Kon's Covered Fisheyes BRD Trial Report

Northern Prawn Fishery 2016

NPF Industry Pty Ltd
Producing the finest quality prawns from a sustainable marine ecosystem

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Australian Government
Australian Fisheries Management Authority

TROPIC OCEAN PRAWNS

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4 Summary

In 2015, NPF Industry Pty Ltd launched the Northern Prawn Fishery's Bycatch Strategy 2015-2018 with the vision to reduce small bycatch by 30% in three years. A key component of the strategy was industry innovation and through this process the Kon's Covered Fisheyes Bycatch Reduction Device (BRD) was developed.

In 2016, at-sea testing of the Kon's Covered Fisheyes Bycatch Reduction Device (BRD) was conducted in the Gulf of Carpentaria to determine its effectiveness in reducing small bycatch in the tiger prawn fishery compared to a currently legislated device. The device was found to significantly reduce small bycatch by approximately 36.7%, with commercial prawn catch increasing by an average of 0.5%. The device proved to be easy and safe for crew to use and due to the significant reduction in bycatch, the time taken for crew to process the catch was reduced.

5 Aims

The aims of the trial were to:

1. Assess the performance in the reduction of small bycatch and retention of target species of the industry developed Kon's Covered Fisheyes BRD compared to the current legislated Square Mesh Panel BRD, in accordance the objectives of the NPF Bycatch Strategy 2015-18, during at-sea trials

2. Statistically measure (using a generalised linear mixed model) the effect of the Kon's Covered Fisheyes BRD compared to the legislated Square Mesh Panel BRD on reduction of small bycatch and retention of target species.

6 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 in the area between Cape York in Queensland and Cape Londonderry in Western Australia. The NPF targets nine commercial species of prawns including White Banana (*Fenneropenaeus merguiensis*), Red-legged Banana (*F. indicus*), Brown Tiger (*Penaeus esculentus*), Grooved Tiger (*P. semisulcatus*), Blue Endeavour (*Metapenaeus endeavouri*), and Red Endeavour (*M. ensis*). Scampi, squid, scallops and bugs are also taken as by product. Since 2012 the fishery has been certified as sustainable under the Marine Stewardship Council (MSC).

The NPF is a tropical prawn trawl fishery where operators tow twin, triple or quad-rigged otter trawl nets. Being a tropical fishery, the volume and species diversity of bycatch caught in the NPF is relatively high. Over many years the NPF industry has been progressively working with the Australian Fisheries Management Authority (AFMA), researchers and gear technologists to develop and implement new ways to reduce bycatch in the fishery. Through the implementation of permanent and seasonal closures, gear reductions, fleet reductions and the introduction of TEDs and BRDs, the NPF has achieved significant reductions in bycatch over the past 20 years. To assist with the development and implementation of new devices, the NORMAC Bycatch

Subcommittee developed the TED and BRD Testing Protocol which requires a device to reduce bycatch by at least 10% with a prawn loss less than 2.5%.

BRDs were made mandatory in the NPF in 2001. There are currently seven BRDs approved for use in the NPF: the Square Mesh Codend, Square Mesh Panel, Radial Escape Section, Fisheye, Yarrow Fisheye, Popeye Fishbox, and Modified Turtle Excluder Device. By 2016, 90% of the fleet was using electronic logbooks. Of these, 83% of operators use Square Mesh Panel BRDs and the remaining use the Fisheye BRD (source: NPF logbook data).

In 2015, NPF Industry Pty Ltd launched its Bycatch Strategy 2015-2018 with a vision to voluntarily reduce small bycatch by 30% in three years in the Northern Prawn Fishery. The initial phase of the strategy was to encourage industry innovation to develop and test new or modified BRDs or gear to achieve this goal.

In order to compare and contrast changes in bycatch level and composition an experimental design that utilised controls (in this case a square mesh panel BRD) was adopted. This approach provided real time comparisons of the effectiveness of the Kon’s Covered Fisheyes BRD against a currently approved BRD type across a number of variables including position, area, season and environmental conditions. This approach was taken after considerable discussion with the Northern Prawn Resource Assessment Group (NPRAG) in early 2015. It was determined that the complexity of the fishery (different species, areas, seasons, gear) made establishing a baseline very challenging.

The Kon’s Covered Fisheyes BRD was developed by Kon Triantopoulos, net maker for A. Raptis & Sons Pty Ltd and was initially trialled by Raptis in November 2015, with encouraging results of 19% bycatch reduction and minimal prawn loss (<2.5%) compared to a Square Mesh Panel BRD located at 120 meshes from the codend drawstrings. As such, it was agreed by NPF Industry that the device should undergo a scientific trial to determine its effectiveness in reducing small bycatch without losing catch of target species.

The Kon’s Covered Fisheyes BRD is modelled on the existing Fisheye BRD, but encompasses a cone shaped insert designed to create an area of reduced water flow for small teleost fishes to take shelter in and escape (Figure 1). The Kon’s Covered Fisheyes BRD is comprised of two of these modified fisheyes in each net, positioned in line with each other.

Figure 1: A single Kon's Covered Fisheye stitched into the net including device specifications. The device was 45cm in total width, but the inside width of the mouth was 37cm.

The device was trialled on *FV Xanadu* from 2 to 10 June (Trial 1) and 31 October to 15 November (Trial 2) 2016 under normal commercial fishing conditions in the Gulf of Carpentaria. AFMA officers were deployed on the vessel to measure the performance of the Kon's Covered Fisheyes BRD (Treatment) compared to a standard Square Mesh Panel BRD (Control) and collect catch composition data. During the trials, data were obtained from 69 shots.

7 Gear Specifications

The *FV Xanadu* used quad-rigged tiger prawn nets with a headrope length of 14.21m, groundrope length of 16.0m, horizontal opening of 13.5m and vertical opening of 1.5m. Mesh was diamond orientation of 50mm in the wings and 42mm in the codends with the codend being 150 meshes around. Nets were fished using number 7 bison boards (300kg in weight, 183cm length, 20cm width and 112cm height), skids of 300kg (170cm length, 18cm width, 112cm height) were also used. Under normal fishing conditions each of the four nets would have a Square Mesh Panel BRD (650mm long x 450mm wide) positioned at 115 meshes from the codend drawstrings. For the duration of the trials, the vessel fished with one Square Mesh Panel BRD and one Kon's Covered Fisheyes BRD on each (port and starboard) side of the vessel.

Nets fitted with the Kon's Covered Fisheyes BRD had one of the modified fisheyes positioned at 78 meshes from the codend drawstrings and the other at 55 meshes (Figure 2). This spacing between the two devices was determined by the manufacturer of the Kon's Covered Fisheyes BRD. Both trial nets fitted with Kon's Covered Fisheyes BRD had the devices mounted identically, the same distances from the drawstrings.

A)

B)

Figure 2: A) The Kon's Covered Fisheyes BRD device stitched into a net prior to use and B) Spilling the codends separately onto the sorting tray (note the KCF mounted in the green net below the lifting ear).

8 Experimental Design

NPFI developed an industry trial guide in consultation with CSIRO to provide a standardised methodology for fishers to collect data when trialling new devices during preliminary industry trials in 2015. A rigorous experimental design for the formal scientific trials was also developed in consultation with CSIRO (Annexure 1). It was essential in the scientific trials that the BRDs, in this case a Square Mesh Panel BRD and Kon's Covered Fisheyes BRD, were swapped during the trial to ensure statistically robust data collection by accounting for possible differences in the fishing efficiency between the four nets (Table 1).

Table 1: Schedule of BRD placements for both trials of the Kon's Covered Fisheyes BRD.

Trial Number	Nights	Port Outside	Port Inside	Starboard Inside	Starboard Outside
1	1, 2, 3	SMP2	KCF2	SMP1	KCF1
1	4, 5, 6	KCF2	SMP1	KCF1	SMP2
1	7, 8, 9	SMP1	KCF1	SMP2	KCF2
2	10, 11, 12	KCF1	SMP2	KCF2	SMP1
2	13, 14, 15	KCF1	SMP2	KCF2	SMP1
2	16, 17, 18	SMP2	KCF2	SMP1	KCF1
2	19, 20, 21	KCF2	SMP1	KCF1	SMP2
2	22, 23, 24	SMP1	KCF1	SMP2	KCF2

8.1 Data Collection

Shots averaged four hours in duration, with three shots being undertaken each night between the hours of 18:00 and 07:30. The four codends were spilled into separated areas of the sorting tray to keep the catches split (Figure 3), so the performance of the Kon's Covered Fisheyes BRD could be analysed against the square mesh panel BRD control nets.

To obtain accurate bycatch weights for each codend, the bycatch was diverted via chute into 60L lug baskets and weighed. During processing, each lug basket of bycatch was weighed prior to the contents being discarded. The commercial prawn component of each of the four codends were also processed separately to measure any prawn loss or gain between the treatment and control BRDs. Although weights for each prawn group (Tiger, Banana, Endeavour and King) were recorded, only total commercial prawn weight for each codend was used for the BRD comparisons.

Catch composition analysis was undertaken for every shot, with a 10kg subsample of bycatch being collected from one Square Mesh Panel BRD net and one Kon's Covered Fisheyes BRD net. The bycatch in the subsamples were identified to species level, and weights for each species recorded. All Threatened, Endangered and Protected (TEP) species and 'at-risk' bycatch species (determined to be at-risk from trawling using the Environmental and SAFE risk assessments analyses) caught in the trawls were also identified, measured and recorded as per standard AFMA observer protocols. An analysis of catch composition between the treatment and control BRDs has not been undertaken for this report as the main objective of the trial was to assess the effectiveness of the Kon's Covered Fisheyes BRD in reducing small bycatch, rather than identifying exclusion of specific species.

Underwater video footage was also collected to provide insights into how the device functioned, fish behaviour and whether any potential improvements could be made to the BRD design. No lighting system was used in conjunction with the camera so footage was only able to be collected during the first shot of the evening. The decision was made not to pursue any form of independent lighting source for the camera as this may have impacted the efficacy of the Kon's Covered Fisheyes BRD and added another variable to the data.

Figure 3: Catch from the net with the Kon's Covered Fisheyes BRD (left) compared to a control net with a Square Mesh Panel BRD (right side), excluding the catch on the conveyer in the center. When compared, these two codends had the same quantity of prawns but significantly less bycatch in the net with the Kon's Covered Fisheyes BRD.

8.2 Bycatch Recapture

The recapture of bycatch from the previous trawl shot was an issue raised by CSIRO prior to the trials being undertaken. As vessels operating in the NPF use a technique referred to as 'line fishing' whereby a vessel will conduct multiple shots along the same trawl line over a relatively short period of time, there is a possibility that discards may be recaptured during the subsequent shots.

The likelihood of this occurring is anecdotally much higher in areas with little tidal or current movement and when trawls are carried out in shallower water depths. In order to ascertain whether bycatch recapture was occurring during this trip, 40kg of randomly selected bycatch was dyed using methylene blue on the first and second nights of fishing and discarded as per standard vessel operations.

The following shots of the night were monitored for stained bycatch recaptures. On the first night, one dyed crab was recaptured (alive) on the third shot and on the second night no dyed bycatch was recaptured. Fishing was carried out between 16 and 18m water depths on both night.

During the November trial, 40kg of randomly selected bycatch was stained and discarded on the second night of fishing in approximately 24-26m depths. None of the stained bycatch was recaptured during subsequent shots. Fishing was conducted at this depth range throughout the entire November trial.

Concentrations used for the dying of bycatch were: 10g of methylene blue concentrate powder to 10L of seawater. In addition, 500ml of 'Blue Planet Multi Cure' water treatment for aquarium fish, containing Malachite Green 0.40mg/ml and Methylene Blue 4.00mg/ml was added to another 10L of seawater. It should also be noted that once mixed, the solution was only effective for staining biological material for approximately 12 hours.

8.3 Data Analysis

Total bycatch and total commercial prawn weights were recorded separately for each of the four nets for each shot. This data was given to CSIRO for further analysis (for full report see Annexure 2). The bycatch volume and commercial prawn data from the two trials was combined for analysis. As there was always a control and treatment net on the port and starboard side, the differences in the bycatch volumes and prawn catch (kg per hour) between the two nets for each side for each shot was compared.

The bycatch data was assessed using a generalised linear mixed model (glmm). After trying various model forms the bycatch data was fitted to a glmm with a Gamma distribution to the data to determine the effectiveness of the treatment net after removing the effect of time trawled, position in the quad gear, Trial Number (1 or 2) and random effect of shot. Standard model diagnostics were checked and showed that the model fit was adequate. A similar model was then fitted to the commercial prawn catch data. Model diagnostics were checked and this model was shown to also be a good fit for the prawn data.

9 Results

Due to deteriorating weather conditions during the June trial, the trial was stopped after 9 nights of trawling. The BRD position in the second at-sea trial in November trial continued from where the first trial in June ceased to account for these lost sampling days, followed by another full rotation of the BRD types across the four net positions over 15 nights of trawling. The first trial was carried out within the Karumba and Mornington Island regions while the second trial started at Weipa for the first night then moved to north Vanderlins followed by the Groote Eylandt region (Figure 4).

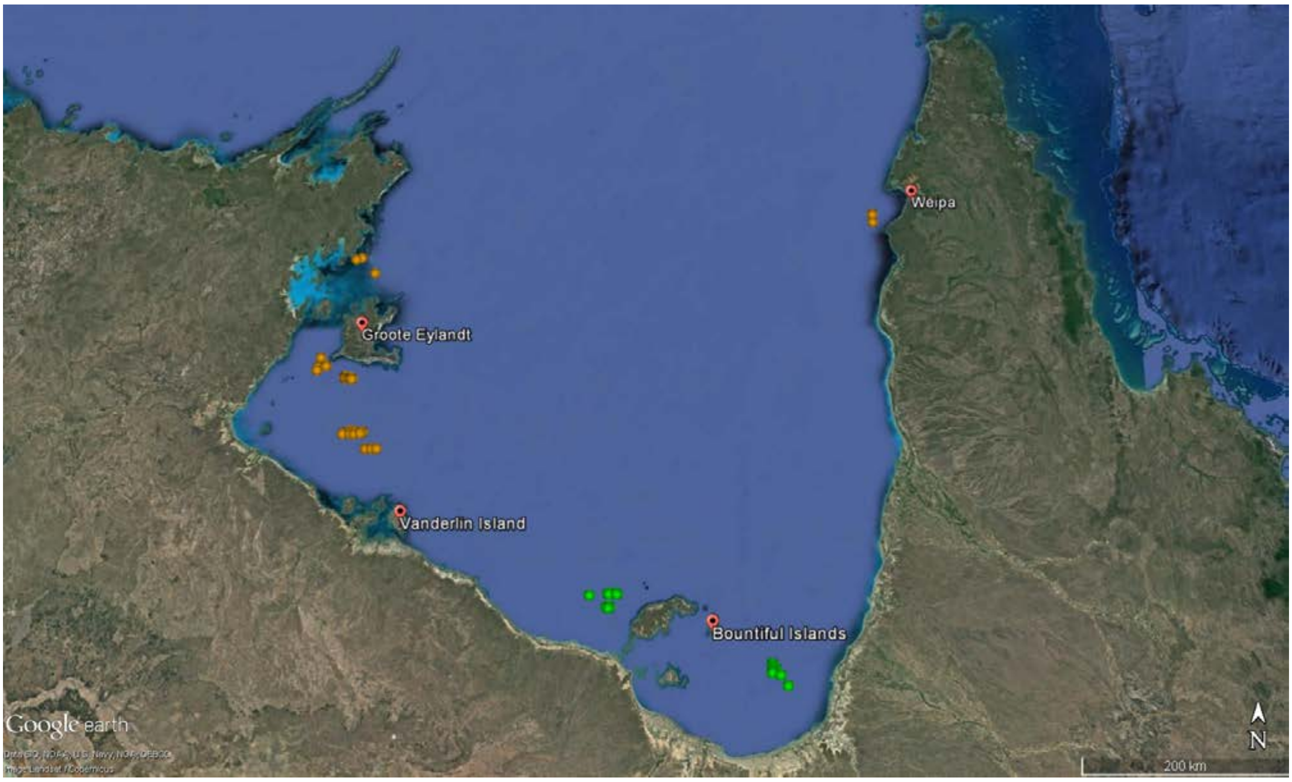

Figure 4: Area fished, showing show locations, during the 2016 scientific trials of the Kon's Covered Fisheyes BRD in June (green) and November (orange) in the Gulf of Carpentaria (source: Google Earth).

Analysis of the data shows significantly less bycatch is caught ($p<0.0001$) in the nets with the Kon's Covered Fisheyes BRDs installed compared to the nets with the standard Square Mesh Panel BRD installed. Mean bycatch reduction by weight achieved by the Kon's Covered Fisheyes BRDs was 36.7% (95% Confidence Interval: 33.6 – 39.6%), when compared to the Square Mesh Panel nets across the 69 shots. The difference in prawn catch rates, between the two gear configurations, was not significantly different ($p=0.815$).

There were large variations in both the total bycatch caught and the commercial prawns retained between each of the four quad gear nets for most shots during the two trials (Table 2). While the prawn catch was similar across the two trials, approximately 6.5kg per hour of trawling for one main quad gear net, the bycatch caught during the second trial (34.51kg) was about half that of the first trial (71.39kg). This may be due to either differences in bycatch communities across the Gulf of Carpentaria and/or the different time of year the trials were undertaken.

Table 2: Comparison of the average bycatch caught and commercial prawns retained (kgs/hr) during the two at-sea trials (Annexure 2).

	Trial 1 (June)	Trial 2 (November)
Bycatch Weight	71.39kg	34.51kg
Commercial Prawns	6.53kg	6.76kg

9.1 Bycatch reduction

There was almost always more bycatch caught in the codends with the Square Mesh Panel (Control) compared to the nets with the Kon's Covered Fisheyes (Treatment) (Figure 5). There were only 10 trawls where one of the Kon's Covered Fisheye BRD nets caught more bycatch than the adjacent Square Mesh Panel BRD net and eight of these occurred during one rotation (for three nights; Trawls 52 to 59) on only one side.

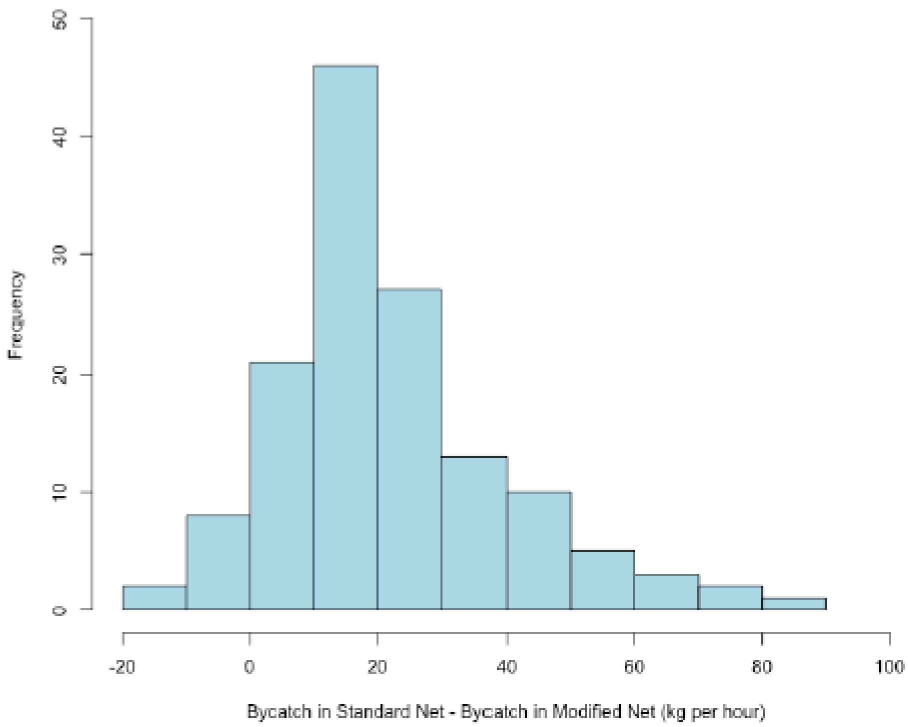

Figure 5: The frequency of the differences in total bycatch (kgs caught per hour of trawling) caught between the Kon's Covered Fisheye BRD net and Square Mesh Panel BRD net on each side during the two at-sea trials (Annexure 2).

The results indicate that a large amount of the variability in the catches of bycatch is accounted for by the random effect. For example, the correlation between nets within a shot is very high (see Annexure 2) whereas the fixed effects (net, position, trial number) show significantly less bycatch was caught in the Kon's Covered Fisheyes BRD nets compared to the Square Mesh Panel BRD nets. The transformed model coefficients indicate a reduction of approximately 36.7% in bycatch weights in the Kon's Covered Fisheyes BRD nets (95% Confidence Interval: 33.6 – 39.6%) compared to the Square Mesh Panel BRD nets. The catch rates in the different main quad gear positions were compared against the Port Inside and some significant differences were detected. The highest catch rates of bycatch were in the Port outside and the lowest was in the Port Inside nets.

9.2 Prawn catch

For the commercial prawn catches, there was a more even distribution around 0 than the bycatch weights between the Kon's Covered Fisheyes BRD and Square Mesh Panel BRD nets (i.e no difference between the treatment and control) during the two at-sea trials (Figure 6).

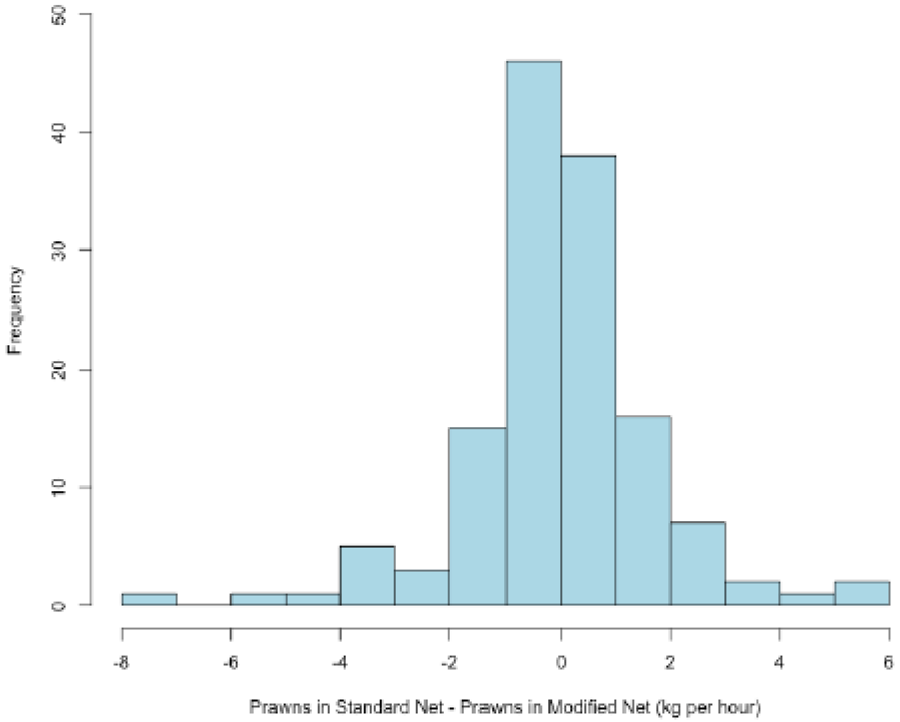

Figure 6: The frequency of the differences in commercial prawn catch (kgs caught per hour of trawling) between the Kon's Covered Fisheyes BRD net and Square Mesh Panel BRD net on each side during the two at-sea trials (Annexure 2).

As seen with the bycatch, most of the variability in commercial prawn catches is described by shot to shot variability (see Annexure 2). There were significantly more commercial prawns caught on the Port Outside net compared to the other main quad gear net positions. The fixed effects show negligible difference between the commercial prawns caught in the Kon's Covered Fisheye BRD nets (Treatment) compared to the Square Mesh Panel BRD nets (Control) with 0.5% more commercial prawns caught using the Kon's Covered Fisheye BRD nets (Confidence Interval: -3.8 – 5.1%).

10 Discussion

There is sufficient data from the two scientific trials to demonstrate that the Kon's Covered Fisheyes BRD, located at 55 and 78 meshes from the codend drawstrings, reduces bycatch by 36.7% with no significant difference in the commercial prawn catch compared to a Square Mesh Panel BRD at 115 meshes from the codend drawstrings.

Based on analysis of underwater video footage, slightly extending the front bar of the device could further assist fish in utilising the escape opening. Some fish were observed struggling to use the escape opening due to their size and swimming speed. The design tested in this trial demonstrated the specifications required to achieve the 36.7% reduction in bycatch compared to a Square Mesh Panel BRD when they are positioned at 55 and 78 meshes from the codend drawstrings. With further refinement of this device, greater escapement rates of the larger sized bycatch species may be achieved.

In addition to reducing bycatch in the NPF, there may be a number of other significant benefits of using the KCF. The reduction in volume of bycatch demonstrated by the use of Kon's Covered Fisheyes BRD may reduce net drag thereby having a fuel saving effect. This reduced catch volume in the codends and reduced net drag also has the potential to increase the swept area of the trawls due to trawl doors being maintained at the optimal distance apart. Furthermore, with significantly less bycatch to sort through for the crew, processing times (from hopper to freezer) and potential prawn damage from larger volumes of bycatch in the codend would be reduced.

This device is most suited to tiger prawn fishing where there is generally lower volumes of total catch caught in each shot and a greater proportion of small bycatch caught compared to banana prawn fishing. As the two covered fisheyes of Kon's Covered Fisheyes BRD that were assessed are located at 55 and 78 meshes from the codend drawstrings, it is possible that during very large shots (i.e banana prawn fishing), product could be lost through the escape opening, however trials of the device in this fishery have not been undertaken.

Due to the shape of the device and the need for small animals to swim through an escape opening, it is highly unlikely that the Kon's Covered Fisheyes BRD would be an effective mitigation device for larger bycatch species such as sea snakes, sawfish and other elasmobranchs or benthic species such as crabs and other invertebrates.

11 Adoption

The skipper of the *FV Xanadu* commented that the significant visual difference between nets with the Kon's Covered Fisheyes compared to the nets with a Square Mesh Panel was very disconcerting when the trials began. So much so he considered ceasing the first trial after the first night believing there was significant prawn loss when in actual fact the catch was the same (J. Ball pers. comm).

To assist industry with the transition from the Square Mesh Panels or standard Fisheye BRDs to the Kon's Covered Fisheyes BRD a combination of both could be used initially i.e Kon's Covered Fisheyes in two nets and Square Mesh Panels or standard Fisheyes in the other nets for the first few nights of fishing. As there will be significantly lower net volumes while using the Kon's Covered Fisheyes BRDs compared to what skippers are used to, comparing their catches between the new device and what they previously used could alleviate concerns and show commercial prawn catch is not being compromised. This will assist with the long-term adoption of the new device and the NPFs initiative to reduce bycatch by 30% by mid-2018.

12 Further Research

During initial trials of the Kon’s Covered Fisheyes BRD by Raptis in 2015 the skipper noted that the frame of the BRD would at times catch on the gunwale of the vessel when hauling the nets (M. Robson pers. comm). This is unlikely to occur on most other NPF vessels due to the specific design of the Raptis vessels. However, further research could investigate the effectiveness of the Kon’s Covered Fisheyes BRD without the fisheye frame and utilising just the cone insert. Such a design may also make the device easier to install or replace (P. Robson pers. comm). Initial trials of such a design were undertaken by Raptis in November 2016 with varying results. Further fine-tuning of the design of the device should also improve its operational performance and the likelihood of its successful adoption.

It would also be worth investigating whether using only one covered fisheye of the Kon’s Covered Fisheyes BRD fitted to each net would have similar bycatch exclusion rates as the current Kon’s Covered Fisheyes BRD. This could be examined by installing an underwater camera in front of and behind the covered fisheyes and recording the difference in bycatch exclusion rates between both of the covered fisheyes in the same codend. This would identify if the position of the covered fisheyes has an effect on bycatch exclusion rates and (following species analysis) any species-specific differences.

As this device is not likely to be suitable for banana prawn fishing because of the larger catches, a single covered fisheye located further away from the codend drawstrings may still be effective at reducing bycatch in the banana prawn fishery. Different configurations of the fisheyes could be investigated to assess effectiveness when vessels are targeting banana prawns and the nets are much fuller. The fisheyes could also be tailored to remove specific bycatch species currently not effectively removed by the Kon’s Covered Fisheyes BRD however this would require further research.

The catch composition data collected during this trial could be analysed to determine if there is any species-specific differences in the bycatch, differences in TEP and at-risk species and to provide additional information for further fine-tuning of the device to further improve its effectiveness, including in relation to escapement of larger or different shaped bycatch species.

13 References

Burke. A, Barwick, M. and Jarrett. A. (2012). *Northern Prawn Fishery Bycatch Reduction Device Assessment*. NPF Industry Pty Ltd, Australia.

NPF Bycatch Strategy 2015-2018: http://www.afma.gov.au/wp-content/uploads/2014/02/NPF-Bycatch-Strategy-2015-18-FINAL-VERSION.pdf

Annexure 1: Kon's Covered Fisheyes BRD trial design

Purpose:

To trial methods for reducing bycatch in the Northern Prawn Fishery using the industry developed double fisheye BRD (Kon's Covered Fisheyes or KCF) in accordance the objectives of the NPF Bycatch Strategy 2015-18 to reduce the capture of small bycatch by 30% in three years.

Methods:

Phase 1: Arrival and Calibration

A. Field team travel to Karumba to rendezvous with vessel.

B. Consult with skipper about the experimental design including:
- separating each net when dumped on top of the hopper
- processing each net separately through the hopper
- discarding of bycatch to eliminate recapture
- prawn loss strategy
- any additional ways to manage the process

C. Prepare lug baskets with colour-coded surveyor tape for sea snakes (1 lug basket per net). Close handle gaps with tape (or plywood and cable ties) to stop snakes escaping through the holes and/or fingers being put through the handles.

D. Mark sections of the hopper for each net using colour-coded surveyor tape (see Fig 1)

E. Undertake initial trawls (approx. 4) with normal fishing gear to become familiar with sampling protocols and evaluate relative fishing performance of quad gear:
- Weighing total bycatch in each net separately for each shot.
- Sort prawn catch from each net separately for each shot.
- Record number and lengths of TEP and at-risk species from each net for every shot.
- Photograph all TEP and at-risk species with colour-coded scale tag.

F. Refine fishing performance to ensure equal fishing efficiency of nets to the extent possible, or document variance to enable this to be accounted for in analysis.

NOTE: the nets should already be fishing efficiently and comparably as the crew would have adjusted the chains at the start of the season. However, once the trial begins, there should be no fine-tuning or adjusting of the gears. The direct comparison to standard BRDs during each shot and the rotation schedule for nets will account for any fishing efficiency differences.

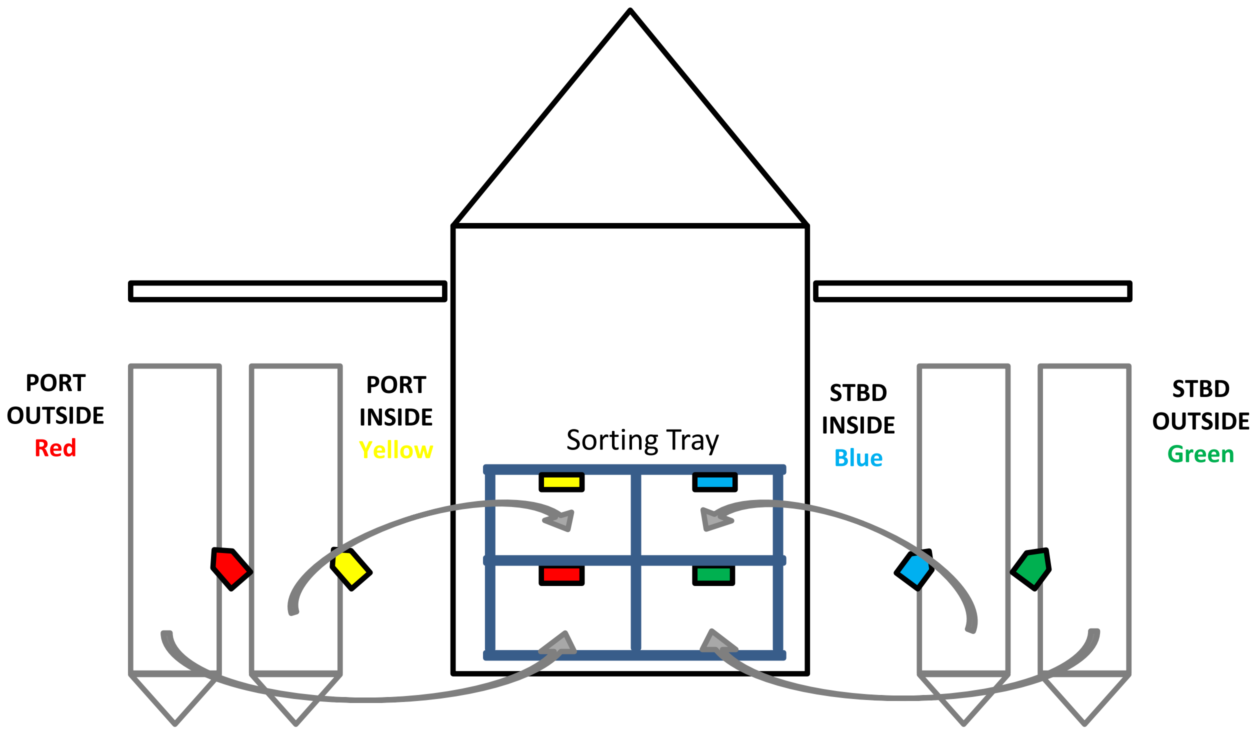

Figure 1: Diagrammatic representation of the colour coding to set up on back deck to facilitate separate codend catch processing. Diagram courtesy of CSIRO

One issue will be discarded bycatch being caught in the next shot. To test if this is happening, soak 40+kg of bycatch in methylene blue for the duration of one shot. Discard when the gear is next fully deployed. This is to test if the bycatch is recaptured; bycatch recaptures are more likely to occur in shallow water trawling. Therefore, it should be carried out in the depths likely to be fished by the vessel during the trial.

*If blue bycatch is recaptured, run the blue test again discarding the bycatch from the stern of the vessel. The bycatch chute is generally on the starboard side of the vessel, it may be possible that by discarding the bycatch over the stern of the vessel it is pushed past the open nets before it descends**

*<u>NOTE:</u> turning the vessel is not likely to counteract the recapture issue; weighing bycatch from quad gear will take up to an hour, too long for a vessel to be carrying out a turning manoeuver; bycatch will most likely be sucked into the whirlpool created behind the vessel in a turn and be pushed out, and possibly down, by the propeller wash; having a vessel in a turn for that duration will also change the fishing efficiency of each of the four nets differently.

Phase 2: Installation and trial of KCF BRD

G. Install one KCF in the Port Outside net and one KCF in the Starboard Inside net. Cover up existing SMP BRD in these two nets. Colour code each of the codend nets using the colour-coded surveyor tape supplied so crew will know where to dump the catch. Data collection to include:

- Weighing total bycatch in each net separately for each shot.
- Sort prawn catch from each net separately for each shot. Get species, weights and grades from crew for each net.
- Record number and lengths of TEP and at-risk species from each net for every shot.
- Photograph all TEP and at-risk species with colour-coded scale tag.
- Take a 10kg subsample from one Experimental BRD (KCF) net and one Control BRD (SMP) net for each shot and ID, where possible, to species level.
- Collect video footage on one shot during the night and last (dawn) shot to further evaluate performance.

H. At the end of the nights fishing, calculate the percentage of prawns for the Experimental BRDs versus Control BRDs for each shot and averaged across the night. This will show any possible prawn loss per shot and per night between the Experimental and Control BRDs. If possible, do this by prawn grade. If there is a loss, knowing the grade will help determine what size class might be escaping or being excluded. At the end of the three nights, average across all nights.

I. At the end of three fishing nights of the BRD trial, move codends as detailed in Table 1. This will require unstitching the whole codend and re-stitching it onto another trawl net throat as described in Table 1. <u>Ensure the surveyor tape is removed from each net before relocating and put tape on the new net in the positions as detailed in Table 1.</u>

J. Repeat data collection as described at H with codends in new positions.

K. Repeat H and I according to nights and BRD configuration in Table 1.

Rotating the BRDs is essential to ensure a statistically robust data collection by accounting for possible differences in the fishing efficiency between the four nets. If a problem occurs and a night of fishing is missed, continue with this schedule of rotation.

Table 1: BRD placements for trial

Night(s)	Port Outside	Port Inside	Starboard Inside	Starboard Outside
1	Calibration of standard nets (SMP @ 120 meshes)			
2,3,4	**KCF1**	SMP1	**KCF2**	SMP2
5,6,7	SMP2	**KCF1**	SMP1	**KCF2**
8,9,10	**KCF2**	SMP2	**KCF1**	SMP1
11,12,13	SMP1	**KCF2**	SMP2	**KCF1**

Prawn Loss/Gain

It is important to evaluate the nights prawn catch to determine if there's any loss or gain of product. There is an industry agreement that a <2.5% prawn loss is acceptable. This is the acceptable percentage of prawn loss specified in the NPF TED and BRD testing protocol.

After six nights of fishing, if the average prawn loss is greater than 2.5% for the KCFs then move the KCFs to 90 or 100 meshes from the codend drawstrings (in consultation with skipper and crew). Ensure you note on the datasheets that this has occurred. Fish for another one to two nights collecting data as detailed in Phase 2. After each nights fishing, calculate prawn loss or gain again.

Bycatch Loss/Gain

Calculate bycatch in the same manner as the prawn catch. This will give an indication of the effectiveness of the trialled BRD compared to the control BRD. Note: this is only an indication, scientific analysis of the data after the trial will be required to determine any significant changes and factoring in differences in the fishing efficiency of each net.

Equipment List

Item		Item	
Lug baskets (x10)		Dressmakers tape measure	
Lug basket lids (x4) to cover sea snakes		White board markers x 2	
Laptop to enter data daily		Colour-coded scale tags laminated (3 – 4)	
External hard drive for backup		Clipboard	
Land camera and SD card		Cable ties	
GoPro cameras		Duct tape	
Data sheets (AFMA observer section)		5m of 6mm rope for weighing luggies	
50kg scales x 2 (CSIRO)		ID books (Ben)	
Gloves/protective equipment		First aid kits	
Methylene blue			
Surveyors tape in red, green, yellow & blue			

Annexure 2: CSIRO Final Analysis of NPFI's 'Kon's Covered Fisheye' BRD Trial Data

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Final Analysis of NPFI 'Kon's Covered Fisheyes' BRD Trial Data

Emma Lawrence and Gary Fry

19 December 2016

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1 Background

The Northern Prawn Fishery Industry (NPFI) initiated a bycatch reduction program in 2015 with a target of 30% bycatch reduction across the fleet by 2018. The NPF currently has eight Bycatch Reduction Devices (BRDs) approved for use in the NPF. Whilst some of these devices may reduce bycatch, potential prawn loss from the use of these devices continues to be of major concern for the fishing industry. As gear technology and understanding of fish behaviour improves, scientists and commercial fishers are able to better design and tailor BRDs to retain target species and allow bycatch species to escape.

In 2016, scientific data was collected by AFMA scientific observers during two industry-led trials to test a new BRDs; 'Kons Covered Fisheyes' developed by Kon Triantopoulos from A. Raptis & Sons Pty Ltd, against a currently approved BRD; ‘Square Mesh Panel’. Prior to the first at-sea trial, NPFI contacted CSIRO to request expert opinion on the sampling design of the trial. Once the data was collected, NPFI and AFMA requested CSIRO's expertise in statistically assessing the data for bycatch reduction levels and commercial prawn retention rates. This analysis will be used in a peer-reviewed report published by NPFI and AFMA.

2 Objective

To assess the performance of the ‘Kons Covered Fisheyes’ BRD against a currently used bycatch reduction device, ‘Square Mesh Panel’ BRD, using a Generalized Linear Mixed Model analysis of the at-sea trial data.

3 Methods

The data was collected during two at-sea trials by AFMA scientific observers onboard the ‘*FV Xanadu*’ during the two industry-led trials between 2nd June – 10th June 2016 and 31st October – 15th November 2016. The at-sea trials used two ‘Kon’s Covered Fisheyes’ and two ‘Square Mesh Panel’ BRDs, where each BRD was placed in one of the four main nets of the quad gear configuration. At the commencement of the first trial, the ‘Kon’s Covered Fisheyes’ BRDs were placed in the Port Inside and Starboard Outside nets and the ‘Square Mesh Panel’ BRDs were placed in the Port Outside and Starboard Inside nets. After every three nights fishing, the BRDs were rotated into a different quad gear position so each specific BRD was tested in each of the four main quad gear nets. Due to deterioration of weather and shortening of the first trial by three days, each BRD was only tested in three of the four positions. At the commencement of the second trial, the BRDs were placed in the positions of the main quad gear nets that were missed in the first trial and trialled for three nights before another full rotation was completed.

Total bycatch and total commercial prawn weights were recorded separately for each of the nets for each shot. This data was given to CSIRO for further analysis.

After trying various model forms we fitted a generalized liner mixed model (glmm) with a Gamma distribution to the bycatch data to determine the effectiveness of the treatment net after removing the effect of time trawled, position in the main quad gear, Trial Number (1 or 2) and accounting for correlation within a shot. Standard model diagnostics were checked and showed that the model fit was adequate.

A similar model was then fitted to the prawn catch data. Model diagnostics were checked and this model was shown to also be a good fit for the prawn data.

4 Results

There were nine nights of trawling completed during the first at-sea BRD trial and 15 nights of trawling during the second at-sea trial. The first trial was carried out within the Bountiful Island and Mornington Island region while the second trial started at Weipa for the first night then moved to the north Vanderlins region followed by the Groote Eylandt region (see Appendix 1).

There were large variations in both the total bycatch caught (Table 1) and the commercial prawns retained between each of the four quad gear nets for most shots (Table 2) during the two trials. While the prawn catch was similar across the two trials, approximately 6.5kg per hour of trawling for one main quad gear net, the bycatch caught during the second trial (34.51kg) was about half that of the first trial (71.39kg) (Table 3). This may be due to either differences in bycatch communities across the Gulf of Carpentaria or the different time of year the trials were undertaken.

The bycatch volume and commercial prawn data from the two trials was then combined for analysis. As there was always a control and treatment on the port and starboard side at any one time, the differences in the bycatch volumes and prawn catch (kg per hour) between the two nets for each side for each shot was compared. There was almost always more bycatch caught in the main quad gear nets with the ‘Square Mesh Panel’ (Control BRD) compared to the nets with the ‘Kon’s Covered Fisheyes’ (Treatment BRD) (Figure 1). There was only 10 trawls where one of the ‘Kons’ Covered Fisheyes’ BRD nets caught more bycatch than the adjacent ‘Square Mesh Panel’ BRD net and eight of these occurred during one rotation (for three nights; Trawls 52 to 59) on only one side. For the commercial prawn catches, there was a more even distribution of catch between the ‘Kon’s Covered Fisheyes’ BRD and ‘Square Mesh Panel’ BRD nets during the two at-sea trials (Figure 2).

Table 1. Comparison of the total bycatch (kgs) caught in each of the quad gear nets using the 'Kons Covered Fisheyes' (KCF) and 'Square Mesh Panel' (SMP) Bycatch Reduction Devices during the two at-sea trials. (BRDs: KCF1 – light green; KCF2 – dark green; SMP1 – light blue; SMP2 – dark blue).

Trip	Night Start Date	Shot Number	Port Outside	Port Inside	Starboard Inside	Starboard Outside
1	02-Jun-16	1	551	367	476	310
1	02-Jun-16	2	426	175	372	141
1	03-Jun-16	3	311	89	255	117
1	03-Jun-16	4	237	82	183	99
1	03-Jun-16	5	119	90	127	70
1	03-Jun-16	6	229	71	182	60
1	04-Jun-16	7	207	85	213	67
1	04-Jun-16	8	344	200	264	215
1	04-Jun-16	9	259	102	195	118
1	04-Jun-16	10	223	142	177	110
1	05-Jun-16	11	255	354	256	318
1	06-Jun-16	12	407	645	518	595
1	06-Jun-16	13	318	480	306	471
1	06-Jun-16	14	268	440	314	337
1	07-Jun-16	15	196	287	236	300
1	07-Jun-16	16	265	357	189	399
1	07-Jun-16	17	143	232	146	265
1	08-Jun-16	18	364	234	342	283
1	08-Jun-16	19	298	185	254	214
1	09-Jun-16	20	188	93	169	115
1	09-Jun-16	21	530	286	503	326
1	09-Jun-16	22	375	157	401	213
1	10-Jun-16	23	329	145	335	152
1	10-Jun-16	24	229	159	178	180
2	31-Oct-16	25	151	280	107	231
2	31-Oct-16	26	130	225	71	148
2	31-Oct-16	27	86	165	63	127
2	02-Nov-16	28	152	225	160	221
2	02-Nov-16	29	68	114	69	103
2	02-Nov-16	30	188	234	137	261
2	03-Nov-16	31	187	230	151	226
2	03-Nov-16	32	91	113	79	130
2	03-Nov-16	33	82	157	100	188
2	04-Nov-16	34	267	355	261	405
2	04-Nov-16	35	62	126	84	140
2	04-Nov-16	36	175	253	98	201
2	05-Nov-16	37	144	215	104	164
2	05-Nov-16	38	56	77	82	121
2	05-Nov-16	39	83	145	83	122
2	06-Nov-16	40	110	186	79	169
2	06-Nov-16	41	52	75	48	80
2	06-Nov-16	42	102	127	92	47

2	07-Nov-16	43	245	151	180	138
2	07-Nov-16	44	159	80	136	85
2	07-Nov-16	45	131	90	161	104
2	08-Nov-16	46	223	121	179	108
2	08-Nov-16	47	136	54	99	66
2	08-Nov-16	48	176	88	117	71
2	09-Nov-16	49	219	130	176	125
2	09-Nov-16	50	105	58	91	75
2	09-Nov-16	51	162	116	135	98
2	10-Nov-16	52	140	123	90	190
2	10-Nov-16	53	89	60	56	71
2	10-Nov-16	54	119	95	63	119
2	11-Nov-16	55	150	127	88	206
2	11-Nov-16	56	74	53	52	82
2	11-Nov-16	57	107	66	58	108
2	12-Nov-16	58	120	97	96	169
2	12-Nov-16	59	58	43	45	78
2	12-Nov-16	60	139	155	65	160
2	13-Nov-16	61	164	135	217	166
2	13-Nov-16	62	115	81	121	109
2	13-Nov-16	63	162	96	218	171
2	14-Nov-16	64	147	98	175	107
2	14-Nov-16	65	178	125	217	132
2	14-Nov-16	66	178	90	230	134
2	15-Nov-16	67	95	60	150	70
2	15-Nov-16	68	180	100	250	160
2	15-Nov-16	69	280	190	350	200

Table 2. Comparison of the commercial prawns retained (kgs) in each of the quad gear nets using the 'Kons Covered Fisheyes' (KCF) and 'Square Mesh Panel' (SMP) Bycatch Reduction Devices during the two at-sea trials. (BRDs: KCF1 – light green; KCF2 – dark green; SMP1 – light blue; SMP2 – dark blue).

Trip	Night Start Date	Shot Number	Port Outside	Port Inside	Starboard Inside	Starboard Outside
1	02-Jun-16	1	21.32	29.15	16.6	19.81
1	02-Jun-16	2	29.5	27.8	27.6	21.3
1	03-Jun-16	3	26.8	26.95	25.44	27.6
1	03-Jun-16	4	14.01	9.06	10.7	11.6
1	03-Jun-16	5	12.11	16.65	12.89	15.91
1	03-Jun-16	6	44.23	31.19	35.54	29.39
1	04-Jun-16	7	22.55	17	17.95	19.72
1	04-Jun-16	8	60.4	36.82	40.4	44
1	04-Jun-16	9	38.9	19.1	24	45
1	04-Jun-16	10	12.08	16.5	11.6	20.1
1	05-Jun-16	11	45	44.6	41.5	51.4
1	06-Jun-16	12	25.9	23.1	19.2	22.8
1	06-Jun-16	13	23.9	21.7	18.8	28.8
1	06-Jun-16	14	12.3	12.5	12.3	11.7
1	07-Jun-16	15	16.72	16.2	17.5	17.4
1	07-Jun-16	16	41	36.7	47.4	45.7
1	07-Jun-16	17	44.7	37.2	45.8	42
1	08-Jun-16	18	6.4	7.5	5.8	5.5
1	08-Jun-16	19	29.5	33.6	31.4	34.2
1	09-Jun-16	20	31.2	31.65	31.1	27.3
1	09-Jun-16	21	22.2	19.7	15.4	20.4
1	09-Jun-16	22	38.6	29.8	52.5	51.4
1	10-Jun-16	23	3.8	4.1	4	3.7
1	10-Jun-16	24	0.6	0.4	0.9	0.2
2	31-Oct-16	25	9.9	11	6.5	8.4
2	31-Oct-16	26	34.2	39.1	25.4	17.8
2	31-Oct-16	27	16.2	16.7	12.7	16
2	02-Nov-16	28	19.7	18.5	17.5	16.5
2	02-Nov-16	29	32.4	32.8	29.7	25.1
2	02-Nov-16	30	16	15.9	14.8	14.9
2	03-Nov-16	31	21.3	19.7	17.2	24.3
2	03-Nov-16	32	36.3	37	30.3	33.1
2	03-Nov-16	33	22.4	20.7	15.9	21.6
2	04-Nov-16	34	23.8	19.6	17.3	20.5
2	04-Nov-16	35	24	37.5	36.1	34
2	04-Nov-16	36	26.7	21.5	15.7	16.9
2	05-Nov-16	37	40.1	41.5	29.3	33
2	05-Nov-16	38	31.1	37.2	50	44.1
2	05-Nov-16	39	20.9	27.7	22.6	28.3
2	06-Nov-16	40	25.5	24.5	19.1	23.8
2	06-Nov-16	41	23.3	29	24.2	22.3
2	06-Nov-16	42	15.9	11.6	14.3	0.8

2	07-Nov-16	43	33.1	32.2	27.3	27.8
2	07-Nov-16	44	34	28.7	27.4	24.1
2	07-Nov-16	45	27.2	24.3	26.6	23.7
2	08-Nov-16	46	32.5	31.1	27.1	26.5
2	08-Nov-16	47	34	28.9	33.3	24.5
2	08-Nov-16	48	36.7	31.1	30.6	20.5
2	09-Nov-16	49	45.1	43.5	34.5	36
2	09-Nov-16	50	87.6	71.1	62.9	64.6
2	09-Nov-16	51	33.4	33.2	24.7	30.1
2	10-Nov-16	52	37.9	33.6	31.8	36
2	10-Nov-16	53	76.5	45.6	50.6	32.7
2	10-Nov-16	54	29.9	24.7	27.4	29
2	11-Nov-16	55	41.6	32.5	29.5	34.4
2	11-Nov-16	56	63.5	50.9	56.7	54
2	11-Nov-16	57	33.3	18.7	24	24
2	12-Nov-16	58	40.5	29.5	32.5	36.3
2	12-Nov-16	59	60.1	44.7	52.8	57.4
2	12-Nov-16	60	23.9	22.6	21.2	20.6
2	13-Nov-16	61	17.3	20.1	19.7	19.7
2	13-Nov-16	62	15.4	16.4	16.6	19.3
2	13-Nov-16	63	8.3	6.4	8.3	8.7
2	14-Nov-16	64	13.5	12.1	16	16.1
2	14-Nov-16	65	21.7	18.1	21.5	22.1
2	14-Nov-16	66	14.8	12.4	17.6	17.2
2	15-Nov-16	67	17.1	13.6	16.8	18.9
2	15-Nov-16	68	10.7	11.4	12.8	16
2	15-Nov-16	69	5.4	6.4	6.2	8.2

Table 3. Comparison of the average bycatch caught and commercial prawns retained (kgs) during the two at-sea trials.

	Trial 1	Trial 2
Bycatch Volume	71.39kg	34.51kg
Commercial Prawns	6.53kg	6.76kg

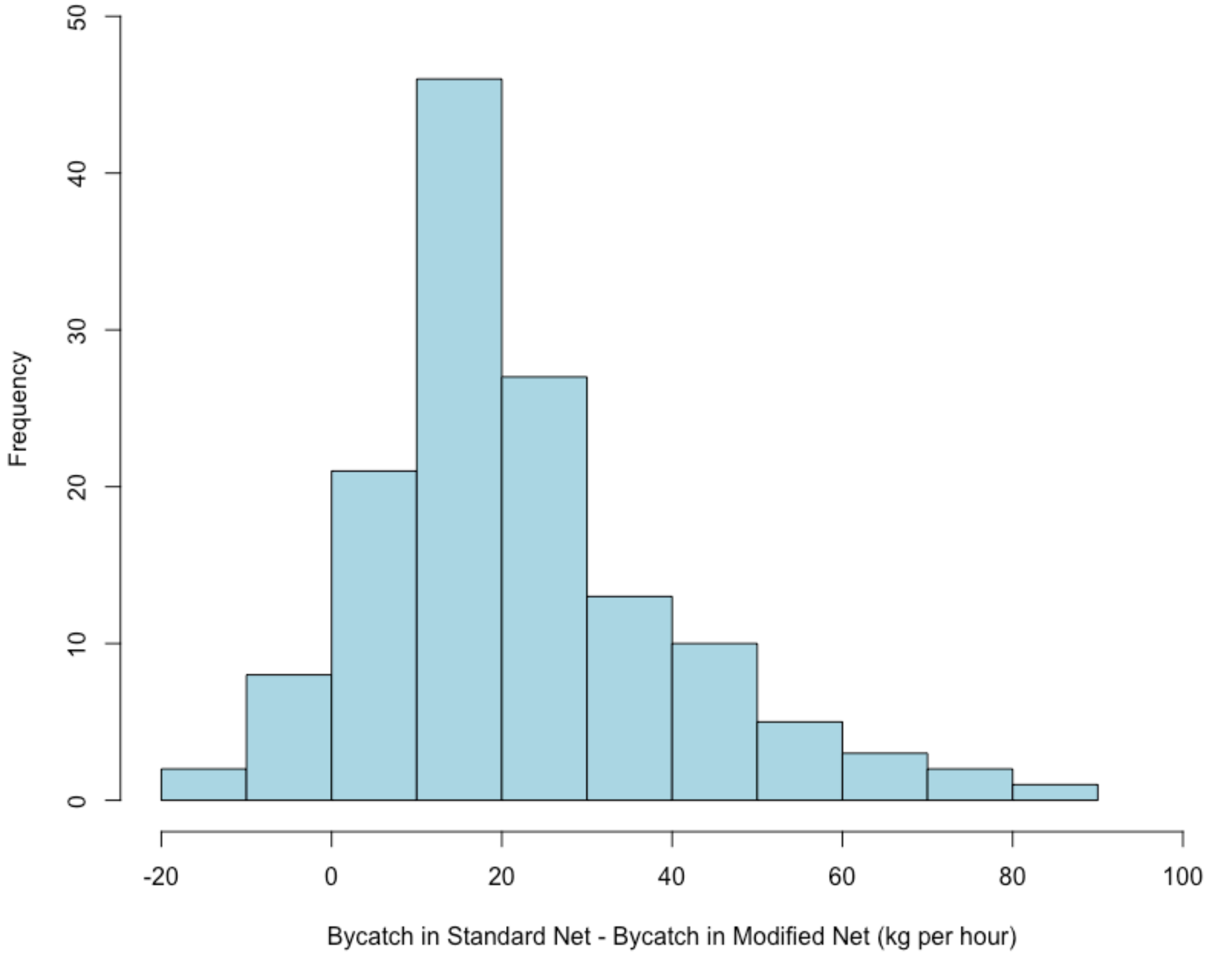

Figure 1. The frequency of the differences in total bycatch (kgs caught per hour of trawling) caught between the 'Kons Covered Fisheyes' BRD net and 'Square Mesh Panel' BRD net on each side during the two at-sea trials.

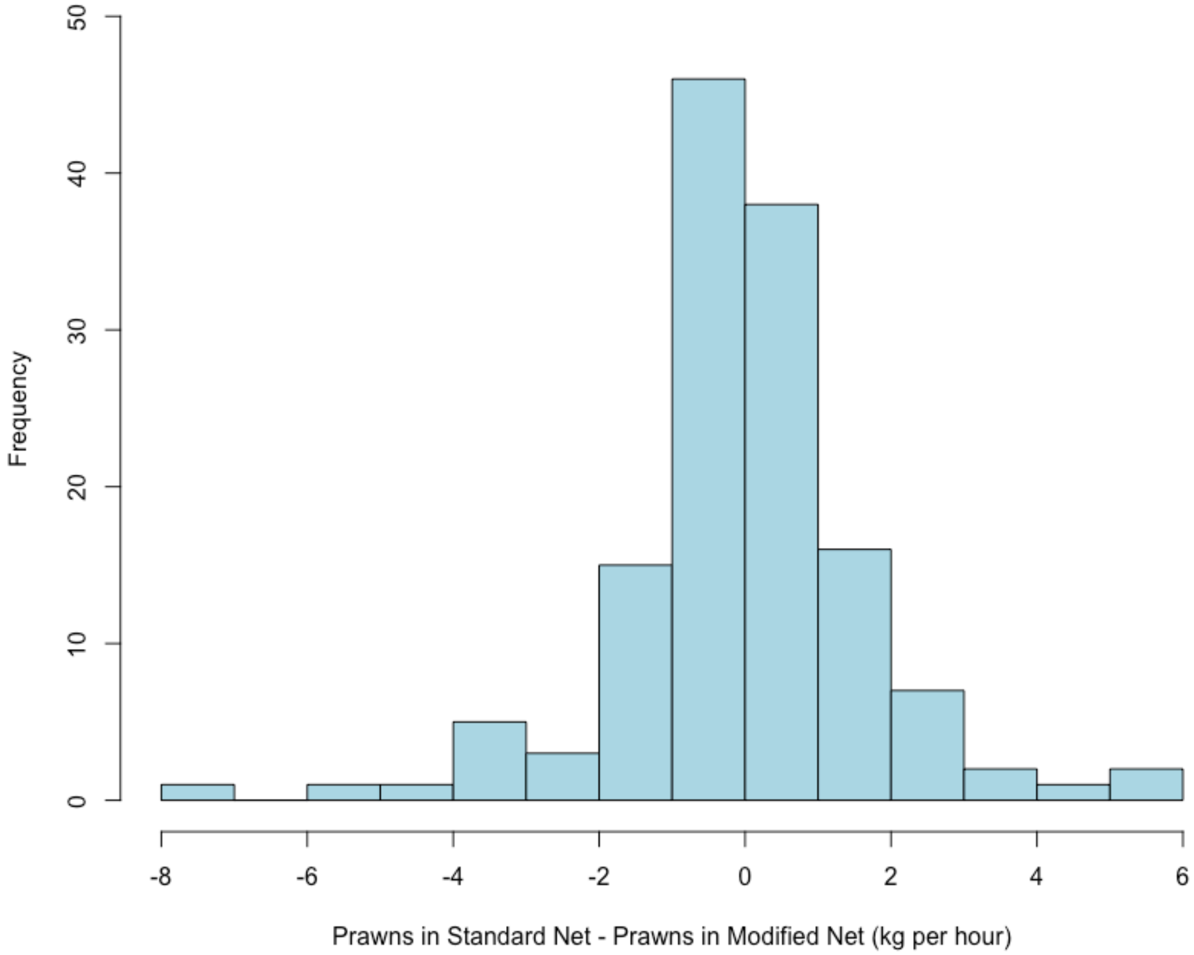

Figure 2. The frequency of the differences in commercial prawn catch (kgs caught per hour of trawling) between the 'Kons Covered Fisheyes' BRD net and 'Square Mesh Panel' BRD net on each side during the two at-sea trials.

4.1 Bycatch

The model for the bycatch data was fitted in R using the glmmPQL package in R and was of the form:

glmmPQL(Bycatch~offset(Duration)+Net+Position+Trial Number, random=~1|Shot, family=Gamma(link=log), data=AFMA_trial, maxit=100)

A summary of the fitted model is:

Random effects:

	Formula: ~1 |	Shot
	(Intercept)	Residual
StdDev:	0.4063487	0.1960974

Fixed effects: Bycatch ~ offset(Duration) + Net + Position + Trial Number

	Value	Std.Error	DF	t-value	p-value
(Intercept)	0.1652787	0.08940809	203	1.848588	0.0660
NetF	-0.4572924	0.02424490	203	-18.861384	0.0000
PositionPO	0.1774058	0.03375658	203	5.255445	0.0000
PositionSI	0.0574370	0.03375658	203	1.701506	0.0904
PositionSO	0.0200215	0.03384424	203	0.591576	0.5548
Trial 2	-0.6529772	0.10683954	67	-6.111756	0.0000

The results indicate that a large amount of the variability in the catches of bycatch is accounted for by the random effect i.e. the correlation between nets within a shot is very high. The fixed effects show significantly less bycatch was caught in the Treatment (F) nets ('Kon's Covered Fisheyes' BRD nets) compared to the control nets ('Square Mesh Panel' BRD nets). The transformed model coefficients indicate a reduction of approximately 36.7% in bycatch weights in the 'Kon's Covered Fisheyes' BRD nets (95% Confidence Interval: 33.6 – 39.6%) compared to the 'Square Mesh Panel' BRD nets. The catch rates in the different main quad gear positions are compared against the Port Inside and some significant differences were detected. The highest catch rates of bycatch were in the Port Outside and least in the Port Inside.

4.2 Commercial Prawns

The model for the commercial prawn data fitted was of the form:

glmmPQL(Prawns~offset(Duration)+Net+Position+Trial Number, random=~1|Shot, family=Gamma(link=log), data=AFMA_trial, maxit=100)

A summary of the fitted model is:

Random effects:

	Formula: ~1 |	Shot
	(Intercept)	Residual
StdDev:	0.6720651	0.1815889

Fixed effects: Prawns ~ offset(Duration) + Net + Position + Trial Number

	Value	Std.Error	DF	t-value	p-value
(Intercept)	-2.4763864	0.14164021	203	-17.483640	0.0000
NetF	0.0052603	0.02245884	203	0.234218	0.8151
PositionPO	0.0846957	0.03125906	203	2.709476	0.0073
PositionSI	-0.0227372	0.03125906	203	-0.727379	0.4678
PositionSO	-0.0044679	0.03134030	203	-0.142560	0.8868
Trial 2	0.1650870	0.17331795	67	0.952509	0.3443

Again, most of the variability in commercial prawn catches is described by shot to shot variability. There were significantly more commercial prawns caught on the Port Outside net compared to the other main quad gear net positions. The fixed effects show negligible difference between the commercial prawns caught in the Treatment nets ('Kon's Covered Fisheyes' BRD nets) compared to the Control nets ('Square Mesh Panel' BRD nets) with 0.5% more commercial prawns caught using the 'Kon's Covered Fisheyes' BRD nets (Confidence Interval: -3.8 – 5.1%). This shows that there is a mean percentage increase of 0.5% in commercial prawn catches when using the 'Kon's Covered Fisheyes' BRD with 95% confidence that any reduction in commercial prawn catch will be no more than 3.8% for any one trawl and an increase of 5.1% for any one trawl.

5 Interpretation

There is sufficient data to clearly show that there is significantly less bycatch caught in the nets with 'Kons Covered Fisheyes' BRDs installed compared to the nets with the standard 'Square Mesh Panel' BRD installed. This was mainly due to the quite notable and consistent reduction, around 36.7%, in bycatch volumes in these Treatment nets.

There was also no significant difference in commercial prawn catches between the nets fitted with 'Kons Covered Fisheyes' BRD compared to nets with the standard 'Square Mesh Panel' BRD. The initial analysis of the data from first trial showed that due to the complexity of the model fitted for this size sample and the large standard errors associated with the data, it was not possible to state that there no difference with any statistical confidence in commercial prawn catches between the Treatment and Control BRD nets.

By undertaking the second trial and increasing sample numbers, it was possible to demonstrate that was an overall mean increase in commercial prawn catches of 0.5% by weight. There is 95% certainty that the loss of commercial prawns using the 'Kon's Covered Fisheyes' BRD is less than 3.8% in any one trawl and an increase in catch of up to 5.1% for any one trawl.

It was not possible to examine other variables such as dawn/dusk and bycatch volume effects on bycatch volumes and commercial prawn catches due to the small sample sizes and highly variable data from the two at-sea trials.

6 Appendix 1

The raw data from the two at-sea trials comparing the 'Kons Covered Fisheyes' BRD net and 'Square Mesh Panel' BRD net on total bycatch volumes and commercial prawn caught.

									Starboard Outside			Starboard Inside			Port Inside			Port Outside		
Trip	Shot	Date	Shot Start Time	Shot Finish Time	Start Latitude	Start Longitude	Finish Latitude	Finish Longitude	Net	Bycatch (kg)	Prawn Catch (kg)	Net	Bycatch (kgs)	Prawn Catch (kgs)	Net	Bycatch (kgs)	Prawn Catch (kgs)	Net	Bycatch (kgs)	Prawn Catch (kgs)
1	1	2/06/2016	18:15	21:15	17° 01 . 41'	140° 24 . 11'	16° 57 . 93'	140° 24 . 09'	F1	310	19.81	C1	476	16.6	F2	367	29.15	C2	551	21.32
1	2	2/06/2016	21:40	0:35	16° 58 . 12'	140° 23 . 79'	17° 01 . 52'	140° 23 . 79'	F1	141	21.3	C1	372	27.6	F2	175	27.8	C2	426	29.5
1	3	3/06/2016	0:50	3:55	17° 01 . 78'	140° 24 . 11'	16° 58 . 27'	140° 24 . 09'	F1	117	27.6	C1	255	25.44	F2	89	26.95	C2	311	26.8
1	4	3/06/2016	4:10	6:50	16° 58 . 02'	140° 23 . 78'	16° 59 . 77'	140° 23 . 80'	F1	99	11.6	C1	183	10.7	F2	82	9.06	C2	237	14.01
1	5	3/06/2016	18:35	22:25	17° 01 . 32'	140° 24 . 96'	17° 00 . 04'	140° 24 . 63'	F1	70	15.91	C1	127	12.89	F2	90	16.65	C2	119	12.11
1	6	3/06/2016	22:35	2:25	17° 00 . 56'	140° 24 . 64'	16° 58 . 70'	140° 24 . 63'	F1	60	29.39	C1	182	35.54	F2	71	31.19	C2	229	44.23
1	7	4/06/2016	2:35	6:25	16° 59 . 23'	140° 24 . 63'	16° 54 . 18'	140° 24 . 92'	F1	67	19.72	C1	213	17.95	F2	85	17	C2	207	22.55
1	8	4/06/2016	19:15	23:25	16° 22 . 79'	139° 01 . 04'	16° 22 . 78'	140° 56 . 15'	F1	215	44	C1	264	40.4	F2	200	36.82	C2	344	60.4
1	9	4/06/2016	23:35	3:30	16° 22 . 75'	138° 56 . 53'	16° 22 . 77'	139° 00 . 55'	F1	118	45	C1	195	24	F2	102	19.1	C2	259	38.9
1	10	5/06/2016	3:45	6:25	16° 22 . 78'	139° 00 . 95'	16° 25 . 52'	139° 00 . 27'	F1	110	20.1	C1	177	11.6	F2	142	16.5	C2	223	12.08
1	11	5/06/2016	22:40	2:55	16° 22 . 60'	138° 55 . 76'	16° 22 . 58'	138° 59 . 39'	C2	318	51.4	F1	256	41.5	C1	354	44.6	F2	255	45
1	12	6/06/2016	3:10	7:25	16° 22 . 57'	138° 58 . 76'	16° 22 . 59'	138° 57 . 62'	C2	595	22.8	F1	518	19.2	C1	645	23.1	F2	407	25.9
1	13	6/06/2016	18:15	22:25	16° 22 . 46'	139° 00 . 30'	16° 22 . 46'	138° 56 . 33'	C2	471	28.8	F1	306	18.8	C1	480	21.7	F2	318	23.9
1	14	6/06/2016	22:40	2:55	16° 22 . 44'	138° 56 . 83'	16° 23 . 14'	138° 45 . 34'	C2	337	11.7	F1	314	12.3	C1	440	12.5	F2	268	12.3
1	15	7/06/2016	3:05	6:55	16° 23 . 52'	138° 45 . 89'	16° 22 . 44'	139° 00 . 87'	C2	300	17.4	F1	236	17.5	C1	287	16.2	F2	196	16.72
1	16	7/06/2016	20:05	23:55	16° 29 . 56'	138° 57 . 21'	16° 29 . 85'	138° 56 . 63'	C2	399	45.7	F1	189	47.4	C1	357	36.7	F2	265	41
1	17	8/06/2016	0:10	4:25	16° 29 . 85'	138° 56 . 37'	16° 29 . 57'	138° 56 . 73'	C2	265	42	F1	146	45.8	C1	232	37.2	F2	143	44.7
1	18	8/06/2016	17:45	19:40	16° 29 . 51'	138° 57 . 07'	16° 29 . 79'	138° 56 . 76'	F2	283	5.5	C2	342	5.8	F1	234	7.5	C1	364	6.4
1	19	8/06/2016	19:55	0:30	16° 29 . 47'	138° 57 . 20'	16° 29 . 49'	138° 55 . 38'	F2	214	34.2	C2	254	31.4	F1	185	33.6	C1	298	29.5
1	20	9/06/2016	0:40	4:55	16° 29 . 50'	138° 54 . 88'	16° 29 . 58'	138° 53 . 59'	F2	115	27.3	C2	169	31.1	F1	93	31.65	C1	188	31.2

									Starboard Outside			Starboard Inside			Port Inside			Port Outside		
Trip	Shot	Date	Shot Start Time	Shot Finish Time	Start Latitude	Start Longitude	Finish Latitude	Finish Longitude	Net	Bycatch (kg)	Prawn Catch (kg)	Net	Bycatch (kgs)	Prawn Catch (kgs)	Net	Bycatch (kgs)	Prawn Catch (kgs)	Net	Bycatch (kgs)	Prawn Catch (kgs)
1	21	9/06/2016	18:55	22:55	17° 02 . 88'	140° 28 . 41'	16° 57 . 14'	140° 24 . 74'	F2	326	20.4	C2	503	15.4	F1	286	19.7	C1	530	22.2
1	22	9/06/2016	23:05	2:55	16° 56 . 95'	140° 24 . 21'	16° 59 . 59'	140° 25 . 78'	F2	213	51.4	C2	401	52.5	F1	157	29.8	C1	375	38.6
1	23	10/06/2016	3:05	7:00	17° 00 . 06'	140° 26 . 12'	17° 12 . 73'	140° 34 . 55'	F2	152	3.7	C2	335	4	F1	145	4.1	C1	329	3.8
1	24	10/06/2016	18:20	22:25	17° 07 . 98'	140° 31 . 93'	17° 14 . 84'	140° 35 . 66'	F2	180	0.2	C2	178	0.9	F1	159	0.4	C1	229	0.6
2	25	31/10/2016	18:05	20:45	12° 50 . 76'	141° 27 . 31'	12° 50 . 83'	141° 27 . 32'	SM1	231	8.4	FE1	107	6.5	SM2	280	11	FE2	151	9.9
2	26	31/10/2016	21:00	1:10	12° 50 . 39'	141° 27 . 35'	12° 55 . 15'	141° 27 . 32'	SM1	148	17.8	FE1	71	25.4	SM2	225	39.1	FE2	130	34.2
2	27	31/10/2016	1:25	5:20	12° 55 . 49'	141° 27 . 34'	12° 51 . 12'	141° 27 . 32'	SM1	127	16	FE1	63	12.7	SM2	165	16.7	FE2	86	16.2
2	28	2/11/2016	18:35	22:30	15° 05 . 55'	136° 46 . 95'	15° 05 . 59'	136° 41 . 77'	SM1	221	16.5	FE1	160	17.5	SM2	225	18.5	FE2	152	19.7
2	29	2/11/2016	22:40	2:45	15° 05 . 55'	136° 41 . 23'	15° 05 . 58'	136° 44 . 96'	SM1	103	25.1	FE1	69	29.7	SM2	114	32.8	FE2	68	32.4
2	30	2/11/2016	2:55	7:00	15° 05 . 59'	136° 44 . 42'	15° 05 . 55'	136° 44 . 35'	SM1	261	14.9	FE1	137	14.8	SM2	234	15.9	FE2	188	16
2	31	3/11/2016	18:40	22:35	14° 57 . 48'	136° 33 . 98'	14° 57 . 39'	136° 28 . 57'	SM1	226	24.3	FE1	151	17.2	SM2	230	19.7	FE2	187	21.3
2	32	3/11/2016	22:45	2:45	14° 57 . 37'	136° 28 . 04'	14° 57 . 38'	136° 31 . 69'	SM1	130	33.1	FE1	79	30.3	SM2	113	37	FE2	91	36.3
2	33	3/11/2016	2:55	7:10	14° 57 . 40'	136° 32 . 17'	14° 57 . 37'	136° 31 . 24'	SM1	188	21.6	FE1	100	15.9	SM2	157	20.7	FE2	82	22.4
2	34	4/11/2016	18:40	22:35	14° 56 . 27'	136° 33 . 70'	14° 56 . 29'	136° 31 . 19'	SM1	405	20.5	FE1	261	17.3	SM2	355	19.6	FE2	267	23.8
2	35	4/11/2016	22:45	2:45	14° 56 . 30'	136° 30 . 57'	14° 56 . 29'	136° 30 . 25'	SM1	140	34	FE1	84	36.1	SM2	126	37.5	FE2	62	24
2	36	4/11/2016	2:55	7:05	14° 56 . 31'	136° 30 . 73'	14° 56 . 30'	136° 31 . 49'	SM1	201	16.9	FE1	98	15.7	SM2	253	21.5	FE2	175	26.7
2	37	5/11/2016	18:35	22:30	14° 56 . 01'	136° 33 . 34'	14° 56 . 01'	136° 31 . 71'	SM1	164	33	FE1	104	29.3	SM2	215	41.5	FE2	144	40.1
2	38	5/11/2016	22:40	3:25	14° 56 . 04'	136° 32 . 29'	14° 55 . 99'	136° 31 . 26'	SM1	121	44.1	FE1	82	50	SM2	77	37.2	FE2	56	31.1
2	39	5/11/2016	3:40	7:00	14° 56 . 01'	136° 31 . 91'	14° 56 . 00'	136° 30 . 16'	SM1	122	28.3	FE1	83	22.6	SM2	145	27.7	FE2	83	20.9
2	40	6/11/2016	18:35	22:25	14° 55 . 95'	136° 33 . 31'	14° 55 . 93'	136° 30 . 99'	SM1	169	23.8	FE1	79	19.1	SM2	186	24.5	FE2	110	25.5
2	41	6/11/2016	22:40	2:40	14° 55 . 95'	136° 30 . 74'	14° 55 . 93'	136° 29 . 43'	SM1	80	22.3	FE1	48	24.2	SM2	75	29	FE2	52	23.3
2	42	6/11/2016	2:50	7:00	14° 55 . 96'	136° 28 . 96'	14° 55 . 93'	136° 30 . 67'	SM1	47	0.8	FE1	92	14.3	SM2	127	11.6	FE2	102	15.9
2	43	7/11/2016	18:50	22:30	14° 56 . 26'	136° 34 . 95'	14° 56 . 42'	136° 39 . 84'	FE2	138	27.8	SM1	180	27.3	FE1	151	32.2	SM2	245	33.1
2	44	7/11/2016	22:45	2:45	14° 56 . 40'	136° 39 . 32'	14° 56 . 79'	136° 37 . 07'	FE2	85	24.1	SM1	136	27.4	FE1	80	28.7	SM2	159	34
2	45	7/11/2016	3:00	7:00	14° 56 . 81'	136° 37 . 58'	14° 56 . 26'	136° 34 . 89'	FE2	104	23.7	SM1	161	26.6	FE1	90	24.3	SM2	131	27.2
2	46	8/11/2016	18:40	22:25	14° 56 . 17'	136° 34 . 99'	14° 56 . 53'	136° 38 . 15'	FE2	108	26.5	SM1	179	27.1	FE1	121	31.1	SM2	223	32.5
2	47	8/11/2016	22:40	2:40	14° 56 . 54'	136° 37 . 64'	14° 56 . 18'	136° 38 . 83'	FE2	66	24.5	SM1	99	33.3	FE1	54	28.9	SM2	136	34

									Starboard Outside			Starboard Inside			Port Inside			Port Outside		
Trip	**Shot**	**Date**	**Shot Start Time**	**Shot Finish Time**	**Start Latitude**	**Start Longitude**	**Finish Latitude**	**Finish Longitude**	**Net**	**Bycatch (kg)**	**Prawn Catch (kg)**	**Net**	**Bycatch (kgs)**	**Prawn Catch (kgs)**	**Net**	**Bycatch (kgs)**	**Prawn Catch (kgs)**	**Net**	**Bycatch (kgs)**	**Prawn Catch (kgs)**
2	48	8/11/2016	2:55	7:00	14° 56 . 52'	136° 38 . 68'	14° 56 . 18'	136° 38 . 27'	FE2	71	20.5	SM1	117	30.6	FE1	88	31.1	SM2	176	36.7
2	49	9/11/2016	18:35	22:25	14° 25 . 40'	136° 27 . 44'	14° 26 . 41'	136° 31 . 84'	FE2	125	36	SM1	176	34.5	FE1	130	43.5	SM2	219	45.1
2	50	9/11/2016	22:40	2:45	14° 26 . 30'	136° 31 . 46'	14° 25 . 85'	136° 29 . 44'	FE2	75	64.6	SM1	91	62.9	FE1	58	71.1	SM2	105	87.6
2	51	9/11/2016	2:55	7:05	14° 25 . 94'	136° 29 . 87'	14° 25 . 69'	136° 27 . 85'	FE2	98	30.1	SM1	135	24.7	FE1	116	33.2	SM2	162	33.4
2	52	10/11/2016	18:35	22:25	14° 25 . 32'	136° 27 . 41'	14° 26 . 32'	136° 31 . 88'	SM2	190	36	FE2	90	31.8	SM1	123	33.6	FE1	140	37.9
2	53	10/11/2016	22:40	2:45	14° 26 . 25'	136° 31 . 47'	14° 25 . 75'	136° 29 . 31'	SM2	71	32.7	FE2	56	50.6	SM1	60	45.6	FE1	89	76.5
2	54	10/11/2016	2:55	6:45	14° 25 . 87'	136° 29 . 80'	14° 25 . 96'	136° 28 . 53'	SM2	119	29	FE2	63	27.4	SM1	95	24.7	FE1	119	29.9
2	55	11/11/2016	18:35	22:25	14° 26 . 57'	136° 31 . 05'	14° 26 . 03'	136° 28 . 62'	SM2	206	34.4	FE2	88	29.5	SM1	127	32.5	FE1	150	41.6
2	56	11/11/2016	22:40	2:50	14° 26 . 14'	136° 29 . 07'	14° 25 . 82'	136° 27 . 71'	SM2	82	54	FE2	52	56.7	SM1	53	50.9	FE1	74	63.5
2	57	11/11/2016	3:00	7:00	14° 25 . 90'	136° 28 . 02'	14° 26 . 16'	136° 29 . 20'	SM2	108	24	FE2	58	24	SM1	66	18.7	FE1	107	33.3
2	58	12/11/2016	18:30	22:25	14° 26 . 71'	136° 31 . 35'	14° 26 . 05'	136° 28 . 37'	SM2	169	36.3	FE2	96	32.5	SM1	97	29.5	FE1	120	40.5
2	59	12/11/2016	22:40	2:45	14° 26 . 17'	136° 28 . 91'	14° 25 . 93'	136° 27 . 86'	SM2	78	57.4	FE2	45	52.8	SM1	43	44.7	FE1	58	60.1
2	60	12/11/2016	3:00	6:55	14° 25 . 83'	136° 27 . 41'	14° 26 . 35'	136° 29 . 65'	SM2	160	20.6	FE2	65	21.2	SM1	155	22.6	FE1	139	23.9
2	61	13/11/2016	18:40	22:25	14° 25 . 84'	136° 27 . 17'	14° 19 . 72'	136° 16 . 42'	FE1	166	19.7	SM2	217	19.7	FE2	135	20.1	SM1	164	17.3
2	62	13/11/2016	22:40	2:45	14° 19 . 25'	136° 16 . 31'	14° 19 . 65'	136° 16 . 43'	FE1	109	19.3	SM2	121	16.6	FE2	81	16.4	SM1	115	15.4
2	63	13/11/2016	2:55	7:00	14° 19 . 15'	136° 16 . 35'	14° 14 . 14'	136° 14 . 57'	FE1	171	8.7	SM2	218	8.3	FE2	96	6.4	SM1	162	8.3
2	64	14/11/2016	18:35	22:30	14° 14 . 32'	136° 12 . 79'	14° 19 . 41'	136° 12 . 06'	FE1	107	16.1	SM2	175	16	FE2	98	12.1	SM1	147	13.5
2	65	14/11/2016	22:40	2:45	14° 19 . 54'	136° 11 . 63'	14° 21 . 38'	136° 10 . 69'	FE1	132	22.1	SM2	217	21.5	FE2	125	18.1	SM1	178	21.7
2	66	14/11/2016	2:55	7:05	14° 20 . 97'	136° 10 . 86'	14° 15 . 98'	136° 11 . 79'	FE1	134	17.2	SM2	230	17.6	FE2	90	12.4	SM1	178	14.8
2	67	15/11/2016	18:35	22:30	13° 16 . 50'	136° 32 . 85'	13° 17 . 17'	136° 30 . 00'	FE1	70	18.9	SM2	150	16.8	FE2	60	13.6	SM1	95	17.1
2	68	15/11/2016	22:40	2:45	13° 17 . 48'	136° 29 . 67'	13° 25 . 30'	136° 40 . 82'	FE1	160	16	SM2	250	12.8	FE2	100	11.4	SM1	180	10.7
2	69	15/11/2016	3:00	7:00	13° 25 . 71'	136° 40 . 86'	13° 30 . 88'	136° 41 . 60'	FE1	200	8.2	SM2	350	6.2	FE2	190	6.4	SM1	280	5.4

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