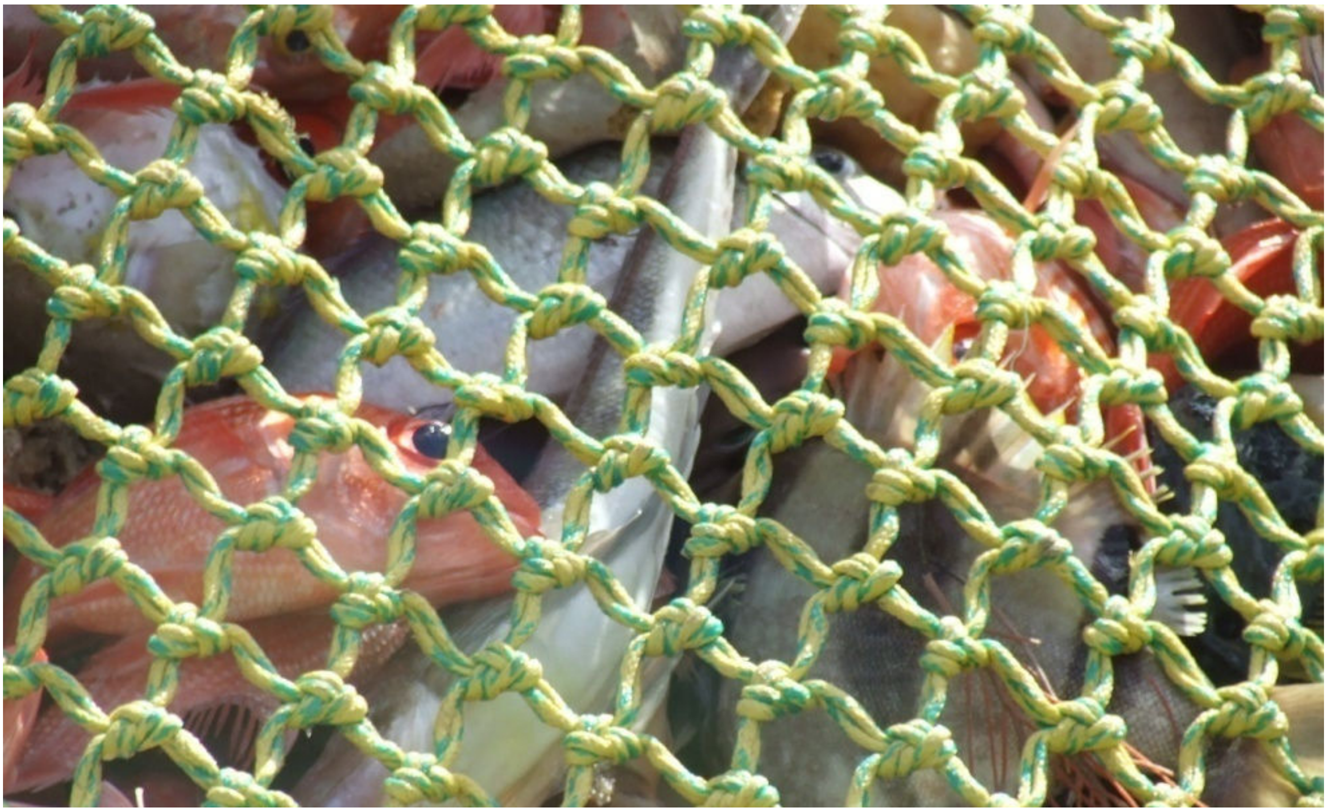
Trials of T-90 mesh configuration in the Great Australian Bight Trawl Fishery



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2008

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GABIA

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2007/063 Trials of T-90 mesh configuration in the Great Australian Bight Trawl Fishery

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Objectives

1. Run sea trials to compare catch composition of "standard" GABTF net design with the full T-90 net design
2. Obtain preliminary quantitative estimates comparing target species catch composition of each net design
3. Obtain preliminary quantitative estimates comparing bycatch species catch composition of each net design
4. Quantitatively compare and assess the towing efficiency of each net design
5. Qualitatively assess and compare differences in fish quality among net designs
6. Effectively convert the results into tangible benefits for the GABTF and AFMA's Bycatch Reduction Program

Non-technical Summary

OUTCOMES ACHIEVED

This trial has demonstrated that the use of T-90 nets may help to reduce unwanted incidental catches of small fish without undue loss of commercially valuable species. The reduction in discarded catch from the T-90 net was particularly large during day time shots. In addition, deepwater flathead caught in the T-90 net had slightly less damage than those caught in the control net. These results have been communicated to industry and management and further exploration of the costs and benefits of using T-90 nets during normal commercial fishing activities would be beneficial. Wider use of this net by industry would be a positive step towards meeting the fisheries obligations of reducing discarding in accordance with AFMA's *Program for Addressing Bycatch and Discarding in Commonwealth Fisheries – An Implementation Strategy*, but may have some financial cost. At least one vessel is continuing to use a T-90 net during normal commercial fishing operations.

The Great Australian Bight Trawl Fishery (GABTF) is a sub-fishery of the Southern and Eastern Scalefish and Shark Fishery (SESSF), managed by the Australian Fisheries Management Authority (AFMA). The fishery targets two main species on the outer continental shelf: deepwater flathead (*Neoplatycephalus conatus*) and Bight redfish (*Centroberyx gerrardi*), but catches many other byproduct and bycatch (discarded) species. As part of its Bycatch Action Plan, the Great Australian Bight Industry Association (GABIA) has been working with AFMA to reduce discarding in the fishery. GABIA wanted to trial a new "T-90" net to examine the potential to reduce bycatch, improve fish quality and maximise fuel efficiency, with the overall aim of increasing the profitability of fishing operations.

T-90 nets have been shown in international studies to improve both selectivity and towing efficiency. It is also suggested that T-90 nets have the added benefit of being "gentler" on the catch than standard nets because turbulence in the codend is reduced. GABIA had designed and purchased a purpose built T-90 net in order to conduct tests to determine if the benefits observed in other countries could be replicated in the Great Australian Bight, without compromising catch of target species. This report details the results of the T-90 net trial.

During 20th–29th January 2008, a sea trial was successfully undertaken to obtain quantitative estimates of catches (and discards) using a T-90 net and a standard "control" net. A total of 30 shots were undertaken during the trial, with shots alternating between T-90 and "control" nets during both day and night. The T-90 net caught significantly less incidental catch, particularly of high discard species such as sponge, barracouta, spikey dogfish, Australian burrfish, jack mackerel, rusty carpetshark and sergeant baker. Although this was seen as a positive result, there was also some degree of loss of commercial species. During night shots, the control net had higher catch rates of Bight redfish and deepwater flathead, while the T-90 net caught more deepwater flathead during the day. Overall, differences in catch rates of these two key commercial species were not significant.

No notable difference in length-frequencies of Bight redfish and deepwater flathead were observed between the control and T-90 net. Very few small deepwater flathead and Bight redfish are caught in GABTF, so any improved selectivity precluding the capture of small fish would have been difficult to detect. The T-90 net did catch significantly less small latchet, indicating that there may be better escapement of small, less commercially important fish species from the T-90 net.

Deepwater flathead caught by the T-90 net appeared to be in slightly better condition than those caught by the control net, supporting the theory that T-90 nets have less turbulence in the codend thus reducing scale and mucus loss. The condition of other species with small scales and heavy mucus would probably also be improved in the same manner. Reduced sorting time because of lower levels of incidental catch would also increase the quality of the catch of all species, regardless of their scale covering.

The benefits of increased fuel efficiency while towing the T-90 net were not realised. Fuel efficiency was measured by a flow meter, but was difficult to interpret because of influence of so many external factors such as current direction and strength. These were not taken into account in this study.

Overall, this preliminary trial revealed that selective use of T-90 nets in the GABTF may help to reduce unwanted incidental catches of small fish without undue loss of commercially valuable species. This was particularly evident during daytime shots. Potential loss of commercial catch may be offset to some extent by the improved quality of deepwater flathead. GABTF operators should consider wider uptake of T-90 nets in the fishery to reduce overall discard levels, but may require further trials and/or the ongoing use of T-90 nets during normal commercial fishing operations to provide a better understanding of potential financial costs and benefits of T-90 nets.

Keywords: Great Australian Bight Trawl Fishery, T-90 net, bycatch reduction,

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Background and Need

The Great Australian Bight Trawl Fishery (GABTF) ranges from Cape Leeuwin in Western Australia to Cape Jervis in South Australia, and out to the edge of the Australian Fishing Zone (Figure 1). It mainly operates over the outer continental shelf/upper slope region (120–250 m depth) targeting Bight redfish (*Centroberyx gerrardi*) and deepwater flathead (*Neoplatycephalus conatus*). There is also a sporadic upper slope fishery (300–750 m depth) mainly for western gemfish and blue grenadier, and a seasonal deepwater (greater than 750 m) fishery for orange roughy (*Hoplostethus atlanticus*), accessible only by scientific permit.

Trawl fisheries such as the GABTF are generally considered to be relatively non-selective and non-target species may represent a large component of the total catch. During 2000, the Australian Fisheries Management Authority (AFMA) and stakeholders developed a Bycatch Action Plan for the fishery. This Plan aimed to provide a strategic approach to reduce the impacts of fishing on bycatch species and the marine environment, ensure the ecological sustainability of the fishery, and to increase community awareness and industry support for the activities taken to address bycatch in the GABTF. An important component of the Plan was the initial collection of detailed information on the species composition of both the catch and bycatch. A pilot study was undertaken during 2000 (Knuckey and Brown 2002), which quantified and identified the nature of the GABTF bycatch, demonstrating that 40-55% (by weight) of the catch may be discarded (comprising over 300 species) from shots targeting deepwater flathead and Bight redfish (Knuckey and Brown 2002). The discarded catch was dominated by latchet, wide stingaree, draughtboard shark, southern frostfish, sponge, hard coral and small chinaman leatherjacket. The GABTF Integrated Scientific Monitoring Program (ISMP) is an onboard observer program that followed the pilot study and has been monitoring GABTF catches since 2001. Over this period, the annual quantity and composition of bycatch in the fishery have remained similar (Brown and Knuckey 2002; Brown and Talman, 2003; Talman *et al.* 2004; 2005; Koopman *et al.* 2006; 2007).

In December 2005, the Minister for Fisheries, Forestry and Conservation directed AFMA to cease overfishing, to recover overfished stocks, to avoid further species becoming overfished, and to manage the broader environmental impacts of fishing including protected species. AFMA has since released its *Program for Addressing Bycatch and Discarding in Commonwealth Fisheries – An Implementation Strategy*.

Recently, the Great Australian Bight Industry Association (GABIA) has been working with AFMA in trying to implement measures in line with this strategy to reduce bycatch and minimize discarding in the fishery. Part of this has been an investigation of the use of T-90 nets to reduce bycatch as outlined in this project.

T-90 net is traditional trawl mesh that has been turned 90 degrees. Originally this was done to stabilise the codend and improve the quality of the catch (Digre *et al.* 2006), but it had the added benefit of also allowing smaller fish to escape (Hansen 2006). T-90 nets have been used internationally, and while detailed results of gear trials are limited and the technological development of these nets is in its infancy, preliminary results have been promising. One member of the T-90 research and development team, Thorsteinn Benediktsson, now resides in Australia providing a unique opportunity to draw on his knowledge and experience and trial T-90 nets in the GABTF. GABIA acquired a T-90 net designed specifically for the GAB shelf fishery.

Although GAB catches of Bight redfish generally contain only mature fish, small numbers of unmarketable, immature deepwater flathead are sometimes caught (Brown and Sivakumaran, 2007). GABIA expected that T-90 nets would reduce the number of small deepwater flathead being caught, as well as reduce catches of small latchet and ocean leatherjacket, both of which constitute a significant proportion of GABTF bycatch. In addition, T-90 nets have been shown to greatly increase towing efficiency, saving fuel costs, use less material during construction, and may increase the quality of the landed catch (Moderhak, 2000). In essence, T-90 nets have the potential to reduce environmental impacts of the GABTF and increase efficiency and profitability at the same time.

Methods

Net Design

Two nets were used during the trial; a T-90 net (the T-90) that was constructed completely of T-90 material (Figure 2); and a typical GABTF net (the 'control net') (Figure 3). Construction of the T-90 net used 30% less material than the control net, however, was more expensive to construct. The T-90 net was trialled in a flume tank (Figure 4) prior to deployment and the following observations were made (Hugh McKenna, pers. Comm.); "the net fished evenly and there was no lay back whatsoever" and "ground contact was good but it could be lighter without interfering with the catch rate".

Survey Procedures

The T-90 net trial was conducted during 20th–29th January 2008 on the commercial fishing vessel *Explorer S*. Nets were changed after each shot, apart from on every fifth shot when the use of the net was repeated. This reduced potentially confounding diurnal effects.

Operational and environmental data were collected for each shot. These included direction of shot, speed of shot, direction of current, wind speed and direction, swell height, sea conditions, depth range of shot, and engine revs at the start middle and end of each shot. Fuel flow was measured using a FloScan Series 75000 Multifunction Fuel Monitoring System. All tows were conducted at as close to the same speed as practicable; to minimise introducing further variables, propeller pitch was set the same for each shot, with engine revs used to control speed.

When the shot was completed, the net was hauled onboard and the catch emptied on to the deck. Commercial species were gathered in fish bins and approximate weights of each species estimated. Discarded bycatch were identified to species where possible and an approximate weight of each species estimated. Length measurements were collected randomly during the survey for deepwater flathead, Bight redfish, knifejaw, latchet, ocean jacket and jackass morwong. Length measurements used are shown in Appendix 1.

Fish quality

To assess fish quality, approximately 10 deepwater flathead were randomly selected from the catch of several shots and given a rating from 0 (unacceptable condition, discarded) to 10 (quality excellent, no scales missing). Mean quality rating was calculated for fish from each net. The quality of Bight redfish was not examined because their robust structure means that they are generally not damaged during capture.

Data analysis

For describing results, *incidental catch* is defined as the catch of all species other than deepwater flathead and Bight redfish, *high discard species* are those for which greater than 50% discarding was observed during the 2000–2006 Integrated Scientific Monitoring Program (unpublished data) and *low discard species* are those for which less than 50% discarding was observed during the 2000–2006 Integrated Scientific Monitoring Program (unpublished data).

Because of the variability in shot duration, catch per hour (kg/hrs) was used to compare performance of the two nets; however, total catch (kg) and catch per shot (kg/shot) are also presented. Catch rates of Bight redfish were much greater during the night than during the day (Knuckey et al, 2008), so shots were classified as either day or night shots. Day shots are those that started between 06:00-18:00 hrs. All others are treated as night shots.

Catch rates were analysed using appropriate analysis of variance (ANOVA) with net and day/night as fixed factors. To satisfy the assumptions of normality (Shapiro-Wilk test) and heteroscedacity (Levene's test), catch rates were transformed to square-root (x+1).

Length-frequencies of Bight redfish, deepwater flathead, knifejaw, latchet, ocean jacket and jackass morwong from each net were plotted and compared using two-sample Kolmogorov-Smirnov tests (P=0.05).

Fuel consumption rates were calculated from total liters used per shot and shot duration. Mean fuel consumption rates observed during shots with each net were compared using a two-sample t-test after checking of normality (Shapiro-Wilk test) and heteroscedacity (Levene's test). Data from the first shot was omitted because it was the only shot that did not have the paravanes deployed, which may affect fuel consumption. Data from shot 17 was also omitted because of transcribing error.

Results and Discussion

With each net, seven shots were made during the day and eight shots were made during the night (Table 1). Mean tow speed was fairly constant ranging 3.16–3.25 kts, while shot duration ranged 5.08–5.47 hrs.

Total catch of the T-90 net was 17,111 kg compared to 24,452 kg by the control net (Table 2). The T-90 net caught less of each of the ten most commonly caught species during the survey (Figure 5). Particularly big differences in catches were observed for some high discard species such as sponge, barracouta and spikey dogfish (Table 2). Some low discard species such as ocean jacket and ornate angelshark were also caught in much smaller quantities by the T-90 net.

Total retained catch in the control net (11283 kg) was greater than in the T-90 net (9375 kg) (Table 3), however, the mean retained catch per shot was not significantly different between nets (Table 4 and Figure 6). Overall, mean retained night time catches were significantly higher than retained day time catches. Total discarded catch was highest in the control net

(13168 kg) than in the T-90 net (7737 kg) (Table 3). This difference was particularly large during day time shots. Mean discard catch per shot was significantly lower (Table 4 and Figure 7) in the T-90 net (516 kg/shot) compared to the control net (878 kg/shot) (Table 3).

As expected, significantly more Bight redfish were caught during the night than during the day (Table 5, Table 8, Figure 7). The mean night time catch rate of this species using the control net (68.93 kg/hrs) was higher that the T-90 net (50.79 kg/hrs), but this difference was not significant (Table 8). The standard deviation of the night-time catch rate using the control net (46.40 kg/hrs) was also much higher than the T-90 net (17.30 kg/hrs) because of two very large catches of Bight redfish using the control net. The difference in catch rates was not as large when data from day and night shots were combined (Table 5), being 39.02kg/hr for the control net and 29.82kg/hr for the T-90 net.

Day time catch rates of deepwater flathead were highest using the T-90 net (45.52 kg/hrs compared to 35.65 kg/hrs using the control net). Night time catch rates were highest using the control net (39.65 kg/hrs compared to 24.93 kg/hrs using the T-90 net) (Table 6, Figure 7). Contradictory results between day and night shots resulted in a significant interaction; however there were no overall significant differences in catch rates between T-90 and control nets or between day and night shots (Table 8).

Significantly lower catch rates of incidental catch species were observed in the T-90 net compared to the control net (Table 3, Table 8, Figure 7). Nearly all of this difference is attributable to day time shots when the T-90 net had a mean catch rate of 95.87 kg/hrs compared to 237.81 kg/hrs for the control net. Catch rates of incidental catch in night shots were nearly identical (224.72 kg/hrs for T-90 net and 227.36 kg/hrs for control net). Differences in comparisons of catch rates of incidental catch between day time and night time shots resulted in a significant interaction (Table 8).

The biggest differences in catches of individual incidental catch species between nets was of sponge and ocean jacket (Figure 5). The T-90 net caught much less of both species. The greater catch of ocean jacket by the control net was largely influenced by a single very large catch comprising 43% of total catch of that species by that net. It is unlikely that this was influenced by the net design, however excluding this large catch, the control net still caught 25% more ocean jacket than the T-90 net. Differences in catch of sponge is difficult to explain. Sponge that is retained in trawl nets generally ranges in size from that of a grapefruit to a basket ball so is unlikely to fit through the codend. The control net may have scraped the seabed harder than the T-90 net as it also caught more coral and sea stars.

The T-90 net also caught reduced volumes of other high-discard species, particularly barracouta, spikey dogfish, Australian burrfish, jack mackerel, rusty carpetshark and sergeant baker. The difference in catches of these species between nets was greatest during daytime shots. Reduced catches of these species (except Australian burrfish) by the T-90 net may have been caused by increased escapement through the larger opening of the mesh, aided by increased water flow.

Two-sample Kolmogorov-Smirnov tests comparing the length-frequencies of Bight redfish, deepwater flathead, and jackass morwong did not reveal significant differences in length-frequency samples between the T-90 and control nets (Figure 8). The control net caught significantly more small latchet (<26 cm) than the T-90 net. Significant differences were found for length-frequency samples of knifejaw and ocean jacket, however these are difficult to interpret as there are no obvious trend in length-frequency histograms. It was expected that the T-90 net would reduce catch of small deepwater flathead. While no deepwater flathead less than 33 cm were caught with the T-90 net, only three fish of that size were caught with the control net so it is impossible to tell if there was any influence of the nets used without more sampling. Brown and Sivakumaran (2007) found that maximum egg production occurs at a size of first capture of about 42 cm TL (4 yrs of age), which is higher than the size of first capture using the standard GABTF nets (30–35 cm TL, 2 yrs of age). No increase in size at first capture was observed by using the T-90 nets. It may be an important aspect of GABTF management to ensure that juvenile deepwater flathead remain relatively protected by the net's selectivity.

There was no significant difference ($t(24)=-0.38$, $p=0.707$) in fuel consumption rates between shots made with the two nets. Mean fuel consumption rates when using the control net and T-90 nets were 78.55 L/hr and 79.14 L/hr (Table 9). The capacity of full T-90 nets to reduce fuel consumption requires further study. Fuel efficiency is difficult to interpret because of influence of so many external factors such as current direction and strength. Although attempts were made to minimise the effects, these were not fully taken into account in this study. Increasing shot numbers and more closely monitoring and accounting for the range of variables that can impact on fuel consumption are highly recommended in any future trials.

Observations were made to compare the quality of catches made by each net. Deepwater flathead caught in the T-90 net (mean quality rating = 7.7) appeared to be in slightly better condition (retained more scales and slime) than those caught by the control net (mean quality rating = 7.1). There are a few reasons why T-90 nets might yield superior quality fish; 1) T-90 reportedly have less turbulence in the codend due to less water flow, reducing scale and mucus loss (Hansen, 2006); 2) reduced number of fish in the codend due to reduced unwanted catch during the tow, minimising damage; and 3) reduced incidental catch leads to less exposure on deck because of reduced sorting times. Although reduced sorting times would still be an advantage, no obvious quality differences were observed for Bight redfish. This is likely due to their heavy, more securely attached scales, which appear to protect them from damage during capture.

Reduced cost of net production was not realised, however T-90 nets do use 30% less material than standard nets. Continued trials of the T-90 net have proved it to be at least as durable as standard GABTF trawl nets.

Benefits and Adoption

The immediate benefits from this project are that GABTF operators have been shown the potential benefits of T-90 nets in reducing impacts of fishing on non-target species. As with other sectors of the SESSF, the GABTF are required to reduce bycatch and minimise discarding in accordance with AFMA's *Program for Addressing Bycatch and Discarding in Commonwealth Fisheries – An Implementation Strategy*. This trial has demonstrated by using the T-90 net, discarding can be significantly reduced, while not greatly affecting the catch of commercially important species. Mean discarded weight by the T-90 net was 516 kg per shot compared to 878 kg by the control net. This difference was even greater when only daytime shots are considered. Nevertheless, there is also some loss of commercial species which needs to be considered. Not enough small deepwater flathead and Bight redfish were caught during the trial to determine if the T-90 net reduced their catch, however the T-90 net did catch significantly less small latchet. A further benefit was an increase in quality of the fish landed by the T-90 net. An increase in fuel efficiency when towing the T-90 net was not found, possibly due to external factors that were not measured such as current direction and strength.

Results of this trial have been communicated to stakeholders including GABTF operators and AFMA management.

Further Development

Further trials would be required to determine the impact of using the T-90 on the catch of small deepwater flathead and Bight redfish, however, given the low frequency of capture of small deepwater flathead and Bight redfish by the fishery (Brown and Knuckey 2002; Brown and Talman, 2003; Talman *et al.* 2004; 2005; Koopman *et al.* 2006; 2007) such trials might not be justifiable. If such trials were required, historical observer data could be used to identify times when the capture of small fish is most likely to increase the probability of catching a large enough sample for analysis. Likewise, more data are required to fully quantify the loss of commercial catch and whether this can be somewhat offset by improved prices of the other retained catch; given the variability in market prices, this may be difficult. Also further work could also focus on a comparison of the fuel efficiency of the vessel when towing each net. Factors such as tow direction and the speed and direction of current need to be measured to properly measure differences in efficiency.

Planned Outcomes

Outputs of this project have the potential to achieve most planned outcomes including a reduction of the catch of non-target species, reducing overall environmental impact and presenting a more acceptable image in the trawl sector. Based on the results described in this report, if the T-90 net is adopted as an Industry standard net, significant reductions of incidental catch by the GABTF could be made, while at the same time adding value to the catch by increasing fish quality. Voluntary industry experimentation with the full T-90 net is continuing, and at least one vessel is regularly using the net as a part of standard fishing operations.

Conclusions

A sea trial was successfully undertaken to obtain quantitative estimates of catches using the full T-90 and control nets during 20th–29th January 2008. The T-90 net caught significantly less incidental catch, particularly of high discard species and some low discard species. Although this is seen as a positive result, there was also some degree of loss of the commercial species. During night shots, the control net had higher catch rates of Bight redfish and deepwater flathead than the T-90 net, while the T-90 net caught more deepwater flathead during the day. Overall however, differences in catch rates of these two species were not significant.

No difference in length-frequencies of Bight redfish and deepwater flathead were observed because as very few small deepwater flathead were caught. The T-90 net did catch significantly less small latchet, indicating that there may be better escapement of small, less commercially important fish species from the T-90 net. This would potentially reduce sorting times and improve the quality of the retained catch.

Overall, this preliminary trial revealed that there may be benefits in using T-90 nets to reduce unwanted incidental catch in the GABTF, thus reducing discarding. Potential loss in catch of commercial species would be minimised by only using the T-90 net during daytime shots; this is also when the greatest reduction of bycatch was observed. While increased fuel efficiency when towing the T-90 net was not found, the quality of deepwater flathead caught by that net was better than when caught by the control net. Voluntary industry experimentation with the full T-90 net is continuing.

Acknowledgments

We wish to thank the owner, Mr Semi Skoljarev, and the skipper and the crew of the Explorer S for their professional approach to conducting the field trials of the T-90 net. The work of Hugh McKenna of Neptune Trawls and Thorsteinn Benediktsson of Fisheries Supply in developing and building the T-90 net are gratefully acknowledged.

Intellectual Property

There is not intellectual property associated with this project.

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Table 1. Number of shots, mean (SD) shot speed (knots) and shot duration (hrs) of shots using each net configuration.

Night day	Net	Number of shots	Tow speed		Shot duration	
			Mean (knots)	SD	Mean (hrs)	SD
Day and night shots	T-90 net	15	3.23	0.07	5.14	0.86
	Control net	15	3.19	0.12	5.35	0.76
Day shots	T-90 net	7	3.25	0.08	5.08	0.53
	Control net	7	3.23	0.05	5.22	0.81
Night shots	T-90 net	8	3.22	0.04	5.20	1.10
	Control net	8	3.16	0.16	5.47	0.74

Table 2. Total catch (kg) of all species in each stratum and across all strata during the 2008 survey.

Species	Catch (kg)		
	T-90 net	Control net	Total
Alfonsino	9		9
Anchovy	30		30
Arrow squid	612.9	752.7	1365.6
Australian burrfish	97.7	387.7	485.4
Banded grubfish	0.05		0.05
Barracouta	362.9	875.3	1238.2
Bight redfish	2365	3155.7	5520.7
Bigscale rubyfish	2	51.9	53.9
Blackspot boarfish	125	87.3	212.3
Blackspotted gurnard perch	16	30	46
Blue morwong	316	214.5	530.5
Blue warehou	13	18.6	31.6
Bluefin leatherjacket	56.9	54.6	111.5
Common bellowsfish	0.64	2.08	2.72
Common sawshark	56.8	36.5	93.3
Common veilfin	16.2	16.6	32.8
Conger eel	27	35.3	62.3
Coral	65	244	309
Cucumberfishes	2.9		2.9
Cuttlefish	64	118.9	182.9
Deepwater bug	3.55	0.64	4.19
Deepwater flathead	2725.9	3001.4	5727.3
Deepwater stargazer	116.2	128.1	244.3
Elephantfish	5.5	3	8.5
Footballer sweep		16	16
Gemfish	32	12.9	44.9
Gummy shark	182.5	163	345.5
Hapuka	37	35	72
Hermit crab	1		1
Jack mackerel	93.9	887.4	981.3
Jackass morwong	530.7	278	808.7
John dory	14.5	4.1	18.6
King crab	6	3	9
Knifejaw	668	692.4	1360.4
Latchet	2326	2676	5002
Melbourne skate	206	62.4	268.4
Ocean jacket	1136.4	2514.8	3651.2
Ornate angelshark	980.5	1327.7	2308.2
Painted latchet	30.3	74.3	104.6
Pink ling		1.5	1.5
Port Jackson shark	61	101.8	162.8
Red cod	71	41.8	112.8
Red gurnard	84.2	267.94	352.14
Redbait	3	26.9	29.9
Ringed toadfish	109.9	171.9	281.8
Rusty carpetshark	9.9	157.5	167.4
Sandpaper fish	3.1		3.1
Sawtail catshark		5.3	5.3
School shark	5	1.8	6.8

Species	Catch (kg)		
	T-90 net	Control net	Total
Seastars	2.9	15.45	18.35
Sergeant baker	39.25	162.3	201.55
Silver dory	72.5	103.3	175.8
Silver trevally	24.8	6.5	31.3
Slender orange perch	0.7	3	3.7
Smooth stingray	220	92.5	312.5
Snapper	19	42	61
Southern eagle ray		218	218
Southern fiddler ray	151	121	272
Southern rock lobster	0.05		0.05
Southern round skate	8.2	13.4	21.6
Southern sawshark	115.9	200.8	316.7
Spikey dogfish	324.1	681	1005.1
Spiny boxfish	11.7	17.8	29.5
Spiny gurnard	99	40	139
Splendid perch	0.4		0.4
Sponge	1279.1	2610.844	3889.944
Spotted wobbegong		80	80
Swallowtail	405.1	633.6	1038.7
Tasmanian numbfish	3.8		3.8
Thetis fish	48.2	35.3	83.5
Tusk	39	59	98
Velvet leatherjacket	50.6	26.2	76.8
Whitebarred boxfish	55.4	69.2	124.6
Wide stingaree	302.4	306.9	609.3
Yelloweye redfish	65.7	65.4	131.1
Yellowspotted boarfish	90.5	110.2	200.7
Total	17111.3	24452.0	41563.3

Table 3. Total and mean (SD) retained and discarded catch per shot of all species using each net configuration in day and night shots.

Night/day	Net	Total retained catch (kg)	Mean retained weight		Total discarded catch (kg)	Mean discarded weight	
			Mean (kg/shot)	SD		Mean (kg/shot)	SD
Day and night shots	T-90 net	9374.8	625.0	270.4	7736.5	515.8	410.3
	Control net	11283.6	752.2	327.4	13168.4	877.9	500.6
Day shots	T-90 net	3381.3	483.0	299.7	1882.1	268.9	130.1
	Control net	3636.9	519.6	146.6	6575.6	939.4	580.1
Night shots	T-90 net	5993.5	749.2	177.5	5854.4	731.8	455.9
	Control net	7646.7	955.8	307.2	6592.7	824.1	453.5

Table 4. Summary of results of two-factor analysis of variance comparing mean total retained catch per shot and mean total discarded catch per shot by the T-90 net and the control net in day and night shots. Net and day/night were treated as fixed factors. Data were square-root transformed to stabilise variances. Significant differences are in italics.

	DF	MS	F	p
Retained catch				
Net	1	46.461	2.167	0.153
Day/night	1	367.212	17.128	*<0.001*
Interaction	1	7.405	0.345	0.562
Residual	26	21.440		
Discarded catch				
Net	1	379.727	5.479	*0.027*
Day/night	1	122.151	1.763	0.196
Interaction	1	252.260	3.640	0.068
Residual	26	69.308		

Table 5. Total catch, mean (SD) catch per shot and catch per hour trawled of Bight redfish using each net configuration in day and night shots.

Night/day	Net	Total catch	Catch per shot		Catch per hrs	
		(Kg)	Mean (kg/shot)	SD	Mean (kg/hrs)	SD
Day and night shots	T-90 net	2365	157.7	146.4	29.82	26.39
	Control net	3155.7	210.4	249.9	39.02	46.87
Day shots	T-90 net	200	28.6	19.9	5.86	4.41
	Control net	165	23.6	29.3	4.84	6.03
Night shots	T-90 net	2165	270.6	106.2	50.79	17.30
	Control net	2990.7	373.8	242.3	68.93	46.60

Table 6. Total catch, mean (SD) catch per shot and catch per hour trawled of deepwater flathead using each net configuration in day and night shots.

Night/day	Net	Total catch	Catch per shot		Catch per hrs	
		(Kg)	Mean (kg/shot)	SD	Mean (kg/hrs)	SD
Day and night shots	T-90 net	2725.9	181.7	86.5	34.54	15.30
	Control net	3001.4	200.1	72.3	37.78	13.41
Day shots	T-90 net	1640	234.3	83.8	45.52	13.72
	Control net	1310	187.1	62.9	35.65	10.72
Night shots	T-90 net	1085.9	135.7	61.3	24.93	8.98
	Control net	1691.4	211.4	82.2	39.65	15.90

Table 7. Total catch, mean (SD) catch per shot and catch per hour trawled of all other species combined (excluding deepwater flathead and Bight redfish) using each net configuration in day and night shots.

Night/day	Net	Total catch	Catch per shot		Catch per hrs	
		(Kg)	Mean (kg/shot)	SD	Mean (kg/hrs)	SD
Day and night shots	T-90 net	12020.4	801.4	448.1	164.59	117.68
	Control net	18294.9	1219.7	492.2	232.24	104.00
Day shots	T-90 net	3423.4	489.1	268.9	95.87	50.09
	Control net	8737.5	1248.2	547.0	237.81	98.14
Night shots	T-90 net	8597.0	1074.6	395.9	224.72	129.20
	Control net	9557.3	1194.7	475.9	227.36	115.40

Table 8. Summary of results of two-factor analysis of variance comparing catch per unit effort (kg/hr) of Bight redfish, deepwater flathead and all other species by the T-90 net and the control net in day and night shots. Net and day/night were treated as fixed factors. Data were square-root transformed to stabilise variances. Significant differences are in italics.

	DF	MS	F	p
Bight redfish				
Net	1	0.364	0.112	0.740
Day/night	1	228.770	70.603	*<0.001*
Interaction	1	3.723	1.149	0.294
Residual	26	3.240		
Deepwater flathead				
Net	1	0.699	0.564	0.460
Day/night	1	4.427	3.568	0.070
Interaction	1	7.627	6.147	*0.020*
Residual	26	1.241		
Other species				
Net	1	55.528	4.490	*0.044*
Day/night	1	40.744	3.295	0.081
Interaction	1	57.140	4.620	*0.041*
Residual	26	12.367		

Table 9. Mean (SD) fuel consumption rate and number of shots measured using each net and for both nets combined.

Net	Mean fuel consumption rate (L/hr)	StdDev of fuel efficiency (L/hr)	Number of shots measured
Control net	78.55	4.86	15
T-90 net	79.14	3.25	13
All shots	78.82	4.13	28

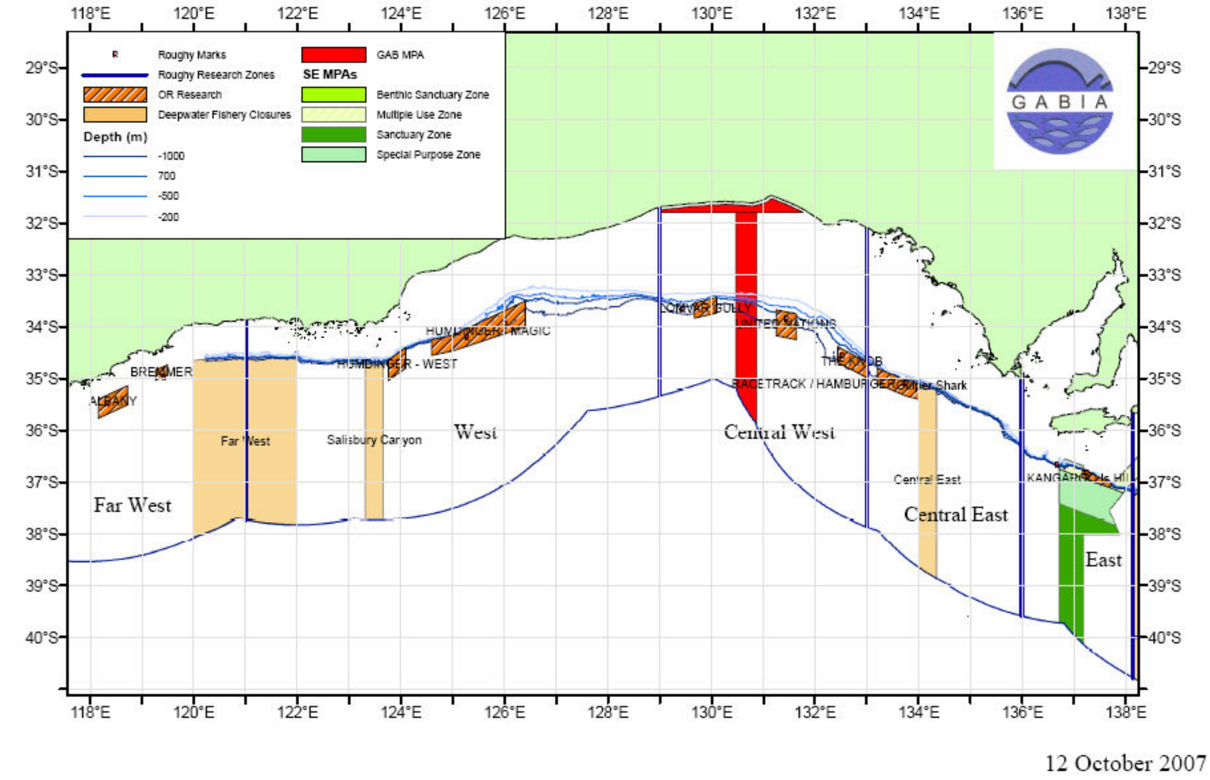


Figure 1. Diagram of the GABTF showing limits of the fishery and current fishery and Commonwealth marine protected areas.

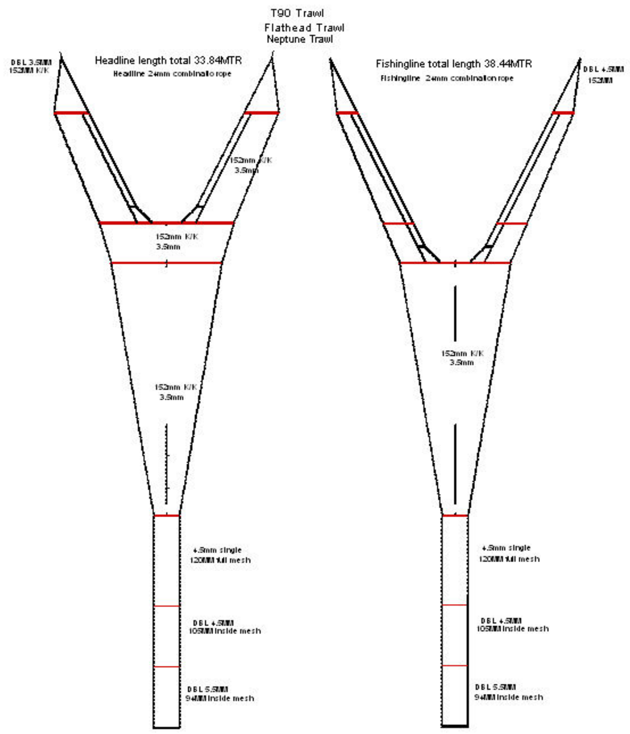


Figure 2. Specifications of design of the T-90 net trialled during this survey.

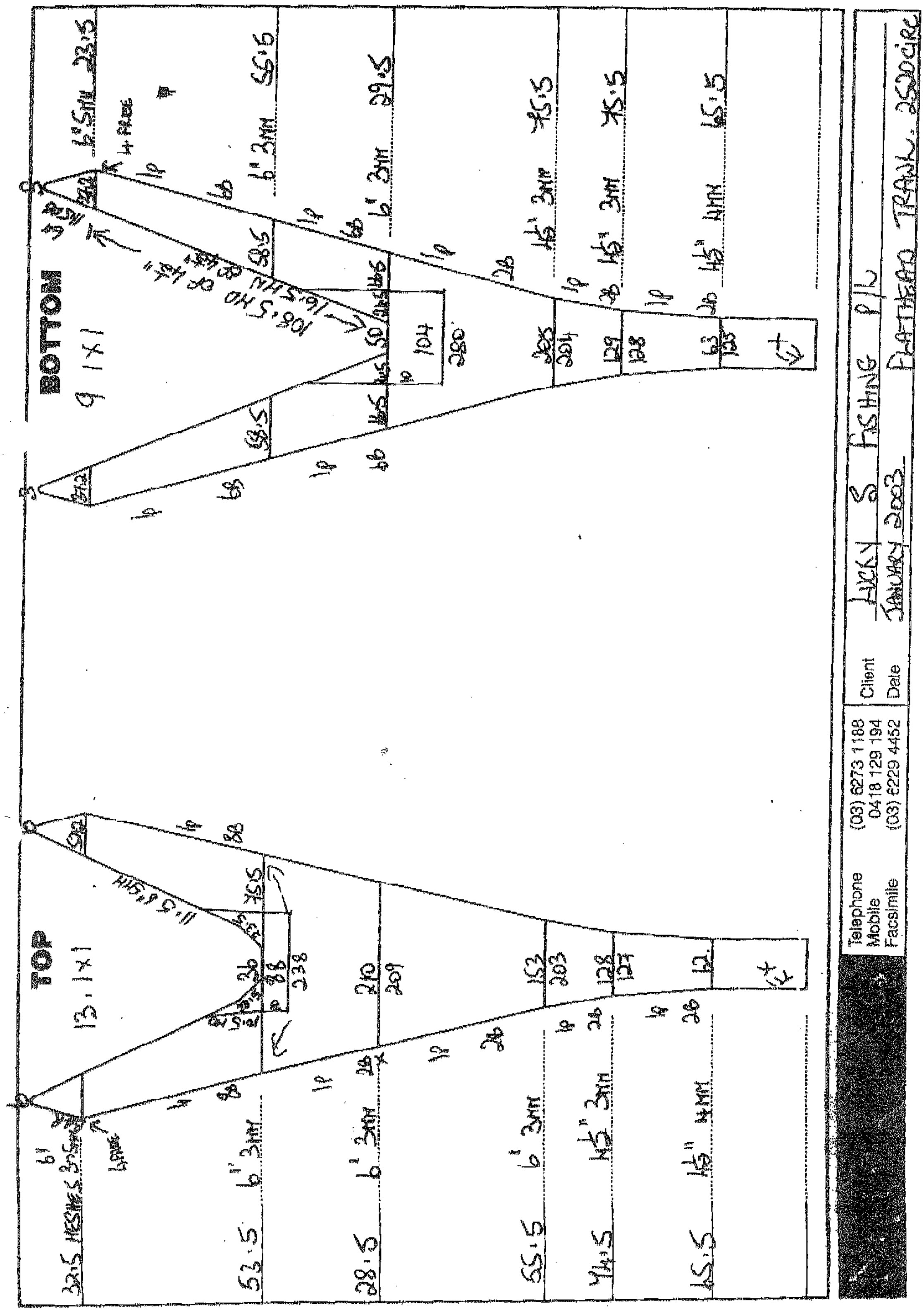


Figure 3. Specifications of design of the control net used during this survey.

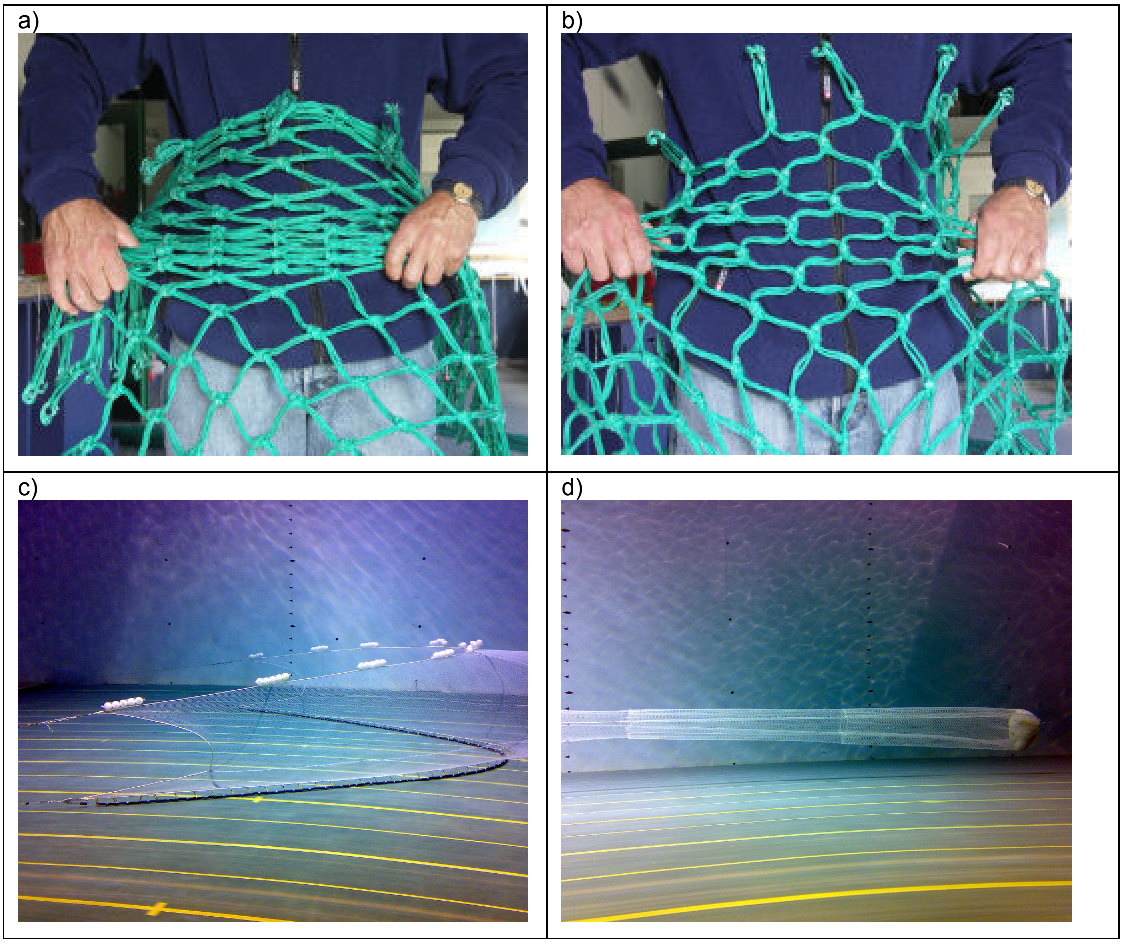


Figure 4 a) When the codend is stretched by the weight of the catch in a traditional net, the meshes close up compared to the meshes in the T-90. b) In T-90 net, the meshes are turned 90 degrees and remain open even when the net is stretched. c) The opening of the net during flume tank trials. d) The codend of the T-90 net during flume tank trials showing very little turbulence.
Photo credits a) and b): SINTEF Fisheries and Aquaculture; c) and d) Hugh McKenna.

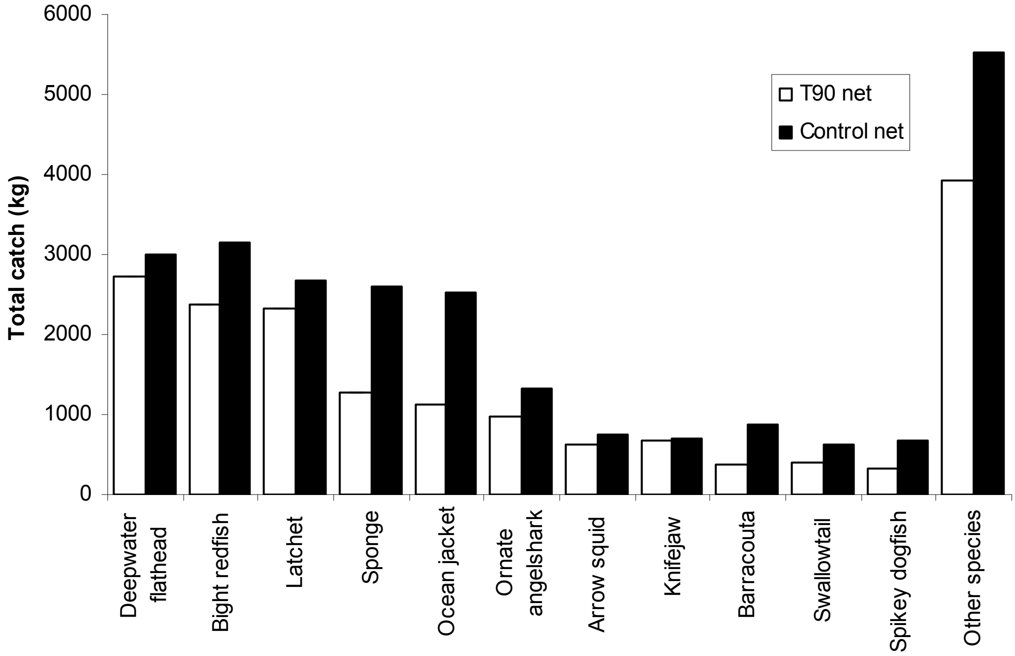


Figure 5. Comparison of catches (kg) of the top ten species caught using the T-90 net (open bars) and the control net (dark bars).

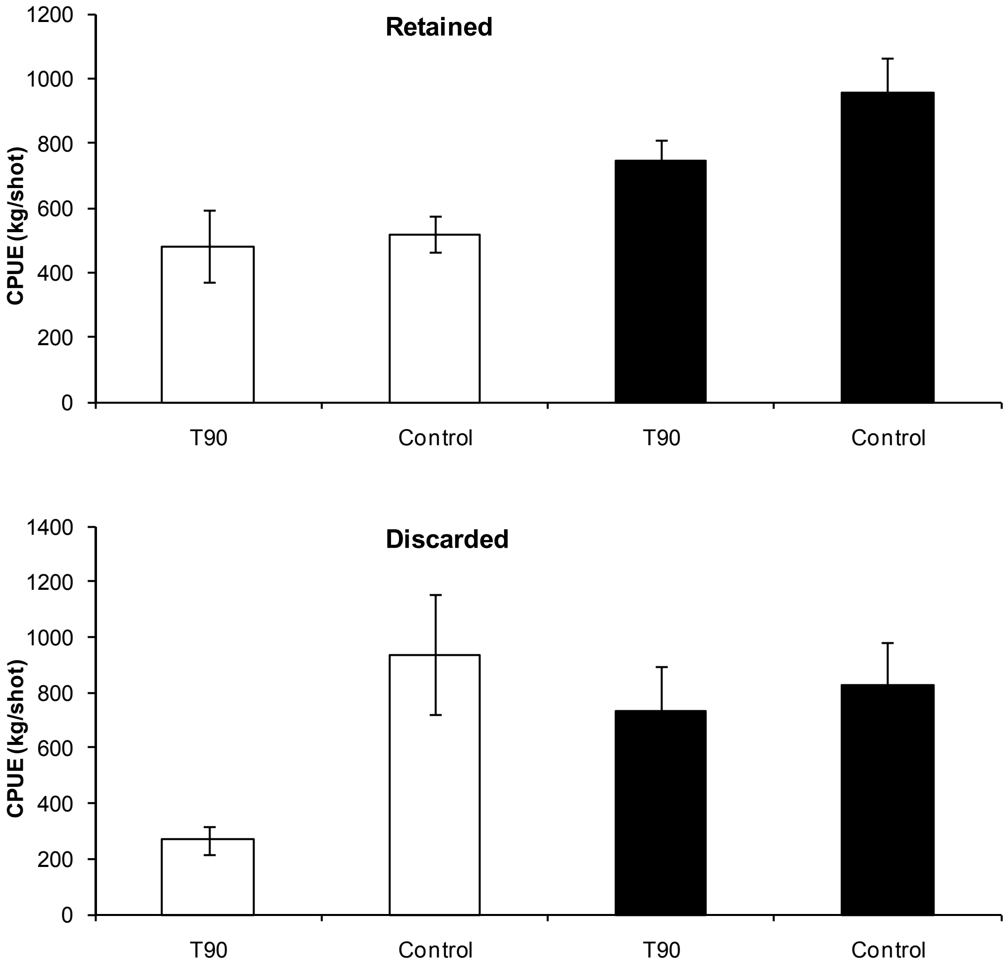


Figure 6. Difference in mean retained and discarded (±s.e.) catch per shot of all species caught by each net during day (open bars) and night (dark bars) shots.

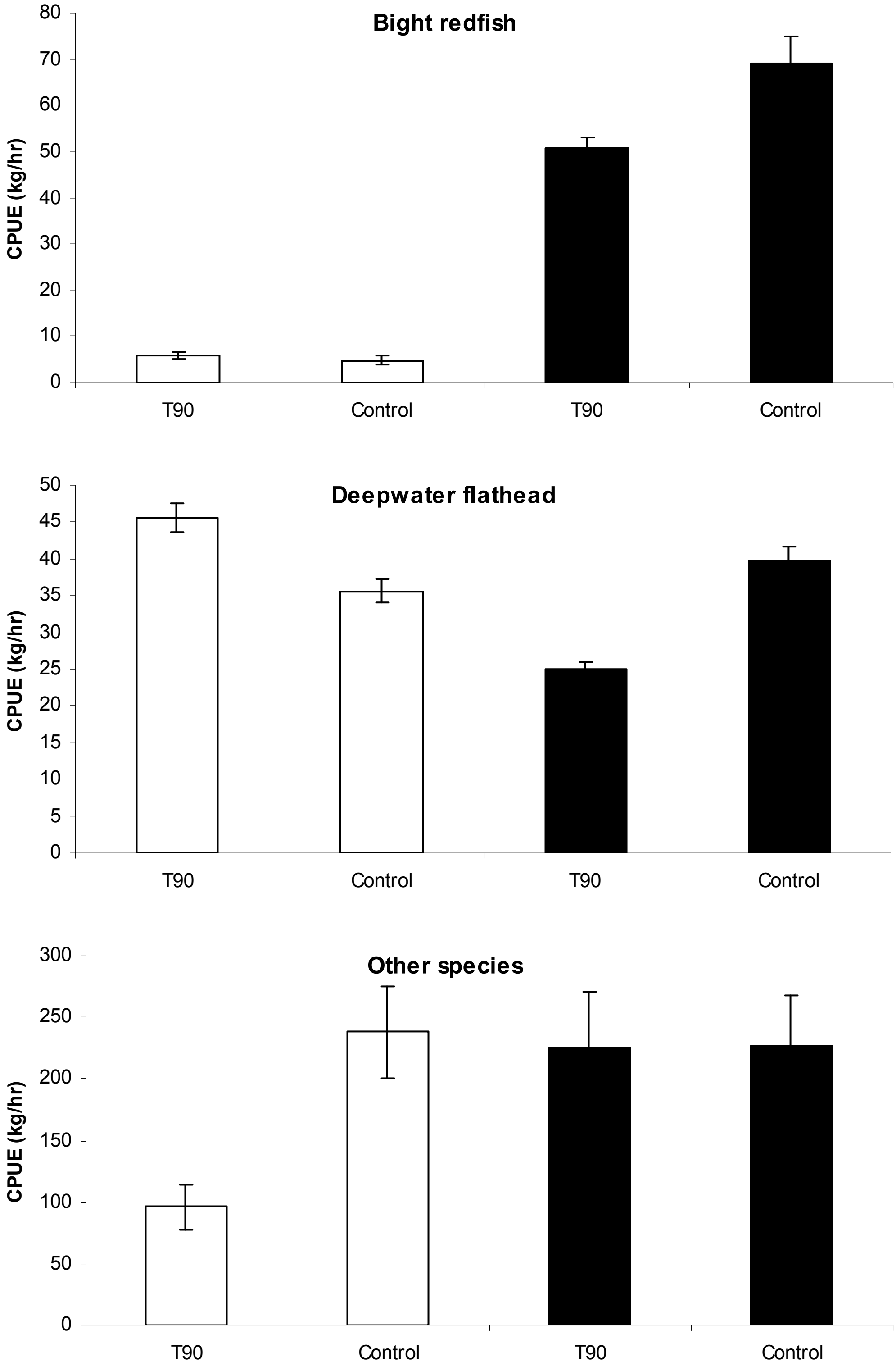


Figure 7. Difference in mean (±s.e.) catch per unit effort (kg/hr) of Bight redfish, deepwater flathead and all other species caught by each net during day (open bars) and night (dark bars) shots.

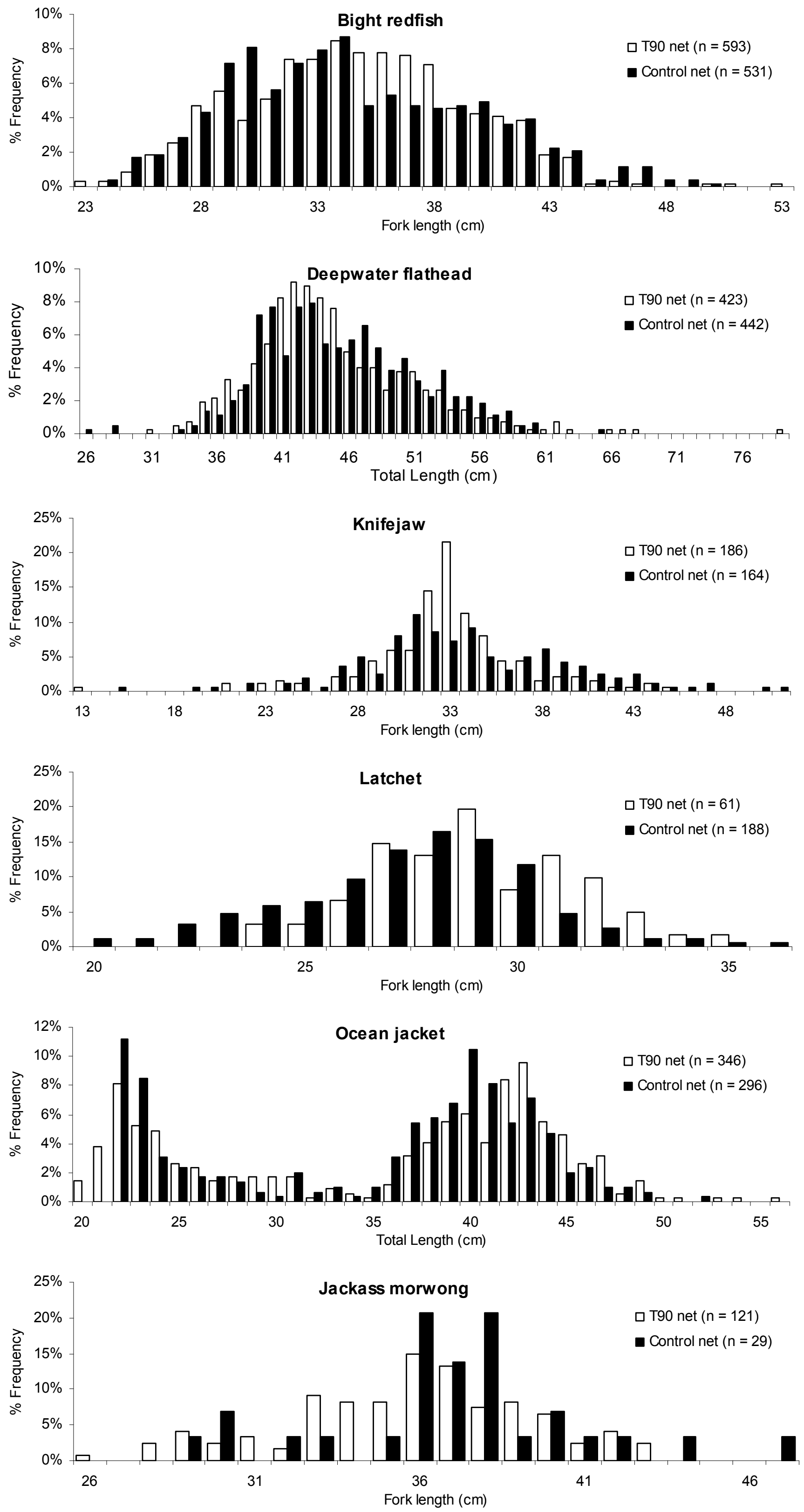


Figure 8. Length-frequency of Bight redfish, deepwater flathead, knifejaw, latchet, ocean jacket and jackass morwong by T-90 and control nets.

Appendix 1 - Species sampled

Table 10. Species sampled for length-frequency, number of fish measured and length measurement used.

Main retained species	Number of fish measured	Length code
Bight redfish	1124	LCF
Deepwater flathead	865	TOT
Knifejaw	350	TOT
Latchet	249	LCF
Ocean leatherjacket	642	TOT
Jackass morwong	150	LCF

Appendix 2 – T90 article

SINTEF

T90 – the gentle codend with many advantages

Preservation of Fish Quality - Netting turned 90°

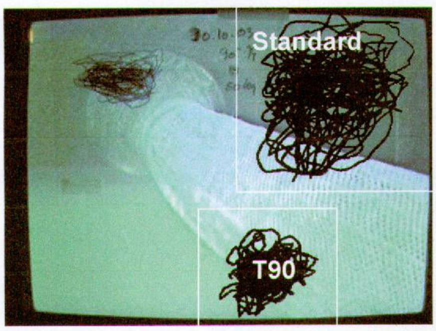
When it is not possible to solve the problems by fishing more, you got to sell the catch at a higher price. Better quality can get higher prices in the market. SINTEF has for some time been developing a new cod-end, which is better in preserving the quality of the fish. The solution is remarkably simple: Turn the netting 90° in the cod-end.

Background

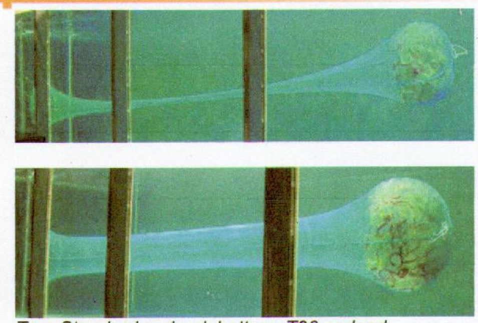
The background for the project was the fact, that fish caught in trawls too often are damaged by the cod-end. Scales and mucous are worn off, and in the filet you can find blood marks from bruises in the skin. Underwater video recordings of trawls in operation reveal the cause: There is much turbulence around the catch in the cod-end and it is waving from side to side. The fish therefore are washed around in the cod-end and rubbed against the netting.

The aim was to develop a cod-end, which had a large cross-section, in order to reduce the flow and hence the turbulence. At the same time the inner surface had to be made of more smooth material. Many different cod-ends were tested in the SINTEF Flume Tank at the North Sea Centre. They were made in a scale 1:2 and filled with a "catch" equal to 450 kg. The cross-section area was measured and the waving action was registered on a video screen with a picture of the net from the front.

The best results were with the cod-end with the netting turned 90°. The cross-section was 12 times larger and the swinging reduced dramatically in relation to the standard two-panel cod-end with two external seams.



Motion in water of Standard and T90 codends as seen with a front mounted camera



Top: Standard codend; bottom: T90 codend

Many advantages

Quite a few tests have been made in full scale at sea during 2003 and 2004 using T90 cod-ends in various fisheries. At this stage there are no quality measurements available. However, the impact on the catch is clear, and there a less shells and debris normally hampering the quality of the target catch.
It is also very interesting, that the T90 codend is reported to catch much more than standard codends. No doubt part of the reason for the positive effect of the catch is that there is an increased water flow from the belly of the trawl to the cod-end. Here it will pass out again through the open meshes all along the entire length of the cod-end. Therefore it can be expected that another bonus of using T90 netting is that the larger flow will pull more – and larger – fish to the cod-end.

The selectivity of the cod-end will inevitably be higher, letting more small fish escape the trawl. But it is worthwhile noticing that the escapees will also have a better quality, for them meaning a better condition and survival rate.

By measuring the breaking strength of the 90°-turned net, it was surprisingly found that it is slightly stronger than when used in the traditional direction, a magnitude of around 10%.

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Mike Gurner	AFMA	Field scientist
Matt Koopman	Fishwell Consulting	Analysis/reporting