An Observer Report:

At Sea Testing and Assessment of a Modified Fisheye Bycatch Reduction Device Aboard the *Rosen C* for Approval in Australia's Northern Prawn Fishery.

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AFMA

INTRODUCTION

The Northern Prawn Fishery (NPF) exports the majority of its product and is Australia's most valuable Commonwealth managed fishery. The NPF, as a sub-tropical penaeid trawl fishery, is categorised by its high bycatch volume and biodiversity. Since the 1980's, 411 fish species have been recorded in the NPF bycatch (Stobutzki et al., 2000). In recent survey's by Stobutzki and colleagues (2000) over 390 fish species, 56 elasmobranch species and 234 invertebrate species were identified and evaluated amongst the bycatch of the NPF.

As a Commonwealth managed fishery the NPF's management falls under the auspices of the Australian Fisheries Management Authority (AFMA). A key legislative objective of AFMA is to 'ensure that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development and the exercise of the precautionary principle, in particular the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment'. This is consistent with the ongoing evolution of fisheries management in incorporating an ecosystem approach as opposed to the traditional focus on sustaining maximum yields of target stocks.

The NPF has in place a Bycatch Action Plan (BAP) and strongly emphasises the reduction of the volume of bycatch captured. This has largely been successful through the compulsory introduction of Turtle Excluder Devices (TEDs) and Bycatch Reduction Devices (BRDs) into the fishery in 2000. TEDs successfully exclude turtles and other large animals including the larger elasmobranchs while BRDs aim at reducing the total amount of bycatch, particularly teleosts.

The introduction, and concurrent use, of TEDs and BRDs is a relatively new concept in fishing practice with the devices now compulsorily employed in the NPF for just over two years. Consequently there is an ongoing process of development in order to maximise bycatch exclusion and minimise prawn loss (Day, 2000). Whilst legally binding definitions of TEDs and BRDs have been developed and approved by NORMAC (The Northern Prawn Fishery Management Advisory Committee), and NPF vessels must use devices that conform to these specifications, NORMAC has provided for scientific permits to be granted to operators wishing to trial new designs. This encourages NPF operators to develop new, innovative and effective TEDs and BRDs (Day, 2000).

Skipper Jim Yarrow aboard the FV Rosen C had made structural strengthening changes to his standard fisheye (see Attachment 1 for definition) under a scientific permit. The aim of this report is to identify and quantify the effectiveness of this modified fisheye in excluding bycatch during commercial fishing towards the end of the 2002 Tiger Prawn Season. Results would assist in determining approval to the modifications of the fisheye and may lead to further research in understanding the dynamics involved in excluding bycatch.

METHODS

Jim Yarrow, the skipper aboard the FV Rosen C, had made structurally strengthening changes to the standard fisheye, an approved BRD. This involved welding of two new bars into the frame, one vertically across the middle of the eye opening, effectively halving the maximum open width of the 'eye', the second running from the centre top exterior of the eye to the anterior apex of the support frame (see red lines in figure 1). These changes were not intended to alter the effectiveness of the BRD, rather they are to strengthen the frame and prevent collapse of the eye during hauling when the eye is often bashed against the net deck of the vessel.

Axis	Length (mm)
A - B	380
A - C	380
A - D	350
A - E	350
B - C	380
B - F	190
D - E	150
Each Float	115 long x 70 dia.

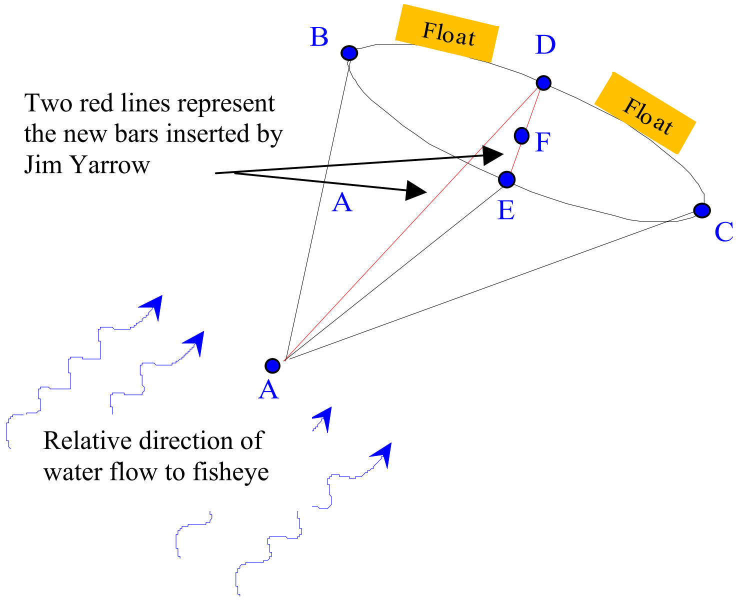


Figure 1: Diagrammatic representation of the modified fisheye being assessed.

Assessment of the modified fisheye took place through at sea testing, by an AFMA observer (the author), in the final two weeks of the commercial 2002 Tiger prawn season. The aim was to quantify the effectiveness of the BRD in excluding bycatch when compared to a standard net. For this purpose the paired nets were put through an initial and final calibration phase, where both nets omitted the BRD, to measure the comparative fishing efficiency between the two gear sets. Additionally the BRD was rotated through both the port and starboard nets to reduce sources of bias on the results that may be derived from gear related factors. It was decided that the BRD would be assessed while the TEDs remained in place hence best replicating the commercial conditions during fishing at sea (ie. any alteration of water flow due to TED).

The project period ran over 13 nights from the 16th Nov 2002 till the morning of the 29th Nov 2002. The vessel consistently performed four shots each night such that 51 shots were observed over the period of this project. Where possible, and if the nets were not obviously biased by a 'TEDing'[1], bycatch weight was quantified for each net. Codends were spilt into separate trays and weight was quantified through collection of the bycatch from the individual trays into lug baskets that were weighed on a hanging 50kg spring scale. Generally, where possible, each lug-basket of bycatch was measured to the nearest 100gram, however under poor weather and sea conditions some shots were

[1] A 'TEDing' refers to when a large organism, typically a ray, shark or turtle, becomes wedged in either the TED or the escape flap through which the TED directs these organisms. Under these circumstances the large organism can substantially block the flow of catch into the codend and redirect it through the escape flap resulting in significant loses of both catch and bycatch. A TEDing is identified by an unusually large difference in the volume between the two codends that can not be explained by other factors.

collected only to the nearest kilogram due to the pendulum motion of the scales. Tiger and endeavour prawn weights were predominantly recorded by the crew and measured to the nearest kilogram. Where this was not the case, and the observer weighed the product, then the weight was to the nearest 100 gram. On most occasions elasmobranchs were separated and not included in the bycatch weight. These were generally removed from the bycatch and identified to species level then individually weighed, sexed and measured.

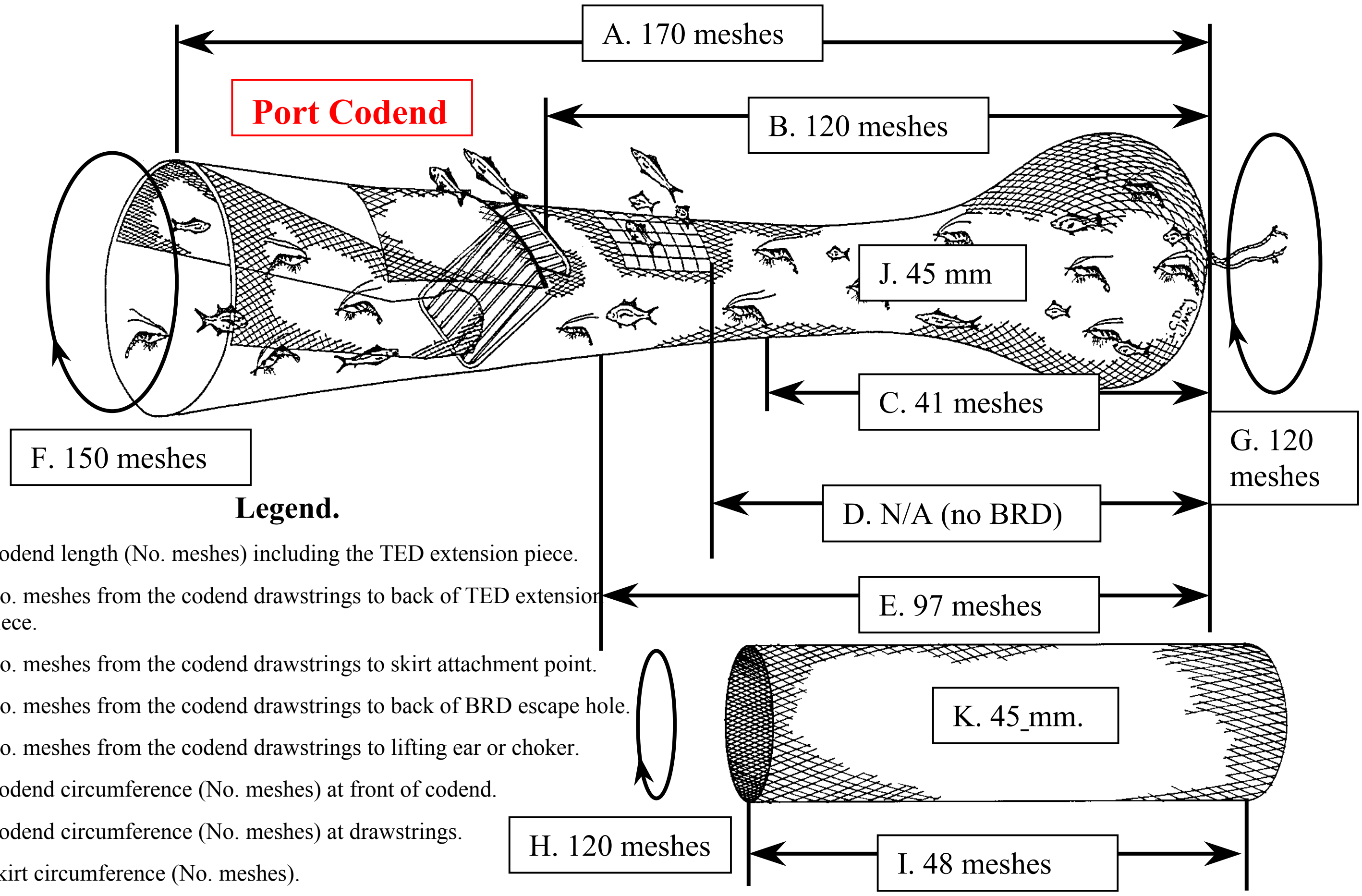
Not all of the 51 shots had their bycatch quantified. Dependant on the volume of the catch or if a net was suspected to have been TEDed, then this data was excluded from the assessment. Comparison of tiger prawn catch between nets was used as a measure of the possibility of a TEDing. If one net was substantially down in tiger prawn weight then this could represent a large elasmobranch having become stuck in the TED opening, leaving the flap ajar, and hence experiencing prawn and bycatch loss. This is a reliable measure of a TEDing as each trawl involves numerous runs over the same ground during a shot, consequently the randomness of spatial and temporal catch distribution should become relatively evened out between the nets over the period of the shot.

The configuration of the Starboard net was a headrope length of 14.86 metres, footrope length of 16.60 metres, (AFMA Tag 2133) with the headrope pulled up two links per side and the ground chains pulled up three links per side. There was also a bubble placed in the middle of the headrope to stop it from collapsing when stretched out. The Port net had the same headrope and footrope lengths (AFMA Tag 2132) however the net was set up square while the ground chains were pulled up three links per side. Both nets had size eight Bison Boards and a drop chain height of 7 links. With the exception of alternating the BRD the nets were not altered over the duration of the BRD assessment.

1. Calibration phases

The calibration phases were carried out over the initial two nights and final two nights of the project. The aim of the calibration phase was to identify how evenly the two nets were fishing and quantify any differences the individual nets may have in catch and bycatch rates. For the purposes of calibration both nets had their BRDs (figure 2) sewn up and hence differential quantification of the catch and bycatch should represent differences in the fishing efficiency of the nets. If one net was fishing ‘heavier’ or ‘dirtier’ then this should turn up in the results of the calibration and any consistent difference observed could then be factored out of the results for the BRD analysis. This is important as the model used to analysis the data assumes that both nets fish evenly for catch and bycatch when configured as standard nets. This then allows the BRD to be entered as the single controlled variable. Figure 2 displays the codend configurations during the calibration period.

For the purpose of this report both the initial and final calibration were analysed together and any differences between the nets were averaged out over both calibration periods. This difference in bycatch fishing efficiency was then deducted from the differences observed when comparing the BRD net with a standard net.



Legend.

- **A.** Codend length (No. meshes) including the TED extension piece.
- **B.** No. meshes from the codend drawstrings to back of TED extension piece.
- **C.** No. meshes from the codend drawstrings to skirt attachment point.
- **D.** No. meshes from the codend drawstrings to back of BRD escape hole.
- **E.** No. meshes from the codend drawstrings to lifting ear or choker.
- **F.** Codend circumference (No. meshes) at front of codend.
- **G.** Codend circumference (No. meshes) at drawstrings.
- **H.** Skirt circumference (No. meshes).
- **I.** Skirt length (No. meshes).
- **J.** Codend mesh size (mm).
- **K.** Skirt mesh size (mm).

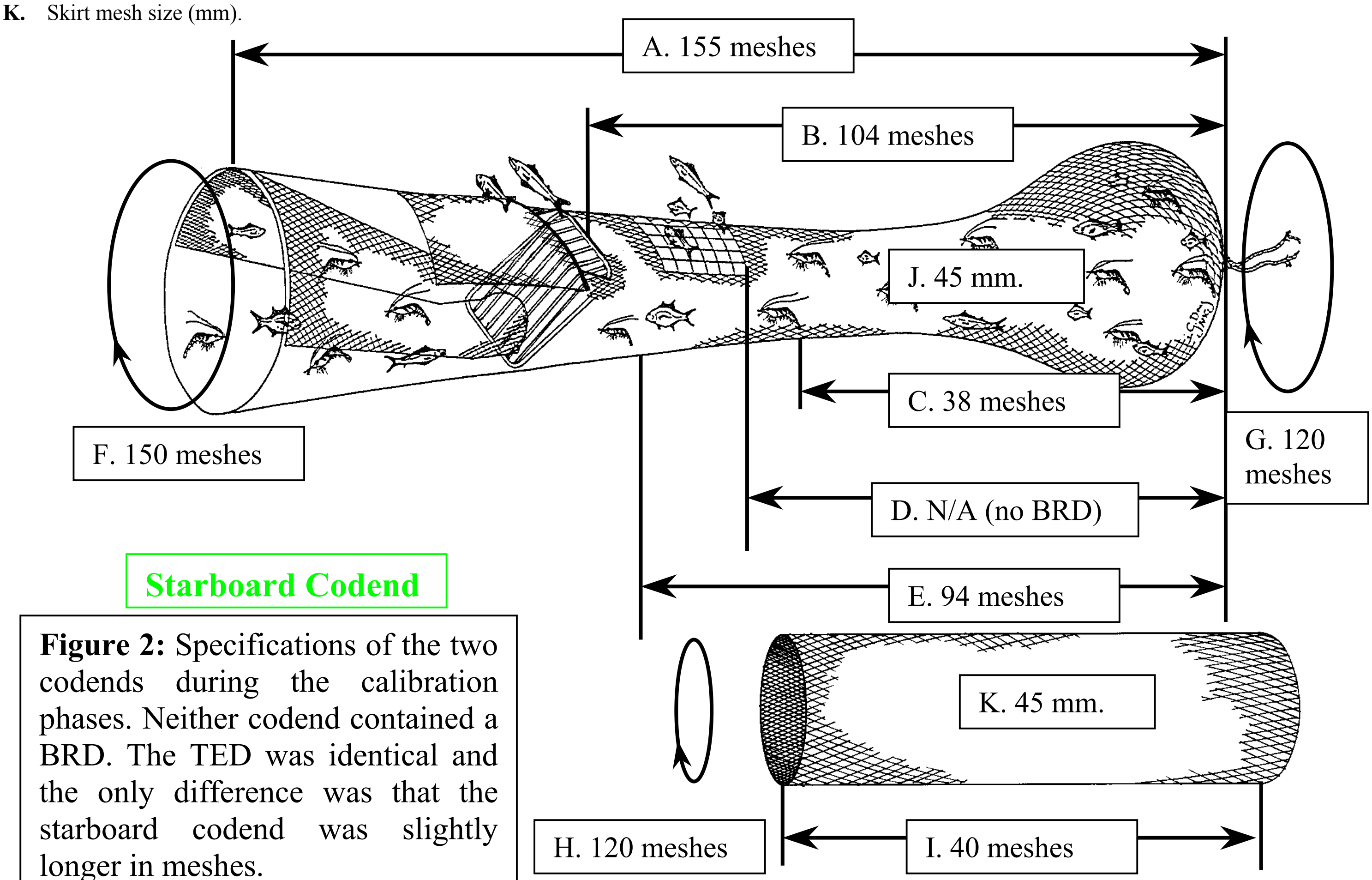
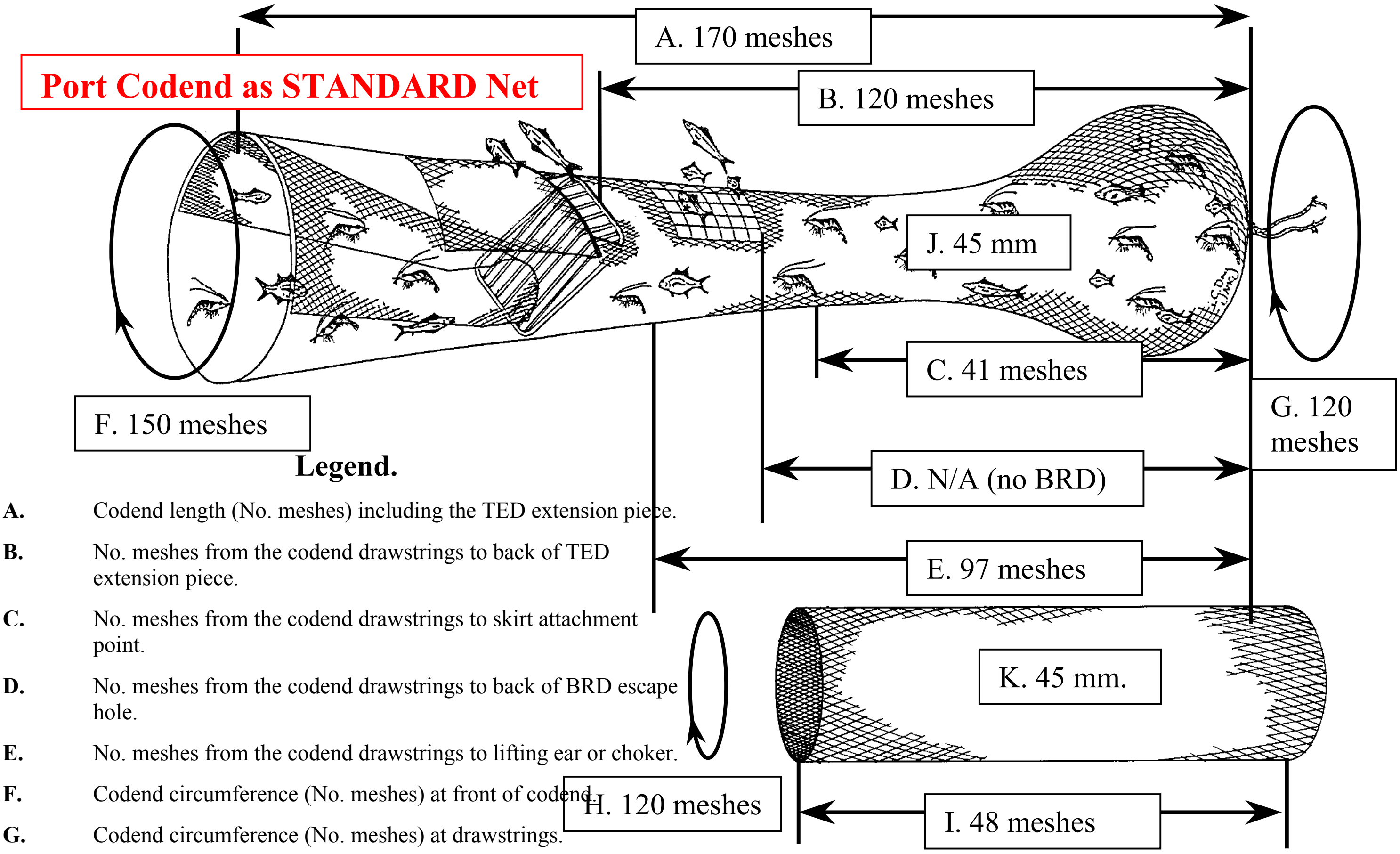


Figure 2: Specifications of the two codends during the calibration phases. Neither codend contained a BRD. The TED was identical and the only difference was that the starboard codend was slightly longer in meshes.

Analysis of BRD

In order to quantify the effectiveness of the modified fisheye in excluding bycatch, a net containing the BRD was compared to a net lacking a BRD (Standard net). Using the presence or absence of a BRD in the paired nets as the sole controlled variable, one could then assume that differences in bycatch between nets reflects the impact of the BRD. Again, any shots that appeared strongly askew or biased, possibly by a TEDing were excluded from the analysis (this was generally identified through a large difference between codends in the tiger prawn catch).

The comparison of a BRD net against a Standard net was duplicated. Initially the BRD was installed in the Starboard net for nights three to seven inclusive (shots 9 – 28). Figure 3 displays the codend configurations with the BRD in the starboard net whilst the port net omits the BRD (Standard net). Subsequently the BRD was switched to the Port net for nights eight to eleven (shots 29 – 44). Changing the BRD from one net to the other involved switching the codends over at the point of attachment at the trailing edge of the TED panel. Figure 4 displays the codend configurations for this stage of the assessment. Replication of the BRD in both codends reduces the possibility of observed bycatch difference between nets having resulted from other net associated factors. A similar performance in bycatch reduction from both nets would strengthen the argument of the BRDs effectiveness.



Legend.

A. Codend length (No. meshes) including the TED extension piece.

B. No. meshes from the codend drawstrings to back of TED extension piece.

C. No. meshes from the codend drawstrings to skirt attachment point.

D. No. meshes from the codend drawstrings to back of BRD escape hole.

E. No. meshes from the codend drawstrings to lifting ear or choker.

F. Codend circumference (No. meshes) at front of codend.

G. Codend circumference (No. meshes) at drawstrings.

H. Skirt circumference (No. meshes).

I. Skirt length (No. meshes).

J. Codend mesh size (mm).

K. Skirt mesh size (mm).

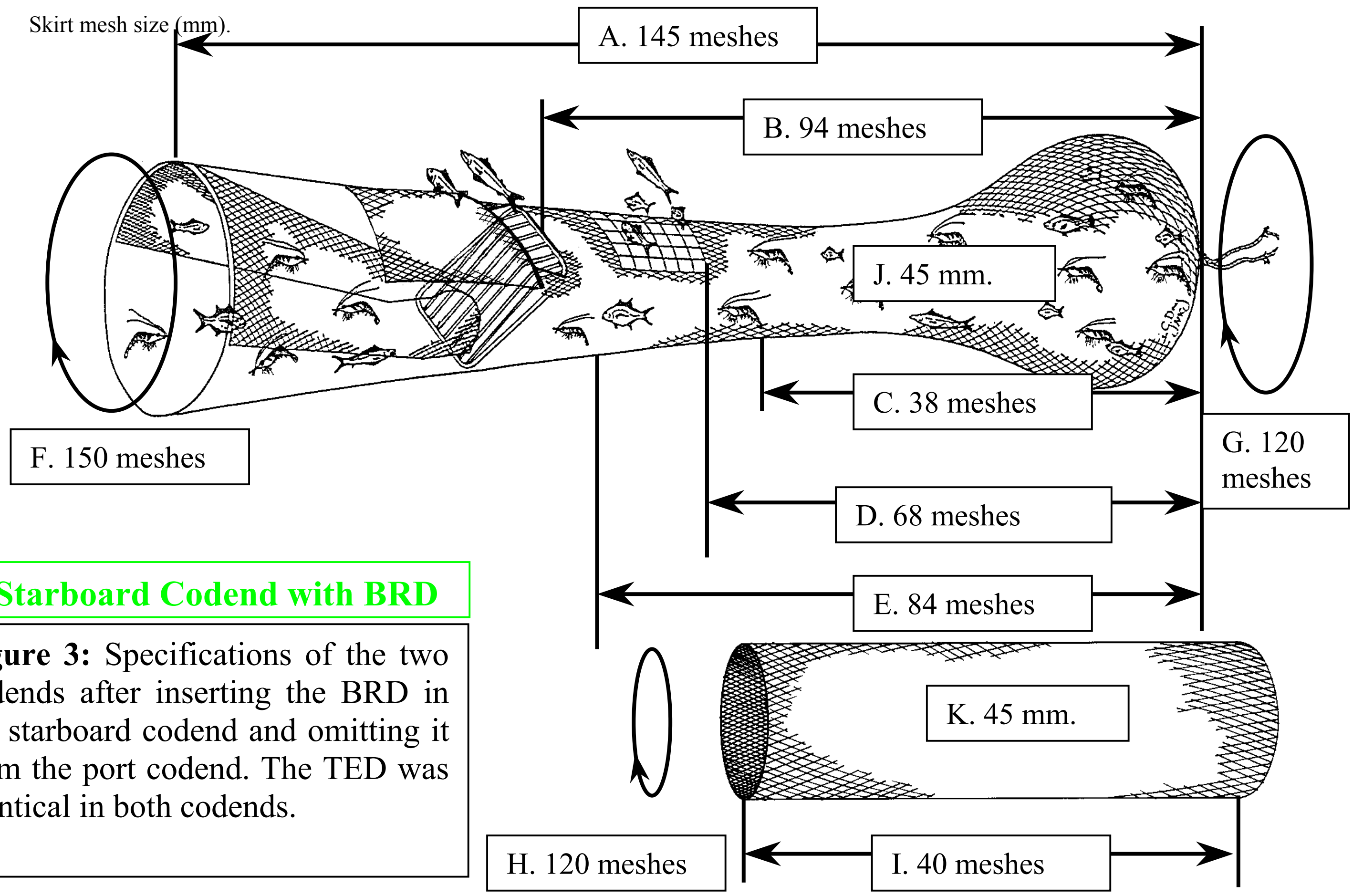
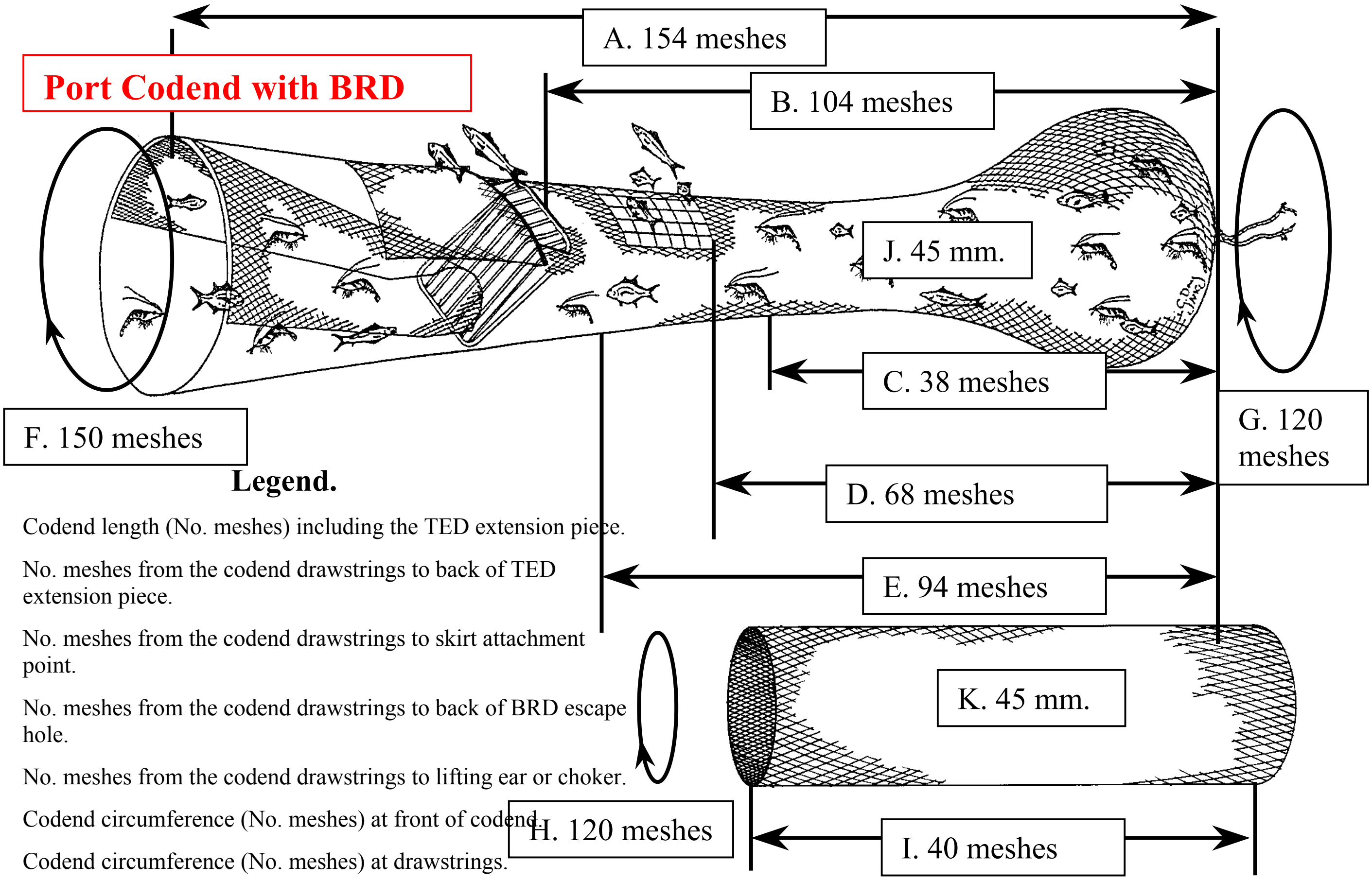


Figure 3: Specifications of the two codends after inserting the BRD in the starboard codend and omitting it from the port codend. The TED was identical in both codends.



Legend.

- **A.** Codend length (No. meshes) including the TED extension piece.
- **B.** No. meshes from the codend drawstrings to back of TED extension piece.
- **C.** No. meshes from the codend drawstrings to skirt attachment point.
- **D.** No. meshes from the codend drawstrings to back of BRD escape hole.
- **E.** No. meshes from the codend drawstrings to lifting ear or choker.
- **F.** Codend circumference (No. meshes) at front of codend.
- **G.** Codend circumference (No. meshes) at drawstrings.
- **H.** Skirt circumference (No. meshes).
- **I.** Skirt length (No. meshes).
- **J.** Codend mesh size (mm).
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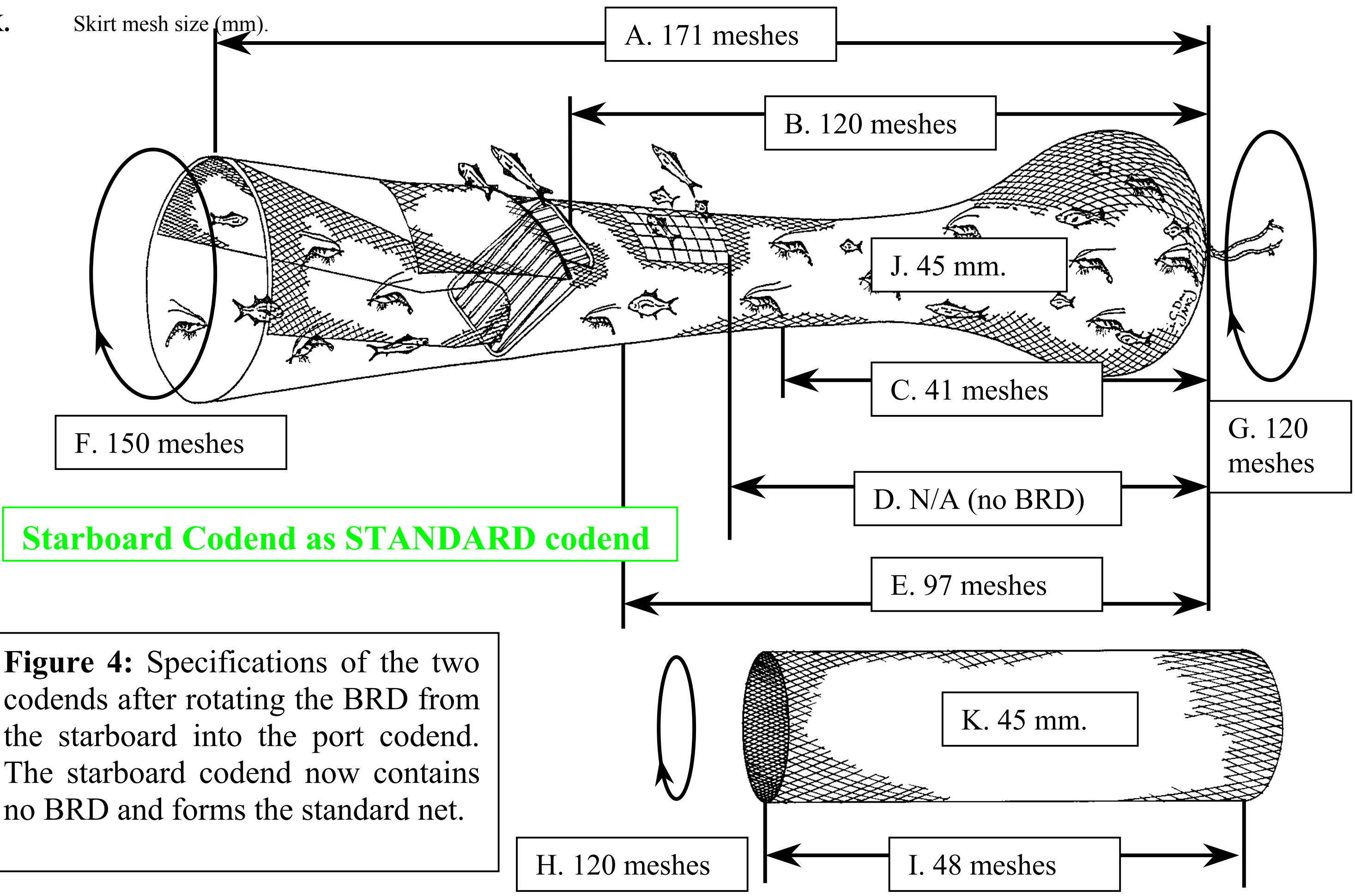

Figure 4: Specifications of the two codends after rotating the BRD from the starboard into the port codend. The starboard codend now contains no BRD and forms the standard net.

RESULTS

1. Calibration Phase

A total of eight shots were undertaken over two nights during the initial calibration period. A further seven shots were assessed over two nights during the final calibration period. Of the fifteen shots recorded during the calibration phases two were flagged as being unreliable for analysis due to bias from TEDs or due to observer error in collating the data. A shot could be flagged as unreliable for bycatch analysis, tiger prawn catch analysis or both. Only one of the shots could not be utilised for tiger prawn catch analysis while two shots could not be used for bycatch analysis.

a. Bycatch

Table 1 and Figure 5 display the bycatch weights per shot for the port and starboard nets over the two calibration phases. The data from the initial and final calibration phases can be presented together because a Mixed Procedure (SAS) analysis of bycatch rate per net over time indicated that there was no interaction (P=0.9277, df=11). This implies that any difference in bycatch rate between the nets remained consistent between the initial and final calibration periods and that the relative fishing efficiency of the nets did not change over the period of the BRD assessment.

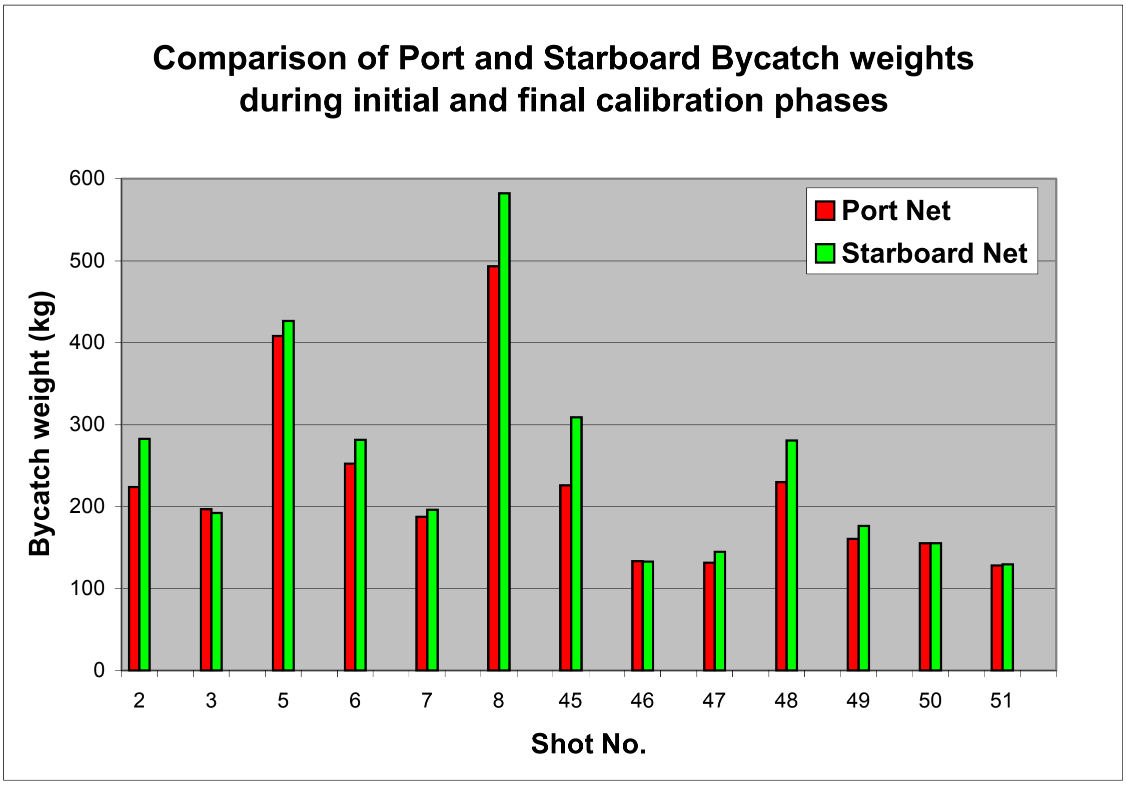

Figure 5: Shot-by-shot comparison of bycatch weights between port and starboard nets over the two calibration phases.

Table 1: Shot-by-shot comparison of bycatch weight between the standard and port net during the initial and final calibration phases.

Shot No.	Bycatch weight of Port Net with no BRD (kg)	Bycatch weight of Starboard Net with no BRD (kg)	Difference in port bycatch relative to starboard (kg's)	% Difference of port net relative to starboard
2	223.8	282.2	-58.4	-20.69
3	196.9	192.4	4.5	2.34
5	408.1	426.5	-18.4	-4.31
6	251.9	280.9	-29	-10.32
7	187.3	195.9	-8.6	-4.39
8	493	582.4	-89.4	-15.35
45	225.5	309	-83.5	-27.02
46	133.4	132.8	0.6	0.45
47	131.6	144.4	-12.8	-8.86
48	229.4	280.4	-51	-18.19
49	160.7	176.3	-15.6	-8.85
50	155.1	154.8	0.3	0.19
51	128	129.7	-1.7	-1.31
		Average % difference in bycatch weight of port net relative to starboard		-8.95

As the table and graph demonstrate, the port net fished consistently down in bycatch relative to the starboard net. The model calculated that the port net fished down in bycatch weight by 9.37%[2] relative to the starboard net. This difference in bycatch between nets was found to be significant at the 1% level (P=0.0074).

The model used to assess the impacts of the BRD on catch and bycatch rates assumes that there is no difference between the nets when they are both configured as standard nets (no BRD). Subsequently in order to analysis the data during the treatment phases the port net bycatch requires scaling prior to assessment. Scaling was calculated at 9.37% and during the treatment phase was always applied to the catch from the standard net[3].

[2] Note that the percentage difference in bycatch weight between standard port and starboard nets determined from the model (9.37%) varies slightly from the un-scaled data recorded in table 1 (8.95%). This is because the table utilises raw data.

[3] If the port net was standard during the treatment phase then the starboard net catch weight was scaled up by 9.37% to reflect the expected relative starboard catch, alternatively, if the starboard net was standard then the port net catch weight was scaled down by 9.37% to reflect the expected relative port catch weight.

b. Tiger Prawn Catches

Table 2 displays the tiger prawn catch weights of the port and starboard nets during the initial and final calibration phases. This comparison is visualised in Figure 6. Whilst there was natural variation in the net catch rates of tiger prawns within and between shots, overall the nets did not have significantly different catch rates. From table 2 it can be observed that the average difference in tiger prawn catch rates over both calibration phases equates to 0.46%.

Table 2: Shot-by-shot comparison of tiger prawn weight between the standard and port net during the initial and final calibration phases.

Shot No.	Tiger prawn catch for Port codend using no BRD (kg)	Tiger prawn catch for Port codend using no BRD (kg)	Difference in catch weight of port net relative to starboard (kg's)	% Difference in tiger prawn catch of port net relative to starboard
1	44	37	7	15.91
2	69	72	-3	-4.35
3	68	76	-8	-11.76
5	31	31	0	0.00
6	44	44	0	0.00
7	50	47	3	6.00
8	18	17	1	5.56
45	11.3	12.5	-1.2	-10.62
46	15	17	-2	-13.33
47	18.8	18.7	0.1	0.53
48	4	4	0	0.00
49	10	9.4	0.6	6.00
50	16	14	2	12.50
51	26	26	0	0.00
		Average % difference in tiger catch weight of port net relative to starboard		0.46

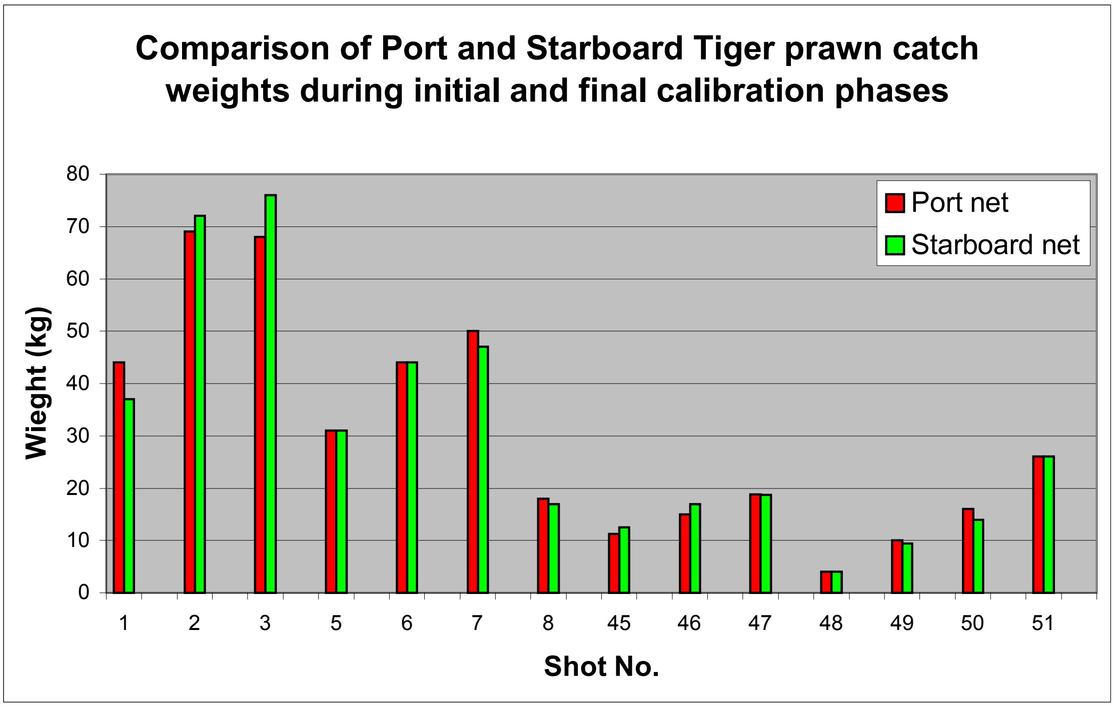

Figure 6: Shot-by-shot comparison of tiger prawn catch weights between port and starboard nets over the two calibration phases.

A Mixed Procedure (SAS) was used to analyse the two sets of calibration trawls separately. Assessing the interaction of catch rates per side over time indicated that there was no significant difference (P=0.6332, df=11). Consequently it was assumed that the tiger prawn catch rates of the port and starboard nets relative to each other did not change over the period of the project. The model also demonstrated that whilst the port net fished down 0.8%[4] in catch rate relative to the starboard net, this value was not significantly different to the nets fishing evenly (P=0.7411, df=12).

For the purposes of the treatment phases this implied that we could assume that the nets fished for tiger prawns with equal efficiency over the entire duration of the project. Subsequently any observed difference could be attributed to the single controlled variable over the project period, that is the presence/absence of the modified BRD.

2. *Effect of BRD*

a. Bycatch

There were two treatment phases with the BRD being rotated through first the starboard and then the port net (Figure 3). Twenty shots were recorded over six nights with the BRD in the starboard net, of these, four were flagged as unsuitable for analysis of bycatch weight. A further sixteen shots were observed over four nights with the BRD in the port

[4] Note that the percentage difference in tiger prawn catch weight between the standard port and starboard nets determined from the model (0.80%) varies slightly from the un-scaled data recorded in the table (0.46%). This is because the table utilises raw data.

net and the starboard configured as a standard net (Figure 4). During this treatment three shots were flagged as unsuitable for bycatch evaluation.

Figure 7 displays the shot by shot bycatch weight comparisons between BRD and standard nets after scaling of the port net due to the difference identified from the calibration phases. From this graph it can be visualised that the BRD reduces the bycatch weight during both treatment phases. On only one shot out of twenty-nine was the BRD net up in bycatch relative to the standard net after scaling of the data (Figure 7). Table 3 summarises the mean bycatch weights for the BRD and standard net over the duration of each treatment phase. Using the mean data only, the BRD is seen to reduce bycatch weight by 21.25% whilst in the starboard net and by 17.8% whilst in the port net (after scaling for differences observed in calibration phase).

Table 3: Summary of mean bycatch weight for BRD versus standard net over the two treatment phases of the project and the percentage reduction in bycatch rate attributed to the BRD after scaling the port net.

	Net				
	BRD		Standard		
Side	Mean Bycatch Weight (kg)	StDev (kg)	Mean Bycatch Weight (kg)	StDev (kg)	% reduction in bycatch weight associated with BRD (using scaled data)
Port			253.9	58.67	21.25
Stbd	218.6	48.67			
Port	136	60.36			17.8
Stbd			182.7	82.21	

Using this scaled data the model returns a reduction of 20.32% in bycatch for the BRD when assessed against a standard net. This reduction is statistically significant (P=0.0024, df=38) and remains consistent over both treatment phases of the project (P=0.7690, df=38). This implies that the BRDs effectiveness in excluding bycatch does not change when altered between the port and starboard nets.

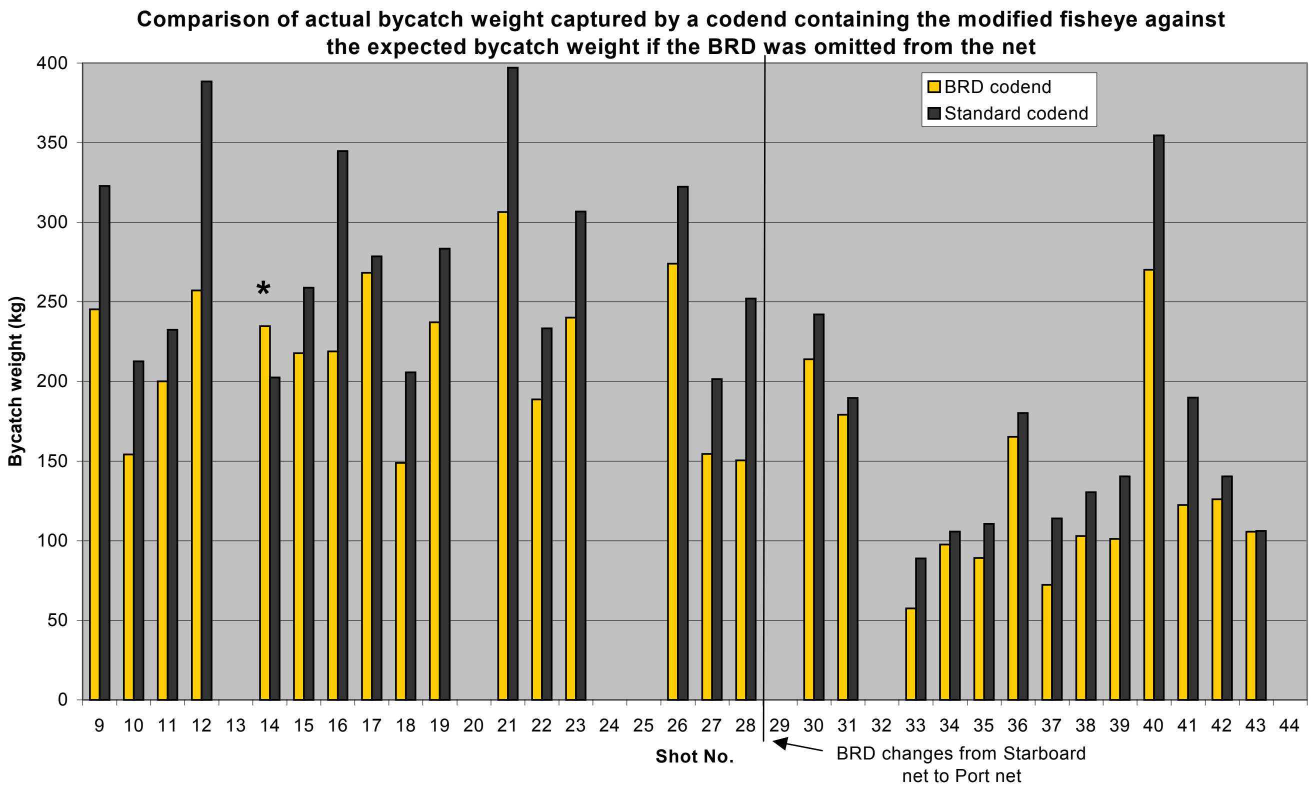

Figure 7: Shot-by-shot comparison of observed bycatch weights for a codend containing the modified BRD against its scaled expected catch when omitting the BRD. Note that the modified BRD changes from the starboard net to the port net after shot 28.

b. Tiger Prawn Catches

The model indicates that the BRD displays a reduction in tiger prawn catch of 0.87% when compared with the standard net. This reduction is not significantly different from the BRD showing no impact at all on the tiger prawn catch (P=0.2481, df=42). This lack of difference in tiger prawn catch between nets containing and omitting the BRD remained consistent over the period of the project (P=0.7288, df=42). Table 4 summarises the mean tiger prawn catch weights for the BRD and standard net over the duration of each treatment phase.

Table 4: Summary of mean tiger prawn catch weight for BRD versus standard net over the two treatment phases of the project and the percentage reduction in tiger catch rate attributed to the BRD after scaling the port net (these impacts were insignificant).

	Net				
	BRD		Standard		
Side	Mean tiger prawn catch weight (kg)	StDev (kg)	Mean tiger prawn catch weight (kg)	StDev (kg)	% reduction in tiger catch weight associated with BRD (using scaled data)
Port			18.74	12.93	5.12
Stbd	17.78	11.36			
Port	12.65	4.56			-0.88
Stbd			12.54	4.84	

DISCUSSION

1. Calibration Phase

a. Bycatch

A total of 13 shots were analysed for bycatch weight over the initial and final calibration period. During the calibration phase the bycatch catch trend indicated that the standard port net fished down in bycatch weight by an average of 9.37% (~27.9kg $shot^{-1}$) relative to the standard starboard net. A Mixed Procedure Analysis (SAS) indicated that the lower volume of bycatch captured by the port net remained consistent between the initial and final calibration phase (P=0.9277, df=11). This implies that for the purposes of this project it could be assumed that the two nets fished consistently relative to one another over the entire period of the project. Subsequently, to isolate the impact of the modified Fisheye during the treatment phase, the catch of the BRD net always had to be scaled relative to the standard net to account for the consistent catch variation between nets.

This is important as the model assumes that the random distribution of the bycatch on the sea floor is evened out in the catch of the nets due to the trawl behaviour which repeatedly runs back and forth over the same ground over the duration of a shot. Making this assumption, and given the close physical and structural dimensions of the two nets, the introduction of the BRD into one net enables assessment as the sole controlled variable responsible for changes in the catch rates.

b. Tiger Prawn Catch

Over the two calibration periods no significant difference was identified in the tiger prawn catch weights between the standard port and standard starboard nets. The model identified that the port net fished down by 0.8% (~40g $shot^{-1}$) relative to the starboard net and that this difference remained consistent between the initial and final calibration phases (P=0.7411, df=12). Essentially this small difference in catch weight (equivalent of an individual average size prawn) between the two nets can be attributed to the randomness of the prawn distribution on the grounds and natural variation. For the purposes of this project it could be assumed that the nets captured tiger prawns with equal efficiency relative to one another and that any changes in relative tiger catch during the treatment phase could be attributed to the introduction of the modified BRD as the sole introduced factor.

2. BRD Assessment

a. Bycatch

Twenty-nine shots were deemed unbiased and suitable for bycatch analysis during the assessment of the modified BRD against a standard net. Sixteen of these shots saw the BRD in the starboard net with the other 13 shots assessing the BRD whilst in the port net. Of the 29 shots the BRD net was up in bycatch weight only once relative to the standard net (Figure 7, shot # 14). For the remaining 28 shots the BRD net was down in bycatch weight relative to the standard net. This is suggestive of the BRD producing a consistent reduction in the volume of the bycatch retained in the codend.

The model indicated that the net containing the BRD reduced bycatch retained in the codend by 20.32% relative to a standard net. This averaged out to approximately a 41kg shot^{-1} reduction in bycatch over the duration of the treatment phase. This reduction is significantly different (P=00.24, df=38) and remained consistent regardless of which net the BRD was installed in. It can be concluded from this that introducing the modified BRD into a codend resulted in the exclusion of a significant volume of bycatch.

b. Tiger Prawn Catch

The model identified that the net containing a BRD had a reduced tiger prawn catch weight of 0.87% relative to the standard net. Over the treatment phase the average reduction in tiger prawn weight was 420g shot^{-1}. This reduction was not significantly different to the BRD showing no impact at all on the tiger prawn catch (P=0.2481, df=42). Thus it can be concluded that the introduction of the modified fisheye into the codend does not result in the loss of tiger prawns.

Further research into the performance of the modified fisheye should be funded to better understand the reasons for its effectiveness in excluding bycatch. The modifications made to the fisheye effectively halve the maximum width of the escape hole and hence, would be expected to reduce the effectiveness of the BRD in excluding the larger bycatch species, including small sharks and larger finfish species, relative to the unmodified fisheye. While the modified fisheye effectively excludes small bycatch species, it is unknown how it performs relative to the currently defined fisheye.

Additional research may enable a better comprehension of the factors that affect the performance of the BRD. Factors such as the position of the BRD in the codend relative to the drawstrings, choker lift and TED in addition to variable net specifications (headrope length, codend diameter and length) may alter the efficiency of the BRD in excluding bycatch. Furthermore, research into which species of bycatch are excluded and an enhanced understanding of the reason for exclusion will further assist in improving BRD performance.

CONCLUSION

To date operators have generally avoided the use of BRDs that are located in the codend aft of the TED. This is because of the concern over the potential for loss of prawn catch. From the results of this project it can be concluded that the modified fisheye utilised aboard the ‘Rosen C’ excluded significant volumes of bycatch without any associated loss in the catch of tiger prawns. This result that may assist industry in adopting BRDs that are positioned in the codend.

From the performance of the modified fisheye during the observer trials, the author would encourage the TED/BRD Subcommittee to recommend that NORMAC include the modified fisheye as an approved BRD design under the relevant Direction.

Further research into the performance of the modified fisheye should be funded to better understand the reasons for its effectiveness in excluding bycatch. The modifications made would be expected to reduce the effectiveness of the BRD in excluding the larger bycatch species, including small sharks & larger finfish species relative to the unmodified fisheye. It is important to note that the nets utilised in the current study are smaller than the majority used in the fishery (only 6 vessels out of 95 have smaller nets) and that fine tuning of the BRD in nets of different specifications/TED configurations would be required.

REFERENCES

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