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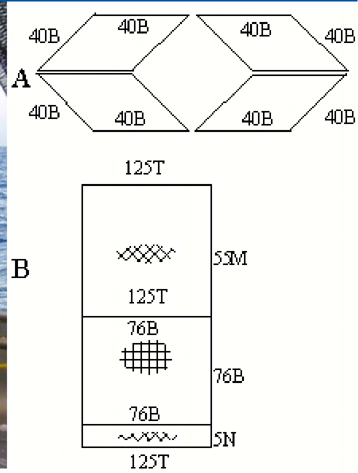
FRDC Project 2005/054

Final report

July 2007





A collaborative extension program by the Queensland Department of Primary Industries and Fisheries, SeaNet and Ecofish for the development and adoption of square mesh codends in select prawn and scallop trawl fisheries in Queensland.

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Australian Government
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SEANET
SMARTER FISHING FOR INDUSTRY

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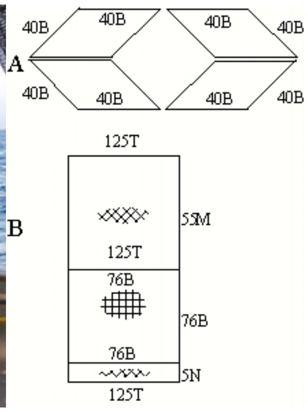

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AJ Courtney, MJ Campbell and DE Ballam

Report to the Fisheries Research and Development Corporation

Project No. 2005/054

July 2007

The Department of Primary Industries and Fisheries (DPI&F) seeks to maximise the economic potential of Queensland's primary industries on a sustainable basis.

This publication has been compiled by AJ Courtney and MJ Campbell of the Sustainable Fisheries Unit (DPI&F), and DE Bellam of SeaNet Extension Services (OceanWatch Australia).

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1 Non-technical summary

2005/054	A collaborative extension program by the Queensland Department of Primary Industries and Fisheries, SeaNet and Ecofish for the development and adoption of square mesh codends in select prawn and scallop trawl fisheries in Queensland

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OBJECTIVES:

1. To inform and consult with commercial fishers operating in the deepwater king prawn, scallop and black tiger (leader) prawn fisheries regarding the development of square mesh codend BRDs.
2. To encourage and promote the use of square mesh codend BRDs.
3. To offer assistance and ongoing support to fishers by providing relevant information and gear loans.
4. To further document performance of square mesh codends under commercial conditions and widely disseminate the information.

NON-TECHNICAL SUMMARY:

OUTCOMES ACHIEVED TO DATE

1. Increased awareness of the benefits of square mesh codends to fishers operating in Queensland's deepwater eastern king prawn, broodstock (i.e. black tiger prawn) collection and scallop fisheries.
2. An increase in the number of fishers using highly effective square mesh codends in the Queensland trawl fishery, which has lead to a significant reduction in bycatch.
3. The development of improved construction methods for square mesh codends that reduce their costs to fishers.
4. Improved selectivity of the principal target species in the Queensland trawl fishery, specifically reductions in the incidental capture and mortality of sub-optimal or undersize prawns, scallops and bugs.
5. Preliminary tests indicate that square mesh codends reduce drag compared to standard diamond mesh codends and therefore use of the devices is likely to reduce fuel costs to fishers.

Prawn trawl fisheries generate a higher proportion of bycatch than any other fishery type and account for more than one-third of the estimated total global discards from fisheries. Prawn trawls are inherently non-selective and in most prawn trawl fisheries, the weight of the

bycatch exceeds that of the prawn catch by several times. Tropical and subtropical prawn species share their habitat with a diverse range of animals, a large proportion of which are susceptible to capture by prawn trawl gear.

In this report bycatch is defined as that part of the catch discarded by fishers. Recent research has revealed that trawl bycatch in Queensland is comprised of at least 1300 species. Bycatch is a complicated issue due to the fact that it not only includes species that are not marketable, it also includes species that are marketable but are discarded due to restrictions based on size or gender. Further, bycatch can include species of conservation interest that are protected by law such as sea turtles and sea snakes. Bycatch can also include species of interest to other sectors which can cause conflict between trawl fishers and other stakeholder groups.

In the 1990s, managers of prawn trawl fisheries around the world recognised the need to minimise the incidental capture of turtles by trawlers. This was due to the fact that some sea turtle species were classified as endangered or threatened. As such, the use of turtle excluder devices (TEDs) became mandatory in northern Australian prawn trawl fisheries. In Queensland, TEDs became mandatory on all otter trawl vessels by the end of 2001.

Since that time, there has been increasing pressure from conservation agencies, the public and the Federal Department of Environment and Water Resources (formerly the Department of Environment and Heritage) to introduce measures to reduce the amount of discarded bycatch. The implementation of the *Environment Protection and Biodiversity Conservation Act 1999* allows the Australian Government to assess the sustainability of all export fisheries within Australia. The Act is designed to ensure ecologically sustainable development through the conservation and ecologically sustainable use of natural resources, including both targeted and non-targeted species. Apart from the sustainability issues, there are other reasons to reduce bycatch including reducing sorting times, safer catch processing, improvements in product quality, minimising the impacts of trawling on recreational species, bycatch wash-up issues and increasing trawl efficiency.

In an attempt to quantify the effects of TEDs and bycatch reduction devices (BRDs) in Queensland's trawl fishery, the Fisheries Research and Development Corporation funded a research project (FRDC Project No. 2000/170 *Bycatch weight, composition and preliminary estimates of the impact of bycatch reduction devices in Queensland's trawl fishery*) in collaboration with the Queensland Department of Primary Industries and Fisheries in 2001. During this project, the effects of different TEDs and BRDs on the catch rates of target species, bycatch and by-product were quantified under commercial fishing conditions and dedicated research charters. Of several BRDs tested during this project, the square mesh codend was the most effective at reducing bycatch in both the deepwater eastern king prawn and scallop fisheries. Square mesh codends were chosen for testing in these fisheries because a large proportion of the bycatch species in these fisheries were small compared to the targeted prawns and scallops and, as such, it was thought that good bycatch exclusion rates could be expected.

The results from these charters, which were undertaken in 2002, revealed that bycatch could be reduced in Queensland's scallop and deepwater king prawn fisheries by 77% and 29% respectively by using square mesh codends in conjunction with efficient TEDs, with no loss of the target species catch. The results suggested that if all vessels operating in these fisheries used square mesh codends, bycatch could be reduced by over 10,000 tonnes annually. Despite disseminating the results through magazine articles and presentations, very few fishers were using square mesh codends by the end of 2004. It became apparent that if the devices were going to be voluntarily adopted by industry, then a dedicated extension project was required to promote their uptake. Hence, this extension project proposal was developed and funding was successfully obtained from the Fisheries Research and Development Corporation (FRDC) in 2005.

During the project, project staff constructed several square mesh codend BRDs as part of a gear library and loaned them out to fishers free of charge for trialling at sea. A total of 40 square mesh codends were constructed and loaned to 36 fishers, mainly in the deepwater king prawn fishery. Of those fishers who trialled square mesh codends, most reported reductions in bycatch and over 35% of fishers reported reductions greater than 20%. Importantly, the reductions occurred with little or no loss of marketable prawns or scallops.

A recent research charter, which was undertaken as part of the FRDC Project No. 2005/053, *Reducing the impact of Queensland's trawl fisheries on protected sea snakes*, provided new information on the effects of square mesh codends in the north Queensland tiger/endeavour prawn fishery. During this charter, the square mesh codend reduced bycatch by approximately 33%, without any significant loss of marketable prawns or Moreton Bay bugs. Further, the square mesh codend reduced the capture of sea snakes by approximately 60%. Importantly, the square mesh codend was able to significantly reduce the catches of small, non-marketable prawns. This information was used to further promote adoption of the devices by industry.

Observer-based sea trials were also conducted as part of the current project aboard commercial vessels operating in the deepwater king prawn and black tiger prawn broodstock collection fisheries. During these trials, nets containing square mesh codends reduced bycatch whilst maintaining target species catch rates, when compared to a standard codend.

Project staff visited ports and met 170 to 180 fishers to discuss the benefits of using square mesh codend BRDs and their construction methods. These discussions also allowed us to present and discuss research results from fisher-based, and research charter-based sea trials of square mesh codends.

Several articles about the project were published in relevant industry magazines. The articles incorporated information on the methods for constructing and using square mesh codends, research results and information on the gear library. The project also produced a DVD with a) underwater video footage of square mesh codends, b) research results from testing the devices, c) a “how-to” section showing methods for constructing a square mesh codend for the deepwater king prawn and broodstock collection fisheries, and d) a design plan for a scallop fishery square mesh codend. The DVD was posted to all licensed otter trawl operators in Queensland (i.e. approximately 480 recipients) in early 2007.

In collaboration with project staff, Brisbane netmaker Mr Wally Hill developed a faster method for constructing square mesh codends. This method has proven to be much more attractive to fishers as it is less complicated than previous methods and reduces the construction cost. Further, a Brisbane net importer has begun importing specially made mesh that is manufactured square rather than the normal diamond shape. This has further simplified construction and reduced costs to fishers. Several different types of square mesh, which are suitable for use in the sectors targeted in this extension project, are now being imported.

During the observer-based sea trials of square mesh codends, a project staff member noticed that the vessel's autopilot steered toward the side containing the square mesh codend. This was thought to be due to the square mesh codend offering less resistance (i.e. less drag) through the water compared to the standard net codend on the opposite side of the vessel. It suggested that, not only are square mesh codends effective at reducing bycatch and improving selectivity of the target species, but that they may also reduce drag and therefore offer the added benefit of saving on fuel costs. We thought this was an important enough finding to try to quantify the reduction in drag and made arrangements to test a square mesh codend at the Australian Maritime College's Flume Tank. The tests were undertaken on a scaled-down prawn trawl at various speeds and simulated catches. Net drag in the square mesh codend was found to be reduced by up to 6.5% compared to a standard diamond mesh codend, which suggests that significant fuel savings could be achieved for individual operators, and for whole fleets, if square mesh codends are adopted.

In summary, project staff consulted with 170 to 180 fishers, and constructed and loaned out 40 square mesh codends to 36 Queensland trawler operators to trial under commercial conditions. Of those fishers who trialled a device, most reported that bycatch was significantly reduced, with little or no loss of product, and that they would continue to use the device. As a result of the project, improvements to the design and reductions in their production costs by netmaker Mr Wally Hill, and positive word-of-mouth reports, square mesh codend use in Queensland has increased. At present, about 10% of the otter trawl fleet are now using square mesh codends, mainly in the scallop fishery. This proportion will increase markedly if the mandatory use of the devices in the scallop fishery is accepted in an upcoming Regulatory Impact Statement.

Currently, the *Fisheries (East Coast Trawl) Management Plan 1999* specifies a minimum mesh size of 45 mm (22.5 mm bar by 22.5 mm bar) for square mesh codends. This largely restricts use of the devices to those sectors where the target species are relatively large and is why the project targeted the scallop, black tiger prawn broodstock collection and deepwater eastern king prawn fisheries. Further research is required to determine the optimum mesh size for square mesh codends in other sectors, most notably the shallow water eastern king prawn fishery. Further research that quantifies the reduced incidental fishing mortality on the target species, and the subsequent increase this has on their exploitable biomass, would also help promote adoption of square mesh codends. Given that the preliminary flume tank trials showed that reductions in net drag were achievable with square mesh codends in scaled-down trawl nets, further research is also required to quantify drag reductions and the subsequent fuel savings in full-scale gear trials at sea.

KEYWORDS: **Square mesh codend, bycatch, bycatch reduction device, net drag reduction, extension project.**

2 Acknowledgments

This project was jointly funded by the Fisheries Research and Development Corporation and the Queensland Department of Primary Industries and Fisheries (QDPI&F) and we gratefully acknowledge their support.

The authors wish to thank fishers who participated in the at-sea trials of the square mesh codends, particularly Mr Peter Gaddes, Mr Roger Green, Mr Peter Lee, Mr Jeff Saverin and Mr Guy Schulz. Further, we would like to thank Mr Wally Hill for his contribution to the project and his ongoing self-funded research. Additionally, we would like to thank Mr Jason Gerharty from ATS Nets and Ropes for his continued support throughout the project. Mr John Wakeford and Mr Allan Faulkner from the Australian Maritime College assisted with the square mesh codend flume tank trials. We also thank the QDPI&F Southern Fisheries Centre staff of Mr Tony White, Ms Kelly Breddin, Ms Melissa Whitford, Mr Bob Cooper and Mr Ben Bassingthwaighte for administrative and financial assistance throughout the project.

3 Background

Legislation requiring the mandatory use of turtle excluder devices (TEDs) and bycatch reduction devices (BRDs) was introduced in Queensland as part of the *Fisheries (East Coast Trawl) Management Plan 1999*. The legislation was introduced in response to the need to manage fisheries with an ecosystem perspective and growing community concern regarding the impact of benthic trawling on marine ecosystems.

Of particular concern were the incidental catches of sea turtles, including the endangered loggerhead turtle, *Caretta caretta*. In 1995, trawling was nominated as a key threatening process to sea turtles under the Australian *Endangered Species Protection Act 1992*. As a result, management intervention was required to reduce interactions between trawl fishers and sea turtles. This motivated the development of efficient TEDs by the entire trawl industry, with the help of several FRDC projects, including FRDC Project No. 1996/254 *Commercialisation of bycatch reduction strategies and devices within northern Australian prawn trawl fisheries* (Robins et al. 2000).

In Queensland, the development of BRD designs that exclude smaller species such as finfish was largely left to fishers operating in the banana prawn fishery. Legislation requiring the use of BRDs in daytime trawl operations prompted these fishers to develop BRDs that were extremely effective, with some fishers reporting bycatch reduction rates in excess of 75% during daytime operations. As BRDs became mandatory in other sectors, fishers adopted the BRDs used in the banana prawn fishery. However, once the devices were used during night trawling, they were much less effective. This was due to a number of factors including the reduced visual acuity of the fish bycatch species at night, faster towing speeds and changes in bycatch composition.

After the implementation of the Management Plan, trawl fishers were required to install at least one BRD in every net. Currently, there are seven BRDs listed in the Plan that fishers can choose from and the square mesh codend BRD is one of these devices. During the FRDC Project 2000/170 *Bycatch weight, composition and preliminary estimates of the impact of bycatch reduction devices in Queensland's trawl fishery*, several of the BRDs listed in the Plan were tested during both normal commercial fishing operations and dedicated research charters. The project found that, in general, the BRDs that fishers were using were having little effect on bycatch rates, possibly because a) the devices being tested were ineffective, or installed in such a way that they were ineffective, or b) a lack of experimental control needed to detect a significant change. Hence the need to test the devices under controlled research charters as well as commercial fishing operations.

During the charters several a) BRDs, b) TEDs and c) combinations of TEDs and BRDs were thoroughly tested. Square mesh codends were tested in the scallop and deepwater eastern king prawn sectors and found to be highly effective. Square mesh codend BRDs were selected for testing in these sectors because:

- the majority of bycatch species in these sectors are smaller than the target species and so it was suspected that many of the bycatch species might be able to escape through square mesh of an appropriate size;
- they can completely surround the bycatch, thus allowing a higher proportion of individuals to escape compared to other BRD types which rely on the bycatch species to “seek out” the escape opening and swim through it; and
- the relatively large size of scallops and eastern king prawns suggested that they would not be excluded by the device, and therefore a high proportion of the targeted catch could be retained.

During the scallop fishery charter total bycatch rates were reduced by a mean of 77%, with no reduction in the catch rate of legal size (>95 mm) scallops, using a TED in combination with a square mesh codend with a mesh size of 100 mm, which equates to a square of 50 mm by 50 mm (Courtney et al. 2007)). These results were very encouraging and suggest that there is a high potential to reduce bycatch in the scallop fishery by several thousand tonnes annually, without incurring any loss in scallop catch. Further, during the project’s deepwater eastern king prawn charter, total bycatch rates were reduced by a mean of 29% with no loss of king prawns, using a TED and a square mesh codend with mesh size of 47 mm, which equates to a square of 23.5 mm by 23.5 mm (Courtney et al. 2007).

Despite these very encouraging results, and that square mesh codends are one of the seven recognised BRDs that Queensland trawl fishers are legislated to use, uptake of the devices was low. This was primarily due to the additional expense and time required to construct square mesh codends, a perceived reduction in the catch rates of target species, peer-group pressure and perceived operational difficulties. This extension project proposal was therefore developed over a two-year period as a collaborative effort between the Queensland Department of Primary Industries and Fisheries, SeaNet and Ecofish to promote awareness and uptake of square mesh codend BRDs in the Queensland trawl fishery. The proposal was rated highly by the Queensland Fishing Industry Research Advisory Committee (QFIRAC).

4 Need

In recent years, increased community awareness of bycatch in prawn trawl fisheries and scrutiny from conservation agencies have brought pressure upon governments and fisheries management agencies to implement bycatch reduction initiatives. This is of particular importance in Queensland as about 70% of the effort in the East Coast Trawl Fishery occurs within the boundary of the Great Barrier Reef Marine Park.

During the late 90s, managers of prawn trawl fisheries around the world recognised the need to minimise the incidental capture of turtles by trawlers. This was due to the fact that some sea turtle species were classified as endangered or threatened. As such, the use of turtle excluder devices or TEDs became mandatory in northern Australian prawn trawl fisheries. In Queensland, TEDs became mandatory on all otter trawl vessels by the end of 2001.

Immediately following the introduction of TEDs, there was increasing pressure from conservation agencies, other user groups and the general public to introduce measures to reduce the amount of discarded bycatch. Apart from the sustainability issues, there are other reasons to reduce bycatch, including reducing sorting times, improvements in product quality, minimising the impact on species of recreational interest and eliminating bycatch wash-up events. As such, during the development of this project, several stakeholders stated that bycatch reduction is a high priority area. This project addressed the following priorities from key stakeholder groups:

1. Priority 1.3 of QFIRAC's current goals and priorities as reviewed with stakeholders "Effects of fishing activities on fish and their ecosystems", specifically point b, "Bycatch reduction, reduce volume of bycatch, improve bycatch reduction devices".
2. Section 2 of the Queensland Fisheries Business Group's Trawl Research Priority Areas for 2004/05, specifically "the development of management tools to reduce bycatch including alternative devices that minimise impacts and/or increase bycatch survival".
3. Part of Recommendation 26 of the Great Barrier Reef Marine Park Authority's audit of the East Coast Trawl Fishery which states "that designs need to be developed to increase the chances of escape for unwanted bycatch, but do not result in significant product and by-product losses".

Further, the implementation of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) allows the Australian Government, through the Department of Environment and Water Resources, to assess the sustainability of all export fisheries within Australia. The Act is designed to ensure ecologically sustainable development through the conservation and ecologically sustainable use of natural resources, including both targeted and non-targeted animals. A significant reduction in bycatch is a favourable step in this regard.

Results from the FRDC Project No. 2000/170 *Bycatch weight, composition and preliminary estimates of the impact of bycatch reduction devices in Queensland's trawl fishery* highlight that bycatch can be reduced by 77% in the scallop fishery and 29% in the deepwater eastern king prawn fishery without significant reductions in catch. This represents a reduction of bycatch in the order of thousands of tonnes annually. Although robust estimates of bycatch reduction are unavailable for the black tiger (leader) prawn fishery, significant reductions in bycatch will occur if square mesh codend BRDs are used. Given the large size of the target species, bycatch reduction could be in the order of 50%.

Given the slow uptake of square mesh codend BRDs by commercial fishers, it was necessary to promote the use of this technology via a dedicated extension program. Success of previous extension programs, most notably the FRDC-funded extension project *Commercialisation of bycatch reduction strategies and devices within northern Australian prawn trawl fisheries* (FRDC Project No. 1996/254), is evidence that such programs are crucial for the transfer of new technologies to industry.

5 Objectives

1. To inform and consult with commercial fishers operating in the deepwater king prawn, scallop and black tiger (leader) prawn fisheries regarding the development of square mesh codend BRDs.
2. To encourage and promote the use of square mesh codend BRDs.
3. To offer assistance and ongoing support to fishers by providing relevant information and gear loans.
4. To further document performance of square mesh codends under commercial conditions and widely disseminate the information.

6 Methods

This is an extension project aimed at informing, encouraging and assisting trawler operators to adopt highly effective square mesh codend bycatch reduction devices (BRDs) in the Queensland trawl fishery. The methods used during the project were based on those of Robins et al. (2000) for the abovementioned FRDC-funded extension project. During that project, several successful strategies were used to disseminate information on TEDs and BRDs. These strategies were adopted and tailored to suit the objectives of the current project.

The specifications for square mesh codend BRDs in the Management Plan restrict the mesh size to be used in the devices to a minimum of 45 mm, which largely limits their application to those sectors with relatively large principal target species, such as the deepwater eastern king prawn, scallop and the black tiger (leader) prawn fisheries. For this reason, the project concentrated on promoting uptake of the devices in these sectors. Ports that were targeted included Cairns to Innisfail (black tiger prawn), Gladstone to Bundaberg (scallop), Urangan to Tin Can Bay (scallop and deepwater eastern king prawn), and Mooloolaba to Southport (deepwater eastern king prawn). The extension strategies that were used are listed below.

6.1 GEAR LIBRARY

Given the relatively complex methods required to construct square mesh codends and the time and monetary costs to fishers, a gear library was created. Project staff constructed square mesh codends that could then be loaned to fishers free of charge for trialling at sea. This enabled fishers to test the devices without any initial start up cost, which has been an obstacle to their uptake in the past. During port visits, project staff recorded details of the gear used by interested fishers and then designed and constructed a square mesh codend that suited the individual's needs.

Initially, it was hoped that fishers trialling square mesh codends would weigh and record their catch rate data, including target species and bycatch. However, given the costs and problems associated with supplying measuring equipment (i.e. scales), and persuading crew to weigh bycatch and the likely unreliability of the data, it was decided to simply ask fishers to provide feedback on the performance of the devices via a questionnaire (see 6.3.1, below).

6.2 PORT VISITS

Robins et al. (2000) found that port visits were very beneficial to the successful transfer of bycatch reduction technology and were therefore used in this project. During the port visits project staff recruited fishers to trial square mesh codends at sea. The port visits also provided an opportunity to disseminate information about sea trial results from both research charters and commercial trials. Project staff visited ports during periods of prolonged poor weather to ensure that the greatest number of fishers were available. Fishers were approached on their vessels whilst they were moored. This one-on-one method allowed for greater interaction between fishers and project staff. In the early stages of the project, fishers were shown a PowerPoint presentation (see Appendix 1) on a laptop computer that explained the results from previous research on square mesh codends. This approach enabled project staff to explain the potential benefits of the devices in local fisheries with well-researched supportive data. This was particularly beneficial as fishers who were uncertain about the effectiveness of square mesh codends could be encouraged to trial a device.

As the project progressed, results obtained from fishers during at-sea trials were also incorporated into discussions with potential users. These discussions provided fishers with first-hand results gained during commercial operations, which gave the results more credibility than those obtained during research charters, because commercial fishers tend to view research results with a degree of reservation.

6.3 FIELD TRIALS

6.3.1 Fishery-dependent field trials

At the start of the project, it was envisaged that project staff would manufacture square mesh codends and accompany fishers during the at-sea trials. However, after two such field trials, it became apparent that it was more appropriate to leave the square mesh codends with interested fishers and let them decide when and where to trial them. This enabled project staff to concentrate more on port visits and constructing additional square mesh codends. Feedback on the performance of the devices trialled by fishers was obtained using a questionnaire. The following questions were asked of skippers after they trialled a square mesh codend at sea and designed to assess how the device performed and to determine the general attitude of skipper toward the device that was used:

1. Have you continued to use the square mesh codend provided?
2. If not, why not?
3. If so, in what area was it used?
4. What species were targeted?
5. In what depth ranges?
6. Did you notice any reduction in bycatch?
7. In percentage terms what bycatch reduction would you estimate was achieved?
8. Was there any effect on target catch?
9. Did you notice any rudder angle?
10. Will you persist in using a square mesh codend?

6.3.2 Fishery-independent field trials

A research charter was undertaken in commercial prawn trawl fishing grounds between Cape Upstart and Cairns on the Queensland east coast in May 2006 on board the QDPI&F Research

Vessel *Gwendoline May*. This charter was conducted as part of the FRDC Project No. 2005/053 *Reducing the impact of trawling on protected sea snakes* and was undertaken mainly in banana prawn and tiger/endeavour prawn fishing grounds. As part of the research charter, a square mesh codend was tested to assess the effect of the device on the capture of protected sea snakes. However, the charter also provided an opportunity to test the effect of square mesh codends on the catch rates of both the bycatch and prawns in this fishery. Along with the square mesh codend, two other BRDs – a fisheye and a square mesh panel – were also tested. All nets had turtle excluder devices (TEDs) fitted. The vessel towed four nets (i.e. quad gear) which enabled all four codend types to be towed simultaneously. At the completion of each night the codends were cut off and sewn onto different nets as per a pre-determined protocol. All trawling was undertaken at night and over the eight nights a total of 83 two-nautical mile trawls were completed. The effects of the different codends on sea snake and bycatch catch rates were recorded after each trawl. All prawns were retained for analyses at the Southern Fisheries Centre, where prawns from each net trawl were sorted into species, measured and weighed.

The standard codend was constructed from #60ply, 1¾-inch Markwell blue codend material, 100 meshes round by 100 meshes long. A skirt constructed of the same material 100 meshes round by 30 meshes long was attached to the codend 30 meshes up from the drawstrings. The square mesh codend was the same as those provided to fishers operating in the deepwater eastern king prawn fishery and had the following characteristics:

- Diamond mesh section: 100 meshes round by 55 meshes long, #60ply, 1¾-inch Markwell blue codend from ATS. Also lifting ears of same material 35M wide by 35M long, 11 meshes back from forward edge and sewn from 11th mesh either side of centre. Approx. 5 meshes of same material sewn onto aft edge of SMC for attachment of drawstring.
- Square mesh section: 4 sections, 40 bars by 40 bars, 2-inch (50 mm), 2.5 mm braided polyethylene codend material.

The data obtained during the charter provided further evidence of the effectiveness of square mesh codends in a multi-species prawn fishery. Specifically, the effects of the square mesh codend, and the other BRDs, were determined for bycatch, prawn and sea snake catch rates.

The effects of the BRDs on each catch component were analysed taking into account the influence of location, side of boat (i.e. position of the net) and BRD type, using statistical models developed with GenStat (2005) statistical software (8th edition, VSN International). For marketable prawns, the commercial catch grade was also used as a treatment factor to quantify the variation due to the size of the prawns. Treatment factors (i.e. shot location, net position, BRD type and, where appropriate, commercial grade) were added in a forward step-wise procedure. Analyses for each species were limited to only those sites where they occurred (e.g. if banana prawns occurred in 35 of the 83 sites, then the remaining sites were omitted for the banana prawn analysis).

Three models were used to analyse the weight data of individual marketable prawn species. All models were an accumulated analysis of variance with a normal distribution. Only the link function (identity, square root or logarithm) was altered and the most appropriate model was chosen based on the homoscedasticity of the residual output. The best-fitting models were developed and used to predict mean weights per two-nautical mile trawl for each codend type.

An accumulated analysis of deviance model using a Poisson distribution with a logarithm link function was fitted to the number of marketable prawns and the number of Moreton Bay bugs (both legal and sublegal size classes of bugs). Again, the best-fitting models were used to predict the mean number of individuals per two-nautical mile trawl for each codend type.

An accumulated analysis of deviance developed using a gamma distribution with a logarithm link function was used to analyse bycatch weight. As there were no shots with zero bycatch, data from all net trawls were used. This model was used to predict the mean weight (kg) of bycatch per two-nautical mile trawl for each codend type.

The application of square mesh codends in the north Queensland prawn trawl sectors had not previously been quantified. The sea snake bycatch research charter provided the opportunity to produce and use recent and relevant data on the effects of square mesh codends in this fishery to help promote uptake of the devices.

6.4 NETMAKER VISITS

In order to transfer information on square mesh codends efficiently, project staff liaised extensively with netmakers, net importers and netting manufacturers. These interactions were vital for several reasons:

1. Netmakers have regular contact with fishers and often make suggestions about the design of TEDs and BRDs. As fishers rely on the judgment of netmakers to inform them of the appropriate BRDs to use, this was an efficient way of transferring information on square mesh codends. Also, by liaising with netmakers, we could offer advice regarding the construction of square mesh codends.
2. It was vital to liaise with net importers to ensure that materials appropriate for the construction of square mesh codends were available. Before the project started, most square mesh codends were constructed from diamond-shaped mesh that was hung square (i.e. hung on the bar). As such, project staff liaised with net importers in an attempt to acquire mesh that was already square, thereby simplifying the construction process.
3. Project staff liaised with netting manufacturers to source knotless material that was similar to that used by trawl fishers in New South Wales. Fishers in the Clarence River area of northern NSW have been using square mesh codends constructed from knotless material for a considerable time. As such, it was deemed pertinent to seek the advice of the netting manufacturer and the netmaker responsible for constructing the codends from the knotless material.

6.5 PUBLISHED ARTICLES

The project published several articles to inform fishers, netmakers and others about the project, the benefits of square mesh codends and BRD research results. Some of the articles included information on methods used for constructing square mesh codends, and information and contact details for the gear library.

Articles about square mesh codends were published in relevant magazines including the *Queensland Fisherman* and *Ausmarine*. Similar articles were published in the *Queensland Trawl Fishery Newsletter*, a leaflet published by QDPI&F that was sent to every Queensland trawl fishery licence holder. Further, articles were published in the *SeaNet Newsletter* which is circulated quarterly, and in the *Bycatch Newsletter* which is funded by WWF.

6.6 INFORMATION DVD

The project also produced a DVD that was sent to every otter trawl vessel skipper or owner in Queensland. The DVD included a) a short summary of the project and results from previous research, b) a "how-to" section detailing the methods for constructing a square mesh codend for the king prawn fishery, and c) a net plan for a scallop fishery square mesh codend on the inside of the DVD dust cover. Underwater footage was also included in the DVD as this is particularly popular with fishers.

6.7 MEASURING DRAG IN SQUARE MESH CODENDS

During an observer-based sea trial of a square mesh codend in the Swain Reefs area on board the FV *Alliance* it was noticed that the vessel's autopilot steered toward the side containing the square mesh codend. This was thought to be due to the net on the side of the vessel opposite to the square mesh codend offering greater resistance as the vessel towed the gear through the water and as a result, the autopilot was compensating.

This was discussed after the trial and considered to be a possible important finding. If square mesh codends result in less resistance and less net drag, they would also likely result in reduced fuel costs, which are a major cost in trawl operations. It was thought that if the square mesh codends help to reduce fuel costs than this property could be used to benefit fishers and help promote acceptance of the devices. It was therefore decided to organise a small experiment at the Australian Maritime College's (AMC) Flume Tank, with support from the AMC staff, Mr John Wakeford and Mr Allan Faulkner, to compare the drag of the two codend types.

During the trial, the drag of a scaled down two-seam, six-fathom prawn net was recorded, firstly when it was attached to a square mesh codend, and then again when attached to a standard diamond mesh codend. Four discrete amounts of "catch", in the form of water-filled balloons (0, 10, 20 and 30 water-filled balloons) were added to the codends during the tests to assess the effects of catch size on the net drag. Trawl speed was also varied; tests were undertaken at simulated trawl speeds of 1.07 and 1.67 m s^{-1}, which equate to approximately 2.0 and 3.0 knots, respectively.

The net was attached to a Trawl Evaluation Rig via four load cells. Instantaneous measures of drag were recorded for one minute from each load cell point (i.e. footrope and headrope on either side) under each speed, catch and codend type scenario. During the one-minute measuring periods, 600 measures were obtained from each of the four load cells (i.e. 10 measures per second).

The instantaneous measures from each of the four load cells were then summed to give 600 measures of total drag. Variation in total drag was then examined using generalised linear modelling (GenStat, 2005). The central hypothesis was that total drag of the net with a square mesh codend did not differ significantly from that of the standard diamond mesh codend. Catch and trawl speed were included in the model as covariates.

7 Results and Discussion

7.1 GEAR LIBRARY

A total of 40 square mesh codends were loaned out to 36 fishers for trialling as part of the gear library, with most used in the deepwater eastern king prawn fishery (Table 1). This is because there was some excellent word-of-mouth information relayed among the eastern king prawn operators in Mooloolaba and Southport. Several fishers reported positive results on bycatch exclusion using square mesh codends and started constructing their own devices. Most devices were loaned to fishers after informal discussions during port visits. Information on gear configuration, net size, bycatch composition and target species size was recorded by project staff to ascertain the type of square mesh codend that would be most suited for each fisher.

Table 1 Summary of square mesh codend loans during the extension project. Details of the type of square mesh codend are provided in Table 2

Vessel	Date	Fishery	Area of operation	Square mesh codend type
Elizabeth G	16 Aug 2005	Deepwater EKP	Cape Moreton/Noosa	1
Elizabeth G	29 Aug 2005	Deepwater EKP	Cape Moreton/Noosa	2
Alliance	9 Sept 2005	Deepwater EKP	Swain Reefs	1
Stardancer	9 Dec 2005	Deepwater EKP	Swain Reefs/Double Island	1
Benjamin	9 Dec 2005	Deepwater EKP	Swain Reefs	1
Maddison	9 Dec 2005	Deepwater EKP	Swain Reefs	1
Regulus	20 Dec 2005	Deepwater EKP	Swain Reefs	3
Sarah Jane	10 Jan 2006	Deepwater EKP	Southport	3
Tony Kylie	17 Jan 2006	Deepwater EKP	Southport	3
Friulana	25 Jan 2006	Deepwater EKP	Southport	3
Jaybren	24 Jan 2006	Deepwater EKP	Southport	3
Markane	24 Jan 2006	Deepwater EKP	Southport	3
Canipa	15 May 2006	Deepwater EKP	Swain Reefs/Cape Moreton	6
Iron Cassia	16 May 2006	Deepwater EKP	Swain Reefs	6
Wings Morning	31 May 2006	Deepwater EKP	Mooloolaba	6
Steven C	5 June 2006	Deepwater EKP	Double Is./Fraser Is.	6
Cape Bedford	5 June 2006	Deepwater EKP	Double Is./Fraser Is.	6
C-king	5 June 2006	Deepwater EKP	Double Is./Fraser Is.	3
Miss Melissa	6 June 2006	Deepwater EKP	Mooloolaba	6
Liberty II	21 June 2006	Deepwater EKP	Mooloolaba	3
Red October	21 June 2006	Deepwater EKP	Mooloolaba	6
Krystle J	21 June 2006	Deepwater EKP	Mooloolaba	6
Cinnabar	21 June 2006	Deepwater EKP	Mooloolaba	3
Christy Lee	21 June 2006	Deepwater EKP	Mooloolaba	3
Canipa	15 Sep 2006	Deepwater EKP	Swain Reefs/Cape Moreton	7
Stardancer	9 Dec 2005	Scallop	Gladstone/Hervey Bay	4
Benjamin	9 Dec 2005	Scallop	Gladstone/Hervey Bay	4
Madonna	15 Dec 2005	Scallop	Gladstone	4
Regulus	27 Dec 2005	Scallop	Tin Can Bay/Gladstone	4
Canipa	15 Jan 2005	Scallop	Gladstone	4
Robyn 6	3 Sept 2005	Broodstock	Innisfail	1
Drifter	3 Sept 2005	Broodstock	Innisfail	1
-	3 Sept 2005	Broodstock	Innisfail	1
Bellenden Resch	3 Sept 2005	Broodstock	Innisfail	1
Bellenden Resch	14 Oct 2005	Broodstock	Innisfail	5
Bellenden Resch	14 Oct 2005	Broodstock	Innisfail	3

Although it was thought that spare square mesh codends could be constructed and made available for use by fishers, demand for the devices meant that project staff were making square mesh codends to order. Once a square mesh codend had been constructed for use by a commercial fisher, we immediately set out to find additional fishers to trial a device. Table 2 describes the square mesh codends that were used by fishers during the project. Although the construction methods were the same, the dimensions of the devices were sometimes changed according to fishers' preferences. The first square mesh codends offered to fishers were the same as those used during the FRDC Project No. 2000/170 *Bycatch weight, composition and preliminary estimates of the impact of bycatch reduction devices in Queensland's trawl fishery*. However, most fishers considered these too small, with a diamond mesh section 100 meshes round and a square mesh section only 66 bars round.

Table 2 Description of the square mesh codends used by fishers.

Square mesh codend type	Diamond mesh section	Square mesh section
1	130M round by 55M long, #60ply, 1¾-inch Markwell blue codend. Approx. 5 meshes of same material sewn onto aft edge of SMC for attachment of drawstring.	4 sections, 41B by 41B, 47 mm x 3 mm braided polyethylene codend material, sewn in as per Broadhurst* method, with 1B overlap to ensure structural integrity of knots.
2	145M round by 55M long, #60ply, 1¾-inch Markwell blue codend. Approx. 12 meshes of same material sewn onto aft edge of SMC for attachment of drawstring.	4 sections, 47B by 47B 47 mm x 3 mm braided polyethylene codend material, sewn in as per Broadhurst* method, with 1B overlap to ensure structural integrity of knots.
3	125M round by 55M long, #60ply, 1¾-inch Markwell blue codend. Approx. 5 meshes of same material sewn onto aft edge of SMC for attachment of drawstring.	4 sections, 40B by 40B, 47 mm x 3 mm braided polyethylene codend material, sewn in as per Broadhurst* method, with 1B overlap to ensure structural integrity of knots.
4	50M round by 5M long, 6mm braided polyethylene codend from ATS. No lifting ears. Approx. 3 meshes of same material sewn onto aft edge of SMC for attachment of drawstring.	4 sections, 20B by 20B, 100 mm x 6 mm braided polyethylene codend material, sewn in as per Broadhurst* method, with 1B overlap to ensure structural integrity of knots.
5	130M round by 55M long, #60ply, 1¾-inch Markwell blue codend. Approx. 12 meshes of same material sewn onto aft edge of SMC for attachment of drawstring.	4 sections, 31B by 31B, 55 mm x 1.8 mm braided polyethylene codend material, sewn in as per Broadhurst* method, with 1B overlap to ensure structural integrity of knots.
6	125M round by 55M long, #60ply, 1¾-inch Markwell blue codend. Approx. 12 meshes of same material sewn onto aft edge of SMC for attachment of drawstring.	4 sections, 40B by 40B, 50 mm x 2.4 mm braided polyethylene codend material, sewn in as per Broadhurst* method, with 1B overlap to ensure structural integrity of knots.
7	125M round by 55M long, #60ply, 1¾-inch Markwell blue codend. Approx. 12 meshes of same material sewn onto aft edge of SMC for attachment of drawstring.	Cylinder of mesh, 80B by 80B, 50 mm x 2.4 mm braided polyethylene codend material, as per Wally Hill** method.

Design specifications for * square mesh codends can be found in Figure 9 and for ** square mesh codends are presented in Figure 10.

Feedback from fishers indicated that square mesh codends with a circumference of 66 bars tended to fill up with compacted bycatch. In areas of high bycatch rates, this could occur in a relatively short time. Unlike normal diamond mesh codends, square mesh codends are already "open" and cannot expand laterally and so rather than expanding, the volume of the bycatch tends to fill forward, giving the codend an elongated "sausage" shape. The bycatch can be compacted so tightly into the codend that it becomes difficult and hazardous to empty. For example, the deckhands need to grab and shake the contents lose without their hands coming into contact with the net, which is filled with hazardous/venomous/spiky fauna. Some fishers therefore requested that the circumference of the square mesh codends be increased to prevent the bycatch from becoming compacted. The larger circumferences did not affect the effectiveness of the devices. In fact, there is some evidence to suggest that larger (i.e. baggier and looser) square mesh codends are more effective at excluding bycatch because individuals remain free to move, swim around and thus escape through the large open meshes, rather than being compacted against each other. Following this consultation with fishers, a range of square mesh codends with different designs were constructed to remedy the problem (Table 2).

7.2 PORT VISITS

Table 3 summarises the number of fishers contacted during dedicated port visits and the number of square mesh codends that were constructed and loaned out as a result of each visit. A total of 40 codends were loaned out to 36 fishers. The port visits provided an opportunity to interact with a large number of fishers. Informal discussions proved to be an effective way of conveying project information and discussing other relevant topics, such as management issues. Given that there were quite a few fishers trialling the devices, port visits and informal discussions were topical, with project staff able to convey up-to-date information regularly.

In the original project proposal, we thought that it would be possible to interact with approximately 100 fishers, which equates to about 40 to 50% of fishers operating in those sectors where square mesh codends have strong potential application. While a very small proportion of the total 191 fisher-contacts listed in Table 3 is due to consulting individual fishers more than once, we can state that between 170 and 180 individual trawler operators were contacted during the project, thus greatly exceeding our original target.

In addition to the fishers listed in Table 3, project staff also had regular contact with netmakers, Boating and Fisheries Patrol Officers and other researchers. These interactions were vital to ensure that all relevant information was conveyed to the appropriate audience. For example, project staff discussed the correct interpretation of legislation regarding square mesh codends with Boating and Fisheries Patrol Officers. This was important as most Patrol Officers had not seen a square mesh codend prior to the start of this project and it was vital to the success of the project that fishers using square mesh codends were not breached by the Boating and Fisheries Patrol because of incorrect interpretation of the legislation.

Table 3 The numbers of fishers contacted and square mesh codends that were constructed during the project. Note: Only a very small proportion of these 191 consultations were attributed to two or more consultations with the same fisher.

Week starting	Port/s	Number fishers contacted	Number of square mesh codends constructed
29 Aug 2005	Cairns, Innisfail	10	1
5 Sep 2005	Southport, Mooloolaba	5	1
12 Sep 2005	Tin Can Bay	3	1
19 Sep 2005	Southport, Scarborough	2	1
26 Sep 2005	Innisfail, Gladstone	11	0
3 Oct 2005	Southport	2	1
10 Oct 2005	Bundaberg	4	1
17 Oct 2005		5	1
24 Oct 2005	Hervey Bay, Mooloolaba	6	1
31 Oct 2005		0	2
7 Nov 2005	Tin Can Bay, Hervey Bay	3	1
14 Nov 2005	Gladstone, Bundaberg	5	0
21 Nov 2005	Mooloolaba	4	0
28 Nov 2005	Tin Can Bay, Hervey Bay	7	1
5 Dec 2005	Tin Can Bay	3	2
12 Dec 2005		4	1
2 Jan 2006	Southport, Gladstone	12	0
9 Jan 2006	Southport, Mooloolaba	7	2
16 Jan 2006	Southport, Gladstone	7	2
23 Jan 2006	Gladstone, Bundaberg	9	1
27 Feb 2006	Southport	4	1
6 Mar 2006	Tin Can Bay/Hervey Bay	5	1
13 Mar 2006	Southport, Mooloolaba	4	2
20 Mar 2006	Mooloolaba	3	1
27 Mar 2006	Mooloolaba, Southport	7	1
1 May 2006	Mooloolaba	4	2
8 May 2006	Southport	2	2
15 May 2006	Hervey Bay	3	1
22 May 2006	Mooloolaba, Tin Can Bay	4	2
29 May 2006	Mooloolaba	3	2
5 Jun 2006	Tin Can Bay, Mooloolaba	7	2
12 Jun 2006	Mooloolaba	4	1
19 Jun 2006	Bundaberg, Tin Can Bay	7	1
26 Jun 2006	Southport, Mooloolaba	2	1
3 Jul 2006	Hervey Bay, Tin Can Bay	5	0
10 Jul 2006	Mooloolaba, Scarborough	7	0
14 Aug 2006	Mooloolaba, Tin Can Bay	4	0
21 Aug 2006	Mooloolaba, Scarborough	3	0
28 Aug 2006	Mooloolaba	2	0
4 Sep 2006	Mooloolaba	2	0
	Total	**191**	**40**

7.3 FIELD TRIALS

7.3.1 Fishery-dependent field trials

At-sea trials of square mesh codends were undertaken aboard vessels operating under commercial conditions. Project staff accompanied fishers during trips to record catch rate data and observe the square mesh codends in use. Two such trips were undertaken in the early stages of the project. Fishers were asked if they would allow project staff on board their vessel during normal fishing activities to measure and record the catch rates of bycatch and target species. To assess the effect of square mesh codends the crew were asked to remove their BRDs from both nets and install the square mesh codend into one net to facilitate a paired comparison with a standard net during each trawl shot.

Trip 1 – black tiger prawn broodstock fishery

This trip was conducted aboard a vessel operating in the black tiger prawn fishery just to the south of Innisfail using a Type 1 square mesh codend (see Table 2). The square mesh codend was sewn into the starboard net, the catches from which were compared to the port net. The data recorded during this trial are presented in Table 4.

Table 4 Catch data from the at-sea trial of a square mesh codend in the Queensland black tiger prawn (*Penaeus monodon*) broodstock collection fishery. Note: Because very high prices are paid for individual live black tiger prawns, their catches were recorded in numbers, while prawn bycatch is typically recorded in kilograms.

Trip Shot	Net	BRD type	No. of individual black tiger prawns caught	Weight of bycatch (kg)
1	Port	TED only	0	42
1	Starboard	TED + SMC	0	32
2	Port	Ted only	0	27
2	Starboard	TED + SMC	1	21
3	Port	TED only	1	43
3	Starboard	TED + SMC	2	45
4	Port	TED only	4	20.5
4	Starboard	TED + SMC	5	28.5
5	Port	TED only	1	24
5	Starboard	TED + SMC	0	22
6	Port	TED only	0	17
6	Starboard	TED + SMC	1	16
7	Port	TED only	3	13
7	Starboard	TED + SMC	4	10
8	Port	TED only	2	12
8	Starboard	TED + SMC	3	12
9	Port	TED only	1	17
9	Starboard	TED + SMC	1	18
10	Port	TED only	2	38
10	Starboard	TED + SMC	5	32
11	Port	TED only	1	36
11	Starboard	TED + SMC	2	32
12	Port	TED only	3	33
12	Starboard	TED + SMC	5	27
13	Port	TED only	0	28
13	Starboard	TED + SMC	1	19
	Total	**TED only**	**18**	**350.5**
	Total	**TED + SMC**	**30**	**314.5**

During the first few shots the square mesh codend performed well, reducing bycatch significantly. Bycatch consisted of a high proportion of goatfish approximately 70 mm in length. These were obviously escaping through the square meshes. However, during the night, the average individual size (i.e. length) of the bycatch increased, and consisted mostly of larger trevally, ponyfish, ribbonfish and soles. Individual trawl shot catches are provided in Table 4, where the target consists of all black tiger prawns caught, not just those retained by the fisher. No large fauna such as turtles or rays were caught during the trial. In total, the TED+square mesh codend combination caught 314.5 kg of bycatch, compared to 350.5 kg in the net containing the TED only. This represents a reduction of 36 kg or 10.3% in the observed bycatch weight. Although bycatch reduction was relatively poor, the TED+square mesh codend caught more individual black tiger prawns than the net containing the TED only (30 and 18 respectively). Note the *P. monodon* broodstock catches are recorded as "numbers of prawns" while the bycatch is typically recorded as weight (kg).

We hypothesise that the square mesh codend allows a greater volume of water to flow through the net and codend, which results in increased catches of black tiger prawns. There are two reasons for this: firstly, because a greater volume of water is able to flow through the net and out of the large open square meshes, there is a smaller pressure wave in front of the net, which we suspect reduces the number of prawns that "detect the net" before they enter it, resulting in more prawns entering the net. Secondly, the greater flow of water through the net makes it more difficult for prawns to escape. That is, there is a greater flow of water washing the prawns down into the codend. The fisher who trialled this device has used several more devices constructed by project staff, has continued to use square mesh codends throughout the current season and intends making his own devices when those supplied as part of this project are discarded through wear.

Trip 2 – deepwater eastern king prawn fishery

This trial was undertaken in the Swain Reefs area, using a Type 1 square mesh codend (Table 2). The square mesh codend was sewn into the port net and the catches compared to those from the starboard net. We completed three shots per night along the same depth contour. Bycatch consisted of a high proportion of *Nemipterids* and crabs of the genus *Charybdis*. These individuals were relatively large (approximately 200 mm total length and 80 mm carapace width, respectively) and as such, bycatch exclusion rates were poor. Similarly, the majority of the prawns caught were large, i.e. U6 (industry grading categories referring to fewer than six prawns per pound or individual prawns weighing more than 80 grams); U8 (prawns weighing more than 60 grams) and U10 (prawns weighing more than 50 grams); and therefore prawn retention rates were excellent. Over the following three nights, the length of the discarded animals decreased and the composition changed. The average length of the individuals became smaller resulting in higher bycatch exclusion rates. Individual trawl shot details are provided in Table 5.

Toward the end of the trip, smaller species such as *Paramonacanthids*, smaller *Nemipterids*, and *Solenocera chopra* formed a high proportion of the discarded animals. Therefore bycatch exclusion increased, while prawn retention remained fairly consistent throughout the trip. Prawn catch rates varied but increased toward the end of the trip. This coincided with the build up to the new moon. Conversely, bycatch catch rates decreased, with only 30 to 40 kg per net per shot compared to 70 to 80 kg from the first night. This is consistent with the crew's anecdotal reports that bycatch tends to decrease as successive shots are completed on the same trawl path.

Table 5 Catch data from the at-sea trial of a square mesh codend in the eastern king prawn fishery.

Trip Shot	BRD type	Targeted catch of eastern king prawns (kg)	Bycatch (kg)
1	TED + Fisheye	6.25	93
1	TED + Fisheye + SMC	7.25	85
2	TED + Fisheye + SMC	15.25	62
2	TED + Fisheye	11	97
3	TED + Fisheye + SMC	9.5	58
3	TED + Fisheye	9.75	67
4	TED + Fisheye + SMC	7.75	89
4	TED + Fisheye	8.25	83
5	TED + Fisheye + SMC	12.25	69
5	TED + Fisheye	11	77
6	TED + Fisheye	11.75	72
6	TED + Fisheye + SMC	12.25	63
8	TED + Fisheye + SMC	10.25	54
8	TED + Fisheye	8.75	65
9	TED + Fisheye + SMC	10.25	60
9	TED + Fisheye	10	74
10	TED + Fisheye + SMC	7	34
10	TED + Fisheye	6	42
11	TED + Fisheye + SMC	8.75	37
11	TED + Fisheye	7.25	48
12	TED + Fisheye + SMC	8.25	34
12	TED + Fisheye	7.5	48
Total	**TED + Fisheye + SMC**	**108.75**	**645**
Total	**TED + Fisheye**	**97.5**	**766**

As stated earlier, these results should be interpreted carefully as the influence of trawl location and the position of the net on the vessel (i.e. port or starboard) on these figures cannot be quantified. Robust statistical data can only be recorded during scientifically designed trials to ensure that any variation in catch due to the above factors can be quantified and removed in order to assess the effect of the square mesh codend only. During the FRDC Extension Project No. 1996/254 *Commercialisation of bycatch reduction strategies and devices within northern Australian prawn trawl fisheries*, observer-based trials were deemed necessary as the observer was able to offer advice as to the use of TEDs and BRDs during trials with fishers who had no prior experience with the technology being trialled. However, there was no need to have observers aboard for this reason during the current project.

Questionnaire Results

At the conclusion of these observer-based sea trials, it was thought greater efficiency would be achieved if square mesh codends were delivered to interested fishers for them to trial. This left project staff more time to construct additional square mesh codends and to organise additional fishers to trial the devices.

The following questions were asked of those fishers who received a square mesh codend from project staff. Generally, the questions were asked during informal discussions with the skippers of the vessels. The questions were asked to assess the effects of square mesh codends and the general feeling each skipper had about the device used.

Have you continued to use the SMC provided?

Yes – 96.6%
No – 3.4%

The only fisher who did not use the square mesh codend provided had problems with crew and had his vessel tied up for a considerable time. This result reflects the fact that square mesh codends were provided to fishers who actually wanted to use them to assess whether they were an appropriate BRD in their chosen fishery. Given past reluctance shown by fishers to even try the devices, this is an extremely pleasing result. The fact that there were robust, defendable research data available through previous research projects (notably FRDC Project No. 2000/170), fishers could be convinced that square mesh codends could be considered an appropriate BRD.

Initially, project staff showed fishers a PowerPoint presentation showing the results gained during the above research project. These results convinced fishers that they could decrease bycatch significantly when using square mesh codends, while maintaining target species catch rates. Having these robust research results certainly helped sway some fishers toward using a square mesh codend.

If not, why not?

Tied boat up for repair/crew problems – 100%

What species were targeted?

Eastern King Prawn – 75.0%
Scallop – 10.7%
Black tiger prawn – 14.3%

The scallop fishery in Queensland has changed significantly in the last few years. Before the introduction of the Management Plan in 1999, a large number of smaller vessels fished for scallops year-round. However, the introduction of a limited number of nights fished for each vessel lead to reductions in effort and a significant number of vessels leaving the fishery. A significant amount of effort occurs in the scallop fishery during two separate periods. Firstly, as the minimum legal size for scallops is reduced from 95 mm to 90 mm at the end of the southern closure period (20 Sept to 31 Oct) a large number of vessels target scallops for a two-week period from 1 November. Secondly, rotational spatial closures are opened on 1 January resulting in significant amounts of effort being expended for approximately two weeks after this date. Project staff found it very difficult to convince fishers to use square mesh codends during these periods. Fishers were primarily concerned that the square mesh codends would not be able to cope with the large quantities of scallops that would be caught during these intensive fishing periods and that gear failure might result.

All fishers operating in the broodstock collection (black tiger prawn) fishery used a square mesh codend. After Cyclone Larry, only one fisher continued operating in this fishery and he continues to use square mesh codends. This fisher was particularly helpful, hosting an at-sea trial conducted by project staff.

Most of the fishers who used the square mesh codends were operating in the deepwater eastern king prawn (EKP) fishery. In the last three years, this fishery has received higher levels of effort than previous years. This is due to several reasons, including displaced effort from the north Queensland tiger/endeavour prawns fishery, the scallop fishery and the Torres

Strait fishery. Effort has been displaced from the prawn fisheries because vessel owners are reluctant to use large volumes of fuel steaming to these remote northern fisheries. Effort levels in the eastern king prawn fishery are also high because this species is the largest endemic Australian prawn and its market prices appear to be less affected by the influx of smaller, imported vannamei prawns. This has seen an increase in the number and size of vessels operating in this fishery, with a resultant increase in effective effort. The deepwater EKP fishery is now a year-round fishery, particularly now that the Swain Reefs area has been "discovered". Therefore, this fishery was targeted by project staff during the initial stages of the project. Once again, the good results achieved during previous research projects provided ample evidence that square mesh codends were an effective BRD in the deepwater EKP fishery. Project staff targeted some of the larger companies that have vessels operating in the deepwater in the hope that other owners and/or skippers would see the good results achieved and perhaps trial a device themselves.

In what area was it used?

Ballina/Southport – 3.6%
Bundaberg/Swain Reefs – 3.6%
Cape Moreton – 3.6%
Cape Moreton/Swain Reefs – 3.6%
Ballina Deepwater – 7.1%
Gladstone – 10.7%
Innisfail area – 10.7%
Mooloolaba – 14.3%
Southport – 7.1%
Swain Reefs area – 17.9%
Swain Reefs/Mooloolaba – 14.3%
Wide Bay bar – 3.6%

As expected, the deepwater EKP areas dominate. Interestingly, some of the fishers contacted in Southport (southern Queensland) used square mesh codends in northern NSW. These dual-endorsed fishers originally enquired about using square mesh codends in the shallow water fishery around Point Lookout on North Stradbroke Island but used the devices in their home waters as well. Generally, use of square mesh codends occurred throughout the entire range of EKP fishery, from the Queensland/NSW border, north to the Swain Reefs area.

The black tiger prawn fishery is dominated by vessels operating in the Innisfail area, while the fishers contacted operating in the scallop fishery were from Gladstone in central Queensland.

In what depth ranges?

Less than 50 fathoms – 25.0%
Greater than 50 fathoms – 75.0%

This result reflects the fact that the majority of square mesh codends trialled were used by fishers operating in the deepwater EKP fishery. Eastern king prawns tend to move north and into deeper water throughout their lifecycle. When the prawns are in the deepwater, they tend to be larger, allowing the use of square mesh codends in relatively large mesh sizes.

In contrast, both scallops and black tiger prawns are found in relatively shallow water, much closer inshore.

Did you notice any reduction in bycatch?

No – 10.7%
Yes – 89.3%

As expected, most fishers using a square mesh codend reported some reduction in bycatch. When supplied with the square mesh codend, fishers were asked to estimate the amount of bycatch reduction either by looking at both codends together or, better still, weighing the bycatch from both nets.

In percentage terms what bycatch reduction would you estimate was achieved?

0-10% – 17.9%
10-20% – 46.4%
20-30% – 28.6%
30+% – 7.2%

Bycatch reduction by square mesh codends is influenced by the composition of the bycatch. That is, if larger animals dominate the bycatch, then very few will be able to escape. Conversely, if smaller animals dominate, then bycatch exclusion rates will increase. Those fishers who had zero or low reductions (0–10%) were fishing in the Swain Reefs area, where the bycatch is dominated by relatively large *Nemipterus* species, resulting in lower bycatch reduction rates. Most fishers operating in the deepwater EKP fishery achieved significant reductions in areas where the bycatch was dominated by *Apogonops anomalus* or *Macrorhamphosus scolopax* (see below), which are relatively small fish, found in large schools.

Apogonops anomalus

Macrorhamphosus scolopax

Significant reductions were also achieved in the scallop fishery as the mesh used is very large and allows a high proportion of the bycatch to escape. The large meshes also allow crabs and other invertebrates to escape. Excellent results were obtained with square mesh codends during a dedicated research charter in the scallop fishery as part of the FRDC Project No. 2000/170 project (see Chapter 7 of this project Final Report, obtainable from FRDC).

In the black tiger prawn fishery, bycatch composition is variable. The fishery is located in relatively shallow water and, as such, the volume of bycatch is generally high. This is exacerbated by the fact that trawling often occurs during daylight areas. This fishery was the subject of criticism several years ago for bycatch wash-up events that occurred on beaches near Mission Beach. The use of square mesh codends would certainly alleviate this problem.

Was there any effect on target catch?

No loss noticeable – 50%
Loss of small size classes only – 32.1%
Slight increase in catch – 14.3%

Some loss of target – 3.6%

During previous research, it was shown that using square mesh codends does not significantly reduce the catch rate of scallops or eastern king prawns (see FRDC Project No. 2000/170 Final Report). Half of the fishers trialling a square mesh codend noticed no loss, while 14.3% noticed a slight increase.

When the square mesh codends were given to the fishers, project staff ensured the fishers were aware that the devices would allow smaller king prawns to escape. Unfortunately, most fishers who worked the deepwater fishery this season noticed a high percentage of 15/20 count and 21/30 count prawns (that is, 15 to 20 prawns per pound). Although some fishers reported losing prawns in these size ranges, others reported no loss. Further, the loss of targeted prawns mentioned above was reported by a fisher catching smaller size classes in around 50 fathoms off Mooloolaba. The fisher reported losses in the 21/30 grade.

Fishers from Southport originally showed interest in square mesh codends after project staff displayed a square mesh codend during a port visit. The fishers had been working an area that had been producing a high proportion of very small king prawns and, to their credit, wanted to trial a square mesh codend to reduce the incidental mortality of the small size classes. As a result, the fishers could work this area without catching "hundreds of kilos of fleas".

Although it is difficult to prove, project staff attribute the slight increases in catch when using square mesh codends to:

a) Improved water flow in the nets – the open meshes of a square mesh codend allow water to flow through a net, negating problems associated with turbulent flow and pressure waves at the mouth of the net; and
b) The reduction in bycatch results in less net drag and, therefore, slight improvements in wing-end spread. This means that swept area is increased, resulting in slight improvements in catch rate.

Did you notice any rudder angle?

Yes – 25.0%
No – 75.0%

This question was asked after project staff noticed that one vessel conducting sea trials of square mesh codends always had some rudder angle, steering toward the square mesh codend. This was thought to mean that the standard net opposite the square mesh codend (the port net in triple gear) was creating more drag and, hence, the autopilot was correcting the course to allow for this. Some fishers reported that they did notice some rudder angle while using a square mesh codend. Project staff used the Australian Maritime College's Flume Tank to test whether using a square mesh codend reduces net drag, the results of which are reported in Section 7.7.

Will you persist in using a square mesh codend?

Yes – 82.1%
No – 17.9%

It was very encouraging that most fishers would continue to use square mesh codends. Several fishers now have a square mesh codend in each net when working in the deepwater fishery. Of those who stated they would persist in using square mesh codends, a high proportion said that there were clear advantages to using the devices, particularly in areas where small fish species dominated the bycatch.

Various reasons were given by those fishers who reported that they would not be persisting in using a square mesh codend. Two of the black tiger prawn fishers who used a square mesh codend were badly affected by Cyclone Larry and don't trawl any more. Several fishers had worn out their square mesh codends and had not manufactured replacements at the time of the questionnaire. Notably, three fishers who used the devices in the Swain Reefs area stated that because the square mesh codends didn't reduce bycatch they wouldn't be using them again. They also stated that it was difficult to spill the catch from the square mesh codends and would not alter the device to suit them, which was disappointing. This was one example of where the skippers of the vessels were less willing to experiment than the owner. In the majority of cases, it is more efficient to target owner operators rather than targeting the owners of the larger companies. In this case, the owner of the vessels was more than willing to trial the square mesh codends, but the skippers were less willing, disregarding the square mesh codends as soon as possible.

Summary

Overall, the results from these trials were encouraging. The majority of fishers using square mesh codends reported significant reductions in bycatch. Additionally, most also reported that there was no loss of the targeted species. These results compare favourably to those achieved during the dedicated research charters conducted as part of the FRDC Project No. 2000/170 *Bycatch weight, composition and preliminary estimates of the impact bycatch reduction devices in Queensland's trawl fishery*.

The number of fishers participating in trials was surprising. During the development of the project, we anticipated that there would be only about 20 fishers who would be willing to participate in the sea trials. However, the very promising results gained from the FRDC Project No. 2000/170 provided strong evidence of the effectiveness of square mesh codends and this helped generate a great deal of interest in the devices and convince fishers to trial them.

The most encouraging results from the questionnaire are the high proportion of fishers (82.1%) who said they would continue to use a square mesh codend and that fishers are designing and manufacturing their own devices.

7.3.2 Fishery-independent field trials

The following results were obtained from the sea snake bycatch research charter conducted as part of the FRDC Project No. 2005/053 *Reducing the impact of Queensland's trawl fisheries on protected sea snakes*. The charter tested the effects of three different BRDs, including a square mesh codend, on the catch rate of sea snakes, prawns and bycatch in Queensland's tiger/endeavour prawn fishery.

<u>Bycatch</u>

Trawl site location, net position (i.e. inner port, outer port, inner starboard and outer starboard) and BRD type all had a significant effect ($P<0.001$) on bycatch rates. The bycatch rate from the square mesh codend was significantly less than that of the standard net (square mesh codend≠Standard, *P*<0.001). An interaction between net position and BRD type also had a significant effect on bycatch rate (*P* = 0.001). The model predicted a bycatch rate of 10.8 kg (±0.3 kg) per two-nautical mile trawl from the square mesh codend, compared to 15.7 kg (±0.5 kg) from the standard net. This represents a statistically significant (*P*<0.001) reduction in bycatch of 31.2% which is consistent with the bycatch reduction achieved during the research charter conducted in the deepwater eastern king prawn fishery as part of the FRDC Project No. 2000/170 (see Chapter 9 of the project Final Report). Previous research conducted in the tiger/endeavour prawn fishery showed that a high proportion of the animals in the discarded bycatch were relatively small, making the square mesh codend a suitable BRD. The 50 mm mesh size (25 mm x 25 mm square) used allowed a large proportion of these small animals to escape.

<u>Moreton Bay bugs</u>

Throughout the charter a total of 692 Moreton Bay bugs were caught. Of these, 228 were of legal size (i.e. ≥ 75 mm carapace width) and 464 were sublegal. Only trawl site location (*P*<0.001) had a significant effect on the catch rate of legal bugs. Both net position (*P* = 0.319) and BRD type (*P* = 0.158) did not significantly affect catch rate. From the model, the mean predicted catch rate of legal bugs from the square mesh codend (SMC) was 1.045 (±0.152) bugs per two-nautical mile trawl, compared to 0.920 (±0.142) bugs from the standard net. This result is similar to previous research in the deepwater king prawn fishery (Courtney et al. 2007), where the square mesh codend used had no significant effect on the catch rates of Balmain bugs (*Ibacus* spp.).

Both trawl site location (*P*<0.001) and net position (*P* = 0.019) had a significant effect on the catch rate of sublegal Moreton Bay bugs. However, BRD type did not significantly affect catch rate (*P* = 0.356). From the model, the mean predicted catch rate of sublegal bugs from the SMC was 1.891 (±0.183) bugs per two nautical mile trawl, compared to 1.684 (±0.173) per shot from the standard net.

<u>Prawns</u>

During the charter, a total of 15,983 prawns were caught. A summary of the marketable prawn species is presented in Table 6. The charter was designed to sample areas within the Queensland East Coast Trawl Fishery where there were relatively high incidental catches of sea snakes, based on the species of conservation interest (SOCI) logbook data.

Table 6 Number of individuals for the marketable prawn species caught in all nets during the sea snake charter.

Species	**Number of individuals**	**Occurrence (Number of trawl sites out of a total of 83 where the species was present)**
M. endeavouri	488	27
M. ensis	6443	62
P. esculentus	1273	52
P. latisulcatus	412	36
P. longistylus	723	9
P. merguiensis	3788	44
P. monodon	208	33
P. semisulcatus	2648	64

Sea snake bycatch tended to be higher in the shallower, inshore areas, hence a greater number of red-tailed endeavour prawns (*Metapenaeus ensis*), banana prawns (*Penaeus merguiensis*), brown tiger prawns (*P. esculentus*) and grooved tiger prawns (*P. semisulcatus*), and lower numbers of western king prawns (*P. latisulcatus*), red-spot king prawns (*P. longistylus*) and blue-tailed endeavour prawns (*M. endeavouri*) were observed.

Other species of prawns were also caught. These were mostly very small (≈10 mm carapace length) and referred to as coral prawns and hardback prawns. They consisted mostly of species from the genera *Trachypenaeus*, *Metapenaeus* and *Metapenaeopsis*. A summary of the catch of these animals is presented in Table 7.

Table 7 Occurrence and mean weight of coral and hardback prawns caught during the sea snake charter.

Genus	Occurrence (Number of trawl sites out of a total of 83 where the species was present)	Mean weight per shot (g)
Trachypenaeus	67	217.4
Metapenaeus	39	379.5
Metapenaeopsis	50	294.0

Following are the results of the effects of the square mesh codend on each individual marketable prawn species compared to the standard codend. The number of individuals caught is the number caught from all nets.

Penaeus merguiensis – banana prawn

A total of 3788 individual *P. merguiensis* were caught at 44 of the 83 trawl site locations during the charter, ranging in size from 14 mm to 49 mm carapace length. From the model, trawl site location ($P<0.001$), commercial grade ($P<0.001$) and BRD type ($P<0.001$) significantly affected the number of *P. merguiensis* caught, while net position ($P = 0.431$) had no significant effect. Similarly, location ($P<0.001$), commercial grade ($P<0.001$) and BRD type ($P = 0.013$) had a significant effect on the weight of *P. merguiensis* caught, while net position had no significant effect ($P = 0.610$).

These results (Figure 1) suggest that the square mesh codend is an effective BRD in the banana prawn fishery because both models found that it had a positive significant effect on the number (square mesh codend≠Standard, $P = 0.001$) and a marginally positive effect (square mesh codend=Standard, $P = 0.055$) on the weight of banana prawns caught during the survey. That is, the square mesh codend caught more banana prawns during the charter than the standard net. The fact that the square mesh codend also reduced bycatch significantly throughout the charter further demonstrates its suitability in the banana prawn fishery – a fishery that has been scrutinised due to its past problems with bycatch wash-up on north Queensland beaches.

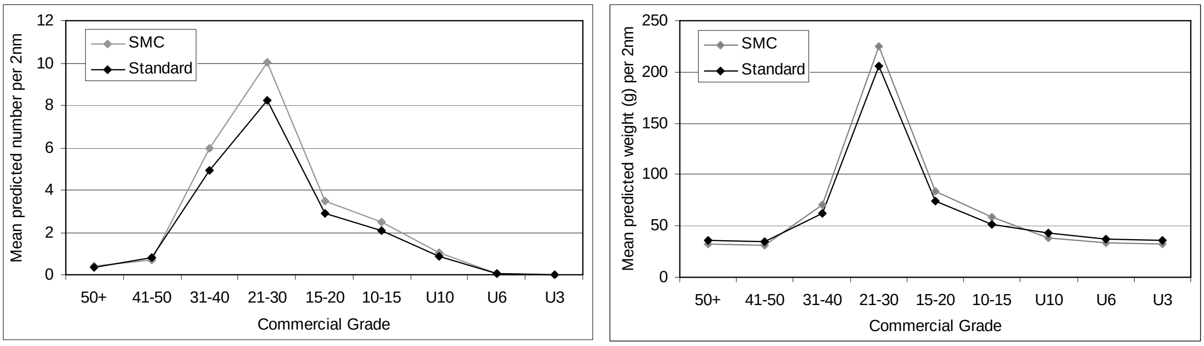

Figure 1 Catch rate of *P. merguiensis* caught during the sea snake bycatch research charter. Note that more banana prawns were caught in the net with the square mesh codend (SMC). Predicted catch rates in number of prawns caught are provided on the left graph while predicted catch rates in weight are provided on the right-hand side graph. Error bars were omitted for clarity.

Penaeus semisulcatus – grooved tiger prawn

A total of 2648 individual *P. semisulcatus* were caught at 64 of the 83 trawl sites during the charter, ranging in size from 15 mm to 49 mm carapace length. From the model, trawl site location ($P<0.001$), commercial grade ($P<0.001$) and net position ($P = 0.003$) significantly affected the number of *P. semisulcatus* caught. However, BRD type ($P = 0.079$) had only a marginal effect on the number of *P. semisulcatus*. Similarly, location ($P<0.001$), commercial grade ($P<0.001$) and net position ($P<0.001$) all had significant effects on the weight of *P. semisulcatus* caught, while BRD type had no significant effect ($P = 0.368$).

The fact that BRD type did not significantly affect the catch of *P. semisulcatus* (Figure 2) suggests that the square mesh codend did not adversely affect the catch rate. This fact combined with the bycatch exclusion rates achieved suggests that fishers operating in the northern tiger prawn fishery could reduce bycatch significantly without losing significant amounts of marketable grooved tiger prawns.

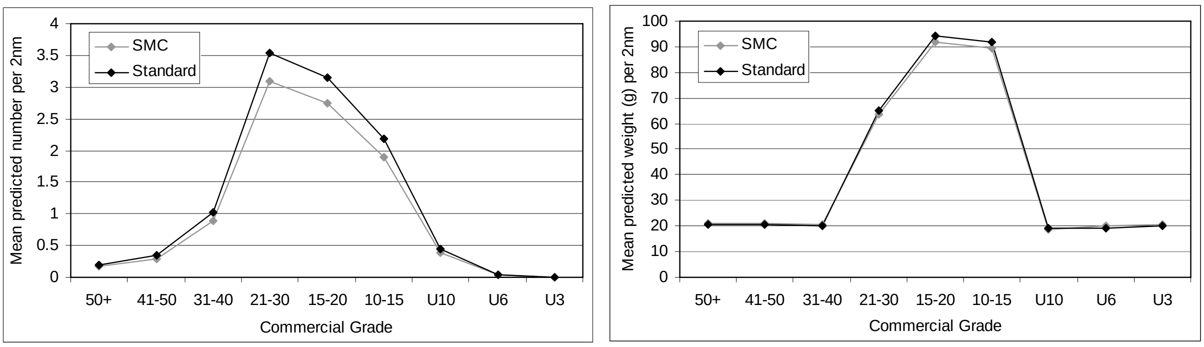

Figure 2 Catch rate of *P. semisulcatus* caught during the sea snake bycatch research charter. Predicted catch rates in number of prawns caught are provided on the left graph while predicted catch rates in weight are provided on the right-hand side graph. Error bars were omitted for clarity.

Penaeus esculentus – brown tiger prawn

A total of 1273 individual *P. esculentus* were caught at 52 of the 83 trawl site locations during the charter, ranging in size from 12 mm to 49 mm carapace length. From the model, trawl site location ($P<0.001$) and commercial grade ($P<0.001$) significantly affected the number of *P.*

esculentus caught. However, net position (*P* = 0.609) and BRD type (*P* = 0.523) had no significant effect on the numbers of *P. esculentus* (Figure 3). Similarly, location (*P*<0.001) and commercial grade (*P*<0.001) had a significant effect on the weight of *P. esculentus* caught, while net position (*P* = 0.854) and BRD type (*P* = 0.840) had no significant effect.

As expected, the effect of the square mesh codend on the catch of brown tiger prawns was similar to the effect on the grooved tiger prawns. Their similar morphology and size range suggested that the effects on these species would be similar. Given that both species occur in the northern tiger prawn fishery, these results suggest that it is irrelevant which species is dominating tiger prawn catches, and fishers can expect that their catch will not be reduced by using a square mesh codend (Figure 3).

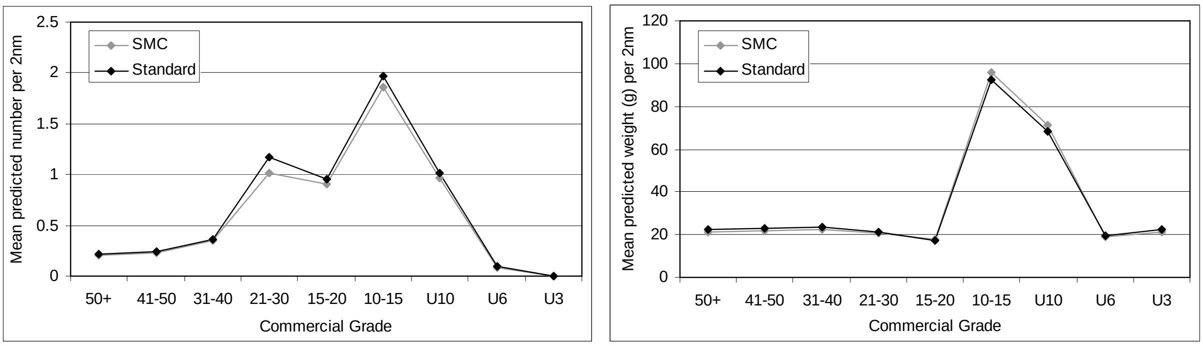

Figure 3 Catch rate of *P. esculentus* caught during the sea snake bycatch research charter. Predicted catch rates in number of prawns caught are provided on the left graph while predicted catch rates in weight are provided on the right-hand side graph. Error bars were omitted for clarity.

Penaeus latisulcatus – western king prawn, blue-legged king prawn

A total of 412 individual *P. latisulcatus* were caught at 36 of the 83 trawl site locations during the charter, ranging in size from 17 mm to 54 mm carapace length. From the model, location (*P*<0.001), commercial grade (*P*<0.001) and net position (*P*<0.001) significantly affected the number of *P. latisulcatus* caught. However, BRD type (*P* = 0.194) had no significant effect on the number of *P. latisulcatus*. Similarly, trawl site location (*P*<0.001), commercial grade (*P*<0.001) and net position (*P*<0.001) all had significant effects on the weight of *P. latisulcatus* caught, while BRD type had no significant effect (*P* = 0.163).

The fact that BRD type had no significant effect on the catch of *P. latisulcatus* suggests that the square mesh codend had no adverse affect on the catch rate of this species (Figure 4). *P. latisulcatus* was often caught with large numbers of smaller coral prawns, which the square mesh codend was able to significantly exclude. This, combined with the significant reductions in bycatch, results in reductions in both sorting time and product damage.

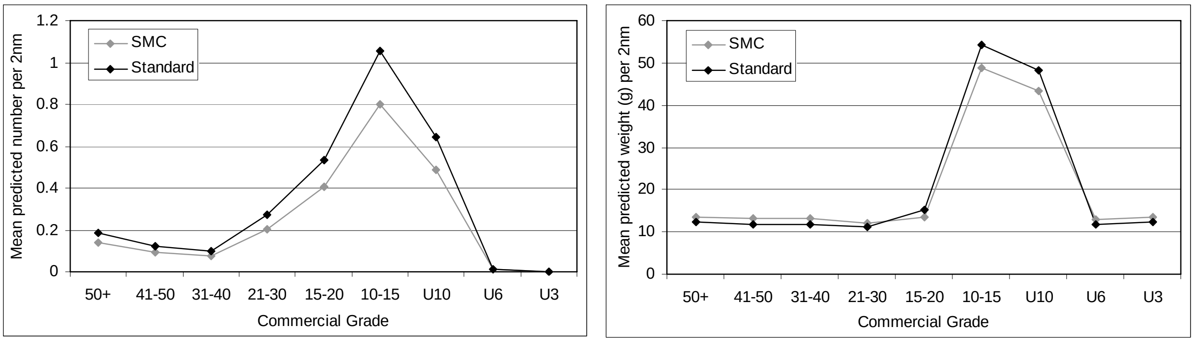

Figure 4 Catch rate of *P. latisulcatus* caught during the sea snake bycatch research charter. Predicted catch rates in number of prawns caught are provided on the left graph while predicted catch rates in weight are provided on the right-hand side graph. Error bars were omitted for clarity.

Penaeus longistylus – red-spot king prawn

A total of 723 individual *P. longistylus* were caught at nine of the 83 trawl site locations during the charter, ranging in size from 15 mm to 52 mm carapace length. From the model, trawl site location ($P<0.001$), commercial grade ($P<0.001$), net position ($P<0.001$) and BRD type ($P<0.001$, Figure 5) significantly affected the number of *P. longistylus* caught. However, the number caught from the standard net was not significantly different from the net containing the square mesh codend (square mesh codend=Standard, $P = 0.105$). Similarly, trawl site location ($P<0.001$), commercial grade ($P<0.001$), net position ($P<0.001$) and BRD type ($P<0.001$) all had significant effects on the weight of *P. longistylus* caught. Further, the weight of *P. longistylus* caught from the standard net was significantly different from the net containing the square mesh codend (square mesh codend=Standard, $P = 0.028$)

P. longistylus occurred at only nine trawl sites where the standard net caught more *P. longistylus* than the other three nets combined, suggesting that the catches were biased due to net position rather than BRD type. Given that *P. longistylus* and *P. latisulcatus* have similar morphology, it would be reasonable to suggest that the square mesh codend would have a similar effect on the catch rates of both species. Square mesh codends have been shown to have a positive effect on the catch rate of a similar species, *P. plebejus*, during research charters conducted as part of FRDC Project No. 2000/170 (see Chapter 9 of the Final Report).

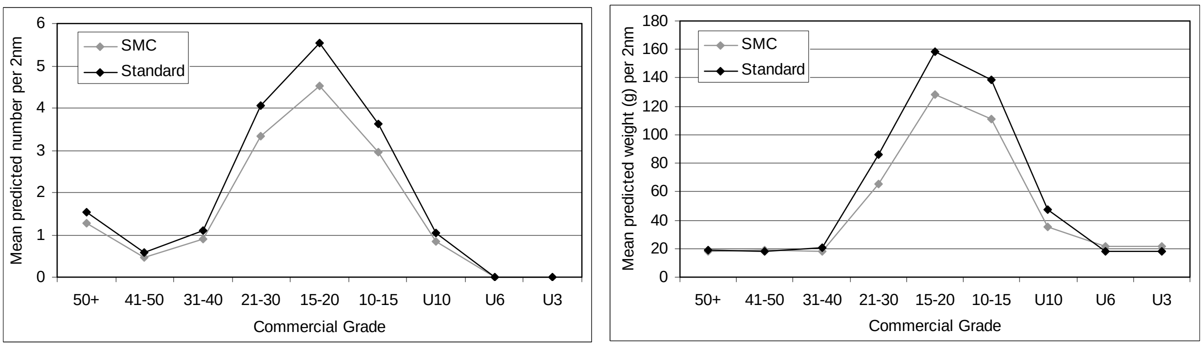

Figure 5 Catch rate of *P. longistylus* caught during the sea snake bycatch research charter. Predicted catch rates in number of prawns caught are provided on the left graph while predicted catch rates in weight are provided on the right-hand side graph. Error bars were omitted for clarity.

Penaeus monodon – black tiger prawn

A total of 208 individual *P. monodon* were caught at 33 of the 83 trawl site locations during the charter, ranging in size from 27 mm to 69 mm carapace length. From the model, trawl site location ($P<0.001$) and commercial grade ($P<0.001$) significantly affected the number of *P. monodon* caught, while net position ($P = 0.077$) had a marginal effect and BRD type ($P = 0.151$) had no significant effect on the numbers of *P. monodon*. Similarly, trawl site location ($P<0.001$) and commercial grade ($P<0.001$) significantly affected the weight of *P. monodon* caught, while net position ($P = 0.527$) and BRD type ($P = 0.853$) had no significant effect on the weight. *P. monodon* is the basis of a broodstock collection fishery for the aquaculture industry.

At-sea trials of square mesh codend have been conducted by project staff in the broodstock collection fishery (refer to Table 4). The results gained during those trials are consistent with those obtained from the research charter. That is, a square mesh codend does not adversely affect the catch of *P. monodon*, while significantly reducing bycatch (Figure 6). Given that it is vital individual *P. monodon* are kept alive for sale to hatcheries, a reduction in bycatch is likely to result in reduced crushing and higher survival rates of individuals.

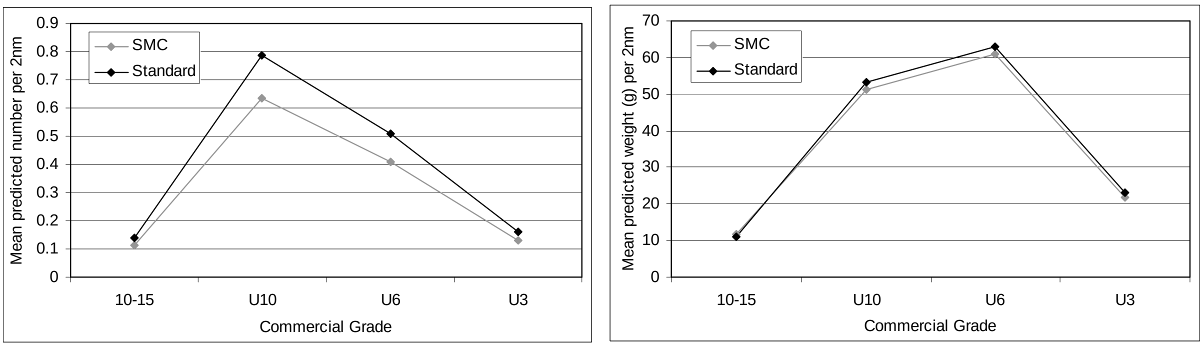

Figure 6 Catch rate of *P. monodon* caught during the sea snake bycatch research charter. Predicted catch rates in number of prawns caught are provided on the left graph while predicted catch rates in weight are provided on the right-hand side graph. Error bars were omitted for clarity.

Metapenaeus endeavouri – blue-tailed endeavour prawn

A total of 488 individual *M. endeavouri* were caught at 27 of the 83 trawl site locations during the charter, ranging in size from 12 mm to 49 mm carapace length. From the model, trawl site location ($P<0.001$) and commercial grade ($P<0.001$) significantly affected the number of *M. endeavouri* caught, while net position ($P = 0.683$) and BRD type ($P = 0.874$, Figure 7) had no significant effect on the number. Similarly, trawl site location ($P<0.001$) and commercial grade ($P<0.001$) significantly affected the weight of *M. endeavouri* caught, while net position ($P = 0.561$) and BRD type ($P = 0.379$) had no significant effect on the weight.

Due to the location of the trawl sites, only a relatively small number of *M. endeavouri* were caught. As with *P. longistylus* and *P. latisulcatus*, *M. endeavouri* occurred in areas adjacent to coral reef, in relatively deep water. Given that the charter was designed to catch sea snakes, most trawl effort was directed at shallower sites where a larger number of sea snakes are found.

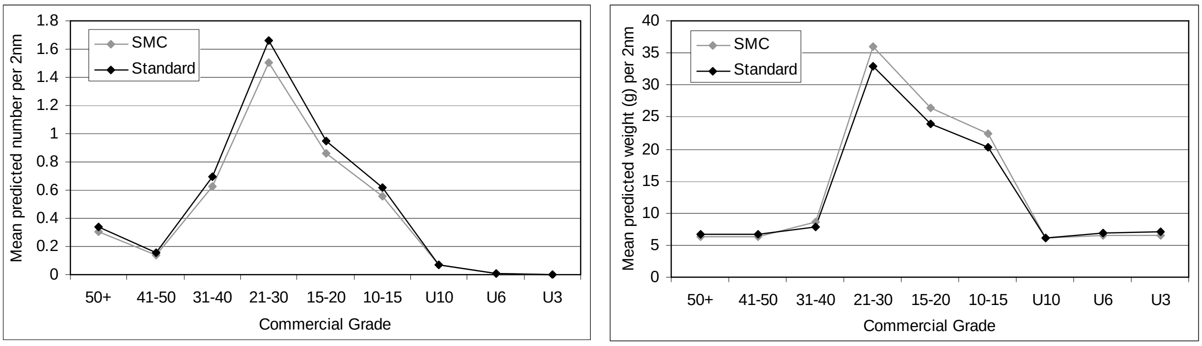

Figure 7 Catch rate of *M. endeavouri* caught during the sea snake bycatch research charter. Predicted catch rates in number of prawns caught are provided on the left graph while predicted catch rates in weight are provided on the right-hand side graph. Error bars were omitted for clarity.

Metapenaeus ensis – red-tailed endeavour prawn

A total of 6443 individual *M. ensis* were caught at 62 of the 83 trawl site locations during the charter, ranging in size from 11 mm to 43 mm carapace length. From the model, trawl site location (P<0.001), commercial grade (P<0.001), net position (P<0.001) and BRD type (P<0.001) all significantly affected the number of *M. ensis* caught (square mesh codend≠Standard, P<0.001). Similarly, trawl site location (P<0.001), commercial grade (P<0.001), net position (P<0.001) and BRD type (P<0.001) all significantly affected the weight of *M. ensis* caught (square mesh codend≠Standard, P<0.001).

More *M. ensis* were caught than any other species and occurred in more trawls. This species was the smallest of the commercially important species and therefore the models were able to determine that the catch rates of the smaller size classes could be significantly reduced using a square mesh codend (Figure 8). The fact that the smaller size classes of the other species weren't encountered by any net suggests that they don't occur in these areas. It would be reasonable to assume that if the smaller size classes did occur in the areas trawled, then similar results would have been obtained for the other species.

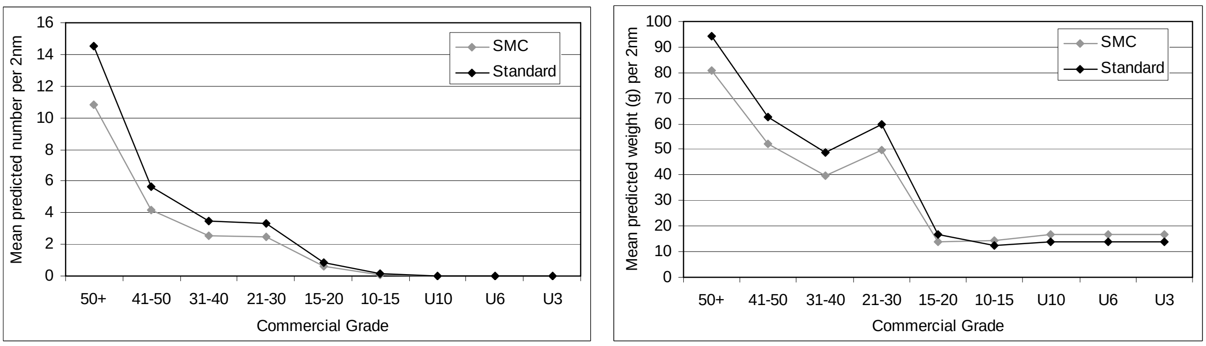

Figure 8 Catch rate of *M. ensis* caught during the sea snake bycatch research charter. Predicted catch rates in number of prawns caught are provided on the left graph while predicted catch rates in weight are provided on the right-hand side graph. Error bars were omitted for clarity.

Further analyses

Further analyses were carried out on the smaller prawn species. As these species are marketed by some fishers, we thought it prudent to quantify reductions. During sample processing, these smaller species were grouped by genus and weighed. Catches were then modelled using the same methods described above and the results provided in Table 8. As expected, the weight of *Metapenaeopsis* sp. (square mesh codend≠Standard, P=0.001), *Trachypenaeus* sp. (square mesh codend≠Standard, P<0.001) and *Metapenaeus* sp. (square mesh codend≠Standard, P<0.001) were reduced significantly in the net containing the square mesh codend.

Analyses were also undertaken to examine whether the square mesh codend had an effect on marketable prawns of all species. We determined that the majority of species caught would be marketable at approximately 20 mm carapace length. The weight of the marketable and non-marketable prawn catch was modelled using the methods described above. As expected, the square mesh codend did not significantly affect the weight of marketable-sized prawns, but it did have significant effect on the weight of "undersize" marketable prawns (square mesh codend≠Standard, P<0.001).

Table 8. Predicted mean catch rates (grams per 2 nm trawl) of prawns from the FRDC Project No. 2005/053 sea snake bycatch research charter. Standard errors in brackets. Note: Prawns do not have a minimum legal size and therefore do not have "undersize" size classes. The term "undersize" as used here refers to small prawns that are below marketable size, where marketable size was defined as >20mm CL. The generalised linear models included all trawls (83 trawls x 4 nets), including zero counts.

	Square mesh codend	**Standard**
Marketable prawns (>20 mm CL)	1018.8 (33.33)	1037.4 (33.98)
"Undersize" prawns (≤20 mm CL)*	18.70 (1.81)	38.86 (2.41)
Metapenaeopsis sp.*	31.10 (16.50)	60.30 (29.40)
Trachypenaeus sp.*	32.30 (2.44)	66.09 (3.94)
Metapenaeus sp.*	46.40 (7.34)	110.97 (7.38)

*denotes that BRD type had a significant effect on catch rate.

In conclusion, the results suggest that the square mesh codend can be used to significantly reduce bycatch, while maintaining and even improving the catch rates and selectivity of commercially important prawns. This is the first time that a square mesh codend has been scientifically tested in Queensland's tiger/endeavour prawn fishery which is one of the largest and most important sectors of the Queensland trawl fishery. The significance of this successful trial and the subsequent potential adoption of square mesh codends by fishers in the tiger/endeavour prawn fishery should not be understated. Currently, according to the Management Plan, square mesh codends must have a minimum mesh size of 45 mm (22.5 mm by 22.5 mm on the bar). For several years now we have assumed that this relatively large mesh size would dissuade fishers from using the device in the tiger/endeavour prawn fishery, but the results suggest that a square mesh codend constructed from 45 mm, and even larger 50 mm mesh that was trialled here, could be suitable BRDs in this sector.

The square mesh codend significantly reduced the amount of "undersize" prawns (Table 8). It is reasonable to assume that these small prawns would experience a reduction in incidental fishing mortality as a result of the square mesh because they would not:

a) be as traumatised by being towed along the bottom inside the net,
b) be crushed from bycatch inside the net and on the sorting tray,
c) be brought to the surface and dropped on the sorting tray, and
d) be released on the surface and therefore be vulnerable to predation.

This reduction in incidental fishing mortality would likely result in more prawns surviving to marketable sizes and therefore increase the prawn catches in the future. When this is combined with the 31.2% reduction in bycatch that was achieved with the square mesh codend and its ability to maintain marketable prawn and Moreton Bay bug catch rates, the benefits to industry from using square mesh codends become obvious and help promote their adoption.

7.4 NETMAKER VISITS

Project staff continually liaised with netmakers regarding the construction of square mesh codends. Several netmakers (and fishers) are now constructing the devices, and project staff have provided advice where necessary. One netmaker in particular, Mr Wally Hill, has been extolling the benefits of square mesh codends to the fishers that he services and has developed a faster method of construction.

The first method for constructing square mesh codends was based on methods described by Broadhurst et al. (1999), who used four separate pieces of square mesh sewn together with the knots orientated in opposite directions. In the current project, when the four individual pieces of mesh were sewn together (see Figure 9A) one bar overlap was used to allow each mesh on the seams to have four bars. This results in a stronger seam and reduced chance of knots along the seam slipping or distorting. As the Management Plan only requires square mesh codend BRDs in Queensland to be 75 bars long, a diamond mesh section was sewn to the top of the square mesh codend to increase its length, making it comparable in length to that of a standard codend. This reduced variation between the square mesh codend and the standard codend which helped facilitate a comparison of the devices when they were deployed alongside each another. Another section of diamond mesh was added to the aft edge of the square mesh codend to allow drawstrings to be attached (see Figure 9B).

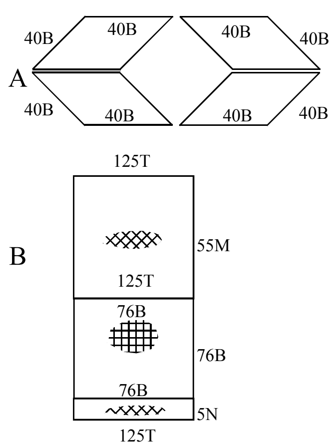

Figure 9 Net plan (Broadhurst method 1999) of a square mesh codend for use in the eastern king prawn and black tiger prawn fisheries.

The method developed by Wally Hill, however, is far less time consuming, thereby making the devices more affordable to fishers. Basically, a single panel of square mesh 76 bars by 78 meshes is sewn into a cylinder of mesh 76 meshes round and 78 bars long (see Figure 10A). This is then cut in half, the lower cylinder is turned inside-out and reattached. A diamond mesh section is then sewn to the forward end to ensure the codend is the same length as a standard codend. A small section of diamond mesh is also added to the aft edge of the square mesh codend to allow the drawstrings to be attached (see Figure 10B). Mesh and bar counts will change according to fishers' preferences as per Table 2 in Section 7.1.

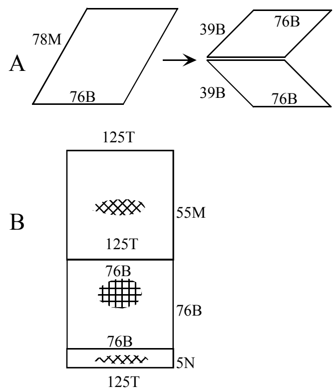

Figure 10 Net plan (Wally Hill method) of the improved method of construction of a square mesh codend for use in the eastern king prawn and black tiger prawn fisheries.

Using this method, construction time for a square mesh codend is reduced by approximately one hour and overall production costs per codend (i.e. the codend excluding the TED section) are reduced by 30 to 40%. Prior to the project, the cost of purchasing square mesh codends hindered their uptake so this development has made the devices far more attractive to fishers. Further, by simplifying the construction method with resultant decreases in construction time, fishers will find it more acceptable to construct the devices themselves.

A Brisbane net importer, ATS Nets and Ropes, has begun importing bundles of square mesh specifically for the construction of square mesh codends. Initially, some 50 mm x 2.4 mm (50 metres x 75 bars) bundles were imported after consultation with project staff. This material has been used by netmakers and fishers to construct square mesh codends for the deepwater eastern king prawn fishery. Subsequently, ATS imported several bundles of 88 mm x 5 mm (25 metres x 41 bars) and 88 mm x 6 mm (25 metres x 41 bars) after consultation with project staff. The fact that this mesh is manufactured "on the square" allows for easier construction of square mesh codends, effectively reducing construction time. This cuts the price of the square mesh codends when fishers buy them from netmakers. Further, this material results in less wastage as the bundles were ordered to cater for the methods of construction employed by project staff.

Project staff liaised with netmakers in Yamba (NSW) who have previously constructed square mesh codends for fishers. The project purchased a square mesh codend used in the northern NSW area for use by a fisher based at Mooloolaba. The square mesh codend was constructed of knotless material with a mesh size of 35 mm. The fisher in question had previously worked with fishers in Yamba who had suggested that the 35 mm square mesh codend was the best device to use. This is well below the current minimum legal size for a square mesh codend in Queensland (45 mm, as stated in the Management Plan), but the fisher could have trialled it under the QDPI&F's General Fisheries Permit. The fisher decided to try a square mesh codend after a bycatch wash-up incident occurred on Sunshine Coast beaches but unfortunately he changed his mind.

7.5 PUBLISHED ARTICLES

A total of seven media releases and articles were produced during the project (see Appendix 2). The details are as follows:

1. Fisheries Research and Development Corporation (FRDC) funds square mesh codend extension project for Queensland trawl fishery. *SeaNet News,* pages 1–2 (July 2005).
2. Queensland Department of Primary Industries and Fisheries launches trawl bycatch extension project. *FRDC Media Release* (August 2005).
3. Square mesh codend project. *Queensland Fisheries Business Group's Trawl Fishery Newsletter* (December 2005).
4. Fisheries Research and Development Corporation (FRDC) funds square mesh codend extension project for Queensland trawl fishery. *The Queensland Fisherman* (December 2005).
5. Benefits of square mesh codends promoted in Queensland scallop and prawn trawl fisheries. *Ausmarine,* 29(1):14 (November 2006).
6. Square mesh delivers. *FRDC R&D News,* 14(4):13 (November 2006).
7. Benefits of square mesh codends promoted in Queensland scallop and prawn trawl fisheries. *Bycatch Communication Network Newsletter,* Issue 3:13-15 (November 2006).

7.6 INFORMATION DVD

A DVD was produced as part of the project showing a) footage of trawl bycatch and research results on how bycatch rates can be reduced by using square mesh codends, with no effects on prawn and scallop catch rates, and b) design plans and methods for constructing and installing square mesh codends. A copy of the DVD script is provided (see Appendix 3). The DVD was approved by FRDC and a copy posted to all Queensland trawl operators in May 2007.

7.7 EFFECTS OF SQUARE MESH CODENDS ON NET DRAG

Net drag was measured on the Australian Maritime College's Trawl Evaluation Rig (see Figure 11) at both water speeds (2.0 and 3.0 knots) for each of the four relative catch sizes (0, 10, 20 and 30 water-filled balloons) and each of the two codend types (standard and square mesh codend). A total of 600 drag measurements were obtained from each of the four load cells for a period of one minute (i.e. 10 measures per second) under each treatment scenario.

Figure 11 Scaled-down six-fathom prawn trawl net attached to the Trawl Evaluation Rig in the Australian Maritime College's Flume Tank.

The generalised linear model indicated that water speed, catch size and codend type all had a significant effect ($P<0.001$) on total net drag. The observed means for total net drag for each catch size at water speeds of 2.0 knots and 3.0 knots are presented in Figure 12 and Figure 13, respectively.

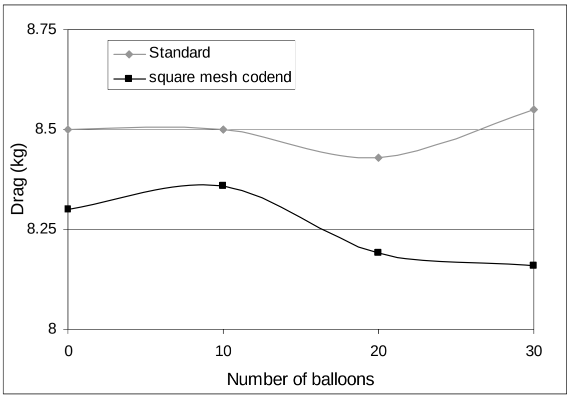

Figure 12 Total drag for each "catch" size at approximately 2.0 knots water speed. The plotted points are observed means. The standard errors were so small that they could not be clearly presented at this resolution.

At a water speed of 2.0 knots (Figure 12) the square mesh codend significantly reduced net drag for each catch size. Further, as catch size increased, the difference in net drag between the two codends increased. This suggests that as trawl duration increases and the weight of the catch increases, the relative benefit of the square mesh codends, in terms of reducing drag, also increases. A similar result can be seen at the higher water speed of 3.0 knots (Figure 13).

Once again, the square mesh codend had a proportionally greater effect on net drag at higher catches.

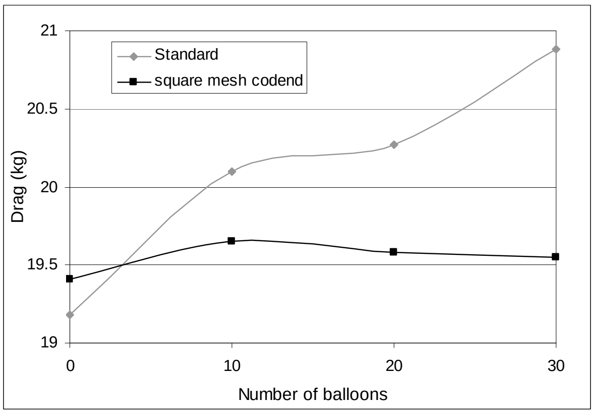

Figure 13 Total drag for each "catch" size at approximately 3.0 knots water speed. The plotted points are observed means. The standard errors were so small that they could not be clearly presented at this resolution.

During the tests, the geometry of the codends varied greatly according to water speed and catch size. As catch size increased, the standard codend assumed a more pronounced "bell" shape that is characteristic of standard codends (see Figure 14). Further, at the highest speed and largest catch size, the standard codend became unstable, with pronounced oscillating vertical movement.

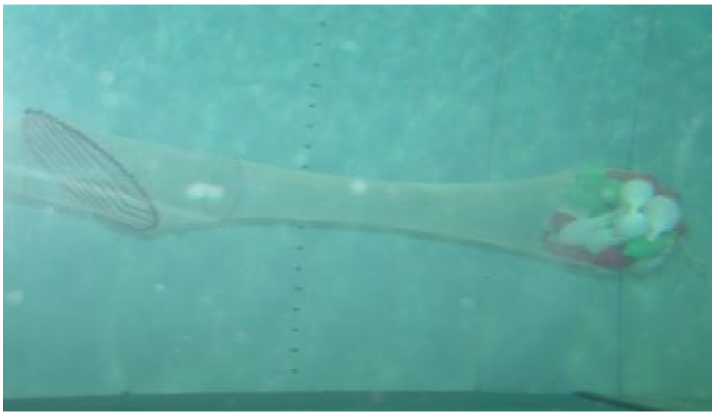

Figure 14 Shape of the standard codend with a "catch" of 30 balloons at 3.0 knots water speed.

In contrast, the square mesh codend maintained a much more streamlined shape and remained relatively stable in the water column, with very little vertical movement (Figure 15). This is due to very limited lateral expansion of catch inside the square mesh codend. Unlike standard diamond mesh codends, square mesh codends cannot expand laterally. Expansion of the catch causes the codend to become bell-shaped and to oscillate vertically, resulting in increased net drag.

These results suggest that significant reductions in drag could be achieved using square mesh codends which would certainly reduce fishers' running costs. At a water speed of 3.0 knots, net drag was reduced by an average of 2.72% (range 2.25% to 6.37%). Given that net drag is responsible for approximately 75% of overall drag in triple and quad gear (David Sterling pers comm.), the drag reductions due to the square mesh codend would reduce overall net drag by an average of 2.04% (range 1.69% to 4.78%). A conservative estimate of fuel usage in Queensland is approximately 400 litres per night per vessel and recently fishers have been paying in the order of 90c per litre. In 2006, there were approximately 50,000 boat-nights of effort expended in the fishery, which would equate to approximately $18 million in fuel consumption across the entire fleet, excluding Moreton Bay. A 2.04% (range 1.69% to 4.78%) reduction in this cost equates to a $367,200 (range $304,200 to $860,400) saving to industry – a very conservative estimate. Further research is required to investigate the effects of square mesh codends in full-scale gear to determine more precise reductions in net drag and their subsequent fuel cost savings.

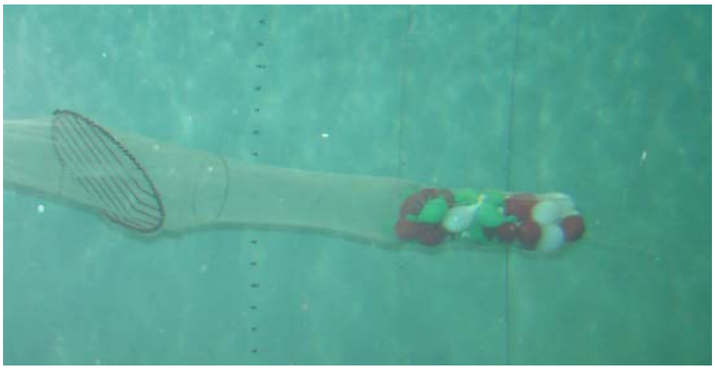

Figure 15 Shape of the square mesh codend with a “catch” of 30 balloons at 3.0 knots water speed.

8 Benefits and adoption

The adoption of square mesh codends has a direct benefit to commercial fishers operating in Queensland’s deepwater king prawn, black tiger prawn broodstock collection and scallop fisheries in the form of reduced bycatch from trawling. These significant reductions in bycatch provide social and economic benefits to trawl fishers while addressing important sustainability issues facing all trawl fisheries.

The economic benefits of square mesh codends to fishers can be attributed to reductions in net drag due to reductions in bycatch and improvements in water flow through the net. Firstly, reductions in net drag contribute to fuel savings, an important consideration to fishers. Further, reductions in net drag result in improvements in wing-end spread and increases in swept area, improving the catch rates of target species. Improvements in water flow through nets containing square mesh codends also result in slightly higher catch rates of target species. These increases in catch rate of target species were observed during at-sea trials as part of the project. Further, one fisher using square mesh codends during the project reported that the prawns caught in nets containing square mesh codends are livelier and in better condition as a result of water flow improvements, increasing the value of the prawns to fishers.

Less tangible economic benefits are also possible for fishers using square mesh codends. Reductions in the catch of small, sub-optimal or undersize prawns, scallops and bugs result in lowered rates of incidental fishing mortality. Excluding these small size classes prevents their exposure to capture, crushing in the codend and on the sorting tray, and other hazards associated with being trawled. Although this benefit is not quantified, the number of individuals excluded via the square mesh codends that would be left to grow to larger more commercially valuable sizes, could be significant (e.g. Courtney et al. 2007 showed that 63% fewer undersized scallops were caught using square mesh codends).

Square mesh codends provide a social benefit to trawler operators. That is, by using square mesh codends fishers mitigate conflict between themselves and other stakeholders. Conservation agencies, recreational fishers and the general public have applied pressure to trawler operators to use more effective BRDs. Square mesh codends improve selectivity and reduce bycatch, thus reducing the impacts of trawling and making trawl fishing more acceptable to the community.

Courtney et al. (2007) quantified the reductions in bycatch rates and extrapolated estimates of reductions in total annual bycatch due to square mesh codend BRDs. They estimated that if square mesh codends were used in conjunction with efficient TEDs in Queensland's scallop and deepwater king prawn fisheries, bycatch could be reduced by 10,725 tonnes and 390 tonnes annually, respectively, compared to pre-TED and pre-BRD conditions. This would be a significant step towards reducing the incidental fishing mortality on bycatch species and reducing community concern over the impacts of trawling, thus benefiting trawler operators.

During project development it was envisaged that the recreational fishing sector would benefit significantly from the project. This was because project staff thought the species excluded from square mesh codends would include species of recreational importance. However, Courtney et al. (2007) when describing the bycatch from the Queensland trawl fishery found there were relatively few recreationally important species in the sectors that were examined in this extension project. As such, the project largely benefits the commercial trawl fishery with relatively little benefit to the recreational sector.

The number of trawler operators using square mesh codends in Queensland has increased as a result of the project, but quantifying precise numbers is difficult. Information on the types of BRDs used in Queensland is recorded as part of the "gear information sheets" in the front of their logbooks. We examined these data which indicated that there were over 10,000 boat-nights of effort expended by fishers using square mesh codends since 1999. We suspect that this figure is too high and due to many fishers not differentiating between square mesh codends and square mesh panels when they record their BRD details. A proportion of the effort is due to some fishers using square mesh codend BRDs, but we strongly suspect that most of it would be attributed to square mesh panels, based on our observations and interactions with fishers and their vessels.

Although the precise number of vessels using square mesh codend BRDs as a result of the project is difficult to quantify, we can state that 36 fishers were given 40 square mesh codend BRDs to trial during the project, and that 82% said they would continue to use the devices. Queensland netmaker Mr Wally Hill, who has been constructing square mesh codends for trawler operators since October 2006, reports strong demand for the devices and said that he was now supplying 10 Queensland vessels with them. Uptake of square mesh codend BRDs is now increasing due to word-of-mouth reports among fishers. Collectively, based on the efforts of project staff, production of square mesh codends by netmakers and word-of-mouth promotion by industry, we estimate that approximately 10% of the state's 480 licensed otter trawl vessels are using the devices regularly. At the time of writing, the Queensland Fisheries Business Group were drafting a Regulatory Impact Statement which included making square mesh codend BRDs mandatory in the scallop fishery. If this management measure proceeds, it would result in approximately 25% of all trawl effort expended on the Queensland east coast (i.e. about 17,000 boat-days) using square mesh codends.

9 Further development

1. Bycatch rates in the shallow water eastern king prawn fishery are relatively high and the BRDs being used by fishers in this sector were recently shown to have little effect (2007; 2006). Square mesh codends could be used in this sector to significantly reduce bycatch rates but as stated earlier, further research is required to ascertain the appropriate mesh size. Although it appears the 50 mm mesh used to construct the square mesh codend trialled during the FRDC Project No. 2005/053 sea snake bycatch project research charter is appropriate for the tiger/endeavour fishery, this mesh size would not be appropriate for the shallow water eastern king prawn fishery. According to the Management Plan, the current minimum mesh size that can be used in the construction of square mesh codends in Queensland is 45 mm. The shallow water eastern king prawn fishery targets relatively small prawn grades and the results from the sea snake research charter suggest that significant reductions in catch rates of these small grades would occur in the shallow water eastern king prawn fishery if fishers used square mesh that complies with the Plan’s specifications. There is therefore a need to review the acceptable minimum mesh size that can be used to construct square mesh codends in Queensland. Further research using knotless material is also warranted because advanced manufacturing techniques have resulted in much stronger material, without the problems associated with knot slippage.

2. As stated earlier, reductions in the number of undersize prawns, scallops and bugs have occurred as a result of using square mesh codends. For example, we know that square mesh codends of 50 mm by 50 mm when applied in the scallop fishery reduce the incidental capture of undersize scallops by 63% and undersize bugs by 76%. The potential positive effects of this on exploitable biomass of these stocks have not been quantified, but may it may be substantial. It would be worthwhile estimating the increase in biomass that could be achieved if square mesh codends applied in the major trawl sectors. This is of particular importance in the shallow water king prawn fishery where large numbers of juvenile (mostly non-marketable) king prawns are subjected to incidental trawl mortality during the early part of the season.

3. The effect of square mesh codends on net drag is another area that warrants further research. Given the current price of fuel and a lack of identifiable alternative fuels, more efficient use of fuel is pertinent. The preliminary flume tank trials conducted at the Australian Maritime College during the project suggest that some reductions in net drag are attainable in scaled-down model trawls and, therefore, further full-scale sea trials should be undertaken to quantify the effects of square mesh codends under conditions that closely reflect commercial fishing operations.

10 Planned Outcomes

A significant reduction in the amount of bycatch caught and discarded in the Queensland scallop, deepwater eastern king prawn and black tiger prawn (leader prawn) fisheries. We propose to achieve this outcome by encouraging and persuading trawler operators to use highly effective square mesh codend bycatch reduction devices (BRDs).

Output: Increased awareness of square mesh codends. Increased understanding of how the devices work and why they work.

Prior to commencement of the project, very few, if any, fishers used square mesh codends in Queensland as their primary bycatch reduction device. A small number of fishers had used the devices previously, mostly fishers from northern New South Wales and fishers that had participated in research surveys during the FRDC Project No. 2000/170. As such, it was vital that this project increase the awareness of square mesh codends to fishers operating in the target sectors, persuading fishers that the square mesh codend was a practical, effective bycatch reduction device.

The project was a collaborative effort between SeaNet, Ecofish and the Queensland Department of Primary Industries and Fisheries (QDPI&F). The general approach was for SeaNet and Ecofish (both organisations were based in Cairns, north Queensland) to coordinate extension in the State's northern tiger/endeavour prawn and black tiger prawn broodstock collection fisheries and the QDPI&F to oversee extension in the scallop and eastern king prawn fisheries, located in southeast Queensland. While this approach worked successfully, the lack of previous research trials of square mesh codends in the north Queensland tiger/endeavour prawn fishery meant that extension in this sector was always going to be more challenging. All of the previous square mesh codend research trials were conducted in the scallop and eastern king prawn sectors, with very promising results. Furthermore, promoting uptake of the devices in the black tiger prawn broodstock collection fishery was greatly hampered by tropical Cyclone Larry in early 2006. Five of the seven operators in this small fishery were severely affected by the cyclone and no longer participate in the fishery. Nevertheless, the project demonstrated that square mesh codends are highly effective in this fishery and both remaining operators have continued to use them.

Several project outputs contributed to increased awareness of square mesh codends. Firstly, articles appearing in relevant publications were designed to inform fishers of the effectiveness of square mesh codends by summarising results from previous research. The articles summarised the findings from research charters where square mesh codends were used to reduce bycatch without significant losses of target species.

Secondly, face-to-face consultations between project staff and fishers greatly helped communicate the message that square mesh codends can be highly effective BRDs. During these informal discussions, it was possible to answer questions posed by fishers, questions that invariably concerned the drawbacks of using square mesh codends. Project staff were able to discuss these issues and assure fishers that any shortcomings could be overcome. Further, we were able to inform fishers about favourable results gained during the project from both fishery-dependent and fishery-independent sea trials. In all, 170 to 180 individual fishers were consulted in this manner and, although this output is not tangible, its value to the achievement of the planned outcome is significant.

It was through these informal discussions that we were able to persuade fishers to borrow square mesh codends. The gear library was the single most important project output contributing to the achievement of the planned outcome. By supplying square mesh codends free of charge, fishers were able to test the devices without cost. This enabled fishers to observe the device in operation first-hand and allowed them to make an informed decision about using them. This output in itself increased the use of square mesh codends and, therefore, contributed to the project's planned outcome.

Another less tangible project output that contributed to the achievement of the planned outcome was the interaction with netmakers and net importers. The new method of construction developed by Brisbane netmaker Mr Wally Hill is a significant step in reducing the cost of square mesh codends, making the devices more appealing to fishers. Further, the importation of square mesh will reduce construction time and, therefore, initial cost. These two project outputs are beneficial to the increased uptake of square mesh codends, which will contribute to the projects' planned outcome.

The result of these project outputs is an increased awareness of the use and construction of square mesh codends. This contributes significantly to the achievement of the project's planned outcome. As stated earlier, it is difficult to quantify the precise uptake of square mesh codends as a result of the project. However, we know that about 10% of the fleet are now using the devices, largely as a result of the project and through the innovative improvements and reduced construction costs achieved by Mr Hill. If the QDPI&F Fisheries Business Group Regulatory Impact Statement (RIS) is accepted by the Queensland community, it will result in about 25% of all otter trawl fishing effort expended using square mesh codends.

Mr Hill now supplies about 10 Queensland trawler operators in the scallop and deepwater king prawn sectors with his square mesh codends. The current scallop season is reportedly very good and several vessels are using square mesh codends. The master of the *Canipa*, a vessel now using square mesh codends in the scallop fishery, provides Mr Hill with regular reports and he has been particularly pleased with the performance of the device. Interestingly, the vessel master has said that he has observed an increase in Moreton Bay bugs, although this is difficult to quantify because there is a square mesh codend on all of his nets. Further communication with Mr Hill has revealed that other fishers are enquiring about square mesh codends for use in the scallop fishery as a consequence of the excellent results achieved by the master of the *Canipa.* The fact most fishers are seeking a competitive advantage over other fishers means that if a fisher is having success with one method or another, he will tend to keep it to himself, hindering the transfer of technology. Unfortunately, this is occurring with square mesh codends to an extent. However, we believe that as square mesh codends become more cost-effective and fishers are made aware of the benefits of the devices, that uptake will increase further. It is noteworthy that Mr Hill is also now supplying trawler operators in the Exmouth Gulf (Western Australia), the Northern Prawn Fishery (Gulf of Carpentaria) and Torres Strait with square mesh codends.

As such, we believe that bycatch has been significantly reduced in all of the sectors targeted during the project (i.e. scallop, deepwater king prawn and broodstock collection fisheries) as a result of the outputs mentioned above. Further reductions in bycatch will occur as voluntary uptake of the devices continues, particularly in the scallop fishery. The proposed changes drafted in the Regulatory Impact Statement will also lead to additional significant reductions, if they are supported by industry, and at present the indications are that the new regulations will be adopted.

11 Conclusion

1. To inform and consult with commercial fishers operating in the deepwater king prawn, scallop and black tiger (leader) prawn fisheries regarding the development of square mesh codend BRDs.

Several strategies were used to disseminate information on the use and construction of square mesh codends. Project staff had face-to-face discussions with 170 to 180 fishers during dedicated port visits. This represents a significant (i.e. approximately 40%) proportion of fishers operating in the Queensland East Coast Trawl Fishery. We found this the best way of communicating with fishers as it was a consultative process where fishers could ask questions and talk about their misgivings with the use of square mesh codends. Typically, fishers were approached in port and shown a PowerPoint presentation that highlighted the results of previous FRDC-funded at-sea trials of square mesh codends. This encouraged them to trial a device as they could see that bycatch could be significantly reduced without reducing the catch rate of the target species. As further results were gained from at-sea trials during the project, we incorporated these into discussions with potential users. During the port visits project staff had a square mesh codend on hand for fishers to scrutinise as most had not seen the device prior to the commencement of the project.

We consulted with netmakers, net importers and netting manufacturers regarding more appropriate methods and netting material for construction of square mesh codends, in an attempt to reduce the initial cost of the devices to fishers. These interactions resulted in improvements to both the methods and materials of square mesh codend construction. This is a significant step toward increasing the use of square mesh codends in Queensland and, indeed, other fisheries in northern Australia. Reductions in construction time, with resulting reductions in initial cost, will make the devices more appealing to fishers.

The consultative project outputs used resulted in information being conveyed to a large proportion of the fleet and focused on those sectors where square mesh codends have strong potential, fulfilling the requirements of this objective.

2. To encourage and promote the use of square mesh codend BRDs.

Commercial fishers were encouraged to use square mesh codends using several methods. In addition to the port visits mentioned in Objective 1, several articles were published in relevant industry magazines to inform fishers about a) the benefits of square mesh codends (i.e. reduced bycatch, improved selectivity of target species), b) research trials of square mesh codends, and c) construction methods. The fact that we were able to produce results from previous research that showed bycatch could be reduced significantly without loss of targeted prawns and scallops encouraged fishers to trial a device. A total of 40 square mesh codends were loaned out to 36 fishers to trial under commercial conditions. These devices were custom-made to suit the target species and trawl gear. A DVD, that was produced as part of the project and includes details on the methods for constructing square mesh codends, was posted to all 480 licensed otter trawl operators in Queensland. The reduction in drag that we detected in the square mesh codends and then measured at the Australian Maritime College, and the subsequent likely reduction in fuel costs, were also used to promote uptake of the devices, thus fulfilling this objective.

As a result of the project's efforts, and innovative improvements in the design and cost of square mesh codends by netmaker Mr Wally Hill, about 10% of Queensland trawler operators are now using the devices regularly. We expect this figure to increase significantly as positive reports of the devices spread and the Regulatory Impact Statement aimed at making the devices mandatory in the scallop fishery is implemented.

3. *To offer assistance and ongoing support to fishers by providing relevant information and gear loans.*

The gear loans were an effective way of promoting the benefits of square mesh codends. During port visits, we ascertained the appropriate type of square mesh codend (see Table 2) for each individual fisher. Fishers were then given a complete square mesh codend so that they could simply install the device and go fishing. In all, 40 square mesh codends were loaned to 36 fishers, with most being used in the deepwater king prawn fishery. By allowing fishers to use a device free of charge, they were able to make a decision about the appropriateness of the square mesh codend and decide whether it would be beneficial to their trawling activities. The most pleasing aspect was that most fishers (82%) who borrowed a square mesh codend indicated that they would continue to use it.

Whilst in possession of a square mesh codend, fishers were encouraged to contact us if they experienced problems. We also contacted them regularly to check the progress of the at-sea trials, providing advice regarding modifications when necessary.

4. *To further document performance of square mesh codends under commercial conditions and widely disseminate the information.*

Three methods were employed to further document the performance of square mesh codends. Firstly, fishers provided with a square mesh codend as part of the gear library were asked to provide feedback on its performance. We preferred a short questionnaire rather than asking fishers to weigh and record bycatch at sea and fill in data sheets because the data would not have been statistically robust. It is also not practically feasible for fishers to weigh and record bycatch. Further, the cost of providing measuring scales was prohibitive. The questionnaire was posed to fishers during informal discussion. From the questionnaire, most fishers observed reductions in bycatch with little or no loss of target species. As stated earlier, most fishers said that they would continue to use a square mesh codend.

The second method of recording performance was via observer-based sea trials. Project staff accompanied fishers during trips and recorded the effects of the square mesh codends on target species and bycatch. However, as with previous observer-based sea trials, project staff had little experimental control over the design of such trials. Nevertheless, the sea trials conducted during the project indicated that bycatch can be significantly reduced without loss of target species. During both sea trials, the catch of eastern king prawns and black tiger prawns actually increased, while reductions in bycatch were observed in most trawl shots.

The performance of square mesh codends was also documented as part of a dedicated research charter, assessing the effects of BRDs on the catch rates of sea snakes, prawns and other bycatch. This provided an opportunity to gain statistically robust information from sea trials. Given that we had full control over the fishing operation we were able to record precise measures of prawn and bycatch catch rates. Further, we were able to retain all prawns, which facilitated a more detailed analysis of the prawn catch. We demonstrated from the research charter that marketable prawn catch rates could be maintained, compared to a standard codend, while bycatch was reduced by 31.2%. Further, the square mesh codend significantly reduced the catch of undersized, or non-marketable prawns. This suggests that trawl-induced mortality of these non-marketable prawns, and possibly other target species such as scallops, would be reduced by using square mesh codends, possibly resulting in an increase in the exploitable biomass of the target stock. Further, the catch rate of Moreton Bay bugs, a highly valued by-product worth $5–10 million annually in Queensland, was not affected by the square mesh codend.

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13 Intellectual property

Intellectual property arising from this work relates to the methods of construction developed by Mr Wally Hill of Hills Nets. Mr Hill has given permission for the method to be presented as part of this report. No other intellectual property has arisen from this work.

14 Staff

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Matthew Campbell

SeaNet
Denis Ballam

Ecofish
Ryan Donnelly

Appendix 1: PowerPoint presentation used during port visits throughout the project

This presentation was used to convey some of the research results gathered during the FRDC Project No. 2000/170 *Bycatch weight, composition and preliminary estimates of the impact of bycatch reduction devices in Queensland's trawl fishery*. This presentation was particularly useful when trying to convince fishers of the benefits of using a square mesh codend.

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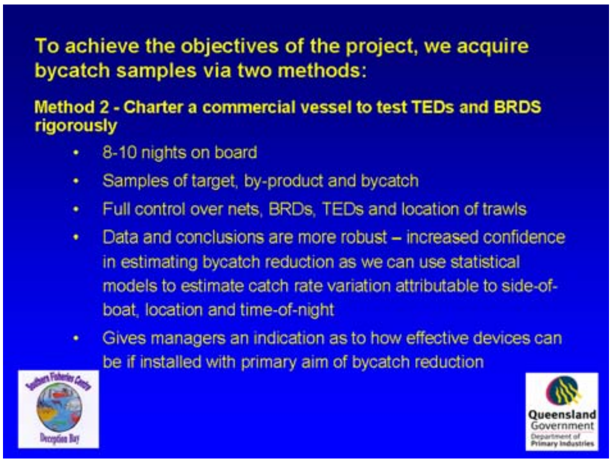

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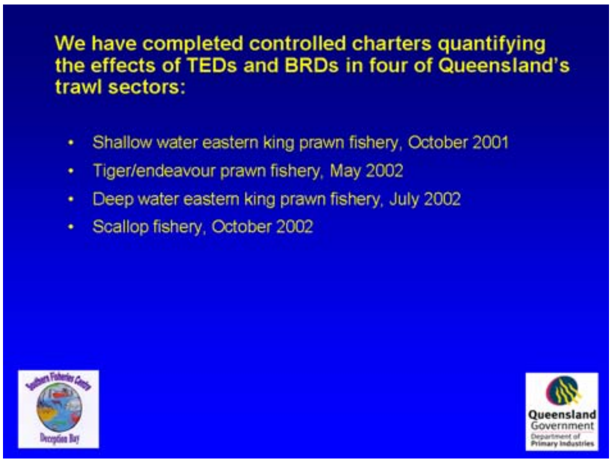

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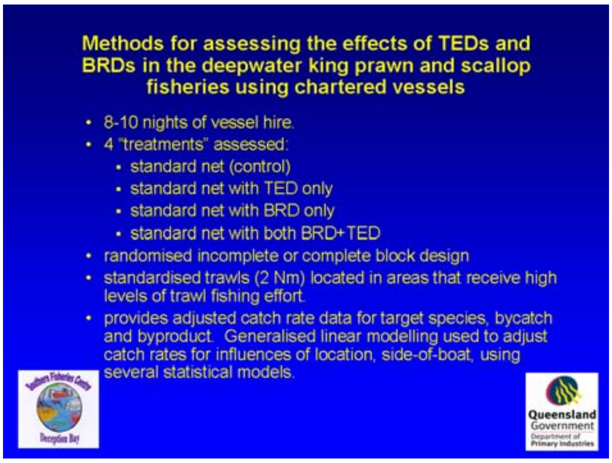

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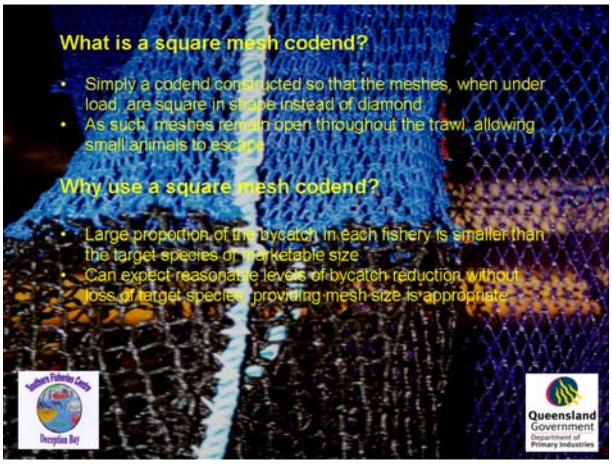

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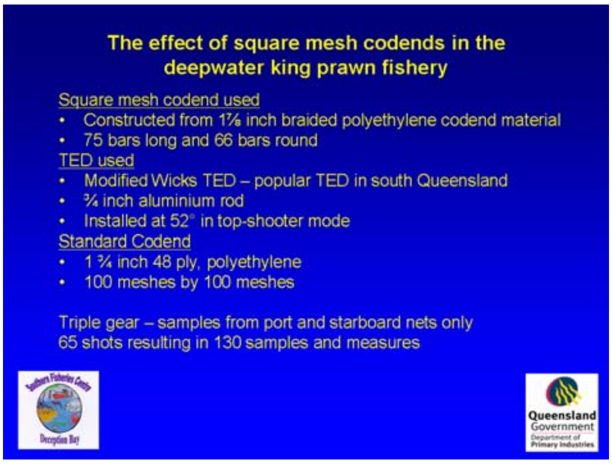

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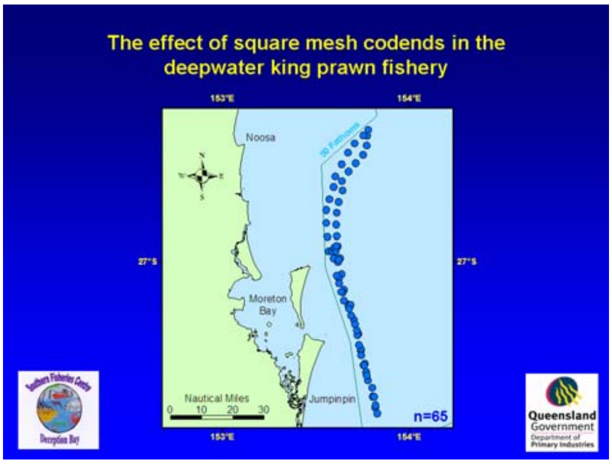

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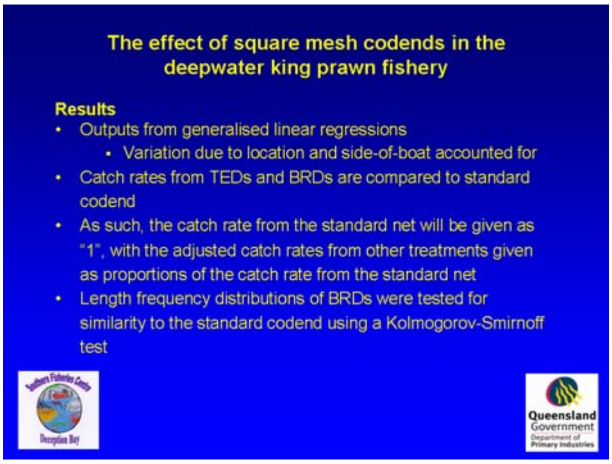

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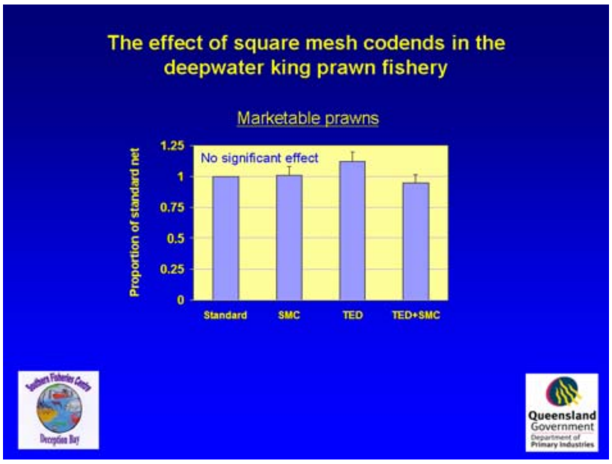

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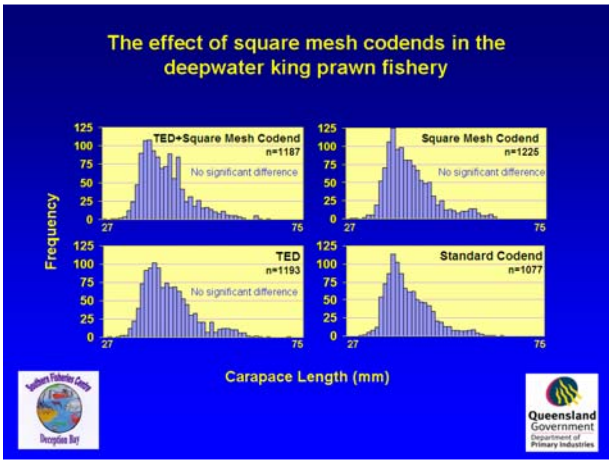

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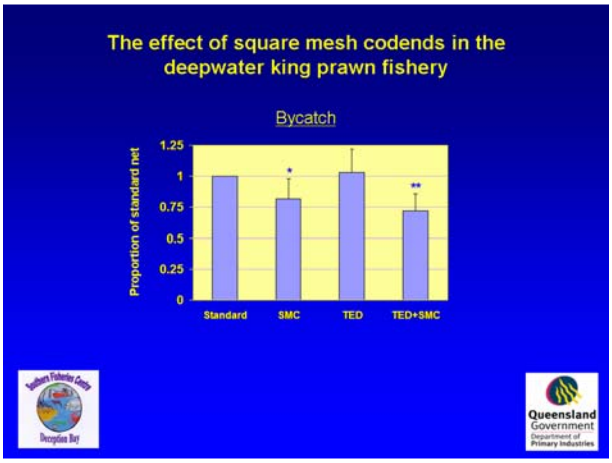

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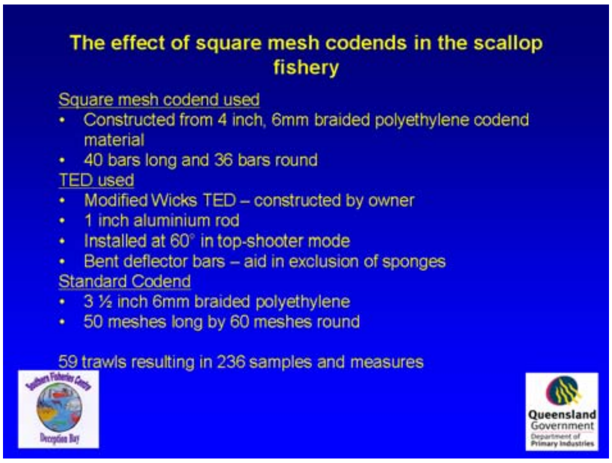

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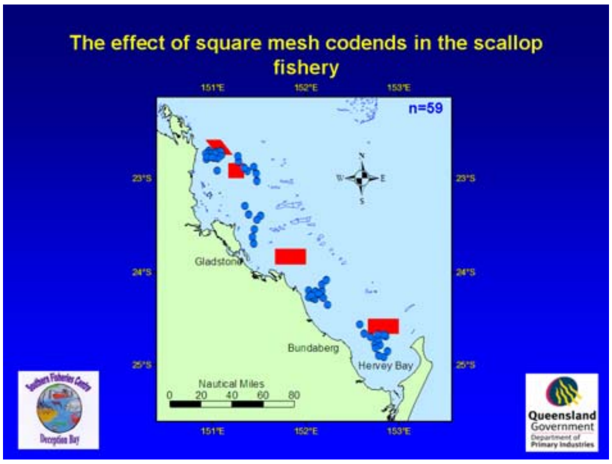

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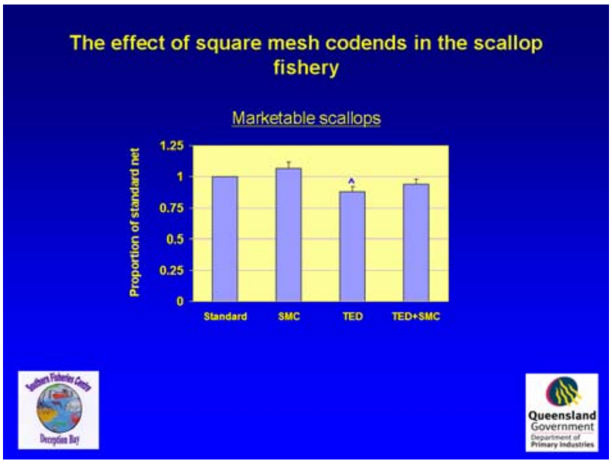

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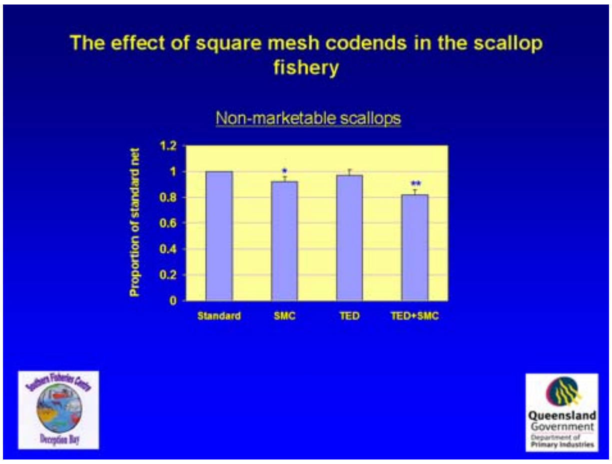

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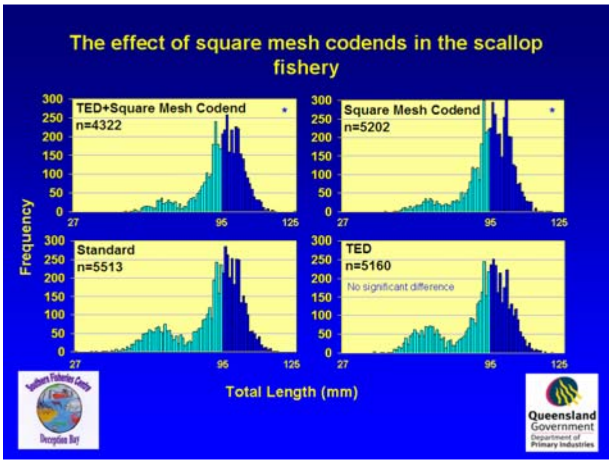

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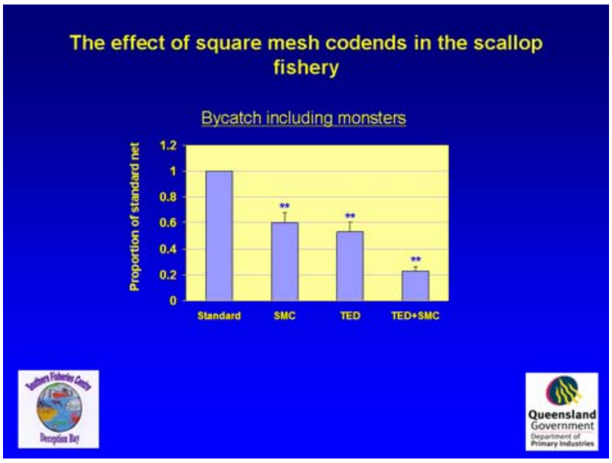

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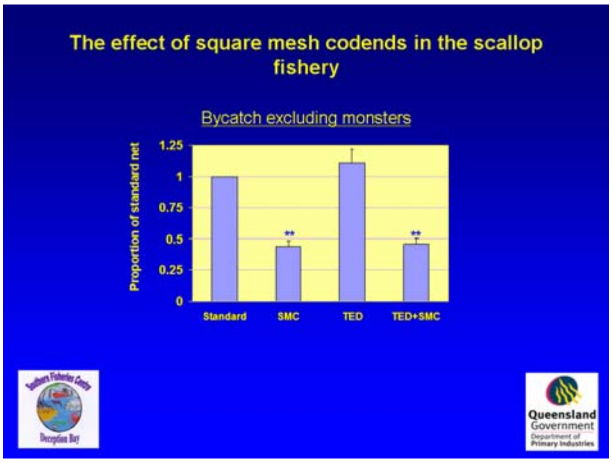

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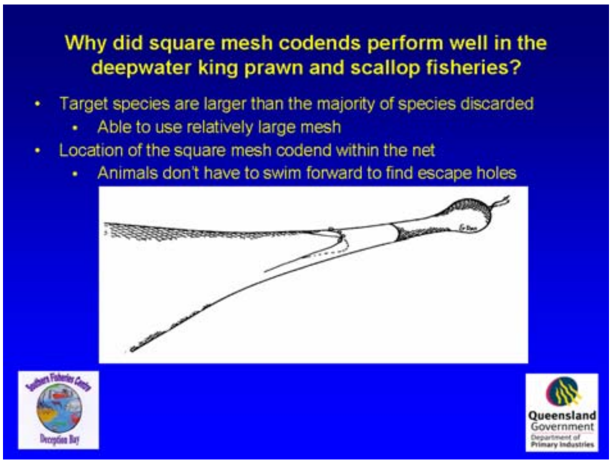

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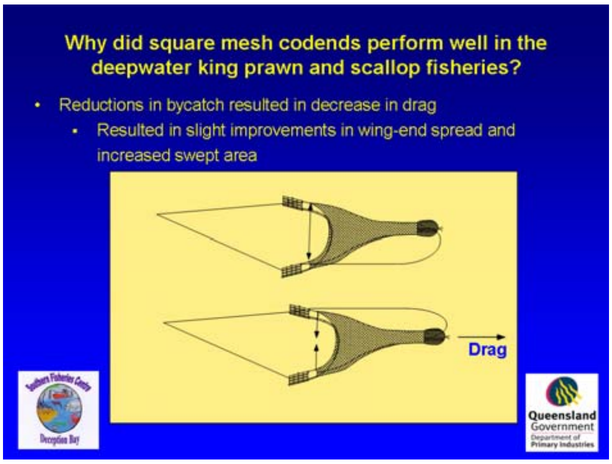

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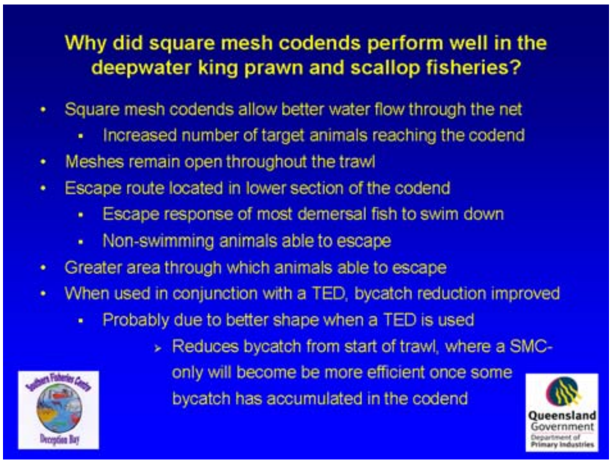

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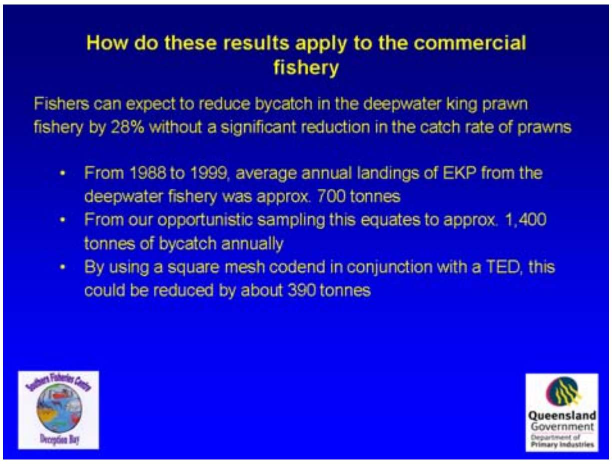

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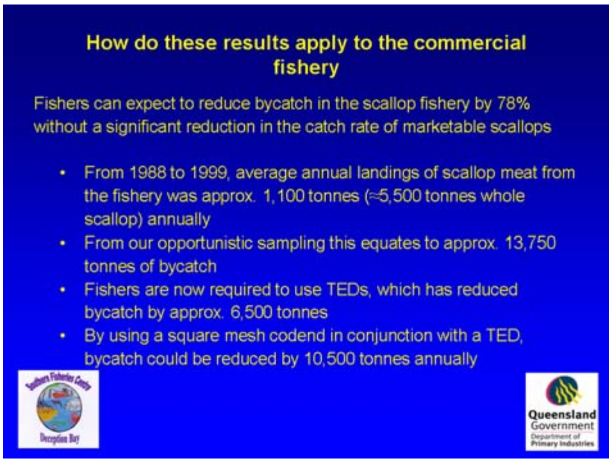

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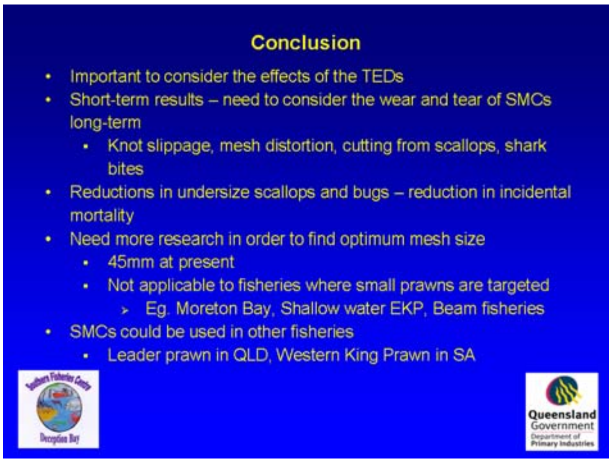

Appendix 2: Articles published as part of the project

Media Release

Queensland Department of Primary Industries and Fisheries launches trawl bycatch extension project

The Queensland Department of Primary Industries and Fisheries (QDPI&F) is currently running a fisheries extension project aimed at encouraging the State's 450+ commercial trawler operators to use square mesh codend bycatch reduction devices (BRDs) as a means of reducing bycatch and improving the selectivity of the targeted prawn and scallop catch.

Prawn trawling produces more bycatch than almost any other form of fishing and Queensland has the largest prawn trawling fleet in Australia. In most fisheries, for every kilogram of prawns caught and sold, there are several kilograms of small fish and invertebrates that are caught. There are no markets for the majority of the bycatch and although it is returned to the sea, many species experience high mortality rates from being trawled incidentally.

The extension program is funded by the Fisheries Research and Development Corporation (FRDC) and the QDPI&F and is being implemented over 15 months (July 2005 to September 2006).

Previous FRDC funded research has shown that square mesh codend BRDs can significantly reduce bycatch. When used in conjunction with Turtle Excluder Devices (TEDs), square mesh codend BRDs have been shown to reduce bycatch rates in Queensland's deepwater eastern king prawn fishery and scallop fishery by 29% and 77%, respectively, with no loss of prawns or scallops. These reductions equate to several thousand tonnes when extrapolated to the whole fleet.

Researchers from the QDPI&F have been manufacturing the square mesh codend BRDs and loaning them out to fishermen free of charge to trial on their vessels. So far, 39 square mesh codend BRDs have been manufactured and loaned out to fishers in Queensland's scallop fishery, eastern king prawn fishery and black tiger prawn aquaculture broodstock collection fishery.

Uptake of the devices by fishers appears to be increasing, mainly by word-of-mouth. Some fishers have requested additional square mesh codends so they can install them in all their nets. Evidence of the increased use of the devices is also apparent as some commercial netmakers are now importing bundles of square mesh for manufacturing the devices. In addition, some fishers are also reporting that they are now making their own square mesh codend BRDs.

The extension program is an example of innovative research - that was funded by FRDC - now being adopted and implemented by commercial fishers.

Further details of the extension program can be obtained from Dr Tony Courtney and Mr Matthew Campbell from the QDPI&F (Phone 07 3817 9582).

BOATS & GEAR

Extension project on square-mesh codends Queensland trawl fishery

An extension project* is being conducted in Queensland to inform trawler operators and net makers about square mesh codends, as Matthew Campbell reports.

RECENT research has shown that "square-mesh" codends can be very effective at reducing bycatch and regulating the size of target species such as prawns and scallops.

The "diamond-mesh" codends used by the majority of trawler operators close up whenever the net is under any appreciable load, but square mesh codends remain open and allow bycatch (that is, small fish and invertebrates) to escape. (See Figure 1.)

By regulating the size of the square meshes, the selectivity of the prawns and scallops can also be controlled more effectively.

Figure 1. *Square mesh codend in use.*

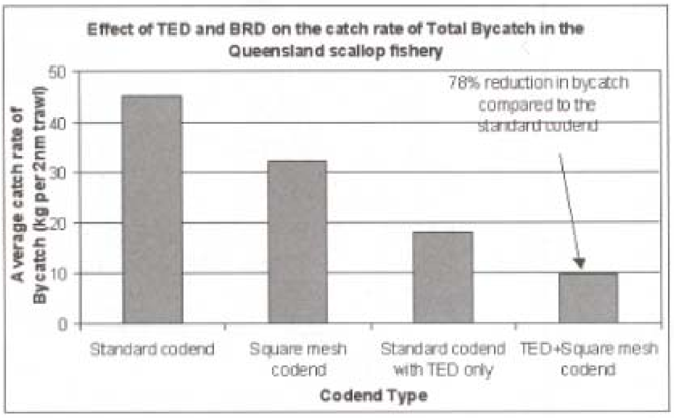

Figure 2. *The effect of different codend types on the catch rate of bycatch in the Queensland scallop fishery. The bycatch includes all species that are discarded, including sharks, rays and sponges. Bycatch was reduced by 78% when the square mesh codend and TED were installed in same net.*

Figure 2 shows the effect of a 100mm (50mm bar x 50mm bar) square mesh codend on bycatch catch rates in the Queensland scallop fishery.

When the square mesh codends were used with a turtle excluder device (TED), bycatch was reduced by 78% compared with a standard net codend with no TED.

Importantly, there was no reduction in the catch rate of legal sized scallops, but the catch rate of undersize scallops was greatly reduced. The small scallops just passed through the square meshes, remaining on the sea floor.

During this extension project, several square mesh codends for prawn and scallop fisheries have been constructed and loaned out to fishers, free of charge, for testing.

Project staff are also providing advice on how to manufacture and install the devices. If you are interested in trialling a square mesh codend in your prawn or scallop fishery on the east coast, then contact the following project staff:

- Matthew Campbell or Tony Courtney, Queensland Department of Primary Industries and Fisheries, tel (07) 3817 9591 or (07) 3817 9582, e-mail: Matthew.Campbell@dpi.qld.gov.au or Tony.Courtney@dpi.qld.gov.au
- Denis Ballam, Queensland SeaNet Officer, Cairns, tel (07) 4032 2234, e-mail burbrook@bigpond.com or
- Ryan Donnelly, Executive Officer, Ecofish TNQ Ltd, Cairns, tel (07) 4040 4444.

* The project is a collaborative effort between the Queensland Department of Primary Industries & Fisheries, Seanet Extension Services and Ecofish, and is funded through the Fisheries Research & Development Corporation. Matthew Campbell works with the Department of Primary Industries & Fisheries.

26 — The Queensland Fisherman December 2005

SEANET
smarter fishing for industry

SeaNet Wins National Award!

Well, we finally did it! After six years on the job, SeaNet has at last received national recognition. July 3rd saw the gala dinner presentation of the United Nations (Association of Australia) Environment Day Awards at the Sofitel Hotel in Melbourne. Ocean Watch Australia won the prestigious Excellence in Coastal and Marine Management Award for the SeaNet Extension Service. Receiving the Award, Anissa Lawrence (Executive Officer, Ocean Watch) went on to thank the SeaNet team (past and present) and Australia's fishers for their effort and dedication to environmental sustainability.

In another win for SeaNet, Claire van der Geest (SeaNet SA) took away the 2005 SA Seafood Fishing Industry Future Environment Award for her project developing and extending strapless bait cartons in the SA rock lobster fishery. Winning these awards, not only provided a great night out, but acknowledged the value of SeaNet's work and confirmed the status of Australia's fishing industry as accomplished stewards of the sea.

Anissa Lawrence (Executive Officer, Ocean Watch), Jim Newman (SeaNet Officer, Victoria) and Emma Bradshaw (SeaNet Program Manager) with the award.

Fisheries Research and Development Corporation (FRDC) Funds Square Mesh Codend Extension Project for Queensland Trawl Fishery.

The FRDC are funding an extension project through SeaNet in Queensland to inform trawler operators and net makers about square mesh codends. The project is a collaborative effort between the Queensland DPI&F, SeaNet and Ecofish, a non-profit regional economic development cluster representing the seafood and marine industry in Far North Queensland.

Natural Heritage Trust
Helping Communities Helping Australia
An Australian Government Initiative

Figure 1. This square mesh codend was used in a research charter in the Queensland scallop fishery in 2002. The 12mm polyethylene rope was used to take the weight of the catch, reducing knot slippage and distortion. The squares were 50mm x 50mm.

Recent research has shown that square mesh codends can be very effective at reducing bycatch and regulating the size of target species such as prawns and scallops. Diamond mesh codends used by the majority of trawler operators close up whenever the net is under any appreciable load, but square mesh codends remain open and allow bycatch (i.e., small fish, invertebrates) to escape. By regulating the size of the square meshes, the selectivity of the prawns and scallops can also be controlled more effectively.

Figure 2 shows the effect of a 100mm (50mm bar x 50mm bar) square mesh codend on bycatch catch rates in the Queensland scallop fishery. When the square mesh codends were used with a turtle excluder device (TED), bycatch was reduced by 78% compared to a standard net codend with no TED. Importantly, there was no reduction in the catch rate of legal sized scallops, but the catch rate of undersize scallops was greatly reduced. The small scallops passed through the square meshes, remaining on the sea floor.

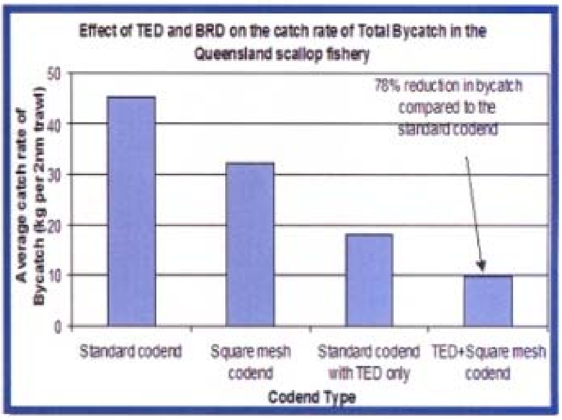

Figure 2. The effect of different codend types on the catch rate of bycatch in the Queensland scallop fishery. The bycatch includes all species that are discarded, including sharks, rays and sponges. Bycatch was reduced by 78% when the square mesh codend and TED were installed in same net.

The extension project has constructed several square mesh codends for prawn and scallop fisheries and is lending them to fishers for trialing, free of charge. Project staff are also providing advice on how to manufacture and install the devices. If you are interested in trialing a square mesh codend in your prawn or scallop fishery on the east coast, contact the following project staff.

- Denis Ballam - Queensland SeaNet Officer, Cairns. Phone: (07) 4032 2234, e-mail: burbrook@bigpond.com
- Ryan Donnelly, Executive Officer, Ecofish TNQ Ltd, Cairns. Phone: (07) 4040 4444,
- Matthew Campbell or Tony Courtney, Queensland Department of Primary Industries and Fisheries. Phone: (07) 3817 9591 or (07) 3817 9582, e-mail: matthew.campbell@dpi.qld.gov.au or tony.courtney@dpi.qld.gov.au.

Smart State smart fishing

Fisheries

Trawl Fishery Newsletter

December 2005 Edition

December 2005

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Ph: 1800 017 116

Square mesh codend project

Research conducted by staff at the Southern Fisheries Centre in 2002 showed that square mesh codends can significantly reduce the amount of discarded bycatch, while maintaining the catch of target species in certain trawl fisheries. This was particularly evident during dedicated research charters where the devices were used in the scallop and deepwater eastern king prawn fisheries.

The Fisheries Research and Development Corporation (FRDC) are funding an extension project in Queensland to inform trawler operators and net makers about square mesh codends. The project is a collaborative effort between the Queensland DPI&F, Seanet Extension Services and Ecofish.

Part of the extension project involves DPI&F staff constructing and trialling square mesh codends on-board commercial vessels at sea. Recent trials on vessels operating in the broodstock collection and deepwater eastern king prawn fisheries have shown that square mesh codends not only reduce bycatch, but can increase the catch of target species.

The extension project has constructed several square mesh codends for prawn and scallop fisheries and is loaning them out to fishers, free of charge, for trialling. Project staff are also providing advice on how to manufacture and install the devices.

If you are interested in trialling a square mesh codend in your prawn or scallop fisheries on the east coast then contact Matthew Campbell on (07) 3817 9591.

Industry forum

DPI&F invited license holders and trawl operators to attend an open forum with TrawlMAC to discuss future management options for the Deepwater Eastern King Prawn Fishery (DEKPF) on 20th October 2005.

Industry members were presented with an update on the catch and effort from the entire Eastern King Prawn Fishery and the outcomes of the modeling of different management arrangements. Specifically industry members were informed of the concerns regarding increased catch and effort in the Eastern King Prawn Fishery.

(Continued p2)

Edited by Shane Gaddes T 07 3225 1855 F 07 3227 8792 shane.gaddes@dpi.qld.gov.au

Queensland Government
Department of Primary Industries and Fisheries

FISHERIES and AQUACULTURE

Benefits of square mesh codends promoted in Queensland scallop and prawn trawl fisheries

By MATTHEW CAMPBELL and TONY COURTNEY

A fisheries extension project aimed at assisting Queensland's trawl fishers to adopt square mesh codends is approaching completion.

The project, a collaborative effort supported by the Fisheries Research and Development Corporation (FRDC), the Queensland Department of Primary Industries and Fisheries (QDPI&F), Seanet Extension Services and Ecofish, was initiated after research showed that square mesh codends can be highly effective at reducing bycatch in Queensland's saucer scallop and prawn fisheries.

Research has shown that square mesh codends in commercial trawl fishing nets can be used to significantly lower bycatch and improve the selectivity of target species. For example, by using a combination of square mesh codend and turtle excluder devices (TEDs), bycatch rates in Queensland scallop trawls were reduced by 77 per cent compared to a standard diamond-mesh net codends.

The square mesh codends were also shown to be very effective at reducing the catch rates of undersize scallops. Similar at-sea research trials have also demonstrated that bycatch rates in the deepwater eastern king prawn fishery off southern Queensland were reduced by 29 per cent by using a combination of square mesh codend and TED. Importantly, these reductions in bycatch were achieved with no loss of marketable sizes of scallops and prawns.

Another recent research charter undertaken further north in the state's tiger/endeavour prawn fishery showed that bycatch can be reduced by 34 per cent as a result of square mesh codends (see Figure 1) compared to standard diamond-mesh codends, with no significant loss of marketable size prawns (all species pooled). Detailed analyses of the prawn catch revealed that the square mesh codend actually caught significantly more banana prawns than the standard codends (Figure 2).

These reductions in bycatch are significant when one considers that Queensland has the largest prawn trawl fleet in Australia and that the total amount of bycatch produced annually is in the order of several thousand tonnes.

Two factors contribute to the effectiveness of the square mesh codends. First, because the catch accumulates in the codend, the square meshes allow small fish to escape easily from the net without having to expend large amounts of energy trying to find an escape hole or route. This is important when trying to exclude small fish as they generally lack swimming speed and stamina. Further, small prawns, undersize scallops and small crabs, sea urchins, shellfish, etc. are excluded from the square mesh codends as they simply fall through the large square meshes.

Figure 1. The square mesh codend used during an at-sea research charter trial in the north Queensland tiger/endeavour fishery. The 12mm polyethylene rope was used to take the weight of the catch, reducing knot slippage and distortion. The squares were 23mm by 23mm. Note how the squares remain open allowing small fish and other bycatch to escape. Standard diamond mesh codends tend to close up, thus retaining large amounts of bycatch.

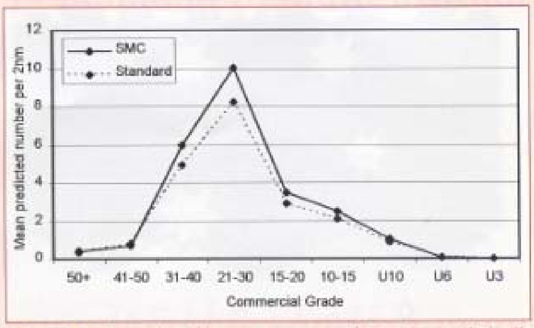

Figure 2. The number of banana prawns caught per two nautical mile trawl during the charter located in the north Queensland tiger/endeavour prawn fishery. The net containing the square mesh codend (SMC) caught significantly more banana prawns than the net containing a standard diamond-mesh codend. The commercial grades refer to prawns of increasing size and are usually measured as the number of prawns per 500 grams, for example, U3 refers to large prawn size classes of fewer than three prawns per 500g.

Secondly, large mesh sizes appear particularly suited to these fisheries as the targeted animals are relatively large compared to the bycatch species. This, combined with the fact that the meshes remain open throughout the trawl, allows most of the small bycatch species to escape, while retaining the marketable scallops and prawns.

Other preliminary research on square mesh codends indicates that they may also reduce drag while being towed through the water, compared to standard diamond mesh codends, thus reducing vessel fuel costs. Reasons for this are unknown at this stage, but results suggest that drag may be reduced as a result of the reduced weight and volume of bycatch that is towed around by the vessel. Drag may also be reduced because the flow of water through the net increases due to the square meshes remaining "open". As a result, the pressure wave that is being "pushed" in front of the net is reduced compared to nets with standard diamond mesh. At this time of record fuel prices, any reduction in the costs of fishing operations can only be seen as a benefit to commercial fishers.

The main objective of the extension project was to construct square mesh codends and lend them to trawler operators free-of-charge to trial. The project also offered assistance and on-going support to these fishers, as well as providing advice on the construction of square mesh codends to net makers.

Overall, 36 square mesh codends were trialled by fishers during commercial trawl fishing operations in Queensland's eastern king prawn, leader prawn and saucer scallop fisheries. 28 per cent of fishers reported bycatch reductions greater than 20 per cent, while 46 per cent reported reductions of 10-20 per cent. Importantly, 90 per cent of fishers reported that there was no effect on the catch rates of the target species. The most promising result from these trials was that 82 per cent of the fishers said that they will continue to use the square mesh codends in their chosen fishery.

The extension project is approaching completion. Project staff also intend to produce a DVD on the construction and installation of square mesh codends that fishers and net makers can use. The DVD will also present some research results that show the reductions in bycatch that can be achieved by using these devices.

For further information contact: Matthew Campbell or Tony Courtney, Queensland Department of Primary Industries and Fisheries.
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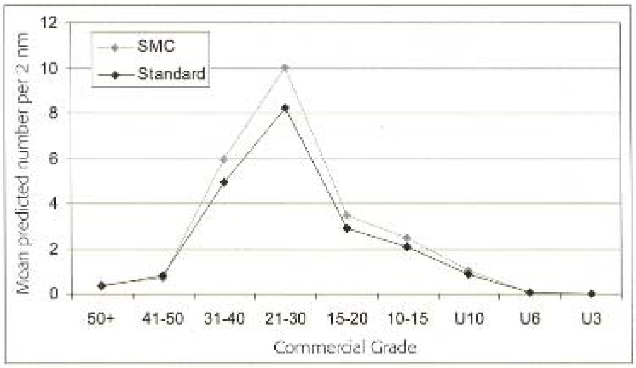
Email: matthew.campbell@dpi.qld.gov.au;
tony.courtney@dpi.qld.gov.au

Square mesh delivers

SQUARE mesh codends trialled in Queensland's prawn and scallop trawl fisheries have significantly cut bycatch without reducing the catch rates of target species.

In research trials in the saucer scallop fishery the codends, used in conjunction with turtle excluder devices (TEDs), reduced bycatch by 77 per cent, according to Queensland Department of Primary Industries and Fisheries researchers.

In the deepwater eastern king prawn fishery a similar combination of square mesh codend and TED, cut bycatch by 29 per cent.



In the north Queensland tiger-endeavour prawn fishery, the net with a square mesh codend (SMC) caught significantly more banana prawns per two nautical mile tow than the net containing a standard codend. Commercial grade indicates the number of prawns per 500 grams e.g: U3 refers to fewer than three prawns per 500g.

The square mesh codend trialled in the northern tiger-endeavour prawn fishery. A 12mm polyethylene rope was used to take the weight of the catch, reducing knot slippage and distortion. Squares are 23mm x 23mm and, unlike diamond mesh, remain open while towed, allowing more bycatch to escape.

In further trials in the tiger and endeavour prawn fishery square mesh codends reduced bycatch by 34 per cent, with no significant effect on catch rates of marketable-size prawns. For species such as banana prawns catch rates actually increased, as the attached graph shows.

The researchers say square mesh codends effectively reduce bycatch in two ways: They let small finfish that generally lack swimming speed and stamina escape easily. And undersize prawns and scallops, small crabs, sea urchins and shellfish simply fall through the big squares that, unlike diamond mesh, remain open during a trawl.

Preliminary results indicate that square mesh codends may also reduce drag and thus fuel costs, possibly because less bycatch is towed and because improved water flow through the net reduces the pressure wave pushed in front of the net.

Based on these results, QDPIF, Seanet and Ecofish collaborated in a FRDC-funded extension project that saw commercial operators trial 36 square mesh codends in the scallop, eastern king prawn and leader prawn fisheries.

Twenty-eight per cent reported bycatch reductions greater than 20 per cent and 46 per cent of them reported reductions between 10 per cent and 20 per cent. Nine out of 10 fishers said catch rates of target species had not been affected and eight out of 10 said they would continue to use square mesh.

With the extension project nearing completion project staff plan to produce a DVD for fishers and net makers that shows them how to make and install the codends and outlines the benefits they can deliver to users.

MORE: Denis Ballam, Seanet, phone: 07 4032 2234; Matthew Campbell, QDPIF, phone 07 3817 9591; email Matthew.Campbell@dpi.qld.gov.au; Tony Courtney, QDPIF, phone 07 3817 9582; email Tony.Courtney@dpi.qld.gov.au.

"Demand that imports be allowed only from management regimes that at least match Australian requirements," he urged consumers.

"Let's eliminate any concept of a tax on sustainability in Australia and work to ensure that the only fish on sale are those caught in an environmentally-sustainable way."

MORE: Martin Exel, phone 08 9202 2444; email mexel@newfish.com.au.

SA unity

MOVES are underway to re-establish a single peak industry body for South Australia.

The initiative comes from the two competing organisations - the SA Fishing Industry Council (SAFIC) and the Seafood Council of SA (SCSA) - and is supported by other key industry groups.

MORE: Neil MacDonald, SAFIC General Manager, email neil macdonald@safic.com.au.

will concentrate on implementing strategies that will strengthen and enact government legislation and inter-governmental treaties/agreements that catalyse bycatch reduction. New approaches to site-based strategies are being explored and developed, providing relief to key species and ecosystems, while also promoting economic benefits for local communities.

Additionally, a comprehensive communications program will broadcast the lessons learnt and the key messages to audiences at a local to global level. For further information contact Robin Davies, Manager - Global Bycatch Intiiative at: rdavies@wwfint.org.

Benefits of Square Mesh Codends in Queensland Scallop and Prawn Trawl Fisheries

Matthew Campbell & Tony Courtney
Queensland Department of Primary Industries and Fisheries

A fisheries extension project aimed at assisting Queensland's trawl fishers to adopt square mesh codends is approaching completion. The project, a collaborative effort supported by the Fisheries Research and Development Corporation (FRDC), the Queensland Department of Primary Industries and Fisheries (QDPI&F), the SeaNet Extension Program and Ecofish, was initiated after research showed that square mesh codends can be highly effective at reducing bycatch in Queensland's saucer scallop and prawn fisheries.

Research has shown that square mesh codends in commercial trawl fishing nets can be used to significantly lower bycatch and improve the selectivity of target species. For example, by using a combination of square mesh codend and turtle excluder devices (TED), bycatch rates in Queensland scallop trawls were reduced by 77% compared to standard diamond-mesh net codends. The square mesh codends were also shown to be highly effective at reducing the catch rates of undersize scallops. Similar at-sea research trials have also demonstrated that bycatch rates in the deepwater eastern king prawn fishery off southern Queensland were reduced by 29% by using a combination of square mesh codend and TED. Importantly, these reductions in bycatch were achieved with no loss of marketable sizes of scallops and prawns.

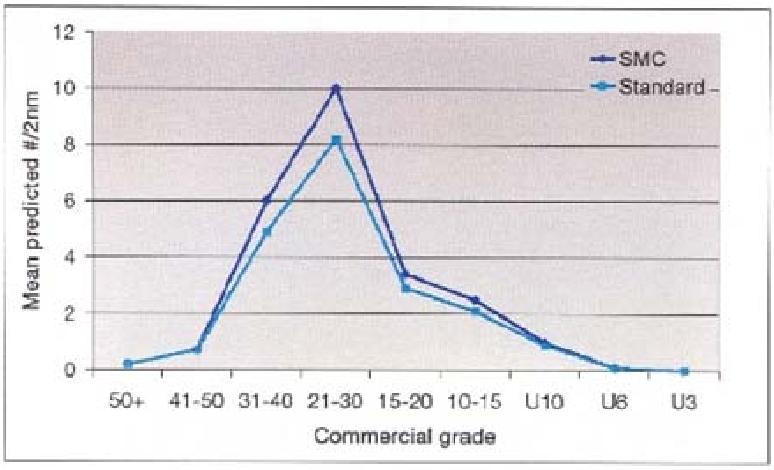
Another recent research charter undertaken further north in the state's tiger/endeavour prawn fishery showed that bycatch can be reduced by 34% as a result of square mesh codends (see Figure 1) compared to standard diamond-mesh codends, with no significant loss of marketable size prawns (all species pooled). Detailed analyses of the prawn catch revealed that the square mesh codend actually caught significantly more banana prawns than the standard codends (Figure 2).

These reductions in bycatch are significant as Queensland has the largest prawn trawl fleet in Australia and the total volume of annual bycatch is in the order of several thousand tonnes.

Two factors contribute to the effectiveness of the square mesh codends. Firstly, because the catch accumulates in the codend, the square meshes allow small fish to escape easily from the net without expending large amounts of energy attempting to locate an escape hole or route. This is important when trying to exclude small fish as they generally lack swimming speed and stamina. Further, small prawns, undersize scallops and small crabs, sea urchins, shellfish, etc. are excluded from the square mesh codends as they simply fall through the large open square meshes.

Figure 1. The square mesh codend used during an at-sea research charter trial in the north Queensland tiger/endeavour fishery. The 12mm polyethylene rope was used to take the weight of the catch, reducing knot slippage and distortion. The squares were 23mm x 23mm. Note how the squares remain open allowing small fish and other bycatch to escape. Standard diamond mesh codends tend to close up, thus retaining large amounts of bycatch.

Figure 2. The number of banana prawns caught per 2 nautical mile trawl during the charter located in the north Queensland tiger/endeavour prawn fishery. The net containing the square mesh codend (SMC) caught significantly more banana prawns than the net containing a standard diamond-mesh codend. The commercial grades refer to prawns of increasing size and are usually measured as the number of prawns per 500 grams e,g., U3 refers to large prawn size classes of fewer than 3 prawns per 500 g.



Secondly, large mesh sizes appear particularly suited to these fisheries as the targeted animals are relatively large compared to the bycatch species. This, combined with the fact that the meshes remain open throughout the trawl, allows most of the small bycatch species to escape, while retaining the marketable scallops and prawns.

Other preliminary research on square mesh codends indicates they may also reduce drag while being towed, compared to standard diamond mesh codends, thus reducing vessel fuel costs. Reasons for this are currently unknown, but results suggest that drag may be reduced as a result of the reduced weight and volume of bycatch being towed. Drag may also be reduced as the flow of water through the net increases due to the square meshes remaining open. As a result, the pressure wave being "pushed" in front of the net is reduced compared to nets with standard diamond mesh. At this time of record fuel prices, any reduction in the costs of fishing operations can only be seen as a benefit to commercial fishers.

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The main objective of the extension project was to construct square mesh codends and lend them to trawler operators free of charge to trial. The project offered assistance and on-going support to these fishers, plus advice on the construction of square mesh codends to net makers.

Overall, 36 square mesh codends were trialled by fishers during commercial trawl fishing operations in Queensland's eastern king prawn, leader prawn and saucer scallop fisheries. Twenty eight % of fishers reported bycatch reductions greater than 20%, while 46% reported reductions of 10-20%. Importantly, 90% of fishers reported no reduction in catch rates of target species. The most promising result from these trials was that 82% of the fishers said that they will continue to use the square mesh codends in their fishery.

The extension project is approaching completion. Project staff intend to produce a DVD on the construction and installation of square mesh codends for fishers and net makers. The DVD will also present some research results that show the reduction in bycatch that can be achieved by using these devices.

For further information contact: Denis Ballam - Queensland SeaNet Officer at: burbrook@bigpond.com, Matthew Campbell or Tony Courtney, Queensland Department of Primary Industries and Fisheries at: Matthew.Campbell@dpi.qld.gov.au or Tony.Courtney@dpi.qld.gov.au

SLEDs in the Australian Western Rock Lobster Fishery

Background - Sea Lion Exclusion Devices (SLEDs)

A small population of the vulnerable Australian sea lion lives along the mid-west coast of Western Australia. This population overlaps the rich fishing grounds for the western rock lobster and interactions between sea lions and rock lobster pots have occurred over many years. However, small sea lion pups can become trapped in pots and drown. All of the recorded deaths have been in less than 20 metres of water between Freshwater Point and Wedge Island (north of Perth).

Sea lions are slow to breed, females only have one pup every 18 months, and they return to the same sites to breed rather than colonising new areas. This makes small local populations highly vulnerable, so seal pup drownings in lobster pots need to be prevented.

Australian sea lions are listed as "vulnerable" under the Environmental Protection and Biodiversity Conservation Act 1999 and "specially protected" under the Wildlife Conservation Act 1950. There is an obligation for the West Coast Rock Lobster Fishery and its managers to address this fishing-related mortality issue and it is also a requirement for continued Marine Stewardship Council (http://www.msc.org/) certification of the fishery.


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Appendix 3: Dialogue for the square mesh codend DVD produced as part of the project and forwarded to all Queensland otter trawl operators

Tony and Matt to camera: Hello, my name is Tony Courtney and this is Matthew Campbell. We are researchers within the Queensland Department of Primary Industries and Fisheries. For the last 6 years, we have been involved in research dealing with bycatch issues in Queensland's otter trawl fishery. In that time, the reduction of non-targeted animals from prawn and scallop trawls has become an important issue facing fishermen and the trawl fishery managers across the world. Here in Queensland, research into bycatch reduction has been ongoing since the mid-90s. Research conducted by ourselves and other agencies showed that square mesh codends are particularly effective at reducing bycatch without impacting on the catch rate of prawns and scallops.

This DVD is part of an extension project assisting trawl fishers familiarise themselves with square mesh codends, their construction and their use. Through this DVD, we hope that you will gain an insight into the potential benefits of the device and prompt you to think about whether a square mesh codend could be used during your trawling operations. We will discuss some of the results gained during recent research projects and conclude the DVD with a "how-to" section detailing the method for constructing a square mesh codend.

Prawn trawl fisheries generate a higher proportion of bycatch than any other fishery type and account for more than one third of the estimated total global discards from fisheries. Prawn trawls are inherently non-selective and in most prawn trawl fisheries, the weight of the bycatch exceeds that of the prawn catch by several times. Tropical and subtropical prawn species share their habitat with a diverse range of animals, a large proportion of which are susceptible to capture by prawn trawl gear.

Bycatch is defined as that part of the catch discarded by fishers. Recent research has revealed that the bycatch in Queensland is comprised of at least 1300 species but could be double that amount. Bycatch is a complicated issue due to the fact that it not only includes species that are not marketable, it also includes species that are marketable but are discarded due to restrictions based on size or gender. Further, bycatch can include species of conservation interest that are protected by law such as sea turtles and sea snakes. Also, bycatch can include species of interest to other sectors which can conflict between trawl fishers and stakeholder groups.

During the late 90s, managers of prawn trawl fisheries around the world recognised the need to minimise the incidental capture of turtles by trawlers. This was due to the fact that some sea turtle species were classified as endangered or threatened. As such, the use of turtle excluder devices or TEDs became mandatory in northern Australian prawn trawl fisheries. In Queensland, TEDs became mandatory on all otter trawl vessels by the end of 2001.

Since that time, there has been increasing pressure from conservation agencies, the public and the Federal Department of Environment and Heritage to introduce measures to reduce the amount of discarded bycatch. The implementation of the *Environment Protection and Biodiversity Conservation Act 1999* allows the Australian Government, through the Department of Environment and Heritage, to assess the sustainability of all export fisheries within Australia. The Act is designed to ensure ecologically sustainable development through the conservation and ecologically sustainable use of natural resources, including both targeted and non-targeted animals. Apart from the sustainability issues, there are other reasons to reduce bycatch including reducing sorting times, improvements in product quality, minimising the impacts of trawling on recreational species, bycatch wash-up issues and increasing trawl efficiency.

In an attempt to quantify the effects of TEDs and BRDs in Queensland's trawl fishery, the Fisheries Research and Development Corporation funded a research project in collaboration with the Queensland Department of Primary Industries and Fisheries in 2001. This research was required to measure the effects of TEDs and BRDs used by fishers were reducing bycatch. During this project, information was collected on the catch rates of the target species and the bycatch using different TEDs and BRDs under commercial fishing conditions and during dedicated research charters.

Of all the BRDs that were tested throughout this project, the square mesh codend was, by far, the most effective BRD at reducing bycatch in both the deepwater EKP and the scallop fisheries. This BRD was tested under controlled conditions during dedicated research charters undertaken aboard commercial vessels. Square mesh codends were chosen for testing because a large proportion of the animals in the bycatch in these fisheries are small compared to the targeted prawns and scallops and, as such, it was thought that good bycatch exclusion rates could be expected.

The first charter was conducted in the deepwater eastern king prawn fishery in southern Queensland. Over 10 nights, 65 individual 2 nautical mile trawl shots were completed in the area between Southport and Noosa (map). The square mesh codend was tested with and without a TED and the catches from these nets were compared to those from a net with neither a TED nor a BRD, referred to as a standard codend. The square mesh codend BRD used was constructed out of 3mm braided polyethylene with a mesh size of 47mm (17/8 inch). The square mesh section was 66 bars round and 76 bars long.

Throughout the charter, the average amount of bycatch per two nautical mile trawl from the standard codend was 6.8kg. When the square mesh codend was used, the catch rate of bycatch was 5.5kg, a reduction of 19%. Further, when the square mesh codend was used in conjunction with a TED, the bycatch catch rate was 4.9kg per two nautical mile trawl, a reduction of 28% when compared to the standard codend. It is important to note that these reductions occurred with no loss of marketable king prawns. There was also no difference in the catch rate of Balmain bugs in the nets containing square mesh codends compared to the net with no TED or BRD.

After these encouraging results, a square mesh codend was tested during a dedicated research charter in Queensland's scallop fishery. Over 8 nights, 59 individual 2 nautical mile trawl shots were completed in the area between Hervey Bay and Yeppoon (map). As with the deepwater eastern king prawn charter, the square mesh codend was tested with and without a TED and the catches from these nets were compared to those from a net with neither a TED nor a BRD. The square mesh codend was constructed out of 6mm braided polyethylene with a mesh size of 100mm (4 inch), and when hung on the square resulted in a square mesh of 50mm (bar) by 50mm (bar). The square mesh section was 36 bars round and 40 bars long.

Throughout the charter, the average catch rate of bycatch from the standard codend was 45.2kg per two nautical mile trawl. When the square mesh codend was used the catch rate was reduced by 29% to 32.3kg per two nautical mile trawl. The bycatch catch rate from the codend with a TED only was 18.0kg per two nautical mile trawl - a reduction of 60% when compared to the standard codend. Furthermore, when the square mesh codend was used in conjunction with a TED, the bycatch catch rate was 9.8kg - a reduction of 78% compared to the standard codend. These reductions in bycatch were achieved without significant losses of legal-sized scallops. However, the square mesh codends excluded a significant amount of undersize scallops, thereby reducing any incidental trawl-induced mortality on these smaller animals. These graphs show the number of scallops caught of each size. Note that the numbers of smaller scallops is reduced significantly when a square mesh codend is used. The catch rate of legal Moreton Bay bugs was significantly reduced using the square mesh codend and the combination of the TED and BRD together. This result can be attributed to the large 4-inch mesh used and it is expected that these reductions would be minimised by using smaller mesh in the square mesh codend. Once again, the number of undersize Moreton Bay bugs was significantly reduced, thereby minimising trawl-induced mortality on these animals.

There are two reasons the square mesh codends performed so well in these fisheries. Firstly, because the catch accumulates in the codend, the square meshes allow small fish to escape easily from the net without having to expend large amounts of energy trying to find an escape hole or route. This is important when trying to exclude small fish as they generally lack swimming speed and stamina. Further, small crabs, sea urchins, shellfish, etc are excluded from the square mesh codends as they simply fall through the large square meshes.

Secondly, large mesh sizes are particularly suited to these fisheries as the target species are relatively large. By using larger mesh sizes, more animals can be excluded. This was particularly the case in the scallop charter where the minimum legal size of scallops is at least 90mm, allowing the use of 4-inch mesh. This allows a large proportion of the bycatch animals to escape and, when combined with a TED that excludes larger animals, bycatch can be significantly reduced without losing legal scallops.

As part of the current extension project, project staff constructed square mesh codends that were offered to fishers free of charge for trials at sea. In all, 40 square mesh codends were given to 36 fishers, with most being used in the deepwater king prawn fishery. Of those that trialled square mesh codends most reported reductions in bycatch with over 35% of fishers reporting reductions greater than 20%. Importantly, these reductions occurred with little or no loss of marketable prawns or scallops.

During the extension project, square mesh codends were tested as part of a research project that was testing the effects of BRDs on the catch rate of sea snakes in the tiger prawn fishery. During these trials, square mesh codends reduced bycatch by approximately 33%, without any significant loss of marketable prawns of any species. Further, the square mesh codend reduced the capture of sea snakes of all species by approximately 60%. Results showed that the square mesh codend was able to reduce the capture of very small size classes as shown here. This graph represents the average weight of endeavour prawns of each size class caught from each shot. Of particular interest is the fact that the square mesh codend reduced the weight of the smaller size classes but maintained the catch rates of the larger prawns.

In conclusion, results achieved during recent research have shown that square mesh codends are an effective bycatch reduction device, provided they are used in suitable fisheries. In Queensland, legislation requires that the mesh used in the construction of square mesh codends be at least 45mm mesh size. This prohibits the use of square mesh codends in areas where smaller size class prawns are targeted. However, providing the target animals are of sufficient size, fishers using a square mesh codend can expect to significantly reduce the catch rate of bycatch without affecting the catch rate of the target species.

Matthew to camera: Although constructing durable square mesh codends has been difficult in the past, methods developed during this extension project have simplified the process. This segment of the DVD details the methods used to construct a square mesh codend for use in prawn trawl fisheries, where the target prawns are relatively large. This particular device is designed to be used in Queensland's deepwater king prawn and black tiger prawn fisheries.

In Queensland, legislation requires that a square mesh codend is at least 75 bars long, with a minimum mesh size of 45mm, knot-to-knot. In this DVD, we will construct a square mesh codend that is 78 bars long and 80 bars round, using 50mm by 3mm braided polyethylene codend material. We will present 2 methods for constructing a square mesh codend for the deepwater king prawn fishery, using both standard diamond mesh material and specially-made square mesh material.

As the square mesh codend need only be 75 bars long, a diamond mesh section is sewn to the top of the SMC to ensure the length of the codend is the same as a standard codend. This allows the SMCs to be spilled, deployed, etc alongside standard codends. Another section of diamond mesh is added to the aft edge of the SMC to allow drawstrings to be attached. Irrespective of which mesh is used in the construction of the square mesh section, these diamond mesh sections are necessary.

<u>Method 1</u>

The first method for the construction of square mesh codends is based on an idea developed by Brisbane netmaker, Wally Hill. In the past, square mesh codends were constructed using 4 separate panels of square mesh sewn together. This method of construction ensures that when load is applied to the codend, it evenly distributed around the circumference of the codend thus minimising knot distortion and slippage. However, this method is very time consuming and, if a netmaker were to construct a square mesh codend using this method, cost prohibitive.

To construct the square mesh codend you will need a 120 mesh by 100 mesh, 50mm by 3mm diamond mesh codend and a roll of 3mm braided twine.

From the codend material, count across 80 meshes and make a cut down 80 bars as shown. From this point cut back 80 meshes before cutting back up the bars to the starting point. The panel of net should look like this.

Next sew the meshes together to form a cylinder, using Maker's knots, before selvedging the knots at either end of the square mesh codend using Figure-8 knots, leaving a 1 bar overlap. This ensures that there are 4 bars originating from each mesh around the circumference of the square mesh section, minimising the chance of knot slippage under load.

The finished square mesh codend is now ready to be attached to the aft edge of the diamond mesh section. Typically, standard codends are 100 meshes long and are constructed from 1¾" 60 ply codend material. As the square mesh codend is only 78 bars long or approximately 39 meshes, a diamond mesh section made from the same material as a standard codend is added to the forward edge of the square mesh codend. This ensures that the square mesh codend is the same length as a standard codend allowing the square mesh codend to be spilled and deployed in the same manner as a standard codend. In this case a codend 125 meshes round and 55 meshes long is sewn onto the forward edge of the square mesh codend. This is laced to the forward edge of the square mesh codend at a ratio of 5 meshes to 3 bars as shown. Similarly, a diamond mesh section 5 meshes long and 125 meshes round is sewn onto the aft edge of the square mesh codend so that drawstrings can be attached in the normal manner.

Next a belly rope is attached to the square mesh codend to provide additional strength. Stretch a length of 12mm polyethylene rope between two items and selvedge 3 meshes to the rope as shown, as close as possible to one end of the stretched mesh. Stretch the square mesh section out and mark the rope. Measure the distance and calculate approximately 90% of this length and selvedge the forward edge of the square mesh section to this point. Next, measure the distance between the 2 attachment points and place a mark on the rope at this point. Count forward 39 bars and attach this bar to the point half-way between the two attachment points. Continue selvedging forward from the first attachment point until at least 5 meshes of the forward diamond mesh section are selvedged to the rope. On completion, trim the rope and burn each end. Repeat this process for both sides. We recommend at least two belly ropes are used but it is possible to use three or four evenly spaced around the codend.

Once completed the square mesh codend will look like this. Because of the shape of the meshes, the codend will form a 'helix' shape. At this point the codend can be stretched out between two points to stretch the mesh square. However, the codends will hang correctly after they have been sewn onto a net and used.

<u>Method 2</u>

Some netting importers have begun importing mesh specifically designed to be used in the construction of square mesh codends. This particular square mesh material is constructed from 3mm braided polyethylene twine with a 50mm or 2-inch mesh size. It comes in a bundle that is 50m long and 152 bars deep.

Once again, we will construct a square mesh section that is 78 bars long and 80 bars round. Starting at one corner, make an 80 mesh cut diagonally down the meshes. We prefer to remove the knots and this is best done at this stage. From this point, cut further into the bundle by 78 bars and then back along the meshes to the top of the bundle as shown. You should now have a piece of net that looks like this.

Next, wrap one corner of the panel over to the other corner and sew the meshes together to form a cylinder, using Maker's Knots. Once again, selvedge the knots at either end, leaving a one bar overlap as shown. Finish the square mesh codend using the same methods described earlier.

Here are the two completed square mesh codends.

Tony to camera: We hope that you have found this DVD informative. We have included a net plan of a square mesh codend for use in the Queensland scallop fishery on the inside of the DVD cover. We encourage you to experiment with a square mesh codend in your fishing activities. Thank you for taking the time to watch this DVD. Goodbye.