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FRDC Project No. 96/254

Queensland Government
Department of Primary Industries

CSIRO AUSTRALIA

Australian Marine College

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

Report Series QO00006

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**96/254 Commercialisation of Bycatch Reduction Strategies and Devices in Northern Australian Prawn Trawl Fisheries.**

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**OBJECTIVES**

1. Inform and consult commercial trawl fishers about ways and means of reducing the catch of non-target organisms in their trawl nets.
2. Further develop promising bycatch reduction devices and other bycatch reduction strategies under commercial conditions.
3. Document, accumulate and publish performance data of turtle excluder devices and bycatch reduction gears suitable for the commercial fishing industry of the Queensland East Coast, the Torres Strait, the Northern Prawn Fishery and other interested parties.
4. Encourage and promote the use of bycatch reduction devices by commercial trawl operators.

## NON-TECHNICAL SUMMARY

Prawn and scallop trawling operations in northern Australia inadvertently catch a range of unwanted species that are landed on the boat, sorted from the marketable catch, and then discarded back into the sea. These discarded species are referred to commonly as bycatch and may include fish, crustaceans, sponges, stingrays and sea turtles. The magnitude (volume or weight) and species composition of bycatch in trawl fisheries of northern Australian is difficult to estimate accurately, as it varies geographically and seasonally. However, reported ratios of bycatch to target species range from 4:1 to 15:1 (by weight) for selected areas in northern Australia.

There is concern about the impact of trawl capture on bycatch species, especially those that are endangered or protected. Sea turtles are of particular concern, especially as they are listed as endangered or vulnerable under the *Endangered Species Protection Act 1992.* Since the issue of sea turtle capture in trawls nets was raised in 1990, it has become increasingly obvious that devices or gear modifications to exclude sea turtles from trawl nets would be a likely management requirement for northern Australian trawl fisheries.

The Fisheries Research and Development Corporation addressed the issues of sustainability, environmental impact and bycatch within trawl fisheries by initiating an Effects of Trawling Sub-program in 1993. The Sub-program coordinated research and development in these areas, and supported a number of research projects to develop and assess gear technology to reduce prawn trawl bycatch levels. Two main types of gear were tested: turtle excluder devices (TEDs), designed to exclude large animals on the basis of physical size; and bycatch reduction devices (BRDs), designed to reduce the catch of unwanted swimming species such as fish. Research testing established an understanding of how the devices function, but time and money constraints limited the extent of controlled research testing. The development of TEDs and BRDs was thought to be better achieved by industry testing coupled with a sound liaison program.

The current project aimed to inform, develop and encourage the use of TEDs and BRDs by working collaboratively with the prawn trawling industry of northern Australia. The project also examined the possibility of modifying the headline height of trawl nets to reduce bycatch. We used several strategies to disseminate the relevant information about TEDs and BRDs. Methods included: (i) informal, hands-on workshops at ports throughout northern Australia, (ii) attending industry meetings and informally visiting the wharfs, (iii) distribution of dedicated bycatch newsletters and videos summarising TED and BRD issues, (iv) loans of TEDs and BRDs custom-built to suit individual needs, (v) at-sea assistance with testing of TEDs and BRDs, and (vi) an incentive award i.e. the 'Prawn Trawling Innovation and Adoption Award' to recognise the contribution of individuals within the northern Australian trawl industry to the development and adoption of TEDs and BRDs.

The project had many outcomes. Tangible outcomes included face-to-face contact by project staff with about 30% of the prawn trawl operators in the Queensland East Coast Trawl Fishery and about 60% in the Northern Prawn Fishery. TED and BRD workshops were attended by over 400 fishers, netmakers, conservationists and other industry personnel. Seventy TEDs and 13 BRDs were lent to commercial fishers. Supervised field tests of TEDs and BRDs occurred on 36 vessels. Research staff spent over 375 days in the field, and recorded performance data on over 750 tows during which a TED or BRD was fitted to a trawl net.

TEDs were very effective at excluding sea turtles and other large animals. In total, 14 turtles were caught in standard nets, while two turtles were caught in TED-equipped nets (i.e. the net was winched in with the turtle positioned at the base of the grid). Generalisations about the effects of TEDs on prawn catches are difficult to make because of variable results. A reduction in prawn catch of between 4% and 10% occurred during many of the supervised at-sea testing of TEDs. However, prawn catch rates were maintained or increased (average 7%) during several supervised TED tests. On some vessels, prawn loss in the TED equipped net was excessive (e.g. 50%), but could be attributed to a particular cause such as shallow grid angle. On other vessels, excessive prawn loss occurred (e.g. 29%), but no obvious cause could be found.

BRDs had a varied effect on unwanted fish bycatch. Exclusion rates depended on the design of the BRD, the composition and quantity of bycatch, and whether trawling was undertaken during the day or night. In most cases, bycatch reduction averaged about 20% during night trawling and about 40% during day trawling. The data collected suggested that BRDs had little impact on prawn catches.

The 'Prawn Trawling Innovation and Adoption Award' had several nominees. Recipients of the award were John Olsen in 1997 and Garry Anderson in 1998. Both recipients actively promoted TED and BRD use amongst their fellow fishers and were ambassadors for the progress industry had made in reducing unwanted bycatch.

Results from the multi-level beam trawl experiment suggested that about 96% of most commercial prawns and 90% of the bycatch entered the trawl within 600 mm of the seabed. This suggests that the majority of the unwanted bycatch occurs at the same proximity to the seabed as prawns. As such, the potential for reducing bycatch simply by reducing the headline height of the trawl seems to be poor. Many fish species demonstrated strong upward escape responses to the approach of the multi-level beam trawl and the strategic placement of BRDs in the top panel of the trawl may be required to exclude these species successfully.

Less tangible outcomes of the project were the exchange of knowledge and information between project staff and individuals within the trawl industry. Information distributed by the project provided an important starting point for the manufacture and use of TEDs and BRDs by fishers and netmakers of northern Australia. First-hand experience using TEDs and BRDs led many individuals to begin developing their own designs. This was assisted by fishers being provided with information that would allow them to understand the underlying principles of fish exclusion.

Less than 2% of the Queensland East Coast Trawl fleet used BRDs when the project began in 1996, and only two vessels (out of 920) regularly used TEDs. A similar situation prevailed in the Northern Prawn Fishery. No vessels were known to use TEDs regularly in the NPF in 1996, but seven vessels were known to have tested a TED previously. TEDs and BRDs were not commercially available and most of the devices in use were made by the skipper or owner of the vessel. A wide variety of TED and BRD designs are now commercially available from at least 20 commercial suppliers in ports throughout northern Australia. While the project targeted otter trawl operations, the concepts and designs for fish exclusion from trawl nets have been utilised by many operators in beam trawl fleet of the Queensland east coast. This is an example of the change in industry attitudes towards bycatch reduction amongst many trawl fishers.

This project clearly demonstrated that a focused extension program can effectively raise the awareness of the fishing industry to sensitive issues, such as sea turtle bycatch, and encourage the use of "environmentally friendly" fishing practices. It also clearly demonstrated that the provision of research and extension information does not necessarily cause or induce all industry operators to change their practices. The acceptance and respect for the work completed by the project can be gauged by the increased industry awareness of TED and BRDs, the continued industry requests for information and assistance, and the nomination of project staff for several awards e.g. winner of the 1997 Queensland Seafood Festival Award for environmental promotion within the fishing industry, nominees for the 1998 and 2000 QDPI Excellence Awards for Research and Development.

## BACKGROUND

Concern about the effects of prawn trawling often relates to the large amounts of bycatch caught in most prawn trawl fisheries (Alverson *et al.* 1994). The quantity of bycatch per trawl varies, but typically less than 20% of the catch consists of prawns. The rest is mostly discarded during the sorting of the catch.

This is true of the trawl fisheries of northern Australia. Most trawlers in northern Australia target a number of prawn and scallop species, and also retain for sale a range of other species. They include crabs, scyllarid lobsters (bugs), squid and fish, and are generally referred as byproduct. However, the trawl fisheries of northern Australia occur in sub-tropical and tropical waters of the continental shelf, where species diversity and abundance is high. Many species that are caught are discarded at sea as bycatch because of they cannot be marketed economically, they are protected or they are below the minimum legal size. Bycatch can include, but is not limited to, fish, crustaceans, sponges, stingrays and sea turtles. Bycatch to catch ratios are highly variable, both spatially and seasonally. For example, ratios of bycatch to target species (by weight) in parts of northern Australia, range from 4:1 to 15:1 (Jones and Derbyshire 1988; Harris and Poiner 1990; Watson *et al.* 1990; Pender *et al.* 1992; Hill *et al.* 1998; Robins and McGilvray 1998). The overall magnitude (by weight or number) and species composition of bycatch in prawn trawl fisheries of northern Australian is difficult to estimate accurately. For recent reviews see Harris and Ward (1999) and Robins and Courtney (1999).

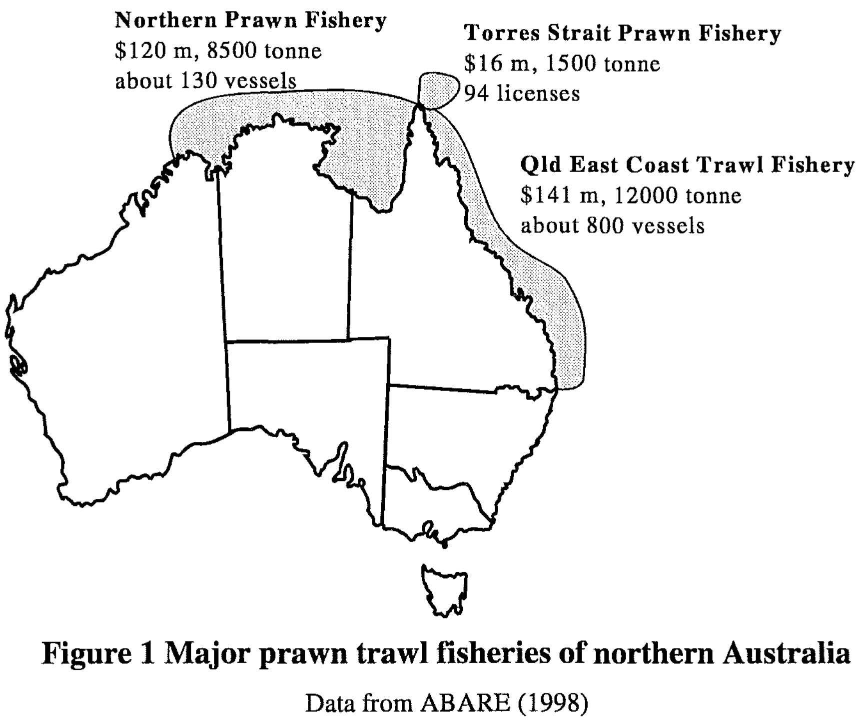


**Figure 1 Major prawn trawl fisheries of northern Australia**

Data from ABARE (1998)

There are three trawl fisheries defined by legislative jurisdiction in northern Australia. They are: (i) the Queensland East Coast Trawl Fishery (QECTF) managed by the Queensland State Government, (ii) the Torres Strait Prawn Fishery (TSPF) managed by a joint Commonwealth-Queensland management consortium, and (iii) the Northern Prawn Fishery (NPF) managed by the Commonwealth Government (Figure 1). Managers of these fisheries are concerned about the issues of long-term ecological and stock sustainability, the maintenance of biodiversity and community structure, the protection of critical fisheries habitats and social welfare.

In 1993, the Fisheries Research and Development Corporation initiated a Sub-program on the effects of trawling in response to the concerns and issues of sustainability, environmental impacts and bycatch within trawl fisheries, particularly where prawns were the dominant target species. The Effects of Trawling Sub-program aimed to coordinate research and development in these areas. Two key issues were identified: (i) quantification of the impacts (direct and indirect) of trawl fisheries on the marine environment in a cost-effective manner (Poiner *et al.* 1999), and (ii) the investigation of gear solutions to minimise the impact of the fishery on the marine environment. The latter focused research on possible gear solutions to bycatch in prawn trawl fisheries. FRDC has sponsored a number of research projects in this area (Blaber *et al.* 1997, Robins *et al.* 1997, Kennelly and Broadhurst 1998). Two main types of gear to reduce bycatch have been tested. They are turtle excluder devices (TEDs), designed to exclude large animals on the basis of physical size, and bycatch reduction devices (BRDs), designed to reduce the catch of unwanted swimming species such as fish by evoking an escape response (Figure 2).

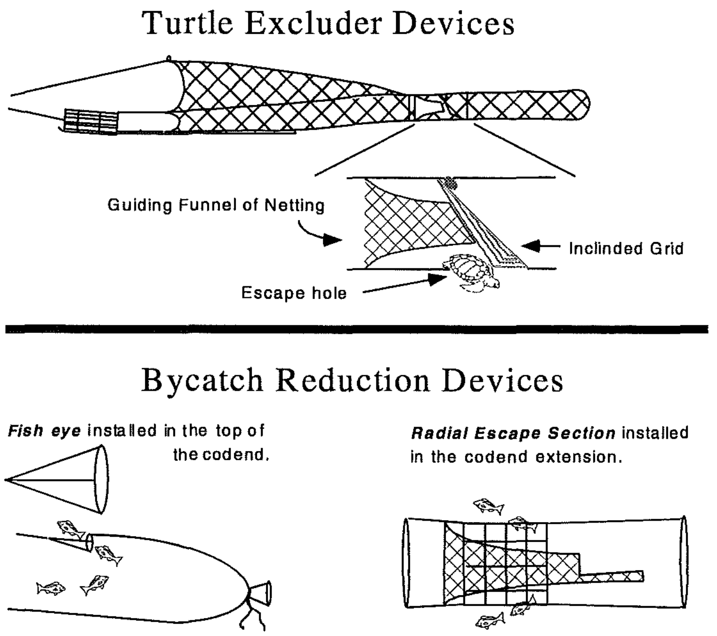


**Figure 2 Diagrammatic representation of a TED and BRD**

TEDs and BRDs are modifications to the trawl net that allow animals to escape after being taken into the net. In many respects, it would be simpler to prevent or reduce the number of unwanted bycatch animals that enter the trawl net in the first instance. Barrier trawls are one method that has been tried without success (Watson and Seidel 1980). Another method involves modifying the headline height and leadahead of prawn trawl nets. This has the potential to reduce bycatch rates, without affecting prawn catch rates, provided prawns and unwanted fish bycatch have different vertical distributions in the water column or exhibit different behaviours in response to the approaching trawl. The headline height of a prawn trawl in the tiger prawn sector of the Northern Prawn Fishery is usually equivalent to the height of the otter board, and may reach 1.8 m. In the case of banana prawn nets, the maximum headline height may be up to 12 m. Modification of the headline height may prove to be a valuable option in reducing unwanted bycatch. Preliminary tests indicated the possibility of increases in the swept-area of the trawl (Eayrs 1993). This strategy of bycatch reduction required further investigation.

Numerous TED and BRD designs have been tested under various research and commercial conditions. Research testing was essential to establish an understanding of how the devices function, but time and money constraints meant that the opportunities for controlled research testing were limited. The development of TEDs and BRDs was thought to be better achieved through extensive industry testing coupled with a sound liaison program. This involved the extension of bycatch reduction strategies from researchers and gear technologists into the fishing industry. The fishing industry could then develop, adapt and improve bycatch reduction devices and strategies to suit local fishing conditions and individual preferences.

## NEED

The Australian trawling industry is under pressure to reduce the impacts that trawling has on the environment, endangered species and other non-target organisms. In 1995, trawling was nominated as a key threatening process to sea turtles and other marine animals under the Commonwealth *Endangered Species Protection Act 1992* (*ESPA*). This Act can require action to be taken to mitigate listed key threatening processes, i.e. require the trawling industry to change its practices to prevent sea turtles from being captured and killed. In August 1999, the Endangered Species Scientific Sub-committee (ESSS) recommended that the incidental catch of sea turtles during coastal otter-trawl fishing operations in Australian waters north of 28°S be listed as a Key Threatening Process, i.e. added to Schedule 3 of the *ESPA*. However, the Commonwealth Minister for the Environment decided that trawling should not be listed at present because of advice from the Attorney-General[1]. It has been recommended that the ESSS advice on trawling as a key threatening process be re-considered when the new Environment Protection and Biodiversity Conservation Bill is enacted. Regardless of the outcome of the key threatening process nomination, fisheries management agencies recognised the need to reduce turtle bycatch in prawn trawl fisheries (Poiner *et al.* 1990, Robins 1995, Anonymous 1996, Poiner and Harris, 1996; Anonymous 1998). It became increasing obvious that devices or gear modifications to exclude sea turtles from trawl nets, i.e. TEDS, would be a likely management requirement of trawl fisheries in far northern Australia.

Prior to the project commencing in July 1996, the trawling industry of northern Australia had limited hands-on experience or knowledge of these devices. There was a wide range of devices known to researchers that could reduce the catch of sea turtles and other bycatch, but this information was not widely available to the commercial fishing industry. Research testing had suggested it was difficult to predict which

[1] Advice from the Commonwealth Attorney-General suggested that under the provisions of the ESPA it was not possible to list any new key threatening processes which occur both in and outside Commonwealth areas, as is the case of the incidental catch of sea turtles during coastal otter-trawl fishing operations in Australian waters north of 28°S. This deficiency with the ESPA will be removed when the Environment Protection and Biodiversity Conservation Bill is enacted.

devices or strategies would work most efficiently in different fisheries or areas within each fishery. Extensive industry-based testing of TEDs and BRDs was required. Information about TEDs and BRDs needed to be disseminated to the operators of prawn trawlers.

Commercial fishers were hesitant to experiment with TEDs and BRDs because of the lack of available information, concerns about the cost of the devices, perceived loss of prawns, peer-group pressure and perceived operational difficulties (Robins *et al.* 1997). Commercial fishers and netmakers needed access to a range of TEDs and BRDs so that designs could be developed and manufactured locally. First-hand testing of TEDs and BRDs would result in a word-of-mouth effect within the commercial fishing industry that would increase the profile and transfer of knowledge on TEDs and BRDs.

# OBJECTIVES

1. Inform and consult with commercial trawl fishers about ways and means of reducing the catch of non-target organisms in their trawl nets.
2. Further develop promising bycatch reduction devices and other bycatch reduction strategies under commercial conditions.
3. Document, accumulate and publish performance data of turtle excluder devices and bycatch reduction gears suitable for the commercial fishing industry of the Queensland East Coast, the Torres Strait, the Northern Prawn Fishery and other interested parties.
4. Encourage and promote the use of bycatch reduction devices by commercial trawl operators.

# METHODS

## *1. Bycatch Technology Extension Program*

The project aimed to set up a coordinated program that would provide the commercial trawling industry with information and advice on TEDs, BRDs and other strategies to reduce bycatch. The prawn trawling industries of northern Australia cover a large geographic area (about 9,000 km of coastline) and operate from about 19 major ports. The Northern Prawn Fishery had about 130 licensed vessels and the Queensland East Coast Trawl Fishery had about 850 licensed vessels, including those endorsed for the Torres Strait Prawn Fishery. These fleets are highly mobile, moving to various sections of the coast as fishing areas come into season. Fishing operations in the Queensland East Coast Trawl Fishery are generally different from those of the Northern Prawn Fishery; the main differences being the proportion of company boats versus owner-operator boats in the fleet, the duration of fishing trips and the type of gear towed. To enhance the probable success of the project, staff and equipment were coordinated across the technology extension program, but were allocated to a key fishery in order to establish and maintain close liaison with each fleet. Methods of extending information to commercial fishers were tailored to suit each fishery, and in the case of the Queensland East Coast Trawl Fishery, sectors within that fishery.

The program strategy involved a lot of face-to-face contact with commercial fishers by research staff, and the wide distribution of free information. The tools used to convey information included:

**Bycatch Workshops** that were designed to allow fishers to inspect full size TEDs and BRDs. Bycatch workshops were conducted at commercial fishing premises such as chandleries or net sheds so as to provide a non-government environment close to fishing wharfs. A variety of TEDs and BRDs from the gear library (see below) were displayed at the workshops. Research staff attended the workshops and consulted with fishers on a one-to-one basis. This enabled the concerns and questions of individual fishers to be discussed and answered.

**Bycatch Newsletters** were designed to provide up-to-date and timely information on available TED and BRD designs, summaries of results of field tests, comments from commercial fishers who had tested devices, up-coming events such as bycatch workshops, and the status of current regulations. The newsletters were distributed directly to owners and skippers of NPF vessels, and to master fishers associated with the Torres Strait Prawn Fishery and Queensland East Coast Trawl Fishery initially by mail then by insertion into the industry magazine *The Queensland Fisherman.*

**Bycatch Videos** provided an alternate way of disseminating information to written material, and were popular with commercial fishers. The project proposed to produce a short annual video summarising the progress and use of TEDs and BRDs. However, this was varied with FRDC approval to two longer videos. The first video introduced and summarised information about TEDs and BRDs during the early phase of the project. The second video documented the progress of adoption and current status of TEDs and BRDs during the final stages of the project.

**Booklets and information sheets** provided details of the design and construction of TEDs and BRDs. These were compiled from a number of sources both within Australia and from overseas. Booklets were distributed through the bycatch workshops, were sent to fishers upon request, advertised in newsletters and other publications. Information sheets on TED design and performance enhancement were also compiled. These were updated twice per year to ensure current information and to include new designs that were developed by the Australian trawling industry.

**The Gear Library** was a collection of promising and suitable TEDs and BRDs from within Australia and overseas. The designs initially selected for the gear library included the super shooter TED, the Seymour TED, the Anthony weedless TED, the AusTED, the Nordmore Grid, the USA fisheye, an expanded-mesh BRD and square-mesh panels. In time, other TED and BRD designs were added to the gear library including the NAFTED, the Wicks TED, the flounder/scallop TED, the Nichols TED, a square-mesh codend, the Jones-Davies BRD, fish cones, the John Olsen monofilament BRD and the bigeye BRD. The gear library also included a number of TEDs and BRDs that, while based upon the standard designs were modified to suit individual vessels. These custom-made TEDs and BRDs were lent to fishers for testing during commercial trawling conditions. Verbal and, where possible, written feed-back were sought from fishers who borrowed TEDs and BRDs from the gear library.

**Field Tests** were designed so that research staff were available to assist fishers to test, evaluate and document the performance of TEDs and BRDs during commercial trawling operations. This required negotiation with commercial fishers to coordinate the gear to be tested (including its manufacture in many cases) and the date and location of work to be undertaken. Many field tests were instigated through bycatch workshops or following telephone enquiries from commercial fishers. Where possible, the following measurements were recorded during field tests: a) fishing gear specifications, b) fishing conditions, c) bycatch reduction, d) prawn reduction, e) ease of operation and handling, and f) special considerations for use.

## *2. PRAWN TRAWLING INNOVATION AND ADOPTION AWARD*

During the project, it became obvious that some fishers were showing leadership in the development and implementation of TEDs and BRDs that would be of great long-term benefit to the industry. The need for positive reinforcement of environmentally acceptable practices was also obvious. FRDC approved an amendment to the project in August 1997, which developed an annual award for fishers.

The 'Prawn Trawling Innovation and Adoption Award' promoted the important contribution that commercial fishers were having in reducing bycatch and recognised the participation of individuals in the development and adoption of TEDs and BRDs. The award included a tied travel grant of $10,000 to assist the recipient undertake an overseas study tour of countries where TEDs or BRDs were developed and used. The award recipient was expected to write a short report on the tour for publication in fishing industry magazines.

Nominations were sought from members of the Australian fishing industry for persons who had made significant contributions to the development, use or industry adoption of environmentally acceptable fishing practices to reduce bycatch in the prawn trawl fisheries of Australia. To be eligible, nominees had to be active members of the Australian fishing industry (excluding government employees) and the subject of a written application documenting the nominees' contribution.

Applications were judged by a committee representing the fishing industry, government and conservation groups. Nominees were assessed on their contribution to the development, use or adoption of TEDs and BRDs under one or more of the following categories: (i) leadership in encouraging industry adoption of environmentally acceptable fishing practices, (ii) initiation of widespread industry use or adoption of TEDs or BRDs, (iii) design or development of gear to reduce bycatch and (iv) practical demonstration and evaluation of existing TEDs or BRDs. The award was offered in 1997 and 1998.

## *3. MULTI-LEVEL BEAM TRAWL EXPERIMENT*

The aim of the multi-level beam trawl (MBT) experiment was to examine the vertical distribution and some behavioural aspects of prawns and fish as they entered the trawl.

Current understanding of the vertical distribution of prawns and fish immediately ahead of the trawl is limited and generally based on anecdotal reports. For example, many NPF fishers claim that tiger prawns swim amid shoals of fish while others argue that the prawns are on the seabed but in higher abundance where the shoals of fish are located. The headline of commercial prawn trawls targeting tiger, endeavour or king prawns, is traditionally attached to the top of the trailing edge of the otter board irrespective of the height of the otter board. Therefore, headline height is usually equivalent to otter board height.

It is unclear whether fish bycatch could be reduced through modifications to the headline height of the trawl. Information on prawn and fish behaviour derived from the MBT could be used to: (i) assess the potential of headline height modifications to reduce bycatch while retaining valuable prawns, (ii) improve the effectiveness of current BRD designs, and (iii) assist the development of species-specific BRDs.

### Equipment

The multi-level beam trawl consisted of a four-seam trawl towed from an aluminium frame (Figure 3). The height of the frame was equivalent to the maximum otter board height used in the tiger prawn sector of the NPF (i.e. 1.8 m), and the design of the net was modelled on a Florida Flyer prawn trawl.

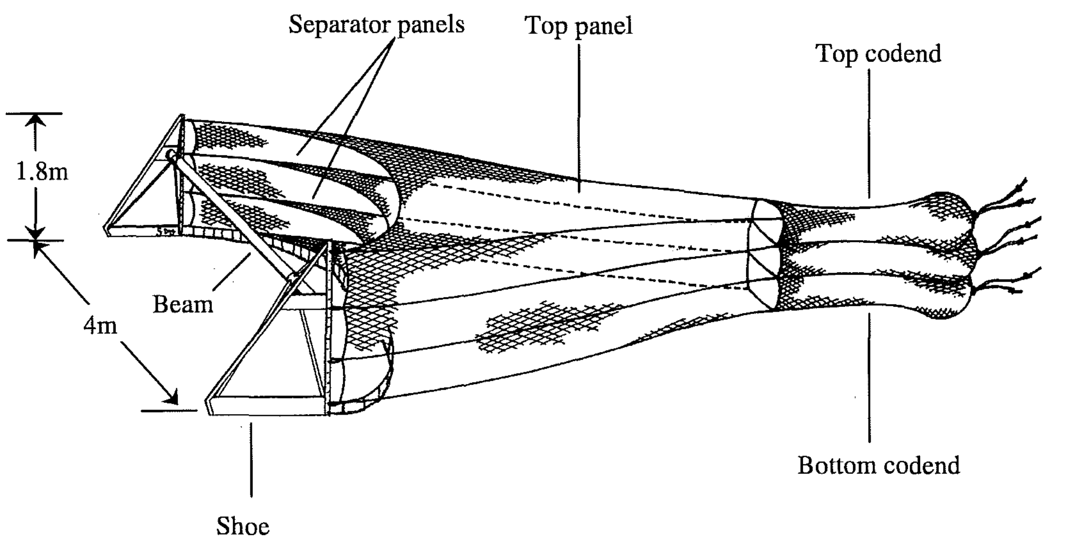


**Figure 3 Diagrammatic Representation of the Multi-level Beam Trawl**

The MBT was divided into three levels by two horizontal separator panels extending the length of the trawl. Each level was 600 mm high and led to a separate codend. The top and bottom panel of the net and both separator panels were identical in design and constructed to eliminate leadahead (cover) as this could hamper the vertical escape responses of prawns and fish. The main body of the trawl and both separator panels were constructed from 210d/30 ply polyethylene netting with a nominal mesh size of 50.8 mm. All codends were constructed from 210d/60 ply polyethylene netting with a nominal mesh size of 44.45 mm. The ground gear consisted of a single 8 mm (link diameter) galvanised-steel ground-chain of equal length to the footrope.

The MBT was tested in three rigging configurations. The first configuration had three leadahead panels attached to the MBT; one to the headline of both separator panels and one to the upper most (= top) panel of the trawl. Each leadahead panel extended directly between the wingends of the headline to prevent the migration of animals between levels. In this way, the catch in each codend provided information about the vertical distribution of prawns and fish at the time of capture. The second configuration involved the removal of the lowest leadahead panel, i.e. the panel separating the lowest (= bottom) and middle levels. This configuration allowed animals in the trawl mouth to migrate between the lowest and middle level as they encountered the trawl. The third configuration involved removal of the middle leadahead panel, i.e. the panel separating the middle and highest (= top) levels. In this way the catch in each codend comprised animals swimming ahead of each level at the time of capture plus those that reacted vertically to the trawl.

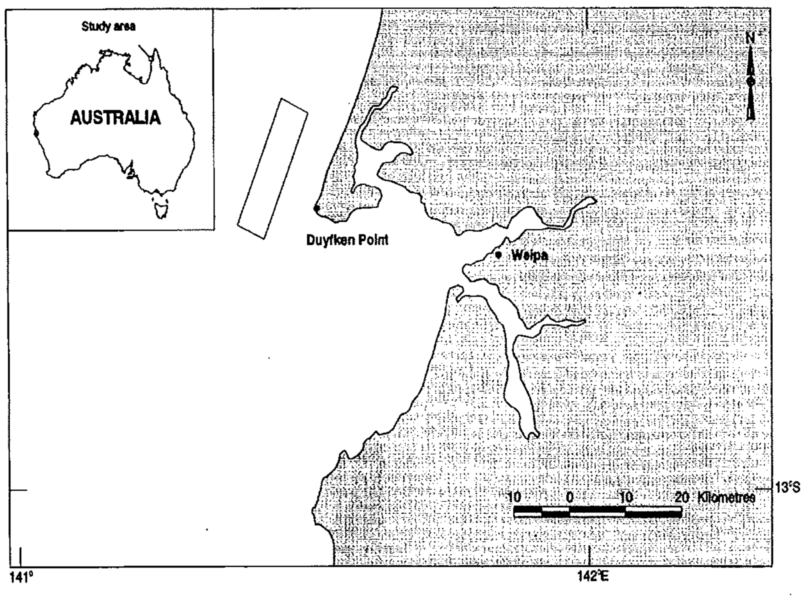


**Figure 4 Location of multi-level beam trawl sea trials**

Sea trials occurred on commercial fishing grounds north-west of Duyfken Pt in the Gulf of Carpentaria (Figure 4). The first and second configurations were trialed in 1998 onboard the 18.2 m steel trawler, FRV *Gwendoline May*, while the third configuration was trialed previously in 1993 onboard the 64 m FRV *Southern Surveyor*. Nominal towing speed was 1.5 m/s and a warp to depth ratio of 6:1 was used. All tows were 30 mins in duration and conducted in a north-south direction. Additional details are provided in Table 1.

**Table 1 Details of multi-level beam trawl sea trials in 1993 and 1998**

| | Date | No. of tows | Avg. speed (m/s) | Depth range (m) | Avg tow distance (N.M.)$^C$ |
|---|---|---|---|---|---|
| Configuration 1 | Nov. 98 | 43 | 1.54$^A$ | 18 to 22 | 1.43 ± 0.022 |
| Configuration 2 | Nov. 98 | 57 | 1.54$^A$ | 18 to 22 | 1.48 ± 0.019 |
| Configuration 3 | Nov. 93 | 45 | 1.37$^B$ | 14 to 21 | 1.39 ± 0.041 |

A. Recorded by GPS. B. Recorded by doppler log. C. Straight line distance between start & finish positions

## *4. Survey of TED and BRD Use*

It was difficult to quantify the timing and extent of the use of TEDs and BRDs by fishers in northern Australia. This was due to the high mobility of the fleets, the difficulty of maintaining regular contact with the 1000 or so vessels licensed to trawl in northern Australia and the multiple means by which a vessel could acquire a TED or BRD (i.e. netmaker, chandlery or "home-made"). Prawn trawl fishers of northern Australia were surveyed to determine the types of devices being used, the manufacturing sources of these devices and the general performance of the gear during commercial fishing operations. Separate surveys were undertaken of the Queensland East Coast Trawl Fishery and the Northern Prawn Fishery.

### Queensland East Coast Trawl Fishery

Licence holders of the Queensland East Coast Trawl Fishery (including Torres Strait endorsed vessels) were surveyed in June 1999 for their use of TEDs and BRDs prior to regulations coming into force on the 1$^{st}$ May 1999. The survey aimed to measure the increase in acceptance and adoption of TEDs and BRDs by operators in the Queensland East Coast Trawl Fishery. The survey form appears in Appendix 1. A survey conducted as part of the FRDC project 93/231.07 (AusTED II) suggested that prior to 1997 few individuals used a TED or grid-like structure (Robins *et al.* 1997). The earlier survey also reported that a small number of operators trawling for eastern king prawns in oceanic waters used a 10 mesh "V" cut in the codend to exclude unwanted fish bycatch.

### Northern Prawn Fishery

Skippers of vessels in the Northern Prawn Fishery were surveyed by AFMA personnel at the start of the 1999 banana prawn season to determine the use of TEDs or BRDs during 1998. AFMA supplied a list of skippers who had indicated that they had tested a TED or BRD in 1998. These skippers were contacted subsequently by project staff to determine the use and performance of TEDs and BRDs during commercial trawling in the NPF. A telephone survey was conducted between the 6$^{th}$ and 10$^{th}$ May 1999, where the following questions were discussed:

1. Did you use TEDs or BRDs during the 1998 season?
2. What design did you use?
3. Who constructed the device?
4. Where was the device used?
5. How long was the device used for?
6. Were you happy with the performance of the device?
7. Did the device lose prawns? If so, how much?
8. Did the device put the crew in danger at any time whilst in use?

# RESULTS

Overall, this project clearly demonstrated that a focused extension program can effectively raise the awareness of the fishing industry to sensitive issues, such as sea turtle bycatch, and encourage the use of "environmentally friendly" fishing practices such as TEDs and BRDs. However, it also clearly demonstrated that the provision of research and extension information does not necessarily cause industry operators to change their practices. A voluntary change in trawling practice is a choice made by individual operators within the fishery until regulations require the change in practice. This was demonstrated by many fishers across all three fisheries not adopting TEDs and BRDs until regulations requiring their use were in place and enforceable. The acceptance of the TED and BRD extension program can be gauged by the increased industry awareness of TED and BRDs and the awards that project staff won e.g. the 1997 Queensland Seafood Festival Award for environmental promotion within the fishing industry or were nominated for e.g. QDPI Excellence Awards for Research and Development in 1998 and 2000.

## *1. BYCATCH TECHNOLOGY EXTENSION PROGRAM*

### Bycatch workshops

Twenty-one bycatch workshops were held at various locations throughout northern Australia (Table 2). The workshops were attended by over 400 fishers, netmakers, conservationists, and other industry personnel. Fishers expressed mixed reactions to TEDs and BRDs, but in general those who attended the workshops showed significant interest in inspecting the design and manufacture of the TEDs and BRDs on display and learning more about their operation.

**Table 2 Locations of bycatch workshops held throughout northern Australia**

| Date | Location | Target fishery (no of attendees) |
|---|---|---|
| 18-19 October 1996 | Southern Fisheries Centre, Deception Bay | Moreton Bay (38) |
| 26 October 1996 | Australian Trawl Net Company, Bulimba | Moreton Bay (10) |
| 5-6 December 1996 | "Saltys" Fishing Team, Bundaberg | Central Queensland (33) |
| 11-13 February 1997 | GNM Chandlery, Cairns | NPF, Torres Strait, north Qld (48) |
| 14-15 February 1997 | Townsville Ross River Marina, Townsville | NPF, Torres Strait, north Qld (34) |
| 7 June 1997 | Seafood Festival, Tin Can Bay | Tin Can Bay (10) |
| 24-26 July 1997 | Newfishing Shed, the Duckpond, Darwin | NPF (38) |
| 9-11 September 1997 | Mackay Reef Fish | Central Qld (7) |
| 29 November 1997 | Morgan's, Scarborough | Moreton Bay (15) |
| 16 December 1997 | Innisfail Fish Depot, Innisfail | North Qld (19) |
| 20-21 January 1998 | Forgacs Slipway, Gladstone | Central Qld (22) |
| 9-11 March 1998 | MG Kailis, Fremantle | NPF (24) |
| 27 March 1998 | Carters Basin, Southport | Southport (20) |
| 6 July 1998 | Seafood Festival, Tin Can Bay | Tin Can Bay (10) |
| 20-21 July 1998 | Northern Fisheries Centre, Cairns | NPF, Torres Strait, north Qld (8) |
| 23 July 1998 | Lucinda | North Qld (5) |
| 24-25 July 1998 | Townsville | NPF, Torres Strait, north Qld (8) |
| 22-24 July 1998 | Newfishing Shed, Darwin | NPF (30) |
| 11 October 1998 | Seafood Festival, Hervey Bay | Central Qld (5) |
| 29 January 1999 | Tewantin/Noosa | Laguna Bay (10) |
| 6 June 1999 | Seafood Festival, Tin Can Bay | Tin Can Bay (5) |

The workshops played a significant role in introducing project staff to fishers and netmakers, many of who had had little previous contact with government or academic researchers. The workshops enabled the face-to-face discussions of technical aspects of bycatch reduction as well as the issues involved with bycatch. Several aspects of TED and BRD design were improved through these discussions.

In addition to the workshops listed, the TED and BRD display was freighted to Port Lincoln, South Australia, for an industry-organised workshop on bycatch reduction for the Spencer Gulf and West Coast prawn fishers. TEDs and BRDs were displayed at the 1997 Brisbane Boat Show, 1998 Queensland Primary Industries Week, and the 1999 Queensland Seafood Festival. The AMC had a permanent display of TEDs and BRDs with tank demonstrations, that was seen by national and international researchers, students, fisheries managers, members of the fishing industry and the general public.

Workshops around Moreton Bay suggested it would be beneficial to have direct contact with gear technologists from the USA, where TEDs and BRDs have been under development for a number of years. Staff from the USA National Marine Fisheries Service (NMFS), Pascagoula Laboratory were invited to visit Australia. The visit was funded partially by the project (accommodation expenses in Australia for two NMFS researchers) and partially by the NMFS (airfares and some accommodation costs) through the USA foreign TED program.

Three NMFS personnel visited Australia in February 1997. They were John Watson (Harvesting Team Leader), Wil Seidel (Senior Scientist Fisheries Administration) and Jack Forrester (Fishery Method & Equipment Specialist). They participated in the Bycatch Workshops held in Cairns and Townsville, gave two oral presentations at the 1997 pre-season Cairns Bycatch Conference for operators in the Northern Prawn Fishery and undertook impromptu wharfside discussions with fishers and netmakers at the ports of Bundaberg, Tin Can Bay and Brisbane. John Watson also discussed the implementation, regulation and enforcement of TEDs with officers of the Queensland Boating and Fisheries Patrol, and gave a presentation on TED development, implementation and regulation to QFMA staff involved with the Queensland East Coast Trawl Fishery.

The visit by the NMFS personnel was extremely timely and valuable. Many fishers were interested to hear first-hand how the devices performed in overseas fisheries. Government personnel were interested in the implementation and regulation of TEDs and BRDs. The visit also confirmed previously established links with the NMFS and has assisted in the continued exchange of information on TEDs and BRDs between Australia and the USA. This visit initiated discussions between Spencer Gulf fishers and Mr Jack Forrester on his assistance in the development of BRDs suitable for the Spencer Gulf Prawn Trawl Fishery.

Project staff also undertook ten trips to visit fishers in port and at-sea to inform them of the availability of TEDs and BRDs from the gear library and to discuss the associated bycatch issues. Project staff took advantage of the pre-season check of Torres Strait boats by the Queensland Boating and Fisheries Patrol and accompanied the Patrol in February 1997. Over the 10 days, project staff had discussions about TEDs and BRDs with the skipper and crew of the 47 boats that were boarded. Project staff used the motherships that service NPF vessels to discuss TEDs and BRDs with a large number of skippers and crew: 20 vessels in October 1996, 31 vessels in September 1999 and 21 vessels in October 1999.

**Bycatch newsletters**

Six issues of the Bycatch Newsletter were produced and distributed to fishers of northern Australia. Copies of the newsletter were requested by other stakeholders with an interest in trawl bycatch including the North Queensland Conservation Council, state coordinators of the Marine and Coastal Community Network, Environment Australia, the Great Barrier Reef Marine Park Authority, and other fishing organisations in WA, SA, NSW and NT. An example of the bycatch newsletter is provided Appendix 2.

**Bycatch videos**

Two videos were produced during the project and distributed free-of-charge to fishers. The first, entitled *Bycatch Reduction Devices: a summary* was distributed in September 1997. It summarised available TEDs and BRDs, and included copies of three USA National Marine Fisheries Service programs explaining the functioning of TEDs and the behaviour of fish to trawl nets. The video contained the following segments:

- Bycatch reduction devices: a summary (20 minutes),
- Installing a grid into a trawl net (10 minutes),
- The behaviour of fish and shrimp encountering trawls in the southeastern USA penaeid shrimp fishery (28 minutes, reproduced courtesy of NMFS),
- Hard grid TEDs – a guide to better performance (68 minutes, reproduced courtesy of NMFS),
- Modifications to reduce bycatch in the trawl fishery of southeastern USA (15 minutes, reproduced courtesy of NMFS).

The second video, entitled *Reducing Bycatch in Prawn Trawl Fisheries, current knowledge and status* was distributed in August 1999. It summarised the progress in the adoption and use of TEDs and BRDs in northern Australia, and included segments on proposed regulations, and theories of fish and prawn reactions to trawl nets. The video contained the following segments:

- Current status of regulations of TEDs and BRDs within prawn trawl fisheries of northern Australia,
- Designs of TEDs and BRDs currently used by the Australian trawling industry,
- Current knowledge of how fish and prawns react to trawl nets,
- How to install a Bigeye BRD into a trawl net.

Copies of the two videos were distributed to all licence holders within the Northern Prawn Fishery and the Queensland East Coast Trawl Fishery, as well as other interested parties. The videos were made available for purchase through the Queensland Department of Primary Industries Publication Bookshop (ph 1800 816 541) as demand for the videos from inter-state fishers and other interested parties exceeded the quantity produced by the project.

### Booklets and information sheets

The summary of TEDs and BRDs (Appendix 3) and design components of TEDs (Appendix 4) were popular with commercial fishers. Over 500 copies of the booklets were distributed.

### Gear library

TEDs and BRDs were added to the gear library on a continuous basis. In total, some 88 TEDs and 15 BRDs were constructed for the project. Seventy TEDs and 13 BRDs were lent to the following commercial fishers or vessels:
**AusTED** – *Carinna Anne, Jurara*
**Flounder Style TED** – *Battlestar*
**GNM pyramid TED** - *Newfish I*
**NAFTED** - *Taroona II, Ocean Exporter, Titan, Surefire, Gulf Viking, Sea Fever*, NTDPI&F
**Super Shooter TED** - *Gulf Viking, Striker, KFV Goldsmith, KFV Carlisle, Comac Enterprise, Sandpiper, LN2, Galveston, Adriatic Star, Seabring, Lin G*, MG Kailis WA, *Takari, Agrosta, Rebecca Mae*, Norm McDonald, *Valhalla*
**Seymour TED** – *LN2, Vansittart, Beachcomber, Diamond Lil, Restless, Lin Far, Debonair, Barook, Patricia J, Furora*
**Wicks TED** – *Shuna, Kyeeta, Gemini Star, Southern Intruder, W Dee*, Ross Golchert, Roger Green, Peter Moisel, John Webber, WA Fisheries, *Swansong II, Sanda Lee, Jabiru, Gwendolyn May, Haley, Trevanna*, Russel Carylon, Spencer Gulf Fishers, *Dynasty, Gulf Bounty, Rosen C, Markina, Baralda*, Barry Dorron, *Tapania*
**Morrison soft TED** – Bill Harris, *Taroona II*
**Nichols TED** – *Cumberlege*
**Expanded mesh BRD** – *Katie M, El Cid, Sonya M, Ocean Exporter*
**John Olsen Monofilament BRD** – *Patricia M*
**Neil Olsen BRD** – *Patricia M*
**Jones Davies BRD** – *Rebecca Mae, Magic, Comac Enterprise, Surefire*
**Fisheye** – *Dynasty, Markina, Petanne*

Most vessels returned verbal comments on the performance of the TED or BRD borrowed. Specific details of the gear performance were obtained from two vessels (see below).

- FV *Ocean Exporter* - A NAFTED was lent to the *Ocean Exporter*. It was installed in the starboard net and tested for 19 consecutive nights in November 1998 around Groote Eylandt. A total of 55 shots were recorded. The net fitted with the NAFTED recorded an increased tiger prawn catch of 5.5 kg (0.6%) and an increased endeavour prawn catch of 84.5 kg (11.5%) compared to the unmodified net. The skipper was extremely happy with the NAFTED and there were no handling problems.
- FV *Katie M* – An expanded mesh BRD was tested by the *Katie M* in the deep water eastern king prawn fishery off Bundaberg. The bycatch was composed mostly of small toadfish that were extremely abundant. The gear was tested for one four-hour tow. There was no appreciable difference in prawn catch, but the expanded mesh BRD did not markedly reduce the catch of small toadfish.

## Field tests

Many fishers approached by project staff to undertake an assisted field test were hesitant to test TEDs or BRDs or hesitant take a researcher onboard their vessel. However, 36 vessel operators took advantage of the availability of research staff to assist with field testing and enabled TED and BRDs to be tested over a wide geographic scale in northern Australia (Figure 5).

**Figure 5 Location of field tests of TEDs and BRDs**

In total, research staff spent over 752 days in the field, and recorded performance data on over 752 tows during which a TED or BRD was fitted to the net (Table 3). Detailed information on the performance data collected during field tests is presented as individual trip summaries in Appendix 5.

It is difficult to generalise the results from the field tests, given the diverse range of fishing conditions and number of devices that were tested. The field tests of TEDs and BRDs were not conducted with standard scientific rigour due to the voluntary participation of skippers and crew and the testing of devices during commercial fishing operations. As such, the extent of data collected was determined by the willingness or ability of the crew to modify their standard fishing operations. One of the greatest difficulties was eliminating different catching efficiencies between port and starboard nets. Sometimes, standardisation data was collected, other times, the TEDs and BRDs were swapped between nets. On some vessels, no information on the relative efficiency of port and starboard nets could be collected. However, the following general comments can be made about the performance results of TEDs and BRDs. The experience research staff gained during the at-sea testing of TEDs and BRDs also enhanced our knowledge of the optimal installation of TEDs and BRDs into trawl nets.

**Table 3 Field tests of TEDs and BRDs**

| Date | Location | Device | Vessel | Days | Test days | Tows | Staff * |
|---|---|---|---|---|---|---|---|
| 25/02/97 | Bundaberg to Bowen | John Olsen BRD | *Stardancer* | 9 | 8 | 35 | MC |
| 20/05/97 | Torres Strait | super shooter TED | *Lin G* | 4 | 4 | 12 | JM |
| 20/05/97 | Torres Strait | Seymour TED | *Lin Far* | 4 | 3 | 11 | MC |
| 29/07/97 | Cairns north | super shooter TED | *Seabring* | 4 | 4 | 15 | JM |
| 20/05/97 | Townsville | radial escape device BRD | *Kimissa Lee* | 4 | 4 | 14 | MC |
| 22/08/97 | Townsville | Seymour TED | *James Kirby* | 3 | 3 | 24 | MC<br>JM |
| 26/10/97 | Torres Strait | Seymour TED | *Beachcomber* | 3 | 3 | 11 | JM |
| 23/10/97 | Torres Strait | Seymour TED | *Vansittart* | 3 | 3 | 9 | JM |
| 29/10/97 | Torres Strait | Seymour TED | *Diamond Lil* | 3 | 3 | 9 | JM |
| 11/05/98 | Bundaberg | modified TED | *John D* | 5 | 5 | 54 | JM |
| 13/09/98 | Lucinda | top Bigeye BRD | *Karool* | 5 | 5 | 19 | JM |
| 04/01/99 | Bundaberg | Wicks TED | *Haley* | 2 | 2 | 10 | MC |
| 20/05/97 | Mornington Island | super shooter TED | *KFV Carlisle* | 27 | 7 | 19 | GD |
| 28/07/97 | Joseph Bonaparte Gulf, Kimberley coast | super shooter TED, NAFTED | *Ocean Exporter* | 17 | 16 | 63 | GD |
| 01/09/97 | Bountiful Island | Seymour TED | *Dampier Pearl* | 10 | 2 | 6 | GD |
| 18/09/97 | Weipa | super shooter TED + square mesh windows in 8 different configurations | *Petanne* | 22 | 9 | 33 | GD |
| 30/09/97 | Cape Arnhem to Cape Grey | super shooter TED | *Takari* | 24 | 16 | 61 | MC |
| 10/10/97 | Weipa | super shooter TED | *Dampier Pearl* | 8 | 4 | 15 | GD |
| 27/10/97 | Groote Eylandt to Cape Grey | super shooter TED, NAFTED | *KFV Goldsmith* | 11 | 8 | 16 | GD |
| 27/10/97 | Cape Arnhem to Cape Grey | super shooter TED | *Amelia C* | 12 | 2 | 8 | MC |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13/05/98 | Mornington Island | wicks TED | *Dynasty* | 11 | 9 | 32 | MC |
| 24/05/98 | Mornington Island | Popeye TED | *Cathy Wren* | 6 | 5 | 16 | MC |
| 28/07/98 | Groote Eylandt | super shooter TED | *Inspiration* | 11 | 7 | 24 | GD |
| 12/08/98 | Tully | NAFTED, super shooter TED, expanded mesh BRD | *Titan* | 27 | 9 | 36 | GD |
| 02/09/98 | Cape Arnhem to Groote Eylandt | wicks TED | *Markina* | 21 | 18 | 42 | MC |
| 13/09/98 | Groote Eylandt, Gove | super shooter TED,NAFTED | *Tarni* | 6 | 2 | 4 | GD |
| 19/09/99 | Cape Grey | super shooter TED top & bottom opening, NAFTED, fisheye | *Comac Enterprise* | 2 | 2 | 6 | GD |
| 21/09/98 | Cape Grey | super shooter TED | *Comac Endeavour* | 17 | 5 | 20 | GD |
| 22/09/98 | Cape Arnhem to Groote Eylandt | wicks TED | *Babirusa* | 4 | 4 | 15 | MC |
| 10/10/98 | Groote Eylandt to Vanderlin Island | GNM TED, super shooter TED | *KFV Carlisle* | 20 | 9 | 25 | GD |
| 03/11/98 | Bombard Shoal, Vanderlin Island | NAFTED, super shooter TED | *Gulf Viking* | 28 | 3 | 10 | GD |
| 21/04/99 | north Mornington Island | wicks TED | *Rosen C* | 6 | 5 | 18 | MC |
| 23/04/99 | Croaker Island to Gove | super shooter TED | *Striker* | 18 | 7 | 24 | GD |
| 12/05/99 | Groote Eylandt to Cape Grey | super shooter TED | *Tarni* | 6 | 2 | 7 | GD |
| 18/05/99 | Groote Eylandt to Robertson River | GNM TED | *Newfish I* | 7 | 6 | 14 | GD |
| 25/05/99 | Groote Eylandt to Gove | super shooter TED | *Libertine* | 5 | 5 | 15 | GD |

*Staff coding: JM – Jason McGilvray, MC – Matthew Campbell, GD – Garry Day

## TEDs

*Effects on prawn catch*

The effect of TEDs on prawn catch varied, depending on the design of the TED, and the composition and quantity of bycatch. Catch rates were maintained when fishing trawl grounds that were relatively "clean" i.e. few sponges, rocks or large animals (see Appendix 5 e.g. FV *Takari,* FV *Diamond Lil,* FV *Gulf Viking*). On some occasions, catch rates of prawns increased in TED equipped nets, e.g. an average 7% increase in prawn catch on the FV *Seabring*. Generally, TEDs had a negative effect on prawn catch rates during trawling in fishing grounds that had a high number of large or bulky animals, such as rays and sponges. Many of the tests reported a reduction in prawn catch of between 4% and 10% (e.g. FV *Lin-G*, FV *Beachcomber*, FV *Petanne*, FV *Titan*, FV *Comac Enterprise*). On some occasions prawn loss was excessive, but could be attributed to a particular cause e.g. a 50% loss on the FV *Carlisle* was due to a shallow grid angle. However, on some occasions, no obvious cause could be found for the significant loss of prawns e.g. a 29% loss on the FV *Dampier Pearl.* The extensive at-sea work by project staff confirmed the variable effect of TEDs on prawn catch and the difficulty of providing a single number to quantify the effect of TEDs.

*Effects on large animals*

TEDs were very effective at excluding large animals (Table 4). TEDs were tested during 666 tows. A total of 14 turtles were caught in the control nets during the testing and two turtles were caught at the base of the grid of the TED equipped net. TEDs were also effective at excluding sponges, rays, sharks, large fish and jellyfish. The extent of exclusion of these species, depended on the bar spacing of the grid i.e. 60 mm vs 100 mm vs 130 mm. Obviously the smaller the bar spacing, the greater the exclusion of large animals. For example, the 60 mm bar spacing of the NAFTED excluded up to 95% of the jellyfish encountered during trawling for red-leg banana prawns in Joseph Bonaparte Gulf (see FV *Ocean Exporter*).

**Table 4 Catches of large animals in standard net and TED nets**

| | Turtles | Rays | Sharks > 45cm total length | Large fish > 60 cm total length | Sponges >10 l bucket in size |
|---|---|---|---|---|---|
| Standard nets | 14 | 85 | 551 | 68 | 342 |
| TED nets | 2 | 6 | 252 | 11 | 33 |

*Effects on unwanted bycatch*

TEDs were not very effective at excluding unwanted fish bycatch, if the TED was considered to be working properly. This fits our theory that TEDs exclude animals on the basis of physical size and as such should mostly exclude only those animals that are larger than the bar spacing. Little or no exclusion of unwanted fish bycatch occurred during ten of the supervised at-sea tests of TEDs. However, on three vessels, bycatch reduction was in the order of 7% to 10% (FV *Vansittart*, FV *Dynasty*, FV *Markina*), whilst on five vessels, bycatch reduction was about 20% (FRV *James Kirby*, FV *Beachcomber*, FV *Takari*, FV *Lin Far*). Bycatch was not quantitatively compared on the remaining vessels due to poor weather, set-up of the vessel (e.g. hoppers) or unwillingness of the crew. Reduction in bycatch may be linked to the size of the bar spacing (see below). In general, the composition of the bycatch was not investigated. Visual observation of bycatch on the tray suggested that TEDs were poor at excluding unwanted invertebrate bycatch e.g. crabs, molluscs.

*Effect on other marketable species i.e. byproduct*

Many vessels retained species other than prawns as part of the saleable catch, including bugs, blue swimmer crabs, squid and selected fish species. The byproduct retained is particular to each vessel, and differs between the Northern Prawn Fishery and the Queensland East Coast Trawl Fishery. Project staff collected information on the effect of TEDs on other marketable species on a limited number of occasions. TEDs had a variable effect on the catch rates of bugs, ranging from no effect (e.g. FV *Takari*, FV *Babirusa*) to a 27% decrease (FV *Petanne*).

*Top opening versus bottom opening TEDs*

It is very much a matter of personal preference as to whether to fish a TED as a top or bottom-opening TED. Both were equally effective in excluding sea turtles. However, bottom-opening TEDs were more efficient in "dirty" areas, where sponges were frequently encountered: e.g. 50 sponges greater in size than a ten litre bucket were caught in the standard net on the FV *Cathy Wren* compared to none in the TED net. Top-opening TEDs were compared against the same design bottom-opening TEDs on three occasions (see FRV *James Kirby*, FV *Comac Enterprise*, FV *Carlisle*). Results confirmed speculation that bottom-opening TEDs were more likely to lose prawns than top-opening TEDs; the difference being about 7% to 10%. Top-opening TEDs were well-suited to clean areas because few sponges or rocks lodged at the base of the grid and top-opening TEDs were less likely to lose prawns.

*Bar spacing: 60mm versus 100mm versus 150 mm*

Bar spacing is important in determining what animals will pass through the bars and into the codend and what animals will be directed towards the escape opening. Seven different bar spacings were tested: 60 mm, 76 mm, 90 mm, 95 mm, 102 mm, 137 mm, and 146 mm. Bar spacing was related to the design of the TED (e.g. 60 mm NAFTED) as well as the width of the TED. A narrow bar spacing (i.e 60 mm) was very effective in excluding 95% of jellyfish (FV *Ocean Exporter*). The relationship between bar spacing and bycatch exclusion was not consistent, being affected by the composition of the bycatch and the fishing conditions. However, in general TEDs with a bar spacing of 90 mm to 102 mm resulted in a 15% to 20% reduction in bycatch (e.g. FV *Lin Far*, FV *Beachcomber*, FV *Takari*, FV *Amelia C*). Larger bar spacing (i.e. 137 mm and 146 mm) resulted in a 3% to 8% reduction in bycatch (e.g. FV *Haley*, FV *Dynasty*, FV *Markina*). Large bar spacing was effective in excluding large animals such as sea turtles, but allowing the fishers to retain certain marketable byproduct, such as small sharks for trunking (e.g. FV *John D*). Bar spacing is very much dependent on the type of catch retained for market, with the upper limit being determined by the size that still prevents sea turtles from passing through the bars and into the codend.

*Codend size and design*

The codend should be as long as possible (either legally or practically) in nets fitted with a TED, so that the ball of catch in the codend is located as far behind the TED as possible. This is intended to minimise the chance of the catch washing forward during haulback and escaping out of the TED. Where codend size is limited, for either legal or practical reasons, fishers should consider using a codend with an increased number of meshes around the codend (e.g. 150 meshes) or a bell-codend so that the ball of catch can expand outwards rather than forwards.

*Grid angle*

The angle at which the TED is installed can have a significant effect on the efficiency of the TED at excluding sea turtles and retaining prawn catch. All angles discussed refer to the angle between the bottom of the net and the grid. Top-opening TEDs were installed initially at 52° to the horizontal, but this changed during the course of the project to 47° and then to 42°. Bottom-opening TEDs were installed at 50° to the horizontal, but over time and with experience, were installed between 52° and 55° to the horizontal. TEDs that are installed too steeply (i.e. tending towards vertical) will not efficiently exclude turtles and other large animals. Grids that are installed at a shallow angle (i.e. tending towards horizontal) will exclude large animals, but will tend to lose prawns.

*Internal funnels and deflector flaps*

Internal funnels and deflector flaps are used to guide the catch away from escape openings. They were used in many of the TED tests conducted in the Northern Prawn Fishery. They are essential in all bottom-opening TEDs, as they guide the prawns away from the escape opening in the bottom of the net and minimise the chance of losing prawns. However, internal funnels and flaps can cause the TED to clog, particularly if sponges and starfish are caught frequently. They also require regular cleaning to ensure that the TED is efficient.

*Escape openings*

Escape openings should be as large as possible, being limited in their width by the width of the TED. The escape opening cuts should be selvedged to prevent distortion of the meshes around the cut. This is easily done in a triangular-shaped escape opening, but requires rope or some other load-bearing material in rectangular-shaped escape openings. The escape opening should be anchored to the grid, preferably at the intersection of the outer-frame and the first deflector bar or a gusset to reduce slippage of the escape opening down the side of the TED. It is very important to ensure that the escape opening maintains its original form and dimensions despite the rigours of fishing. Stretching or slipping of the escape opening will result in a change of the effective angle of the TED during fishing which can lead to prawn loss.

*Escape opening covers (= flaps)*

Most of the TEDs tested were fitted with escape opening covers. In general, escape opening covers were constructed so that the cover had 20% to 25% more meshes across its width than the escape opening. This enabled the cover to stretch and exclude large animals but then spring back to a snug fit against the net. Escape covers should be replaced when they are stretched as this can improve the TEDs performance at retaining prawns. The escape cover should extend past the grid to ensure the escape opening is covered, but not so far as to hinder the exclusion of turtles. Escape opening covers were constructed by project staff to extend 15 meshes past the grid, with eight of these meshes sewn to the TED extension behind the grid. The netting of the escape opening cover was orientated so that the water flow over the knots pushed the cover toward the net e.g. on top-opening TEDs, the escape opening cover was pushed downwards.

*Construction of TEDs*
Most TEDs were constructed from either steel or aluminium. Solid aluminium rod welded using the Metal Inert Gas (MIG) tended to be stronger than TIG welded grids. TIG welding tended to weaken the aluminium rod and bending can result. Many NPF operators have chosen to use TEDs made from stainless steel for increased strength. This is because the large "monsters" caught in the NPF are capable of bending or demolishing grids made of material with insufficient strength. Regardless of the material, all grids should have the weld of the outer frame located on the side of the grid. This lessens the risk of bending or cracking at the weld due to stresses on the grid from large animals.

*Construction material*
TEDs need to be of sufficient strength to withstand the rigours of trawling and encounters with large sharks, rays and slabs of rock. Many of the TEDs constructed during the project were made from solid aluminium rod, the thickness depending upon the intended fishing location. Hollow aluminium tubing was used in the manufacture of the Seymour TED. Some fishers prefer to construct TEDs of steel, sometimes stainless steel, for strength and the ability to weld this steel at-sea.

*Installation of the TED extension to the main body of the trawl*
Several netmakers have commented that the throat of some modern two-seam nets have an unequal number of meshes at the aft end of the top and bottom panels. This is a result of the method used to create leadahead in the top panel. Generally, there are more meshes in the lower panel of a two-seam net than in the top panel. This results in unequal tension in the meshes of the throat of the net, with the lower section hanging slack. It is assumed that this causes the seam of the throat-codend join to lean forwards, instead of being vertical. This could cause a change in the effective fished angle of the grid when the trawl net was towed underwater.

*FEPs: Frequently encountered problems*
The major problems encountered with TEDs were stretching of escape covers, loss of grid angle, the total destruction of one device due to fouling on the lazy line guides, and the total destruction of another due to fouling on the bottom. Like any piece of fishing equipment, TEDs need to be checked regularly to ensure their efficient configuration.

## BRDs

Comments on BRDs result mostly from testing in the Queensland East Coast Trawl Fishery, due to the limited number of BRDs tested in the Northern Prawn Fishery. BRDs observed by research staff at-sea include the John Olsen monofilament BRD, the Neil Olsen BRD, the Bigeye BRD, the Herb Olsen modified TED-BRD, the expanded mesh BRD and the fisheye.

*Effect on prawn catch*
In general, the BRDs that were tested had no discernible impact on the quantity of the prawn catch (see FV *Stardancer*, FV *Kimissa Lee*, FV *Karool*, FV *Titan*). There was also no discernible effect on the quality of the prawn catch during field tests. However, this may be a result of the relatively short-term nature of the field tests, and

that over a longer period of time, small improvements in catch quality may sum to have a significant effect.

*Effects on large animals*
Large animals, such as sharks and rays, were not excluded by most BRD designs, because the escape openings were too small e.g. a fisheye or 50 mm square-mesh panel. However, the bigeye and certain designs of radial escape devices (i.e. Neil Olsen BRD) had potential to exclude large animals because the escape openings in these devices were large i.e. > 300 mm. Anecdotal reports from fishers suggested that turtles and stingrays escaped from some nets fitted with a Bigeye BRD. This could not be confirmed by research staff as during the only supervised test of a Bigeye BRD (FV *Karool*) no large animals were caught in either of the nets.

*Effects on unwanted bycatch*
The exclusion of unwanted bycatch in nets fitted with BRDs depended on the design of the BRDs, the composition and quantity of bycatch and whether trawling was undertaken during the day or night. Bycatch reduction averaged about 20% during night trawling and about 40% during day trawling. (see FV *Stardancer*, FV *Kimissa Lee*). However, it difficult to see a definite trend in bycatch reduction when the total bycatch was small (i.e. <50 kg per net, FV *Karool*). During night trawling, greatest reductions in fish bycatch occurred during tows undertaken at dusk and dawn, while little bycatch reduction occurred during tows undertaken in the middle of the night.

### Additional work conducted onboard commercial trawlers

Video work was conducted onboard a number of vessels to visually document how TEDs and BRDs work in practice, both underwater and at the surface. Commercial vessels that volunteered their time and nets included the *Sonya M* and the *Melissa Jane* in Moreton Bay, the *Southern Intruder* (off Gladstone) and the *Karool* (off Hinchinbrook Island). Much of this footage was used to aid in the understanding of fish and prawn reactions to trawl nets.

In addition, project staff observed and reviewed the commercial use of alternate industry ideas in regards to reducing trawl bycatch. These included the “curtain trawl” designed by Andrew Bruce. This modified three-fathom-headline, four-panel trawl had a vertical curtain sewn to the headline of the net and partially down the forward section of the wing panel. Research staff observed the performance of the net during three daytime tows. The results were inconclusive due the small catches of prawns (i.e. < 1.5 kg per net) and bycatch, and low level of replication.

## 2. *PRAWN TRAWLING INNOVATION AND ADOPTION AWARD*

The 1997 Award selection committee was Mike Dredge (QDPI), Dr Colin Buxton, (AMC/FRDC Effects of Trawling Steering Committee), Ted Loveday (QCFO), Peter Billam, (NPF stakeholder/NORMAC Research Committee), and Eddie Hegerl, (Australian Marine Conservation Society). All nominees who met one or more of the selection criteria were recognised for their contribution to promoting environmentally sustainable prawn trawling practices, in the form of a certificate. The Award was launched by the Honourable Minister Warwick Parer on the 29th November 1997 in Brisbane. Nomination details appeared in *The Queensland Fisherman*, *NSW Fisherman*, *Professional Fisherman*, *ProWest*, the NSW government-sponsored fisheries magazine, the SAFIC industry newsletter *Lets Fish SA* and *WAFIC News*. Nominations were collated by staff at the Southern Fisheries Centre.

In 1997, nine individuals from three fisheries were nominated. They were:

- Steve Everson, for support and assistance in developing BRDs for estuarine prawn-trawl fisheries (New South Wales);
- Laurie Holt, for initiative and leadership in the Moreton Bay trawl fishery (Queensland east coast);
- Herb Olsen, for development and use of TEDs and fish excluders in the Bundaberg area (Queensland east coast);
- Kevin Wicks and Bryan Davies, for design and initiation of TEDs in Moreton Bay (Queensland east coast);
- Peter Holmes, for support and assistance in testing TEDs in the Northern Prawn Fishery;
- Bill Izard for longstanding use and development of BRDs in north Queensland trawl fisheries;
- Garry Anderson, for support, development and leadership in the industry adoption of BRDs in New South Wales prawn trawl fisheries; and
- John Olsen, for contributions to developing, using, initiating broadscale industry use and leadership in the adoption of BRDs into banana prawn fisheries of the Queensland east coast.

The selection committee awarded John Olsen as the 1997 winner, and Garry Anderson and Bill Izard as runner-ups. John Olsen intended to travel to the USA to visit Lindsay Parker, USA Sea Grant Extension Specialist, based at the University of Georgia in Brunswick, Georgia, then visit John Watson and his team of TED and BRD specialists at the National Marine Fisheries Services facility in Pascagoula, Mississippi, and also Captains Harry Jones and Leroy Davies, designers of the Jones-Davies BRD in Freeport, Texas. Unfortunately, two days into the trip a serious family illness resulted in the trip being cancelled.

In 1998, the selection committee was changed to reflect the national perspective of the award. Selection committee members were Murray France (Newfishing Australia), Duncan Leadbitter (Oceanwatch), Eddie Hegerl (Australian Marine Conservation Society), Peter Billam (ex-NORMAC member) and Mike Dredge (QDPI). Nominations were called in December 1998 and January 1999. In 1998, three industry members were nominated. They were:

- Garry Anderson, for support, development and leadership in the industry adoption of BRDs in NSW prawn trawl fisheries;
- Robert Bennett ("Popeye"), for support and development of TEDs and BRDs in the Queensland East Coast Trawl Fishery, Torres Strait Prawn Fishery and Northern Prawn Fishery.
- Les Lowe, for development of TEDs and BRDs for prawn trawl fisheries.

Garry Anderson was the 1998 winner of the Award. Garry is intending to visit the shrimp fisheries of the southeastern USA to assist in trialing of square-mesh panels in the Gulf of Mexico and be an observer on the annual NMFS TED and BRD field testing cruises.

The concept of an industry incentive award seemed to be positive in every practical sense, but the selection committee reported some disappointment at the level of nomination and the lack of positive industry feedback. This award was probably run for an insufficient number of years to develop and generate the industry recognition and prestige that is usually associated with such awards.

## 3. *MULTI-LEVEL BEAM TRAWL EXPERIMENT*

### Catch results

*Prawn catches*

The grooved tiger prawn (*Penaeus semisulcatus*) and the red endeavour prawn (*Metapenaeus ensis*) accounted for 65% to 70% and 16% to 30% of the commercial catch weight respectively during both test periods (Table 5). Other commercially important species caught were the brown tiger prawn (*P. esculentus*), blue endeavour prawn (*M. endeavouri*), western king prawn (*P. latisulcatus*) and banana prawn (*P. merguiensis*).

**Table 5 Species composition of commercial prawns caught by the MBT.**

No weights were recorded for configuration 3, and note the effect of rounding-off on total percentages.

| Species | Configuration 1 | | | | Configuration 2 | | | | Configuration 3 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | wt. (g) | % | n | % | wt. (g) | % | n | % |
| *P. semisulcatus* | 398 | 69.8 | 18855 | 75.0 | 404 | 61.0 | 21855 | 67.8 | 307 | 64.6 |
| *M. ensis* | 101 | 17.7 | 4060 | 16.1 | 163 | 24.6 | 7295 | 22.6 | 142 | 29.9 |
| *M. endeavouri* | 44 | 7.7 | 890 | 3.5 | 66 | 10.0 | 1310 | 4.1 | 13 | 2.7 |
| *P. esculentus* | 24 | 4.2 | 1530 | 6.1 | 28 | 4.2 | 1740 | 5.4 | 13 | 2.7 |
| *P. latisulcatus* | 2 | 0.3 | 25 | 0.1 | 1 | 0.1 | 15 | 0.1 | 0 | 0.0 |
| *P. merguiensis* | 1 | 0.2 | 60 | 0.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Total | 570 | 99.9 | 25 120 | 101.1 | 662 | 99.8 | 32 215 | 100.0 | 475 | 99.9 |

*Bycatch composition*

During the 1993 tests 13,927 teleosts, invertebrates and other bycatch were caught weighing 388,779 g and consisting of 137 taxa of 56 families. In 1998, 41,845 bycatch animals weighing 1,181,542 g were caught, consisting of 172 taxa of 97 families. Teleosts dominated the bycatch, accounting for 68% to 83% of the total number of taxa caught, followed by crustaceans and elasmobranchs (Table 6). Seventeen of the 25 most abundant species caught in each configuration were recorded in all three configurations, and an additional seven species were recorded in two configurations.

For each configuration, the 25 most abundant teleost species accounted for nearly

80% of the total bycatch weight (Table 7). For all configurations combined, Leiognathidae accounted for 36% of the total catch weight, followed by Haemulidae. The dominant bycatch species was the black-tipped ponyfish (*Leiognathus splendens*), accounting for 21% to 36% of the total bycatch weight in each configuration, and 34% to 52% by number. The blotched javelinfish (*Pomadasys maculatum*) followed, accounting for 4% to 9% by weight in each configuration and 3% to 8% by number.

**Table 6 Species composition of total bycatch of the MBT by major group**

| | Configuration 1 (tow nos = 43) | | Configuration 2 (tow nos = 57) | | Configuration 3 (tow nos. = 45) | |
|---|---|---|---|---|---|---|
| Group | No. species | % total | No. species | % total | No. species | % total |
| Teleosts | 101 | 68.2 | 108 | 67.5 | 113 | 82.5 |
| Crustaceans | 20 | 13.5 | 22 | 13.7 | 9 | 6.6 |
| Elasmobranchs | 5 | 3.4 | 5 | 3.1 | 4 | 2.9 |
| Reptiles | 2 | 1.4 | 4 | 2.5 | 0 | 0.0 |
| Cephalopods | 3 | 2.0 | 2 | 1.3 | 3 | 2.2 |
| Bivalves | 1 | 0.7 | 2 | 1.3 | 1 | 0.7 |
| Other | 16 | 10.8 | 17 | 10.6 | 7 | 5.1 |
| Total | 148 | 100.0 | 160 | 100.0 | 137 | 100.0 |

*L. splendens* and the pearly-finned cardinal fish (*Apogon poecilopterus*) were the most frequently caught species, being recorded in 144 from possible 145 tows. The zig-zag ponyfish (*Leiognathus mortoniensis*) was recorded in 140 tows, and a further eight species were recorded in over 80% of tows.

## Table 7 The 25 most abundant teleost species, by weight, caught in each configuration of the MBT

Numbers of individuals and frequency of occurrence (f) are also shown. Cumulative weights and numbers for each species are expressed as a percentage of the total bycatch for each configuration. n = the number of tows for each configuration.

| Rank | Configuration 1 (n = 43) | | | | | |
|---|---|---|---|---|---|---|
| | Species | Wt (g) | Σ Wt. (%) | Nos. | Σ Nos. (%) | f |
| 1 | *Leiognathus splendens* | 84 489 | 22.03 | 4 563 | 34.34 | 43 |
| 2 | *Sillago sihama* | 21 753 | 27.70 | 338 | 36.88 | 39 |
| 3 | *Arius thalassinus* | 18 660 | 32.57 | 445 | 40.23 | 29 |
| 4 | *Johnieops vogleri* | 17 480 | 37.12 | 246 | 42.08 | 38 |
| 5 | *Saurida micropectoralis* | 15 680 | 41.21 | 120 | 42.99 | 38 |
| 6 | *Pomadasys maculatum* | 13 910 | 44.84 | 355 | 45.66 | 40 |
| 7 | *Terapon theraps* | 11 085 | 47.73 | 232 | 47.40 | 38 |
| 8 | *Leiognathus equulus* | 10 675 | 50.51 | 239 | 49.20 | 37 |
| 9 | *Upeneus sulphureus* | 10 545 | 53.26 | 286 | 51.35 | 35 |
| 10 | *Pomadasys trifasciatus* | 9 520 | 55.74 | 349 | 53.98 | 39 |
| 11 | *Drepan punctata* | 9 440 | 58.21 | 164 | 55.22 | 39 |
| 12 | *Nemipterus hexodon* | 9 070 | 60.57 | 223 | 56.89 | 40 |
| 13 | *Pseudorhombus arsius* | 8 825 | 62.87 | 112 | 57.74 | 38 |
| 14 | *Johnius amblycephalus* | 7 865 | 64.92 | 105 | 58.53 | 26 |
| 15 | *Apogon poecilopterus* | 6 630 | 66.65 | 859 | 64.99 | 43 |
| 16 | *Upeneus sundiacus* | 6 480 | 68.34 | 132 | 65.98 | 36 |
| 17 | *Polydactylus multiradiatus* | 6 050 | 69.72 | 75 | 66.55 | 27 |
| 18 | *Inegocia japonica* | 6 031 | 71.49 | 212 | 68.14 | 39 |
| 19 | *Gerres filamentosus* | 5 205 | 72.85 | 121 | 69.05 | 35 |
| 20 | *Pomadasys kaakan* | 5 190 | 74.20 | 47 | 69.41 | 28 |
| 21 | *Psettodes erumei* | 4 570 | 75.39 | 40 | 69.71 | 27 |
| 22 | *Torquigener whitleyi* | 4 503 | 76.57 | 167 | 70.97 | 41 |
| 23 | *Sardinella gibbosa* | 3 715 | 77.54 | 177 | 72.30 | 24 |
| 24 | *Paraplagusia bilineata* | 3 670 | 78.49 | 32 | 72.54 | 21 |
| 25 | *Leiognathus mortoniensis* | 3 500 | 79.40 | 263 | 74.52 | 40 |
| | Total | 304 541 | 79.40 | 9 902 | 74.52 | |
| | Other species | 78 990 | 20.60 | 3 386 | 25.48 | |
| | Total (all species) | 383 531 | 100.00 | 13 288 | 100.00 | |

| Rank | Configuration 2 (n = 57) | | | | | |
|---|---|---|---|---|---|---|
| | Species | Wt (g) | Σ Wt. (%) | Nos. | Σ Nos. (%) | f |
| 1 | *Leiognathus splendens* | 286 695 | 35.93 | 14 765 | 51.70 | 56 |
| 2 | *Pomadasys maculatum* | 41 920 | 41.18 | 992 | 55.18 | 51 |
| 3 | *Leiognathus equulus* | 35 735 | 45.66 | 777 | 57.90 | 51 |
| 4 | *Terapon theraps* | 26 440 | 48.97 | 524 | 59.73 | 51 |
| 5 | *Sillago sihama* | 24 620 | 52.06 | 524 | 61.57 | 45 |
| 6 | *Upeneus sulphureus* | 23 275 | 54.97 | 598 | 63.66 | 55 |
| 7 | *Saurida micropectoralis* | 21 415 | 57.66 | 183 | 64.30 | 47 |
| 8 | *Pomadasys trifasciatus* | 15 595 | 59.61 | 494 | 66.03 | 50 |
| 9 | *Johnieops vogleri* | 15 563 | 61.56 | 230 | 66.84 | 38 |
| 10 | *Secutor insidiator* | 12 721 | 63.15 | 627 | 69.03 | 36 |
| 11 | *Leiognathus mortoniensis* | 11 248 | 64.56 | 811 | 71.87 | 56 |
| 12 | *Pseudorhombus arsius* | 11 215 | 65.97 | 137 | 72.35 | 47 |
| 13 | *Nemipterus hexodon* | 10 763 | 67.32 | 238 | 73.19 | 52 |
| 14 | *Caranx bucculentus* | 9 325 | 68.49 | 76 | 73.45 | 37 |
| 15 | *Arius thalassinus* | 9 285 | 69.65 | 159 | 74.01 | 30 |
| 16 | *Pomadasys kaakan* | 9 265 | 70.81 | 92 | 74.33 | 37 |
| 17 | *Polydactylus multiradiatus* | 9 165 | 71.96 | 101 | 74.69 | 42 |
| 18 | *Upeneus sundiacus* | 8 695 | 73.05 | 177 | 75.31 | 45 |
| 19 | *Apogon poecilopterus* | 8 651 | 74.13 | 1 098 | 79.15 | 56 |
| 20 | *Gerres filamentosus* | 8 055 | 75.14 | 164 | 79.72 | 46 |
| 21 | *Inegocia japonica* | 6 950 | 76.01 | 237 | 80.55 | 50 |
| 22 | *Drepan punctata* | 6 650 | 76.85 | 100 | 80.90 | 40 |
| 23 | *Gazza minuta* | 6 260 | 77.63 | 190 | 81.57 | 35 |
| 24 | *Torquigener whitleyi* | 5 941 | 78.38 | 188 | 82.23 | 51 |
| 25 | *Psettodes erumei* | 5 665 | 79.09 | 52 | 82.41 | 32 |
| | Total | 631 112 | 79.09 | 23 534 | 82.41 | |
| | Other species | 166 899 | 20.91 | 5 023 | 17.56 | |
| | Total (all species) | 798 011 | 100.00 | 28 557 | 100.00 | |

| Rank | Configuration 3 (n = 45) | | | | | |
|---|---|---|---|---|---|---|
| | Species | Wt (g) | Σ Wt. (%) | Nos. | Σ Nos. (%) | f |
| 1 | *Leiognathus splendens* | 80 880 | 20.80 | 5 629 | 40.42 | 45 |
| 2 | *Pomadasys maculatum* | 35 840 | 30.02 | 1 098 | 48.30 | 44 |
| 3 | *Pomadasys trifasciatus* | 30 480 | 37.86 | 1 109 | 56.26 | 45 |
| 4 | *Leiognathus equulus* | 21 100 | 43.29 | 484 | 59.74 | 40 |
| 5 | *Pomadasys kaakan* | 21 000 | 48.69 | 327 | 62.09 | 44 |
| 6 | *Leiognathus mortoniensis* | 13 050 | 52.05 | 1 139 | 70.27 | 44 |
| 7 | *Terapon theraps* | 9 550 | 54.50 | 201 | 71.71 | 36 |
| 8 | *Upeneus sulphureus* | 9 290 | 56.89 | 254 | 73.53 | 40 |
| 9 | *Psettodes erumei* | 8 600 | 59.11 | 53 | 73.91 | 23 |
| 10 | *Saurida micropectoralis* | 8 100 | 61.19 | 75 | 74.45 | 35 |
| 11 | *Pseudorhombus arsius* | 7 180 | 63.04 | 111 | 75.25 | 33 |
| 12 | *Apogon poecilopterus* | 7 080 | 64.86 | 596 | 79.53 | 45 |
| 13 | *Caranx bucculentus* | 6 030 | 66.41 | 90 | 80.18 | 34 |
| 14 | *Platycephalus indicus* | 5 600 | 67.85 | 37 | 80.44 | 20 |
| 15 | *Torquigener whitleyi* | 5 450 | 69.25 | 143 | 81.47 | 38 |
| 16 | *Gerres filamentosus* | 5 360 | 70.63 | 123 | 82.35 | 31 |
| 17 | *Sillago sihama* | 4 460 | 71.78 | 71 | 82.86 | 29 |
| 18 | *Johnieops vogleri* | 4 380 | 72.90 | 63 | 83.31 | 27 |
| 19 | *Sardinella albella* | 4 380 | 74.03 | 155 | 84.43 | 31 |
| 20 | *Euristhmus nudiceps* | 4 300 | 75.14 | 34 | 84.67 | 18 |
| 21 | *Chelonodon patoca* | 4 180 | 76.21 | 56 | 85.07 | 28 |
| 22 | *Drepan punctata* | 4 000 | 77.24 | 77 | 85.63 | 28 |
| 23 | *Johnius amblycephalus* | 3 720 | 78.20 | 48 | 85.97 | 22 |
| 24 | *Anodontostoma chacunda* | 3 610 | 79.13 | 47 | 86.31 | 25 |
| 25 | *Leiognathus bindus* | 3 260 | 79.96 | 162 | 87.47 | 17 |
| | Total | 310 880 | 79.96 | 12 182 | 87.47 | |
| | Other species | 77 899 | 20.04 | 1 745 | 12. 53 | |
| | Total (all species) | 388 779 | 100.00 | 13 927 | 100.00 | |

## Vertical distribution of prawns

The vertical distribution of prawns was tested with leadahead panels fitted to the two horizontal separator panels and the upper most panel (configuration 1). Results from 43 tows clearly indicated that commercial prawns were caught mainly on or near the seabed, with few prawns swimming greater than 600 mm above the seabed (Table 8). Of the four dominant commercial prawn species caught, over 96% of three species were caught in the bottom level, but only 52% of *M. endeavouri* was caught in this level. *Trachypenaeus* spp. was caught in higher numbers close to the seabed while *Metapenaeopsis* spp. was caught in higher numbers off the seabed.

### Table 8 Prawn species caught in configuration 1 of the MBT

| Species | Level | n | % | wt (g) | % | Species | Level | n | % | wt (g) | % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *P. semisulcatus* | Top | 4 | 1 | 190 | 1 | *P. latisulcatus* | Top | 1 | 50 | 10 | 40 |
| | Middle | 12 | 3 | 720 | 4 | | Middle | 0 | 0 | 0 | 0 |
| | Bottom | 382 | 96 | 17945 | 95 | | Bottom | 1 | 50 | 15 | 60 |
| | Total | 398 | 100 | 18855 | 100 | | Total | 2 | 100 | 25 | 100 |
| *P. esculentus* | Top | 0 | 0 | 0 | 0 | *P. merguiensis* | Top | 0 | 0 | 0 | 0 |
| | Middle | 0 | 0 | 0 | 0 | | Middle | 1 | 100 | 60 | 100 |
| | Bottom | 24 | 100 | 1530 | 100 | | Bottom | 0 | 0 | 0 | 0 |
| | Total | 24 | 100 | 1530 | 100 | | Total | 1 | 100 | 60 | 100 |
| *M. ensis* | Top | 1 | 1 | 5 | 0 | *Trachypenaeus* spp | Top | 13 | 2 | 79 | 2 |
| | Middle | 3 | 3 | 65 | 2 | | Middle | 185 | 27 | 696 | 23 |
| | Bottom | 97 | 97 | 3990 | 98 | | Bottom | 478 | 71 | 2284 | 75 |
| | Total | 101 | 100 | 4060 | 100 | | Total | 676 | 100 | 3059 | 100 |
| *M. endeavouri* | Top | 4 | 9 | 35 | 4 | *Metapenaeopsis* spp | Top | 34 | 13 | 157 | 16 |
| | Middle | 17 | 39 | 225 | 25 | | Middle | 154 | 59 | 530 | 54 |
| | Bottom | 23 | 52 | 630 | 71 | | Bottom | 73 | 28 | 301 | 30 |
| | Total | 44 | 100 | 890 | 100 | | Total | 261 | 100 | 988 | 100 |

Results from configuration 1 show that there was no significant difference in the mean length of *P. semisulcatus* between levels, but the size of *M. ensis* and *M. endeavouri* was significantly smaller in the upper levels (Table 9). Insufficient numbers of *P. esculentus* were caught in the upper levels to assess the distribution of this species.

**Table 9 Back-transformed mean carapace length (mm) and 95% confidence intervals of commercial prawn species caught in each configuration of the MBT.**

T = top level, M = middle level, B = bottom level

| Species | Level | Configuration 1 | | | | Configuration 2 | | | | Configuration 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | C. I. | | | | C. I. | | | | C. I. | | |
| | | $\bar{x}$ | Lower | Upper | n | $\bar{x}$ | Lower | Upper | n | $\bar{x}$ | Lower | Upper | n |
| *P. semisulcatus* | T | 36.0 | 29.04 | 44.67 | 4 | 41.9 | 35.81 | 48.86 | 4 | 35.1 | 33.04 | 37.24 | 56 |
| | M | 36.9 | 32.28 | 42.17 | 12 | 37.8 | 36.81 | 38.64 | 156 | 35.4 | 33.27 | 37.67 | 15 |
| | B | 37.1 | 36.56 | 37.58 | 382 | 37.1 | 36.31 | 37.93 | 243 | 31.4 | 30.55 | 32.21 | 225 |
| *M. ensis* | T | 11.0 | 10.99 | 10.99 | 1 | - | - | - | 0 | 33.8 | 29.79 | 38.37 | 15 |
| | M | 23.4 | 6.50 | 83.95 | 3 | 39.5 | 37.76 | 41.40 | 17 | 24.0 | 3.59 | 161.44 | 3 |
| | B | 36.5 | 35.32 | 37.67 | 97 | 36.8 | 36.06 | 37.58 | 144 | 36.4 | 35.40 | 37.41 | 122 |
| *M. endeavouri* | T | 16.9 | 13.37 | 21.28 | 4 | 13.1 | 11.59 | 14.79 | 6 | - | - | - | 0 |
| | M | 16.4 | 15.03 | 17.91 | 15 | 17.0 | 14.09 | 20.56 | 16 | - | - | - | 0 |
| | B | 25.5 | 22.34 | 29.04 | 23 | 20.6 | 18.32 | 23.28 | 44 | 34.7 | 29.31 | 41.02 | 13 |
| *P. esculentus* | T | - | - | - | 0 | - | - | - | 10 | - | - | - | 0 |
| | M | - | - | - | 0 | 36.9 | 33.81 | 40.27 | 16 | 27.0 | 26.98 | 26.98 | 1 |
| | B | 39.3 | 36.56 | 42.07 | 24 | 39.7 | 36.90 | 42.76 | 11 | 24.7 | 21.93 | 27.93 | 12 |

## Prawn escape reactions

The escape reaction of commercial prawns was tested by removing the leadahead panels. Removal of the bottom leadahead panel (configuration 2) allowed prawns to react vertically to the trawl and enter either the bottom or middle levels. Therefore, catches in the top level were those prawns swimming between 1200 mm and 1800 mm above the seabed at the time of capture. Removal of the bottom and middle leadahead panels (configuration 3) allowed prawns to respond vertically to the trawl and enter either the middle or top levels. Catches in these levels also included prawns swimming at the time of capture. Catch results for these configurations are shown in Figure 6.

Configuration 2 showed increased proportions of *P. semisulcatus*, *M. ensis* and *P. esculentus* captured in the middle codend. Configuration 3 showed increased catches of *P. semisulcatus* and *M. ensis* in the top codend, suggesting a strong vertical reaction to the trawl by these species. Despite relatively low numbers, the results for *M. endeavouri* indicate a more "pelagic" lifestyle than other species and the absence of reaction to the trawl.

Table 9 shows the relationship between prawn escape reactions and prawn length in all configurations of the MBT. There is a good indication that for *P. semisulcatus,* larger individuals are more capable of reaching the upper levels of the MBT, although only in configuration 3 is the difference in prawn length significant. The mean length of *M. ensis* also increased with height above the seabed following removal of the leadahead panels. In contrast the mean length of *M. endeavouri* decreased with height above the seabed, adding to the notion that larger prawns did not respond vertically to the trawl and the catch was comprised of smaller prawns swimming at the time of capture.

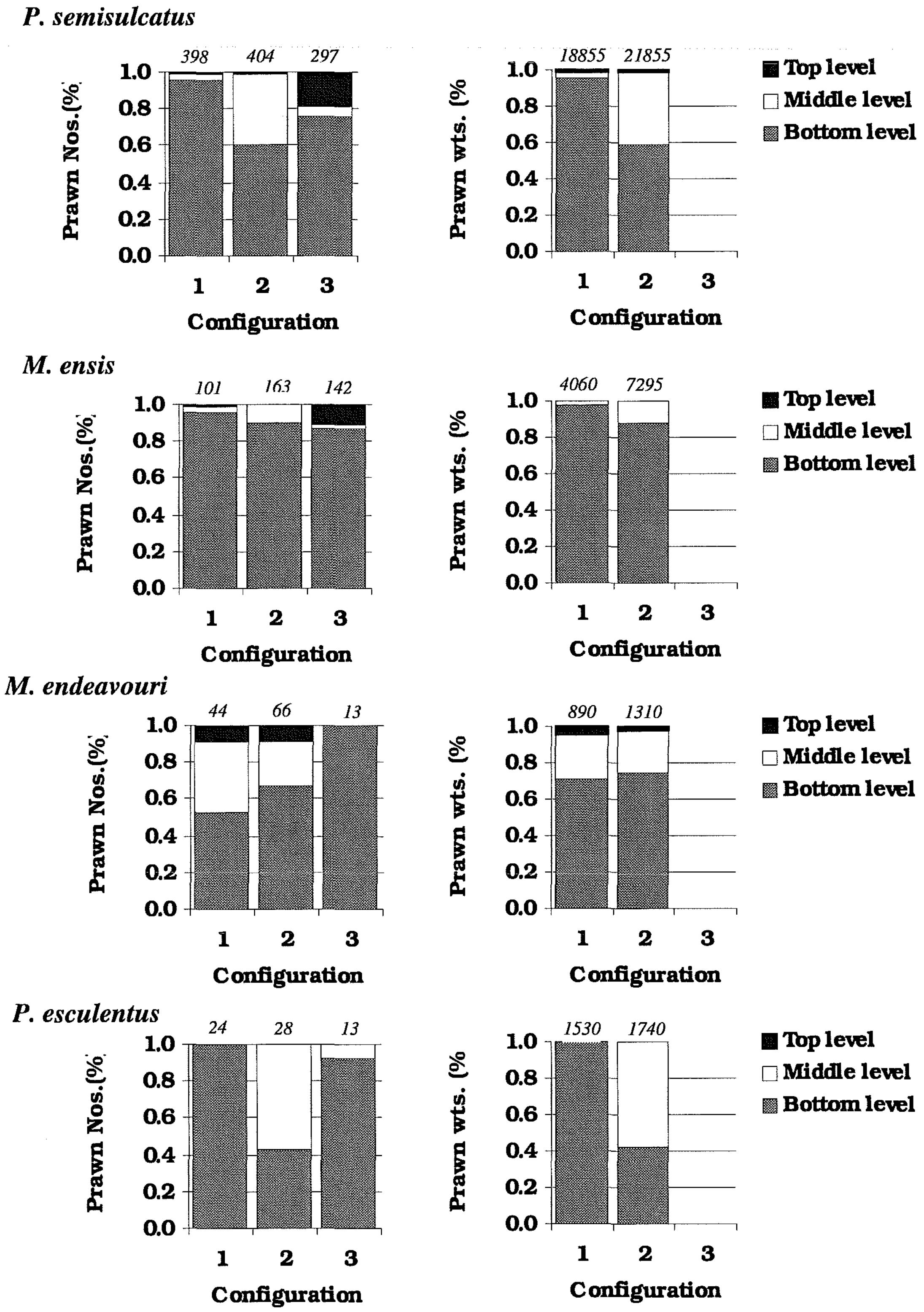


**Figure 6 Commercial prawns caught in the three configurations of the MBT**

Total number of each species in each configuration is shown. No catch weights were collected for configuration 3

# Table 10 The 25 most abundant species, by weight, of configuration 1 of the MBT

Number of tows = 43.

| Rank | Species | Bottom Wt (g) | Bottom % | Bottom Nos. | Bottom % | Middle Wt (g) | Middle % | Middle Nos. | Middle % | Top Wt (g) | Top % | Top Nos. | Top % | Total (all levels) Wt (g) | ∑ Wt. (%) | Nos. | ∑ Nos. (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *1* | *Leiognathus splendens* | 79 324 | 93.89 | 4 327 | 94.83 | 4 860 | 5.75 | 225 | 4.93 | 305 | 0.36 | 11 | 0.24 | 84 489 | 22.03 | 4 563 | 34.34 |
| *2* | *Sillago sihama* | 17 555 | 80.70 | 279 | 82.54 | 3 813 | 17.53 | 53 | 15.68 | 385 | 1.77 | 6 | 1.78 | 21 753 | 27.70 | 338 | 36.88 |
| *3* | *Arius thalassinus* | 18 365 | 98.42 | 438 | 98.43 | 255 | 1.58 | 6 | 1.35 | 40 | 0.00 | 1 | 0.22 | 18 660 | 32.57 | 445 | 40.23 |
| *4* | *Johnieops vogleri* | 17 275 | 98.83 | 243 | 98.78 | 205 | 1.17 | 3 | 1.22 | 0 | 0.00 | 0 | | 17 480 | 37.12 | 246 | 42.08 |
| *5* | *Saurida micropectoralis* | 11 985 | 76.43 | 78 | 65.00 | 2 360 | 15.05 | 29 | 24.17 | 1 335 | 8.52 | 13 | 10.83 | 15 680 | 41.21 | 120 | 42.99 |
| *6* | *Pomadasys maculatus* | 13 270 | 95.40 | 330 | 92.96 | 535 | 3.85 | 13 | 3.66 | 105 | 0.75 | 12 | 3.38 | 13 910 | 44.84 | 355 | 45.66 |
| *7* | *Terapon theraps* | 10 200 | 92.01 | 214 | 92.24 | 785 | 7.08 | 17 | 7.33 | 100 | 0.01 | 1 | 0.43 | 11 085 | 47.73 | 232 | 47.40 |
| *8* | *Leiognathus equulus* | 9 490 | 88.90 | 213 | 89.12 | 1 065 | 9.98 | 24 | 10.04 | 120 | 1.12 | 2 | 0.84 | 10 675 | 50.51 | 239 | 49.20 |
| *9* | *Upeneus sulphureus* | 7 815 | 74.11 | 215 | 75.17 | 2 290 | 21.72 | 59 | 20.63 | 440 | 4.17 | 12 | 4.20 | 10 545 | 53.26 | 286 | 51.35 |
| *10* | *Pomadasys trifasciatus* | 9 080 | 95.38 | 334 | 95.70 | 440 | 4.62 | 15 | 4.30 | 0 | 0.00 | 0 | 0.00 | 9 520 | 55.74 | 349 | 53.98 |
| *11* | *Drepan punctata* | 9 440 | 100.00 | 164 | 100.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 9 440 | 58.21 | 164 | 55.22 |
| *12* | *Nemipterus hexodon* | 7 375 | 81.31 | 177 | 79.37 | 1 665 | 18.36 | 45 | 20.18 | 30 | 0.33 | 1 | 0.45 | 9 070 | 60.57 | 223 | 56.89 |
| *13* | *Pseudorhombus arsius* | 8 825 | 100.00 | 112 | 100.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 8 825 | 62.87 | 112 | 57.74 |
| *14* | *Johnius amblycephalus* | 7 865 | 100.00 | 105 | 100.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 7 865 | 64.92 | 105 | 58.53 |
| *15* | *Apogon poecilopterus* | 4 880 | 73.61 | 503 | 58.56 | 1 540 | 23.23 | 330 | 38.42 | 210 | 3.16 | 26 | 3.02 | 6 630 | 66.65 | 859 | 64.99 |
| *16* | *Upeneus sundiacus* | 3 770 | 58.18 | 77 | 58.33 | 2 225 | 34.37 | 46 | 34.85 | 485 | 7.45 | 9 | 6.82 | 6 480 | 68.34 | 132 | 65.98 |
| *17* | *Polydactylus multiradiatus* | 5 830 | 96.36 | 72 | 96.00 | 145 | 2.40 | 2 | 2.67 | 75 | 1.24 | 1 | 1.33 | 6 050 | 69.72 | 75 | 66.55 |
| *18* | *Inegocia japonica* | 5 356 | 88.81 | 184 | 86.79 | 605 | 10.03 | 26 | 12.26 | 70 | 1.16 | 2 | 0.95 | 6 031 | 71.49 | 212 | 68.14 |
| *19* | *Himantura toshi* | 5 650 | 100.00 | 3 | 100.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 5 650 | 72.96 | 3 | 68.17 |
| *20* | *Gerres filamentosus* | 5 010 | 96.25 | 116 | 95.87 | 195 | 3.75 | 5 | 4.13 | 0 | 0.00 | 0 | 0.00 | 5 205 | 74.32 | 121 | 69.08 |
| *21* | *Pomadasys kaakan* | 4 980 | 95.95 | 45 | 95.74 | 210 | 4.05 | 2 | 4.26 | 0 | 0.00 | 0 | 0.00 | 5 190 | 75.67 | 47 | 69.43 |
| *22* | *Psettodes erumei* | 4 555 | 99.67 | 39 | 97.50 | 15 | 0.33 | 1 | 0.50 | 0 | 0.00 | 0 | 0.00 | 4 570 | 76.87 | 40 | 69.73 |
| *23* | *Torquigener whitleyi* | 3 845 | 85.39 | 142 | 85.03 | 508 | 11.28 | 20 | 11.98 | 150 | 3.33 | 5 | 2.99 | 4 503 | 78.04 | 167 | 70.99 |
| *24* | *Thenus indicus* | 1 790 | 47.66 | 20 | 51.28 | 166 | 31.04 | 12 | 30.77 | 800 | 21.30 | 7 | 17.95 | 3 756 | 79.02 | 39 | 71.28 |
| *25* | *Sardinella gibbosa* | 890 | 23.96 | 45 | 25.42 | 1 585 | 42.66 | 72 | 40.68 | 1 240 | 33.38 | 60 | 33.90 | 3 715 | 79.99 | 177 | 72.61 |
| | Total | 274 420 | 89.45 | 8 475 | 87.83 | 26 467 | 8.63 | 1 005 | 10.42 | 5 890 | 1.92 | 169 | 1.75 | 306 777 | 79.99 | 9 649 | 72.61 |
| | Other species | 63 191 | 82.33 | 2 356 | 64.75 | 10 788 | 14.06 | 1 074 | 29.51 | 2 775 | 3.61 | 209 | 5.74 | 76 754 | 20.01 | 3 639 | 27.39 |
| | Total (all species) | 337 611 | 100.00 | 10 831 | 100.00 | 37 255 | 100.00 | 2 079 | 100.00 | 8 665 | 100.00 | 378 | 100.00 | 383 531 | 100.00 | 13 288 | 100.00 |

### Vertical distribution of fish and other bycatch

Configuration 1 also provided a measure of the vertical distribution of fish and other bycatch species. A total of 13,288 individuals (including non-commercial prawns) weighing 383,531 g and consisting of 150 taxa of 83 families were caught in configuration 1 (Table 11).

**Table 11 Bycatch of the MBT, configuration 1**

| Level | Weight (g) | % | Number | % |
|---|---|---|---|---|
| Top | 8,655 | 2.0 | 378 | 3.0 |
| Middle | 37,255 | 10.0 | 2,079 | 15.5 |
| Bottom | 337,611 | 88.0 | 10,831 | 81.5 |
| Total | 383,531 | 100.0 | 13,288 | 100.0 |

The bulk of the bycatch was caught in the bottom level within 600 mm of the seabed. This level accounted for 88% of the bycatch by weight and 82% by number. The 25 most abundant species accounted for 80% of the total bycatch weight in this configuration and 73% by numbers (Table 10). These species were dominated by teleosts (23), one species of ray (*Himantura toshi*) and the mud bug (*Thenus indicus*) species.

### Escape reactions of fish bycatch

Figure 7 shows the proportion of total bycatch in each level for all three configurations of the multi-level beam trawl. The effects of the leadahead panels were dramatic, with many bycatch species demonstrating an upward escape reaction in response to the trawl. In configuration 1, almost 90% of the bycatch by weight and 82% by number was caught in the bottom level. Removal of the lower leadahead panel (configuration 2) resulted in only 40% of the bycatch being caught the bottom level. Removal of both leadahead panels (configuration 3) resulted in an almost equal division of the catch between the top and bottom levels, and about 20% of the catch being caught in the middle level.

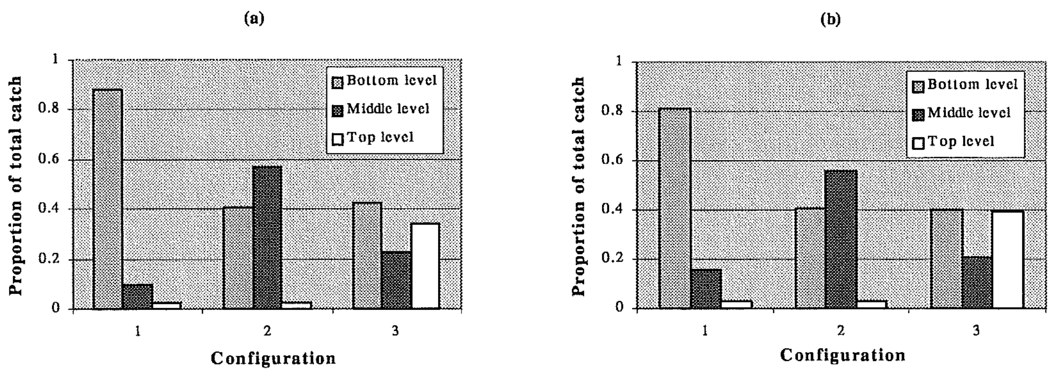


**Figure 7 Proportion of bycatch in each MBT configuration**

(a) by weight and (b) by numbers

Five of the 17 species that were recorded in all three configurations, the pearly-finned cardinal fish *(Apogon poecilopterus)*, the large-toothed flounder (*Pseudorhombus arsius*), northern whiting (*Sillago sihama*), sicklefish (*Drepan punctata*) and tropical halibut (*Psettodes erumei*) were caught mainly in the bottom level of each configuration (Appendix 6). A further ten species were caught mainly within 1200 mm of the seabed (i.e. middle level).

Following the removal of both leadahead panels (configuration 3) nearly all of the 17 species were caught in greater numbers in the upper levels of the MBT. Three species of Leiognathidae, the black-tipped ponyfish (*Leiognathus splendens*), the zig-zag ponyfish (*L. mortoniensis*) and the narrow-banded ponyfish (*L. equulus*) and two species of Haemulidae, the javelinfish (*Pomadasys trifasciatus*) and the yellow-finned javelinfish (*P. kaakan*), were caught mainly in the top level of configuration three, and accounted for almost 45% of the total catch weight of these species in this configuration. *Leiognathus splendens* was the dominant teleost species in this study, accounting for 21% to 36% of the total bycatch by weight. In configuration 1 almost 94% of this species was recorded in the bottom level and only 6% in the middle level. Following removal of the bottom leadahead panel (configuration 2) the proportion of *L. splendens* caught in the bottom level decreased to 38% while the middle level increased to 62%, and the removal of the middle leadahead panel (configuration 3) allowed almost 50% of this species to be retained in the top level. The escape reactions of fish did not appear to be based on their length, with little difference in length range between levels.

### Reducing trawl headline height: potential for bycatch reduction

The results from configuration 1 clearly showed that almost 90% of the bycatch and over 96% of most commercial prawns were distributed on or close to the seabed (<600 mm). Presuming that this behaviour is typical for these species, then simply reducing the headline height of existing prawn trawls will allow only a small proportion of the bycatch to escape over the trawl. A reduction in headline height will also result in a concomitant increase in wingend spread (Eayrs, 1993), which in turn is likely to further increase the amount of bycatch caught. The potential for a reduction in bycatch through the use of lower opening trawls is therefore low, unless the use of BRDs can overcome any increased bycatch. The catch results also suggest that much of the bycatch did not attempt to escape until in close proximity to the trawl. This suggests that these species were unable to respond visually to the trawl under nocturnal conditions and escape as it approached. A reduction in headline height and greater illumination of the trawl using glow netting or even cyalume sticks are novel options that may go some way to making it easier for these species to avoid the trawl.

The results from configuration 2 and 3 show that many bycatch species exhibit strong upward responses to an approaching trawl. In both configurations about 60% of the bycatch was caught in the upper levels. *Leiognathus splendens* was the dominant teleost species in this study and almost 50% of this species was capable of responding vertically to the trawl to heights in excess of 1200 mm. A BRD that takes advantage of this behaviour may substantially reduce the amount of bycatch caught, and the use of large-mesh panels or windows fitted to the top panel of the trawl may allow large numbers of these species to escape from the trawl as they rise vertically.

Alternatively, square-mesh panels could be employed, although careful selection of mesh size would be required to prevent prawn loss.

The MBT was a valuable tool for assessing the behaviour of prawns and fish in low-light conditions unsuitable for contemporary camera equipment. For the first time in a tropical prawn trawl fishery, the vertical distribution of prawns and fish and their behaviour in response to a trawl has been recorded in detail. Knowledge of bycatch behaviour obtained from the MBT experiment can be included in the development of more effective BRDs.

## *4. SURVEY OF TED AND BRD USE*

### Queensland east coast

The questionnaire was distributed to 758 licence holders endorsed for otter trawling in the Queensland East Coast Trawl Fishery. A total of 274 surveys (= 36%) were returned from vessels that fished a wide range of areas and species throughout the fishery (Table 12). Twenty-five respondents also fished for Moreton Bay bugs, 12 for squid and cuttlefish, 10 for crabs, seven for fish, and two for live leader prawns. It should be noted that in Table 12, responses for fished species are not mutually exclusive and therefore do not sum to the total number of responses. Respondents to the survey appeared to represent a cross-section of fishers involved in the Queensland East Coast Trawl Fishery, in terms of the geographic locations they fish and the species they target. However, it is unclear whether or not the survey is biased toward fishers who use TEDs or BRDs. Responses to the survey relied on fishers voluntarily filling in the questionnaire and returning it by reply-paid post, and as such, it is likely that individuals with strong feelings for or against TEDs and BRDs would have taken the trouble to respond. It is impossible to correct for such potential bias without undertaking a complete one-to-one census of the fleet, which was beyond the intentions of the survey.

**Table 12 Area and species fished by respondents to the TED and BRD survey**

| | king prawns | tigers & endeavour prawns | banana prawns | scallops | bay prawns | Total |
|---|---|---|---|---|---|---|
| Cairns north | 19 | 46 | 11 | 1 | 0 | 50 |
| Cairns to Yeppoon | 35 | 33 | 31 | 22 | 0 | 54 |
| Yeppoon to NSW border | 59 | 25 | 13 | 41 | 6 | 65 |
| Moreton Bay | 23 | 22 | 22 | 0 | 22 | 24 |
| Combination of areas | 64 | 55 | 37 | 42 | 9 | 79 |
| Total | 200 | 181 | 114 | 106 | 37 | 274 |

### TEDs

Just over 1% of survey respondents indicated the regular use of TEDs before the 1st January 1997. About 3% indicated they began the regular use of TEDs sometime in 1997 and about 7% indicated they began the regular use of TEDs sometime in 1998. A further 8.5% indicated they began the regular use of TEDs between the 1st January 1999 and the 30th April 1999. This gave a total of 20% of survey respondents

20% of 276 = 55

regularly using of TEDs prior to the regulation of TEDs in the Queensland East Coast Trawl Fishery on the 1st May 1999. An additional 3% of respondents used of TEDs after the 1st May 1999. TEDs were not consistently used in all areas of the fishery. Greatest use of TEDs clearly occurred on vessels that fished inshore areas (Table 13), and in certain geographic areas e.g. in the Moreton Bay fishery (71%) and on vessels that fished from north of Cairns north to Yeppoon (60%).

**Table 13 Usage of TEDs in the Queensland East Coast Trawl Fishery, by area**

| Area fished | Surveys returned | % using TEDs | Area fished | Surveys returned | % using TEDs |
|---|---|---|---|---|---|
| Inshore only | 52 | 48 | Cairns north | 52 | 38 |
| Inshore & Near Reef | 55 | 24 | Cairns to Yeppoon | 55 | 42 |
| Inshore & Near Reef & Offshore/Deepwater | 13 | 15 | Yeppoon to NSW | 70 | 17 |
| Inshore & Offshore/Deepwater | 15 | 0 | Moreton Bay | 24 | 71 |
| Near Reef only | 15 | 13 | Entire Coast | 10 | 30 |
| Near Reef & Offshore/Deepwater | 3 | 0 | Cairns to NSW | 25 | 12 |
| Offshore/Deepwater only | 34 | 9 | Yeppoon to Cairns north | 15 | 60 |
| Not indicated | 86 | 37 | Not indicated | 22 | 0 |

A number of TED designs were used by survey respondents. TEDs designed or made to a unique specification dominated survey responses (n = 22), followed by use of the Wick's TED (19), Seymour TED (10), super shooter TED (4), bigeyes (4), Sharp's TED (4), Popeye's TED (2), GNM's TED (2), Nordmore grid (2), NAFTED (2), hooped hard TED (2), net perfection TED (1) and a soft TED (1), with four respondents not indicating any design. TEDs were most commonly manufactured by the netmakers (31), with the remainder being made by other fishers or project staff (21) and the skipper or owner of the vessel (21).

Many reasons were given for the voluntary use of TEDs prior to the 1st May 1999. The responses were not pre-formulated (i.e. tick a box), but rather represented the reasons expressed by fishers in their own words. This is true of all other comments and reasons given in the summary. In decreasing order of response, the reasons for the voluntary use of TEDs were: (i) no large animals including turtles, (ii) upcoming regulations, (iii) improved prawn quality, (iv) reduced workload, (v) exclusion of jellyfish, (vi) environmental reasons, and (vii) to gain personal knowledge on how TEDs worked. Sixteen fishers had trialed a TED prior to 1st May 1999, but not continued to use a TED. They cited they following reasons for the lack of regular use: (i) no regulation to use a TED, (ii) loss of catch, (iii) no benefits of using a TED, and (iv) "perceived that other threats to sea turtles were greater than that posed by the trawl industry".

Fishers who had not trialed a TED prior to the 1st May 1999 cited the following reasons: (i) didn't fish in turtle areas, (ii) TEDs perceived as unnecessary, (iii) no regulations, (iv) perceived operational problems, (v) TEDs on order or ready for use, (vi) perceived cost of installation, (vii) vessel not fishing or a recent licence change, (viii) lack of information or opportunity to trial TEDs, and (ix) "perceived that other threats to sea turtles were greater than trawl industry".

Sixty-four percent of all survey responses made no comment on the performance of TEDs. The remaining respondents' comments are summarised in Table 14.

**Table 14 Comments about TEDs from the survey of the Queensland East coast Trawl Fishery**

| Positive Comments | Negative Comments |
|---|---|
| would not work without them | prone to clogging |
| should be compulsory | dangerous |
| good for excluding large animals | impossible to work in triple gear |
| great advantage to inshore fishing | harder for small boats to tow |
| benefit the fishery | lose catch |
| work well in Moreton Bay | TEDs are unnecessary |
| no great difference in catch | costly |
| good idea | |

## BRDs

About 38% of survey respondents used a BRD prior to 1st May 1999. BRD designs included "V" cuts (27%), bigeye BRDs, (17%), square-mesh panels (14%), fisheyes (10%), radial escape devices (10%), modified TEDs (9%), and "own design" BRDs (7%). BRDs were most commonly manufactured by the skipper or owner of the vessel (75%), then by a netmaker (17%), with the remainder being manufactured by another fisher or project staff. Fishers were requested in the survey to comment on the effectiveness of their BRDs. Varying levels of bycatch reduction were reported (Table 15).

**Table 15 Bycatch reduction reported for BRDs used in the Queensland East Coast Trawl Fishery**

| Design | 0% to 10% bycatch reduction | 10% to 30% bycatch reduction | 30% to 50% bycatch reduction | greater than 50% bycatch reduction |
|---|---|---|---|---|
| V cut | 3 | 9 | 9 | 8 |
| Bigeye | 2 | 5 | 9 | 4 |
| Square mesh panel | 2 | 8 | 3 | 3 |
| Fisheye | 2 | 3 | 2 | 2 |
| Modified TED | 1 | 3 | 3 | 3 |
| Radial escape device | 3 | 2 | 4 | 1 |
| Own design | 1 | 2 | 3 | 1 |
| Other designs | 0 | 1 | 1 | 1 |
| Total | 14 | 33 | 33 | 23 |

Numbers in the table indicate the number of respondents who reported this category of bycatch reduction.

Survey respondents gave a number of reasons for using a BRD. They included (in decreasing order of response): (i) reduced fish bycatch, (ii) reduced work load, (iii) improved prawn quality, (iv) impending regulations, (v) no loss of catch, (vi) improving the fish exclusion of BRDs, (vii) environmental reasons, and viii) benefits to fishing.

Another seven survey respondents trialed BRDs prior to 1st May 1999 and cited the following reasons for not using a BRD on a regular basis: (i) no regulations, (ii) loss of catch and marketable byproduct (threat to livelihood), and (iii) perceived as unnecessary.

Survey respondents who had not trialed a BRD prior to the 1st May 1999 cited several reasons including: (i) perceived as unnecessary, (ii) did not fish in areas that would require a BRD, (iii), no regulations, (iv) perceived economic considerations, (v) lack of information on BRDs or opportunity to trial a BRD, (vi) vessel not fishing or recent licence change, (vii) waiting for better BRD designs, (viii) BRD on order or ready to use, (ix) perceived operational problems, (x) considered that TEDs work as well as a BRD, and (xi) unwilling to try something new.

About 57% of survey responses made no comment on the performance of BRDs on the Queensland east coast. The remaining comments of respondents are summarised in Table 16.

**Table 16 Survey comments on BRDs in the Queensland East Coast Trawl Fishery**

| Positive Comments | Negative Comments |
|---|---|
| should be compulsory | lose marketable byproduct |
| great benefit to fishery | would not be able to tow BRDs |
| better quality product | lose prawns |
| reduced workload | makes the net too long |
| remove unwanted bycatch | |

### Northern Prawn Fishery

Twenty-three master fishers (18% of the NPF fleet) indicated to AFMA that they had tested some kind of TED or BRD during the 1998 NPF season. However, when contacted directly by project staff, seven of these master fishers responded that they hadn't used TEDs or BRDs during the 1998 season. Of the 16 vessels that did use TEDs or BRDs, eight had tested a device independently of this project i.e. sourced a TED from a commercial netmaker. In addition, three NPF vessels had conducted tests with the help of the project but for one reason or another had been left off the list. This gave a total of 19 vessels (15%) that had tested TEDs or BRDs in 1998. No vessels indicated regular use of TEDs and BRDs. TEDs were tested on NPF vessels for between two nights and a month. Three other vessels (one of which fishes in the Kimberley Coast Prawn Fishery) had received grids to test from Garry Day (AMC) whilst he was in Darwin prior to the 1998 tiger prawn season, but their use of the TEDs could not be confirmed.

## BENEFITS

The commercialisation of TEDs and BRDs has been of direct benefit to trawl operators in the Queensland East Coast Trawl Fishery, the Torres Strait Prawn Fishery and the Northern Prawn Fishery. Prior to the instigation of this project, TEDs and BRDs could not be purchased in Australia because of a lack of local knowledge combined with an absence of commercial demand. Fewer than 2% of the Queensland East Coast Trawl fleet were estimated to use a BRDs on a full-time basis and only two otter trawl vessels regularly used TEDs. TEDs and BRDs are now manufactured by over 20 commercial enterprises in northern Australia. Well-respected industry members have adapted and developed TEDs and BRDs for local conditions.

Information on TEDs and BRDs has been exchanged with research and extension projects in South Australia (Gulf of St Vincent and Spencer Gulf), Western Australia (Shark Bay and Exmouth Gulf) and New South Wales (river and offshore fisheries).

Government agencies have gained knowledge and expertise in TED and BRD technology. Project staff have played a key role in assisting the TED and BRD Sub-committee of NORMAC to develop robust definitions of TEDs and BRDs for regulation in the NPF.

The prawn trawl industry of northern Australia has been able to move in parallel with legislative changes, rather than reacting retrospectively to such changes.

# FURTHER DEVELOPMENT

1. The ongoing development of TEDs and BRDs by the trawling industry of northern Australia warrants some form of monitoring to ensure that these designs are efficient at achieving their stated goals (i.e. excluding sea turtles), as well as documenting the change of direct impact on bycatch composition and quantity. This latter point has potential flow-on effects to ecology of the environment in which trawl fisheries occur.

2. Extensive interactions with operators of the trawling industry of northern Australia reinforced the need to continue developing the relationships (both established and new) between fisheries research and management agencies and individuals within the fishing industry. Our experience suggests that continuity of individual staff over time (i.e. three years) assists in establishing and maintaining relationships with members of the fishing industry. The strength of these relationships contributes significantly to the interchange of information and expertise between the fishing industry and government personnel.

3. The introduction of TEDs and BRDs has instigated a level of conscious thought amongst some members of the trawling industry of northern Australia that current trawling practices need to be modified to minimise their impact. Numerous individuals commented on the possibility of reducing the impact of otter-trawls on benthic habitats and associated species, through the use of "Christmas drops" or "Texas drops" rather than the traditional ground-chain. This supports recommendations from the effects of trawling report (Poiner *et al.* 1999) that contact of the net with the sea floor needs to be standardised and if possible reduced through improvements in fishing technology.

# CONCLUSIONS

*Objective 1. Inform and consult commercial trawl fishers about ways and means of reducing the catch of non-target organisms in their trawl nets.*

We used several strategies to disseminate information on the need to reduce the catch of non-target species and the potential for gear modifications to achieve reductions in bycatch. These included 21 hands-on bycatch workshops at ports throughout northern Australia, six editions of a dedicated bycatch newsletter distributed to all master fishers in northern Australia, two videos summarising TED and BRD issues distributed free-of-charge to all licence holders in the Queensland East Coast Trawl Fishery and the Northern Prawn Fishery, loans of 70 TEDs and 13 BRDs custom-built to suit individual needs, and at-sea assistance with testing of TEDs and BRDs. Project staff frequently visited ports along the coast to talk to fishers and attended industry meetings to promote the availability of excluder device information and technology. Direct contact has been made between project staff and about 30% of the prawn trawl operators in the Queensland East Coast Trawl Fishery and about 60% of operators in the Northern Prawn Fishery. This resulted in an exchange of information, experience and views about the issue of bycatch, and the means for its reduction between project staff and commercial fishers.

*Objective 2. Further develop promising bycatch reduction devices and other bycatch reduction strategies under commercial conditions.*

Promising TED and BRD designs were promoted through the bycatch newsletter and technical information sheets. Innovative ideas from commercial fishers to improve the efficiency of TEDs or BRDs were incorporated into designs custom-built by project staff for at-sea testing by commercial fishers. In addition, three industry-based designs (the pyramid grid, the bigeye BRD and popeye bottom-opening TED) were tested in the AMC flume tank for their hydrodynamic features. Video footage of the gear in the tank assisted the respective developers of the designs to better understand the hydrodynamics of TEDs and BRDs during use.

Modifying the headline height of prawn trawls to reduce unwanted fish bycatch was explored during experiments with a multi-level beam trawl on commercial fishing grounds in the Gulf of Carpentaria. The vertical distribution of prawns and fish, and their behaviour to trawl stimuli were recorded in detail for the first time in a tropical prawn trawl fishery.

The results showed that nearly 96% of most commercial prawn species and 90% of the bycatch entered the trawl within 600 mm of the seabed. The potential for reducing bycatch simply by reducing prawn trawl headline height is therefore poor. The sequential removal of leadahead panels allowed prawns and fish to rise vertically and enter the upper levels. Many fish species such as ponyfish (*Leiognathus splendens*) demonstrated strong upward responses and strategic placement of BRDs in the top panel of the trawl may assist in successfully excluding these species.

*Objective 3. Document, accumulate and publish performance data of turtle excluder devices and bycatch reduction gears suitable for the commercial fishing industry of the Queensland East Coast, the Torres Strait, the Northern Prawn Fishery and other interested parties.*

Performance data of TEDs and BRDs were collected from field tests conducted during commercial fishing operations in the Queensland East Coast Trawl Fishery, the Torres Strait Prawn Fishery and the Northern Prawn Fishery. Results from these tests were disseminated via the six issues of the bycatch newsletter and articles in the industry magazines *Professional Fishermen, The Queensland Fishermen* and *Fishing Boat World.* Articles on TEDs and BRDs were also disseminated to conservation groups through the *Waves Newsletter* of the Coastal Community Network.

*Objective 4. Encourage and promote the use of bycatch reduction devices by commercial trawl operators.*

Commercial fishers were encouraged to use TEDs and BRDs through bycatch workshops, through the loaning of equipment to commercial fishers, and through the provision of at-sea assistance with the testing of TEDs and BRDs. Seventy TEDs and 13 BRDs were lent to commercial fishers. Supervised field tests occurred on 36 vessels. Field testing, combined with the extensive distribution of technical design information, provided an important starting point for the use of TEDs and BRDs by the trawling industry of northern Australia. First-hand experience of TEDs and BRDs lead many fishers and their peers to begin developing their own designs using the underlying principles of fish exclusion.

Less than 2% of the Queensland East Coast Trawl fleet used a BRD, and only two otter-trawl vessels used TEDs when the project began in 1996. A similar situation prevailed in the Northern Prawn Fishery. No NPF vessels were known to regularly use TEDs in the NPF in 1996, but seven vessels were known to have tested a TED (Robins *et al.* 1997). TEDs and BRDs were not commercially available and most of the devices in use were made by the skipper or owner of the vessel. TEDs and BRDs are now readily available from over 20 commercial enterprises in northern Australia. Several well-respected industry members have adapted and developed TEDs and BRDs for local conditions. While the project was targeted at otter trawl operations, the concepts and designs for fish exclusion have been utilised by the several operators in the beam trawl fleet of the Queensland east coast. This is indicative of the change in attitudes towards bycatch amongst many trawl fishers.

The use of TEDs and BRDs, and the important role being played by fishers in developing appropriate designs was promoted through the Prawn Trawling Innovation and Adoption Award. This award was widely advertised and had twelve nominees. The recipients of the award, John Olsen in 1997 and Garry Anderson in 1998, actively promoted TED and BRD use amongst their fellow fisher as well as acting as ambassadors to the general public for the progress the trawling industry was making in addressing the issue of unwanted bycatch.

## INTELLECTUAL PROPERTY

Intellectual property resulting from this study relates to the design and efficiency of turtle excluder devices and bycatch reduction devices collected during collaborative work onboard commercial fishing vessels. The data have been summarised, analysed and interpreted to provide the Fisheries Research and Development Corporation with this Final Report. This report and published papers will allow access by the industry and other interested persons to the summarised data. Intellectual property resulting from the design specification of various TEDs and BRDs has not been patented as this is not considered practical and is therefore freely available for use.

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# APPENDIX 1
# USE OF TEDS AND BRDs WITHIN THE QUEENSLAND TRAWL FISHERY

This survey aims to answer two questions –

1. *How many trawlers used TEDs or BRDs regularly* **prior to the 1st May 1999?**
2. *What were the most common designs used?*

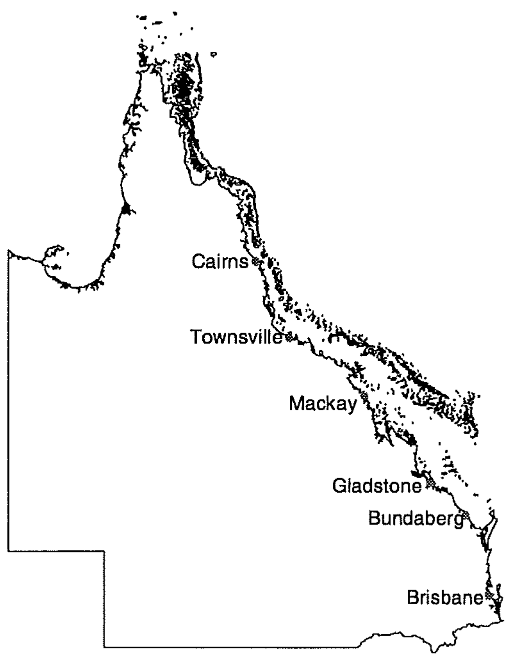
Survey information returned by individual fishermen will remain confidential. Only aggregate or anonymous information will be used in reporting on the questions above. Persons who return the survey will receive a summary of the results.

BOAT NAME: boat name SYMBOLS: symbols

**1. Do you skipper the boat?**
a. most of the time ☐
b. some of the time/as a relief skipper ☐
c. never ☐

**2. Where does the boat work for most of the year and what species are the target catch?**
Please circle the appropriate categories or mark the location(s) on the map

| | | |
|---|---|---|
| a. north of Cairns | a. inshore | a. tigers/endeavours |
| b. Cairns to Yeppoon | b. near reef | b. kings |
| c. Yeppoon to NSW border | c. offshore/deepwater | c. bananas |
| d. Moreton Bay | | d. bays |
| | | e. scallops |
| | | f. other......... |




## TURTLE EXCLUDER DEVICES - TEDs

**3. Prior to the 1st of May 1999, had the boat used TEDs?** Yes ☐ No ☐

**4. If the boat has used TEDs, Who manufactured the TEDs used on the boat?**
(circle answer)
a. the skipper or the owner
b. a netmaker
c. another person (please specify)..............................

**5. What was the design of the TED(s) used?** Please be as detailed as possible, or provide a sketch on the back of this paper.

**6. If the boat has only tested TEDs on a limited basis, where and when were the tests conducted? Please outline the results of these tests.**

**7. If the boat uses TEDs all the time, can you explain why?** (eg regulations, benefits)

**8. When did the boat begin to use TEDs regularly?** month ☐ year ☐

**9. Do you have any comments about the performance of TEDs on the Qld east coast?**

**10. If the boat has never used a TED, can you explain why?** (not necessary because..)

**BYCATCH REDUCTION DEVICES – BRDs**

BRDs are modifications made to the net or a device fitted to the net that allow unwanted bycatch to escape. Examples include square-mesh panels, radial escape devices, bigeyes, fisheyes, or V cuts. The next section of the survey refers to BRDs.

**11. Prior to the 1st of May 1999, had the boat used BRDs?** Yes☐ No☐

**12. If the boat has used BRDs, Who manufactured the BRDs used on the boat?**
(circle answer)
a. the skipper or the owner
b. a netmaker
c. another person, please specify...............................

**13. What was the design of the BRD(s) used?** Please be as detailed as possible, or provide a sketch on the back of this paper.

**14. If the boat has only tested BRDs on a limited basis, Where and when were the tests conducted? Please outline the results of these tests.**

**15. What reductions in fish bycatch were observed during tests of the BRDs?**

0 to 10% ☐ 10 to 30% ☐ 30 to 50% ☐ greater than 50% ☐

**16. If the boat uses BRDs all of the time, can you explain why?** (regulations, benefits)

**17. Do you have any comments about BRDs on the Queensland east coast?**

**18. If your boat has never tested a BRD, can you explain why?** (eg not necessary because.....)

Thank you for answering these questions. Please return this survey form in the enclosed reply-paid, return addressed envelope (no stamps necessary) to TED/BRD Survey, Southern Fisheries Centre, Reply Paid 444, Deception Bay Q 4508.

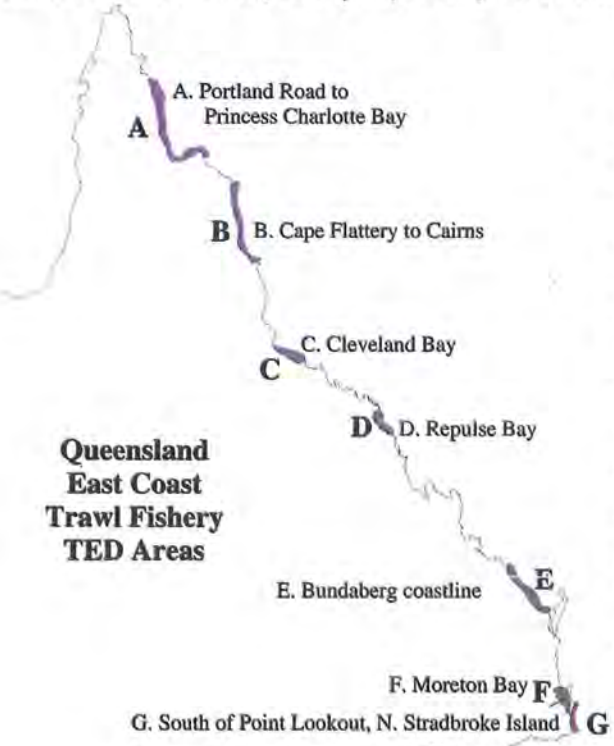
# Appendix 2:

# Example of the Bycatch Newsletter

# THE BYCATCH NEWSLETTER

Welcome to the sixth Bycatch Newsletter. It is part of a research project that aims to assist the fishing industry to develop and adopt TEDs and BRDs. The project also offers free gear loans and at-sea assistance with TEDs and BRDs. The project officially ends in July 1999, but may be extended until the end of December 1999. This issue contains a summary of the use and regulations regarding TEDs and BRDs in Australian prawn trawl fisheries, comments about choosing a suitable TED or BRD, notes on TED design, the economics of TEDs and BRDs, and recent results of TEDs and BRDs tested on commercial boats.

**USA Embargo of Australian prawns:** In 1996, the USA placed an embargo on the import of Australian prawns because Australian fisheries caught sea turtles but did not use TEDs. In 1998, the World Trade Organisation ruled that the embargo was illegal and it is likely that the embargo will be lifted, but it will take some time (i.e. years). However, the USA embargo has little bearing on whether Australian prawn trawl fisheries will use TEDs and BRDs. The use of TEDs in Australian prawn trawl fisheries is being driven primarily by the capture of endangered sea turtles in trawl nets and the Australian *Endangered Species Protection Act 1992*. There is strong political pressure at Federal and State levels for trawling to minimise its impact on the marine ecosystem, especially sea turtles.




**The Queensland East Coast Trawl Fishery:** TEDs will be required in 7 areas (see map). BRDs will be required during all daytime trawling, accept in Moreton Bay. The use of BRDs in Moreton Bay is being considered separately. The timing of these regulations is dependent on the Queensland Parliament and the QFMA.

**Northern Prawn Fishery:** An industry forum in Cairns heard results from commercial testing of TEDs in the NPF during 1998. Discussions included the suitability of TEDs to different parts of the NPF as well as problems in tuning TEDs. The NORMAC TED and BRD subcommittee held its first meeting. Definitions of TEDs were drafted for consideration by NORMAC. A definiton of BRDs will be drafted over the coming months. New desgins outside the definitions can be trialed under a scientific permit system. AFMA will provide details of the regulations and definitons to NPF fishers. It was pointed out many NPF fishers are unaware that NPF boats will be required to tow a TED as well as a BRD in each trawl net when these gears become compulsory in 2000.

**Torres Strait Prawn Fishery:** Mixed results have been reported from boats trialing TEDs in the Torres Strait. Some boats have used TEDs in quad gear all season with no loss of prawns or operational problems. Others have had some problems. Sponges and rocks appear to cause most of the problems. Some fishers overcome this problem by fishing the gear more lightly, while another solution appears to be related to fishing a top opening TED at a less steep angle. Some Cairns based netmakers have been trialing bottom opening TEDs with good reports.

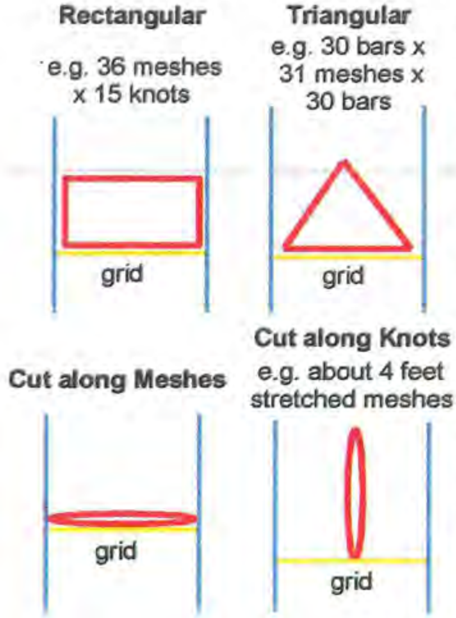
**Shark Bay Prawn Fishery, WA:** WA Fisheries have trialed composite square-mesh panels in Shark Bay trawl nets to exclude snapper and whiting. Results are still being analysed. Industry members continue to trial grids for jellyfish exclusion in Exmouth Gulf.

**Spencer Gulf Prawn Fishery, SA:** Spencer Gulf fishers are continuing their work to develop gear to reduce unwanted catches of crabs, fish and weed. Jack Forrester (fishing gear technologist, USA), spent about 2 weeks in SA in February to assist with field trials. This work is funded primarily by the commercial fishers themselves.

**CHOOSING A TED OR BRD** – Some people naively believe they will be able to go to their local netmaker and get 3 or 4 TEDs or BRDs "that work the best" installed immediately into their nets. Unfortunately, it takes time to install these devices and they need to be built with the likely fishing conditions in mind. **Points to consider when deciding on a particular TED design include:** Will the TED be fished in clean or dirty ground? Which will be more suitable, a top or bottom opening TED? Do I need to be able to change the TED around quickly? What bar spacing do I need to keep prawns and byproduct? What is the size of net the TED is being added to? **Points to consider when choosing a BRD include:** Will it be used mostly for day or night fishing? Do the bag sizes vary a lot? What sort of fish am I looking to exclude? It also takes time for a particular device to be tuned to the operating conditions of the boat and fishing grounds to ensure operational efficiency. Project staff can offer advice about what devices will probably work in what situations. However, skippers and crew can best answer the above questions and when combined with technical advice, appropriate designs can be identified.

## NOTES ON TED DESIGN

These notes give some information about some of the subtle ways fishermen are modifying TEDs.

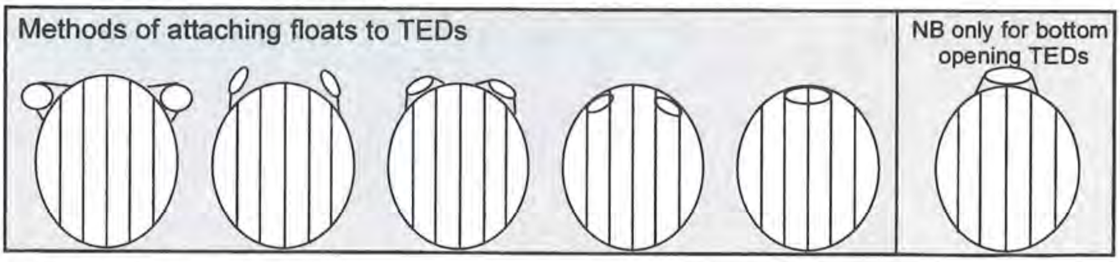



***Escape openings*** can be any size and are largely dependent on the size of the animals or objects likely to be excluded. The shape of the escape opening is a matter of preference. Some TED designs require a certain shape, e.g. soft TEDs need an escape hole cut along the points to ensure the soft TED functions efficiently (see figure), but most shapes will work with any grid. The escape opening is cut in either the top or bottom of the net, depending on the way the grid is inclined. It is important that the edges of any cut be laced, hung onto rope or selvedged. This helps to prevent the escape opening from ripping or stretching. **Points to remember:** i) the escape opening must be of sufficient size to allow large animals to escape, ii) the opening must be positioned forward of the grid, and iii) the opening must not dramatically reduce the strength of the net i.e. tear easily.

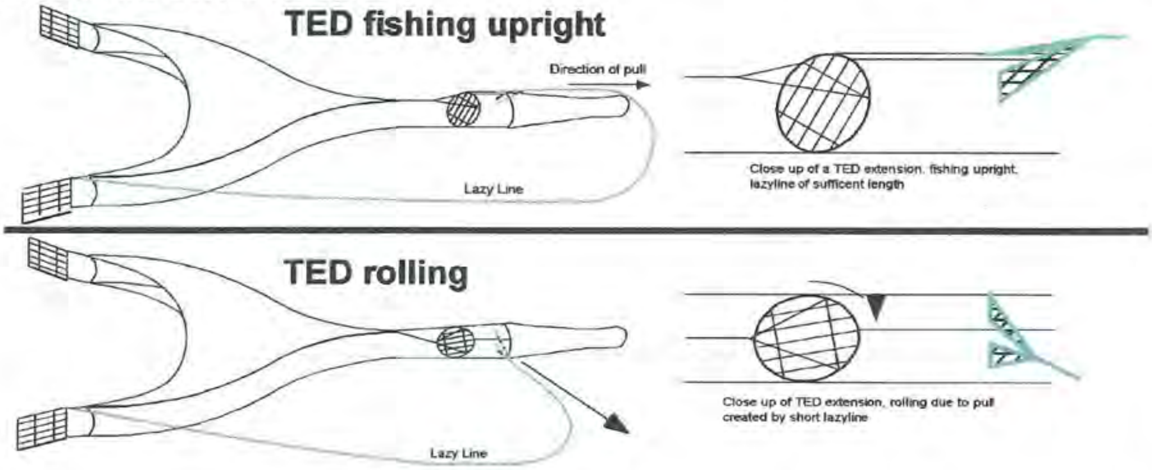
***Escape flaps*** cover the escape opening and help to prevent catch loss. They can be placed on the outside or inside of the TED extension, or two flaps can be used (one inside and one outside). Ideally the flap should be slightly wider than the escape opening. Small net leads can be attached to the flaps aft edge on top opening TEDs to assist in holding the flap closed. Similarly, small floats can be attached to the flaps of bottom opening TEDs. However, if there is too much weight or flotation on the flap, large animals will have difficulty escaping, resulting in clogging, or chafing of the TED and possible loss of prawns. The flap should be attached along or just ahead of the forward edge of the escape opening. It should be sewn down the sides towards the grid and can be sewn slightly past the grid (e.g. 6 meshes). The further the flap is sewn past the grid, the more snugly it fits, but the escape opening becomes smaller. Increasing the length of the flap can also improve its ability to seal the escape opening, as there is a greater amount of water pressure on the flap holding it closed. **Points to remember:** i) a flap that does not open readily will hinder the exclusion of unwanted bycatch, and ii) check the flap regularly to correct for wear (stretching) or problems (sticks lodged in the flap).

***Funnels and deflector flaps*** can be placed forward of a TED to direct catch away from the escape opening. They are sometimes referred to as "accelerator funnels" or "guiding flaps". Tapers can be used to give the funnel shape. Funnels can be attached partly to the grid (not to more than $^{1}/_{3}$ of the grid) to ensure that they guide the catch away from the escape opening. The aft diameter of the funnel must be large enough (or stretch to a sufficient size) to allow unwanted animals and debris to get out of the escape openings. Funnels will not be suitable for all fishing conditions. They are prone to clogging with debris and may not improve TED efficiency in dirty trawl grounds. **Points to remember:** i) funnels must be able to expand to allow large animals to escape, ii) funnels may not work in all areas, and iii) funnels should be checked regularly to ensure the mesh remains elastic.

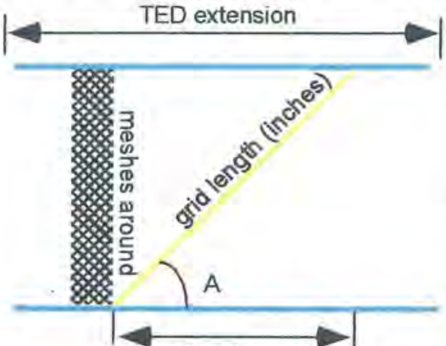
***Floats*** counteract the weight of the grid and help stabilise the TED while steaming or shooting the gear. Floats can be attached inside or outside the TED extension but should never impede the functioning of the escape flap. Floats attached on the outside may snag the lazyline, especially in quad gear. Floats placed inside should be positioned behind the grid to avoid any clogging. Floats that crumple in deep water due to pressure should be replaced as they lose buoyancy and become less effective. Commercial use of TEDs suggests that several methods of attaching floats to TEDs are practical, give the TED stability and prevent chaffing (see figure).



***Lazyline arrangements*** can cause problems with nets fitted with TEDs, especially in triple and quad rigged gear. Generally, the length of the lazyline needs to be increased when a TED is fitted to a trawl net. When a lazyline is too short, tension on the lazyline causes the TED and codend to roll to one side when the gear is fishing. This can lead to prawn loss out of the escape opening. Many fishers report that top opening TEDs will roll 180° when streaming on the surface, but correct themselves when the boards are spread.




The position and type of lifters used may also effect TED performance. Ideally, drag on the lifting ears and lazyline should be towards the end of the codend. Choker arrangements may restrict prawns from entering the codend and hold them forward near the TEDs escape opening, increasing the chance of loss. Similarly, lifting ears can and do hang back in the area of the codend best suited to locating BRDs such as square-mesh windows and fisheyes, and can reduce their effectiveness.




***Calculating grid angle*** - The effectiveness of TEDs is highly dependent on the angle at which the grid is installed. Too steep and clogging will occur, too shallow and prawn loss will occur. Following is a guide to calculate accurately how to install the grid into the net. To calculate the **"number of meshes"** required to install a grid at the angle **"A"** use the following steps.

**1)** Chose the angle you want to install the grid at. This angle is angle **"A"** in the figure. The angle should be between 40° and 55°. The average angle of installation is 45°, but lower grid angles may be more appropriate if sponges are a concern (i.e. 40°). **2)** Find the cosine of angle A (see Table 1). **3)** Substitute the numbers into the following equation to calculate the **number of meshes**

$$\frac{\textbf{cosine of angle A x grid length (inches)}}{\textbf{mesh size in TED extension (inches)}} = \textbf{number of meshes}$$

**EXAMPLE:** I am building a bottom opening TED. My grid is 33 inches long and I want to install it at 47°. My extension is $1^5/_8$ (=1.625) inch mesh, 100 round piece of polyethylene.

Substitute numbers into equation ⟶ $\frac{\text{0.681 (from table below) x 33 (inches)}}{\text{1.625 inches (mesh size in extension)}} = \text{14 meshes}$

To install the grid, sew the top of the grid to the seam in the net, count 50 meshes around, then 14 meshes towards the codend. (For a top opening TED, I would count 14 meshes forward.) Sew the bottom of the grid to this mesh. Evenly distribute the meshes between these 2 attachment points and sew them to the grid.

**Table 1. Cosine of Angle A for calculating how to install a grid at a particular angle**

| Angle A | cosine Angle A | Angle A | cosine Angle A | Angle A | cosine Angle A |
|---|---|---|---|---|---|
| 38 | 0.788 | 44 | 0.719 | 50 | 0.642 |
| 39 | 0.777 | 45 | 0.707 | 51 | 0.629 |
| 40 | 0.766 | 46 | 0.694 | 52 | 0.615 |
| 41 | 0.754 | 47 | 0.681 | 52 | 0.601 |
| 42 | 0.743 | 48 | 0.669 | 54 | 0.587 |
| 43 | 0.731 | 49 | 0.656 | 55 | 0.573 |

**ECONOMICS OF TEDS IN THE NPF:** CSIRO looked at the economics of using TEDs and BRDs during trials onboard the FRV *Southern Surveyor*. Economic benefits included increased catch quality and hence value, because turtles, stingrays and sharks can squash and damage the prawn catch. The reduction in physical damage to prawns caught in nets with 8 different BRDs was compared to that of standard nets. Only the types of damage that would condemn the prawns to a less valuable "soft & broken" category were used. The reduction in prawn damage was between 6% and 35% depending on the BRD. In general, most of the damage occurred in the head region of prawns. The total catch weight and weight of monsters (animals greater than 5 kg) were significantly reduced in the presence of a TED. A reduction in total catch weight significantly reduced damage, while the weight of monsters did not significantly reduce damage. The results demonstrate that some BRDs will improve tiger prawn quality by reducing damage and hence alleviate some of the perceived disadvantages of using TEDs and BRDs compared to with standard codends. CSIRO calculated the increase in value of an average 200 kg tiger prawn catch from the best performed TED and BRD combination, the Super Shooter + fisheye (Table 2). The Super Shooter + fisheye did not affect prawn catches during the trials. A conservative average price difference of $15 per kg between damaged and undamaged prawns was assumed. In this example, the value of tiger prawn catch increases by $105 per night. BRDs will not only be ecologically beneficial to the marine environment, but can improve returns to the fishers.

**Table 2. Economics of using a Super Shooter TED + fisheye compared to a standard net.**

| | VALUE ADDED ($25/kg) | | "Soft & Broken"($10/kg) | |
|---|---|---|---|---|
| | Kg Caught | $ Value | Kg Caught | $ Value |
| standard net | 170 | 4250 | 30 | 300 |
| super shooter & fisheye net | 177 | 4425 | 23 | 230 |
| CHANGE | | +175 | | -70 |
| GAIN | | +$105 | | |

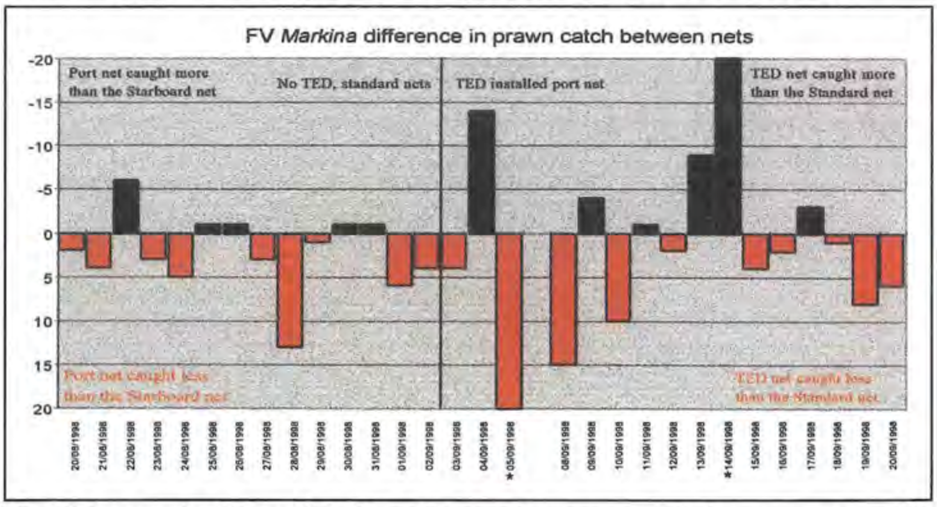
Another example of improved economic performance is from Wood Fisheries, who trawl for deepwater prawns off eastern Australia. The use of TEDs has increased their product value by eliminating sharks, rays and other deepwater monsters from catches. Prior to the use of TEDs, bycatch induced damage had decimated entire shots of these delicate prawns (Sandy Wood-Meredith, Wood Fisheries, Queensland, *FRDC R&D News*, Vol 6 No. 4 October 1998).

**INDUSTRY USE OF BRDS AND TEDS** - More fishers are using TEDs and BRDs as part of their standard fishing operations. Most operators are surprised that the devices perform no where near their worst expectations. Results from trials in the Qld east coast and the NPF are presented.

**FV *Karool*, Lucinda, Qld east coast –** Graham Holt, owner and skipper of the *Karool* has used bigeyes in his trawl nets to exclude fish. In September 1998, Jason McGilvray fished with Graham to look at the effect of the bigeye on bycatch and to place a video camera in the net. The bigeye had a minimal effect on fish bycatch, probably because the trawls were undertaken at night and the amount of total bycatch was not large (i.e. between ¾ and 1½ prawn baskets per 7 fm net for 2½ to 3 hr trawls). This concurs with reports from other fishers that fish excluders work best during daylight hours with good water visibility.

Underwater filming suggested that the front flap of the bigeye did not sink below the level of the top panel of the main net. This possibly results from tension on the front flap and pressure from water flowing down the net. This problem was alleviated somewhat by adding more net leads to the forward panel of the bigeye.

**FV *Markina*, Mornington Island, NPF** –In September 1998, Grant Florence, skipper of the *Markina*, trialed a large Wicks TED with the assistance of Matthew Campbell (QDPI). The TED was top-opening and was 37½" high by 30" wide, with 5⅜" bar spacings. The trial presented several difficulties. Before the trials, the *Markina* had experienced troubles with the port net, it being on average 4% down on prawn catch compared to the starboard net. Also, the throat of the port net was 170 meshes round (2½" 36 ply) while the TED extension was 120 meshes round (2" 60 ply). This difference (a ratio of 17:12) meant that there was excessive gathering of the meshes in the area where the TED extension joined the throat of the net. This caused pocketing and possibly increased the turbulence of the water flow ahead of the TED. As well, the codends were relatively short, being only 75 meshes long, with 60 meshes between the lifting ear and drawstrings. These problems resulted in considerable losses in prawn catch during some tows (ie 05/09/1998). The TED extension was modified, along with the codend, to increase their diameters to 150 meshes round. This reduced pocketing, enlarged the codend and improved the performance of the TED net.




In general the TED did not significantly alter the performance of the port net. However, losses in prawn catch sometimes occurred and could be attributed to: i) large catches of bycatch (ie greater than 100kgs) that resulted in the "overflow" of catch forward from the codend into the TED extension (*05/09/1998 61 kg loss), ii) drawstrings not closing tightly on the TED equipped net

(08/09/1998) and iii) the capture of large animals (e.g. hammerhead shark) that clogged in the grid (10/09/1998). A major increase in prawn catch in the TED net was due to the hook-up of the standard net (*14/09/1998 41 kg gain). Large shovelnose rays, bullrays, large whaler sharks and turtles were not caught in the TED net. The crew of the *Markina* experienced no problems in handling the TED net, racking it between the sorting tray step and the brine tanks during the day. When steaming, the TED rolled over 180°, but when the net was shot away the TED always unrolled, leaving no twists in the net.

**FV *Titan*, Tully to Bountiful Island, NPF** – Paul Nielson skippers this Tiger Fisheries boat and with the assistance of Garry Day (AMC), trialed 4 configurations of TEDs and BRDs during October 1998. The TEDs and BRDs were always installed in the port trawl. The data suggest that TEDs and BRDs had little overall adverse effect on prawn catches and highlights the need to look at how unmodified nets fish against each other. No turtles were caught when the port net was fitted with a TED, but a turtle was caught in the port net fitted only with an RES. On several occasions the RES became fouled with wineglass sponges or starfish when installed without a TED. These blockages could result in prawn losses and highlight the importance of removing large objects before they reach the RES. The Super Shooter TED was also obstructed on several occasions by sponges, starfish and a small slab of rock. These objects tangled on the guiding funnel and may have caused some prawn loss. Catches from the Super Shooter TED and the NAFTED/RES combination were assessed to determine if there was a reduction in soft & broken prawns. The Super Shooter reduced prawn damage by 46.5% (3.54 kg) over 2 shots and the NAFTED/RES reduced prawn damage by 4.3% (1.2 kg) for the 1 shot assessed. Average fish bycatch was reduced by 10 to 20% in the net fitted with an RES. The NAFTED performed better than the Super Shooter, probably due to the easier exclusion of sponges as a result of a less obstructive guiding panel design, a narrower bar spacing (60 mm) and a lower grid angle (40°) than the Super Shooter (100 mm and 45° respectively).

Table 3 Summary of prawn catch onboard the *FV Titan*.

| Device | No. of shots | Prawn catch (kg) Port net | Prawn catch (kg) Stb. net | Average %Difference between Starboard and Port nets* (Upper and Lower Range) |
|---|---|---|---|---|
| None | 7 | 249.6 | 255.7 | - 2.4 (-6.7 to +1.9) |
| NAFTED | 12 | 429.1 | 431.1 | - 0.5 (-4.8 to +5.0) |
| None | 13 | 729.5 | 706.5 | + 3.3 (-14.6 to +9.0) |
| Super Shooter (top opening) | 8 | 400.1 | 418.9 | - 4.3 (-9.6 to +3.5) |
| Radial Escape Section (RES) | 12 | 584.9 | 621.6 | - 5.9 (-6.2 to +4.3) |
| None | 15 | 520.3 | 551.5 | - 5.7 (-14.0 to +1.4) |
| NAFTED + RES + Cone stimulator | 3 | 221.3 | 238.0 | - 7.0 (-10.8 to -1.5) |
| None | 3 | 199.3 | 199.8 | - 0.3 (-5.3 to +3.7) |

(* -ve values indicate port net caught less than the starboard net, + ve values indicate the port net caught more)

Paul was quite happy with the trials overall, but was most impressed with the NAFTED. A NAFTED was kept onboard the *Titan* to trial more extensively in the later part of the 1998 tiger prawn season. Results are not yet available.

RETURN ADDRESS: Southern Fisheries Centre, QLD DPI, PO Box 76, Deception Bay Q 4508.

QUEENSLAND GOVERNMENT

DPI QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

# THE BYCATCH NEWSLETTER

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

AUSTRALIAN MARITIME COLLEGE

CSIRO

Compiled by J Robins, QDPI. Thanks to J McGilvray, M Campbell, G Day, S Eayrs, J Salini, D Brewer, M Farmer and N Rawlinson for contributions. Thanks also to G Holt, G Florence and P Nielson for use of results recorded on their vessels. Comments & contributions are welcome.

**FOR MORE INFORMATION CALL:**

| | | |
|---|---|---|
| Southern Fisheries Centre, QDPI | (07) 3817 9500 | 1800 658 908 |
| Australian Maritime College, Fishing Technology Unit | (03) 6335 4424 | 1800 638 451 |
| CSIRO Marine Laboratories, Cleveland | (07) 3826 7200 | |

# Appendix 3:
# A Summary Of Bycatch Reduction Devices



## AUTHORS NOTE

The Department of Primary Industries, Queensland, has taken all reasonable steps to ensure the information contained in this publication is accurate at the time of publication. Readers should ensure that they make appropriate inquiries to determine whether new information is available on the particular subject matter.

Contained is a compilation of research and extension publications, personal communications and individual ideas. Some TED and BRD designs have not been included in this booklet.

Jason McGilvray, March 1999

## Australian Research Centres Dealing with TED and BRD Technology

- **Queensland Department of Primary Industries,**
  Southern Fisheries Centre, PO Box 76, Deception Bay QLD 4508
- **Australian Maritime College,**
  Fishing Technology Unit, PO Box 21, Beaconsfield TAS 7270
- **NSW Fisheries Research Institute,** PO Box 21, Cronulla NSW 2230
- **Northern Territory Dept of Primary Industries and Fisheries**
  PO Box 990, Darwin NT 0801
- **South Australian Research and Development Institute**
  Aquatic Sciences Centre, 2 Hamra Avenue, West Beach SA 5024
- **CSIRO Division of Marine Research,** PO Box 120, Cleveland Qld 4163
- **Western Australian Marine Research Laboratories**
  Fisheries Department of Western Australia, PO Box 20, North Beach WA 6020

## Overseas agencies dealing with TED / BRD technology -

- **National Marine Fisheries Service**
  Southeast Fisheries Science Centre, Gear Technology Unit, PO Drawer 1207, Pascagoula MS 39568-1207, USA

- **University of Georgia Sea Grant**
  Marine Extension Service, 715 Bay Street, Brunswick GA 31520-4601, USA

# INTRODUCTION

Trawling is considered to be a fishing method that has a relatively poor selectivity because it often catches a wide variety and large quantity of unwanted species as well as the marketable catch. Catches by Australian prawn trawlers can be described in the following manner: *target catch* being the species that are the main reason for fishing (e.g. prawns, scallops); *byproduct* being species that are caught incidentally and are kept for marketing (e.g. Moreton Bay bugs, crabs);and *bycatch* being species that are caught during fishing but are not retained for marketing and are discarded at sea (e.g. rays, turtles and small unwanted fish).

There are two main types of devices designed to reduce trawl bycatch. Turtle Excluder Devices or TEDs are designed to remove turtles and other large animals from trawl catches. Bycatch Reduction Devices or BRDs are designed to reduce the catch of unwanted swimming species such as fish. The definition of TEDs and BRDs can vary between fisheries and depend greatly on the relevant fisheries regulations.

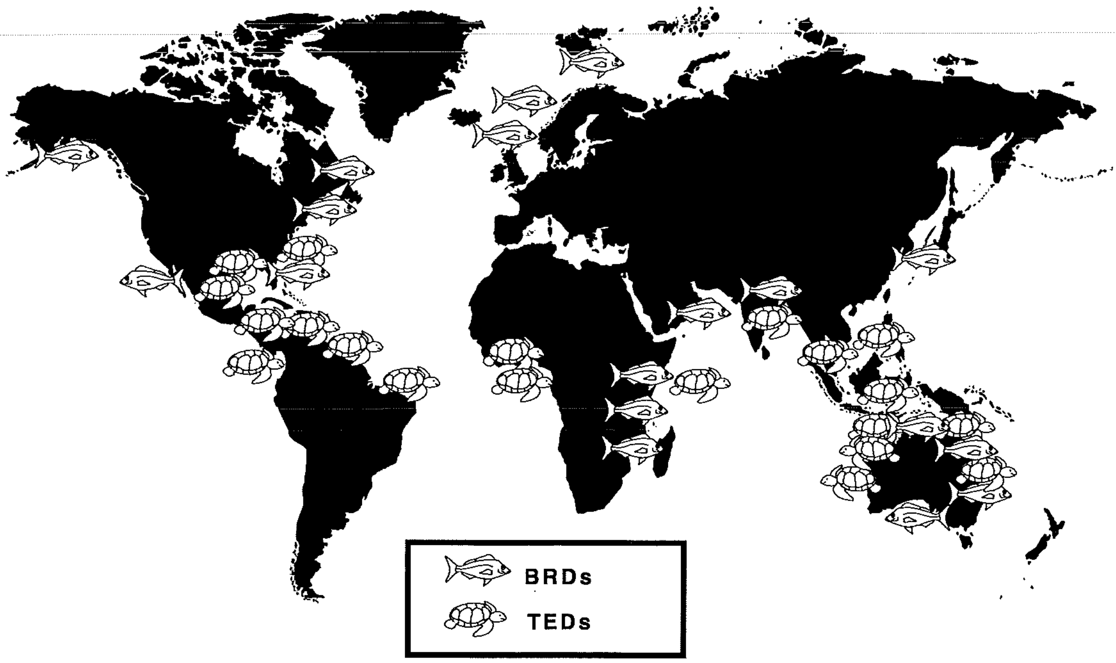
BRDs have been used successfully in Australian banana prawn fisheries to reduce the problem of fish bycatch. Animals captured within trawl gear exhibit quite different behaviour depending on their size and species. Fish are capable of swimming against the water flow inside a trawl net and can escape at any time given the correct conditions. Prawns are unable to swim against the water flow and wash into the codend. This difference in behaviour between prawns and fish is why BRDs have such potential to reduce bycatch whilst maintaining commercial target catch.

TEDs have been used to exclude large animals and sponges from their nets. They can be constructed from hard metallic components, i.e. metal grids, and are categorised as hard TEDs. Those constructed with soft components, i.e. mesh and rope, are categorised as soft TEDs. TEDs constructed with a single grid are the most popular within the fishing fleet of the USA and have gained popularity in Australia. The most important factor effecting the performance of a single grid hard TED is the angle of the grid in relation to the bottom of the trawl. Research and commercial tests have shown that the optimum grid angle for a bottom-opening TED is 45° to 55°. Grid angles for top-opening TEDs can range from 35° to 55°. On dirty trawl grounds top-opening TEDs with a shallower grid angle, ie 35, will allow some debris to roll out the escape opening, avoiding clogging. A top-opening grid installed at 55° under similar circumstances would clog.

Other important factors to consider when using a single grid hard TED include: (i) position of the escape opening (top or bottom), (ii) dimensions and material used in the grid's construction i.e. size and number of bars, (iii) size of the escape opening,( iv) type of escape opening cover or flap used, and (v) whether to include an accelerator funnel.

The mandatory use of TEDs by all USA shrimp trawlers has been in place for many years now. The Queensland State Government is currently considering the use of TEDs and BRDs in areas of its prawn fisheries. TEDs and BRDs are to be incorporated into the Northern Prawn Fishery in the year 2000. New South Wales, South Australia and Western Australia are in various stages of implementing the use of these devices in their prawn fisheries.

Countries that use BRDs
in either a voluntary or mandatory manner




The following pages show an assortment of TEDs and BRDs. The designs for each device have been collected from scientific journals, technical reports, seminars and personal communications. TEDs and BRDs are being constantly developed and changed. As further testing is done the efficiency of these devices should improve.

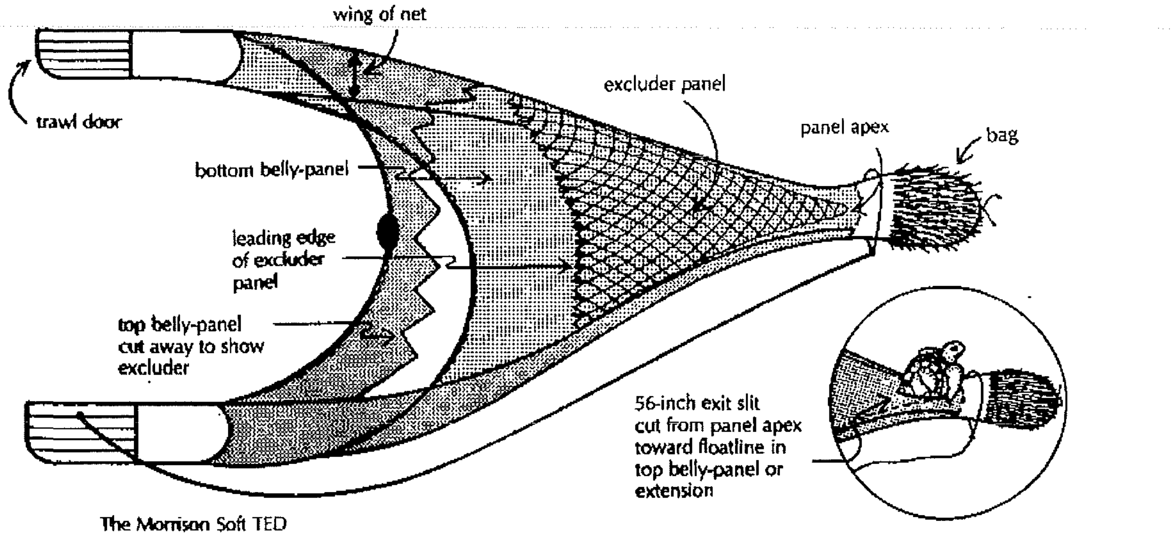
## SOFT TEDS

Soft TEDs are constructed by sewing into the trawl net a panel or panels of large meshes that angle towards an escape opening. For many years, a type of soft TED known as a blubber shoot has been used by estuarine trawl fishers in New South Wales and beam trawl fishers in Queensland. These devices were constructed from relatively small mesh (60 mm) and shaped like a funnel. Soft TEDs gained popularity in the USA where they were deemed 'safer' due to their soft construction. Limited tests of American designed soft TEDs did occur in Australian prawn fisheries in the late 1980's and early 1990's with mixed success.

Soft TEDs appeal to commercial fishers for a number of reasons. They lack hard parts in their construction and are thought to be safer. They are easy to store on deck and they do not distort the shape of the codend. The advantages are offset by some problems with these devices. Soft TEDs are difficult to install, most often requiring expert installation. Soft TEDs tend to clog more easily which leads to catch loss and soft TEDs make the net harder to clean at the end of a nights work.

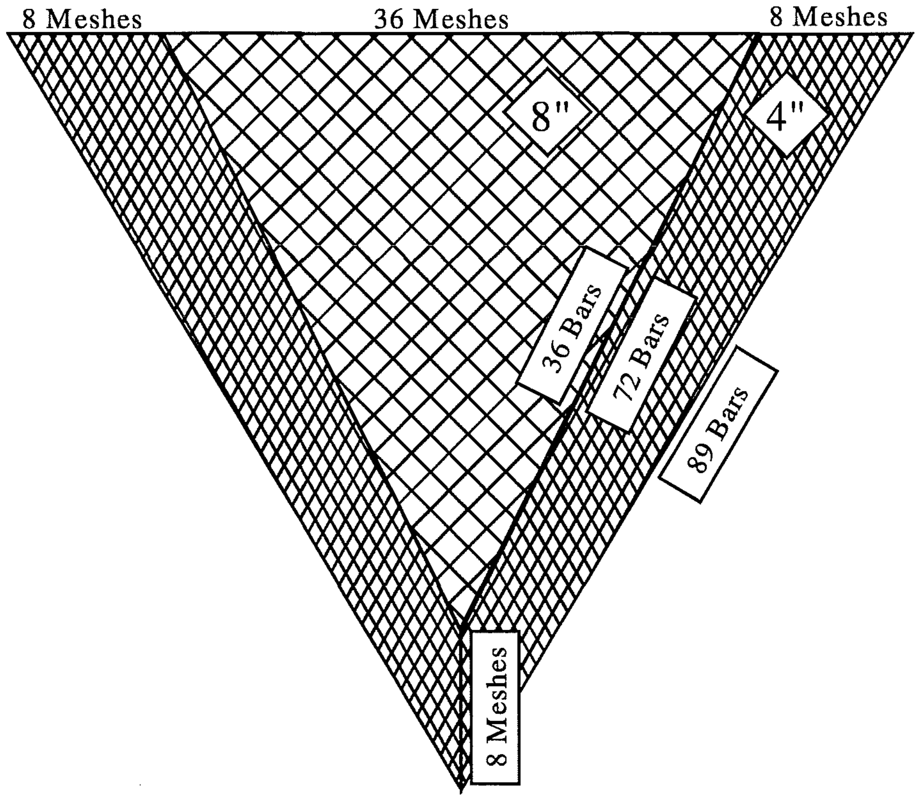
Some soft TED designs used in the USA were banned after it was proven they were unreliable at excluding juvenile turtles. The use of the Morrison, Taylor, Andrews and Parrish soft TEDs is illegal in the USA. Recent research by the NMFS has developed the Parker soft TED. This TED can only be fitted some net designs.

Morrison Soft TED




reproduced from Kendall, D. 1990. *Fisheries Research* 9:31-21.

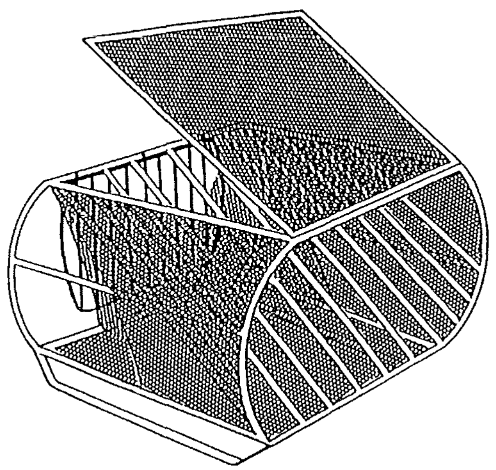
Parker Soft TED - Excluder Panel Detail



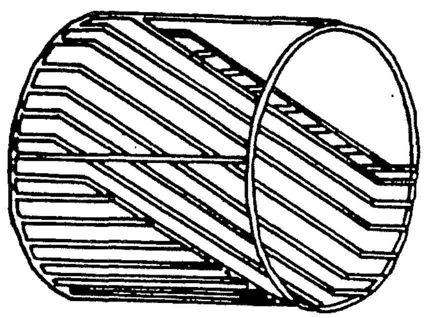

reproduced from NMFS

# HARD TEDS

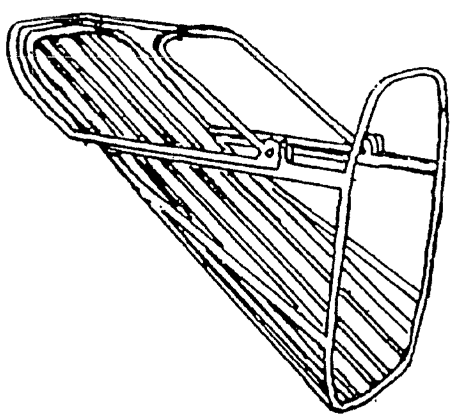
Hard TEDs were among the first designs used by shrimp fishers in the southeastern USA. These devices consisted of angled deflector bars attached to solid rings, front and back. The advantage of this design is that the optimum angle for the deflector bars was maintained at all times regardless of the age of the trawl mesh. The major disadvantage of these devices was their size, weight and the associated handling problems. The HSB, Cameron and Mississippi Hybrid TEDs are no longer used by, or manufactured for, the USA trawl fleet. The NMFS TED can be used if the hinged door is replaced by a flap of webbing. Hinged doors were banned in the USA because they were too difficult for small turtles to push open. Variations of these four American designs have been tested in Australian fisheries with minimal success.



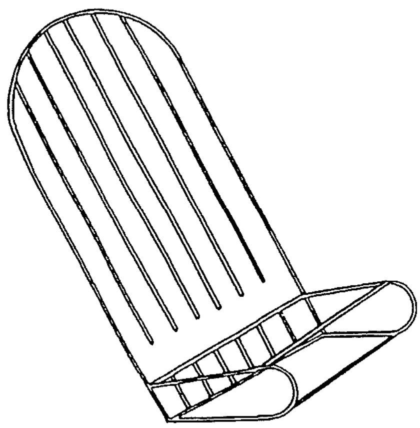
NMFS TED



Cameron TED



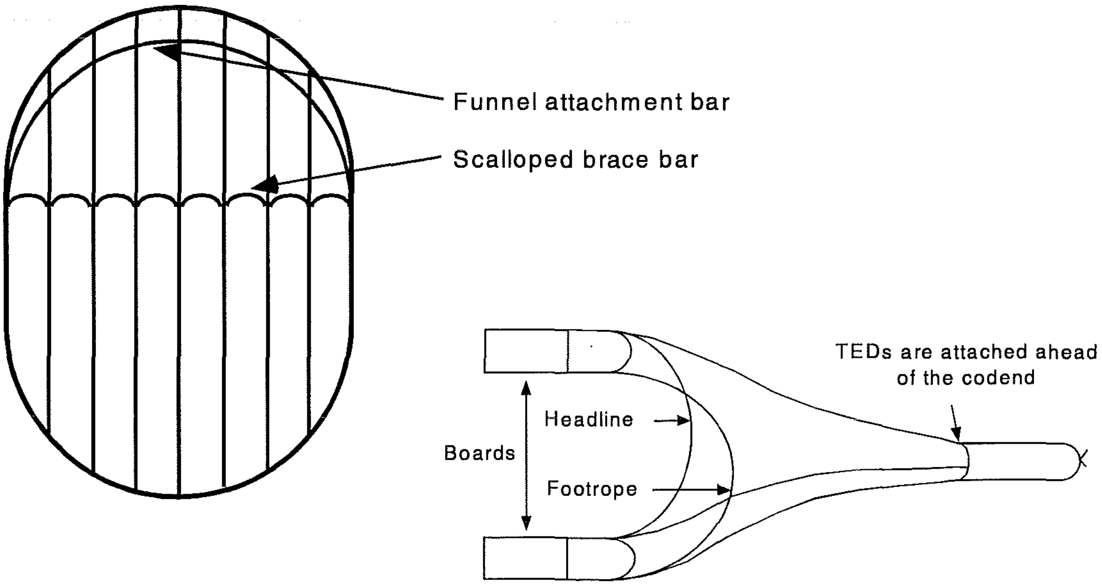
Mississippi Hybrid



HSB TED

reproduced from NMFS Technical Memorandum 1994 NMFS-SEFSC-327

## *Standard TED*




reproduced from NMFS Technical Memorandum 1994 NMFS-SEFSC-327

### Explanation

The Standard TED is built around an oval-shaped grid that comes in three sizes. Bar spacings are 90 to 100 mm depending on the size of the grid. A scalloped brace-bar adds rigidity to the grid. These TEDs can exclude bycatch out the top or bottom of the net depending on the way the grid is installed. It can be fitted with an accelerator funnel to increase efficiency. The grid can be constructed from steel or aluminium.

A variation to this design is the Georgia TED, which is the same shape but has removable bars.

### Advantages

* Gets rid of turtles and other large animals
* Reduces some unwanted fish
* Simple
* No extra space required for storage

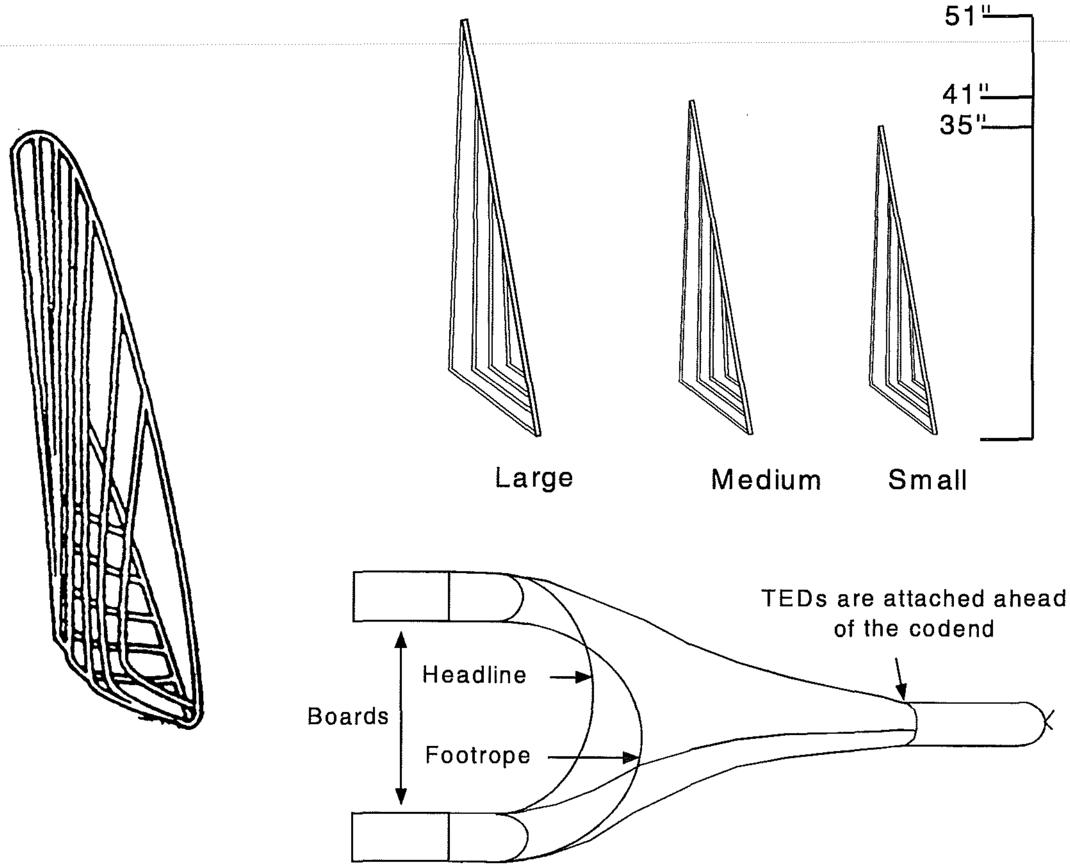
### Disadvantages

* Clogging by weed
* Net chaffing if incorrectly floated

### Comments

USA tests showed increased prawn retention when an accelerator funnel was added. Australian tests have shown that on dirty ground a funnel hinders TED performance.

## *Super Shooter TED*




reproduced from NMFS Technical Memorandum 1994 NMFS-SEFSC-327

**Explanation**

The Super Shooter TED uses a oval-shaped grid to exclude turtles and other large animals from the net. The deflector bars curve backwards at the bottom eighth of the grid but frame of the grid does not bend. It is claimed to be less likely to clog with weed than flat grids. Debris and large animals can be excluded out the bottom or top of the net (depending on which way the grid is installed). The grid is manufactured from aluminium rod and comes in three sizes. The TED can be fitted with an accelerator funnel to increase efficiency. A variation of this design is being constructed by some netmakers in Cairns. The device has been used with success in the fishing grounds north of Cairns.

**Advantages**

* Gets rid of turtles and other large animals
* Reduces some unwanted fish
* Simple
* Less prone to clogging

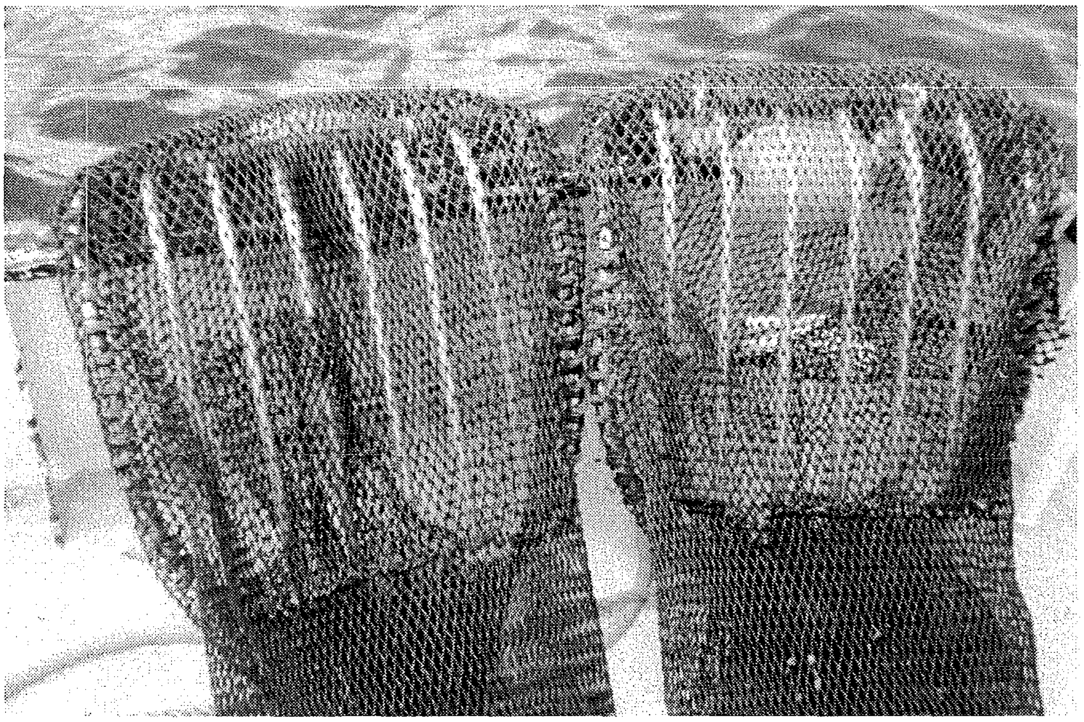
**Disadvantages**

* Net chaffing if incorrectly floated
* Difficult to store

**Comments**

Tests by NMFS with the super shooter TED in bottom-opening configuration revealed little to no prawn loss. Tests of a bottom-opening TED by QDPI in the Torres Strait resulted in some catch loss. Tests of a top-opening TED by Queensland fishers showed no loss of catch.

*Seymour TED*



**Explanation**

The Seymour TED is constructed around a robust grid that has a curved frame and bars. The curve in the bottom of the grid offers the same advantages as mentioned for the Super Shooter TED. The Seymour TED is constructed from 19 to 31 mm aluminium tubing and comes in three sizes. The tubing increases the robustness of the TED and provides some built-in flotation. The grid is flat along three edges and semi-circular along the fourth. The grid can be inserted into the codend either way depending on whether a top or bottom-opening TED is required.

**Advantages**

* Gets rid of turtles and other large animals
* Reduces some unwanted fish
* Simple
* Less prone to clogging

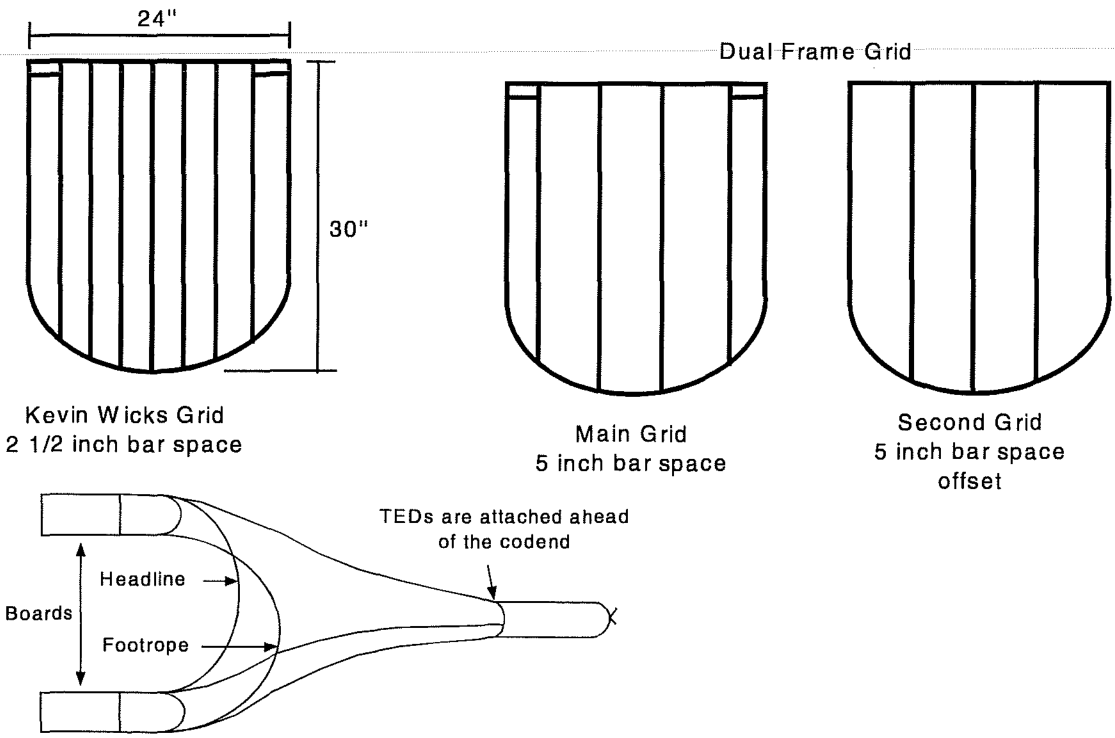
**Disadvantages**

* Net chaffing if incorrectly floated
* Difficult to store

**Comments**

This is a recent design from the USA and as yet insufficient research data has been collected. A bottom-opening Seymour TED was tested in the Torres Strait with some success in 1997. Top-opening Seymour TEDs were used successfully by some fishers in Torres Strait in the 1998 season.

## *Wicks TED / Dual Frame TED*




### Explanation

Designed by Kevin Wicks, this grid is used to primarily exclude jellyfish from prawn trawls in Moreton Bay. The shape allows the bottom half of the codend to assume its normal curved shape, limiting the loss of small prawn through open meshes. Moreton Bay fishers designed a dual-frame grid that allows the bar spacings to be quickly altered to suit different fishing conditions. Narrow bar spacings of 51 mm are used to exclude jellyfish, while 101 mm bar spacings are used to keep marketable sand crabs. This grid has been scaled-up for use in the Gulf of Carpentaria and north east Queensland.

### Advantages

* Gets rid of turtles and other large animals
* Simple
* Dual frame TED is adaptable to different fishing conditions

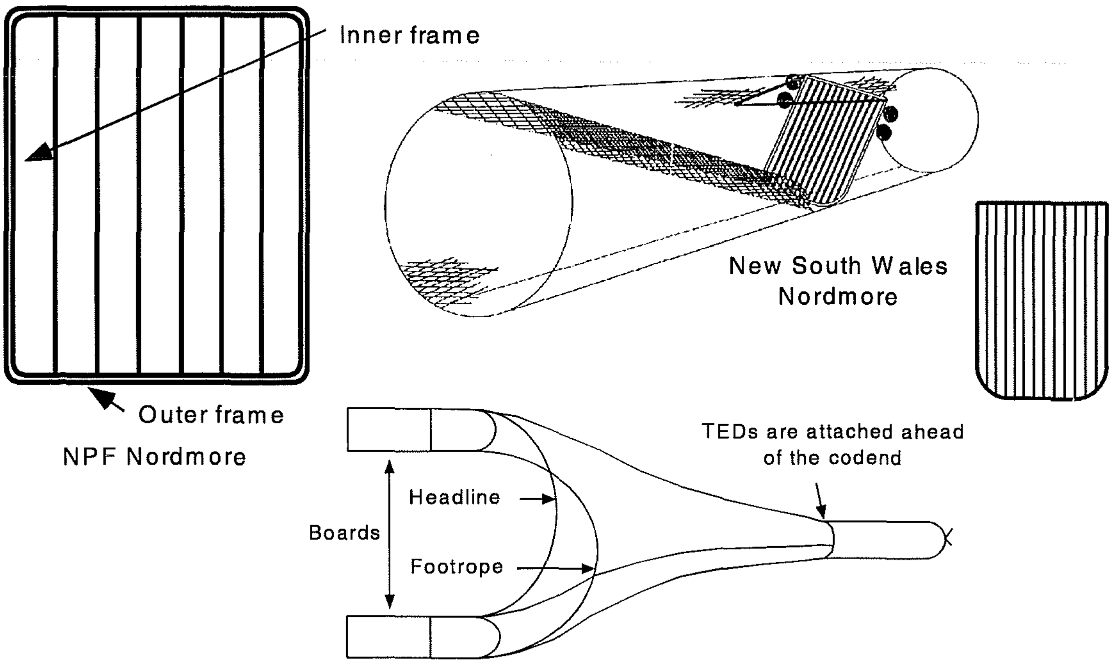
### Disadvantages

* Clogging by weed
* Net chaffing if incorrectly floated

### Comments

A large number of commercial fishers use this design. Anecdotal reports suggest that prawn catches either remain steady or increase slightly.

*Nordmore Grid*




reproduced from NSW Fisheries Nordmore grid pamphlet

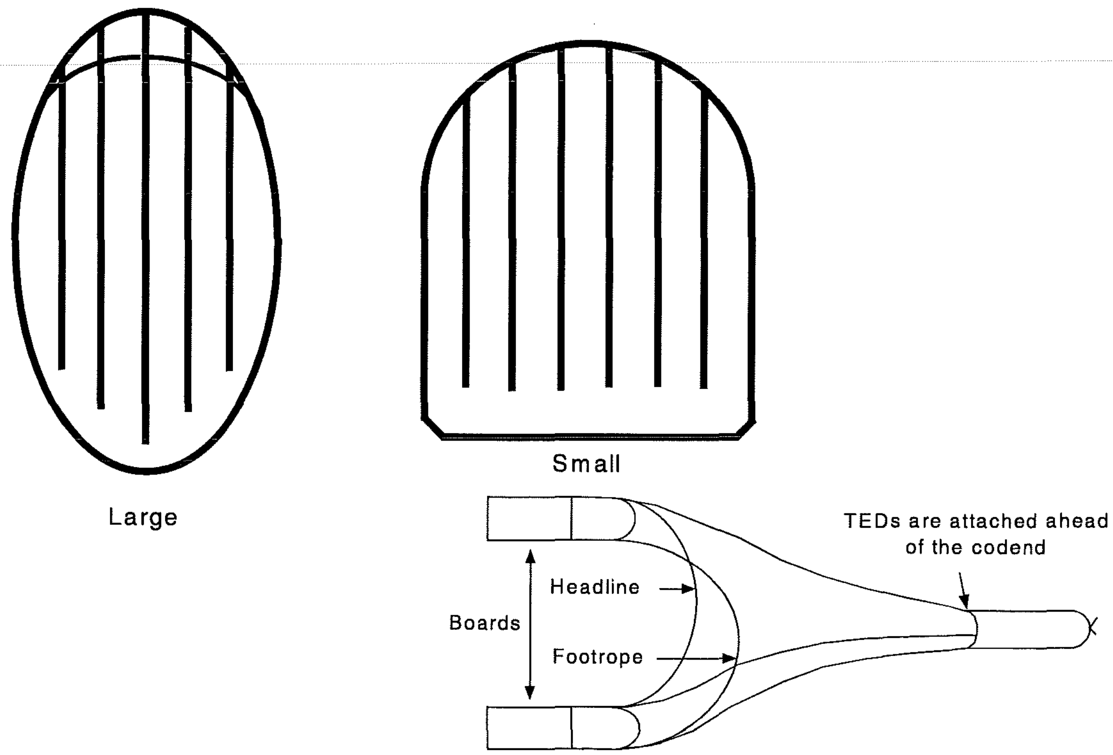
**Explanation**
The Nordmore Grid was designed originally for the cold-water shrimp fisheries of Norway. The device was bought to Australia and adapted for use in the estuarine trawl fisheries of northern New South Wales. This device was altered in size and shape to suit local conditions and made from light gauge (10 and 12 mm) aluminium rod. Bar spacings are 20 mm. A guiding panel pushes catch away from the escape opening in the top of the net. Another modification to the size and shape of the grid made it suitable for use in the prawn trawl fisheries of northern Australia. This grid is constructed from 25 mm and 16 mm aluminium pipe and is rectangular in shape. It uses 101mm bar spacings and large animals are excluded out the top of the net. The inner frame is removable in the event of damage or altered fishing conditions. Further modifications to the device by the Australian Maritime College gave rise to the NAFTED, which has been tested with good results in the Northern Prawn Fishery.

**Advantages**
* Gets rid of jellyfish
* Reduces unwanted fish
* Simple
* Easy to store

**Disadvantages**
* Clogging by weed
* Chaffing if improperly floated

**Comments**
Tests in the Clarence River (NSW) reported no loss of school prawns and a 77% reduction in bycatch. Tests of the NAFTED in the 1997 and 1998 Northern Prawn Fishery season showed good reductions in bycatch, especially jellyfish with minimal prawn loss. It has been tested extensively during trawling for tiger prawns and red leg banana prawns in the NPF.

## *Weedless TEDs*




**Explanation**

The Anthony Weedless TED is a patented design and is used by fishers in the USA. The grid is constructed from aluminium tube and has bars that attach to only one edge of the grid. A 101 mm space is left between the frame and the deflector bars that allows any weed that may collect on the bars to be washed off by water pressure. The Anthony Weedless TED comes in two sizes. The large size is oval-shaped and the small size is flattened on one edge. This TED can be installed as a top or bottom-opening TED. A major disadvantage of this type of grid is that the bars are inclined to break-off due to metal fatigue.

**Advantages**

* Less clogging than other TEDs
* Easy to store
* Excludes large animals
* Reduces some unwanted fish
* Simple

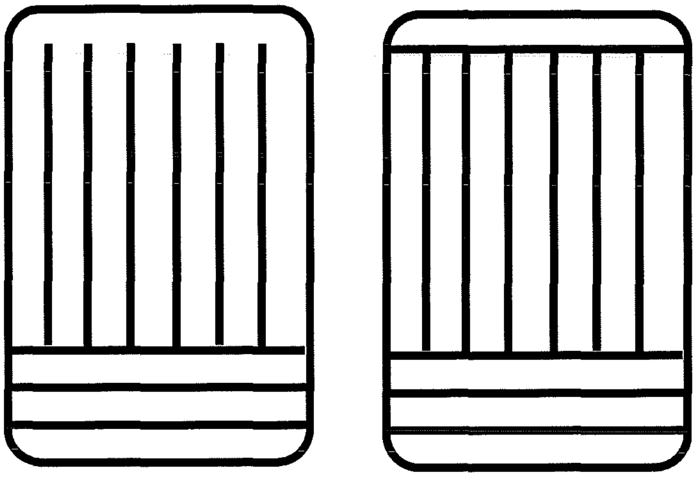
**Disadvantages**

* No extra space required for storage
* Lack of strength, only fixed at one point
* Chaffing if incorrectly floated

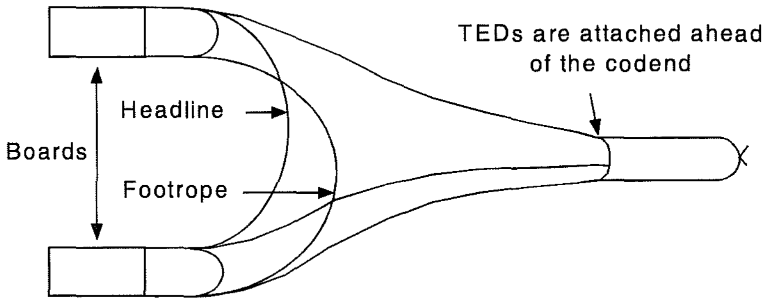
**Comments**

This TED is untried in Australian fisheries. It is becoming less popular with fishers in the USA.

## *Flounder TEDs*



Weedless Flounder TED Flounder TED




### Explanation

The Flounder TEDs consist of a rectangular-shaped grid that has horizontal openings at the base and vertical bars above. This design allows flat animals such as flounder and crabs to enter into the codend. This TED also comes in a weedless design. This type of design may be of benefit in Queensland scallop fisheries.

### Advantages

* May retain some marketable fishes
* Excludes large animals
* Simple
* Easy to store

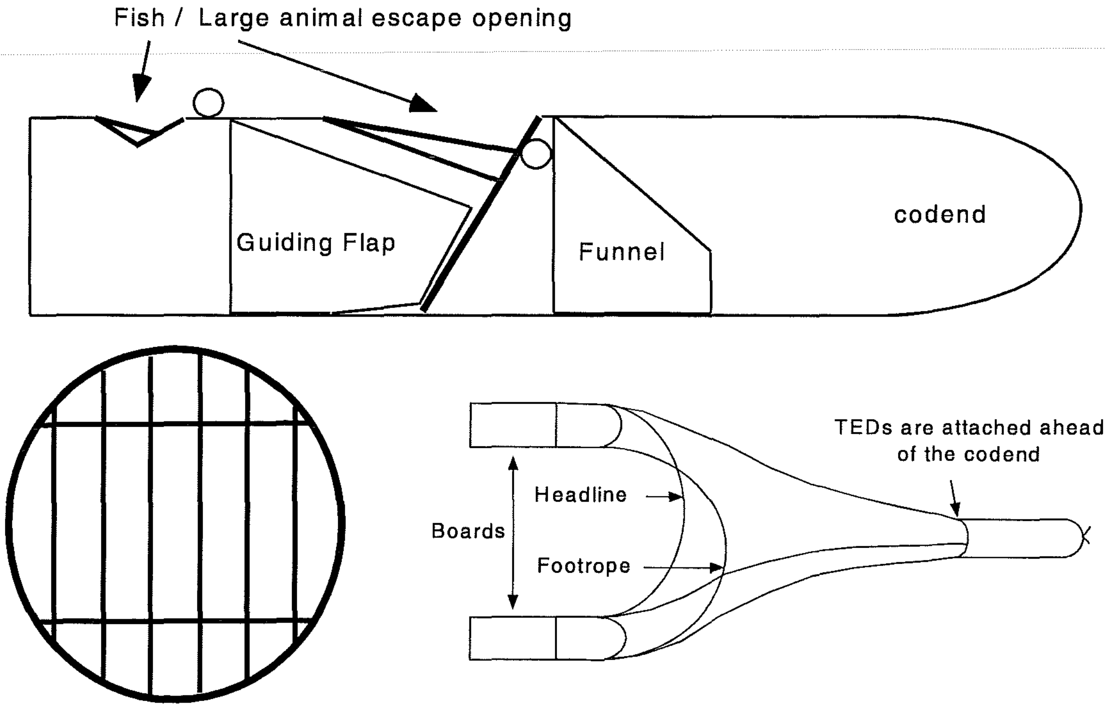
### Disadvantages

* Clogging by weed
* Chaffing if incorrectly floated

### Comments

Some fishers in Moreton Bay are using this idea to allow small sponges and debris to wash past the bottom of grid and into the codend. This stops the base of a top-opening TED from clogging.

## *AusTED*




### Explanation

The AusTED was designed by Richard Mounsey of NT Fisheries for Australian conditions and features a flexible oval-shaped grid made from plastic-coated, steel-wire rope. A guiding flap in front of the grid covers the triangular escape hole at the top of the grid. Animals too large to pass through the grid can push the flap away and escape. A funnel after the grid washes prawns into the codend whilst holding fish close to the opening making escape easier.

### Advantages

* Excludes large animals
* Reduces unwanted fish
* Flexible grid is strong but won't injure crew
* Easy to store

### Disadvantages

* Clogging by weed
* Internal funnels can tangle
* Variable performance

### Comments

QDPI and NT Fisheries tested the AusTED at four locations along the Queensland east coast and at one location in the Gulf of Carpentaria. Prawn loss and bycatch reduction were variable and depended on the conditions of the area fished.

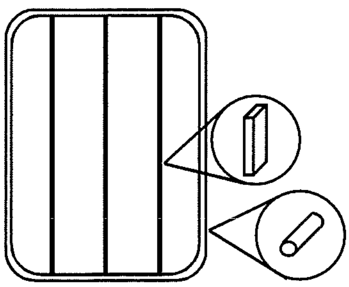
## *Other TEDs*

Australian fishers have developed some single-grid TEDs to exclude turtles and jellyfish (see below).

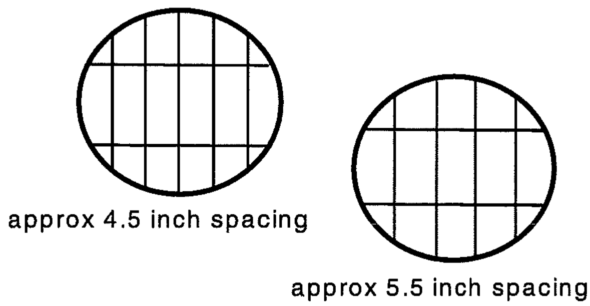
Bundaberg fishers Herb Olsen, developed a single-grid TED to exclude turtles and bull rays from his banana prawn catches. Herb's grid is circular, 762 mm in diameter, and made from 19 mm stainless-steel water-pipe. He has a four and five bar design, both of which have two horizontal cross bars for added strength. Herb has found that the four bar design retains more small shark.

Whilst Herb designed a TED to remove large animals, Brian Davies designed a TED to remove jellyfish from his catches in Moreton Bay. Brian's grids are circular and made from 25 mm aluminium pipe. He uses 90 to 101 mm bar spacings to exclude significant amounts of jellyfish from the net without reducing his prawn catch.

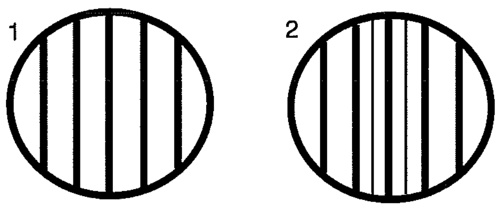
Cairns fishermen Bill Izard, together with a local net maker have designed a TED to exclude large animals from trawl catches. Bill targets live leader prawns as broodstock for the aquaculture industry. The TED allows longer trawl shots without damaging the valuable spawners. The TED is rectangular and constructed from 3 mm aluminium tubing. The TED is 635 mm high and 457 mm wide. It has three defector bars constructed from 101 mm flat bar. Bar spacings spacings vary from wider spacings in the middle to narrower spacings on the outside.



Bill Izard Grid




Herb Olsen Grid



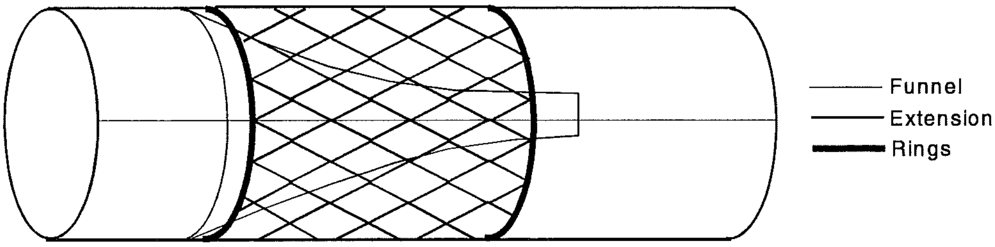

Grids
Material - 1inch ID aluminium pipe
Shape - Circular, 30 inch diameter
Bar Spacing - approx 4 inches

Grid 1 - Excludes jellyfish, leaves the tentacles in heavy concentrations.
Grid 2 - Excludes whole jellyfish, no tentacles in the codend.

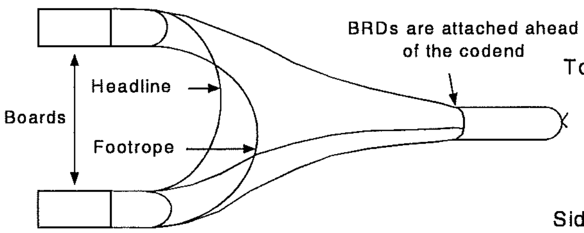
Brian Davies Grid

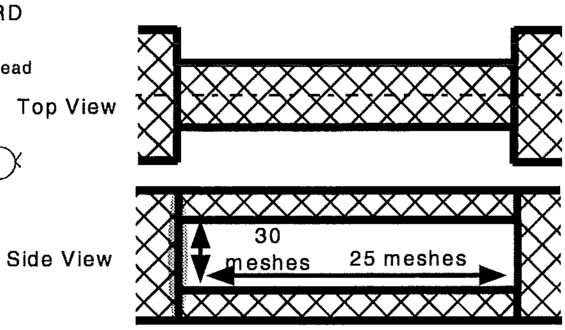
# BYCATCH REDUCTION METHODS

## *Radial Escape Devices for Fish Exclusion*




Jonh Olsen Monfilament BRD




Neil Olsen BRD

### Explanation

A radial escape device, designed for fish exclusion consists of a tapered funnel surrounded by escape openings. The openings are positioned forward of the trailing edge of the internal funnel. Large square-mesh, diamond-mesh or full windows are the most common type of escape opening used. These devices are mainly fitted behind a TED but some types, i.e. Neil Olsen BRD, can be used alone. Other designs are the Radial Escape Section, Expanded Mesh BRD, John Olsen Monofilament BRD and Jones Davies BRD.

### Advantages

* Reduced fish by-catch
* Mostly comprised of soft components
* Maintains codend shape
* Simple to repair (most designs)

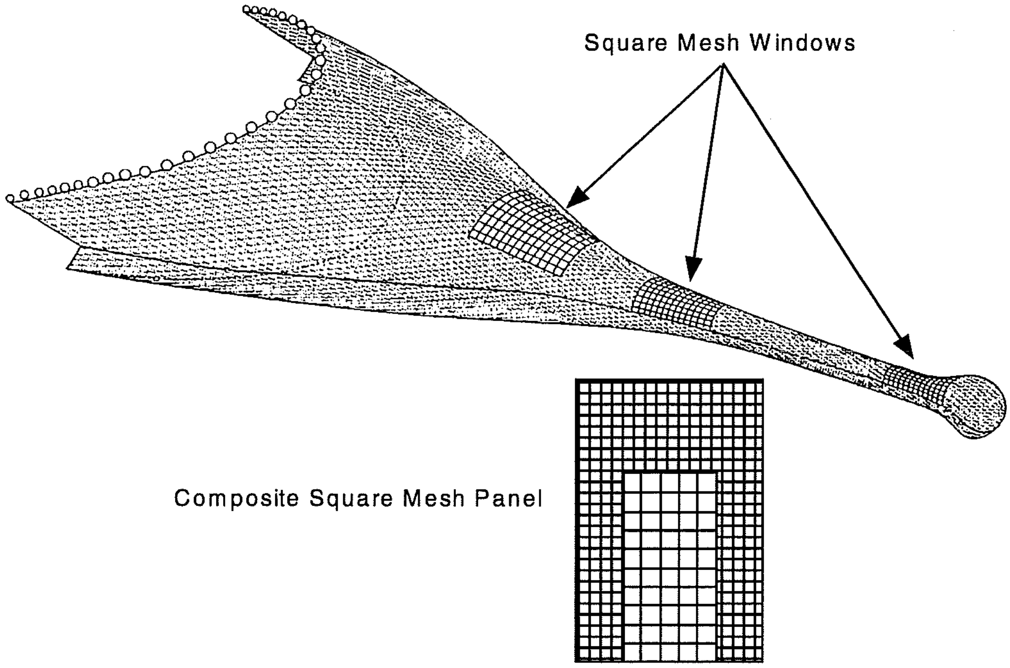
### Disadvantages

* Clogging
* Square meshes can distort
* Increase the length of the net

### Comments

This type of device is currently being used by fishers targeting banana prawns on the Queensland east coast e.g. John Olsen Monofilament BRD and Neil Olsen BRD. Some fishers who target tiger prawns in north Queensland are also experimenting with this type of device.

## *Large Mesh Windows*




Reproduced from NSW Fisheries

**Explanation**
Strategically placed windows of large square or diamond-mesh can effectively exclude unwanted fish bycatch. They can be placed in the top or bottom of the net. Generally they are placed towards the codend.

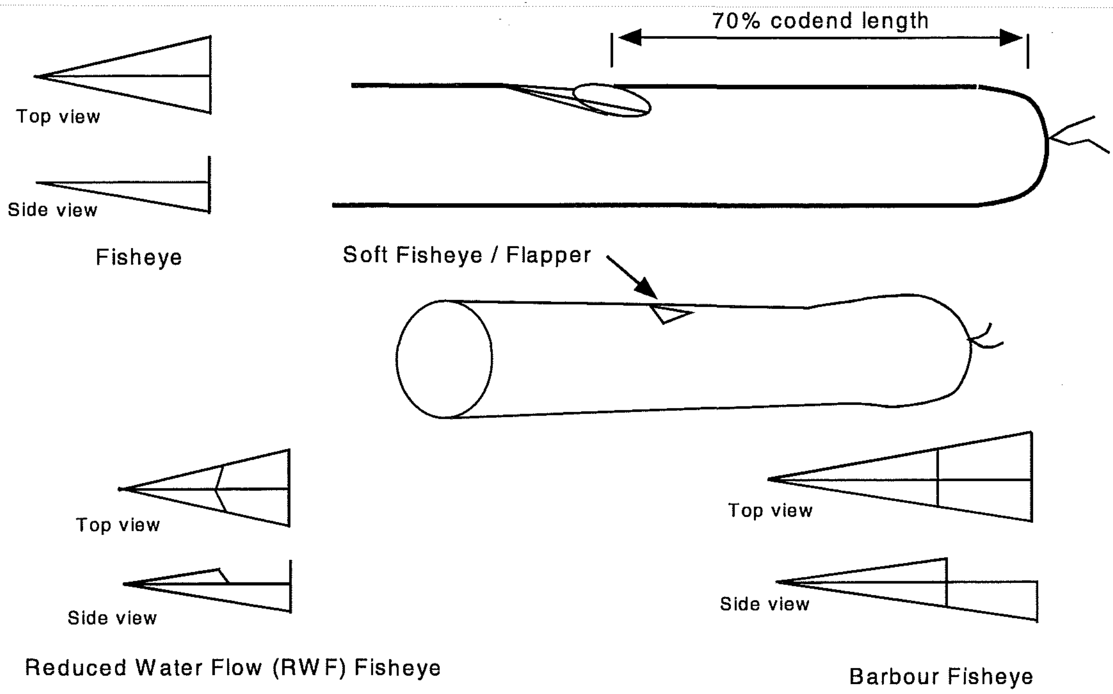
NSW Fisheries have developed a composite square-mesh panel for use in their oceanic king prawn fisheries. This panel is constructed from two different sizes of mesh. The smaller square-meshes on the outside of the panel take the load whilst the centre panel of large square-meshes remains open, allowing juvenile and unwanted fish to escape. This panel is used in conjunction with a bell codend and should be located no more than 30 meshes in front of the draw strings.

**Advantages**
* Allow juvenile fish to escape
* Cheap, easy to install
* No length increase to the net

**Disadvantages**
* May lose catch

**Comments**
Tests in NSW oceanic prawn fisheries of the composite square-mesh panel showed a 40% reduction in discarded bycatch and no reduction in prawn catch. There was also up to a 70% reduction in juveniles of commercially important species.

## *Fisheyes*




modified from NMFS Technical Memorandum 1994 NMFS-SEFSC-327

**Explanation**

Fisheyes can be made from any type of metal rod e.g. galvanised steel rod, stainless steel rod. They are sewn into the codend and provide an area where unwanted fish can escape from the net. The positioning of the fisheye within the codend is the most important factor governing their performance. It is recommended that the fisheye be placed in the top of the codend at least 70% of the codend length away from the codend strings.

**Advantages**

* Reduction of unwanted fishes
* Cheap, easy to install

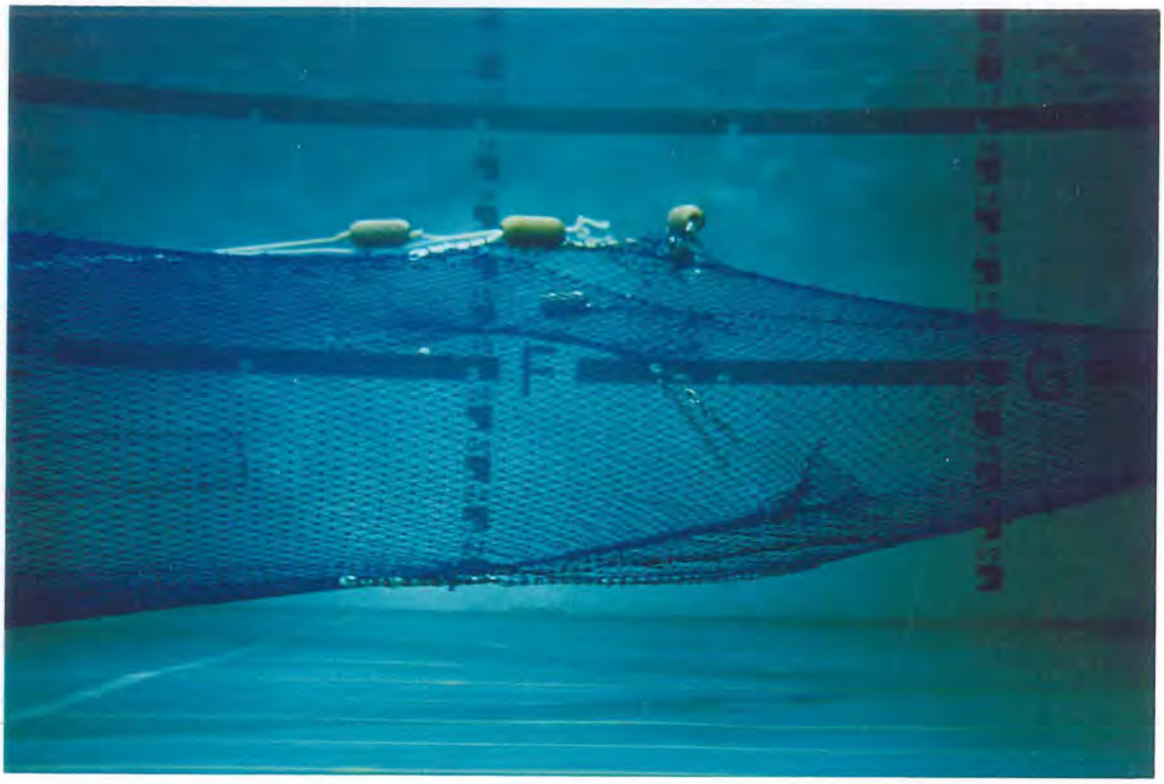
**Disadvantages**

* Position dependent
* Bycatch exclusion limited

**Comments**

Fisheyes are one of the three types of fish excluder that can be used legally in the southeastern USA shrimp trawl fishery. Limited tests in Australian fisheries since 1995 have proved inconclusive.

*Bigeye BRD*



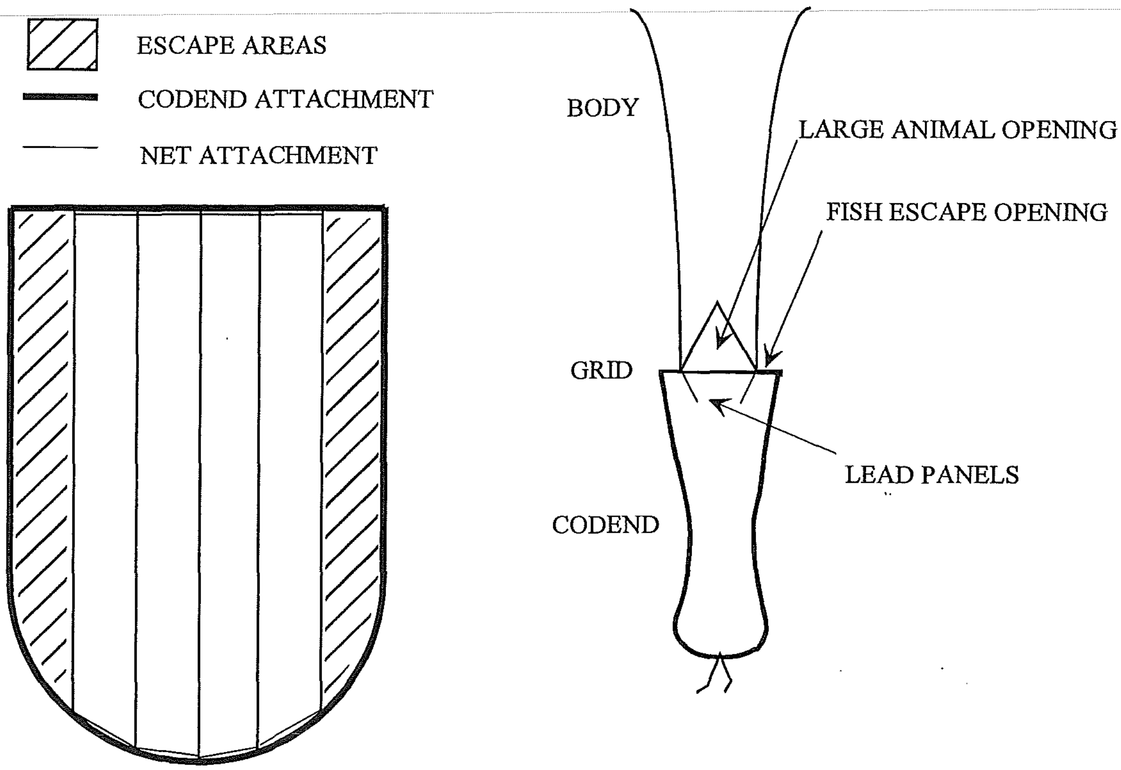
**Explanation**
Bigeyes are a modification to the throat of the trawl net that provides a large opening for fish to escape through. They can be installed in any net design, but require a slightly different approach for two-seam nets compared to four-seam nets. The fish escape opening is created in the top panel of the main body of the net by weighing down the front half of a horizontal cut with chain or net leads and floating the back half of the cut. They can installed into the bottom panel of a trawl net, but the weighting and floating of the cut needs to be reversed i.e. front of the cut is floated and the rear of the cut is weighted.

**Advantages**
* Reduces fish by-catch
* Net length not increased
* Fairly maintenance free
* Consists of soft components

**Disadvantages**
* Can be difficult to install
* May make repair more difficult
* Less effective at night

**Comments**
These devices are gaining popularity with fishers targeting banana prawns on the Queensland east coast. The bigeye BRD is also being used by fishers targeting tiger, endeavour and red spot king prawns as there is no loss of commercial product. Beam trawl operators in south east Queensland are also using a scaled down version of the bigeye BRD.

*Modified TEDs*




**Explanation**
This type of grid is wider than the standard TED. The extra width is needed so that fish escape-openings can be made from the outer bar spacings of the grid. The codend (aft of the grid) is sewn to the outside perimeter of the TED, but the throat of the net (forward of the grid) attaches to the first inside bars, leaving an opening for fish to escape. Lead panels are sometimes sewn after the grid to assist in guiding fish to the escape openings.

**Advantages**
* Reduces fish by-catch
* Length of the net is not increased
* Exclusion occurs in one area of the net

**Disadvantages**
* Need some networking skill to install
* May make repair more difficult
* Less effective at night

**Comments**
Fishers targeting banana prawns and tiger prawns have tried this device. Exclusion rates are undocumented, but it seems that fish exclusion is lower than the other devices mentioned.

## *Square Mesh Codends*

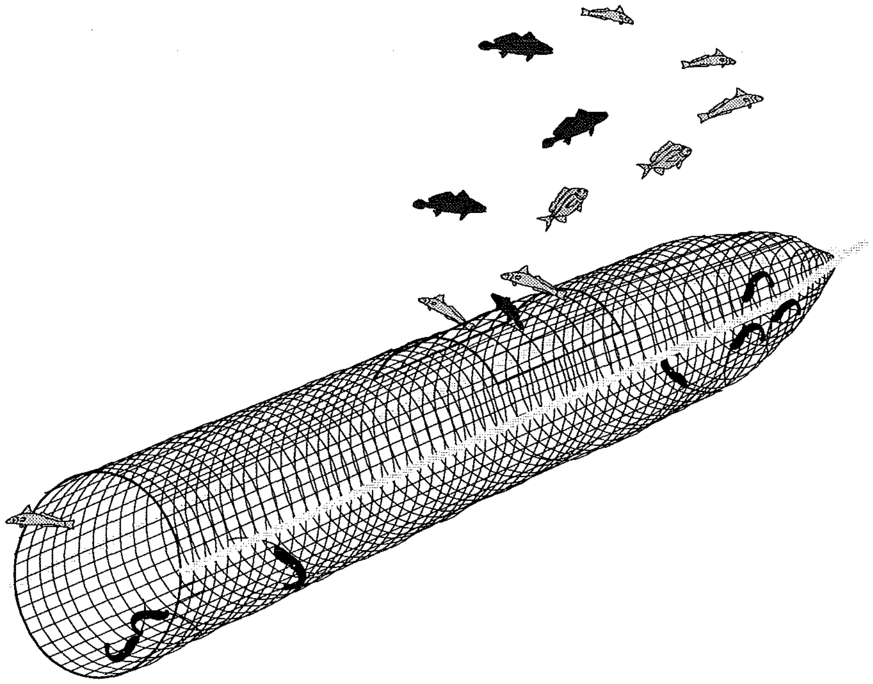


Illustration reproduced from Broadhurst

**Explanation**

As a diamond-mesh codend fills with catch, the meshes close up restricting the escape of small fish. The meshes of a square-mesh codend do not close during a trawl, so small fish and prawns can escape. These codends are useful in fisheries where the catch of small animals impacts on other commercial fisheries.

**Advantages**

* Excludes small fish
* Excludes small prawns

**Disadvantages**

* Load is carried by half of the mesh
* Requires stronger material
* Can wear out quickly

**Comments**

Square-mesh codends have been tested in Gulf of St Vincent (SA), where the capture of small prawns (21-30s) impacts on the value of fishery. These fishers target large prawns (U10s and 10-20s) and prefer not to catch small prawns.

## *Other Strategies*

Queensland fishers trawling for banana prawns are continuing to devise innovative methods of reducing unwanted fish catch. Other Queensland fishers had tested trawl nets with the meshes of the wing-panel hung on the square. This was designed to allow unwanted fish to escape through the square meshes of the wing. The design was tested north Queensland, and markedly reduced unwanted fish bycatch. However, a legal mesh-size restriction of 51 mm for netting in the wing panel, caused the loss of smaller-sized (21-30s, 30-40s) marketable prawns.

A low-profile trawl has been developed overseas. In this net, the wingend height of the net was halved. This allowed many unwanted fish to rise over the oncoming headline. Prawn catch was reported to be unaffected.

## TED SPECIFICATIONS

| Type | Material | Height mm | Width mm | No of bars | Bar Spacing mm | Weight kg |
|---|---|---|---|---|---|---|
| Standard Grid | 9 mm steel rod frame, 13 mm steel rod bars | 1143 | 813 | 7 | 95 | |
| Super Shooter - large | 19 mm aluminium rod frame, 16 mm aluminium rod bars | 1295 | 1067 | 9 | 102 | 8.6 |
| Super Shooter - medium | 16 mm aluminium rod | 1041 | 838 | 7 | 102 | 4.5 |
| Super Shooter - small | 13 mm aluminium rod | 889 | 813 | 7 | 102 | 3.6 |
| Seymour TED - large | 32 mm aluminium pipe frame, 25 mm aluminium pipe bars | 1206 | 978 | 7 | 90 | 10.0 |
| Seymour TED - medium | 25 mm aluminium pipe | 1041 | 838 | 6 | 90 | 6.0 |
| Seymour TED - small | 19 mm aluminium pipe | 787 | 737 | 6 | 76 | 4.0 |
| Anthony Weedless - large | 32 mm aluminium pipe | 1727 | 864 | 6 | 108 | 8.0 |
| Anthony Weedless - small | 25 mm aluminium pipe | 965 | 813 | 5 | 114 | 4.0 |
| AusTED -large | 7*7 steel wire rope, 12 mm frame, 12 and 8mm bars | 900 | 800 | 5 | 150 x 300 | 5.5 |
| AusTED - small | 7*7 steel wire rope, 12 mm frame, 10 and 6 mm bars | 750 | 700 | 5 | 100 x 250 | 4.5 |
| NAFTED - AMC | 25 mm pipe frame, 16mm pipe bars | 1100 | 880 | 13 | 100 | 8.0 |
| Nordmore grid -NSW | 12 mm aluminium rod frame, 10 mm aluminium rod bars | 600 | 400 | 12 | 20 | 3.0 |
| Wicks TED – standard size | 13 mm aluminium rod | 762 | 610 | 7 | 63 | 1.5 |
| Wicks TED- standard size, dual frame | 13 mm aluminium rod | 762 | 610 | 4<br>3 | 127 | 2.0 |
| Wicks TED – gulf size I | 19 mm aluminium rod | 952 | 762 | 4 | 146 | |
| Wicks TED – gulf size II | 19 mm aluminium rod | 1016 | 812 | 7 | 102 | |

# Appendix 4:
# TED DESIGN: A LOOK AT COMMON COMPONENTS

Compiled by Jason McGilvray, Fisheries Technician
Bycatch Project

## Escape Openings

**Size** **Shape** **Direction**

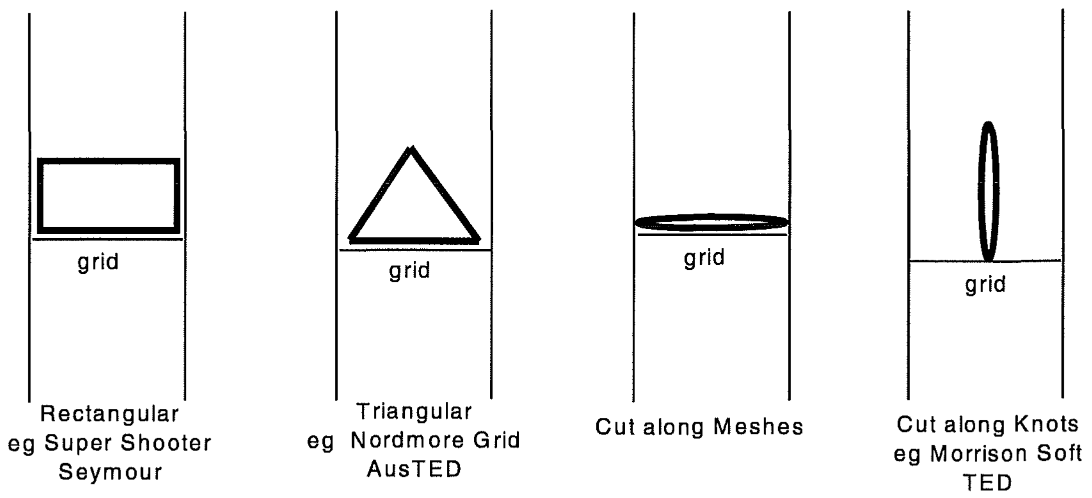
An escape opening forms the basis of all BRD designs, including TEDs. The opening can be of any size and is largely dependent on the size of the animal or object likely to be excluded. The size of the escape opening will also be related to the size of the grid.

The shape of the escape opening is a matter of preference. Some TED designs require a certain shape e.g. the Morrison soft TED must have an escape opening cut along the knots, but most shapes will work with a grid.

The escape opening can be cut in the top or bottom of the net, depending on the way the grid is slanted.

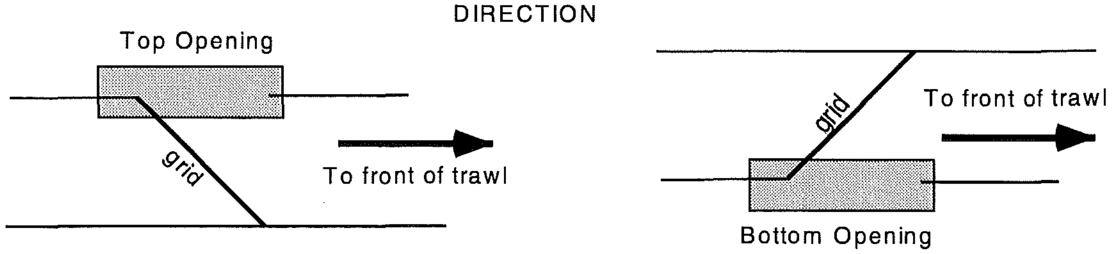
It is important that the edges of any cut be lace or hung onto rope or be reinforced by selvedging. This will ensure that the escape opening does not rip or stretch during fishing.

SHAPE




Examples: AusTED – triangular opening, 30 bars by 31 meshes by 30 bars
Super shooter TED - rectangular opening, 36 meshes by 15 knots
Morrison soft TED – cut along , about 1219 mm stretched meshes

DIRECTION




Points to remember

- Must be of sufficient size to allow large animals to escape
- Must be positioned before the grid
- Must maintain the strength of net i.e. will not easily tear

## Flaps

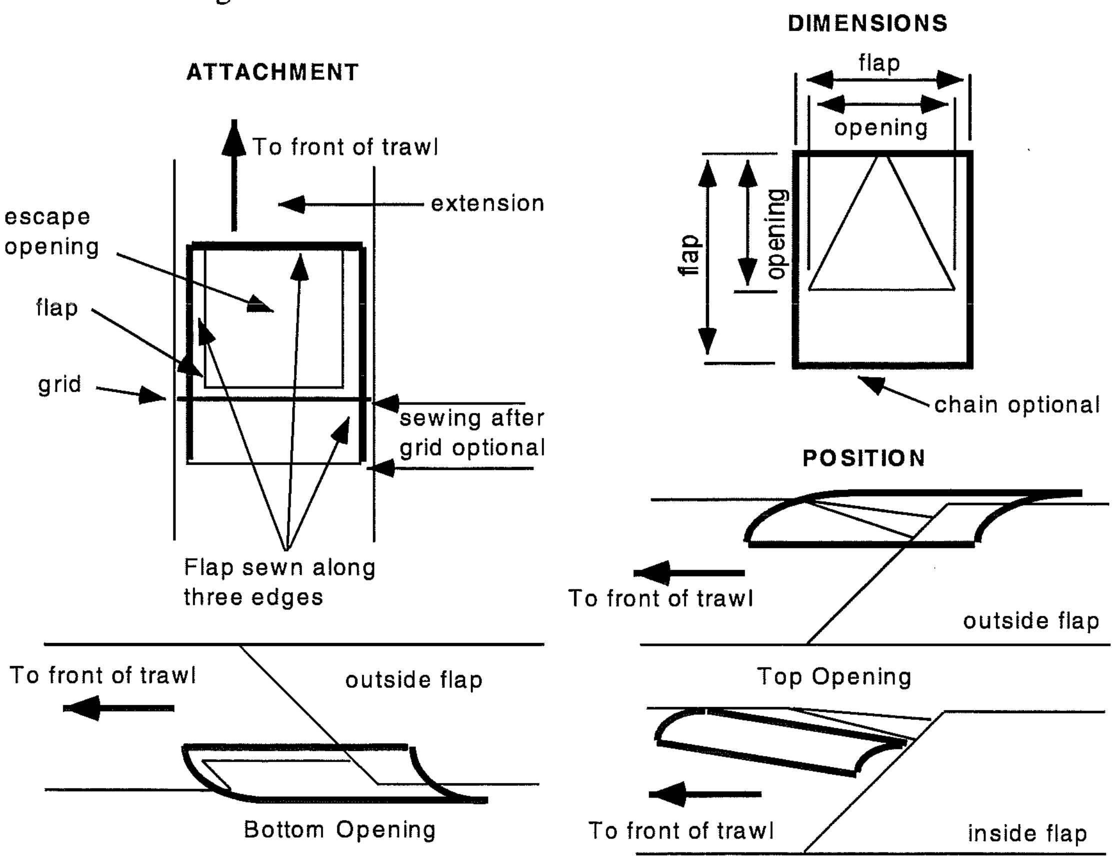
**Position** **Dimensions** **Mesh Size** **Attachment**

The main purpose of the flap is to cover the escape opening and prevent catch loss when a large animal or object is not being excluded.

A flap can be positioned outside or inside the TED extension. A top-opening TED can have two flaps, one inside one outside, to increase the efficiency of the TED.

The dimensions of the flap will depend on the size of the escape opening. Ideally, the flap should be a little wider than and half as much longer as the escape opening. Top-opening TED can have a length of chain attached to the aft edge of the flap to hold it closed. Floats can be attached to the flap of a bottom-opening TED to serve a similar purpose. Care must be taken not to have too much weight or flotation, as this will hinder the exclusion of large animals from the trawl. The result will be clogging and loss of catch.

The flap should be attached along or just ahead of the leading edge of the escape opening. It should be sewn down the side towards the grid and can be sewn a bit past the grid. The further the flap is sewn past the grid, the more snugly it fits. As you sew the flap past the grid, the escape opening becomes smaller, which may lead to large animals not being excluded from the trawl.




Points to remember:

- a flap sewn on too tightly will hinder fish exclusion
- regularly check the flap during fishing for signs of stretching

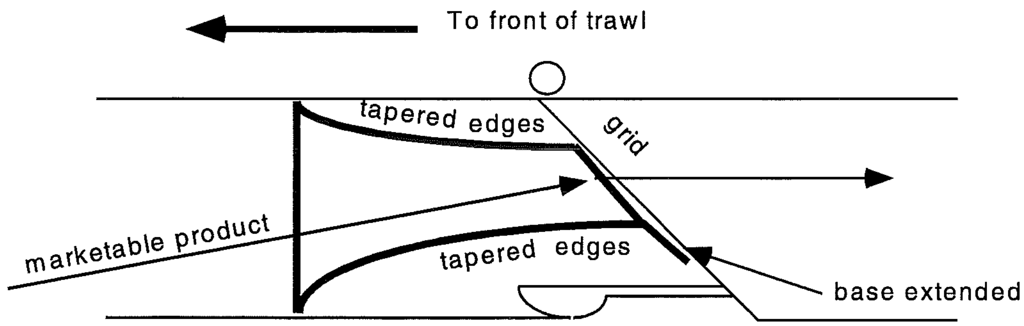
# Funnels

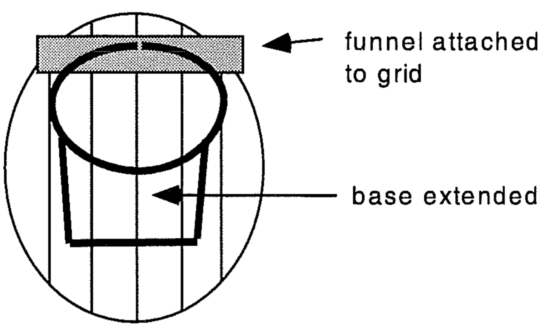
Funnels are placed before a grid to direct catch away from the escape opening. Tapers can be used to give the funnel shape. The base of the funnel may be longer than the top to help retain catch.

Funnels can be attached partly to the grid (greater than 1/3 not recommended) to ensure that the catch is washed in the correct direction. Such an attachment needs to be opposite the escape opening. The exit of the funnel must be large enough (or stretch to a sufficient size) to allow unwanted animals and debris to be excluded through the escape opening.

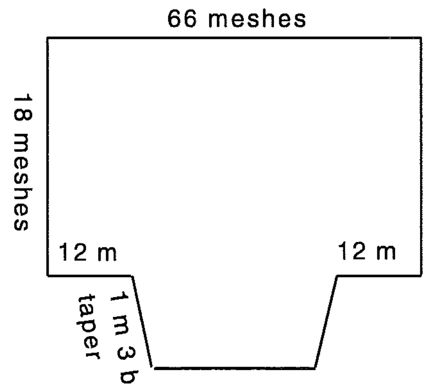
Funnels made from polyethylene mesh will stretch to allow large animals to pass through but then return to their original shape. This elastic effect ensures the best performance possible.

Funnels may hinder the operation of TEDs on dirty ground where the funnels may become clogged with debris.




ATTACHMENT




**FUNNEL NET PLAN**
**(for 100 round extension)**

Points to remember

- The funnel must expand to a size large enough for big animals to escape
- Will increase efficiency on clean trawl ground
- May hinder efficiency in dirty trawl grounds

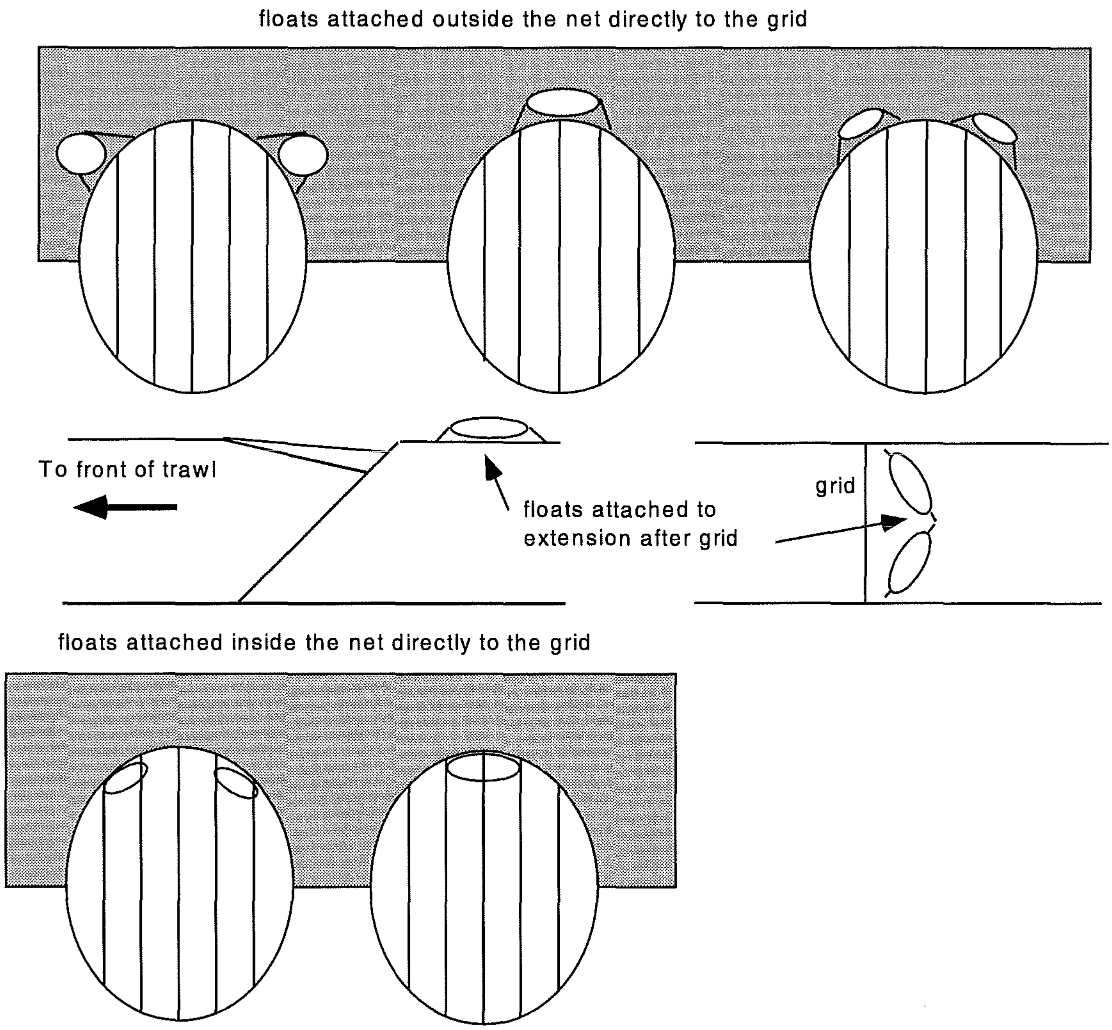
# Floats

Correct flotation of the TED is imperative for optimal performance.

Inadequate flotation can lead to TED instability, chaffing and inefficient operation. A bottom-opening TED with inadequate flotation will operate to near the sea bed and will not easily exclude large animals. Flotation on a top-opening TED need only keep it just off the sea bed to avoid chaffing.

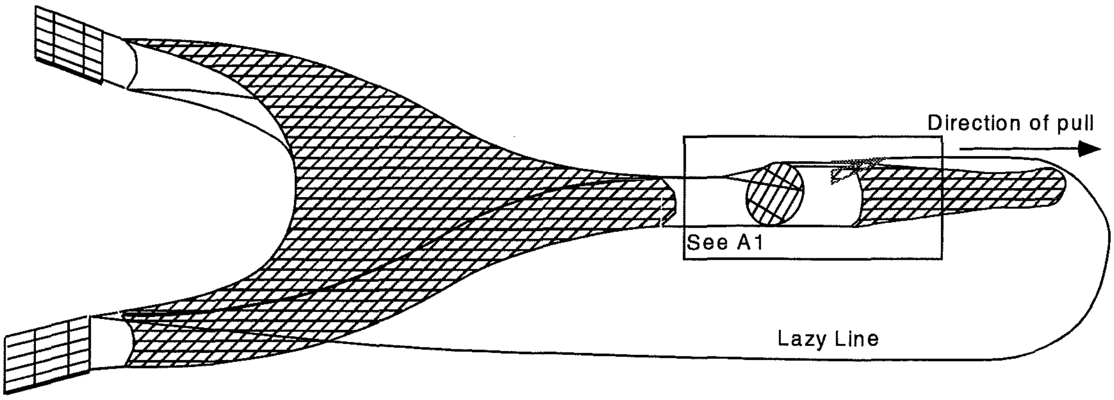
Floats can be attached inside or outside the extension. Floats attached outside may snag the lazy line. Floats attached inside the net may collect debris and lead to clogging. Floats placed inside the extension should be positioned behind the grid to avoid such clogging.

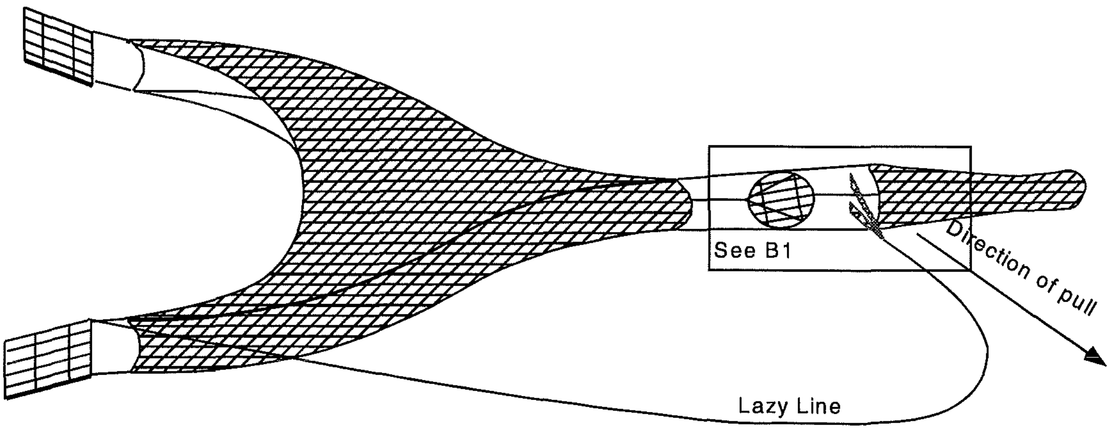
Floats that implode due to water pressure during a tow or over a period of time should be avoided as the resultant loss of buoyancy will cause the above mentioned problems. Plastic fish trawl floats are appropriate.



## Lazy Lines

Lazy lines can adversely effect the way a TED operates. Generally, the length of the lazy line needs to be increased when a TED is fitted to a net. Below is an illustration of what happens when the lazy line is too short. The position and type of lifters used may also effect TED performance. Trial and error is the only way to find the best system for any particular boat. Rolling of TEDs due to lazyline arrangements is a more frequent problem in triple and quad-rigged gear rather than in twin gear.



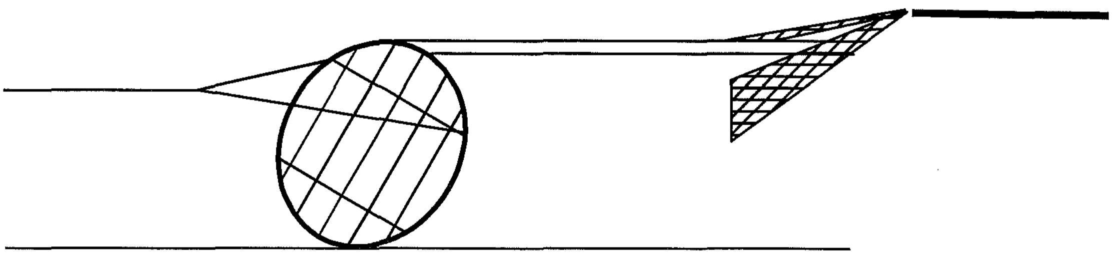



Figure A1 - TED fishing upright

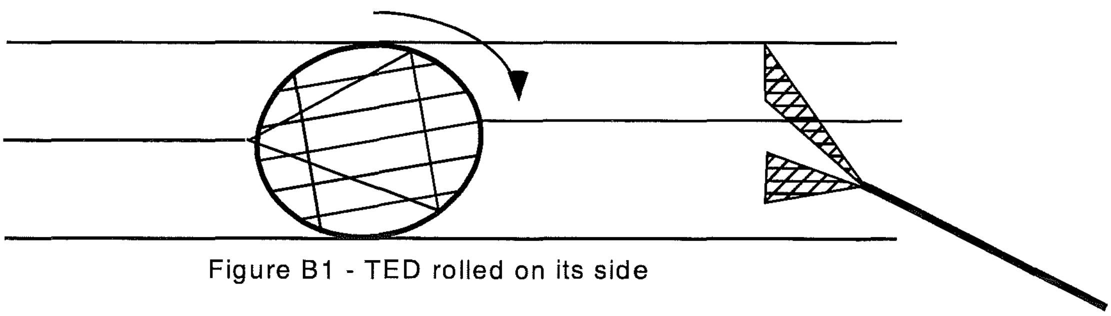


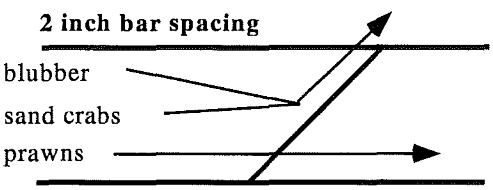
Figure B1 - TED rolled on its side

## Bar Spacing

The space between the bars of a grid determines what size or shape animal will pass through. Bar spacings of 76 to 102 mm cover a wide range of fishing applications. The following factors should be considered when choosing a bar spacing:

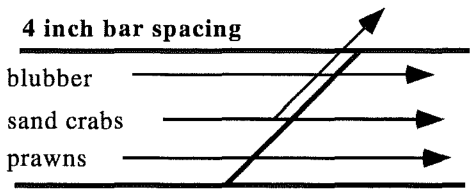
- size of the target species,
- size of any marketable bycatch species,
- size of the animals and objects to be excluded.

The size of the target species must be looked at and the appropriate bar spacing determined. If small prawns are the target species, a space as small as 25mm may be suitable e.g. Clarence river prawn trawls have grids with 20 mm bar spacing. If large prawns are the common target species bar spacing may need to be closer to 76 mm. More animals are able to pass through the grid and into the codend as bar space increases. If you are interested in keeping marketable bycatch such as small sharks, crabs or edible fish, bar spacing will need to be increased to allow these animals through. Bar spacings of 102 to 152 mm have been tested, successfully retaining small sharks and blue swimmer crabs. Bar spacings must be sufficiently narrow to stop the passage of large animals such as turtles and stingrays. If these animals pass through the grid or snag in the grid clogging and catch loss will occur. The space between the bars of the grid generally involves some type of trade off.




- No blubber in the codend
- Prawns undamaged
- No lost shots
- Gear undamaged

Trade off - Loss of marketable crabs

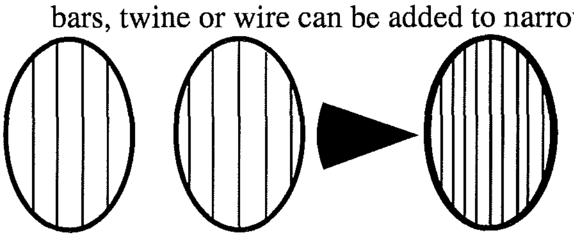



- Exclude some blubber
- Keep marketable crabs

Trade off - Suffer some damage to prawns
- More unwanted by-catch in codend

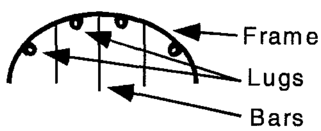
**Removable Bars:** If you fish in different areas and need to exclude different animals in each area, then a grid with removable bars may be beneficial. There are several methods that can be used to change the spacings between the bars quickly.

1. Another grid: where a second grid is placed in front of the first and held in place with electrical ties. The second grid has offset bars to that of the main grid and when laid on top makes the bar spacings smaller (figure 1).
2. Wire or twine between bars: whereby welding a lug on the frame between the bars, twine or wire can be added to narrow the space (figure 2).

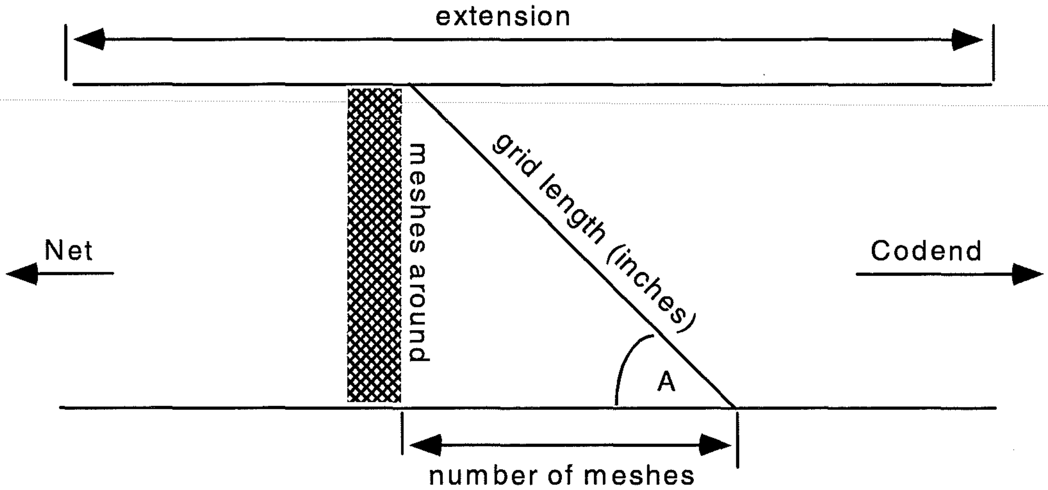


Main grid 4 inch space    Second grid 4 inch space offset    Two grids together 2 inch space

Figure 1



## Calculating Grid Angle




To calculate the "**number of meshes**" required to install a grid at the angle "**A**" (in the diagram above) use the following steps.

1. choose the angle **A** that you want to install the grid at.
2. find the cos angle (cosine of angle A) from the table below
3. substitute the numbers into the following equation to calculate the **number of meshes** required to count along the net for the installation of the opposite side of the grid-

$$\frac{\text{COS ANGLE} \times \text{GRID LENGTH (inches)}}{\text{MESH SIZE IN EXTENSION}} = \text{NUMBER OF MESHES}$$

EXAMPLE :
My grid is 33 inches long and I want to install it at 47°. My TED extension is an 1 $^5/_8$ inch mesh piece of polyethylene with 100 meshes around.

substitute numbers into equation →

$$\frac{.681 \text{ (from table below)} \times 33 \text{ (inches)}}{1.625 \text{ (mesh size in extension)}} = 14 \text{ meshes}$$

To install the grid I would sew the top of the grid to the seam in the net, count 50 meshes around, then 14 meshes towards the codend and sew the bottom of the grid to this mesh. The remaining meshes are sewn evenly between the these two points.

| Angle A | COS Angle A | Angle A | COS Angle A | Angle A | COS Angle A |
|---|---|---|---|---|---|
| 30 | 0.866 | 39 | 0.777 | 48 | 0.669 |
| 31 | 0.857 | 40 | 0.766 | 49 | 0.656 |
| 32 | 0.848 | 41 | 0.754 | 50 | 0.642 |
| 33 | 0.838 | 42 | 0.743 | 51 | 0.629 |
| 34 | 0.829 | 43 | 0.731 | 52 | 0.615 |
| 35 | 0.819 | 44 | 0.719 | 53 | 0.601 |
| 36 | 0.809 | 45 | 0.707 | 54 | 0.587 |
| 37 | 0.798 | 46 | 0.694 | 55 | 0.573 |
| 38 | 0.788 | 47 | 0.681 | | |

# Appendix 5: TED & BRD FIELD TESTS - QUEENSLAND EAST COAST

## FV *Stardancer*, 24th February to 6th March 1997

Fishing gear specifications: This 15.5 m trawler towed three seven-fathom, two-panel Florida Flyer prawn nets and a two-fathom try-net operated off the port boom. A John Olsen monofilament BRD, a type of radial escape device, was tested. The monofilament meshes were 305 mm (stretched mesh). The BRD included two 750 mm diameter Noreslay wire net-opening hoops fore and aft of the tapered funnel.

Fishing conditions: Fishing occurred between Yeppoon and Cape Upstart, mostly during the day for banana prawns.

Bycatch reduction: Bycatch was reduced, on average by 36% (20% s.d.) per tow in the BRD compared to the standard net. This translated to a total bycatch of 855 kg in the BRD net compared to 1520 kg of bycatch in the standard net. A visible reduction in the catch of Grunter (*Pomadasys* spp.) was observed.

Prawn reduction: Prawn catch increased slightly, on average by 2% (34% s.d.) per tow in the BRD. The increase in prawn catch may have been an effect of the BRD or may have been due to the patchiness of banana prawns.

Ease of operation and handling: There were no operational problems with the BRD net, nor did the BRD clog with bycatch or debris.

Special considerations for use: This BRD was well suited to daytime trawling operations for banana prawns.

## FV *Seabring*, 29th July to 1st August 1997

Fishing gear specifications: This 16.8 m prawn trawler towed four five-fathom prawn nets. A top-opening super shooter TED, of small size (889 mm high x 813 mm wide), and 95 mm bar spacing was tested. The TED was fitted to the outside starboard net and its catches were compared with the inside starboard net.

Fishing conditions: Fishing occurred between Cairns and Alexandra Bay (south of Cape Tribulation) over the full moon. Target species were tiger and endeavour prawns.

Bycatch reduction: There was on average, no difference (0%) in the quantity of bycatch per tow (15% s.d.). This was due mainly to the lack of large animals, such as stingrays, turtles or sponges, encountered during the test.

Prawn reduction: Prawn catch increased, on average, by 7% (12% s.d.) per tow in the TED net compared to the standard net. The TED net recorded an increased tiger prawn catch of 11% (s.d. 16%) and an increased endeavour prawn catch of 2% (s.d. 19%).

Ease of operation and handling: The TED showed no signs of wear and tear, and few fish gilled in the escape flap or internal funnel. Rough weather did not effect on the ease of use of the TED.

Special considerations for use: The otterboards on this vessel spread extremely well upon entry into the water. The water flow and the short throat design of the net ensured the stability of the TED in the water. The TED was kept onboard the *Seabring* for testing in other fishing grounds of north Queensland.

## FV *Kimissa Lee*, 27th June to 1st July 1997

Fishing gear specifications: This 18.6 m prawn trawler towed four five-fathom prawn nets. A radial escape type BRD was installed into both starboard nets. The BRD, designed by Neil Olsen (skipper) consisted of an internal tapered funnel, surrounded by two large windows cut into the external netting.

Fishing conditions: Testing occurred during night trawling in the Townsville area, with the target species being tiger and endeavour prawns.

Bycatch reduction: Bycatch was reduced, on average by 12% (16% s.d.) per tow in BRD nets. This translated to a total bycatch of 1,263 kg in the BRD nets compared to 1,562 kg of bycatch in the standard nets. During two additional daytime tows specifically conducted to test fish exclusion, bycatch was reduced by up 68% in the BRD nets. Visual observation suggested that javelinfish (*Pomadasys argentus*), dollarfish (*Leiognathus moretoniensis*) and grinners (*Saurida* spp.) were the predominant fish species excluded.

Prawn reduction: Total prawn catch increased, on average, by 2% (13% s.d.) per tow in the BRD nets. There was on average, no difference between the nets in tiger prawn catches (average 0%, 15% s.d.) and endeavour prawn catches were increased by 4% (20% s.d.) in the BRD nets.

Ease of operation and handling: There were no operational problems with the device.

Special considerations for use: Testing occurred during night trawling and achieved only modest rates of fish exclusion. Better rates of fish exclusion may be achieved during daytime trawling.

**FRV *James Kirby*, 22nd to 24th August 1997**

Fishing gear specifications: The vessel towed two six-fathom Yankee Doodle prawn trawl nets. The devices tested were a top-opening Seymour TED (medium size) and a Jones-Davies BRD constructed by a commercial net maker. Additionally, a bottom-opening Seymour TED was compared to a top-opening Seymour TED.

Fishing conditions: Day and night trawling was undertaken in the Townsville area, with tows lasting about 60 minutes.

Bycatch reduction: The commercial TED and BRD combination recorded a 17% reduction in overall bycatch. The bottom-opening TED caught 9% less bycatch than the top-opening TED.

Prawn reduction: The commercial TED and BRD combination recorded a 22% reduction in overall prawn catch. Overall, the bottom-opening Seymour TED caught 36% fewer prawns than the top-opening Seymour TED, but it should be noted that catch rates were extremely low, and were not representative of commercial catches.

Ease of operation and handling: The TEDs were easy to use, although cable ties used in the TED construction were a potential source of injury for crew.

Special considerations for use: None.

**FV *John D*, May 1998**

Fishing gear specifications: This prawn trawler towed two ten-fathom Yankee Doodle trawl nets. The device tested was a TED modified for enhanced fish exclusion, through the addition of fish escape openings on either side of the TED (Figure 1). This design was developed by Herb Olsen, owner and skipper of the *John D*.

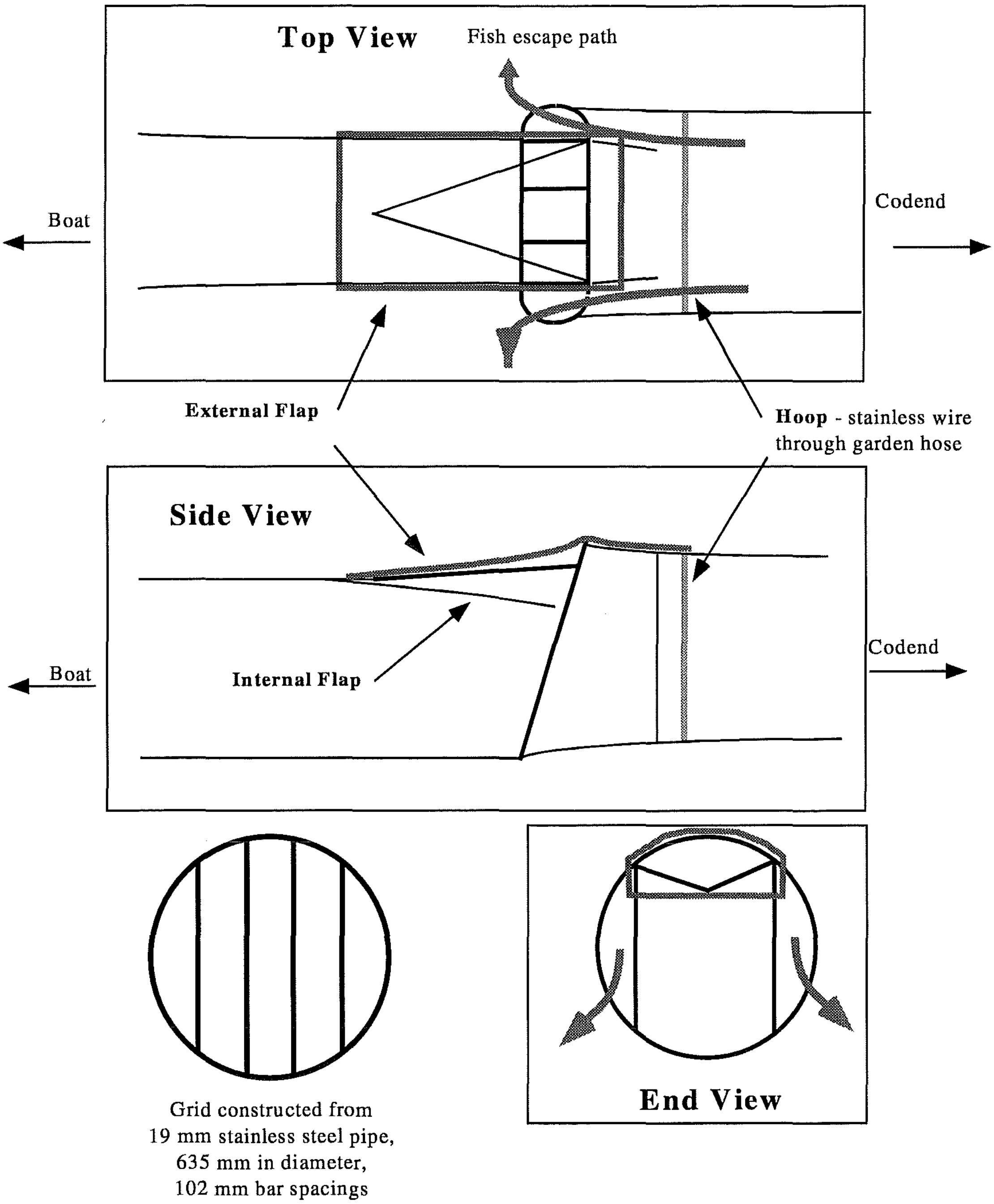
Fishing conditions: Fishing occurred in the Burnett River and adjacent coastal waters during trawling for banana prawns. The sporadic nature of banana prawns catches and the apparent inequality in efficiency of port and starboard nets made the results difficult to interpret.

Bycatch reduction: Bycatch was reduced on average by about 20%.

Prawn reduction: No clear trends in prawn catch rates could be determined.

Ease of operation and handling: The modified TED was easy to use and did not require any extra attention or cleaning.
Special considerations for use: The skipper of the vessel is happy with his design and uses its regardless of its efficiency.

**Figure 1 Modified TED used on the FV *John D***




**FV *Karool*, 13th to 17th September 1998**

Fishing gear specifications: This vessel towed two seven-fathom nets, one modified with a top and bottom bigeye BRD.
Fishing conditions: Night trawling was undertaken in inshore waters adjacent to the port of Lucinda, as well as one night west of Bramble Reef trawling for red spot king prawns.

Bycatch reduction: The bigeye BRD had a minimal effect on unwanted fish bycatch, probably because the trawls were undertaken at night and the amount of total bycatch was not large, i.e. between ¾ and 1½ prawn baskets per seven-fathom net towed for 150 to 180 minutes. (On average a prawn basket holds about 45kg of bycatch). This concurs with reports from fishers that fish excluders work best during daylight hours with good visibility.

Prawn reduction: Catch rates of prawns were very similar between nets. On average there was no difference between the nets (12% s.d.). The catch rates, although commercial, were low.

Ease of operation and handling: No special handling was required.

Special considerations for use: An underwater video camera and housing was installed into the net fitted with the bigeye BRD and a number of daytime trawls were completed to observe the hydrodynamic performance of the device. Video footage suggested that the front flap of the bigeye was not sinking below the level of the top-panel of the main net. This was possibly the result of tension on the front flap and pressure from water flowing down the net. The problem was reduced by adding more net leads to the forward panel of the bigeye.

### FV *Haley*, 4th and 5th January 1999

Fishing gear specifications: The 14m vessel towed four four-fathom banana prawn nets. A top-opening Wicks TED (851 mm high x 686 mm wide), with a bar spacing of 136 mm was tested in the outside port net.

Fishing conditions: Fishing occurred during the day in waters adjacent to Bundaberg. Weather conditions were 20 knot SE winds. The target species were banana prawns, with smaller number of endeavour prawns and greasyback prawns also being caught.

Bycatch reduction: There was little difference in the bycatch of the compared nets (i.e. 179 kg versus 173 kg) and no large animals were caught during the tests. As such, the TED had little effect on bycatch rates.

Prawn reduction: Catches of prawns were small (i.e. < 4 kg per tow). Overall, the TED net caught about 1 kg of prawn less than the standard net, but this equated to a 4% loss. The low catches also resulted in large variation in the effect of the TED, ranging from a 39% loss (i.e. 0.90 kg) to a 15% gain (i.e. 0.35 kg). Results from this test should not be extrapolated to other fishing situations.

Ease of operation and handling: The TED did not pose any danger to the crew.

Special considerations for use: The skipper expressed concern about using TEDs after cyclones or prolonged periods of strong winds due to the "large amounts of weed and grass encountered after such events" in the Bundaberg area.

## TED & BRD FIELD TESTS - TORRES STRAIT

### FV *Lin-G*, 20th to 23rd May 1997

Fishing gear specifications: This 17.8 m prawn trawler towed four five-fathom prawn nets. A medium size (1041 mm high x 838 mm wide) bottom-opening super shooter TED was tested. The TED was fitted to the inside starboard net and compared with the outside starboard net.

Fishing conditions: Fishing was conducted around Yorke Island over the full moon. Weather conditions were good. Target species were tiger and endeavour prawns.

Bycatch reduction: Bycatch was qualitatively compared. The TED net had slightly reduced catches of unwanted bycatch and no catches of turtles, rays or zebra sharks, which were caught in the standard net.

Prawn reduction: Prawn catch was reduced, on average, by 4% (16% s.d.) per tow in the TED net. This was consistent when total prawn catch was separated into tiger prawns, white (endeavour) prawns and various grades of white prawns. The loss was speculated to be due to pocketing in the escape flap that would allow prawns to accumulate and then be swept out the escape opening when a large object such as a sponge was excluded. Alternatively, prawn loss may have been the result of smaller prawns (grade 21-30s) passing through open meshes just behind the grid of the TED.

Ease of operation and handling: The crew suggested that the size of this TED may be a problem for handling during cleaning and net mending, and during fishing operations if TEDs were installed in all four nets.

Special considerations for use: The escape opening provided an easy access to large sponges and logs that had lodged at the base of the grid. Installing the TED into an extension with a greater number of meshes around (the circumference) may reduce the opening of the meshes adjacent to the TED and may reduce any prawn loss associated with small prawns passing out through open meshes.

### FV *Lin Far*, 20th to 23rd May 1997

Fishing gear specifications: This 17.8 m prawn trawler towed four five-fathom prawn nets. A medium size (1041 mm high x 838 mm wide), bottom-opening Seymour TED, with a bar spacing 90 mm was tested. The TED was fitted to the outside starboard net and compared to inside starboard net.

Fishing conditions: Fishing occurred around Yorke Island over the full moon. Weather conditions were good. Target species were tiger and endeavour prawns.

Bycatch reduction: Bycatch was reduced, on average, by 19% (17% s.d.) per tow. This translated to a total bycatch of 182 kg in the TED net compared to 233 kg of bycatch in the standard net.

Prawn reduction: Prawn catch was reduced, on average, by 9% (14% s.d.) per tow in the TED net. However, prawn loss was not consistent across all nights of the test. Prawn loss in the TED net was minimal during the first two nights of trawling, but becoming significant when the vessel trawled near Aureed Island and caught large quantities of sponges and rocks.

Ease of operation and handling: Clogging of the TED was not a problem. The crew member waiting at the stern of the boat for the lazy-line needed to be aware of the position of the TED when the nets are lowered back into the water to ensure that the TED did not hit them.

Special considerations for use: Twisting did not occur when shooting the gear away if care was taken when the TED was dropped into the water.

### FV *Vansittart*, 23rd to 25th October 1997

Fishing gear specifications: This 14.3 m trawler towed four four-fathom polyethylene nets. A small size (787 mm high x 737 mm wide) top-opening super shooter TED was sewn into each of the port side nets. The bar spacing of the TEDs was 76 mm. Catch comparisons were made between the combined TED nets (port side) and the combined standard nets (starboard side).

Fishing conditions: Fishing occurred between Yorke Island and Cladbeck Reef over the full moon. Strong winds and rough seas were experienced at the beginning of the test but gradually reduced. Target species were tiger and endeavour prawns.

Bycatch reduction: Total bycatch was marginally reduced in the TED nets, averaging 8% (8% s.d.) less than in the standard nets. This was expected as this TED was designed so that the escape flap fitted snugly to the codend and only lifted when a large animal or object was excluded from the codend. The TED nets caught similar numbers of sponges as the standard nets, but the sponges in the TED nets tended to lodge at the base of the grid rather than travel though to the codend.

Prawn reduction: Prawn catch rates were similar between TED and standard nets. Total prawn catch was reduced, on average, by 1% (11% s.d.) per tow in the TED nets. Tows where prawn loss did occur are thought to be associated with the exclusion of a large animal.

Ease of operation and handling: During the TED testing, the nets were deliberately towed through a well known "weedy area". The TEDs were retrieved after the trawl shot free from weed and the ground chains of the TED nets had less weed on them than those of the standard nets.

Special considerations for use:. Sponges lodged at the base of the TED should be removed at the end of each tow to prevent any possibility continued blockages.

### FV *Beachcomber*, 26th to 28th October 1997

Fishing gear specifications: This 13.7 m prawn trawler towed two types of net. The starboard side nets and one port side net were two five-fathom "spectra" mesh nets. The other port side net was a four-fathom polyethylene net. A top-opening Seymour TED, of small size (787 mm high x 737 mm wide), and with a bar spacing of 76 mm, was sewn into each of the port nets. Catch comparisons were made between the combined TED nets (port side) and the combined standard nets (starboard side).

Fishing conditions: Fishing occurred between Yorke Island and Aureed Island.

Bycatch reduction: Bycatch was reduced on average by 15% (14% s.d.). The TED nets caught fewer sponges. Two turtles were caught in the standard nets, but none were caught in the TED nets. Unexpectedly, nine sea snakes were caught in the TED nets compared to three sea snakes caught in the standard nets. The majority of snakes were released into the water alive.

Prawn reduction: On average, the total prawn catch in the TED nets was reduced by 5% (10% s.d.). Prawn loss occurred when rocks, sponges or logs were trapped at the base of the TED, especially during one tow where a petrified tree stump jammed at the base of the grid. Tiger prawn catches were reduced on average by 2% (16% s.d.), while endeavour prawn catches were reduced on average by 5% (9% s.d.).

Ease of operation and handling: Strong wind conditions increased the difficulty of deploying the TEDs without twisting. However, the twists would often unravel themselves when the nets were being shot away, possibly due to water pressure.

Special considerations for use: None.

### FV *Diamond Lil*, 29th to 31st October 1997

Fishing gear specifications: This vessel towed four five-fathom nets made from a special New Zealand material (strength of 21 ply polyethylene, but the thickness of 18 ply polyethylene). Two small-size (787 mm high x 737 mm wide), top-opening Seymour TEDs with a bar spacing of 76 mm were tested. Two TEDs were fitted to the starboard nets for the first night, then swapped to the port nets for the remaining two nights.

Fishing conditions: Fishing occurred between Aureed Island and the Warrior Reefs.

Bycatch reduction: The TED nets were consistently cleaner than the standard nets, that caught large sponges, crayfish and rocks. Average bycatch reduction was 7%. (5% s.d.).

Prawn reduction: Prawn catch was about even for the standard nets and the TED nets (average of 1% reduction in total prawn catch, 10% s.d.).

Ease of operation and handling: The TEDs were easy to shoot away and to handle around the boat. The skipper needed to "use some rudder" during the night, perhaps indicating that the TED nets were easier to tow than standard nets. This may have been a cumulative effect of wind and current, but the same situation occurred on the *Vansittart*.

Special considerations for use: The exclusion of crayfish was quite distinct in this test with 16 crayfish being caught in the standard nets and three being caught in the TED nets. Similarly, fewer Moreton Bay bugs were caught in the TED net, i.e. 148 bugs compared with 123 bugs.

## TED & BRD FIELD TESTS - NORTHERN PRAWN FISHERY

### KFV *Carlisle*, 20th May to 15th June 1997

Fishing gear specifications: This 23 m trawler towed one 14 fathom net and one 12 fathom net. Two large super shooter TEDs (1295 mm high x 1067 mm wide, 102 mm bar spacing) were tested. One was installed in standard north Australian blue polyethylene mesh. The other was installed in standard southeastern USA green-dipped nylon mesh. The TEDs were installed into the 14 fathom net as this net consistently caught more rocks, sponges, mud and other debris.

Fishing conditions: Trawling occurred between Mornington Island and north of Groote Eylandt. Weather conditions were extremely poor.

Bycatch reduction: The net fished noticeably cleaner with the inclusion of the TED and sea egg capture was substantially reduced.

Prawn reduction: The TED installed in polyethylene was only tested for one night due to a 50% loss of prawns. The loss was due to shallow grid angle (i.e. about 35° from the horizontal). The TED installed in nylon averaged a 4% loss of tiger prawns, but no difference (0% loss) in the catch of white (= endeavour) prawns.

Ease of operation and handling: Handling of the net equipped with either of the TEDs was not difficult, despite the poor weather conditions. At no time was the TED a danger to the crew. Care was required during deployment of the trawl to ensure that the grid was orientated correctly. Fouling on the lazy line guides (i.e. "bullhorns") did not occur.

Special considerations for use: The crew were pleased that the TED-equipped net fished much cleaner, removed the threat of injury from large dangerous animals and reduced sorting times, so much so that at one stage the crew even argued over which trawl was to be fitted with the device.

### FV *Ocean Exporter*, 28th July to 20th August 1997

Fishing gear specifications: This 23 m vessel towed two 12 fathom banana nets at an average speed of 3 to 3.5 knots. A large (1295 mm high x 1067 mm wide, 102 mm bar spacing), bottom-opening super shooter TED was tested for ten tows. A top-opening NAFTED (1100 mm high x 880 mm wide, 60 mm bar spacing) was tested for 53 tows.

Fishing conditions: Testing occurred at a number of locations from Collier Bay in the Kimberley region to Bathurst Island.

Bycatch reduction: A 90 cm black tip reef shark was the only large animal captured in the codend of the super shooter TED net, while the standard codend caught 38 large animals ranging from small black-tip sharks to a 2 m tiger shark. One of the most notable results of was the exclusion of jellyfish. The net equipped with the super shooter TED caught 72 jellyfish while the standard codend caught well over 400. No large animals were caught in the net fitted with the NAFTED and up to 95% of jellyfish were excluded.

Prawn reduction: Prawn catch for the net equipped with a super shooter TED varied from a 19% loss to a gain of 60%. Prawn catch rates for the NAFTED varied from a 13% loss to a 12% gain. The largest losses occurred while modifying the device to increase fish exclusion rates, but on average, prawn catches were even between sides. Up to 50% fewer soft and broken prawns were recorded in the NAFTED net.

Ease of operation and handling: No handling problems were experienced.

Special considerations for use: The skipper was keen to continue testing TEDs and designed his own TED for the 1998 season. He felt the small prawn loss was insignificant and more than compensated by the improved prawn quality, ease of operation and the reduction of fish, large animals and jellyfish.

### FV *Dampier Pearl*, 1st to 10th September 1997 and 10th to 18th October 1997

Fishing gear specifications: This 24 m trawler towed two 14 fathom Florida Flyer trawls at an average speed of 4 to 4.2 knots. A large (1206 mm high x 978 mm wide, 90 mm bar spacing), bottom-opening Seymour TED and a large (1295 mm high x 1067 mm wide, 102 mm bar spacing), bottom-opening super shooter TED were tested.

Fishing conditions: Testing occur near Bountiful Island and Weipa.

Bycatch reduction: No large animals were caught in the net equipped with either TED, despite high catch rates of sharks and rays in the unmodified net.

Prawn reduction: Prawn loss for the Seymour TED averaged 29%. No obvious cause of the loss was found and several modifications to stem the loss were marginally successful. The super shooter TED performed poorly with an average prawn loss of 10%. This was the same TED used during tests on the *Ocean Exporter*. It was possible that the high trawl speed used by this vessel compared to the majority of the fleet might be a contributing factor to the cause of the loss.

Ease of operation and handling: The crew were happy with the reduced the numbers of sponges and large animals while the TED posing no onboard handling problems.

Special considerations for use: The skipper could see major benefits to his operation by incorporating a TED into the nets.

### FV *Petanne*, 18th September to 9th October 1997

Fishing gear specifications: This 19 m trawler towed two 13 fathom, Guiseppe Flyer nets. A large (1295 mm high x 1067 mm wide, 102 mm bar spacing), bottom-opening super shooter TED was tested for 16 tows and in combination with a square-mesh window and cone fish stimulator for another 16 tows.

Fishing conditions: Fishing occurred near Weipa.

Bycatch reduction: The super shooter TED was effective in excluding large animals.

Prawn reduction: Average prawn loss was 5%. The super shooter TED and square-mesh window combination consistently reduced fish bycatch by about 30% but prawn loss increased substantially. Several modifications were made to the square-mesh window to minimise prawn loss but these were only marginally successful.

Ease of operation and handling: There were no handling problems with the devices.

Special considerations for use: The skipper was keen to improve the efficiency of the nets through the use of TEDs because of the lack of large animals in the catch and fewer fish gilled in the codend.

**FV *Takari*, 30th September to 27th October 1997**

Fishing gear specifications: This 23 m vessel towed two 12 fathom, four-panel Flyer nets. A bottom-opening super shooter TED (1295 mm high by 1067 mm wide, 102 mm bar spacing) was tested.

Fishing conditions: Fishing occurred between Cape Arnhem and Cape Grey

Bycatch reduction: The TED net averaged 20% less bycatch than the standard net, but this figure ranged from 5% to 37%, depending on the tow. The unwanted bycatch was mostly comprised of grinners, hairtail, sole, threadfin bream, goatfish, big-eyes, cardinal fish, ponyfish, grunter, mackerels, scads and Carangids.

Prawn reduction: Prior to testing, the nets were monitored for equality of catches for seven days. Generally, the starboard net fished slightly better than the port net. The super shooter TED was installed into the port net. Overall, there was no loss of total prawn catch by the TED net. In fact, there was a slight increase in tiger prawn catch in the TED equipped net (0.3%). The greatest individual loss of catch occurred on the 19th October when over the night, the TED equipped net caught 5 kg's less than the standard net. This loss of catch could be attributed mostly to the first tow of the night when 4 kg's were lost as a result of a large vase sponge (also known as "wine glass sponges" or "chinamen's hats") becoming stuck at the grid and opening the escape flap. The grid was fouled on one occasion by a large eagle ray that was stuck backwards in the grid. The TED equipped net caught on average a 5% fewer white prawns. This may be due to open meshes behind the grid where small prawns might be able to escape. In some fisheries, this problem has been eliminated by installing the grid into an codend extension with an increased number of meshes to ensure that meshes remain closed.

Ease of operation and handling: The TED was relatively easy to use and the bull-horns did not interfere with the movement of the TED and codend. Gilled fish were removed from the extension and escape flap when the nets were cleaned and was extra work for the crew.

Special considerations for use: None

**KFV *Goldsmith*, 27th October to 7th November 1997**

Fishing gear specifications: This 23 m trawler towed two 14 fathom nets, at about 3.0 knots. A large (1295 mm high x 1067 mm wide, 102 mm bar spacing), bottom-opening super shooter TED and a NAFTED (1100 mm high x 880 mm wide, 60 mm bar spacing) were tested.

Fishing conditions: Trawling occurred north of Groote Eylandt, with long tow durations.

Bycatch reduction: No large animals were caught in nets fitted with either the super shooter TED or NAFTED. Unwanted fish bycatch was reduced by about 5%.

Prawn reduction: The single night of standardisation prior to the testing suggested that the starboard net (into which the TEDs were inserted) caught less than the port net, on average 6% less. This figure was reduced to 3% less with the bottom-opening super shooter TED, but increased to 13% less with the NAFTED. However, standardisation after the TED tests suggested that the difference in catch between the unmodified nets had increased to 10% less in the starboard net. Results from this test are difficult to interpret as there were few large animals to clog the grid or other reasons that could suggest why the TEDs would lose catch. However, it is possible that the super shooter TED did improve the catch rate of the starboard net, through the maintenance of wingend spread. It has been noted in research tests that large amounts of bycatch accumulated over long tow durations may decrease the spread of unmodified nets. Tow durations averaged 361 minutes during testing onboard the *KFV Goldsmith*. It is possible that under these conditions, the TEDs excluded a sufficient amount of bycatch to assist the net in maintaining its swept area compared to the unmodified net. This theory needs to be validated using net measuring instruments such as Scanmar.

Ease of operation and handling: No handling problems were experienced.

Special considerations for use: None.

**FV *Amelia C*, 27th October 1997 to 11th November 1997**

Fishing gear specifications: This 26 m vessel tested a bottom-opening Seymour TED (1026 mm high by 978 mm wide, 7 bars 90 mm apart).

Fishing conditions: Fishing occurred between Cape Arnhem and Cape Grey.

Bycatch reduction: Large animals were excluded from the TED net and overall unwanted bycatch reduction was 24% and 17% for the two nights of TED testing.

Prawn reduction: The unmodified nets were monitored for consistency of catch for seven nights prior to installation of the TED. The nets fished evenly for tiger prawns (average catch per night was 0.5% greater in the port net) but was biased for white prawns (average catch per night was 6% less in the port net). Tiger prawn catch was slightly increased on the first night of TED testing (by about 2%) but reduced by 15% on the second night. White prawn catch was reduced on both nights by 24% and 17% respectively. These differences in prawn catch were well beyond those recorded between the port and starboard nets. The loss of prawn catch is attributed to the following reasons: (i) frequent exclusion of sponges from the TED net with a small prawn loss each time, contributing to a significant cumulative reduction in prawn catch, (ii) clogging of the grid on the second night for two tows with a large wineglass sponge may have held the escape flap open and (iii) fishing characteristics of the *Amelia C* that may bias the catch of one net compared to the other, but no swapping of codends was undertaken to verify this theory.

Ease of operation and handling: No handling problems were experienced.

Special considerations for use: The prawn loss that occurred was unacceptable to the skipper and the TED was removed from the net.

**FV *Dynasty*, 13th to 23rd May 1998**

Fishing gear specifications: This 17.25 m trawler towed two ten-fathom Florida Flyer nets. A medium-sized (952 mm high by 762 mm wide, 137 mm bar spacing) top-opening Wicks TED was tested. The TED was installed at 52° from the horizontal.

Fishing conditions: Tests occurred north east of Mornington Island.

Bycatch reduction: The standard net caught 111 sponges greater than a ten litre bucket, while the TED net caught only five. There was frequently no difference between nets in the quantity of bycatch, but on average the TED reduced unwanted bycatch by about 7%. No large animals were caught in the TED net, and the catch of small whaler sharks (up to 1260 mm) was reduced.

Prawn reduction: The average catch of the TED net was 2% less than the standard net, which may be the consequence of a large number of sponges encountered during fishing. Tiger prawn catch averaged 4% less in the TED net, but there was no difference between nets for endeavour prawns.

Ease of operation and handling: Removing the internal funnel from the design of the TED made the device easier for the crew to clean.

Special considerations for use: None.

**FV *Cathy Wren*, 24th to 30th May 1998**

Fishing gear specifications: This 19.35 m trawler towed two 11 fathom Florida Flyer nets, one being a two-seam net, the other being a four-seam net. A top-opening Popeye design TED, similar to a large-size super shooter TED, but with straight sides and a bar spacing of 95 mm, was tested.

Fishing conditions: Fishing occurred on the grounds north and north-west of Mornington Island.

Bycatch reduction: The standard net caught 50 sponges greater in size than a ten litre bucket, while the TED net caught none. This may be a reflection of the 95 mm bar spacings. The reduction in unwanted bycatch was small, being consistently around 5%. The TED net caught markedly fewer sharks and shovelnose rays.

Prawn reduction: Tiger prawn catches were very similar between the TED and standard nets. Over all nights combined, the TED net averaged 3% less than the standard net. Endeavour prawn catches were very similar, with no noticeable difference between the nets (average 1%).

Ease of operation and handling: The TED was easy to handle. Sponges lodged at the base of the grid were removed are every tow. This practice probably assisted in keeping the TED at its most efficient configuration.

Special considerations for use: None.

**FV *Inspiration*, 28th July to 12th August 1998**

Fishing gear specifications: This 24 m trawler towed two 14 fathom nets, at an average speed of 3.2 knots. A large (1295 mm high x 1067 mm wide, 102 mm bar spacing), bottom-opening super shooter TED was tested.

Fishing conditions: Fishing occurred from north west of Mornington Island to the west of Tully. The weather was poor, with winds up to 40 kts and 3 to 4 m seas.

Bycatch reduction: The standard net caught over 40 large sponges, one large fish (>1 m), and nine large rays or sharks. The super shooter TED caught only a few small sponges and one saw shark that was fouled in the guiding funnel.

Prawn reduction: The super shooter TED recorded on average a 4% reduction in prawn catch, but the loss in prawn catch could be attributed predominantly to five of the 24 test tows.

Ease of operation and handling: Care needed to be taken when hauling in the codend of the TED net. The bullhorns on the *Inspiration* were located low on the forward side of the poop deck and were a potential cause of damage to the TED. Indeed, during the hauling of the codend on the last tow of the 10th August, the super shooter TED was winched up straight into the bullhorn, and the TED folded in half. This was predominantly due to a momentary lapse in concentration by a member of the crew.

Special considerations for use: A large sawshark was fouled in the guiding funnel of the TED and its tail protruded through the escape opening. This event caused significant stretching of the escape flap, which in subsequent tows, allowed some loss of prawns. Replacement of the escape flap, along with correcting the stretched meshes of the grid, improved the performance of the TED net.

**FV *Titan*, 13th August to 10th September 1998**

Fishing gear specifications:. This 24 m trawler towed two 14 fathom nets. A NAFTED (1100 mm high x 880 mm wide, 60 mm bar spacing), a large (1295 mm high x 1067 mm wide, 102 mm bar spacing), top-opening super shooter TED, and an expanded mesh BRD were tested during commercial fishing. A combined NAFTED and expanded mesh BRD were tested for one night.

Fishing conditions: Trawling occurred from west Tully through to Bountiful Island.

Bycatch reduction: The TEDs excluded large animals. The expanded mesh BRD caught about 25% less bycatch than the standard nets. Several large animals and sponges clogged the expanded mesh BRD when it was used singly, without a TED.

Prawn reduction: The TEDs and expanded mesh BRD in general had a minimal effect on the catch rate of prawns. The results were: NAFTED - 2% loss, super shooter TED - 5% loss, expanded mesh BRD - 2% loss, NAFTED combined with the expanded mesh BRD - 7% loss. These figures should be considered in light of standardisation tests conducted inbetween the use of the TEDs and BRDs. Results from these tests suggested that the port net caught 2% more, 2% more, 5% less and 3% less prawns than the standard net.

Ease of operation and handling: The TEDs and BRD posed no handling problems.

Special considerations for use: Clearing large animals (such as turtles) or calcified sponges from the expanded mesh BRD proved time consuming. This is one of the reasons it is recommended that the expanded mesh BRD be used in combination with a TED.

**FV *Tarni*, 13th September to 18th September 1998**

Fishing gear specifications: This 23.78 m vessel towed two 14 fathom, four seam Srialo Flyer nets. A large (1295 mm high x 1067 mm wide, 102 mm bar spacing), top-opening super shooter TED and a NAFTED (1100 mm high x 880 mm wide, 60 mm bar spacing) were tested.

Fishing conditions: Fishing occurred between Groote Eylandt and Cape Grey.

Bycatch reduction: Only two large animals were caught during TED testing on the FV *Tarni*. A 140 cm narrow saw shark was caught in the standard net and an 80 cm white-spotted guitarfish was caught in the net equipped with the super shooter TED.

Prawn reduction: The super shooter TED (installed in the port net) was tested for three tows and compared to the standard (starboard) net recorded a 1% prawn increase, and a 3% and a 14% prawn loss. It is difficult to generalise about the performance of the TED, given the low number of test tows. Catch comparison between port and starboard trawls immediately prior to these tests indicated that the port net caught from 10% less to 15% more prawns than the starboard net, but over a number of tows, this averaged out as no difference. The first tow with the NAFTED installed was a disaster with over 90% prawn loss. A 20 cm stingray barb caught in the netting funnel immediately ahead of the grid suggested that a very large stingray had become fouled in the netting, possibly blocking the grid and guiding prawns out through the escape opening. Concerns over additional prawn loss prevented this device from being tested any further.

Ease of operation and handling: There were no handling problems with the TED around the bullhorns of the *Tarni*, despite the 2m southeast swell.

Special considerations for use: None.

**FV *Markina*, 2nd to 21st September 1998**

Fishing gear specifications: This 18.7 m trawler towed two 12 fathom, two panel flat nets. A Gulf-size (952 mm high x 762 mm wide, 146 mm bar spacing), top-opening Wicks TED was tested.

Fishing conditions: Fished occurred between Cape Arnhem to Groote Eylandt, generally adjacent to reefs or shoals between the 20 m and 40 m depth contours.

Bycatch reduction: No large animals were caught in the TED net, while two turtles, two shovelnose rays, a bull ray and a whaler shark were caught in the standard net. On average general bycatch (i.e. unwanted fish, crustaceans) was reduced by 8% in the net equipped with the TED.

Prawn reduction: Initial problems in the set-up of the net (see below) resulted in considerable prawn losses during some shots (i.e. 5th September, 72% and 46%). The TED extension and codend were modified to 150 meshes round in an attempt to alleviate the problem of short codends and bagging of netting at the throat/TED extension seam. The results from the test are difficult to interpret as the boat had experienced troubles with the port net (into which the TED was installed) prior to the TED tests. Over a two week period prior to the test, the port net was on average 4% down on prawn catch compared to the standard net (95% confidence interval – 24% to +22%). However, major losses in prawn catch could be attributed to: (i) large catches of bycatch (i.e. > 100 kg's) that resulted in the "overflow" of catch forward from the codend into the TED extension; (ii) drawstrings not closely tightly on the TED equipped net and (iii) the capture of large animals (e.g. hammerhead shark) that clogged the grid. A major increase (41 kgs) in prawn catch in the TED net was due to the hook-up of the standard net.

Ease of operation and handling: There were no handling problems associated with the TED.

Special considerations for use: Prior to testing the TEDs, two possible problems with the set-up of the nets on the *Markina* were noted. Firstly, the throat of the port net was 170 meshes round and was made from 63.5 mm 36 ply mesh. The TED extension was only 120 meshes round (the standard size for NPF TEDs) and was made from 50.8 mm 60 ply mesh. The codend matched the TED extension (i.e. 120 meshes round, 50.8 mm, 60 ply mesh). The difference between the throat of the net and the TED extension (a ratio of 17:12) meant that there was excessive gathering of the meshes in the area where the TED extension joined the throat of the net. This could cause pocketing as well as increasing the turbulence of the water ahead of the TED.

**FV *Babirusa*, 22nd to 28th September 1998**

Fishing gear specifications: This 17 m vessel towed two 11 fathom, four panel flat nets, spread by Bison Boards. A gulf-size (952 mm high x 762 mm wide, 146 mm bar spacing), top-opening Wicks TED, made from 19 mm aluminium rod, sewn into an extension 120 meshes round, was sewn into the starboard net and compared to the port net.

Fishing conditions: Testing occurred between Cape Arnhem to Groote Eylandt.

Bycatch reduction: The TED had a minimal effect on overall bycatch. Two large animals were caught in the standard net (hammerhead shark and bull ray) whilst none were caught in the TED net.

Prawn reduction: The TED net generally caught very similar quantities of prawns to that of the standard net. The greatest differences (i.e. 5 kgs to 2 kgs) occurred during the first night of testing when the standard net used a tickler chain, but the TED net did not. For the remaining three nights the TED net was also fitted with a tickler chain, making prawn catches very similar between nets.

Ease of operation and handling: The TED net was easily stored and deployed. The TED was lowered onto the surface of the water in the correct orientation ensuring no twists formed in the body of the net. The TED usually steamed upside-down, even at low speeds but rolled into the correct position once the boards were spread.

Special considerations for use: None.

**FV *Comac Endeavour*, 19th to 21st September 1998**

Fishing gear specifications: This 23 m trawler towed two 14 fathom trawls. A large (1295 mm high x 1067 mm wide, 102 mm bar spacing), top-opening super shooter TED was tested.

Fishing conditions: Fishing occurred between Cape Grey and RS Shoal.

Bycatch reduction: The standard net caught a whaler shark (200 cm), and a leopard ray (140 cm) while the TED net caught a narrow saw shark (150 cm) that had passed through the grid and into the codend.

Prawn reduction: The TED was tested for one night in each of the port and starboard nets, and on average caught 4% less prawn than the unmodified net. This is based on a small number of tows and it is difficult to determine if the loss was due solely to the TED because the crew of the *Comac Endeavour* suggested that the unmodified nets did not usually fish evenly, with the port net usually catching less than the starboard net.

Ease of operation and handling: The TED caused no handling problems.

Special considerations for use: None.

**FV *Comac Enterprise*, 21st September to 9th October**

Fishing gear specifications: This vessel towed two 14 fathom trawls. Two TEDs (a large, top-opening super shooter TED and a large, bottom-opening super shooter TED) and a fisheye (by itself) were tested. A NAFTED (1100 mm high x 880 mm wide, 60 mm bar spacing) was also tested.

Fishing conditions: Fishing occurred between Cape Grey and North Vanderlin Island.

Bycatch reduction: *Top-opening super shooter TED*: The standard net caught white-spotted guitarfish (130 cm), five saddletail perch, fork-tail catfish (15 x 100 cm), an olive ridley turtle (68 cm), while the top-opening SS net caught one blacktip shark (105 cm), a white-spotted guitarfish (80 cm), and a fork-tailed catfish. Three seasnakes were caught in each of the standard and super shooter TED net. *Bottom-opening super shooter TED:* The standard net caught five cactus sponges (2 x 80 cm, 40, 95, &120 cm), a leopard ray (80 cm), and a flatback turtle (82 cm), while the bottom-opening super shooter TED caught none. *Fisheye:* Results from testing the fisheye for one night were inconclusive. Although not directly measured, the fisheye was estimated to reduce unwanted fish bycatch (mostly dollarfish and grinners) by 10 to 15%. The following large animals were caught. The standard net caught two flatback turtles (86 & 88 cm), a jenkins whipray (170 cm), 26 blacktip sharks (90 to 110 cm), cowtail ray (160 cm) three white-spotted guitarfish (80, 100

& 220 cm), an eagle ray (150 cm), a great hammerhead shark (110 cm) a narrow sawshark (180 cm) while the fisheye net caught a two jenkins whiprays (2 x 80 cm), 22 blacktip sharks (90-110 cm), a white-spotted guitarfish (120 cm) a cowtail ray (120 cm), a shovelnose ray (300 cm), and a winghead shark (110 cm). *NAFTED:* The standard net caught a 36 blacktip and milk sharks (80 to 110 cm), a shark ray (190 cm), a leopard ray (70 cm), a flatback turtle (58 cm), a bullshark (140 cm), three white-spotted guitarfish (90, 140 & 170 cm), a tawny shark (220 cm). The NAFTED caught 4 blacktip sharks (90 cm).

Prawn reduction: The super shooter TED in the top-opening position was tested in the Cape Grey area and recorded an average prawn loss of 2%. When fished as a bottom-opening TED, the average prawn loss was 9%. This may have been due to numerous cactus sponges becoming fouled in the TED for a short time before their exclusion. The NAFTED was tested in the Tasman Point area and compared to the standard trawl caught 2% more prawn. However, it should be noted that the port net, into which the NAFTED was installed, on average caught 3% more prawns than the starboard net during standardisation tows. The narrow bar spacing of the NAFTED effectively excluded almost 100% of small sharks, giving a noticeable improvement in prawn quality in the NAFTED codend.

Ease of operation and handling: No handling problems were encountered.

Special considerations for use: None.

### FV *Carlisle*, 10th October to 2nd November 1998

Fishing gear specifications: This 23 m trawler towed two 14 fathom trawls. Three TEDs were tested: (i) a GNM TED, (ii) a large (1295 mm high x 1067 mm wide, 102 mm bar spacing), top-opening super shooter TED and (iii) a large bottom-opening super shooter TED.

Fishing conditions: Fishing occurred between south Groote Eylandt and north Vanderlin Island. Numerous net problems were encountered including the ripping out of nets and hooking up of ground chains making it difficult to document the relative efficiency of the unmodified port and starboard nets. This trawler was boarded following claims that prawn losses up to 30% were being recorded with a bottom-opening super shooter TED. The problem turned out to be caused by poor groundchain settings and a badly stretched escape flap. The groundchain problem was rectified and prawn loss was eliminated.

Bycatch reduction: The standard net caught eight large animals including a porcupine ray (130 cm,) two leopard rays (80 & 170 cm) two white-spotted guitarfish (100 & 220 cm), two flatback turtles (82 & 84 cm) and a tawny shark (200 cm) .The TED equipped nets caught none. Two and four sea snakes were caught in the standard and TED nets respectively. Vase and ball sponges tallied ten in the standard net and eight in the TED nets. In general, the total catches of the nets were visually similar, suggesting no major reduction in fish bycatch by any of the TEDs tested.

Prawn reduction: A Seymour TED constructed by GNM Chandlery was tested for seven tows north of the Vanderlin Islands and returned an 8% prawn loss, above the observed difference between the unmodified nets. The TED was orientated to exclude animals through the top of the codend and had a tendency to foul sponges in the bars of the grid. A top-opening super shooter TED (with a new escape flap) was tested for nine tows. On average there was no difference in prawn catch between the nets. The bottom-opening super shooter TED consistently caught 10% fewer prawns than the standard net during the nine tows it was tested. There was no obvious cause for this loss. The area fished (Bombard Shoal and South Groote Eylandt) did not have excessive amounts of sponges or debris.

Ease of operation and handling: All TEDs were easy to use and handle.

Special considerations for use: None.

### FV *Gulf Viking*, 3rd to 30th November 1998

Fishing gear specifications: This 23 m trawler towed two 16 fathom, two seam Srialo trawls constructed from knotless netting. The NAFTED (1100 mm high x 880 mm wide, 60 mm bar spacing) was tested for three tows before a catch of rocks demolished the TED. A large (1295 mm high x 1067 mm wide, 102 mm bar spacing), top-opening super shooter was then tested for ten tows.

Fishing conditions: Testing occurred during fishing at north of Vanderlin Island and at Bombard Shoals. Sea eggs were frequently encountered during fishing as was medium size (i.e. 50 cm) rock slabs. Tow durations ranged from 60 to 390 minutes.

Bycatch reduction: The standard net caught two large animals: a reticulated ray (150 cm) and a winghead shark (150 cm), plus two 20 cm rock slabs compared to none in the codend of the NAFTED. However a shovelnose ray (220 cm), a shark 170cm and three 30 cm slabs of were stuck in funnel or at base of the NAFTED. The standard net caught nine sponges (2 x 20 cm, 2 x 30 cm, 4 x 40 cm ball sponges and a 40cm vase sponge) and five large animals: ray (70 cm) cowtail rays (2 x 130 cm), blacktip shark (180 cm), white-spotted guitarfish (270 cm) Super shooter TED caught a great hammerhead shark (70 cm) and an unidentified ray (70 cm).

Prawn reduction: The data were insufficient to determine the effect of the NAFTED on prawn catches. Results from the testing the super shooter TED indicated that it did not effect on the average catch rates of the port net compared to the starboard net. The large number of standardisation tows observed during this field test gave strong evidence that the port net consistently caught 3% to 4% fewer prawns than the starboard net. This remained the trend during the ten tows with the super shooter TED.

Ease of operation and handling: The TEDs posed no operational problems.

Special considerations for use: Rock slabs caused fatal damage to the NAFTED, but were also a major cause of damage to unmodified nets.

### FV *Rosen C*, 22nd to 28th April 1999

Fishing gear specifications: This 18 m vessel towed two 12 fathom, four-panel flat nets. A gulf-size (1016 mm high x 812 mm wide) top-opening Wicks TED, with 102 mm bar spacings was tested.

Fishing conditions: Fishing occurred north of Mornington Island. Tiger prawns were the main species targeted, despite the catch consisting of 1/3rd tiger prawns and 2/3rd endeavour prawns.

Bycatch reduction: Bycatch rates were not recorded because of rough weather. The standard net caught a large shark ray (1400 mm), a large blacktip shark (1250 mm TL), 17 large sponges and several large rays, while the TED net caught none.

Prawn reduction: Catch rates were highly variable. On average, the TED equipped net caught 0.7% (13% s.d.) more prawns than the standard net. When broken into marketable species, the TED net caught on average 9% (29% s.d.) more tiger prawns but 2% (9% s.d.) fewer endeavour prawns than the standard net.

Ease of operation and handling: The TED was entangled on the bullhorn during rough weather after the codend was spilt. The TED snapped at the weld, as a result of strong pressure and poor positioning of the weld in the centre of the TED frame.

Storing and deploying the TED net was achieved by lowering the TED onto the surface of the water in the correct orientation, ensuring no twists formed in the body of the net. On one occasion, the grid was thrown into the water in very rough conditions with a full twist in the net, just forward of the TED. After a short steam the grid turned over so that the net only had 180° twist. Once the gear was being shot away, this twist came undone. The grid usually steamed upside-down, even at low speeds, due to the adverse weather conditions.

Special considerations for use: None.

### FV *Striker*, 23rd April to 11th May 1999

Fishing gear specifications: This 25 m vessel towed two 15 fathom Srialo Flyers nets (banana nets) at 3 to 3.5 knots. A large top-opening Super Shooter TED (1295 mm high x 1067 mm wide, 102 mm bar spacing) was tested.

Fishing conditions: Fishing started at Croaker Island, then progressed eastward. Testing occurred during day and night fishing between Elcho Island and Gove. Banana prawns were the predominate catch, but significant quantities of tiger and endeavour prawns were also caught. Weather conditions deteriorated from 10 knot SE winds, 1 m swell to 25 knots SE winds, with 2 m swells.

Bycatch reduction: The standard caught 20 large animals including mulloway (2 x 100 cm), trevally (1 x 80 cm), leopard rays (2 x 80 cm), unidentified rays (3 x 130 cm, and one @ 140, 160, 180 and 200 cm), a reticulated ray (100 cm), a cowtail rays (120 cm), a Jenkins ray (170 cm), great hammerhead sharks (170 cm and 250 cm), white spotted guitarfish (170 cm and 180 cm) and a dead flatback turtle (81 cm). No large animals were caught in the codend of the TED net, but two narrow sawfish (110 cm, 180 cm) were entangled in the funnel ahead of the grid on separate occasions.

Prawn reduction: The effect of the TED on catch rates of prawns was difficult to measure, because both nets were spilled into the hopper of the boat. The codends were visually assessed prior to spilling for their evenness of weight. The skipper was of the opinion that the TED net was generally of the same size as the standard net, although on a couple of occasions, the TED net was thought to have caught more prawn than the standard net. Noticeably fewer soft and broken prawns were present in the TED when great hammerhead sharks were caught in the standard net.

Ease of operation and handling: The vessel has no rear gantry, no A-frame, and no bullhorns. The TED net was easy to handle and the skipper and crew were impressed with the effective exclusion of large animals.

Special considerations for use: The frequent capture of large animals in the standard net suggested that the TED net was frequently excluding large rays, fish and sharks. The escape flap on the top-opening TED did appear to be slightly stretched after about 20 tows. Floats attached to the super shooter TED fell off once and became loose another time, possibly due to the excessive amount of steaming with the nets in the water that occurs during searching for banana prawns.

### FV *Tarni*, 12th to 17th May 1999

Fishing gear specifications: This 23.8 m vessel towed two 14 fathom Srialo Flyer banana nets at an average speed of 3 to 3.5 knots. A large (1295 mm high x 1067 mm wide, 102 mm bar spacing), top-opening super shooter TED was tested.

Fishing conditions: Fishing occurred around Groote Eylandt. Weather conditions were 15 knot SW winds and 1 m swell.

Bycatch reduction: The standard net caught four large animals including a whaler shark (130 cm), a hammerhead shark (80 cm), and 2 stingrays (60 cm). No large animals were caught in the codend of the TED net, but a 70 cm wineglass sponge and a narrow sawfish (200 cm) were entangled in the funnel forward of the TED.

Prawn reduction: It is difficult to determine the effect of the TED on catch rates during this test because the four standardisation tows suggested that the starboard net caught significantly more prawns than the port net (i.e. on average 14%). After installation of the TED, the difference between the port and starboard net was on average 2%. This suggests that the TED did adversely effect the prawn catch, but due to a lack of replicates, this trend was difficult to confirm.

Ease of operation and handling: On this vessel, the mate had poor visual sighting of the TED as it passed the starboard side bullhorn. On one occasion, the TED caught on the bullhorn and a hole was torn in the top of the extension directly behind the top of the grid. Care needed to be exercised to ensure that the TED was not entangled on the bullhorns.

Special considerations for use: None.

**FV *Newfish I*, 18th May to 26th May 1999**

Fishing gear specifications: This 23 m vessel towed two 14 fathom GNM Chandlery Flyer banana nets (with the fly wires removed) at an average speed of 3 to 3.5 knots. A top-opening GNM TED[1] (similar in design and size to a large, super shooter TED) was tested.

Fishing conditions: Fishing occurred between Groote Eylandt, Maria Island and the Robertson River. Fishing varied between short tows targeting banana prawns in the day to long tows for tiger and endeavour prawns at night.

Bycatch reduction: The standard net caught one great hammerhead shark (220 cm), one eagle ray (130 cm), two stingrays (60 & 100 cm), 12 golden snapper (50 cm) and one sea snake. The TED equipped net caught no large animals. There was no marked reduction in general fish bycatch that could be visually observed.

Prawn reduction: The weights of the codends were not quantitatively measured on this boat, partly due the to hopper system. Instead, codends were compared visually. The skipper was happy with the performance of the TED and in his opinion, the TED net contained no less prawn than the standard net. Catches ranged between nine and 180 kgs.

Ease of operation and handling: The TED posed no handling problems.

Special considerations for use: None.

**FV *Libertine*, 25th to 31st May 1999**

Fishing gear specifications: This 23 m vessel towed Srialo banana nets, with a 12 fathom net on the port side and a 14 fathom net on the starboard side. Average tow speed was 2.7 knots. A large top-opening super shooter TED (1295 mm high x

[1] The GNM TED has two polyethylene floats attached to the top-centre of the grid inside the extension. The guiding funnel is of similar design to the GNM Seymour TED and is not attached to the front of the extension. This has to be done when the TED is attached to the throat of the net, which takes a little longer than normal. This grid is only roped into the extension, not pre-laced with twine of any sort. The TED is sewn into the front section of a 150 mesh deep codend, and as a result, shortens the standard codend length to about 100 meshes aft of the TED. There is also a square mesh panel cut into the codend. The escape cover extends about seven meshes beyond the top centre of the grid where a length of lead core rope is laced across its trailing edge.

1067 mm wide, 102 mm bar spacing), was tested for one night in the port net and three nights in the starboard net.

Fishing conditions: Testing occurred between north Groote Eylandt and Gove. Tiger and endeavour prawns were the main species targeted but some fishing for banana prawns also occurred.

Bycatch reduction: The standard net caught 180 blacktip sharks (50 cm to 130 cm TL), 1 spotted ray (80 cm), three white spotted guitarfish (100 cm to 260 cm) and a 69 cm flatback turtle. The TED net caught markedly fewer 107 black tipped sharks that were slightly smaller in size (80 to 115 cm). The escape flap of the TED was sewn down severely in an attempt to improve prawn catch rates. This had the effect of causing two blacktip sharks, 2 hammerhead sharks (90 cm), 1 turtle, 1 manta ray (200 cm) and 2 narrow sawsharks (100 cm and 260 cm) to be retained in the net, stuck at the grid and unable to escape. There was no marked reduction in general fish bycatch that could be visually observed.

Prawn reduction: Prawn catch results varied during the testing. A 19% reduction in prawn catch occurred during the one night that the TED was installed in the port net. Over the three nights the TED was installed into the starboard, the TED net averaged a 4% increase in total prawn catch. It is difficult to determine the cause of these results because the port and starboard net were not the same size, and there was no opportunity to standardise the nets prior to testing.

Ease of operation and handling: A couple of saw sharks entangled in the internal funnel of the TED. The severely restricted escape flap caused a number of large animals to be retained in the net at the base of the grid. During the testing, the net bogged in soft bottom sediment, but the TED did not cause any problems.

Special considerations for use: None

# Appendix 6
# CATCH WEIGHT (G), NUMBERS AND LENGTH RANGE (CM) OF THE 17 TELEOST SPECIES THAT OCCURRED IN ALL THREE CONFIGURATIONS

Table 1 The top 17 teleost species, ranked by frequency of occurrence (all tows combined). Figures in bold type indicate level where catch was most abundant for each configuration. The number of tows for configurations 1, 2 and 3 was 43, 57 and 45 repectively. Bottom level = 0 to 600 mm, Middle level = 600 to 1200 mm, Top level = 1200 to 1800 mm.

| | | Weight (g) | | | | Numbers | | | | Length range (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Configuration | | | | Configuration | | | | Configuration | | | |
| Species | Level | 1 | 2 | 3 | Total | 1 | 2 | 3 | Total | 1 | 2 | 3 | Overall |
| *Leiognathus splendens* | Top | 305 | 625 | **40 260** | 41 190 | 11 | 24 | **2 769** | 2 804 | 8 - 11 | 7 - 11 | 6 - 10 | 6 - 10 |
| | Middle | 4 860 | **177 525** | 13 140 | 195 525 | 225 | **9 154** | 820 | 10 199 | 7 - 10 | 6 - 11 | 5 - 9 | 5 - 11 |
| | Bottom | **79 324** | 108 545 | 27 480 | 215 349 | **4 327** | 5 587 | 2 040 | 11 954 | 7 - 11 | 7 - 9 | 2 - 11 | 2 - 11 |
| | Total | 84 489 | 286 695 | 80 880 | 452 064 | 4 563 | 14 765 | 5 629 | 24 957 | 7 - 11 | 6 - 11 | 2 - 11 | 2 - 11 |
| *Apogon poecilopterus* | Top | 210 | 173 | 3 094 | 3 477 | 26 | 54 | **278** | 358 | 2 - 9 | 2 - 7 | 3 - 9 | 2 - 9 |
| | Middle | 1 540 | 3 795 | 371 | 5 706 | 330 | 511 | 53 | 894 | 2 - 9 | 2 - 9 | 4 - 9 | 2 - 9 |
| | Bottom | **4 880** | **4 593** | **3 615** | 13 088 | **503** | **533** | 265 | 1 301 | 2 - 9 | 1 - 9 | 3 - 10 | 1 - 10 |
| | Total | 6 630 | 8 561 | 7 080 | 22 271 | 859 | 1 098 | 596 | 2 553 | 2 - 9 | 1 - 9 | 3 - 10 | 1 - 10 |
| *Leiognathus mortoniensis* | Top | 285 | 5 27 | **5 450** | 6 262 | 5 | 375 | 465 | 1 058 | 4 - 8 | 6 - 8 | 3 - 10 | 3 - 10 |
| | Middle | 530 | **5 491** | 2 210 | 8 231 | 40 | **406** | 170 | 616 | 2 - 10 | 1 - 10 | 4 - 9 | 1 - 10 |
| | Bottom | **2 885** | 5 230 | 5 390 | 13 505 | **218** | 30 | **504** | 539 | 2 - 10 | 3 - 10 | 2 - 9 | 2 - 10 |
| | Total | 3 500 | 11 248 | 13 050 | 27 998 | 263 | 811 | 1 139 | 2 213 | 2 - 10 | 1 - 10 | 2 - 10 | 1 - 10 |
| *Pomadasys maculatus* | Top | 105 | 340 | 7 560 | 8 005 | 12 | 7 | 253 | 272 | 11 | 10 - 11 | 9 - 14 | 10 - 14 |
| | Middle | 535 | **27 080** | 12 760 | 40 375 | 13 | **669** | 367 | 1 049 | 10 - 12 | 9 - 15 | 9 - 15 | 9 - 15 |
| | Bottom | **13 270** | 14 500 | **15 520** | 43 290 | **330** | 316 | **478** | 1 124 | 9 - 15 | 10 - 14 | 9 - 14 | 9 - 15 |
| | Total | 13 910 | 41 920 | 35 840 | 91 670 | 355 | 992 | 1 098 | 2 445 | 9 - 15 | 9 - 15 | 9 - 14 | 9 - 15 |

Cont…

Table 1, Appendix. 6 Cont…

| Species | Level | Weight (g) Configuration 1 | 2 | 3 | Total | Numbers Configuration 1 | 2 | 3 | Total | Length range (mm) Configuration 1 | 2 | 3 | overall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Pomadasys trifasciatus* | Top | 0 | 130 | **11 010** | 11 140 | 0 | 4 | 340 | 344 | - | 8 - 9 | 7 - 12 | 8 - 12 |
| | Middle | 440 | **11 830** | 9 970 | 22 240 | 15 | **372** | **397** | 784 | 8 - 10 | 8 - 12 | 6 - 12 | 6 - 12 |
| | Bottom | **9 080** | 3 635 | 9 500 | 22 215 | **334** | 118 | 372 | 824 | 8 - 12 | 7 - 12 | 7 - 12 | 7 - 12 |
| | Total | 9 520 | 15 595 | 30 480 | 55 595 | 349 | 494 | 1 109 | 1 952 | 8 - 12 | 7 - 12 | 6 - 12 | 6 - 12 |
| *Torguigener whitleyi* | Top | 150 | 156 | 1 550 | 1 856 | 5 | 5 | 39 | 49 | 7 - 9 | 2 - 9 | 7 - 10 | 2 - 10 |
| | Middle | 508 | 2 740 | **2 280** | 5 528 | 20 | 87 | **59** | 166 | 7 - 9 | 7 - 10 | 7 - 10 | 7 - 10 |
| | Bottom | **3 845** | **3 045** | 1 620 | 8 510 | **142** | **96** | 45 | 283 | 7 - 17 | 6 - 10 | 6 - 11 | 6 - 11 |
| | Total | 4 503 | 5 941 | 5 450 | 15 894 | 167 | 188 | 143 | 498 | 7 - 17 | 2 - 10 | 6 - 11 | 2 - 11 |
| *Upeneus sulphureus* | Top | 440 | 2 635 | 3 940 | 7 015 | 12 | 63 | 106 | 181 | 10 - 13 | 9 - 12 | 5 - 13 | 5 - 13 |
| | Middle | 2 290 | **16 955** | **4 330** | 23 575 | 59 | **451** | **126** | 636 | 5 - 14 | 5 - 25 | 2 - 12 | 2 - 25 |
| | Bottom | **7 815** | 3 685 | 1 020 | 12 520 | **215** | 84 | 22 | 321 | 7 - 13 | 9 - 13 | 5 - 13 | 5 - 13 |
| | Total | 10 545 | 23 275 | 9 290 | 43 110 | 286 | 598 | 254 | 1 138 | 5 - 14 | 5 - 25 | 2 - 13 | 2 - 25 |
| *Leiognathus equulus* | Top | 120 | 115 | **9 900** | 10 135 | 2 | 2 | **242** | 246 | 11 - 13 | 10 - 11 | 8 - 14 | 8 - 14 |
| | Middle | 1 065 | **29 025** | 4 600 | 34 690 | 24 | **633** | 97 | 754 | 9 - 13 | 8 - 14 | 8 - 14 | 8 - 14 |
| | Bottom | **9 490** | 6 595 | 6 600 | 22 685 | **213** | 142 | 145 | 500 | 7 - 15 | 9 - 15 | 8 - 14 | 7 - 15 |
| | Total | 10 675 | 35 735 | 21 100 | 67 510 | 239 | 777 | 484 | 1 500 | 7 - 15 | 8 - 15 | 8 - 14 | 7 - 15 |
| *Terapon theraps* | Top | 100 | 90 | 3 450 | 3 640 | 1 | 2 | **80** | 83 | 15 | 11 | 9 - 16 | 9 - 16 |
| | Middle | 785 | **18 795** | 1 900 | 21 480 | 17 | **382** | 41 | 440 | 6 - 15 | 9 - 16 | 9 - 15 | 6 - 16 |
| | Bottom | **10 200** | 7 555 | **4 200** | 21 955 | **214** | 140 | **80** | 434 | 10 - 15 | 5 - 16 | 8 – 15 | 5 –16 |
| | Total | 11 085 | 26 440 | 9 550 | 47 075 | 232 | 524 | 201 | 957 | 6 - 15 | 5 - 16 | 8 - 16 | 5 - 16 |
| *Saurida micropectoralis* | Top | 1 335 | 2 245 | 2 200 | 5 780 | 13 | 33 | 22 | 68 | 7 - 25 | 9 - 26 | 9 - 26 | 9 - 26 |
| | Middle | 2 360 | **12 685** | 2 800 | 17 845 | 29 | **116** | **31** | 176 | 7 - 24 | 4 - 28 | 8 - 28 | 4 - 28 |
| | Bottom | **11 985** | 7 185 | **3 100** | 22 270 | **78** | 46 | 22 | 146 | 12 - 32 | 4 - 31 | 6 - 31 | 4 - 32 |
| | Total | 15 680 | 22 115 | 8 100 | 45 895 | 120 | 195 | 75 | 390 | 7 - 32 | 4 - 31 | 6 - 31 | 4 - 32 |

Cont…

Table 1, Appendix 6 Cont...

| Species | Level | Weight (g) Configuration 1 | 2 | 3 | total | Numbers Configuration 1 | 2 | 3 | total | Length range (mm) Configuration 1 | 2 | 3 | overall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Pseudorhombus arsius* | Top | 0 | 0 | 1 000 | 1 000 | 0 | 0 | 16 | 16 | - | - | 12 - 17 | 12 - 17 |
| | Middle | 0 | 805 | 0 | 805 | 0 | 9 | 0 | 9 | - | 14 - 18 | - | 14 - 18 |
| | Bottom | **8 825** | **10 410** | **6 180** | 25 415 | **112** | **128** | **95** | 335 | 12 - 21 | 14 - 20 | 11 - 23 | 11 - 23 |
| | Total | 8 825 | 11 215 | 7 180 | 27 220 | 112 | 137 | 111 | 360 | 12 - 21 | 14 - 20 | 11 - 23 | 11 - 23 |
| *Sillago sihama* | Top | 385 | 430 | 1 420 | 2 235 | 6 | 8 | 23 | 37 | 14 - 18 | 14 - 19 | 15 - 18 | 14 - 18 |
| | Middle | 3 813 | 6 110 | 500 | 10 423 | 53 | 85 | 6 | 144 | 12 - 21 | 12 - 21 | 16 - 20 | 12 - 21 |
| | Bottom | **17 555** | **18 080** | **2 540** | 38 175 | **279** | **262** | **42** | 583 | 11 - 22 | 12 - 21 | 12 - 20 | 11 - 22 |
| | Total | 21 753 | 24 620 | 4 460 | 50 833 | 338 | 355 | 71 | 764 | 11 - 22 | 12 - 21 | 12 - 20 | 11 - 22 |
| *Gerres filamentosus* | Top | 0 | 165 | 1 440 | 1 605 | 0 | 3 | 32 | 35 | - | 10 - 12 | 9 - 13 | 10 - 13 |
| | Middle | 195 | **4 095** | 1 720 | 6 010 | 5 | **88** | 40 | 132 | 10 | 4 - 15 | 9 - 13 | 4 - 15 |
| | Bottom | **5 010** | 3 795 | **2 200** | 11 005 | **116** | 73 | **51** | 240 | 5 - 13 | 9 - 14 | 9 - 13 | 5 - 14 |
| | Total | 5 205 | 8 055 | 5 360 | 18 620 | 121 | 164 | 123 | 407 | 5 - 13 | 4 - 15 | 9 - 13 | 4 - 15 |
| *Pomadasys kaakan* | Top | 0 | 0 | **7 600** | 7 600 | 0 | 0 | **126** | 126 | - | - | 10 - 17 | 10 - 17 |
| | Middle | 210 | **7 240** | 6 100 | 13 550 | 2 | **70** | 93 | 165 | 17 | 11 - 20 | 11 - 21 | 11 - 20 |
| | Bottom | **4 980** | 2 025 | 7 300 | 14 305 | **45** | 22 | 108 | 175 | 11 - 21 | 11 - 20 | 11 -17 | 11 - 21 |
| | Total | 5 190 | 9265 | 21 000 | 35 455 | 47 | 92 | 327 | 466 | 11 - 21 | 11 - 20 | 10 - 17 | 10 - 21 |
| *Drepan punctata* | Top | 0 | 0 | 160 | 160 | 0 | 0 | 2 | 2 | - | - | 9 | 9 |
| | Middle | 0 | 400 | 0 | 400 | 0 | 8 | 0 | 8 | - | 3 - 10 | - | 3 - 10 |
| | Bottom | **9 440** | **6 250** | **3 840** | 19 530 | **164** | **92** | **75** | 331 | 7 - 15 | 8 - 15 | 7 - 12 | 7 - 15 |
| | Total | 9 440 | 6 650 | 4 000 | 20 090 | 164 | 100 | 77 | 341 | 7 - 15 | 3 - 15 | 7 - 12 | 3 - 15 |
| *Johnieops vogleri* | Top | 0 | 435 | 540 | 975 | 0 | 6 | 7 | 13 | - | 10 - 16 | 12 - 14 | 10 -16 |
| | Middle | 205 | **9 200** | 1 870 | 11 275 | 3 | **139** | 26 | 168 | 10 - 15 | 6 - 18 | 10 - 18 | 6 - 18 |
| | Bottom | **17 275** | 5 928 | **1 970** | 25 173 | **243** | 85 | **30** | 358 | 12 - 18 | 11 - 19 | 12 - 17 | 11 - 19 |
| | Total | 17 480 | 15 563 | 4 380 | 37 423 | 246 | 230 | 63 | 539 | 10 - 18 | 6 - 19 | 10 - 18 | 6 - 19 |

Cont...

Table 1, Appendix 6 Cont....

| | | Weight (g) | | | | Numbers | | | | Length range (mm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Configuration | | | | Configuration | | | | Configuration | | | |
| Species | Level | 1 | 2 | 3 | total | 1 | 2 | 3 | total | 1 | 2 | 3 | overall |
| *Johnieops vogleri* | Top | 0 | 435 | 540 | 975 | 0 | 6 | 7 | 13 | - | 10 - 16 | 12 - 14 | 10 -16 |
| | Middle | 205 | **9 200** | 1 870 | 11 275 | 3 | **139** | 26 | 168 | 10 - 15 | 6 - 18 | 10 - 18 | 6 - 18 |
| | Bottom | **17 275** | 5 928 | **1 970** | 25 173 | **243** | 85 | **30** | 358 | 12 - 18 | 11 - 19 | 12 - 17 | 11 - 19 |
| | Total | 17 480 | 15 563 | 4 380 | 37 423 | 246 | 230 | 63 | 539 | 10 - 18 | 6 - 19 | 10 - 18 | 6 - 19 |
| *Psettodes erumei* | Top | 0 | 0 | 3 100 | 3 100 | 0 | 0 | 15 | 15 | - | - | 7 - 29 | 7 - 29 |
| | Middle | 15 | 1 115 | 600 | 1 730 | 1 | 15 | 5 | 21 | 6 | 9 - 19 | 11 - 16 | 6 - 19 |
| | Bottom | **4 555** | **4 550** | **4 900** | 14 005 | **39** | **37** | **33** | 109 | 11 - 31 | 3 - 31 | 6 - 27 | 3 - 31 |
| | Total | 4 570 | 5 665 | 8 600 | 18 835 | 40 | 52 | 53 | 145 | 6 - 31 | 3 - 31 | 6 - 29 | 3 - 31 |

# Appendix 7 List of presentations

Commercialisation of bycatch reduction devices. *Cairns Bycatch Conference*, 12 February 1997, Cairns, Australia. J Robins.

The adoption of bycatch reduction gear technology: a Cook's tour. *Asia-Pacific Fishing '97* 8-10 July 1997, Cairns, Australia. J Robins 1997.

Strategies used to achieve the industry adoption of bycatch reduction devices in northern Australian trawl fisheries. Centre for Conservation Biology Conference on Management for Ecological Sustainability, 25 September 1998. University of Queensland Brisbane. J Robins and M Dredge.

A summary of results of TEDs and BRDs. 1999 Northern Prawn Fishery Pre-season Workshop. 11$^{th}$ February 1999. Cairns. G. Day, M. Campbell and J. Robins.

A review of the progress made in reducing prawn trawl bycatch in prawn trawl fisheries of northern Australia. *Asia Pacific Fishing 99*, 6$^{th}$ – 8$^{th}$ July 1999, Cairns. J Robins.

Recovery planning in Australia: benefits of a coordinated approach. *The 2$^{nd}$ ASEAN Symposium and Workshop on Sea Turtle Biology and Conservation: "beyond the beach"*, 15$^{th}$ to 17$^{th}$ July 1999, Kota Kinabalu, Malaysia. M Armstrong, J Robins and K Maguire.

# Appendix 8 List of publications


Increasing the trawling industry's awareness of TEDs and BRDs. J Robins, *Waves*, Marine and Coastal Community Network.

Cairns conference shows unity to reduce bycatch. Fishers keen to try out designs. *Professional fisherman* April 1997, 19-20.

Update on study of bycatch devices. J Robins *The Queensland Fisherman*, June 1997, 31-

Bycatch display hit Darwin in July. *Professional Fisherman*, June 1997, 9.

Bycatch video for fishermen launched. *The Queensland Fisherman*, September 1997, 6.

The adoption of bycatch reduction gear technology: a Cook's tour. *Professional Fisherman*, October 1997, 12-16.

The adoption of bycatch reduction gear technology: a Cook's tour. *Fishing Boat World,* September 1997, 12-17. J Robins

Fish exclusion from trawl nets – how do you do it? J Olsen, J Robins and J McGilvray. *The Queensland Fisherman*, November 1997, 29-35.

Prawn industry continues to test BRDs in northern Australia. G Day. *Professional Fisherman*, May 1998, 18-22.

Industry tests of TEDs in the Northern Prawn Fishery. M Campbell. *Professional Fisherman,* June 1998, 12-14.

Bigeyes – the myth explained. J. McGilvray and M. Campbell. *The Queensland Fisherman,* 1999, June 1999, 25-27.

Reducing bycatch in northern Australia's prawn trawl fisheries. J Robins *Fishing Boat World* August 1999, 32-33

A review of the progress made in reducing prawn trawl bycatch in prawn trawl fisheries of northern Australia. J Robins *Professional Fisherman*, August 1999, 24-25.

Another year of TEDs and BRDs tests in the NPF. G. Day and M. Campbell. *Professional Fisherman*, September 1999, 18-20.

Strategies used to achieve the industry adoption of bycatch reduction devices in prawn trawl fisheries of northern Australian trawl fisheries (2000). In *Management for Sustainable Ecosystems*, Eds P. Hale, A. Petrie, D. Maloney and P. Sattler. Centre for Conservation Biology, The University of Queensland, Brisbane. pp. 147-153. J Robins and M Dredge.

Reducing prawn trawl fishery bycatch in Australia: An overview and an example from Queensland. (1999) *Marine Fisheries Review, 61(3): 46-55.* J Robins, M Campbell, and J McGilvray.

Asian action of region's marine turtles. R&D News 2000, 8(1):21. J. Robins.