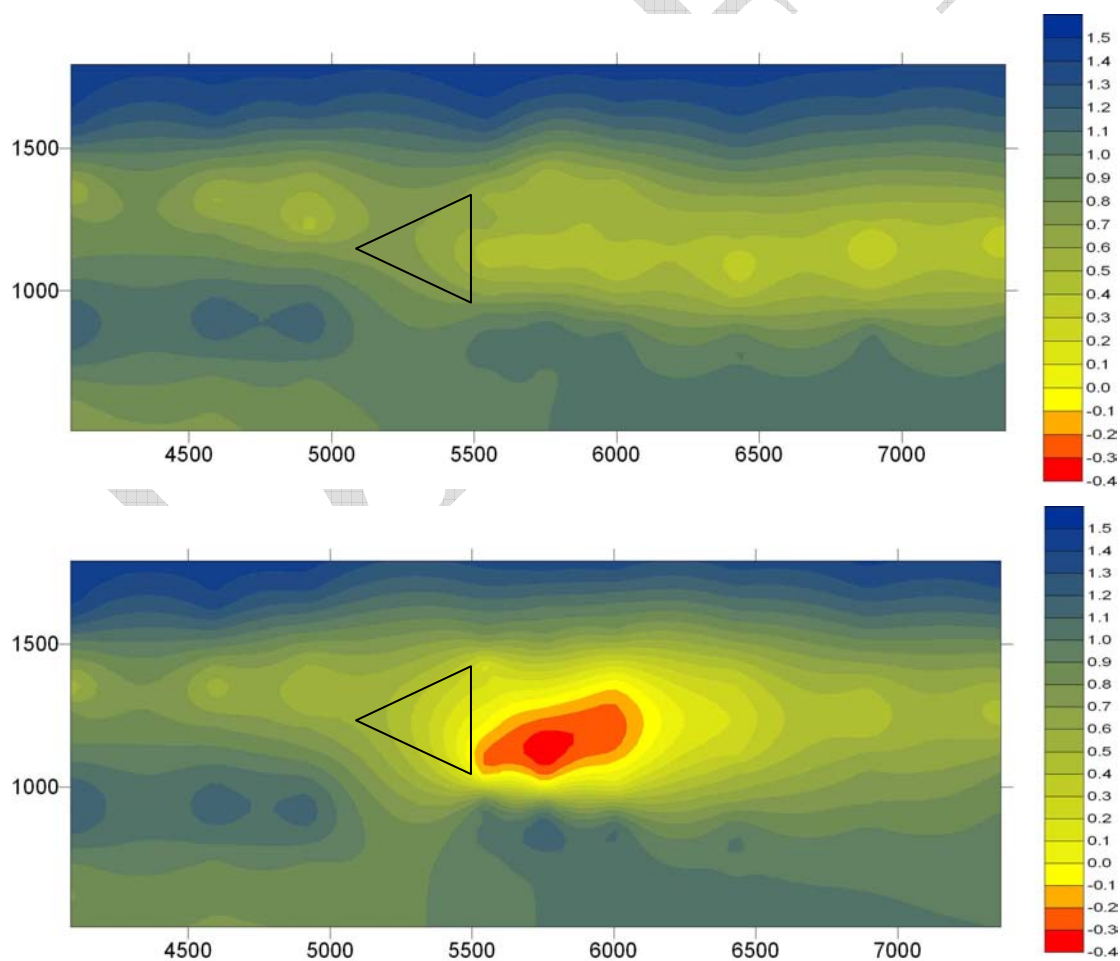
Figure 1. Flow profiles associated with an early design of the witches hat enhancer. Top: control conditions (unskinned enhancer). Bottom: experimental conditions (skinned enhancer). This shows a region of reduced water velocity generated by the early design witches hat enhancer (source: Wakeford 2006).

Field trials

The trial of the witches hat enhancer was conducted in the NPF during the 2009 tiger prawn season in waters between Mornington Island and Groote Eylandt (figure 2). The trials were conducted on the 28 m commercial prawn trawler *Gulf Bounty* during normal fishing operations. The vessel fished using quad-rigged gear (four 7 ½ fathom net, figure 3) each net having an approved square mesh panel BRD (400 x 600 mm panel constructed of minimum 101 mm stretched mesh) positioned with its trailing edge 100 meshes from the codend drawstrings.
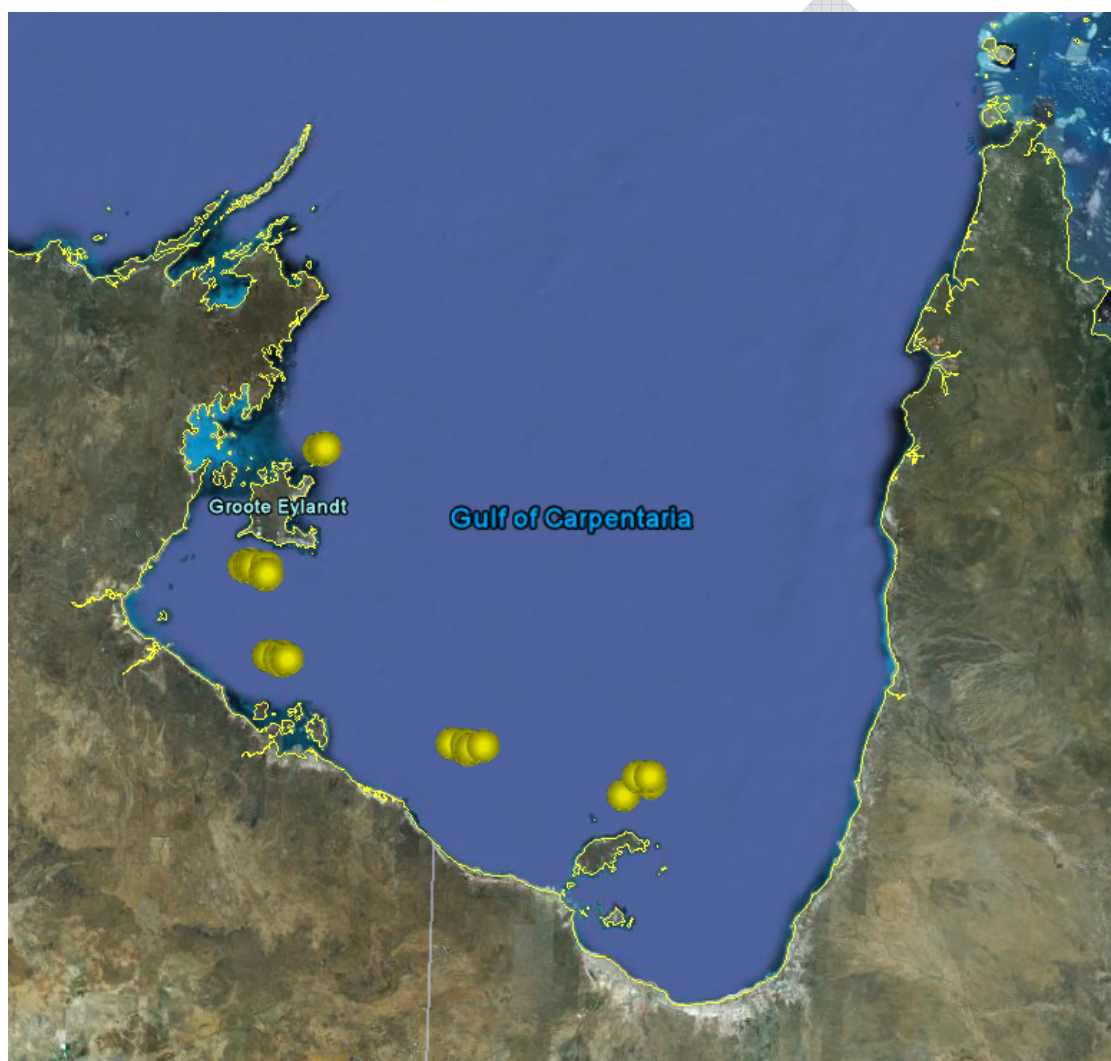
Figure 2. Location of trawls conducted during the experiment (Google Maps 2010).
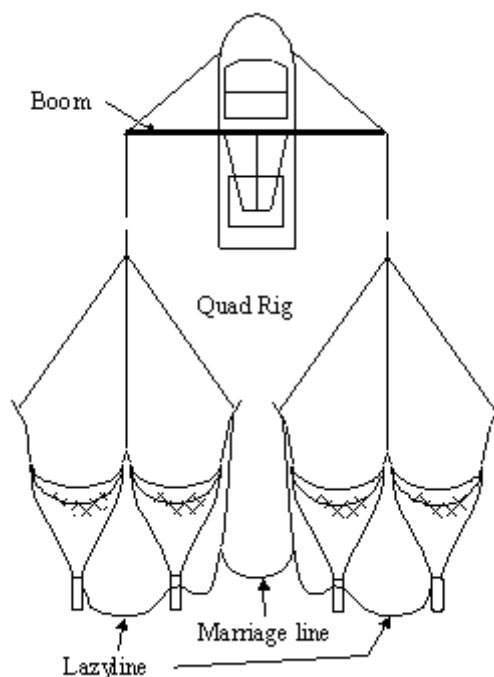
Figure 3. Schematic of the quad-rigged prawn trawl system used in the experiment.

Experimental design

Two trawls were conducted to evaluate the fishing performance of the starboard and portside nets and no side bias in catch rate was identified.

The gear modification was tested using a twin-trawl methodology (Canada Dept. of Fisheries & Oceans, 1995), with the starboard pair of nets acting as controls (witches' hats absent) and portside nets acting as the experiment (witches' hats present). Turtle Excluder Devices remained on all nets during this trial.

A total of 30 shots (95.4 hours trawl time) over a two-week period were measured under experimental conditions. Nightly trawl operations were conducted between 6:45 pm and 8:00 am, with a shot duration of about three hours and tow speeds between 3.7 – 4 knots. For each shot the bycatch weight and target species weight were recorded separately for the control and experimental catches. Data was transformed to catch per unit effort (kg.trawl hour^{-1}) for analysis.

Figure 4. Witches hat BRD enhancers in port side nets.

Subsampling

Three tows were sub-sampled to estimate the catch composition. For each tow about 10 kg of unsorted catch was measured from the control and experiment nets. The catch was identified to family level (except mantis shrimps which are recorded at the order level) and counted and weighed. Catch per unit effort by weight was standardised for subsample size and tow duration (kg.trawl^{-1}).

Data analysis

To identify changes in bycatch and target species catch rates paired t –tests were used.   All values presented in the text are mean values ± SE.

Results

The 30 trawl shots resulted in a catch of 1,956.20 kg of tiger (*Penaeus esculentus* & *P. semisulcatus*) and endeavour prawns (*Metapenaeus endeavouri* & *M. ensis*) and 16,327 kg of bycatch. The gross weight ratio of prawns to bycatch for this trial reduced by 36% when the witches hat BRDs were used (Table 1).

Table 1: The ratio of prawn weight to bycatch weight (kg) under experimental and controlled conditions.

	No BRD (Control)	Witches hat enhancer (Experiment)
Prawn (kg)	969.1	987.1
Bycatch (kg)	9875	6452
Ratio	1:10.2	1:6.5

Target species catch

There were 29 shots used to assess the impact of the witches hat on target species catch rate. There was no significant difference in the target species catch rate (all species) due to the inclusion of the witches hat enhancer (20.9 ± 1.5 kg.trawl hr^{-1}; t=-0.923, df=28, p=0.364, figure 5). This was also the case for each of the target prawn groups (tiger: t=-1.078, df=28, p=0.29; endeavour: t=0.212, df=28, p=0.834).
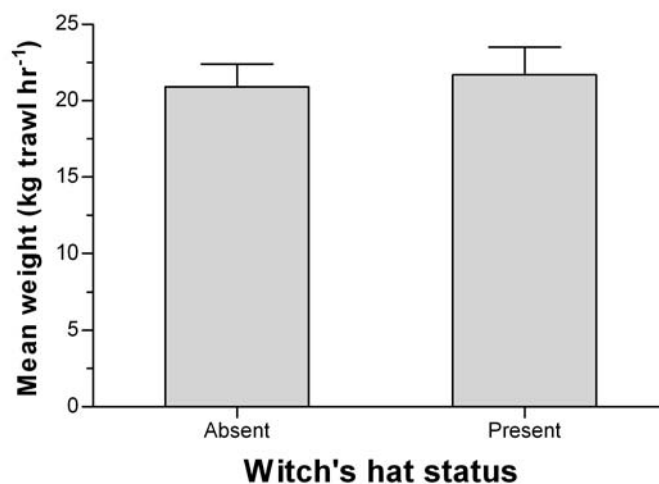
Figure 5. Catch rate of combined target prawn species under control and experimental conditions (t=-0.923, df=28, p=0.364).

The bycatch weight per trawl hour significantly reduced from 227 ± 27 kg.trawl hr^{-1} to 150 ± 18 kg.trawl hr^{-1} due to the inclusion of the witches hat enhancer (t=-7.749, df=29, p<0.001, figure 6). This equates to a 34% reduction in bycatch weight catch rate with no associated loss of target species.
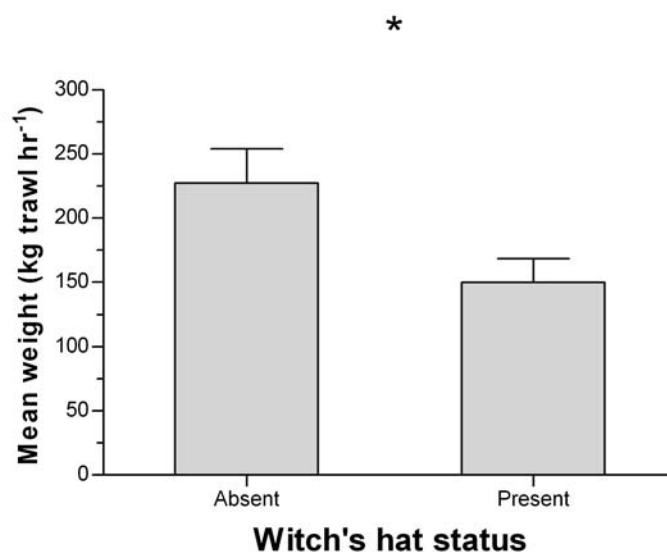
Figure 6. The change in bycatch catch rate (kg.trawl hr^{-1}) due to the witches hat enhancer (t=-7.749, df=29, p<0.001).

Subsampling

A total of 1588 small fish and invertebrates representing 39 families were recorded from three tow subsamples that were collected prior to sorting. The estimated mean catch weight per trawl hour for the eight dominant finfish families (and cuttlefish) is shown in figure 7. The limited replicates don't allow for statistically robust analysis, however it can be seen that grinners (Synodontidae), goatfishes (Mullidae), threadfin breams (Nemipteridae), cardinalfishes (Apogonidae) and cuttlefishes (Sepiidae) had reduced mean weights per trawl hour (not significant). Trevallies (Carangidae) and bigeyes (Priacanthidae) did not show a change is catch rate, most likely due to the mesh size not allowing these generally larger species to escape. Ponyfishes (Leiognathidae) showed a slight increase in catch weight (not significant) that is likely to be an artefact of the number of replicates.
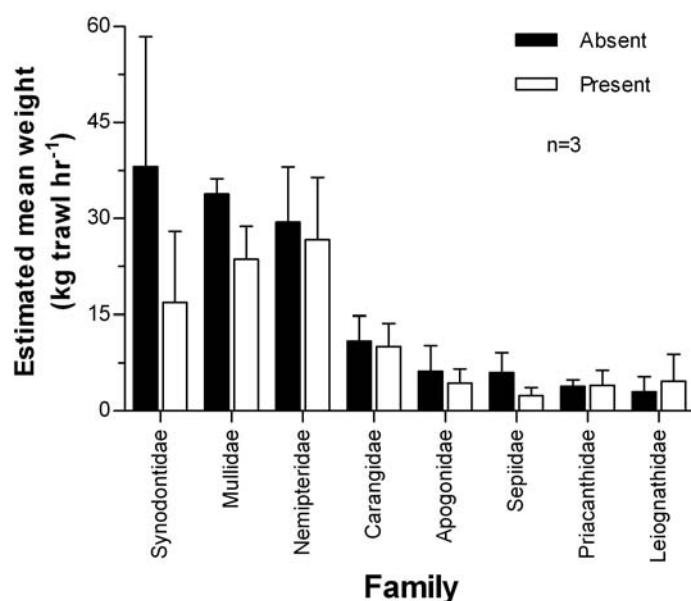
Figure 7. The eight dominant bycatch families (by weight) measured from subsampling.

Discussion

The inclusion of the witches hat enhancer increased bycatch escape through a square mesh panel by 34% without any significant prawn loss (95%CI). This is a biologically significant reduction. If the vessel used in the trials was to adopt the witches hat enhancer, the nightly reduction in landed bycatch would be about 925 kg.

The witches hat is not a BRD in itself and so does not need to gain separate approval for use by the industry. It enhances the efficacy of the square mesh panel, and may be used in association with other devices. The enhancer produces an area of slow, turbulent water in the area of an existing BRD that assists fish to exit. This effect can be exploited by fish within the assemblage that have the ability to swim near the top panel (or are forced there as the codend fills) and can detect or enter the area of influence. Benthic species, most crustaceans and fish that are too large to escape through the square mesh panel will not benefit from this effect the witches hat creates.

Field trialling of the device has identified a number of improvements to the design to make installing it in nets easier for fishers. For example, a two-piece design would allow fishers to lash the two halves to the netting panel without requiring the net to be cut and sewn.

Conclusions/recommendations

The trial of the witches hat provided an adequately statistically robust data set to confidently support claims that it is an effective complementary device for the square mesh panel BRD. It is recommended that the witches hat enhancer be considered as a worthwhile inclusion as an approved BRD enhancer for the Northern Prawn Fishery.

It is also recommended that information on the results of this trial be disseminated to industry members to provide the most recent information on minimising bycatch and improving prawn quality (though not assessed in this trial). To complement this, information on the construction and fitting of approved square mesh panels should be also disseminated. Monitoring the rate of uptake of this device throughout the fleet, and ensuring its correct use would ensure the fishery gains maximum benefit from this technology. Further research into the shape, size and location of the device within the codend is recommended to fully optimise the area of influence.

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Appendix 1:

NOTES ON TESTING PROTOCOL FOR NEW TEDS AND BRDS

- TEDs fail if they catch any turtles in two weeks of sea trials

- Detailed, analysed report produced by the observer and other AFMA staff

- AFMA observer on board for two weeks (BRD and TED trials) - usually determined by opportunities to move via a mothership;

- AFMA meets the observer costs, including relocation via motherships etc

- 3 members of the bycatch subcommittee assess whether the new device should be recommended for inclusion on the list of approved TEDs and BRDs for the fishery

- If the new BRD is located in front of the TED, all BRDs located behind the TEDs must be closed for the trials

- Testing BRDs requires weighing of all bycatch from two nets (separately) using lug baskets or a more accurate method; one net with the new BRD (& a TED) and the other (control net) with no BRD (TED only)

- Observers should attempt to collect data on every shot over the 2 week period. At best this will yield around 56 trials (14 nights x 4 shots/night), of which a proportion will be effected by TED blockages and unusable)

- Prawn catch data will also be recorded from each net separately, usually weighed by the crew. It is important that they keep the two nets catch separate until they are weighed and recorded. This data is critical to assessing whether the trial is confounded by blockages on the TEDs. Similarly, any other information regarding the likelihood of a catch being affected by TED blockages must be recorded accurately -eg. "Skippers says "Port net tedded that shot because ----"

- All commercially important prawns species can be lumped together for this comparison, although keeping species groups separate is more useful

- In boats with hoppers, weighing the bycatch from each net will necessitate the removal of the 'trash' chute so the bycatch spills from the conveyor into lug baskets (and not over the side)

- A lug basket of bycatch filled to the handles usually weighs about 40 kg, but this should be calibrated by weighing the full lug baskets periodically to confirm their 'filled weight'; especially if the skipper moves fishing areas. (Special lug basket inserts and raking tools are available to standardise the volume in lug baskets)

- The BRD should be swapped between nets to help remove any effects of catching differences between nets

BRDs will be considered for approval if they reduce the amount of small bycatch

(bycatch weighed in lug baskets) by an extra 10% compared to the control net with a

TED only. This will be determined by statistical analyses of the data, required to

account for the interaction between BRD performance and any bias between sides