MOVING TOWARDS MORE RESPONSIBLE FISHING PRACTICES IN AUSTRALIA'S NORTHERN PRAWN FISHERY

by

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Abstract

Bycatch in Australia's Northern Prawn Fishery (NPF) is extremely diverse in both species and size composition. This makes developing responsible fishing practices to reduce the amount of bycatch in the NPF, a complex process. During this study we assessed the performance of Bycatch Reduction Devices (BRDs) that could be used in the NPF. We tested 16 different BRDs which can be grouped into one of 3 categories: (1) inclined grids (2) fish exclusion devices and (3) square-mesh codends. Four inclined grids were tested during our study. All the grids were extremely effective at excluding large animals such as sharks, stingrays and sea turtles. Three different fish exclusion devices were tested. Fish exclusion ranged between 0 and 39 percent, depending on the device. Prawn retention rates for both inclined grids and fish exclusion devices varied between devices. Two sizes of square-mesh codend (38 mm and 45 mm) were also tested. More than 95% of market-sized prawns were retained. Fish exclusion varied greatly between species. Optimum exclusion of bycatch for the NPF could be provided by a combination of devices from each of the three categories.

1. INTRODUCTION

The Northern Prawn Fishery (NPF) is the most valuable trawl fishery in Australia with an annual production of prawns between 8 000 and 10 000 tonnes and yearly exports earning between A$100 and A$200 million (Pownall, 1994).

It is estimated that over 30 000 tonnes of bycatch is discarded from the NPF each year (Ramm *et al.*, 1990; Pender *et al.*, 1992). The bycatch of the NPF consists mainly of small fish of at least 250 species.

Fisheries in Australia are managed under the principles of ecologically sustainable development (ESD) and therefore minimising the discarding of bycatch is now a high priority. Funding to assess devices that will reduce bycatch was provided by the fishing industry through their representatives' the Fisheries Research and Development Council and the Australian Government. In 1993, a collaborative research effort between the Australian Maritime College (AMC), the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Northern Territory Department of Industry and Fisheries (NTDPIF) began to assess a number of devices to reduce bycatch.

The selection of BRDs to be tested was based on information from three sources: (1) discussions with international experts during visits to seven major centres of bycatch reduction research around the world; (2) reviews of existing literature and (3) interviews with fishers from the NPF (Rawlinson and Brewer, 1995).

The performance of each BRD was assessed by several criteria: the capability to catch about the same numbers of commercial prawns as the standard trawl gear used in the NPF; the capability to catch less bycatch than the standard trawl gear; and ability to be used safely under commercial fishing conditions.

The types of BRDs to be tested fell into three broad categories: inclined grids for excluding large animals such as turtles, rays, sharks etc; fish exclusion devices which were designed to exclude fish on the principle that fish and prawns exhibit behavioural differences within the trawl; and square-mesh codends to exclude small fish based on size selection.

Four inclined grids (Super Shooter, Nordmøre grid, AusTED and NAFTED), three types of fish exclusion devices (fisheyes, square-mesh windows (four different variations) and a radial escape section (RES)) and two sizes of square-mesh codends (38 mm and 45 mm) were tested during our study. Inclined grids and fish exclusion devices were also used in combination.

This paper summarises the test procedures used to assess the performance of BRDs and the results that were obtained from three scientific cruises and trials onboard a commercial trawler in the NPF.

2. MATERIALS AND METHODS

BRDs

2.1 Inclined grids

2.1.1 The Super Shooter

The Super Shooter is an oval-shaped inclined aluminium grid originally designed to exclude turtles in the Gulf of Mexico shrimp fishery. The grid is secured to the trawl at an angle of 45 degrees and bar spacing is typically 100mm (4"). A funnel of netting guides all animals to the top of the grid. Large animals are then guided by the grid towards an escape opening in the bottom of the codend while prawns and other small animals pass through the grid and enter the codend. A flap of buoyant polyethylene netting over the escape opening minimises prawn loss. During initial trials this BRD was tested with a hummer bar and additional escape openings located behind the grid. A hummer bar is an aluminium hoop containing several tightly strung thin steel wires positioned vertically in the codend. It is designed to vibrate or 'hum' as it moves through the water, stimulating fish to swim through the escape openings located on either side of the codend. The Super Shooter was tested in combination with a fisheye (Fig. 1) and in combination with a square-mesh window.

2.1.2 The Nordmøre grid

The Nordmøre grid was originally designed in Norway to exclude fish from shrimp trawls. This BRD features a rectangular aluminium grid and during NPF tests was secured to the trawl at 35 degrees from the horizontal. Bar spacing was 100mm (4"). In contrast to the Super Shooter, a panel of netting guides all animals to the bottom of the grid, and large animals are then guided by the grid towards an escape opening in the top of the codend. Prawns and other small animals pass through the grid and enter the codend. This BRD was also tested in two combinations. Firstly, with a fisheye located behind the grid and secondly, with a square-mesh window of 150mm (6") meshes, measuring 8 bars lengths wide by 13 bar lengths long. The square-mesh window was also located behind the grid (Fig. 2).

2.1.3 The NAFTED

This BRD is an adaptation of the Nordmøre grid and features a grid designed to improve the exclusion rate of sponges and other debris from the trawl (Fig. 3). Underwater video of the Nordmøre grid showed that the exclusion of sponges is sometimes hampered by the horizontal bar at the top of the grid. This can block the passage of prawns into the codend, resulting in prawn loss through the escape opening. The bars of the NAFTED are bent back near the escape opening to overcome this problem. A flap of netting was located over the escape opening to prevent prawn loss. This BRD was used only during tests on a commercial trawler.

2.1.4 The AusTED

The AusTED is a flexible grid of wire encased in plastic and was designed by researchers at the Northern Territory Department of Primary Industry and Fisheries and the Queensland Department of Primary Industries. The grid was secured to the trawl at approximately 70 degrees from the horizontal and guides large animals through an escape opening in the top of the codend (Fig. 4). Bar spacing was 110mm (4 1/3"). An opening in the top of the codend ahead of the grid was used to reduce fish bycatch and a funnel of netting behind the grid prevents the catch from being flushed through the escape opening during haulback.

2.2 Fish exclusion devices

2.2.1 Square-mesh window

This BRD is simply a panel of 150mm (6") polyethylene meshes orientated so they remain square and open during the tow. This allows fish to swim through the meshes and escape. The square-mesh window measured 8 bars lengths wide by 13 bar lengths long. Three variations of this BRD were tested, one with a hummer bar placed five meshes behind the window, another with a 1.5m long black canvas cylinder inside the codend and placed behind the window, and a third with the window constructed from 150mm square-mesh netting that glowed in the dark. The black cylinder and hummer bar were designed to stimulate fish to swim forward and through the square-meshes. The glow netting was presumed to help the fish orientate visually to the meshes and escape.

During tests on a commercial trawler, this window was reduced to 6 bar lengths wide by 6 bar lengths long and a mesh size of 100mm (4"), and was used in combination with the Super Shooter.

2.2.2 The Radial Escape Section

The Radial Escape Section (RES) was developed in the U.S.A. to reduce the capture of fish bycatch. A funnel of netting is used to guide the catch past a panel of square-meshes. As fish exit the funnel some swim forward and through large 230mm (9") square-mesh openings extending radially around the codend (Fig. 5). Prawns cannot swim forward through the square-meshes and passively enter the codend. A flexible wire hoop extends around the circumference of the codend to help the RES maintain shape.

2.2.3 The Fisheye

The fisheye is an elliptical steel frame measuring 380mm wide by 220mm high. It is designed to provide an elliptical or 'eye shaped' rigid escape opening in the codend through which fish swim. The poor swimming ability of prawns and location of the fisheye in the top of the codend reduces their chances of escape.

2.3 Square-mesh codends

Square-mesh codends are designed to allow bycatch smaller than the prawns to escape from the trawl. In square-mesh construction, the twines run along and across the net, rather than diagonally as in the case of the more traditional diamond-mesh. The two sets of twines in square-mesh netting are always at right angles to one another, maintaining the open square shape of the meshes (MacLennan, 1992). Square-mesh can be used enhance the selectivity of a trawl codend (Robertson and Stewart, 1988).

We tested two sizes of square-mesh codend, a 45mm mesh and a 38mm mesh. The square-mesh codends were constructed from knotless braided polyamide.

2.3.1 Standard codend

The standard diamond-mesh codend, measuring 150 x 150 meshes, used in our tests was constructed from 44.5 mm knotted polyethylene mesh. This construction duplicated the codend used in the NPF.

2.3.2 Test procedures

All BRDs were initially tested in the flume tank at the Australian Maritime College to ensure they were rigged correctly. Each device was tested during three scientific cruises of one month duration made on the MRV *Southern Surveyor* on commercial fishing grounds near Albatross Bay, Gulf of Carpentaria (Fig. 6) The final stage was to test how the 'most promising' devices performed under commercial conditions. These trials took place on an NPF trawler, the FV *Petanné*, on the commercial fishing grounds south west of Weipa, Gulf of Carpentaria (Fig. 6).

The BRDs were tested using a dual-rig prawn trawl arrangement. The trawls were identical Florida Flyers each with a headline length of 25.6m (14 fathoms) and spread by No. 9 Bison boards and a sled. Trawl mesh size of was 57mm (2 1/4") and codend (diamond) mesh size was 45mm (1 3/4"). All codends were divided into 50 mesh long sections. All BRDs except the Super Shooter and Nordmøre grids were placed in the middle section which allowed the lifting strops to remain in a position consistent with industry practice. The Super Shooter and Nordmøre grid were placed in the first 50 mesh section to prevent blockage of the escape openings by the lifting strops. During the first scientific cruise tow duration was 30 minutes in order to maximise the number of trawls. During the second scientific cruise only the best performing devices were tested and tow duration was 120 minutes to more closely relate to commercial operations. Trawls were made at depths between 18 and 25 m.

A balanced semi-systematic incomplete blocks design was used to compare the performance of each BRD and the standard trawl. We decided to treat each trawl as a 'block' with 2 'units' (Cochran and Cox, 1957; Snedecor and Cochran, 1980) and allocate pairs of devices in such a way that all possible combinations were tested. To allow for any systematic difference in catch between the port and starboard nets, we attempted to balance the number of times that any particular device was attached to a given (port or starboard) net. Furthermore, we needed to minimise the time required to change devices on the trawls, and therefore the time between trawls. We therefore designed a sequence of trawls that required only one change of device between trawls, alternating between nets for consecutive trawls. This meant that a given device would be present on one particular net for two consecutive trawls. For repeat sequences, randomisation was necessary. This was achieved by re-allocating the devices to different treatment codes. Analysis of variance was used to analyse the catch data from the scientific trials.

The paired comparisons between the standard (45 mm) diamond-mesh and the square-mesh codends were carried out using the same dual-rig arrangement. The fish passing through the codends were collected in a codend cover constructed of 16 mm diamond netting. Each tow was of 30 minutes duration. The square-mesh codend were used in one of the pair of trawls towed; the other having the standard codend. The codend constructed of square-mesh was switched between the port and starboard nets each night. Differences in catching performance were measured by comparing the mean catch from the trawls with the square-mesh with the mean catch from only the corresponding trawls with standard net. In this way variation due to other factors were minimised.

2.3.3 Data collection

Scientific trials

The catch-sampling procedure during scientific trials involved weighing the entire catch, removing all large animals (greater than about 5 kg), and removing all commercially important prawns if the catch was greater than about 50 kg. A subsample of the remaining catch was taken and processed. Each large animal was identified to species, weighed and measured (standard length [SL] for fish, total length [TL] for sharks and sea snakes, disc width for stingrays and carapace length for sea turtles). The remaining catch (or the subsample) was sorted and identified into species. Each species was counted and weighed, and individual animals measured (as described above). Commercially important prawns were sorted and identified to species. Each species was counted and weighed. A subsample of each species (n = about 50) was measured (carapace length [CL]).

The species composition of the catch was determined by multiplying up the weights and numbers of each species in the subsample by the appropriate factor to estimate their total proportion in the catch.

Differences in the catching performance of the codend designs were measured by comparing catches of animals retained by each codend with those from the standard prawn trawl. Separate comparisons were made for commercially important prawns, small fish bycatch, large animals (>5 kg) and sea snakes. Animals greater than 5 kg (usually stingrays, sharks and sea turtles) warranted a separate category because these animals – known as monsters – are large enough to cause considerable damage to prawns, decreasing their value.

Commercial trials

During trials on the FV *Petanné* , the total catch of commercially important prawns was counted and weighed, but accurate data on the amount of small fish bycatch was not obtained due to time constraints. Stingrays, sharks and sea turtles were identified, counted, weighed and measured in the same way as in the scientific trials.

Separate comparisons were made for mean weights of commercially important prawns, and total numbers of stingrays (greater than 5 kgs), sharks (greater than 5 kgs) and sea turtles.

To measure the effect of bycatch reduction on prawn damage, a sub-sample of 50 tiger prawns was collected from both codends in every shot and examined for external damage.

3. RESULTS

3.1 Scientific trials

Results of the performance of each BRD during the scientific trials are detailed in Table 1.

All three inclined grids (Super Shooter, Nordmøre grid and AusTED) effectively excluded large animals such as turtles, sharks and stingrays. Exclusion rates of these animals approached 100 percent. Fish bycatch exclusion varied between 0 and 39 percent when used in combination with other BRDs such as a fisheye or square-mesh window.

The ability of these BRDs to catch prawns also varied. The Super Shooter showed the best prawn retention, only losing between 2 and 12 percent of the prawns. The higher rates of loss were associated either with early trials or use of the Super Shooter when the weather was rough. The Super Shooter performed well in areas where the upward inclined grids (Nordmøre grid and AusTED) clogged with sponges and other debris.

The fisheye reduced fish catch by 11 percent but prawn catches varied between a 30 percent loss (due to bad weather) and a 22 percent gain. The position of this device was found to be very important and these results are likely to improve with further trials. The RES only excluded up to 8 percent of fish, and prawn catches varied between a 43 percent loss (bad weather) and a 5 percent gain. Video footage suggests that the RES is effective in excluding strong swimming fish, but not small fish with poor swimming ability. The square-mesh window was used alone, with fish stimulators to encourage escapement, or in combination with the Nordmøre grid. Fish loss varied between 3 and 39 percent. Prawn loss varied between 8 and 14 percent in good weather and up to 49 percent in very poor weather.

Thirty three paired trawls were made with the 38 mm square-mesh codend and forty one for the 45 mm square-mesh codend. Results showed that the amount of reduction in bycatch varied greatly between species. For example, whiting (*Sillago sihama*) an important component of the bycatch, were able to escape easily through the square-mesh and were reduced by 67% (in numbers) through the larger mesh and 51% through the smaller square-mesh. Some species were unable to escape from the square-mesh. The retention of market-sized prawns was 99.6 percent for the 38 mm and 96.9 percent for the 45 mm square-mesh codends.

3.2 Commercial trials

Results of the performance of each BRD during the commercial trials are detailed in Table 2.

The final phase of this project included commercial testing of the Super Shooter, the Super Shooter and square-mesh window combination and the NAFTED. Tests were performed onboard the FV *Petanné*. Each BRD was compared against a standard trawl in a twin rig arrangement and alternated between port and starboard sides each night. Tow duration, direction and trawl location was left to the skippers' discretion to ensure that testing of these devices occurred under normal commercial conditions. Tow duration was generally between 120 and 180 minutes.

The Super Shooter caught 3 percent more prawns than the standard codend while the NAFTED lost 3 percent (Table 2). Testing of the NAFTED was limited to seven tows due to clogging by large rocks and sponges. Large numbers of stingrays and sharks were caught by the standard codend and both the Super Shooter and NAFTED successfully excluded these animals.

The combined results for all BRDs yielded a 23 percent reduction in damage to prawns compared to the catch from the standard codend.

3.3 Handling and safety of BRDs

Handling of BRDs onboard the FV *Petanné* posed few problems to the crew. However, careful checking of the codend prior to shooting away was required to ensure it was not twisted.

The grids were attached to the codend ahead of the lifting strops (or haul ropes). In this position the grids remained out-board during hauling and emptying of the catch, and posed no safety hazard to the crew.

4. DISCUSSION

Reduction in bycatch in the NPF can be achieved by modifications to the trawls that are currently used. Gear modifications, such as BRDs, offer the prospect of reducing the magnitude and mortality of bycatch while maintaining the flexibility of fishing operations and acceptable catches of target species and size categories (Suuronen, 1995).

The Super Shooter performed extremely well during our tests and would meet the performance criteria of maintaining prawn catches while reducing bycatch. This particular inclined grid was very effective for excluding large animals and can be easily and safely used under most fishing conditions. However, the Super Shooter is not designed to exclude small fish and this would have to be achieved by including a fish exclusion device in the net. Both the fisheye and the square-mesh window showed potential for excluding bycatch without loss of prawns. It has only been possible, during these trials, to test a few different configurations of these general designs. However size and shape changes as well as positional changes within the codend may improve their performance.

The performance of the specialist fish excluders (fisheye, square-mesh windows and RES) varied between devices, their position in the codend, weather and haulback delay. Much higher levels of fish and prawn loss were measured during the second cruise when poor weather was experienced for two weeks. Haulback delays during this cruise also seemed to cause extra fish and prawn loss for most fish excluder devices. Prawn loss in poor weather may be due to the surging of the catch in the codend, particularly at the surface.

Codends constructed of square-mesh were extremely successful at reducing certain species in the bycatch and may provide an effective option for excluding the component of the fish bycatch that can not be excluded using either inclined grids or the fish exclusion devices.

Due to the diverse composition of the bycatch in the NPF, one single BRD will not be able to reduce all species in the bycatch in the NPF. However a combination of different BRDs may optimise the amount of bycatch that can be excluded from the trawls.

The adoption of BRDs into the NPF will be an important step for the fishing industry. The AMC and state fisheries departments are actively involved in a program to introduce fishers to the concept of using BRDs. A series of workshops are being conducted at different fishing ports which allows fishers to have a look at the devices and view underwater video footage of the devices in action. Fishers are also being offered the opportunity to test BRDs for themselves. A technical officer is also available to go to sea with the fishers to ensure that the BRDs are rigged correctly in the net. Regular newsletters and videos are provided to keep fishers informed of new BRD developments. It is hoped that this approach will increase the awareness of fishers to the need for more responsible fishing practices and meet the aim of managing fisheries under the principles of ecologically sustainable development.

The voluntary adoption of BRDs into the NPF will ultimately be a compromise between the need to reduce bycatch and the need for the fisher to make a profit from the fishery. There is some evidence from this and other studies that BRDs may actually increase prawn catches. We also have some evidence that reducing the amount of bycatch and especially the numbers of large animals in the codend, can decrease the number of damaged prawns in the catch. Undamaged tiger prawns are usually individually 'finger packed' for the export market and command a higher price. This suggests that BRDs may increase the value of the prawn catch by decreasing the number of damaged prawns. If these advantages can be accurately shown, this will make the adoption of BRDs more acceptable to the industry as they will see an increase in economic return for their efforts.

5. REFERENCES

Cochran, W.G. and Cox, G.M. 1957. Experimental Designs, Second edition. New York. Wiley.

MacLennan, D.N. 1992. Fishing gear selectivity: an overview. Fish. Res., 13: 201-204.

Pender, P.J., Willing, R.S., and Cann, B., 1992. NPF bycatch a valuable resource? Australian Fisheries. 51(2), 30-31.

Pownall, P.C., 1994. Australia's Northern Prawn Fishery: the first 25 years, P.C. Pownall (Editor), NPF25, Cleveland, Australia.

Ramm, D.C., Pender, P.J., Willing, R.S., and Buckworth, R.C. 1990. Large scale spatial patterns of abundance within the assemblage of fish caught by prawn trawlers from northern Australian waters. Aust. J. Mar. Freshwater Res., 41, 79-95.

Rawlinson, N. and Brewer, D. 1995. Monsters, blubber and other bycatch - NPF operators' views on bycatch reduction. Australian Fisheries, May 1995.

Robertson, J.H.B. and Stewart, P.A.M., 1988. A comparison of size selection of haddock and whiting by square and diamond mesh codends. J. Cons. int Explor. Mer., 44: 148-161.

Snedecor, G.W. and Cochran, W.G. 1980. Statistical Methods (seventh edition). The Iowa State University Press. Ames, Iowa. 507 pp.

Suuronen, P. 1995. Conservation of young fish by management of trawl selectivity. Finnish Fish. Res. 15: 97-116.

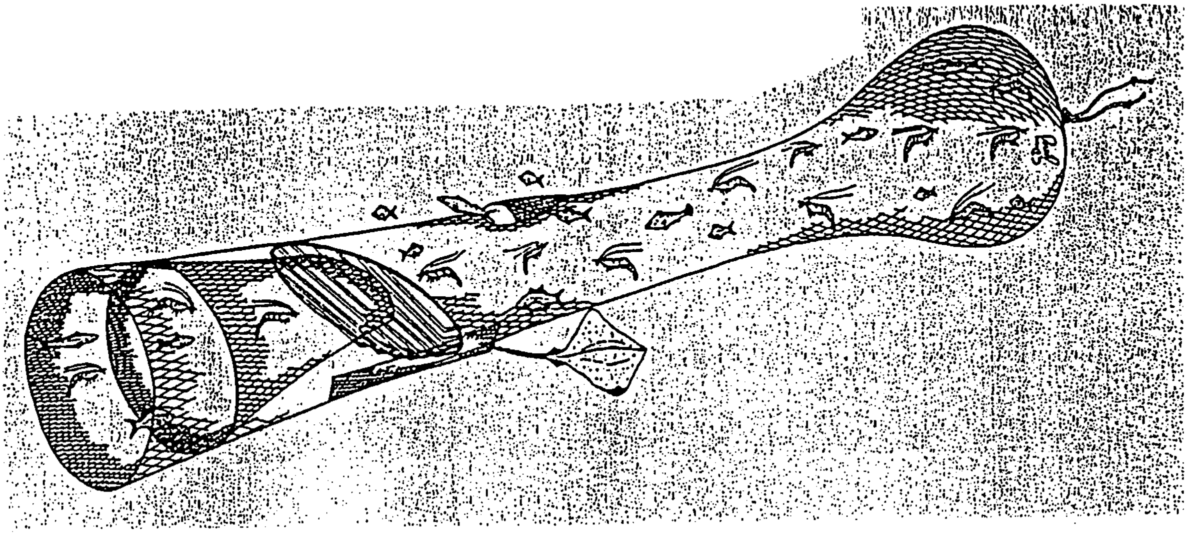

Fig. 1. The Super Shooter and fisheye combination.

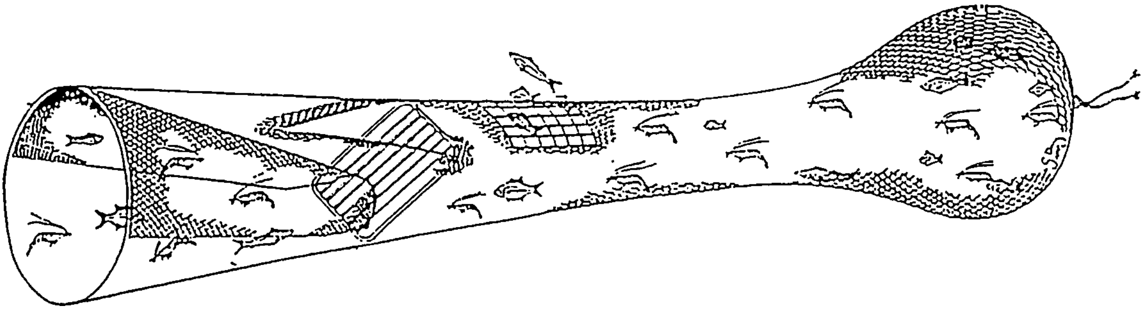

Fig. 2. The Nordmøre grid and square-mesh window combination.

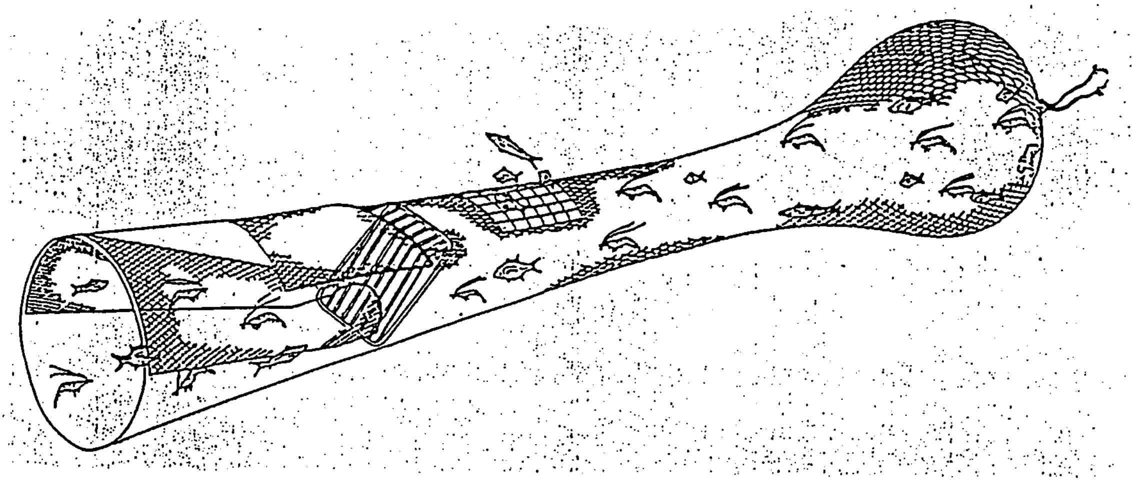

Fig. 3. The NAFTED.

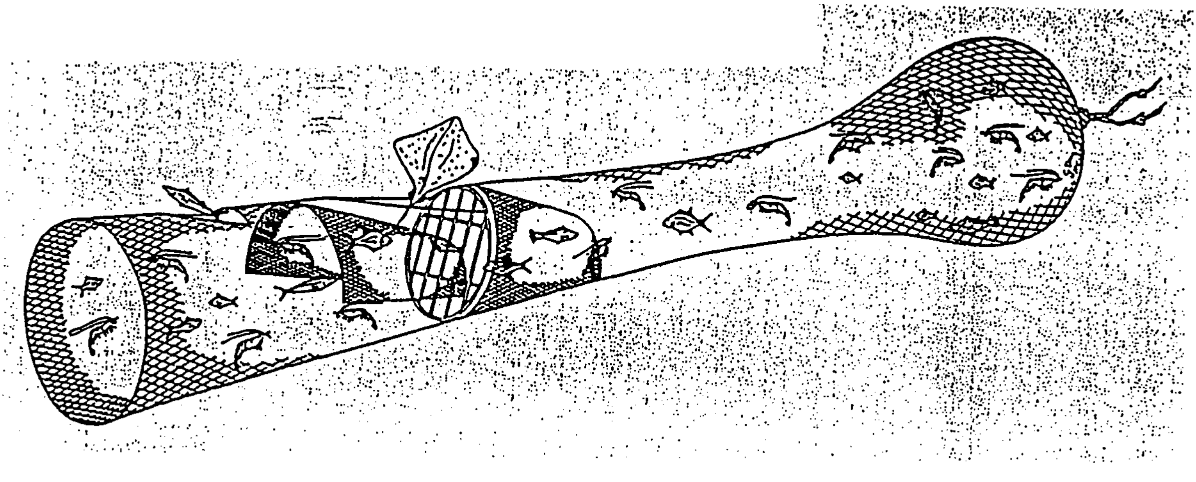

Fig. 4. The AusTED.

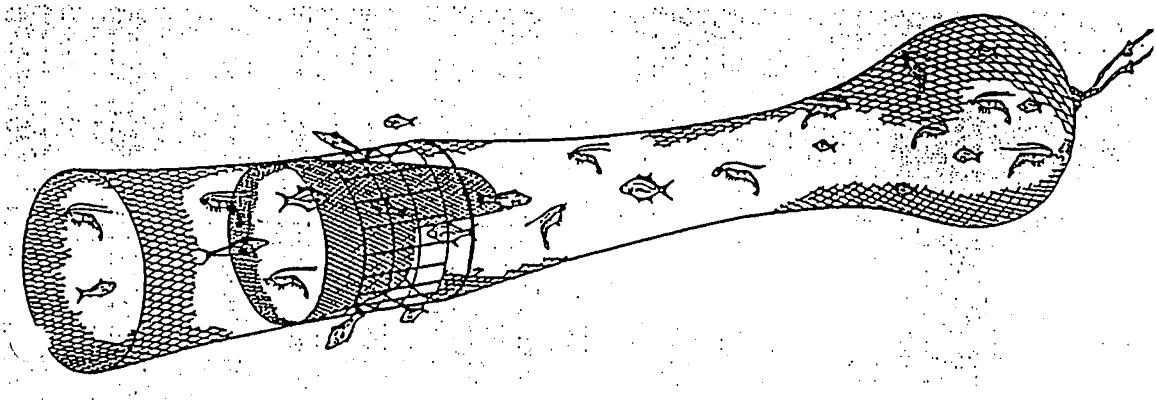

Fig. 5. The Radial Escape Section.

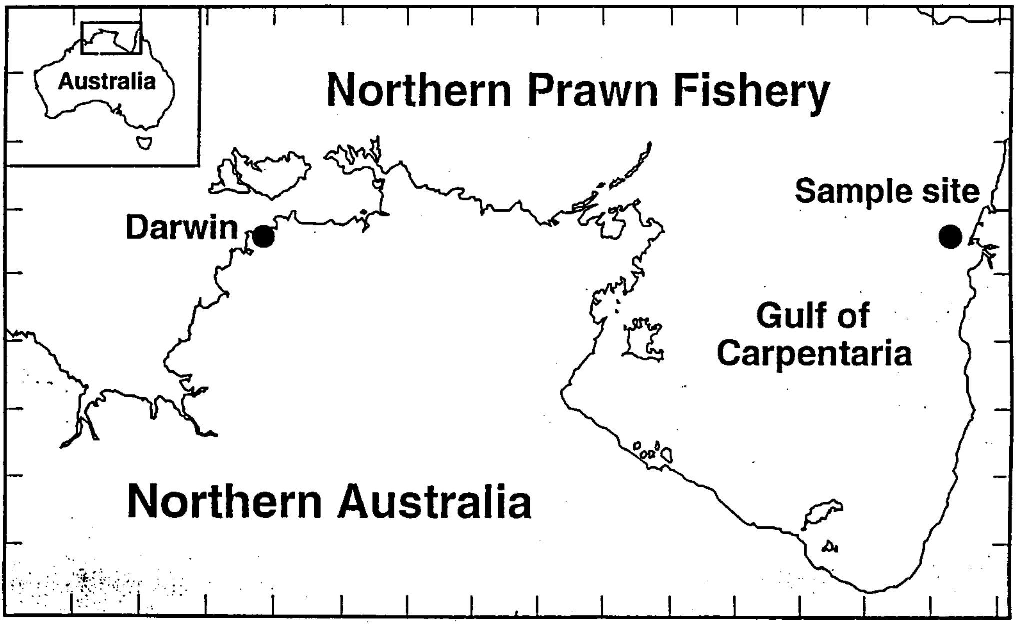

Fig. 6. The Gulf of Carpentaria (part of Northern Prawn Fishery) showing the study site.

Table 1. Bycatch exclusion and prawn-catching performance of bycatch reduction devices during research cruises two and three. The 30 min trials of cruise two are separated into 2 legs: 1 = first leg in good weather, 2 = 2nd leg in rough weather.

Bycatch reduction device	**Cruise leg**	**No. tows**	**No. large sharks & rays (>5kg)**	**No. turtles caught**	**Small fish excluded (% weight)**	**No. prawns caught (%)**	**Weight prawns caught (%)**
30 min trials (Feb 95)							
Super Shooter	1	19	1	1#	0	96	90
Super Shooter	2	4	0	0	1	91	88
Nordmøre grid	1	17	0	0	4	93	88
Nordmøre grid	2	12	0	0	9	55	46
Fisheye	1	3	1	0	0	130	122
Fisheye	2	10	0	2	4	93	70
Radial escape section	1	20	1	2	5	105	105
Radial escape section	2	9	1	0	8	74	57
Square-mesh window	1	20	7	2	5	92	92
Square-mesh window	2	10	1	0	7	64	51
Square-mesh window + black cylinder	1	18	4	1	3	87	87
Square-mesh window + black cylinder	2	14	2	2	6	64	55
Square-mesh window + glow netting	1	16	2	1	3	91	92
Square-mesh window + hummer	1	17	0	3	5	91	90
Standard trawl	1	20	1	2			
Standard trawl	2	15	2	0			

turtle caught in front ofxcluder grid

Table 1 (cont.)

Bycatch reduction device	Cruise leg	No. tows	No. large sharks & rays (>5kg)	No. turtles caught	Small fish excluded (% weight)	No. prawns caught (%)	Weight prawns caught (%)
2 hr trials (Oct 95)							
AusTED	-	15	3	0	27	79	75
Super Shooter + fisheye 1	-	15	3	0	16	95	98
Super Shooter + fisheye 2	-	21	0	0	14	90	89
Nordmøre + fisheye 1	-	15	1	0	31	81	83
Nordmøre + fisheye 2	-	22	1	0	28	85	86
Nordmøre grid + square-mesh window 1	-	15	1	0	39	66	62
Nordmøre grid + square-mesh window 2	-	22	1	0	28	84	84
Fisheye	-	15	11	4	11	90	92
Standard trawl	-	39	24	7			

Table 2: Prawn catch (kg) and large animal bycatch exclusion (Nos.) during commercial trials.

	Super Shooter	Standard	Super Shooter + sq. window	Standard	NAFTED	Standard
Prawns (kg)	289 (8)	280 (8)	855 (23)	945 (23)	141 (6)	146 (6)
Stingrays	0 (13)	15 (13)	0 (24)	2 (24)	0 (7)	0 (7)
Sharks	6 (13)	16 (13)	3 (24)	12 (24)	3 (7)	4 (7)
Turtles*	0 (13)	0 (13)	0 (24)	1 (24)	0 (7)	1 (7)

( ) = no. of tows. *All turtles were released alive.