Assessment & improvement
of TEDs and BRDs in the NPF:



Australian Government
Fisheries Research and Development Corporation
FRDC PROJECT 2000/173

Northern Prawn Fishery TED & BRD Project

CSIRO: David Brewer, Don Heales, David Milton, Brian Taylor, Gary Fry, Quinton Dell, Malcolm Austin, Bob Pendrey, Peter Jones, Bill Venables

AUSTRALIAN MARITIME COLLEGE: Steve Eayrs, Garry Day, John Wakeford FERM: Sevaly Sen

WORLD FISH CENTRE: Ilona Stobutzki NATIONAL UNIVERSITY OF SINGAPORE: You-Gan Wang

NPF INDUSTRY: David Carter, Clayton Nelson, Jeff Nichols, Tony Gofton AUSTRALIAN MARINE CONSERVATION SOCIETY: Eddie Hegerl

Assessment and improvement of TEDs and BRDs in the NPF:

a co-operative approach by fishers, scientists, fisheries technologists, economists and conservationists

Bibliography
ISBN 1 876 996 45 5.

Published by CSIRO Marine Research

This publication should be cited as:
Brewer, DT, Heales, DS, Eayrs, SJ, Taylor, BR, Day, G, Sen, S, Wakeford, J, Milton, DA, Stobutzki, IC, Fry, GC, van der Velde, TD, Jones, PN, Venables, W, Wang, Y-G, Dell, Q, Austin, M, Gregor, R, Pendrey, R, Hegerl, E, Carter, D, Nelson, C, Nichols, J, Gofton, T. (2004). Assessment and improvement of TEDs and BRDs in the NPF: a co-operative approach by fishers, scientists, fisheries technologists, economists and conservationists. Final Report on FRDC Project 2000/173. CSIRO Cleveland. pp. 412.

ASSESSMENT AND IMPROVEMENT OF TEDS AND BRDS IN THE NPF:

a co-operative approach by fishers, scientists, fisheries technologists, economists and conservationists

David Brewer, Don Heales, David Milton, Brian Taylor
Gary Fry, Quinton Dell, Malcolm Austin, Bob Pendrey
CSIRO Marine Research

Steve Eayrs, Garry Day, John Wakeford
Australian Maritime College

Peter Jones, Bill Venables
CSIRO Mathematical and Information Sciences

Ben Bird, Garry Day, Quinton Dell, Chris Gough, Reuben Gregor
Project Observers

Sevaly Sen
FERM

Ilona Stobutzki
World Fish Centre

You-Gan Wang
National University of Singapore

David Carter, Clayton Nelson, Jeff Nichols, Tony Gofton
NPF Industry

Eddie Hegerl
Australian Marine Conservation Society

December 2004

FRDC Project 2000/173

CONTENTS

NON-TECHNICAL SUMMARY

FRDC 2000/173

Assessment and improvement of TEDs and BRDs in the NPF:
a co-operative approach by fishers, scientists, fisheries technologists, economists and conservationists

PRINCIPAL INVESTIGATOR: David Brewer
ADDRESS: CSIRO Marine Research
PO Box 120, Cleveland Qld 4163
Telephone: 07 38267246, Email: David.Brewer@csiro.au

OBJECTIVES:

1. To optimise the performance of approved TEDs and BRDs on NPF vessels.
2. To measure any change in catch rates of total unwanted bycatch and in particular, selected charismatic or vulnerable bycatch species, due to the use of TEDs and BRDs.
3. To measure any change in catches of commercially important prawns and retained byproduct species due to the use of TEDs and BRDs.
4. To assess the economic costs and benefits to industry of the use of TEDs and BRDs.
5. To identify the factors influencing the performance of TEDs and BRDs.
6. To establish a protocol for the ongoing development and testing of new TEDs and BRDs.

OUTCOMES ACHIEVED

This project has made a large contribution to the following range of significant outcomes:

- Effective compliance of TED and BRD use in the NPF through observer presence, workshops and communications material.
- Improved levels of bycatch reduction for NPF fishers through observer assistance and educational information in workshops and written material. This is partly demonstrated by the greatly reduced levels of complaints about their introduction between 2000 and the end of 2001.
- Removal of pressure on the NPF from legislation that protects vulnerable and endangered species by providing the means by which the NPF can demonstrate major reductions in its impacts on a range of species considered to be at highest risk to fishing and/or trawling.
- Improvement in accounting for variations in effort standardisation on prawn stocks by providing an accurate and up-to-date figure on the impact of TEDs and BRDs on prawn catches.
- Demonstration of the cost-benefit implications to NPF operators using BRDs and TEDs.
- Establishment of a practical and accessible means by which fishers can invent improved TED and BRD technology for use in the NPF through the development of a protocol for testing new and innovative designs.

The following outcomes should also transpire beyond the life of the project:

- Improved acceptance of NPF practices by concerned stakeholders such as conservation groups and the community as demonstrated by stakeholder reports.
- Improved marketability for export prawns through demonstrating the use of environmentally friendly fishing practices.
- Demonstration of the NPF’s intent to develop recognised environmental standards for incorporation into fishery certification processes that lead to world’s best practice, initially through using TEDs and BRDs, and secondly through a willingness for ongoing standards improvement, as seen by the prompt removal of the Bigeye BRD due to its ineffectiveness.

All NPF vessels were required to use TEDs and BRDs in their nets from April 15th, 2000. This was a major change in fishing practice, but it was unclear how the catching and economic performance of the fishery would be affected. The observer programs carried out by this project provide the first large-scale, comprehensive assessment of the performance of TEDs and BRDs in the NPF. The impacts of these gears on a wide range of species groups are provided, including effects on the most ecologically sensitive or highest risk species. The results of this study will play an important role in the fishery's ability to demonstrate ecologically sustainable practices, and ultimately its ability to receive a positive assessment under the EPBC Act 1999. A positive assessment may ensure that individual fishers are not required to seek permits to interact with protected species, and will exempt the target species of this fishery from trade restrictions under the wildlife trade provisions of the Act. The impact of TEDs and BRDs reported here will also influence any certification by international environmental auditors such as the Marine Stewardship Council, which can be used to improve the fisheries image to potential markets and the general public.

Change in NPF catches due to TEDs and BRDs

The introduction of TEDs and BRDs in all NPF nets has had a widely varying impact on the different species taken by the fishery. Catches of commercially important prawns have been reduced by 3% to 6%, depending on the ability of fishers to use their TEDs effectively. It is likely that this figure will shift from the higher to the lower value in the few years following the 2001 assessment. Most of the prawn losses appear to be attributable to the effects of TEDs, although there was also a significant loss of tiger prawns from the use of the Bigeye BRD. The other BRD tested, the Square-mesh panel showed no loss of prawns. The loss of prawns due to TEDs+BRDs has been partially offset by a significant reduction (~40%) in the weight of prawns that were damaged by heavy animals that are now rare in these catches. Three groups of byproduct species were also assessed. The use of TEDs and/or BRDs made no measurable impact on catches of Moreton Bay bugs, squid or scallops in this study.

One of the biggest effects was on turtles where the introduction of TEDs has reduced the fishery's impact to almost zero. All species of turtles appear to be very effectively excluded from trawls and a hidden impact on turtle survival is highly unlikely. This translates to a reduction in impact from about 0.05 per trawl in 1989/90 (~5300 per year for the entire fleet) (Harris and Poiner 1996) to 0.0006 per trawl (<50 per year) after the introduction of TEDs and BRDs in 2000. Of these, only 3-5 turtles per year are likely to drown and another 15 may suffer some other adverse affects.

Sea snakes were poorly excluded from catches during the 2001 tiger prawn season. There was a small difference (5%) only between catches from the legal nets (TED+BRD) and nets without these devices. Two species of sea snakes have been identified to be at a relatively high level of risk from prawn trawling (Stobutzki *et al.,* 2000), and the use of TEDs and BRDs in 2001 has done nothing to alter this assessment.

Catches of sharks and rays have been reduced by 17.7% and 36.3%, respectively, since the introduction of TEDs and BRDs in the NPF. Nets with TEDs reduced catches by 13.3% for sharks and 31.3% for rays. Nets with BRDs only, did not affect catches of rays, but reduced shark catches by 16.7%. Large sharks and rays (>1 m) were more effectively excluded by nets with TEDs (86% and 94%, respectively) compared to smaller animals (≤1 m) (4.9% and 25%, respectively). However, individual species differed from no change for 13 shark and eight ray species to >90% exclusion for two shark and seven ray species. The effectiveness of upward and downward excluding TEDs was about the same for rays (26.9% and 34.8% exclusion, respectively). However, upward excluding TEDs were more effective for sharks (20.4% exclusion) compared to downward excluding TEDs (8.8% exclusion). The catches of the most commonly caught sawfish in the NPF, *Anoxypristis cuspidata* (narrow sawfish), have been reduced by 73% due to the introduction of TEDs. However the impact of TEDs on other, more rarely caught species of sawfish is unknown. At least one of the six highest risk species from Stobutzki *et al.,* (2002), *Dasyatis brevicaudata,* is likely to have a high exclusion rate in nets with TEDs, based on its large size. The results from this study are likely to cause a significant reduction in the level of risk from trawling for many other of the elasmobranch species caught in the NPF. Scaled results from this study estimate that 18120 elasmobranchs (12898 rays, 4980 sharks, and 242 narrow sawfish) were excluded from NPF trawls due to TEDs during the 2001 tiger prawn season.

The Small Bycatch has received little benefit from the introduction of TEDs and BRDs. This group comprises hundreds of species of small fish and small invertebrates and accounts for the vast majority by weight or volume of the bycatch. The combination of TEDs and BRDs reduced the Small Bycatch by 5.4% to 8%. This result also appears to be almost entirely attributable to the influence of TEDs. The BRDs trialed in this study (Bigeye and Square mesh panel) had no effect on catches of Small Bycatch. This is a poor result compared to similar studies and appears largely due to the method by which BRDs have been used in the fleet. A significant shift in impact is required and may follow on from an improved use of some BRDs (e.g. use Square mesh panels and Fisheyes within 70 – 100 meshes of the codend drawstrings) following the banning of the Bigeye from 2004.

TEDs had a significant impact on Large Sponges with >85% exclusion from NPF catches. Upward excluding TEDs removed 81.6% of Large Sponges from the trawl net, and downward excluding TEDs were more effective excluding 95.9%. However, exclusion from trawls does not necessarily mean that these species can re-attach to the substrate, and/or survive the trawling process. But their removal, along with the other large animals has transformed trawl catches in the NPF to a 'cleaner' and easier operation for the crew. Processing and sorting catches is now easier, and most skippers and crews assert that they would leave TEDs in their nets if they were given a choice. BRDs had no impact on Large Sponge catches, and sponge catches had no impact on catches of most other groups (e.g. by blocking the TED and redirecting animals out the escape opening).

Economics of using TEDs and BRDs

An economic analysis was carried out to determine whether there is a net benefit or net economic loss from the use of TEDs and BRDs. The annual net gain or loss to the NPF fleet was calculated based on 2003 average prices of tiger and endeavour prawns and 2002 catches. The main impact of the use of TEDs and BRDs was a reduction in total prawn catch (a loss) and a decrease in the proportion of the catch which was damaged (a gain). The use of TEDs and BRDs had no discernible economic impact on the operating costs of the vessel such as fuel consumption, labour costs and gear wear and tear.

The economic analysis shows that overall, the use of a combined TED and BRD will result in an annual estimated loss of $2.4 million to the fleet, based on average 2003 tiger and endeavour prawn prices and the results of the 2001 Observer Program. With 95 vessels currently operating in the fishery, this amounts to an annual cost per vessel of just over $25,000/year. However, estimates of cost/vessel should be treated with some caution as they may not accurately reflect any differing impacts of TEDs and BRDs by vessel size – data which could not be collected. These values would be approximately halved if Garry Day's Observer results were used (representing more experienced use of TEDs and BRDs).

Factors effecting TED and BRD performance

Between 1996 and 2001 an Australian Maritime College Fishing Technologist, Garry Day, spent long periods of time on NPF vessels assisting with and assessing TED and BRD performance. The knowledge and expertise gained from this time provides a valuable resource to help fishers maximise the performance from TEDs and BRDs. The information was gathered during a time when the NPF was mainly concerned with TED performance.

The efficiency of a well designed and maintained TED should ensure that large animals are quickly excluded from the trawl and prawn loss is minimal or non-existent. However, operators have usually found that new TEDs perform well, but that performance deteriorates with time. This is caused by stretching or wear of various TED components during the fishing season and ineffective maintenance of the TED. In response to this, fishers often excessively modify or over-tune their TED in the hope of minimising prawn loss. These modifications normally have the opposite effect because they slow the escape of large animals which in turn provides increased opportunity for prawns to escape between the escape cover and codend.

Maintaining TED efficiency involves a range of factors, many of which should be managed by fishing crews, including the following:

- TED size – having a large enough grid (in total area) to exclude most or all animals encountered in catches.
- TED shape – the shape of the TED can affect the size of the escape opening, the exclusion ability of the TED and wear and tear on the trawl net.
- Bar spacing – smaller bar spacing allows exclusion of more bycatch species, although unfounded concerns over increased prawn losses have prevented fishers using less than 100-120 mm bar spacing.
- Bent bars – these can improve the speed by which TEDs can exclude large animals encountered on the TED and reduce prawn loss.
- TED orientation – can be altered to target the exclusion of particular species groups. For example downward excluding TEDs are thought to be best suited to excluding heavy, negatively buoyant items such as large sponges or rocks.
- TED angle – incorrect TED angle can result in prawn loss or poor bycatch reduction. Downward excluding TEDs are best at 50-55º, and upward TEDs at 40-50º.
- Escape openings – larger escape openings are best for excluding larger animals, although there are issues with maintaining the shape and strength of the net for larger openings.
- Escape covers – there are many misconceptions about these devices. They should be made of depth-stretched or heat set netting; not be too narrow or too long, and not have weight or flotation added. They need to be replaced regularly.
- Guiding panels or funnels – they are easily blocked and are best used for fishing on ‘clean’ grounds. Canvas may also be considered as an alternative to netting.
- Other gear modifications that should be addressed to help maximise TED performance include flotation, backwash funnels and position of lazy lines.

With this knowledge operators should be in a better position to identify suitable TEDs for a particular fishing ground and bycatch species. This will also improve TED performance through improved troubleshooting ability and provide fishers greater confidence in overcoming any problems with these devices.

Optimising TED and BRD performance in the NPF

In order to help NPF operators improve their proficiency in the use of TEDs and BRDs, a fishing technologist (Garry Day) provided at-sea assistance with the rigging, operation and maintenance of these devices between August 2000 and November 2001. During this time 11 vessels were boarded and data from a total of 694 trawls was recorded, including catches of prawn, large animals including turtles, and small bycatch.

The use of TEDs by operators in this fishery has been very successful with high exclusion rates for turtles and most other large animals. Prawn losses were often caused by poor operation and maintenance practices. The most common problem observed was the so-called ‘over-tuning’ of TEDs. This is usually was due to excessive or inappropriate modifications designed to reduce prawn loss (being “TEDD-ed”) caused by a poorly performing TED. In most cases over-tuning simply masked a problem elsewhere with the TED and did not reduce prawn loss – sometimes even increasing the problem. The technologist was usually able to identify the cause of the problem, modify accordingly and improve the catching performance.

The period of study also coincided with the introduction of mandatory TED use in the banana prawn fishery. Assessment of the impact of TEDs revealed little appreciable influence on catch rates of banana prawns despite some additional handling difficulties. In the first two weeks of the 2001 season, it was only possible to weigh prawn catches between nets on one boat, and the net fitted with the TED and BRD caught 4.8% more prawns than the standard net. It was not possible to measure the impact of BRDs on small bycatch.

In 2000/2001 most operators were far more interested in developing TEDs to exclude turtles and retain prawns than improving BRD design. Consequently, there were few attempts to further develop these devices during the study period and additional efforts will be required to further increase bycatch reduction.

History of TEDs and BRDs in the NPF

The history of the use of TEDs and BRDs in the NPF is short. Both were made compulsory in the NPF early in 2000 mainly due to pressure from conservation groups about the perceived threat by trawling to marine turtle populations and the large amount of bycatch caught and dumped by the fishery. NORMAC set up the TED and BRD subcommittee prior to the introduction of these devices in the late 1990's. This group comprises a range of stakeholders and makes recommendations to NORMAC on the range and specifications of devices that should be available to NPF fishers, and under what conditions they should be used. These recommendations were based on the results of several research projects that trialed different devices, and from results in other fisheries.

Prior to 2000, fishers were encouraged to trial the devices to minimise difficulties before it was mandatory to have a TED and BRD in both nets. Only a small number of fishers used this opportunity, and most trialed TEDs only. This contributed towards a fairly unpopular introduction of these devices in 2000, including many complaints about prawn loss and difficulty of use. However, by the end of 2001 most fishers were happy with the cleaner catches that resulted from using TEDs. One BRD, the Bigeye, has been used by most fishers because of its ability to maintain prawn catches. However, the Bigeye has now been shown to have no impact on bycatch reduction and will be illegal from the 2004 tiger prawn season.

Use of TEDs and BRDs in the NPF

During the Observer Program of 2001 (below) five scientific Observers collected comprehensive information and data about TEDs and BRDs and their use. In November of 2001 a phone survey of another 75 trawlers in the NPF fleet collated similar information about TED and BRD design and use. This combined snap-shot of information covered 95 trawlers or over 80% of the fleet at that time. Just over half of the skippers used downward excluding TEDs (53% of the fleet), and a shape that is oval (28%) or curved at one end only (38%). More than half (57%) had straight bars with a spacing of between 110mm and 120mm. The Bigeye BRD was most popular (79% of the fleet), mainly because of its perceived lack of prawn loss rather than its effectiveness in reducing bycatch. The most common problem expressed by industry operators was the lack of opportunity to test and check any one device against a control net with no devices fitted. This was followed closely by the need to modify handling and fishing techniques and complaints about large prawn losses due to being "TEDDed".

Protocol for TED and BRD development and testing

The protocol for testing new TED and BRD designs has been developed by NORMAC's TED and BRD Subcommittee to promote the ongoing development of effective bycatch reduction devices. It has three assessment phases:

- an initial assessment phase;
- a visual assessment phase; and
- an at-sea testing phase

The initial assessment phase involves members of the subcommittee assessing the potential of a new TED or BRD design based on information provided by the fisher, including diagrams and photographs. The visual assessment phase follows and involves members of the subcommittee physically viewing the device and/or separate testing by experts in the AMC flume tank. This phase is required only if some doubt about the claimed ability of the device exists or further clarification is required. It also provides a mechanism to assess complex or unusual BRD designs. The at-sea testing phase involves the fisher being provided with a permit to test the new device under normal operating conditions for a pre-determined period. The subcommittee provides instruction to the fisher regarding testing conditions and data requirements. If the new device performs satisfactorily then an independent observer may board the boat for a period of around two weeks to enable a more rigorous assessment of the device.

Currently a new TED is deemed to have performed satisfactorily if no more than two turtles are caught during the at-sea testing phase. This target now seems excessive given that the range of approved TEDs in this fishery is already excluding almost 100% of turtles and catch rates across the fleet are estimated at around 30 individuals annually. Reducing the allowable catch to one animal is a responsible move and allows for the flukey catch of an animal ahead of the TED during haul-back of the net – an event still possible with existing approved TED designs.

In the case of a BRD, there is no bycatch target at present; the codend with the device simply needs to retain less bycatch than a standard codend. The results of at-sea testing are then provided to the subcommittee for recommendation or otherwise as an approved Bycatch Reduction Device. However, the testing of new or modified BRDs requires a reasonable benchmark for assessing the performance of the device. A bycatch reduction target of 10% (by weight) compared to catches from a standard trawl is a good starting point in a testing environment where the precise measurement of bycatch is not possible. This target sets the benchmark at a reasonable level and is commensurate with performance levels of the currently approved BRD designs. The target could be increased in the future as performance of BRDs improves.

Further refinement of analytical techniques, including accurate assessment of required shot numbers for a given statistical power, will be possible in the future as the protocol becomes more heavily used. This may occur sooner than previously anticipated given the recent removal of the Bigeye from the list of approved BRDs and the need for fishers to adopt another design suited for their fishing operation.

Project communications report

CSIRO and AMC staff maintained frequent and close communication with each other, with external collaborators and with other NPF stakeholders throughout this project. Many forms of written media, one-on-one and group meetings were used to reach the key stakeholders. All communications included delivering current progress reports on the project and up-to-date results. Merchandise in the form of caps and shirts with unique project logos were also distributed to help maintain interest and co-operation. The effectiveness of the projects' communication program is illustrated by the high level of participation, enthusiasm and co-operation shown by commercial industry in this and other concurrent projects.

The communication activities of this project will continue beyond the final report by circulating summaries of the project results to the NPF and other stakeholders by way of industry workshops, face-to-face meetings in ports, industry magazine articles, media releases, industry newsletters and brochures, and scientific papers.

Industry report

Eleven representatives from the NPF industry agreed to play a role as co-investigators on this project. They have had input into the development of the project and most importantly, helped to ensure that the project observer programs were well assisted by the NPF industry. One of their final tasks was to comment on the performance, relevance and impact of the project and these reports are presented in Chapter 16. Four of these representatives provided these reports.

Conservation report

One representative from conservation stakeholders of the NPF industry also agreed to play a role as co-investigator on this project. They have had the opportunity to offer input into project issues throughout. One of their most important responsibilities was to comment on the performance, relevance and impact of the project. This report is presented in Chapter 17.

Validating methods for measuring total bycatch

The Observer Program had an objective to measure the difference in small bycatch between the Standard nets (no TED or BRD fitted) and the Treatment nets (TED + BRD, TED only or BRD only nets). Electronic load cells and codend markers were used to find the most reliable and accurate method of measuring differences in the weight of Small Bycatch between nets. An electronic load cell was used to weigh the full codends before they were spilled onto sorting trays or hoppers and the prawn and bycatch components weighted manually. However, due to technical difficulties in zeroing the load cells after heavy vibration, the electronic load cell method remains unresolved. Coloured markers were tied to the codend to indicate the height of the catch inside before the codend was spilled. These estimates were compared with the manually weighed estimates. In order to calibrate the accuracy of using codend markers we added successive aliquots of small bycatch (40 kg each) to an empty codend, marking the height of the catch inside the codend. The codend markers showed potential for estimating the small bycatch component of a catch but the accuracy was unlikely to be useful for measuring small differences in bycatch between nets. The pattern of accuracy of the calibration was similar to that shown in the field trials.

The results of both methods demonstrate that there is potential for calibrating new codends with a series of markers and using them on commercial trawlers in the field for estimating total small bycatch. The 2001 Observer Program used the laborious method of collecting and weighing the entire small bycatch in lug baskets to estimate differences between the Standard and the Treatment nets.

The Observer program

A scientific Observer Program was set up to assess differences in catches of target species and bycatch due to the use of TEDs and BRDs by operators in the NPF tiger prawn fishery. Five scientific observers sampled on 23 different commercial vessels (20% of the fleet) from August to early November 2001, mostly between Mornington Island and Gove in the Gulf of Carpentaria. AFMA permits allowed the comparison of catches from a Standard net (no TED or BRD fitted) with a Treatment net (either a TED + BRD net; a TED only net or a BRD only net). Data were collected for eight different catch categories including prawns, byproduct (bugs, scallops, squid), turtles, seasnakes, large sharks and rays, sponges, small (trash chute) sharks and rays, and small (trash chute) bycatch species. A total of 1637 paired trawls were sampled but not every catch category was able to be sampled on every trawl. The pattern of spatial distribution shown by the observer fleet was reasonably representative of the whole commercial fleet inside the Gulf during the tiger prawn season. The observer fleet gave a reasonable representation of the use of either upwards or downwards excluding TEDs compared with the commercial fleet. Similarly the distribution of BRD types used on observer vessels reflected the use by the commercial fleet. The observer program was successful largely due to the dedication and patience of the five Observers who jumped from vessel to vessel for three months without a break.

Flume tank trials

A range of different Turtle Excluder Devices (TEDs) and Bycatch Reduction Devices (BRDs) are currently used in Australian prawn trawl fisheries. It was argued that under certain environmental conditions some of these devices rely on water displacement as a primary motivator in guiding unwanted animals to escape openings. The Square-mesh window (SMW) and Fish-eye (F/E) BRD were identified as two possible devices that could be enhanced through improved awareness of nearby water displacements. Measurement of water velocity in close proximity to these two devices and throughout the remainder of a codend containing a declined super-shooter (S/S) TED followed. Water velocity was measured using an electromagnetic log. The experiment was conducted in a flume tank with a full-scale codend and codend extension attached to a towing hoop. Findings included: F/E and SMW BRDs have quite different levels of flow disturbance when placed aft of a S/S TED in the upper panel; F/E BRD created a substantial wake that extended well downstream of the duct and resisted nearby water incursions; SMW BRD had negligible effect on codend shape and water flow; S/S TED caused quite a lot of disruption to the flow field, not so much because of the grid bars restricting water passage, but more so because of the oversize frame causing considerable netting expansion and constriction upstream and downstream of the grid respectively; flow disturbance associated with these BRDs seemed independent of catch amount in the codend, even though noticeable changes in velocity occurred elsewhere; catch induced water displacement was well aft of where the F/E or SMW currently reside (110 meshes anterior to end of codend) and consequently was unlikely to be of little benefit in the exclusion process. It was concluded that the SMW BRD in this position relies predominately on bycatch vision for escapement to occur, whereas the F/E offers additional stimuli in the form of velocity gradients and wake formation.

Conclusions

The NPF has taken the first major step towards minimising its impact on unwanted species by the introduction of TEDs and BRDs. This has removed almost all of the fishery's impact on turtles and greatly reduced its impact on many of the sharks and rays, including some at highest risk. However, there is still a significant step that needs to be taken by the NPF to demonstrate that the introduction of TEDs and BRDs has been a successful change to a more responsible fishing practice. This can be achieved by taking steps towards attaining a level of BRDs performance that produces significant bycatch reduction, without loss of prawns. This is particularly true for small bycatch and seasnakes, but future success in this endeavour relies on the attitude of owners and operators towards this issue.

Further development

The project will be followed by a program of dissemination of results to stakeholders, although it is recommended that there be a concerted effort to promote improved BRD performance to the industry. A project currently underway will re-evaluate the NPF bycatch risk assessment to include the impact of TEDs and BRDs. A repeat of the assessment of TEDs and BRDs on bycatch reduction may also be needed in the future for the industry to demonstrate an improved level of performance from that measured in this study.

Keywords: TED, BRD, Turtle Excluder Device, Bycatch Reduction Device, bycatch, prawn trawling, shrimp trawling, NPF, Northern Prawn Fishery, turtles, seasnakes, elasmobranchs, sponges, byproduct, Bigeye, Fisheye, Square mesh panel

ACKNOWLEDGEMENTS

We acknowledge the support of the following agencies:

FRDC for financial support, CSIRO Marine Research, Australian Maritime College and CSIRO Mathematical and Information Sciences for financial, administrative and infrastructural support.

We thank the following owners and skippers of the FV Apolloair, and their crew for help during the sample design testing in October 2000:

Duncan McKay and Stephanie Bell

We are greatly indebted to the skippers and crew of the vessels in Table 18-7 who particpated in the survey for periods ranging from 10 days to 5 weeks.

We are also greatly indebted to the skippers and crew of the NPF Mothership companies who organised most of the Observers transfers between vessels, and for their expert and professional support throughout this program:

John Richmond, skipper of the "Kestrel Bay";
Richard Rees, skipper of "Roper K";
Mike Mercer, skipper of "Gulf Express" and
Rick Patalano, skipper of "Pacific Pioneer".

We thank the following netmakers for their support throughout the program including:

"Popeye";
Norm McDonald;
GNM Chandlery;
Swede;
Tony La Macchia and
Chris Gough.

We thank Rik Buckworth from NT Fisheries for his assistance in storing the Observer Kits in Darwin before the season.

We thank Kris Curtis and Ian Jackson for their valued work in entering and editing the raw data.

We thank Lea Crosswell for design of the report cover and Louise Bell for design of the project logo.

We are also grateful for the efforts and expertise of Toni Cannard who helped edit and produce the final report, and thank Adrianne Bond-Meehan for formatting the draft report.

And most importantly, we thank the five Observers for their dedication and patience over a long and tedious three months at sea in the Gulf of Carpentaria, ensuring the success of this program:

Ben Bird,
Garry Day,
Quinton Dell,
Chris Gough and
Reuben Gregor.

DEDICATION

This report is dedicated to the NPF skippers and netmakers who were prepared to trial TEDs and BRDs before their compulsory introduction in 2000;

…to the skippers and crews of vessels who agreed to take our project Observers on board;

…to the skippers and crews of the NPF motherships who organised and facilitated the many transfers of Observers between vessels;

…to the five scientific Observers who spent three long months at sea collecting the data;

…and to Garry Day who devoted years to helping NPF fishers use and improve the performance of their TEDs and BRDs.

CHAPTER 1

BACKGROUND

Chapter Author:

David Brewer

CHAPTER 1

BACKGROUND

David Brewer

Australia's prawn trawl fisheries are among our most valuable fisheries. Annually, they yield about $340 million of product and contribute an estimated $180 million in export earnings (ABARE 1997).

Until recently, the primary management aims of these fisheries were to maximise yields of the target species. In general, relatively few resources have been allocated towards minimising effects on the ecosystem. However, current Australian legislation, such as Australia's Oceans Policy, the Commonwealth environmental legislation (Environmental Protection and Biodiversity Conservation Act or EPBC Act) and some Fisheries Acts, require ecosystem level approaches to managing all marine resources. In some cases, these laws have already forced or influenced changes in fishing practices in Australian fisheries (for example, changes to the pelagic longline fishing operations to protect endangered and vulnerable albatross species). Given the scope of the legislation and the public's perception of trawling as a destructive method of fishing, Australian prawn fisheries need to demonstrate that their operations are environmentally sustainable.

The first, but important, step towards reducing the impact of fisheries on the marine ecosystem is to minimise the impact on non-target species. Bycatch is the part of the catch that is returned to the water either because it has no commercial value, or regulations prohibit it from being retained. Reducing the impact on bycatch helps to ensure that the fishery conforms to the requirements that are encompassed in current fishery legislation.

The Northern Prawn Fishery (NPF) catches about 9000 tonnes of prawns per year, but a wide range of unwanted species, including small fish, sharks, stingrays, sea snakes, sea turtles, sponges and other megabenthos, are caught during fishing operations. The ratio of the bycatch to prawns has been estimated to be between 8:1 and 21:1 (Brewer, 1998; Pender *et al.*, 1992). To-date, NPF fishers have demonstrated their commitment to reducing bycatch levels and have been pro-active in supporting research to understand this significant and complex issue.

The Northern Prawn Fishery Management Advisory Committee (NORMAC) has responded to potential pressures on the fishery concerning bycatch by developing a Bycatch Action Plan in 1998, with an update in 2002 (NORMAC, 2003). This plan included the compulsory use of Turtle Excluder Devices (TEDs) and Bycatch Reduction Devices (BRDs) from the 2000 fishing season. It also recommends that a bycatch monitoring program be established in the fishery. NORMAC has set a high priority for research about impacts of trawling on non-target species, and specifically includes the assessment of TEDs and BRDs

Earlier projects have demonstrated the potential for significant levels of bycatch reduction on NPF vessels using TEDs and BRDs (FRDC 93/179, 93/231 & 96/254). However, the adoption of these devices does not give the NPF immunity from scrutiny of its environmental management. The fishery must still demonstrate the benefits of using TEDs and BRDs in their gear during trawling operations.

This was to be the first assessment of TEDs and BRDs in a tropical prawn trawl fishery. Previous assessments of these devices have been made under controlled scientific conditions (Brewer *et al.*, 1997, 1998), or in different environments (e.g. temperate NSW – Broadhurst and Kennelly, 1994, 1996, 1997; Broadhurst *et al.*, 1996, 1997; South Australia – Broadhurst *et al.*, 1999; Southern United States – Brandstetter, 1997; Watson *et al.*, 1993; Norway – Valdemarsen, 1993; United Kingdom – Robertson, 1984), or have focussed specifically on TEDs (e.g. Robins and McGilvray, 1999).

The concurrent use of both TEDs and BRDs is still a relatively new concept, especially in Australian fisheries. Through the co-operation of NPF operators, fisheries technologists, scientists, economists and conservationists, this project aimed to improve and assess the catching, engineering and economic performance of TEDs and BRDs.

References

ABARE 1997. Australian Fisheries Statistics 1997. Australian Bureau of Agricultural & Resource Economics, Canberra

Brandstetter, S. 1997. Bycatch and its reduction in the Gulf of Mexico and South Atlantic shrimp fisheries. Gulf and South Atlantic Fisheries Development Foundation, Inc. Florida, USA. 27 pp.

Brewer, D.T., Eayrs, S.J., Rawlinson, N.J.F., Salini, J.P., Farmer, M., Blaber, S.J.M., Ramm, D.C., Cartwright, I. and Poiner, I.R. 1997. Recent advancements in environmentally friendly trawl gear research in Australia. In: Hancock, D. A., Smith, D. C., Grant, A. and Beumer, J. P. (Eds.) Developing and sustaining world fisheries resources: the state of science and management: 2nd World Fisheries Congress Proceedings, 1996. Brisbane. Qld. pp 501-507.

Brewer, D.T., Rawlinson, N., Eayrs, S. and Burridge, C. Y. 1998. An assessment of Bycatch Reduction Devices in a tropical Australian prawn trawl fishery *Fisheries Research.* 36, 195-215.

Broadhurst, M.K. and Kennelly, S.J., 1994. Reducing the by-catch of juvenile fish (mulloway) in the Hawkesbury River prawn-trawl fishery using square-mesh panels in codends. *Fish. Res.* (Amsterdam) 19: 321-31.

Broadhurst, M.K. and Kennelly, S.J., 1996. Rigid and flexible separator trawls that reduce the by-catch of small fish in the Clarence River prawn-trawl fishery, Australia. *Mar. Freshw. Res*., 47: 991-998.

Broadhurst, M.K., Kennelly, S.J., Watson, J. W. and Workman, I. K., 1997. Evaluations of the Nordmøre grid and secondary bycatch-reducing devices (BRD's) in the Hunter River prawn-trawl fishery, Australia. *Fish. Bull.* 95: 210-219.

Broadhurst, M.K., Kennelly, S.J., and O'Doherty, G., 1996. Effects of square-mesh panels in codends and of haulback delay on by-catch reduction in the oceanic prawn-trawl fishery of New South Wales, Australia. *Fish. Bull.* 94: 412-422.

Broadhurst, M.K., Kennelly, S.J., Watson, J. W. and Workman, I. K., 1997. Evaluations of the Nordmøre grid and secondary bycatch-reducing devices (BRD's) in the Hunter River prawn-trawl fishery, Australia. *Fish. Bull.* 95: 210-219.

Broadhurst, M.K., Larsen, R.B., Kennelly, S.J., and McShane, P.E., 1999. Use and success of composite square-mesh codends in reducing bycatch and in improving size-selectivity of prawns in Gulf St. Vincent, South Australia. *Fish Bull.* 97: 434-448.

NORMAC 2003. Northern Prawn Fishery By-catch Action Plan. Published by The Australian Fisheries Management Authority. 26 pp.

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

Robertson, J.H.B. 1984. Square mesh codend selectivity for Haddock (*Melanogrammus aelgefinus* (L)) and whiting (*Merlangius merlangus* (L)) in a Scottish seine net. International Council for the Exploration of the Sea. CM. 1984/B:30, 4 pp.

Robins, J.B. and McGilvray, J.G. 1999. The AusTED II, an improved trawl efficiency device 2. Commercial performance. *Fisheries Research*. 40: 29-41.

Watson, John, Ian Workman, Dan Foster, Charles Taylor, Arvind Shah, James Barbour, Dominy Hataway, March 1993. Status Report on the Development of Gear Modifications to Reduce Finfish Bycatch in Shrimp Trawls in the Southeastern United States 1990-1992. NOAA Technical Memorandum, NMFS - SEFSC - 327, 131 p.

Valdemarsen, J. W., Lehmann, K., Riget, F. and Boje, J. 1993 . Grid devices to select shrimp size in trawls. International Council for the Exploration of the Sea. Statutory Meeting, Fish capture Committee.

CHAPTER 2

NEED

Chapter Author:

David Brewer

CHAPTER 2

NEED

David Brewer

From 15 April 2000, all NPF vessels were required to use TEDs and BRDs in their nets. This constituted a major change in fishing practice; however, the impact on the fishing industry was unknown. This project will address a number of issues related to TED and BRD usage in the NPF, including:

- An accurate assessment of TED and BRD performance.

  This will be a vital step towards removing pressure on the fishery from legislation aimed at protecting species and the environment. The EPBC Act 1999, encompassing the former Endangered Species Protection Act 1992, enables the listing of trawling, or other activities, as key threatening processes. However, if the NPF can demonstrate adequate reductions in catches of protected species due to the use of TEDs and BRDs, it may avoid any actions arising from such a listing.

- Optimising the performance of TEDs and BRDs.

  The NPF is a large and remote fishery, and at the start of the 2000 fishing season many fishers had little or no experience with TEDs and BRDs. Consequently there was widespread concern by industry over the lack of preparedness as the 2000 season approached. This project addressed this concern by continuing the development TEDs and BRDs using the skills and expertise of industry and the other project collaborators in the first and second years after their compulsory introduction.

- Devising an appropriate assessment and approval process for new BRD and TED designs.

  NORMAC approved a suite of TEDs and BRDs for use in the NPF and regulations pertaining to their design and use. These regulations also provide scope for fishers to develop new exclusion devices. However, an approval process or protocol had not been defined.

- Measuring changes in catch ability resulting from BRD and TED usage.

  The use of TEDs and BRDs also has implications for fishing effort standardisation based on their potential to change a fisher's ability to catch prawns. Therefore, it is necessary to accurately measure the change in catches so that adjustments in fleet effort can be made for stock assessments.

- An economic assessment of the costs and benefits of introducing TEDs and BRDs into the NPF.

  It is also important that fishers are convinced that the use of TEDs and BRDs, rather than just the appearance of use, may be in their economic interest. The economic repercussions of using TEDs and BRDs including their cost, and catching performance must be recognised.

CHAPTER 3

OBJECTIVES

Chapter Author:

David Brewer

CHAPTER 3

OBJECTIVES

David Brewer

The three broad objectives and sub-objectives for this project were as follows:

1. Improve the performance of TEDs and BRDs in the NPF.

    - To optimise the performance of approved TEDs and BRDs on NPF vessels.
    - To identify the factors influencing the performance of TEDs and BRDs.

2. Make a snapshot assessment of the performance of TEDs and BRDs in the NPF.

    - To measure any change in catch rates of total unwanted bycatch and in particular, selected charismatic or vulnerable bycatch species, due to the use of TEDs and BRDs.
    - To measure any change in catches of commercially important prawns and retained byproduct species due to the use of TEDs and BRDs.
    - To assess the economic costs and benefits to industry of the use of TEDs and BRDs.

3. Assist the ongoing development of TEDs and BRDs in the NPF.

    - To establish a protocol for the ongoing development and testing of new TEDs and BRDs.

CHAPTER 4

GENERAL PROJECT PLAN

Chapter Author:

David Brewer

CHAPTER 4

CHAPTER 4

GENERAL PROJECT PLAN

David Brewer

The general project plan is described here. However, the methods employed to achieve each objective will be described separately in the chapter relating to that objective. The evolution of management and activities relating to TEDs and BRDs in the NPF are documented in Table 4-1.

4.1 Improve the performance of TEDs and BRDs in the NPF

The improvement of performance of TEDs and BRDs was achieved in this project through a combination of the following activities:

- Expert assistance at sea.
- Targeted gear adjustments and data comparisons on NPF vessels.
- Flume tank experiments to characterize patterns of water turbulence around TEDs and BRDs.
- Development of a detailed protocol to allow fishers to design and test new devices.
- A strong communications plan to spread information about TEDs and BRDs widely throughout the fleet and to other stakeholders.

These activities are reported separately in this report.

This project builds on various earlier TED and BRD projects in the NPF. It also builds on at-sea research and work by Garry Day in the NPF fleet. Relevant aspects of the knowledge from these earlier projects are also captured in this report (Blaber *et al*., 1997; Poiner *et al*., 1998; Stobutzki *et al*., 2000). The improved performance of TEDs and BRDs seen in the NPF represents an important step in the evolution of the NPF’s goal to minimise its impact on non-target species, while maintaining sustainable catches of commercially valuable prawns. It is the intention of the project team to continue to collate and disseminate this information to NPF operators and other stakeholders by way of magazine articles, fishery newsletters, industry meetings, scientific conferences and literature and media releases. This communication strategy will help to maximise the benefit to industry and other stakeholders of the information gathered on ways to improve performance of TEDs and BRDs in the NPF and other fisheries.

4.2 A snapshot assessment of the performance of TEDs and BRDs in the NPF

The use of TEDs and BRDs was encouraged in the NPF fleet in the late 1990’s, with only limited success. These devices were mandatory from 2000 onward and this represented a major change in fishing gear operation and performance, especially on boats that had not experimented with these devices in the seasons leading up to 2000. In order to demonstrate the impact of this gear change, a snapshot assessment of the performance of TEDs and BRDs was made during a single fishing season using a scientific Observer program. The underlying premise of this objective was to assess the performance of TEDs and BRDs with a view towards the result being representative of the industry in the medium term. It was important that the assessment was not made while the industry was having the major initial teething problems with the performance of these devices. Consequently, at-sea technical assistance was continued throughout 1999 and 2001, and the formal performance assessment (via an Observer program) made during the second half of 2001.

4.3 References

Blaber, Steve, David Brewer, Charis Burridge, Margaret Farmer, David Milton, John Salini, You-Gan Wang, Ted Wassenberg, Colin Buxton, Ian Cartwright, Stephen Eayrs, Nick Rawlinson, Rik Buckworth, Neville Gill, John MacCartie, Richard Mounsey, David Ramm. 1997. Effects of Trawl Design on Bycatch and Benthos in Prawn and Finfish Fisheries. Final Report to FRDC.

Poiner, I., Glaister, J., Pitcher, R., Burridge, C., Wassenberg, T., Gribble, N., Hill, B., Blaber, S., Milton, D., Brewer, D. and Ellis, N. Environmental Effects of Prawn Trawling in the Far Northern Section of Great Barrier Reef: 1991-1996. Final Report to Great Barrier Reef Marine Park Authority and Fisheries Research and Development Corporation. June 1998. Volumes 1 and 2.

Stobutzki, I., Steve Blaber, David Brewer, Gary Fry, Don Heales, Margaret Miller, David Milton, John Salini, Tonya Van der Velde, Ted Wassenberg, Peter Jones, You-Gan Wang, Mike Dredge, Tony Courtney, Keith Chilcott, Stephen Eayrs. 2000. Ecological Sustainability of Bycatch and Biodiversity in Prawn Trawl Fisheries. Final Report to FRDC.

Table 4-1. Chart showing the evolution of management and activities relating to TEDs and BRDs in the NPF

Event in the NPF	pre 1995	1995	1996	1997	1998	1999	2000	2001	2002	2003
Scientific trials of TEDs and BRDs	■	■								
Assistance with TED and BRD performance for fishers*		■	■	■	■	■	■	■		
Convening of the TED and BRD sub-committee						■	■	■	■	■
TEDs and BRDs mandatory in the NPF							■	■	■	■
Term of the current project							■	■	■	
Scientific observers assess performance of TEDs and BRDs								■		
Results of TED and BRD performance assessment available									■	■
Dissemination of project results and performance improvement information									■	■

*carried out by Garry Day – AMC gear technologist

CHAPTER 5

HISTORY OF TEDS AND BRDS IN THE NPF

Chapter Authors:

Brian Taylor and Garry Day

CHAPTER 5

CHAPTER 5

HISTORY OF TEDS AND BRDS IN THE NPF

Brian Taylor and Garry Day

Summary

The history of the use of TEDs and BRDs in the NPF is short. Both were made compulsory in the NPF early in 2000 mainly due to pressure from conservation groups about the perceived threat by trawling to marine turtle populations and the large amount of bycatch caught and dumped by the fishery. In more recent years concern has also been expressed by many groups, including the general community and fishing industry, about other species (particularly sawfish and sea snakes) and about the effect of trawling on the benthic habitat.

NORMAC set up the TED and BRD subcommittee prior to the introduction of these devices in the late 1990's. This group comprised a range of stakeholders and made recommendations to NORMAC on the range and specifications of devices that should be available to NPF fishers, and under what conditions they should be used. These recommendations were based on the results of several research projects that trialed different devices, and from results in other fisheries.

Prior to 2000 fishers were encouraged to trial the devices to minimise difficulties before it was mandatory to have a TED and BRD in both nets. Only a small number fishers used this opportunity, most trialing TEDs only. This contributed towards a fairly unpopular introduction of these devices in 2000, including many complaints about prawn loss and difficulty of use. However, by the end of 2001 most fishers were happy with the cleaner catches that resulted from using TEDs. One BRD, the Bigeye, has been used by most fishers because of its ability to maintain prawn catches. However, the Bigeye has now been shown to have no impact on bycatch reduction and will be illegal after the 2004 banana prawn season.

5.1 Background

5.1.1 Definitions

Currently, the reduction of bycatch in the NPF is primarily being addressed with the implementation of Bycatch Reduction Devices (BRDs) and Turtle Exclusion Devices (TEDs). Broadly, a BRD in this case, is a device fitted to a prawn trawl net to reduce bycatch of any kind. A TED, a device designed specifically to remove turtles from the prawn trawl nets, is strictly a BRD. However, TEDs and BRDs are generally accepted throughout the NPF as separate devices and therefore the definitions used in this report are:

- TED - a hard grid forming a physical barrier to facilitate the exclusion of sea turtles and other large animals (many species of sharks, rays and larger fish) and to redirect sponges, rocks and large shells;

- BRD - a usually smaller-animal escape device relying on behaviour and swimming response of that animal.

5.1.2 Concern regarding sustainability of the NPF

Initial concern about the prawn trawl industry's impact on bycatch in northern parts of Australia was focused on sea turtles. In the early 1990's, the profile of this issue was raised by conservation groups, coinciding with growing pressure from Non-Government Organisations (NGO's) on many international fisheries, including prawn trawl fisheries.

Since then, there has been widespread concern about turtles, various species of shark (including saw sharks) and sea snakes in the NPF from government authorities, NGOs, research scientists, community groups and the Australian fishing industry. There have also been concerns about the impacts of trawling, sustainable fishing practices and ecosystem protection in general.

5.2 Relevant policy and legislation

5.2.1 Regulations regarding TEDs and BRDs

In the late 1990s, and prior to the mandatory adoption of TEDs and BRDs, a subcommittee (including members from the fishing industry, scientific researchers and officers from AFMA) was established. This group considered and advised on matters regarding the use of, and regulations concerning, TEDs and BRDs. At this stage there was already a considerable amount of information available on potential designs and how to successfully operate these devices. Some fishers were also already independently trialling devices and receiving expert at-sea advice from a gear technologist from the Australian Maritime College.

Near the start of the first season in 2000, the use of TEDs and BRDs in all NPF main trawl gear was made compulsory by the Australian Fisheries Management Authority (AFMA) (Fig 5.1). At this stage the legal description of these devices and their fitting (see Appendix 3) was restricted to ensure that they would maintain their effectiveness and allow:

- the choice of a range of TEDs and BRDs that were demonstrated to have potential for reducing bycatch without major prawn loss, and
- a process and pathway through which operators could experiment and trial new and different designs.

The regulations took effect two weeks after the start of the first fishing season on 1 April 2000. This avoided potential problems with new devices at the start of the banana fishing season when operations are traditionally most hectic. Also many fishers maintained that TEDs and BRDs should not be compulsory whilst fishing banana prawns and they claimed bycatch was minimal when targeting banana prawns and that turtle and shark mortality was very low due to short shot- times. For the first two weeks of the following year, 2001, operators were required to use TEDs and BRDs in main gear, but were permitted to remove the TED and BRD from one net (twin-gear was used). This was on condition that comprehensive records were submitted to AFMA for comparison between the two nets. Additionally, scientific observers were placed on some vessels during this same time to verify catches. During 2002 and subsequently, the use of TEDs and BRDs has been compulsory in both nets.

There is no requirement to install TEDs or BRDs in trygear which is a small 2 metre maximum headrope length trawl net towed for short periods to sample the abundance and size of prawns in the area.

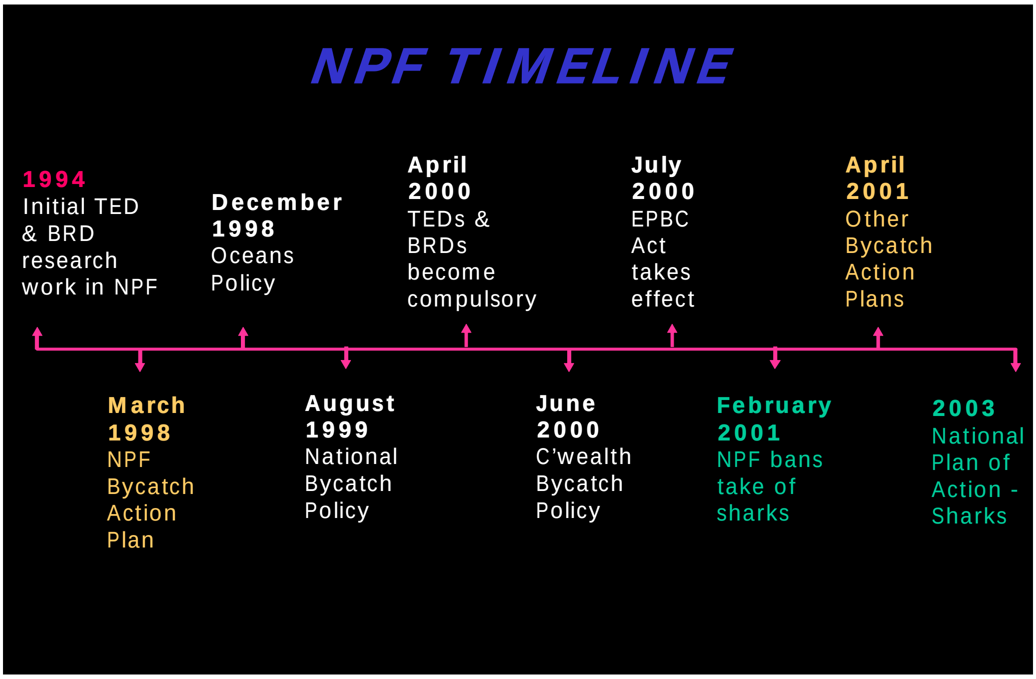


Figure 5.1. NPF bycatch policy and legislation timelines summary (not to scale)

5.3 Government research and liaison

In the past, most marine fisheries research work in Australia tended to concentrate on individual, or sometimes multiple, target species. Recently, however, the number of projects focusing on bycatch and whole ecosystems has increased. The first significant study examining bycatch of the NPF was by Pender *et al.*, (1992), who described the bycatch of the western Gulf of Carpentaria and northern waters. This was followed by a project on the effects of trawl design on bycatch and benthos in prawn and finfish fisheries (Blaber *et al.*, 1997) conducted by FRDC, CSIRO, AMC and Northern Territory Primary Industry and Fisheries; FRDC 93/179). Since the mid 1990's, there have been many other more localised projects studying bycatch, reduction devices and ecosystems by CSIRO; Queensland Department of Primary Industries; and NT, SA and NSW Fisheries.

There are also large volumes of literature from international bycatch reduction research. Initially, TED and BRD designs from other tropical waters (mainly from US fisheries) and western European countries formed the basis of ideas for devices that were trialled in the NPF. A significant step in highlighting and promoting the bycatch reduction issue was in early 1997 when US scientists conducted workshops and meetings in Australia on the installation, use and effectiveness of TEDs and BRDs.

5.4 Acceptance by industry

It is important to the successful deployment of TEDs and BRDs, that fishers are able to operate the new equipment. Initially there was resistance from some fishers to the changes. However, there is now wide-spread acceptance throughout the industry, as indicated by the comments from operators, and the reluctance of fishers to remove TEDs from their nets for research purposes. Many owners and fishermen have manufactured and fitted their own devices and there are currently a number of professional net-manufacturers selling excluder devices to NPF operators. Many ideas and prototypes have come from the commercial sector, fishers and net-manufacturers, and many early proactive operators promoted the development of excluder devices, both financially and operationally. Extensive interactions between scientists, fishers, gear technologists and net-manufacturers at all stages of the TED and BRD development phase, benefited all parties. Also at-sea assistance by a gear technologist assisted the fishers to set-up, modify, and operate their gear effectively.

The development of reduction devices and the acceptance by fishers of significant changes to fishing operations has occurred, despite the significant pressures and many legislative changes introducing unknown impacts on future fishing operations.

5.5 Operational considerations

The gear used and the operational differences between fishing for banana prawns and fishing for tiger prawns are considerable. The total catch of prawns and bycatch is also influenced by

- the species and abundance of fish and other animals and plants colonising the different fishing regions (e.g. sponge and structured substrate versus unstructured mud substrate);
- the behaviour of the target and the often different non-target species;
- the weight of product which may be caught in individual trawl shots in the different fisheries.

Nevertheless, it is not practical to consider differential requirements with respect to TED and BRD regulations as all fishing vessels are licensed to target both banana and tiger prawns. And landings of all species often overlap considerably in area and time.

It has been necessary for fishers to modify former fishing techniques when TEDs and BRDs are used and there can occasional be large losses in target catch. This occurs when the devices are accidentally blocked or when the escape gap is jammed open (known by operators as being 'TEDDed') or during the hauling process when water pressure forces prawns out of the net (“wash-back”).

These losses have generally been seen by commercial fishers as a fact of life as is generally the case when new gear is introduced or when very large catches are made. Before TEDs and BRDs were used, prawn losses did sometimes occur through large animals, sponges or rocks causing torn or distorted nets or because of very large catches.

5.6 The future

On-going research is being conducted to establish an acceptable and cost effective bycatch monitoring system. Irrespective of the recommended system it will involve at-sea operators and it is essential that this monitoring be recognised as critical for the continued viability of this fishery.

5.7 References

Blaber, Steve, David Brewer, Charis Burridge, Margaret Farmer, David Milton, John Salini, You-Gan Wang, Ted Wassenberg, Colin Buxton, Ian Cartwright, Stephen Eayrs, Nick Rawlinson, Rik Buckworth, Neville Gill, John MacCartie, Richard Mounsey, David Ramm. 1997. Effects of Trawl Design on Bycatch and Benthos in Prawn and Finfish Fisheries. Final Report to FRDC.

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

CHAPTER 6

ASSISTING OPERATORS TO OPTIMISE TED AND BRD PERFORMANCE ON BOARD COMMERCIAL VESSELS IN THE NORTHERN PRAWN FISHERY

Chapter Authors:

Garry Day and Steve Eayrs

CHAPTER 6

CHAPTER 6

ASSISTING OPERATORS TO OPTIMISE TED AND BRD PERFORMANCE ON BOARD COMMERCIAL VESSELS IN THE NORTHERN PRAWN FISHERY

Garry Day and Steve Eayrs

Summary

To help NPF operators become proficient in the use of TEDs and BRDs a fishing technologist provided at-sea assistance with the rigging, operation and maintenance of these devices between August 2000 and November 2001. During this time 11 vessels were boarded and data from a total of 694 trawls was recorded, including catches of prawn, large animals including turtles and small bycatch.

The use of TEDs by operators in this fishery has been very successful. Nearly 100% of turtles are now excluded from trawls and most other large animals also have high exclusion rates. Prawn loss is often less than 5% compared to a standard trawl. Higher rates of prawn loss are still experienced on some boats although this is largely caused by poor operation and maintenance practices. The most common problem observed was the so-called 'over-tuning' of TEDs. This is defined as excessive or inappropriate modifications designed to reduce prawn loss (being 'TEDDed') caused by a poorly performing TED. In most instances over-tuning simply masked a problem elsewhere with the TED and did not reduce prawn loss – sometimes even increasing the problem. The technologist was usually able to identify the cause of the problem, modify accordingly and improve catching performance.

The period of study also coincided with the introduction of mandatory TED use in the banana prawn fishery. Assessment of the impact of TEDs revealed little appreciable influence on catch rates of banana prawns despite some additional handling difficulties. In the first two weeks of the 2001 season it was only possible to weigh prawn catches between nets on one boat, and the net fitted with the TED + BRD caught 4.8% more prawns than the standard net. It was not possible to measure the impact of BRDs on small bycatch.

The current range of BRDs used in the fishery is reducing small amounts of bycatch. However, in 2000/2001 most operators were far more interested in developing TEDs to exclude turtles and retain prawns than improving BRD design. Consequently, there were few attempts to further develop these devices during the study period and additional efforts will be required to further increase bycatch reduction.

6.1 Introduction

Since 15 April 2000 fishers in the Northern Prawn Fishery (NPF) have been required to use Turtle Excluder Devices (TEDs) and Bycatch Reduction Devices (BRDs) in their nets. The adoption of TEDs and BRDs in fishing gear has resulted in a major change in traditional fishing practice in the NPF. Many operators have been unsure how to optimise the performance of TEDs and BRDs.

To help operators become proficient in the use of TEDs and BRDs a fishing technologist, Garry Day, provided at-sea assistance with the rigging, operation, maintenance and troubleshooting of these devices. He also collected catch data to facilitate the assessment of TED and BRD performance under a variety of operating conditions. This information was used to understand the variety and magnitude of factors that influence TED and BRD performance, to assist operators to fine-tune their devices for optimal performance, and to develop new and more effective bycatch reduction devices specifically suited to their fishing operations.

This section describes the catching performance of the TEDs and BRDs tested on board fishing boats from August 2000 to November 2001 and how this performance was improved by modifications. Operational aspects affecting TED and BRD performance are detailed in Chapter 12: *Factors influencing TED and BRD performance*.

6.2 Methods

Prior to the commencement of each fishing season in 2000 and 2001, project staff identified operators requiring assistance with their TEDs and BRDs. This occurred at pre-season workshops in the major fishing ports and through informal discussions with operators and boat owners between and during the fishing seasons.

Vessels were boarded in a specific order. Attempts were made to meet the operators at sea in a sequence based loosely on prioritising those that had least experience with these devices and/or degree of difficulty previously encountered with these devices. Another factor that influenced the boarding sequence was boat location. In cases when vessels were fishing in different areas it may not have been possible to change to the next boat on the list. Prior to boarding each boat a scientific permit was obtained from AFMA to allow the removal of a TED and BRD from one net. These permits were effective only for the period that the gear technologist was on board.

For each boat, the design, size and type of TED and BRD were recorded, as well as any operational factors that affected performance. Modifications to the devices by the technologist were documented, as was the effect of the modification on catching performance. The collection of catch data from each trawl shot and net included species identification and counts of large animals, catch weights for each prawn species, including soft and broken prawns, and where possible total bycatch weight. Bycatch weight was recorded by collecting the bycatch in plastic ‘lug’ baskets and weighing each individual basket.

Due to the nature of this work it was not possible to account for natural variation in the distribution of prawns over the seabed. As a result it was assumed that the effect of natural variation was minimal, being accounted for (in most instances) by replicate number of trawls. Moreover, it was assumed that the catching performance of both nets was the same with the only difference being the presence and type of TED and BRD combination used by the operator. Given limited time on board each boat, it was usually not possible to conduct extensive assessment of catches between nets. Although when major differences in rigging between nets was observed, steps were taken to rig them identically. As a result of these limitations, any reduction or gain in prawn catch was attributed to the performance of the TED and BRD combination. For example, a reduction in prawn catch was usually referred to as a loss in catch, while any difference in catches of soft and broken prawns was assumed to be due to the exclusion of large animals from the trawl. Any difference in catches of large animals and small bycatch were attributed to these devices.

6.3 Results

A total 11 boats were boarded during the project and catch data from 694 trawls were recorded. The results are presented in three categories – prawn catches, large animal catches and small bycatch – for each of the three fishing seasons.

6.3.1 Tiger Prawn season (4 August – 9 November 2000)

During the tiger prawn season five boats were boarded and catch data from 226 trawls was recorded from the net with an approved TED and BRD (TED + BRD net) and a so-called standard net (TED and BRD both removed).

The devices assessed during this season included both top and bottom excluding TEDs, such as the Super shooter, Nordmore and Swede TEDs, and BRDs, such as the Radial Escape Section (RES), Fisheye and Bigeye (Table 6-1). A new innovative TED design based on modifying a Bigeye BRD, developed by the owner of the FV *Beachlands,* was tested during the season. Catch data, however, from this boat was not included in this section because the device was tested under a scientific permit from AFMA (see Chapter 14: TED and BRD protocol for catch details and discussion). A full copy of this report is available from the AFMA website: www.afma.gov.au. Most TEDs were also tested in a variety of configurations including with and without guiding funnels or chaffing mats (Figure 6-1). Two configurations of the RES were also tested: a square mesh extending fully around the codend circumference (Figure 6-2) and a square mesh only extending around upper half of codend. All devices were tested under normal commercial fishing conditions, in varying weather conditions and over a range of seabed habitats, from clear grounds with low sponge bycatch to grounds with high numbers of sponges, rocks and other bottom debris. The catch of tiger prawns and bycatch was recorded on all boats, but it was only possible to record the catch of soft and broken prawns on two boats and the catch of endeavour prawns on one boat.

Table 6-1. TED and BRD details for four boats boarded during the 2000 tiger prawn season (excluding FV *Beachlands*). Bar spacing in all instances was 120mm. ↑ = upward excluding TED.

Boat No.	TED and BRD combination				
	Rig No.	TED type	Excluding direction (↑/↓)	Other TED details	BRD type
1	1	Gough	↓	No guiding funnel or panel	Bigeye
		Super shooter			
	2	Swede	↓	No guiding funnel or panel	Bigeye
	3	Swede	↓	Canvas chaffe mat ahead of escape opening	Bigeye
2	1	Swede	↓	Canvas chaffe mat ahead of escape opening	Fisheye
	2	ARJ Nordmore	↑	No guiding funnel or panel	Fisheye
	3	ARJ Nordmore	↓	Grid 20cm wider than previous TED. No guiding funnel or panel	Fisheye
	4	ARJ Nordmore	↓	Grid 20cm wider than previous TED. No guiding funnel or panel	RES (full)
	5	Swede	↓	Canvas chafe mat ahead of escape opening	RES (half)
3	1	Swede	↓	No guiding funnel or panel	Fisheye
	2	Swede	↓	Canvas chafe mat ahead of escape opening	Fisheye
	3	Swede	↓	Canvas chafe mat ahead of escape opening	Bigeye
	4	ARJ Nordmore	↓	Grid 20cm wider than previous TED. No guiding funnel or panel	Bigeye
4	1	TED	↑	Small TED design	Bigeye
	2	TED	↓	Small TED design	Bigeye

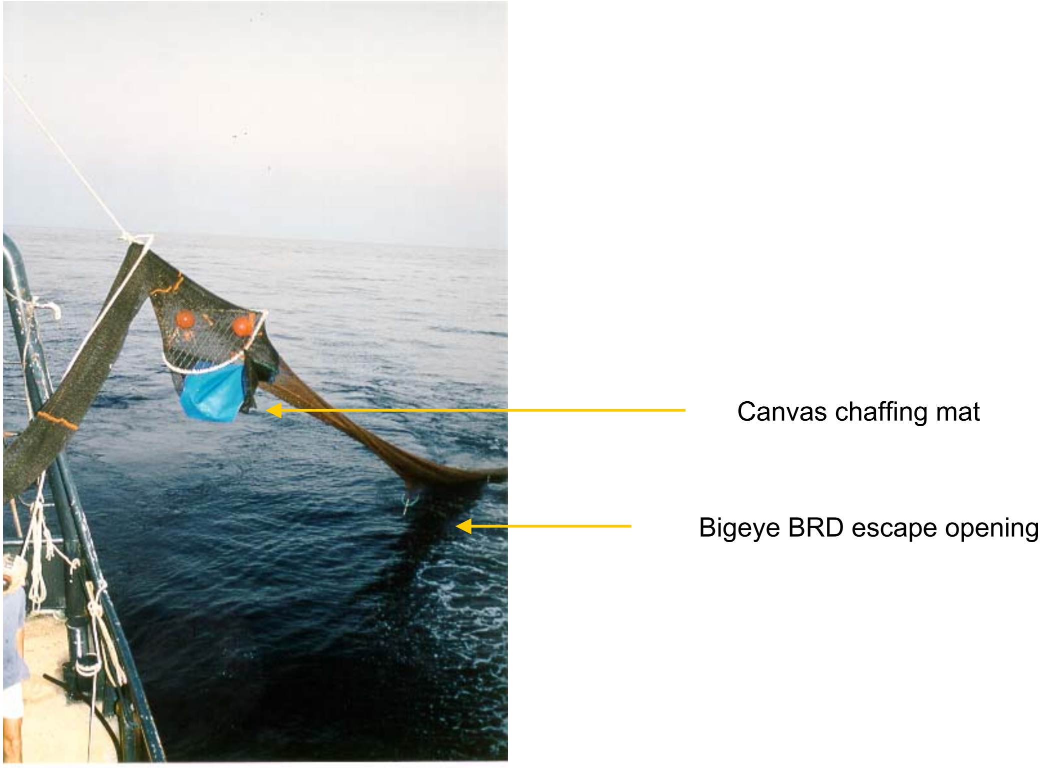


Figure 6-1. The Swede TED with chafing mat and the Bigeye BRD.

Figure 6-2. The full RES with square meshes extending radially around the entire codend circumference.

Prawn catches

Overall, the TED + BRD net caught almost 3% less tiger prawn than the standard net (Table 6-2). However, this figure also includes the large prawn loss that occurred before any changes to the fishing gear were made to increase performance. The incidence of soft and broken prawns was recorded on average one shot a night. Overall, the quality of the prawn catch in the TED + BRD net was superior, with this net containing 37% fewer soft and broken prawns than the standard net for the same catch weight.

Table 6-2. Tiger prawn catch results for four boats combined during the 2000 tiger prawn season using approved TEDs and BRDs. Soft & broken tiger prawn catch was recorded on Boats 3 and 4 only. Note: '-' denotes a smaller catch for the TED + BRD net when compared to the standard net.

Catch Component	No. of trawls	TED + BRD Net (kg)	Standard Net (kg)	Catch difference (kg)	TED + BRD catch (%)
Tiger prawns	226	10152	10450	-298	-2.8
Soft & broken tigers	73	77	122	-45	-36.9

The most extensive testing of a TED and BRD combination during the fishing season, and the best performing, was the Swede TED and Bigeye combination on board Boat 3 (Rig 3) (Table 6-3). From a total of 45 trawls both nets caught about 2000kg of prawn and the TED + BRD net caught 3kg more prawn than the standard net.

Overall, the upward excluding TED and Bigeye BRD used on Boat 4 (Rig 1) was the worst performing combination. This combination recorded 20% less prawns than the standard net. In terms of catch difference by weight, the Super shooter and Bigeye BRD (Boat 1, Rig 1) was the worst performing combination averaging a prawn loss of just over 6kg per shot (18.6%). The likely causes for these differences were TED blockages caused by the slow passage of large animals through the escape opening on Boat 4, and, in the case of Boat 1, the additional problem of twisted lazy-lines reducing codend circumference and retarding the passage of prawns past the escape opening. In both instances, prawns were likely to spend a longer period in the vicinity of the escape opening and increase the likelihood of escape. After the TED was inverted on Boat 4, its catch performance improved dramatically. On Boat 1 modification of the TED over two nights appeared to reduce the difference in catch. This included removal of flotation attached to the escape cover and twists in the lazy-lines.

On Boat 3 the addition of a chaffing mat to the TED, facilitating the exclusion of large animals, coincided with reduced catch difference between nets (Rigs 1 and 2). This may be due to more rapid exclusion of these animals and increased period when the escape cover is seated over the escape opening. However, this result was not replicated on Boat 1 (Rigs 2 and 3). Also the effect of increased TED size on catch difference appeared to be positive, with reduced prawn loss reported on Boat 2 (Rigs 2 and 3).

The presence of a TED had a dramatic impact on the catch of soft and broken prawns. The catch of soft and broken prawns was reduced by 13% compared to the standard net on Boat 3 (Rig 3). On Boat 4 the soft and broken prawn catch was reduced by 66% and 53% respectively, for the bottom excluding and top excluding TEDs.

The catch of endeavour prawns was only recorded on Boat 4. The endeavour prawn catch from the net with the top excluding TED + BRD combination (Rig 1) was reduced by 5% compared to the standard net. An 8% gain, however, was recorded when the same TED was used as a bottom excluding device.

During the fishing season several operators reported incidences of large prawn losses (10% or more) from individual tows, although most noted smaller losses of around 5% on average for the season. Large losses were often attributed to sponges, large animals or debris becoming fouled in the escape opening of the TED (Figure 6-3), an event colloquially referred to as having been ‘TEDDed’. Despite a low mean difference in prawn catch between nets, all vessels boarded experienced catch losses, with the greatest losses attributed mainly to poorly rigged TEDs and associated effect of being 'TEDDed'.

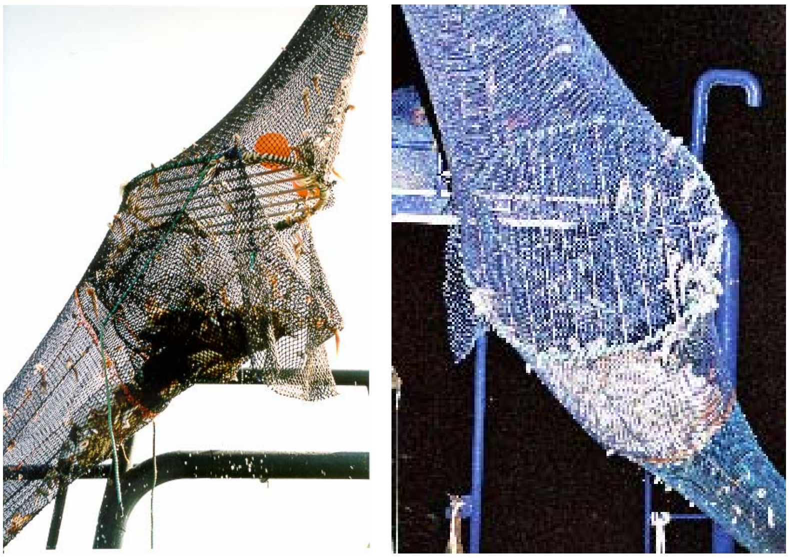


Figure 6-3. Examples of sponges and other debris fouling the escape opening of the TED.

Table 6-3. Summary of tiger prawn catches from each boat and TED + BRD rig tested. ‘-‘ indicates TED + BRD catch less than catch of standard net. n = number of paired trawl trawls. See Table 6-1 for description of details of trawl rigs tested.

Boat No.	Rig No.	n	Prawn catch (kg)		Catch difference		Mean difference	Catch range	
			TED + BRD	Std.	kg	%	kg	kg	%
1	1	9	241	296	-55.0	-18.6	-6.1	-17.3 to -0.3	-63.4 to -0.8
	2	15	588	605	-27.0	-2.8	-1.8	-24.6 to +7.2	-39.4 to +16.9
	3	18	576	619	-43.0	-6.9	-2.4	-7.6 to +2.0	-17.4 to +28.6
2	1	8	258	256	+2.0	+0.9	+0.3	-2.9 to +4.2	-14.6 to +11.9
	2	24	982	1 015	-33.0	-3.3	-1.4	-7.7 to +8.4	-18.6 to +11.2
	3	8	294	291	+3.0	+1.0	+0.4	-2.6 to + 4.7	-6.5 to +8.1
	4	3	106	110	-4.0	-4.0	-1.3	-3.2 to -0.2	-11.9 to -0.5
	5	8	247	244	+3.0	+1.3	+0.4	-1.3 to +3.5	-10.1 to +7.3
3	1	8	221	258	-37.0	-14.1	-4.6	-9.9 to +1.1	-32.9 to +4.1
	2	4	185	194	-9.0	-4.6	-2.3	-8.6 to +1.3	-11.6 to +4.6
	3	45	2 001	1 998	+3.0	+0.2	+0.1	-10.6 to+13.4	-24.7 to +42.9
	4	3	71	77	-6.0	-7.9	-2.0	-2.6 to -1.4	-9.6 to -5.7
4	1	15	233	290	-57.0	-19.6	-3.8	-7.9 to -0.3	-30.9 to 1.4
	2	16	292	288	+4.0	+1.4	+0.3	-3.2 to +8.4	-31.0 to +21.2

Large animal exclusion

Throughout the fishing season, the approved TEDs were successful in reducing the capture of large animals such as turtles, sharks and stingrays (Table 6-4, Figures 6-4, 6-5). Six turtles were caught in the standard net (all were released alive) but none in the TED + BRD net.

The capture of large sharks and stingrays was reduced by 88% compared to the standard trawl. The capture of large animals in the TED + BRD net was generally due to them becoming caught in the meshes of the net or guiding panel (if used), in the bars of the grid (Figure 6-6) or between the escape opening and cover; or swimming freely in the net and presumably having insufficient time to escape.

The number of sponges, rocks and shells in the TED + BRD net was also reduced by 79%. The capture of sponges in the TED + BRD net was largely attributable to Boat 4 using a small upward excluding grid with a small escape opening in a location of high sponge density (Figure 6-5). These sponges were generally located immediately ahead of the TED (see Figure 6-3 for examples). The use of a canvas mat immediately ahead of the TED (Figure 6-7) seemed to overcome this problem and assist the exclusion of sponges (and reduce prawn loss) from the trawl.

Table 6-4. Combined catch results of large animals, rocks and shells for four boats Visited during the 2000 tiger prawn season using approved TEDs and BRDs (excluding FV *Beachlands*) Note: '-' denotes a smaller catch for the TED + BRD net when compared to the standard net.

Catch Component	No. of trawls	TED + BRD Net (kg)	Standard Net (kg)	Catch difference (kg)	TED + BRD catch (%)
Turtles	226	0	5	-5	-100.0
Sharks and Rays	226	8	67	-59	-88.1
Sponge, rocks and shells	226	89	419	-330	-78.8

Figure 6-4. Catch from the bottom excluding Nordmore grid and Bigeye (left) and the standard net (right) from Boat 3 showing sponges and a large shark.

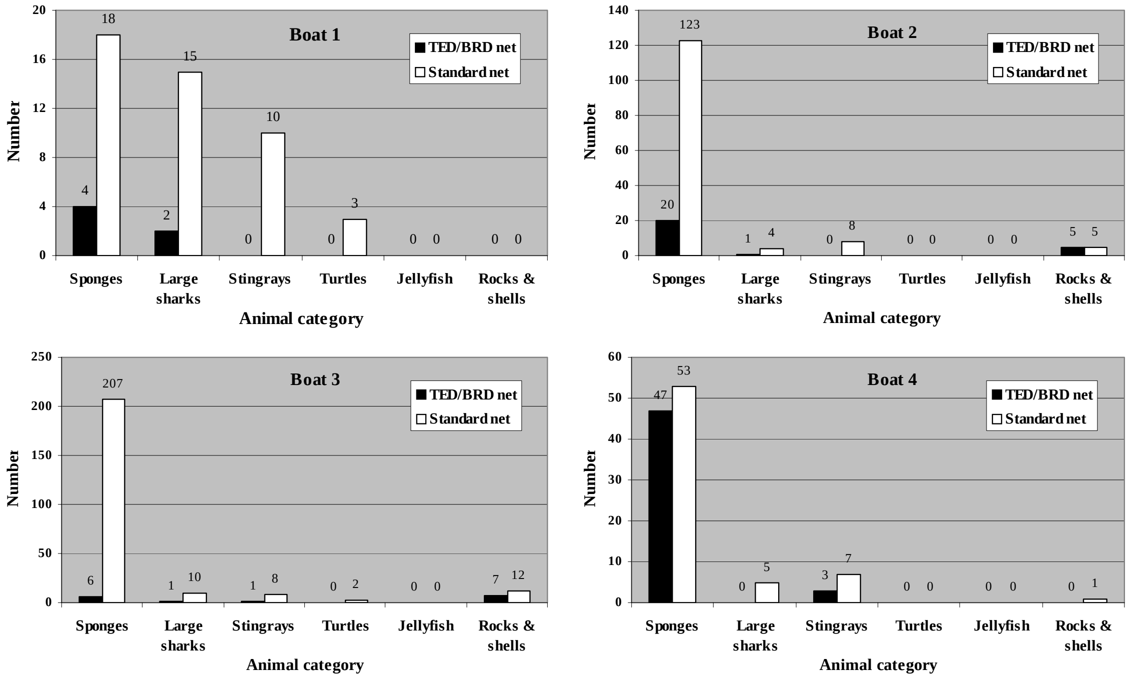


Figure 6-5. Comparison of catches (by number) of large animals, rocks and large shells between TED + BRD net and standard net for four boats sampled.

Figure 6-6. Large sawfish fouled in the bars of a TED.

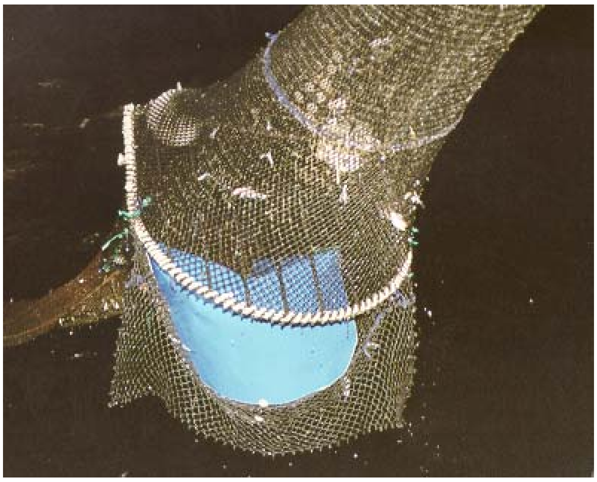


Figure 6-7. Canvas sheet attached to bottom of codend to facilitate the passage of sponges and debris from the trawl.

Small bycatch exclusion

The Bigeye was the most popular BRD used by the five boats to reduce small bycatch (Table 6-1). On all boats this device was located in the top panel of the trawl well ahead of the codend, and its popularity was due to concerns over perceived prawn losses from BRDs that are located in the codend. However, results from Boat 2 indicated that this may not be entirely correct, with both the RES and Fisheye (in combination with a TED) located in the codend and recording less than 2% prawn loss.

The assessment of small bycatch was achieved on average once or twice each night and for a total of 111 trawls. This data was collected from 3 boats including the FV *Beachlands*, (data from this boat is not included here). Usually this was assessed from trawls taken in the middle of the night. The weight of small bycatch in the TED + BRD net was reduced by over 900kg or 5.4% in comparison to the catch in the standard net (Table 6-5).

Table 6-5. Combined small bycatch results from Boats 2 and 3 during the 2000 tiger prawn season using approved TEDs and BRDs. '-' indicates TED + BRD catch less than catch of standard net (excluding FV *Beachlands*).

Catch Component	No. trawls	TED + BRD Net (kg)	Standard Net (kg)	Catch difference (kg)	TED + BRD catch (%)
Small bycatch	89	17098	18081	-983	-5.4

Bycatch assessment of the two boats indicated that the TED + BRD combination reduced small bycatch on average between 4kg and 50kg compared to the standard net (Table 6-6). The bottom excluding Swede TED with Bigeye BRD (Boat 3, Rig 3) was the most extensively tested combination and less than 4% of small bycatch was excluded from the trawl. A 25% reduction in small bycatch was also recorded on this boat, but this loss was attributed to a damaged Fisheye BRD and was accompanied by a 14% loss of tiger prawns. On Boat 2, bycatch assessment of the top excluding Nordmore grid and Fisheye combination over 16 trawls (Rig 2) resulted in an average 10kg reduction in bycatch per shot (5% reduction overall). While only tested for one night, catch results from the Nordmore grid and RES combination indicated approximately 18% of small bycatch were excluded from the trawl. This was accompanied however by a 4% prawn loss.

Table 6-6. Summary of small bycatch from each boat and TED + BRD rig tested. '-' indicates TED + BRD catch less than the catch of standard net. n = number of paired trawl trawls (Excluding FV *Beachlands*). See Table 6-1 for description of details of trawl rigs tested. Small bycatch data was not collected on all boats or for all rigs.

Boat No.	Rig No.	n	Bycatch (kg)		Catch difference		Mean difference	Catch range	
			TED + BRD	Std.	kg	%	kg	kg	%
2	2	16	3 248	3 408	-160.0	-4.7	-10.0	-45.0 to +25.0	-17.6 to +9.8
	3	8	1 600	1 632	-32.0	-2.0	-4.0	-23.0 to +15.0	-11.3 to +7.7
	4	3	408	496	-88.0	-17.7	-29.3	-37.0 to -21.0	-17.6 to -14.7
	5	8	1 294	1 410	-116.0	-8.2	-14.5	-50.0 to +14.0	-31.3 to +12.7
3	1	2	300	400	-100.0	-25.0	-50.0	-55.0 to -45.0	-28.9 to -21.4
	2	4	1 260	1 343	-83.0	-6.2	-27.7	-60.0 to +7.0	-19.9 to +1.4
	3	45	7 684	7 968	-284.0	-3.6	-6.3	-60.0 to +92.0	-26.1 to +21.4
	4	3	1 304	1 424	-120.0	-8.4	-40.0	-70.0 to -5.0	-11.4 to -2.3

Discussion

These trials indicate that well maintained and tuned TEDs can successfully exclude large bycatch species from the trawl with little or no prawn loss. Most TED + BRD combinations that were tested resulted in some prawn loss, although in some instances an overall gain was recorded. As these results reflect the performance of a TED + BRD combination tested over a short time (in some instances for only one or two nights) and with operators (usually) inexperienced in the use of these devices, the results should only be considered indicative, and not reflective of their performance in all locations within the fishery.

TED and BRD catching performance may differ between boats (particularly given different trawl configurations), towing speeds and handling practices. It is possible therefore that these results will be substantially improved in coming seasons as more experience with these devices is acquired. It is also worth noting that average catch losses reported here for a particular boat and TED + BRD combination are indicative of the performance of these devices for the entire time the gear technologist was on board. These averages therefore include the period when catch loss was highest (usually during the first few days testing) and lowest (usually after several days of systematic modification) as well as the occasional losses from an individual shot.

It should also be noted that many fishers blamed the TED for any loss of prawns, often assuming the BRD had little influence. However, BRDs can contribute to prawn loss, particularly during haulback when the catch may surge forward from the codend. In this project it was not possible to solely attribute losses to either device when both were installed in the net.

Despite demonstrating prawn losses, the general attitudes of fishers was that given time and experience the performance TEDs and BRDs will be improved. A small loss of catch was seen as inevitable given the relatively new fishing practice faced by the industry. Although fishers did acknowledge that this was partially compensated for by improved prawn quality. One company reported an average reduction in soft and broken prawns from 9% of total catch to less than 5%. Consequently, the quality of the prawns improved. There was also reports of reduced sorting times, fewer hazards to crew by some bycatch animals, and less time spent returning large animals back into the water.

The most extensively tested TED + BRD combination was the Swede TED and Bigeye. This combination was tested for 45 trawls and there was virtually no difference in the prawn catch between the TED + BRD net and the standard net. The TED was very effective in excluding large animals from the trawl, but the BRD was virtually ineffective in reducing the bycatch.

The most effective BRD, the Fisheye, which excluded up to 25% of the bycatch in each shot, also experienced high rates of prawn loss. However, the highest reduction in bycatch was actually caused by a damaged BRD and therefore is not reflective of the true performance of the device.

The average reduction in bycatch between the eight TED + BRD combinations (Table 6-6) was less than 10% compared to the standard trawl. Clearly greater efforts are required to improve bycatch reduction.

An example of the importance of regular maintenance and checking of the devices is reflected in the results from Boat 3. The initial two TED + BRD combinations tested did not perform well because of high prawn loss. However, upon closer inspection it was revealed that the Fisheye had been damaged. It was causing the distortion of the codend meshes adjacent to the device. This device was replaced with a Bigeye and retention of the prawn catch improved dramatically, although the rate of bycatch reduction also decreased.

The importance of matching TED design to the conditions of the fishing ground, is also shown by results from Boat 4. The first TED + BRD combination tested on this boat was an upward excluding TED in a region characterised by high sponge density. Grid angle was very low (~30 degrees), heavy weights were attached to the guiding funnel inside the TED and the escape cover extended over 15 meshes past the escape opening. In this region prawn loss was high because sponges blocking the bars of the TED increased the likelihood of prawns passing through the escape opening of the device. The second TED + BRD combination involved using the same TED but orientated as a bottom excluder, with grid angle set to 55 degrees. A shorter escape cover extending approximately 8 meshes past the escape opening was used. Over a similar number of trawls, prawn catches between the second TED + BRD combination and the standard net differed on average less than 1 kg per trawl shot.

The catch of sponges on Boat 3 also confirmed the benefit of using a bottom excluding TED in a region of high sponge density. In this case the TED + BRD combination caught over 95% fewer sponges than the standard net.

The correct rigging of the TED and BRD to the net is of paramount importance. On one boat the TED had been attached to the trawl in a manner that caused it to be oriented sideways during operation – clearly highlighting the need for regular checks of the device. Catching performance improved after the TED was rigged in the correct orientation. Further exacerbating the problem of prawn loss on this boat was the use of a ‘choker’ arrangement to attach the lazyline to the codend. In several instances this arrangement seemed to choke-off the codend, thus preventing entry of the prawn catch into the codend. This may have hampered the passage of prawns by holding them in the vicinity of the TED for a longer period and substantially increasing the possibility of loss through the escape opening.

6.3.2 Banana Prawn season (1 April – 28 May 2001)

During the 2001 banana prawn season data was collected from two boats. The TED + BRD combination used on board Boat 1 was a bottom excluding Swede TED with a Bigeye BRD. Boat 2 used a top excluding Super Shooter with Bigeye BRD and a bottom excluding Nordmore grid with Bigeye BRD. Catch data from 124 trawls were collected, and in the first two weeks of the season, an additional 37 trawls were collected for AFMA project No. R01/0228 (Boat 1 only). No small bycatch data were collected during this season.

Prawn catches

Prawn catches on board Boat 1 were compared between the TED + BRD combination and the standard net for the first two weeks of the season. Coloured wires were attached to each codend in a predetermined sequence (refer to Chapter 7: 'validating methods for measuring total bycatch'). When the codends were hauled on board the height of the catch with respect to the coloured wires was recorded. This method enabled visual catch comparison between nets to be made. An underlying assumption of this method was that catch volume was predominantly comprised of prawns. When time permitted attempts were made to weigh the prawn catch from each net.

A total of 37 trawls were assessed using the coloured wires and the results indicated that prawn catches in the TED + BRD net were more often than not even with the standard net (Table 6-7). Similarly, the number of trawls where the catch volumes differed between the two nets was relatively even.

It was possible to separate and weigh the catches from each net on seven occasions (Table 6-8). Despite high variability between nets, overall the TED + BRD net caught 4.2% (58kg) more prawns than the standard net.

For the remaining 3 weeks spent on board Boat 1, identical Swede TEDs and Bigeye BRDs were used in each net and the assessment using coloured wires was maintained. Even with devices installed in both nets the results (Table 6-9) are comparable to those collected for the TED + BRD net versus the standard net in Table 6-7.

Table 6-7. Prawn catch results from Boat 1 for the TED + BRD net when compared to the standard net (no-TED net) using coloured wires to indicate catch volume of each codend (No. of paired trawls = 37). No attempt was made to standardise towing conditions between tows. Both nets were fitted with an identical Bigeye BRD.

Catch volume (TED + BRD net v std. net)	No. of Trawls	% of Total No. of Trawls
TED + BRD net = std. net	20	54.1
TED + BRD net > std. net	9	24.3
TED + BRD net < std. net	8	21.6

Table 6-8. Boat 3 prawn catch results for seven trawls weighed during the first 14 days of the fishing season.

Trawl No.	TED Net (kg)	Std. Net (kg)	TED Net (± kg)	TED Net (± %)
1	122	140	- 18	- 12.9
2	301	231	+ 70	+ 30.3
3	77	77	0	0
4	287	337	- 50	- 14.8
5	420	364	+ 56	+ 15.4
6	133	133	0	0
7	105	105	0	0
Total	1445	1387	+ 58	

Table 6-9. Comparison of prawn catch results between the port net and the starboard net on Boat 1, using the coloured wires as catch volume indicators on the codends (No. of paired trawls = 31). Both nets contained identical TEDs and BRDs.

Catch volume	No. of Trawls	% of Total No. of Trawls
Port net = starboard net	17	54.8
Port net > starboard net	8	25.8
Port net < starboard net	6	19.4

Boat 2 tested both top and bottom excluding Super Shooter TEDs and a bottom excluding Nordmore TED. Quantitative catch comparison between the TED + BRD net and standard net was achieved for 7 trawls during this time (Table 6-10). This TED + BRD combination was used in a region of high sponge density and an average prawn loss of 5.9% (18.3kg) was recorded. Catch results for trawls 5 and 6 reflect improved performance following an increase in grid angle and use of a new escape cover. The prawn catch for shot 7 is the result of fishing in a region with very high sponge numbers. Despite a loss of prawns the skipper was impressed with the improvements in performance after the TEDs were modified and was appreciative of the knowledge gained.

Table 6-10. Comparison of prawn (tiger and endeavour) catch between TED + BRD net and standard net on Boat 2.

Shot No.	TED Net (kg)	Std. Net (kg)	TED Net (± kg)	TED Net (± %)
1	35.7	36.4	- 0.7	- 1.9
2	28.5	28.6	- 0.1	- 0.3
3	35.0	42.7	-7.7	- 18.0
4	39.7	46.6	- 6.9	- 14.8

Shot No.	TED Net (kg)	Std. Net (kg)	TED Net (± kg)	TED Net (± %)
5	61.0	57.6	+ 3.4	+ 5.9
6	43.7	44.1	- 0.4	- 0.9
7	50.1	56.0	- 5.9	- 10.5
Total	293.7	312.0	- 18.3	

Large animal catches

The TEDs were very successful in excluding large animal bycatch from the trawl, in particular turtle, stingrays and sponges (Table 6.11, Figure 6-8a). No turtles were caught by either net and all seasnakes were released alive. Some problems were experienced when sawfish became entangled in the net (Figure 6-8b). These animals were usually caught in the netting immediately ahead of the TED where the netting tapers towards the codend.

Figure 6-8. (a) The effectiveness of a TED is obvious and the prawn catch was even between nets, (b) although sawfish do not always find their way to the TED and become fouled in the netting,

Table 6-11. Large animal catches for Boat 1 (n=37) and 2 (n=28) during the 2001 banana prawn season when the TED was removed from a net.

Boat No	Sponges		Sea snakes		Stingrays		Sharks		Turtles	
	TED	No TED	TED	No TED	TED	No TED	TED	No TED	TED	No TED
1	0	0	2	4	1	14	0	0	0	0
2	9	105	8	10	0	9	0	3	0	0
Total	9	105	10	14	1	23	0	3	0	0

Discussion

Above average catch rates and the hectic nature of banana prawn fishing meant that it was usually impossible to keep the catches from each net separated. In many instances the codends were so full of prawns that mixing of the catch between nets and spillage onto the deck was unavoidable when the drawstrings were pulled (Figure 6-9). Also complicating the testing process was that it was not always possible to process the entire catch before the catch from the following shot was emptied onto the tray. The presence of catch hoppers further hampered the ability to separate catches because there was no way to keep catch from each net separated.

Figure 6-9. Large catches spilling onto the deck and adjacent sorting trays hampered catch comparison between nets.

Comparison of prawn catches between the TED + BRD net and the standard net (Table 6-7) appeared to suggest that the presence of the TED + BRD combination had little effect on overall banana prawn catches. For over half of the trawls recorded there was little difference in catch volume between nets, while higher catch volumes were recorded almost equally between nets for the remaining trawls. When identical TED + BRD combinations were used in both nets (Table 6-9) the relative proportion of trawls with similar or higher catch volume was comparable to those trawls with one TED removed. Collectively, this may mean that the influence of the TED + BRD combination on prawn catches was little different to that of a standard trawl. Due to the nature of commercial fishing, controlled tests of two nets without TEDs installed was not conducted. It may also mean that the influence of the BRDs in reducing bycatch was unable to be detected in this study.

Catch losses were occasionally experienced due to wash-back (flushing) of the prawn catch through escape openings of the TED or BRD during hauling of the nets. This problem occurred either when very large catches were collected in the codend and/or the weather was poor resulting in catch surging through the codend. Prawns located between the TED and lifting points on the codend (‘elephant ears’) were particularly at risk of escaping through the escape openings, especially as the codend was hauled on board.

This problem was overcome by some operators installing a washback funnel. This is a funnel of loose netting fitted directly behind the TED to act as a non-return valve. When fishing, the funnel remains open and allows catch to enter the codend. When the boat slows or stops, the funnel collapses and prevents catch in the codend from moving forward towards the escape opening of the TED. With smaller prawn catches the loss of banana prawns in this way was not a frequent occurrence.

The loss of tiger and endeavour prawns on Boat 2 occurred in areas characterised by high sponge density. Modifications to the TED appeared to improve performance somewhat, although given low shot numbers, further assessment is required.

Another problem with the use of TEDs during the Banana season was the slow deployment of the trawl gear when a prawn mark was found. Care needed to be taken when deploying the TEDs to ensure correct orientation and the absence of twists in the codend. Failure to check for this could potentially be disastrous because the passage of prawns into the codend would be blocked and they could be lost through the escape opening of the TED.

Many operators were reluctant to stream their nets while a TED was installed in case damage to either the TED or trawl (as a result of the TED) occurred. Some fishers kept their gear on board while searching for prawns.

A good banana prawn fishing season in 2001 for most operators appeared to offset many concerns related to TED performance and catch losses. Very few negative comments relative to TEDs were received during the season other than those related to prawns surging forward in the codend and escaping through the escape openings (washback). This usually occurred when very large catches of prawns were being landed. Several operators expressed concerns about having to use BRDs during the height of the banana prawn season given the nature of aggregating banana prawn marks and the lack of fish bycatch.

Very few operators showed an interest in trying to develop new or improved methods to reduce small bycatch, or devote time and effort to experiment with alternative designs. Most operators preferred to use the Bigeye BRD because it was located far from the catch in the codend and perceivably less susceptible to catch loss. There were questions raised on the suitability of the Bigeye in reducing bycatch and some felt that Bigeyes should not have been certified for use in the NPF. Some operators expressed an interest in experimenting with new ideas during the coming tiger prawn season.

Despite the lack of catch data, operators received assistance in tuning their TEDs and BRDs to help prevent or reduce prawn loss. Whilst only two boats were boarded during this period, assistance was also provided to several other operators via radio contact and when visiting mother ships or barges.

6.3.3 Tiger Prawn season (4 August – 9 November 2001)

During the 2001 tiger prawn season, the role of the gear technologist changed to reflect the needs of the project. During this time 5 observers, including the gear technologist, spent most of the fishing season on board separate vessels comparing the performance of a TED + BRD combination against a net without any bycatch reduction devices. The testing conditions required no changes to be made to the fishing gear by the observers, hence little data related to the modification of TEDs and BRDs were collected. Detailed prawn and bycatch results highlighting the performance of devices assessed during this season are described in Chapter 10: ‘Changes in NPF catches due to TEDs and BRDs’. The following section describes the operating performance of the TEDs and BRDs and operator attitudes.

Results

Four boats were boarded during the season and catches from 344 trawls were assessed. Assistance was given to operators in modifying spare devices not in use and in ways of improving TED and BRD performance. Compared to previous seasons, the operators had a greater understanding of TED and BRD performance, however, when catch losses were evident, the causes were common to those experienced in past seasons. These included poor TED construction and maintenance and over-tuning the TED to prevent catch losses. Some TED frames were laced into netting extensions very loosely, with the result that loss of grid angle occurred as the netting became stretched. Others were using top excluding TEDs in areas of high sponge densities hoping that any caught sponges would move up the grid and out the escape opening. Escape covers made of netting were often installed with incorrect knot orientation or required replacement because of stretched meshes. Instruction was given on identifying these problems and preventing them from occurring in the future.

Most operators from boats boarded during the season were relatively happy with the performance of their TEDs. Many skippers recognised the benefits of TEDs in reducing the capture of large animals (monsters) (Figure 6-10) and improving prawn quality. At times it was difficult to get permission from an operator to remove a TED from one of the nets.

On the other hand, many operators were not very confident in the ability of the BRDs to reduce smaller bycatch species from their nets. As with past seasons, the Bigeye was the most common BRD used by operators. This was generally based on catch retention abilities rather than bycatch reduction potential.

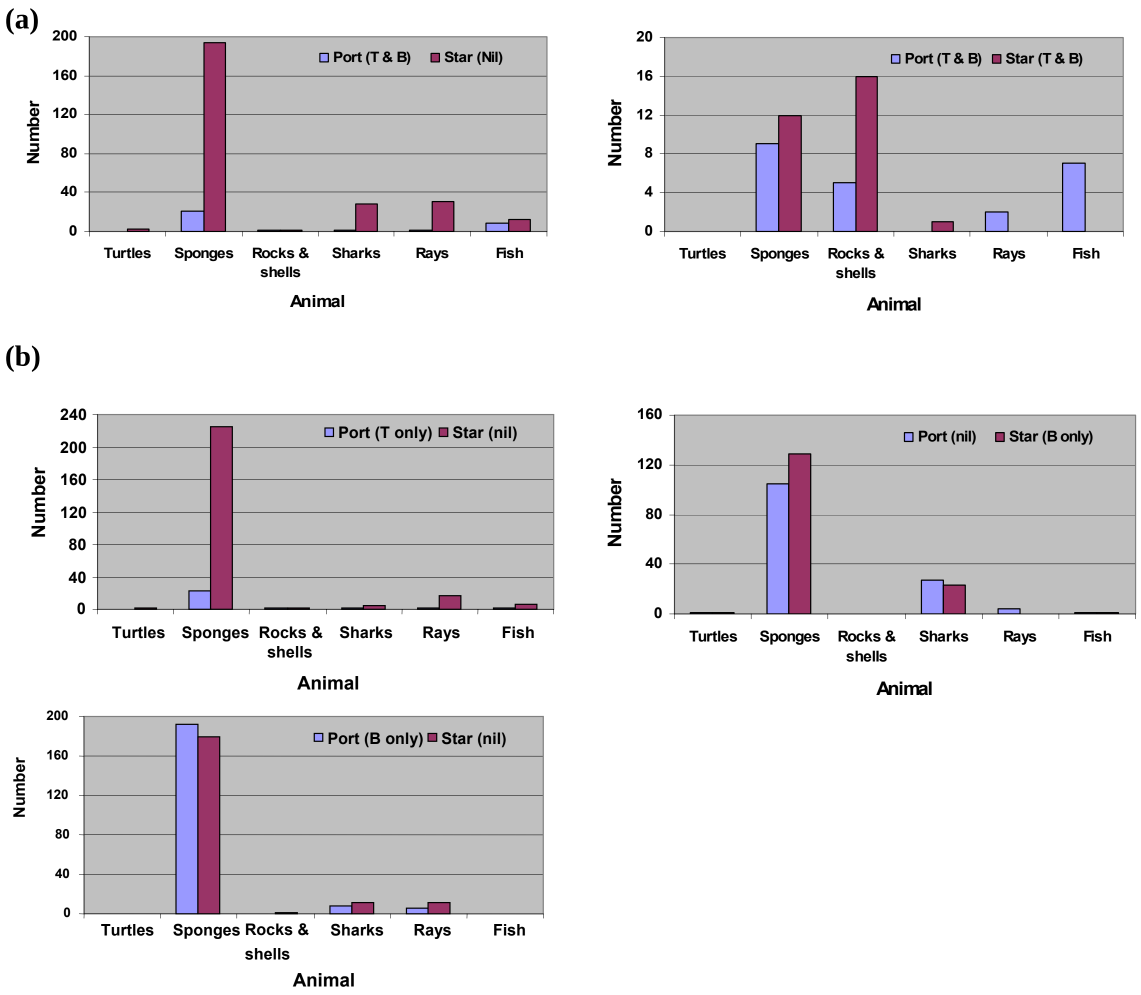
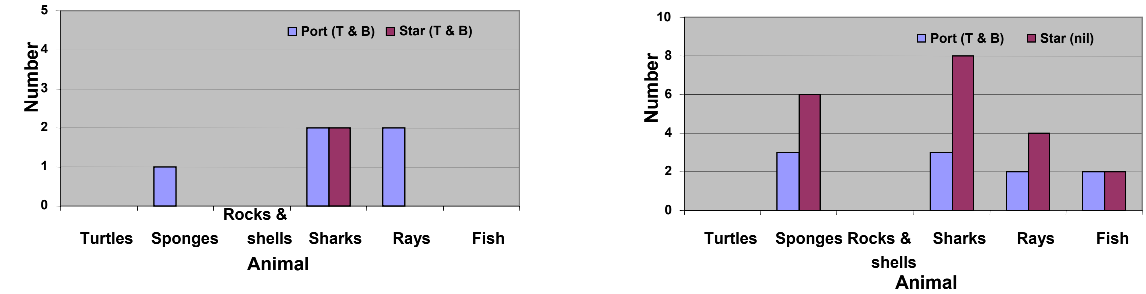


Figure 6-10. Comparisons of large animal (monster) catches for the four boats boarded during the 2001 tiger prawn season. Note there were several comparative tests on all boats except Boat 4. (a) Boat 1 and (b) boat 2

(c)



(d)

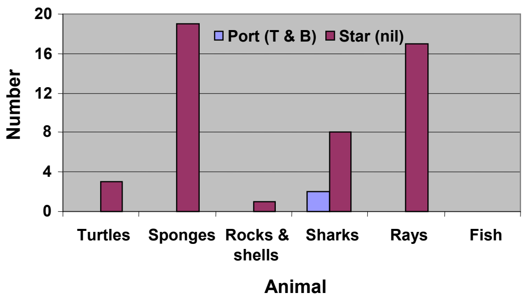


Figure 6-11. Comparisons of large animal (monster) catches for the four boats boarded during the 2001 tiger prawn season. Note there were several comparative tests on all boats except Boat 4. (c) Boat 3 and (d) boat 4

Discussion

The best method of assisting fishers with improving the performance of devices has been by progressively fine-tuning the devices in use and allowing the fishers to see the results in the catches. This was not possible during this season because any changes to the gear may have affected the performance, and therefore, the data collected. The objective was to assess the current status of TED and BRD performance and thus any modifications would potentially bias the obtained results. Results detailing the performance of devices assessed during this season are described in detail in Chapter 10: ‘Changes in NPF catches due to TEDs and BRDs’.

6.4 Discussion

This project has enabled the catching performance of many TED and BRD combinations to be assessed under commercial operating conditions and the assessment of modifications to improve performance. In the majority of instances, the catch comparison was made between a net with a TED + BRD combination and a standard net (TED and BRD removed). In this way the performance of the TED with regard to large animal catches could easily be assessed. However, it was sometimes not possible to directly attribute variations in the prawn catch or the remaining bycatch to either the TED or the BRD. A significant outcome of this project has been the role of the gear technologist in passing on the ability to assess and improve the performance of reduction devices to operators in this fishery.

From an ecological perspective the use of TEDs by operators in this fishery has been very successful. Nearly 100% of turtles that enter the trawl are now excluded, as are most other large animals (also see Chapter 10).

Problems with TEDs still remain. In particular, the incidence of prawn loss associated with being 'TEDDed' has not been entirely overcome. In many instances the fear of prawn loss has led operators to over tune their TEDs in the mistaken belief that these modifications will solve the problem. Many operators have experienced problems with prawn loss using BRDs. Despite reports of bycatch reductions of 15% or more, the performance of these devices requires further development.

At the culmination of this project, there are several outstanding issues that directly or indirectly hamper the ability of operators to optimise TED and BRD performance and reduce prawn loss. These include:

6.4.1 Between-net catch variation and identifying catch losses

One of the difficulties faced when assessing TED and BRD performance was high catch variability between the port and starboard nets. Before the introduction of these devices operators could easily compare catches between nets and modify the net that was catching less prawn. This comparison assumed that equal numbers of prawns were available to both nets. However, with a TED and BRD fitted to both nets it is not possible to determine if the cause of prawn loss is the net or the bycatch reduction devices. Current regulation requires that a TED and BRD be fitted to both nets at all times, thus the removal of these devices to assess net performance or the performance of the TED and BRD combination is not permitted. Operators are therefore reliant purely on their own experience, knowledge and understanding of what effects TED and BRD performance and the ability to then be able to identify and rectify problems as they arise. Unfortunately this ability has been found wanting in many instances and operators are therefore commonly making excessive or inappropriate modifications to their TEDs in the hope of reducing prawn loss.

6.4.2 Over-tuning TEDs

Over-tuning of TEDs is a term used to describe excessive or inappropriate modifications to the TED in order to reduce prawn loss. This loss typically arises from the poor design, rigging or maintenance of a TED, or the poor selection of a TED for a particular fishing ground. Examples include incorrect grid angle, orientation or escape flap design, and the use of small grids in grounds with high sponge numbers.

The chances of prawn loss are determined by the ease and speed with which bycatch is excluded from a TED. A well-tuned TED will rapidly exclude large bycatch from the trawl, thereby reducing blockage of the grid or escape opening. The escape flap (if used) will also be seated against the codend for longer periods and the opportunity for prawns to escape will be minimised. The use of excessive flap lengths, heavy weights attached to trailing edge of the flap on a top excluding TED, and the use of floats on the flap of a bottom excluding TED are examples of over-tuning. Frequently, these modifications are used because of problems elsewhere with the TED. Examples include low grid angles caused by stretched lashings to the TED or adjacent netting. These modifications may keep the flap well seated against the codend. However, they delay the exclusion of rocks, sponges and other large bycatch from the trawl, and prawn loss may occur as the bycatch slowly exits the trawl. Removal of these modifications was required on many boats and the impact of their removal was usually dramatic (Figure 6-11).

One example occurred when an operator had successfully overcome prawn loss in clear grounds by increasing the length of the escape flap and adding weight to the trailing edge of the flap.

These modifications were required because the TED was too small and set at too shallow an angle, hence the escape flap did not seal correctly. Upon making these modifications the vessel moved to a region characterised by high sponge numbers. The average prawn loss over the next

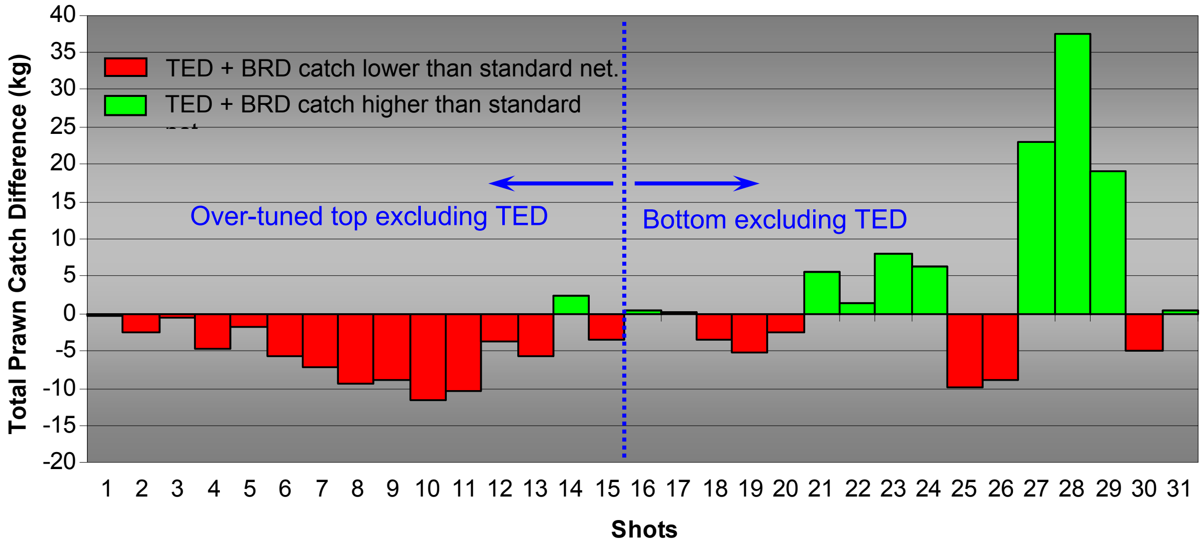


Figure 6-12. The effect of TED over-tuning on catching performance. The dotted line indicates re-rigging of TED + BRD net to make the TED more suited to the conditions of the fishing ground.

6.4.3 BRD Performance

This project demonstrated that although BRDs reduce small amounts of bycatch, further efforts are required to improve their performance. Research efforts to reduce bycatch in this fishery in recent years have focussed mainly on the development of effective TED designs because of threats to vulnerable turtle populations and associated stakeholder concern. The economic benefits of using TEDs, such as improved catch quality and crew safety, have also aided the emphasis on TED research.

In contrast, there has been relatively little effort by operators to develop effective bycatch reduction devices, and there are currently few economic benefits to be realised from reducing fish bycatch. Currently, the vast majority of operators select a BRD design based on its ability to retain prawn catch rather than reduce bycatch. This is evident with the popularity of the Bigeye BRD that is located in the top panel of the net approximately midway between the trawl mouth and codend. All other BRDs must be located in the codend in close proximity to the accumulated catch, and although in this area BRDs have a greater likelihood of reducing bycatch, the risk of associated prawn loss is also higher.

Some operators are experimenting with new designs or modified BRDs with positive anecdotal results being reported. One of these devices is a Square mesh panel with a guiding panel fitted beneath the open meshes. This panel serves two purposes, primarily prevention of prawn loss by guiding prawns below and behind the square meshes of the device, and generating water turbulence around these meshes that might assist fish to escape. Other operators are experimenting with a fish box BRD that influences water turbulence to aid fish escape. However, the vast majority of operators persist with devices renowned for maintaining target catches rather than reducing bycatch.

6.5 Conclusion

During this project significant steps have been taken to assist operators in optimising the performance of TEDs and BRDs in the Northern Prawn Fishery. The role of the gear technologist coupled with pre-season workshops, various literature and word of mouth communication between operators, project staff and others have all contributed to increase operators' knowledge in use and operation of TEDs and BRDs.

TEDs are now successfully excluding almost 100% of turtles and most other large animals from the trawl. The incidence of these animals becoming fouled in the TED and the associated prawn loss ('TEDDed') is still a problem. As operators improve their ability to use these devices such incidents will hopefully become rare events. The over-tuning of TEDs continues to be a problem but ongoing publicity by project staff, experienced operators and others will, over time, result in greater awareness about the impact of such modifications and provide knowledge of appropriate alternatives.

The current range of BRDs used in the fishery is reducing small fish bycatch. However, this is frequently by less than 20% in comparison to a standard trawl. Most operators understandably select and locate devices that will minimise prawn loss, however, this usually means a compromised ability to exclude bycatch. While research is underway to use behavioural differences between prawns and bycatch, including the use of water turbulence to assist bycatch exclusion, additional efforts will be required to further increase bycatch reduction.

CHAPTER 7

TRIALING METHODS FOR ESTIMATING THE WEIGHT OF SMALL BYCATCH IN CODENDS

Chapter Author:

Don Heales

CHAPTER 7

CHAPTER 7

TRIALING METHODS FOR ESTIMATING THE WEIGHT OF SMALL BYCATCH IN CODENDS

Don Heales

Summary

The Observer Program had an objective to measure the difference in small bycatch between the Standard nets (no TED or BRD fitted) and the Treatment nets (TED + BRD, TED only or BRD only nets). In order to find the most reliable and accurate method of measuring differences in the weight of Small Bycatch between nets, we tested electronic load cells and codend markers. Firstly, an electronic load cell was installed above the lazyline block to weigh the full codends before they were spilled onto sorting trays or hoppers. The weight of prawns in the codends was subtracted to give the small bycatch component of the catch. Secondly, a series of coloured markers were tied to the codend to indicate the height of the catch inside before the codend was spilled. These estimates were compared with the estimate from collecting the entire trash chute bycatch in lug baskets and weighing them. In order to calibrate the accuracy of using codend markers to estimate the small bycatch component in codends, we added successive aliquots of small bycatch (40 kg each) to an empty codend, marking the height of the catch inside the codend.

Due to technical difficulties in zeroing the load cells after heavy vibration, the electronic load cell question remains unresolved with further testing required. The codend markers showed potential for estimating the Small Bycatch component of a catch but the accuracy was unlikely to be useful for measuring small differences in bycatch between nets. The pattern of accuracy of the calibration was similar to that shown in the field trials. In hindsight, the trial was flawed by the use of an old codend and a technique of lowering the codend to the ground before each new aliquot of bycatch was added. The results of both methods demonstrate that there is potential for calibrating new codends with a series of markers and using them on commercial trawlers in the field for estimating total small bycatch. The 2001 Observer Program used the time proven but laborious method of collecting and weighing the entire small bycatch in lug baskets as the best option for estimating differences in small bycatch between the Standard and the Treatment nets. The results show promise for estimating the small bycatch component from using standardized and calibrated codends with markers on commercial vessels.

7.1 Introduction

There is clearly a need for a reliable field method of estimating the weight of the small bycatch in the codends of prawn trawlers. This is necessary to be able to estimate the total bycatch taken each year within prawn trawl fisheries, and to accurately calculate the catch rates of species identified in subsamples.

Before the compulsory use of Turtle Excluder Devices (TEDs) in the Northern Prawn Fishery (NPF), the codends regularly contained large sharks, rays, sponges and fish, all of which made estimating the total catch weight and the small bycatch component (unwanted small teleosts and invertebrates) difficult.

However, the use of TEDs has had a grading effect on the catch due to the spacing of the bars (around 110-120mm between adjacent pairs). Consequently, most sharks greater than 1m long, rays wider than 1m and sponges wider than 0.3m are excluded (see Chapter 10). The bycatch caught in the codends now is much less variable in size. Apart from the target species of prawns, and some byproduct, the remainder is mostly unwanted small bycatch, or trash chute bycatch.

In the NPF, two of the many options for estimating the unwanted small bycatch component in catches are:

1. To estimate the total catch size from the codends before they are spilled on to the sorting trays or hoppers, and to subtract the weight of all the other components of the catch that are routinely separated or can easily be measured (e.g. the target species, byproduct, and elasmobranchs) from the total catch.

2. To collect and weigh the entire unwanted small bycatch using lug baskets, after all the target species and byproduct have been removed. This second method is the more accurate but extremely labour intensive.

One of the objectives of this project was to measure the differences between catches from (a) nets with some combinations of TEDs and BRDs, and (b) nets without these devices (control or Standard nets). Finding a reliable field method for recording differences in weights between nets for the small bycatch was important for planning the Observer program sampling procedure, and led to the field and laboratory trials reported here.

7.2 Trialing of methods

In the year 2000, research was undertaken on board the NPF vessel FV *Apolloair* and FV *Austral* during commercial operations in the Gulf of Carpentaria. One important objective was to establish a working method for measuring the difference in small bycatch between different net types. This included assessing the potential for estimating the total catch in a codend before spilling (the majority of the total catch is unwanted small bycatch when TEDs are installed).

Two methods were evaluated:-

- using electronic load cells to weigh codends
- using the catch height in codends as an indicator of small bycatch weight.

These methods are described in detail below.

7.2.1 Electronic load cell to weigh codends

An in-line electronic load cell was rigged between the overhead lazyline block and it’s "A frame" support (see Figure 7-1. for approx. position). The lazyline runs through this block when winching the codends on board for spilling on the sorting tray at the end of a trawl. The weight of the full codend directly suspended above the sorting tray could then be measured before spilling the catch. The weight includes the net suspended above the sorting tray plus the weight of net hanging back into the sea.

The load cell was rated to 5 tonnes which would have been adequate for most lifting situations in the tiger prawn fishery where most codends weigh less than one tonne. Any larger codends would normally be winched on board using a single lift block.

Figure 7-1. Deck layout showing position of load cell above lazyline block.
(Photo- Q. Dell)

Results

The load cell was unable to be dampened sufficiently during the winching in of the lazylines and gave spurious readings, including when the codend was suspended in the air directly below the load cell and ready for spilling of the codend. This problem was not rectified when the codend was lowered on to the sorting tray to take the strain off the load cell; the cell zeroed again; and the codend lifted for weighing.

At this stage, there was no further work conducted on this method.

Conclusions

Despite these teething problems, this method still holds promise and needs to be further tested in field situations.

7.2.2 Catch height in codends as an indicator of small bycatch weight

Catches in the codends of NPF vessels using TEDs can be expressed by the following Equation 1:

TOTAL CATCH = (Target spp + Small sharks/rays + Sponges + Small bycatch)

Because of the grading effect by TEDs on catches, the biggest component of the total catch in most catches is the small bycatch. Field trials were undertaken to test whether the weight of small bycatch in the codends could be represented by the height of the total catch in the codend.

7.2.3 Field trials - Catch height markers in codends calibrated against lug basket estimates of small bycatch weight

Small bycatch estimate from the catch height in the codend

A series of coloured light rope markers were used to indicate the height of catch in the unspilled codends. The markers were tied in a vertical line up one side of the codend on one of the nets on the fishing vessel (see Figure 7-2 for siting of markers). The first marker was set at 10 meshes above the drawstrings and others followed at intervals of 4 meshes to a height of 46 meshes above the drawstrings. At the end of each commercial trawl, the codends were winched aboard for sorting of the catch. As the codend rested against the side of the sorting tray, the crew member controlling the drawstrings, estimated the height of the catch in the codend, using the nearest two coloured markers as the reference heights. The height was converted to an estimated number of meshes above the drawstrings for later comparison with the catch weight estimated from the lug baskets.

Small bycatch estimate from the lug baskets

After the codend had been spilled, the crew commenced sorting the catch from the sorting tray. All the larger elasmobranches, sponges, and fish were separated from the catch of the codend that had already been visually estimated for its weight. The crew then extracted the prawns and byproduct from the remainder of the catch. The only remaining bycatch was the small bycatch component from that codend. The trash chute, which normally directs the small bycatch directly into the sea, was disconnected, and the entire small bycatch from that codend was collected in lug baskets. Each basket was filled to approximately the same height just below the handles, using a plywood catch levelling device (see Chapter 9, Figure 9-21).

The series of levelled baskets were individually weighed to get an average basket weight. This average weight could be applied to all the replicates of this comparison because the composition of the small bycatch was considered to be consistent throughout the period.

The weight of the small bycatch component of the catch from each codend, was calculated by multiplying the number of full (levelled baskets) of bycatch by the average weight per basket, and then adding on the weight of the last partially filled basket. This basket was weighed on 50 kg scales.

At the completion of each replicate, one matched pair of estimates was available, consisting of:
(a) the height of the catch in the codend, estimated by the crew in numbers of meshes from the codend drawstrings, and
(b) the weight of small bycatch from the same codend (from the lug baskets)

The paired estimates for each codend were plotted to assess whether using codend markers (i.e. catch height) provided a reasonable estimate of the small bycatch in codends.

Results

A total of 34 separate codends were measured using this technique. There was a wide range of weights for any given height of catch in the codend indicated by the number of meshes from the drawstrings. For example, individual estimates of total catch weight from lug baskets for those catches with heights around 18 meshes from the drawstring, ranged from 90 to 240 kg.

The paired data of total catch weight and height of catch in meshes, was grouped into class intervals of 2 meshes and the means calculated (± SE) for each group where sufficient numbers of estimates existed (see Figure 7-3). The expected trend towards total catch size increasing with the height of catch was evident.

Conclusions

Using the codend markers to estimate the total catch and subsequently, the small bycatch component of the total catch, shows some potential to be useful, especially for estimating the total bycatch from a codend.

However, further field testing is needed to establish how accurately fishers can estimate the size of the catch from the size of the codend before spilling.

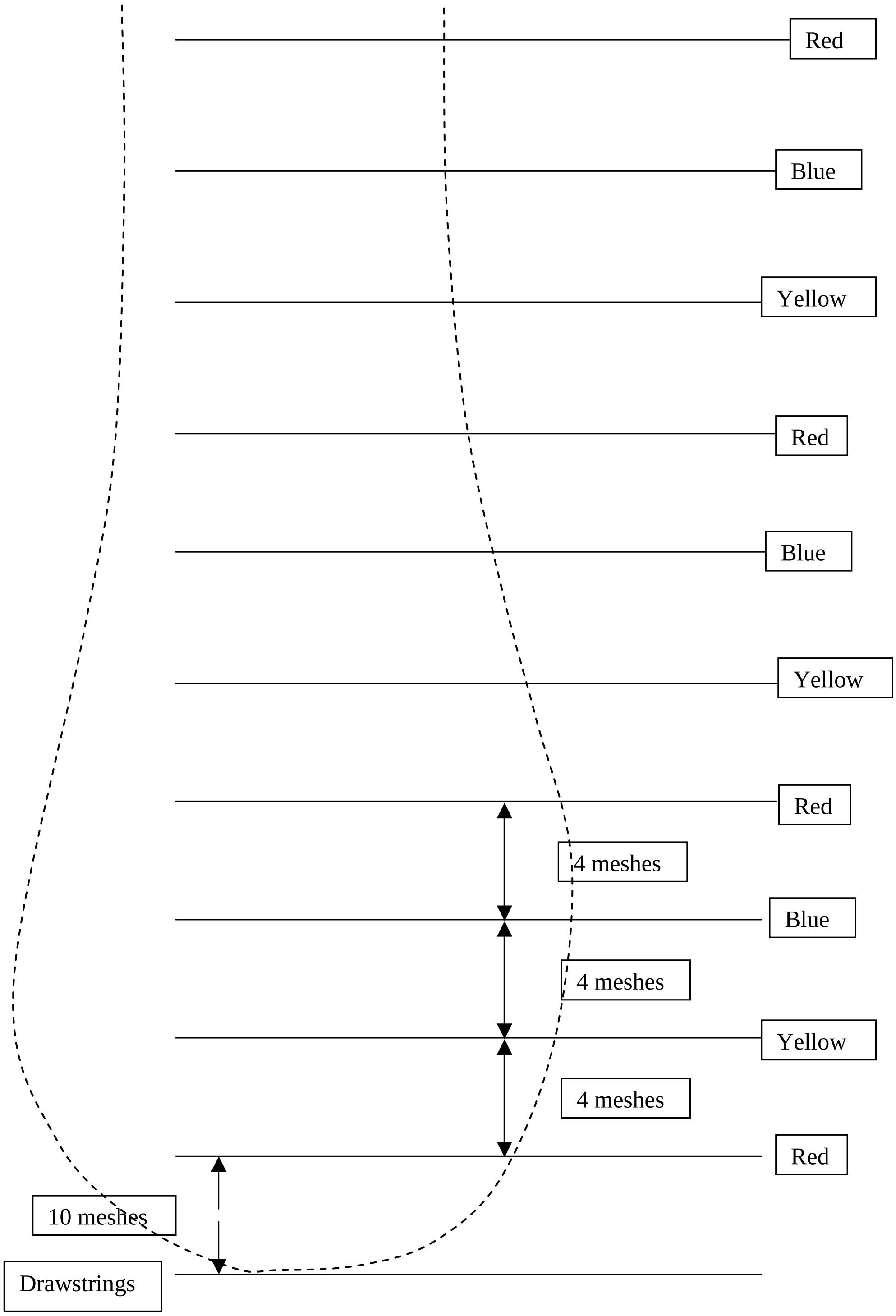


Figure 7-2. Schematic diagram showing the siting of the series of coloured markers tied to codend meshes during field trials.

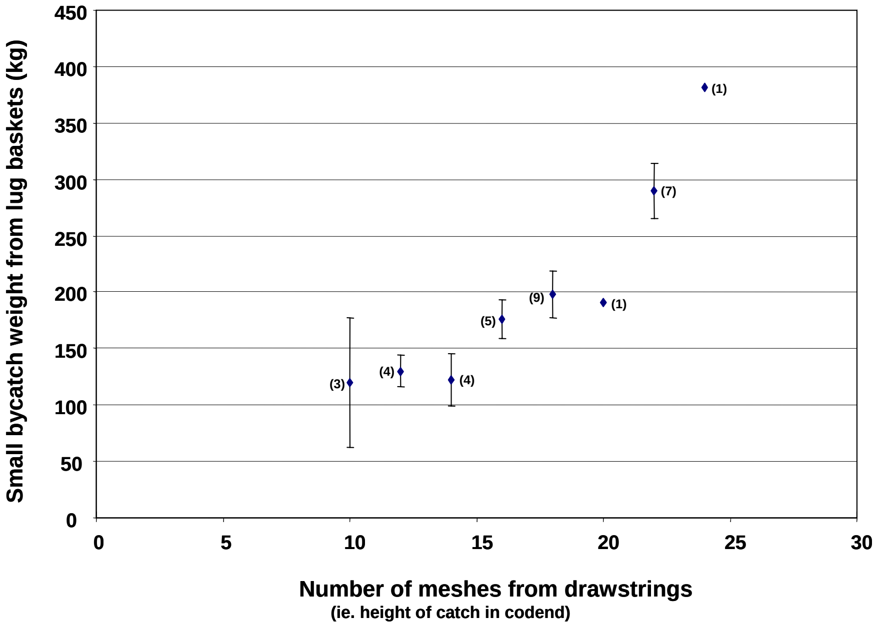


Figure 7-3. Means (± SE) of the 34 pairs of estimates of the height of the catch in the codend (as indicated by the number of meshes from the drawstrings) compared with the lug basket weight of all the trash chute small bycatch. Data were grouped into class intervals of 2 meshes. (n) = number of estimates for each mean plotted.

7.2.4 Laboratory trials - Calibration of a codend using known volumes of bycatch

As a corollary to the second method (field trials) of estimating the weight of small bycatch in codends (see Chapter 7.4.1), an attempt was made to calibrate a codend with known weights of bycatch, in order to test the possible accuracy of this method. The codend calibration trial was undertaken at CSIRO Cleveland laboratories.

While on board FV *Apolloair*, a project member collected approx 900 kg of small bycatch from a series of trawls. The bycatch was snap frozen so that it would remain in good condition after thawing. The frozen samples were transferred to Cleveland laboratory.

A used codend (150 by 150 mesh * 50mm) was fitted with a solid steel ring to allow lug baskets of bycatch to be easily tipped inside. The frozen bycatch was thawed out in a large water tank and scooped out into lug baskets which were levelled to approx 40 kg each, using a plywood catch leveller (See Chapter 9, Figure 9-21 for example). A single basket (40 kg) was tipped into the already tied codend and a crane used to lift the codend (see Figure 7-4). While the codend was suspended above the ground, the height of the catch inside the codend was estimated and marked by tying a cloth marker through the mesh that best represented the height of the top of the catch. The codend was then lowered to the ground again and another lug basket of bycatch was added. This incremental process was repeated until the entire bycatch had been added to the codend and a series of catch height markers tied in their respective positions.

At the completion of the process, each tied marker indicated the number of meshes from the drawstrings for a known cumulative catch weight.

Figure 7-4. A codend being calibrated with known weights of small bycatch (CSIRO, Cleveland, Qld).

Results

The cumulative weight of catch was then plotted against the respective heights up the codend, as indicated by the number of meshes from the drawstrings.

The calibration curve (see Figure 7-5) is not linear and tends to be flatter than was expected. This was true especially in the range where the majority of NPF catches probably fall, between 100 kg and 500 kg per codend (pers. comm.).

In hindsight, there were two problems associated with the calibration process in the laboratory. Firstly, using a worn codend meant that much of the stiffness associated with newer codends was absent. The shape of the fully loaded codend was obviously different to the shape of codends in the field (see Figure 7-4).

Secondly, the ring that was inserted into the codend to make incrementing the bycatch easier, probably compounded the bellying effect by keeping the diameter of the catch wider than normal. Consequently, each time that the crane lowered the codend to the ground to increment the catch weight, the catch within the codend spread out on the ground. The codend then tended to remain at the wider diameter until the next 40 kg was added.

Conclusions

Although the calibration process was not successful, there is still merit in using the height of the catch in codends to estimate the total catch. The results demonstrated here and during the field trials confirm the possibility of estimating the total catch from the size of the codend before spilling.

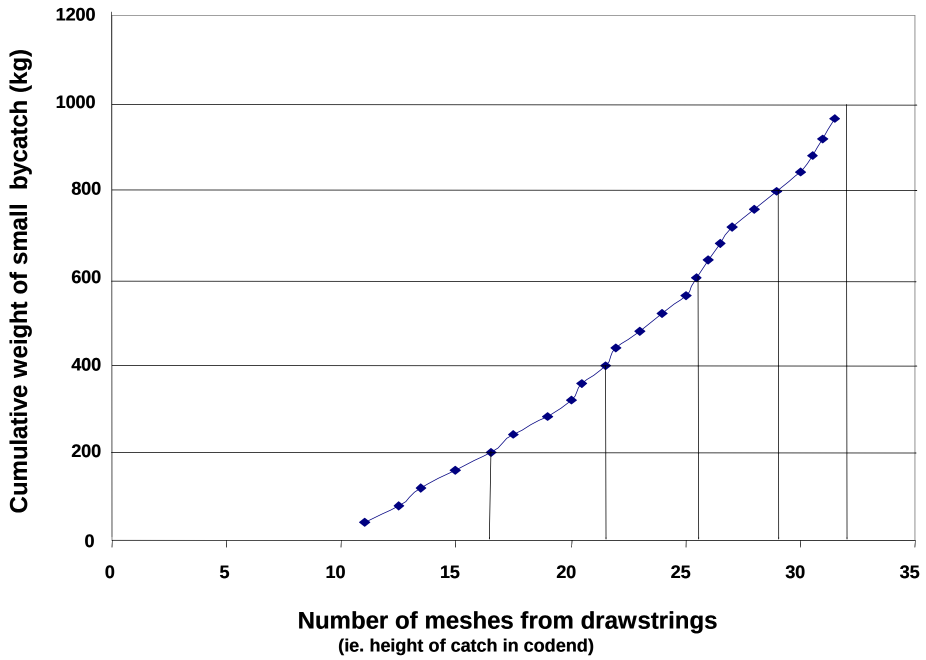


Figure 7-5. Plot showing the relationship between the height of small bycatch in the codend (indicated by the number of meshes from drawstrings) and the cumulative weight of small bycatch in the codend. (Codend size =150 by 150 mesh by 50mm).

7.3 Overall conclusion

In order to more accurately achieve the project objectives of measuring differences in the small bycatch, the labour intensive, but more reliable and accurate method of weighing small bycatch in the lug baskets was instituted. We expected the difference in small bycatch between Treatment and Control nets to be less than 10% (pers. comm. NPF fishers). Based on the results reported in this section, we did not expect that estimating the small bycatch components from the size of codends using codend markers would be able to provide the accuracy needed to detect differences around 10%.

We did however attempt to reduce the numbers of lug baskets that needed to be weighed by the use of catch levelling device (see Chapter 9, Fig. 9-21). These were plywood inserts that were inserted into the top of the lug basket to ensure that the baskets were filled to the same height every time. By weighing a series of baskets filled to that level and calculating the average weight per basket we could then use the average weight as a multiplier and add on the weight of the last partially filled basket, which still had to be weighed individually.

The use of codends fitted with markers attached to the outside skirt holds potential for estimating the total catch size from codends. It could be expected that, if a new codend was used, the calibration curve would tend to be steeper. In an ideal situation, the loaded codends would retain the shape of a cylinder so that the relationship between the height of the catch inside it and the corresponding number of meshes from the drawstrings would be close to linear.

If Scientific observers were to use this method, they would need to supply their own marked codends which were new at the beginning of sea trials. This would be necessary to avoid the variability between different codend sizes, materials, ages (worn or otherwise) and other factors such as flexibility etc.

It also needs to be tested whether load cells permanently fitted to the overhead rigging of NPF trawlers can deliver estimates of total catch. This research will be continued in the near future.

CHAPTER 8

TEDS AND BRDS USED IN THE 2001 TIGER PRAWN SEASON AND FISHERS COMMENTS

Chapter Authors:

Brian Taylor and Garry Day

CHAPTER 8

CHAPTER 8

TEDS AND BRDS USED IN THE 2001 TIGER PRAWN SEASON AND FISHERS COMMENTS

Brian Taylor and Garry Day

Summary

During the Observer Program of 2001, five scientific Observers collected comprehensive data about TEDs and BRDs and their use. In November of 2001 a phone survey of another 75 trawlers in the NPF fleet collated similar information about TED and BRD design and use. This combined snap-shot of information covered 95 trawlers or over 80% of the fleet at that time.

Just over half of the skippers used downward excluding TEDs (53% of the fleet), and a shape that is curved at one end only (38%), oval (28%), or rectangular (23%). More than half (57%) had straight bars with a spacing of 120mm or greater. The Bigeye BRD was most popular (78% of the fleet), mainly because of its perceived lack of prawn loss rather than its effectiveness in reducing bycatch.

The most common problem expressed by industry operators was the lack of opportunity to test and check any one device against a control net with no devices fitted. This was followed closely by the need to modify handling and fishing techniques and complaints about large prawn losses due to being “TEDDed”. However, it was recognized that any new gear needs to be closely watched and modified where necessary, and that large losses occasionally occurred in the past when monsters or rocks were encountered. Losses of banana prawns were common through “washback” with both TEDs and BRDs when large catches were taken.

8.1 Introduction

A survey of the NPF fishing fleet was conducted to establish the types of devices being used and to list common problems being encountered. This was done via a phone survey of commercial fishers and observations recorded by scientific Observers at-sea on NPF trawlers.

8.2 Phone survey

The phone poll was conducted in October 2001, midway through the second tiger prawn season following the introduction of TEDs and BRDs in early 2000. Seventy-five boats were polled out of the fleet of 115 vessels. Co-operation was excellent with 72 of the skippers responding.

8.3 Observer Program data

Five scientific Observers sampled on board a total of 23 trawlers during the tiger season and their observations that are relevant to this survey are included. (Refer to Chapter 9.6. for other gear-related observations).

8.4 Combined data

Information on TEDs and BRDs was collected from a total of 95 vessels (over 80% of the fleet); 72 from the phone survey and 23 from the Observer Program.

8.5 Results

The following data shows the percentage of surveyed vessels that used each gear type. (Preliminary results were distributed to Northern Prawn Fishery participants in the *TED and BRD Newsletter* Number 5 in March 2002 (Appendix 7)).

8.5.1 TEDs

Slightly more than half of those surveyed (53%) were using downward excluding TEDs (Figure 8.1). The most common TED shapes were curved at one end only (38%), oval (28%) or rectangular (23%) (Figure 8.2). About 57% of the TEDs were fitted with straight bars (Figure 8.3) compared to bent bars (for photos of straight bars and bent bars see Figures 12.13 and 12.5, respectively). Nearly 80% had bar spacing of 120 mm or more, but some operators appear to be using a smaller (illegal) bar spacing (Figure 8.4).

Many favourable comments about TEDs were received during the survey. Compliance of TEDs and BRDs appears to be very high. These devices are universally used in the NPF not simply to comply with legislation but because they are useful despite many varying designs.

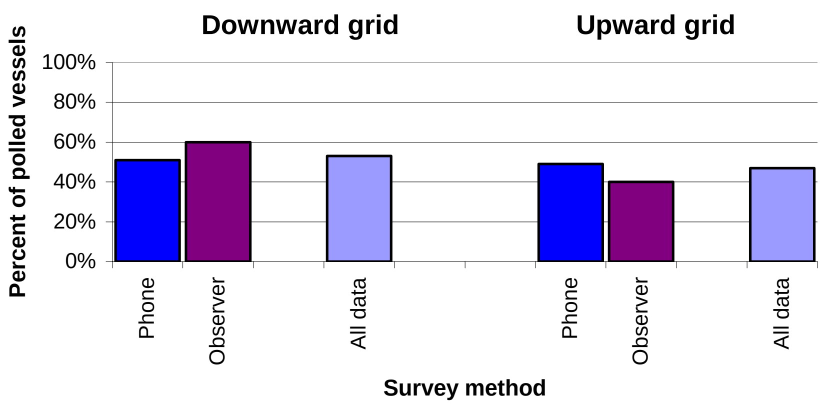


Figure 8-1. A breakdown of upward and downward excluding TEDs/grids used in the NPF in 2001.

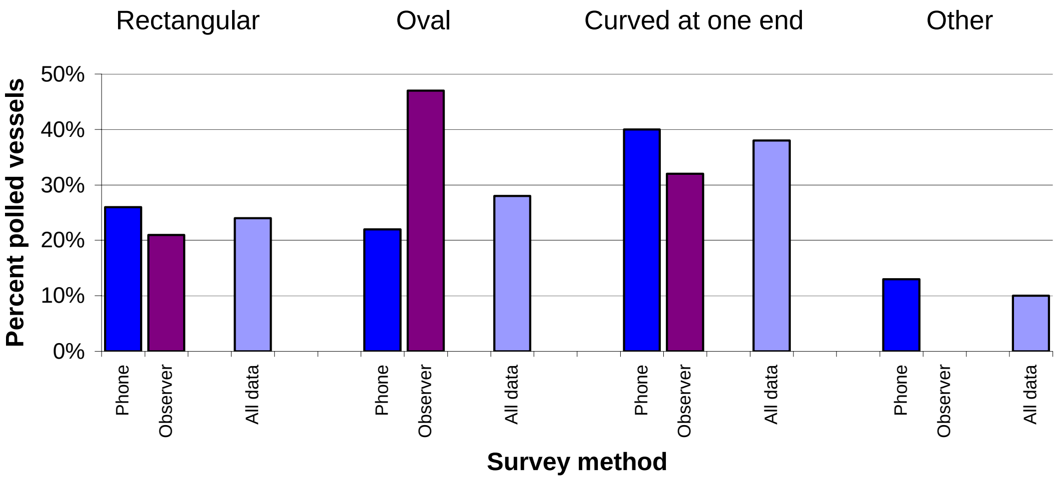


Figure 8-2. A breakdown of the different TED shapes used in the NPF in 2001

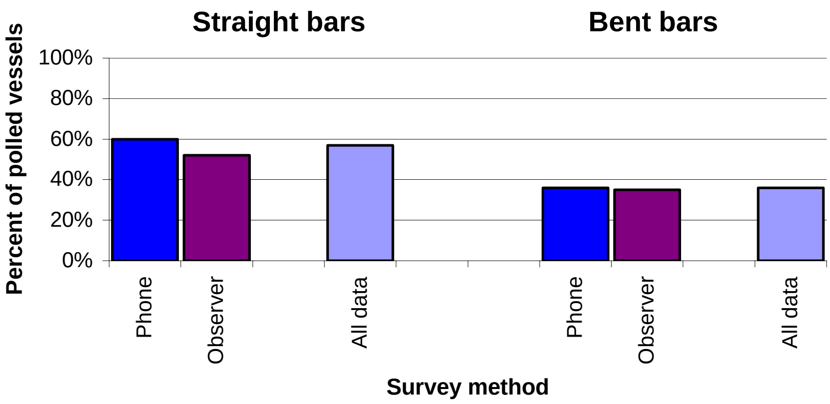


Figure 8-3. A breakdown of the different bar shapes used in TEDs in the NPF in 2001

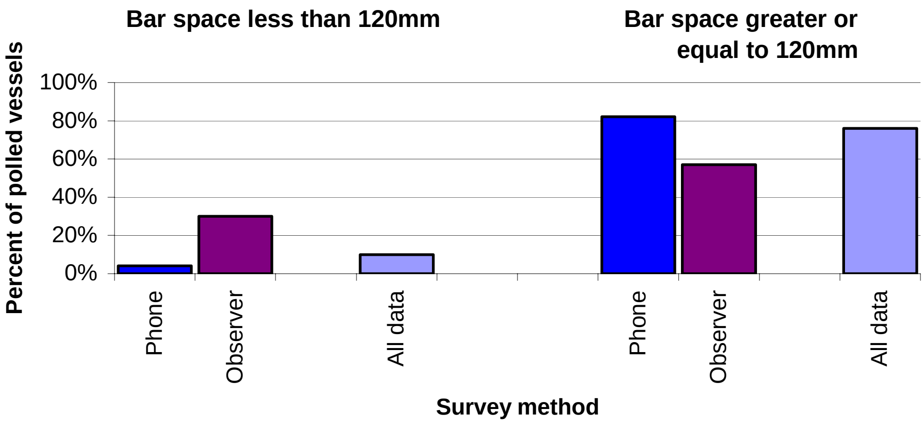
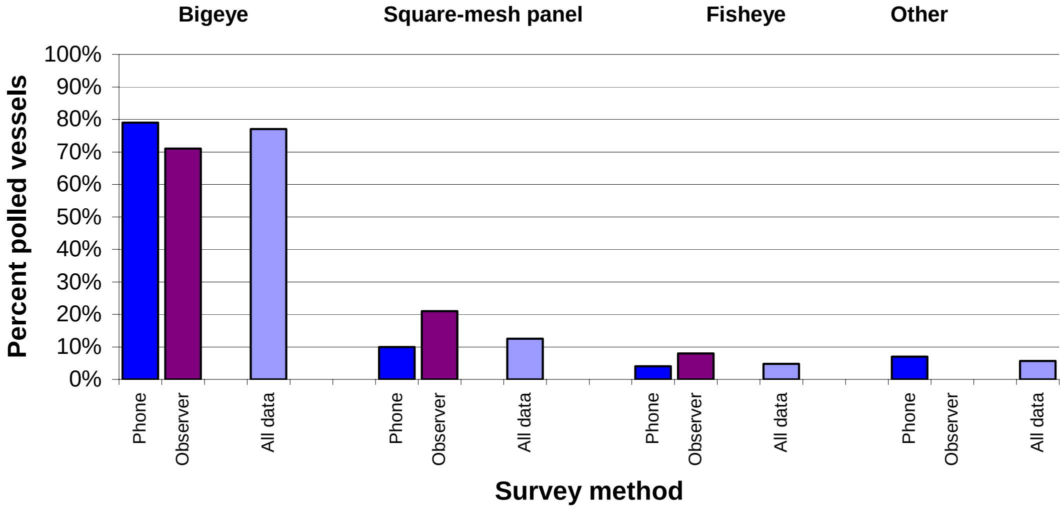


Figure 8-4. A breakdown of the different bar spacings used in TEDs in the NPF in 2001.

8.5.2 BRDs

The Bigeye, the Square mesh panel and the Fisheye were the main three types of BRDs used in the NPF in 2001, although most fishers (78%) used the Bigeye BRD, mainly because of its perceived lack of prawn loss rather than its effectiveness in reducing bycatch. The next most commonly used was the Square-mesh panel (12%), with few vessels using the Fisheye BRD or



any other type (Figure 8-5).

Figure 8-6. A breakdown of the types of BRDs used in the NPF in 2001.

8.6 Comments from the phone survey about TEDs and BRDs.

In order to collate a list of opinions of users of TEDs and BRDs, we also asked fishers to volunteer general comments. Comments received about TEDs and BRDs have been arbitrarily grouped and the number of times that similar comments were recorded is shown in brackets.

The use of TEDs is certainly beneficial to operations but more development of BRDs is needed. As might be expected, there is a range of opinions on the various designs.

8.6.1 TEDs

- Need to change fishing techniques (e.g., slow down before hauling) and gear set ups (5). Grid angle of TEDs critical especially with new meshes in net near the attachment points.
- Gear needs to be set up according to bottom condition and must be closely watched on all grounds (4).
- TEDs are great. Would not fish without these fitted even if they were not obligatory (13). We do not want to catch and have to handle monsters (turtles, large sharks and rays).
- Occasionally get "TEDDed" (17). Could lose as much as 50 kg of prawn in a badly fouled tiger prawn shot. Perhaps 500kg for the whole season (1). Perhaps 20% for the whole season (1).
- Sponges, starfish, rays and other monsters are a problem as they often block the grid or the escape gap hole or jam open the escape gap flap (30).
- Losing banana prawns with “wash back” (15).

- Don’t ever forget, prawn losses occurred through monsters either jamming, distorting or tearing holes in nets before TEDs were introduced.
- We lose some prawns but gain through a reduction in less-valuable "soft and broken" product (4).
- Hard to handle (6), deckie killers, dangerous device and becomes skippers responsibility (2).
- The lazy line guides (“bull horns”) caused some problems earlier.
- Desirable but not feasible to carry multiple TEDs for use on different substrates. Would change TEDs with grounds if practicable.
- Can only fish where clean conditions and where TEDs do not cause foul ups (5). Was losing massive amounts of product and had to move grounds.
- Not really sure what the impact of TEDs are on smaller animals as we have no control net (24) and it does vary a lot with different substrates. We certainly can’t say what used to happen in previously fished areas.
- No consistent problems (3).
- At this stage and to a certain point, bigger is better for grids and escape gaps (2).
- Multiple escape gap flaps are effective (4).
- Legalised removable bars in TEDs are an absolute joke.
- Steel is better but heavy and dangerous, aluminium is light but breaks more easily (2).
- At faster trawl speeds of 3.5 - 3.8 knots steeper TED angles seem efficient. Sponges seem to roll out OK with shallower angle setting (2).
- Stretched escape flaps are costly (3).
- Modified grids are required if changing codend size when switching from banana fishing to tiger fishing (2).
- Not happy having to use any TEDs especially during banana fishing (4).
- TEDs are OK when scratching banana prawns but bad if big shots of these prawns (3).
- Shovel nose sharks get stuck and cause huge losses of banana prawns.
- Sharks are a problem in Joseph Bonaparte Gulf, turtles are not.
- Up excluders are no good in sponge country (3).
- Commend industry for initiative in introducing TEDs (1).
- Leaving industry - too much red tape and interference (1).

8.6.2 BRDs

- Not really sure exactly what the impact of BRDs are as we have no control net (24) and it does vary a lot with different substrates.
- Bigeye may catch less fish but not sure (4).
- Bigeyes are useless, they appear to do nothing (8).
- When trawling at 3.0 - 3.5 knots, small fish cannot swim enough to escape through the Bigeye. Most small bycatch (e.g. dollar fish) swims weakly. Bigeyes are not working. Fit closer to codend.
- Bigeyes are good for removing rocks and sponges when cleaning nets but do little for fish escapement during trawling operations.
- Fisheyes are good but hook on things and bend and tear (4).
- Fisheye close to codend is losing product.
- Losing product through Square mesh panel (3).
- Losing banana prawns with wash back (15).

8.7 Discussion

The information collected on TED and BRD use during the 2001 tiger prawn season demonstrated that the devices used during the Scientific Observer performance assessment reflected the mix of devices used in the fishery at that time. Although a range of TED shapes and orientations were being used, results from the study indicate that all of these devices (i) have high exclusion rates for large animals (Chapter 10) and (ii) need regular tuning to minimise prawn losses and maximize bycatch reduction (Chapter 12). The Bigeye BRD was the most popular device (79% of the fleet), however, it was removed from the list of certified devices for the NPF from the 2004 tiger prawn season and other BRDs will be used in greater numbers from that time. The most common problem expressed by industry operators about TED and BRD performance was the lack of opportunity to test and check any one device against a control net with no devices fitted. This was followed closely by the need to modify handling and fishing techniques and complaints about large prawn losses due to being "TEDDed". These issues are dealt with in Chapter 12.

CHAPTER 9

OBSERVER PROGRAM

Chapter Authors:

Don Heales and Quinton Dell

CHAPTER 9

CHAPTER 9

OBSERVER PROGRAM

Don Heales and Quinton Dell

Summary

A scientific Observer Program was set up to assess differences in catches of target species and bycatch due to the use of TEDs and BRDs by operators in the NPF tiger prawn fishery. Five scientific Observers sampled on 23 different commercial vessels from August to early November 2001, mostly between Mornington Island and Gove in the Gulf of Carpentaria. AFMA permits allowed the comparison of catches from a Standard net (no TED or BRD fitted) with a Treatment net (either a TED + BRD net; a TED only net or a BRD only net). Data were collected for eight different catch categories including prawns, byproduct (bugs, scallops, squid), turtles, seasnakes, large sharks and rays, sponges, small (trash chute) sharks and rays, and small (trash chute) bycatch species.

A total of 1637 paired trawls were sampled but not every catch category was able to be sampled on every trawl. The pattern of spatial distribution shown by the Observer fleet was reasonably representative of the whole commercial fleet inside the Gulf during the tiger prawn season. The observer fleet gave a reasonable representation of the use of either upwards or downwards excluding TEDs compared with the commercial fleet. Similarly the distribution of BRDs types used on Observer vessels reflected the use by the commercial fleet.

The Observer Program provided the platform to best assess the impact of the introduction of TEDs and BRDs into the NPF. The use of this method has implications for assessing the impacts of the uptake of these devices in other trawl fisheries, such as the East Coast Trawl Fishery in Queensland. The Observer Program was successful largely due to the dedication and patience of the five Observers who jumped from vessel to vessel for three months without a break.

Objective

To design, coordinate and execute an Observer Program to assess the impact of TEDs and BRDs on catches from the NPF fleet during the tiger prawn fishing season, 4th August - 9th November, 2001.

9.1 Introduction

The use of Turtle Excluder Devices (TEDs) (see Figures 9-1, 9-2 for examples) and other Bycatch Reduction Devices (BRDs) (see Figures 9-3, 9-4, 9-5 for examples) was made compulsory for the twin-rigged Northern Prawn Fishery (NPF) vessels in the tiger prawn season 2000 (See Chapter 5 for History). In order to assess the impact on catches of NPF trawlers due to TEDs and BRDs, a scientific Observer Program was developed. It was planned that Observers would compare different categories of the catch by changing the gear configuration using a system of temporary permits issued by the Australian Fisheries Management Authority (AFMA). Previously, it had been demonstrated that TEDs could greatly reduce the catch of large animals, as well as retaining most of the catch of the target species of prawns, and presumably byproduct. However, the case for BRD's ability to reduce the unwanted small bycatch, and particularly small fish, was largely untested. Consequently, a wider ranging assessment across the fleet was required, leading to the Observer Program described here.

Figure 9-1. Examples of TEDs used on one of the Observer fleet vessels. *(Photo- G. Day)*

Figure 9-2. Example of TED showing position of installation in net. *(Photo- G. Day)*

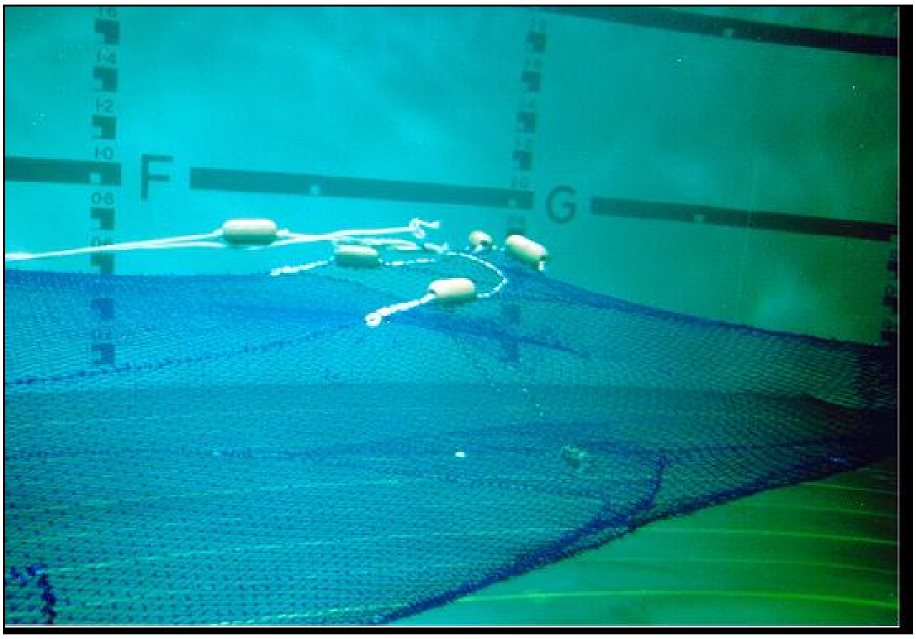


Figure 9-3. Example of a Bigeye installed in a model net (in flume tank) showing position ahead of where a TED would normally be installed. *(Photo- G. Day)*

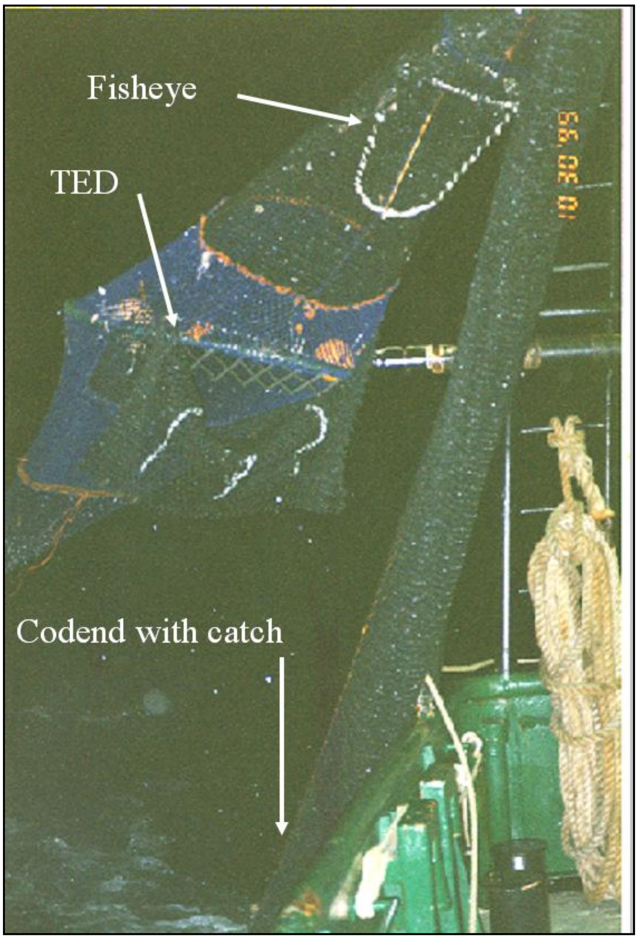


Figure 9-4. Example of Fisheye showing position in net behind the TED. The codend with the catch is hanging over the side. *(Photo- G. Day)*

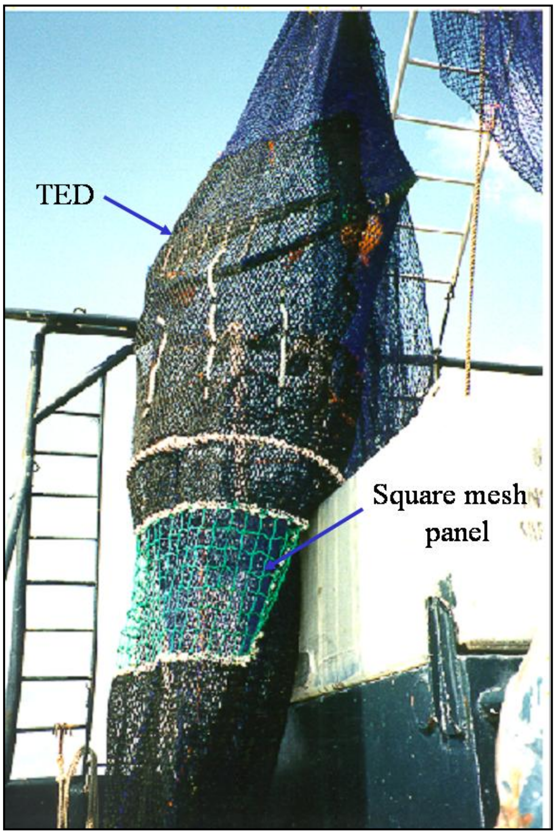


Figure 9-5. Example of Square Mesh Panel showing position in net behind the TED. *(Photo- G. Day)*

9.2 Sample design and testing

9.2.1 Evolution of sample design

In order to comprehensively quantify the impact of TEDs and BRDs on catches, most of the main catch categories need to be assessed. Because NPF vessels are twin -rigged (See Figure 9-6 for example), we could experimentally compare the separate catch categories from the nets on each side. One side has a net with both, or either of, a TED and BRD installed (Treatment net)-- and the other net has no such devices installed (Standard net).

Figure 9-6. Typical NPF trawler using twin-rigged otter trawls*. (Photo – Q. Dell)*

The specific objective of the Observer sampling program, was to record data to measure changes in trawl catches due to TEDs and/or BRDs in the following eight catch categories:

1. Turtles;
2. Large Elasmobranchs (sharks >30cm in length-- or rays > 30cm disc width);
3. Large sponges (greater than 30cm in any dimension);
4. Sea snakes;
5. Prawn catch (including damaged prawn);
6. Byproduct (includes squid, bugs, scallops etc);
7. Small bycatch (trash chute bycatch that is returned to the sea);
8. Small Elasmobranchs (small sharks and rays likely to occur mixed with trash chute bycatch);

Initial trials of sampling methods

In order to assess the likely impact of fleet dynamics, characteristics and Occupational Health and Safety (OH and S) issues, on the proposed sampling design, a project staff member completed a 14 day cruise on board the NPF vessel "**FV Apolloair**" during commercial operations in the Gulf of Carpentaria in October 2000.

The objectives of the cruise were:

Objective 1 *To assess the possible methods and feasibility of collecting accurate data for the eight catch categories.*

Objective 2 *To assess the sampling equipment needed, given the sampling methods chosen.*

Objective 3 *To assess the Occupational Health and Safety concerns of an Observer Program based around the sampling methods chosen.*

Results

Objective 1 – To assess the possible methods and feasibility of collecting accurate data for the eight catch categories

Field testing showed that recording data on all eight catch categories from each trawl (both nets) proved to be difficult without crew help (Table 9-1). For example, collecting and weighing all the small bycatch from both nets conflicted in time with the collection of small sharks and rays within the small bycatch. If you do one task, you cannot possibly do the other. Furthermore, the crew are extremely busy during this period as they sort and package the catch. Observers may receive some help but cannot rely on it.

Mostly, only a subset of the eight catch categories could be sampled fairly easily on the trial vessel. Prior knowledge of the configuration of many other vessels in the NPF fleet led us to conclude that the consistent collection of high quality data from each of the eight catch categories would not be possible. For example some vessels do not separate their prawn catch after each shot from each net because of the deck systems in use. Other vessels do split their catches easily, but is not easy to sample from the deck system used to divert the small bycatch back to sea.

Accurately recording differences in small bycatch between different gear types caused most sampling problems. An electronic load cell rigged above the lazyline blocks was trialled without success due to time constraints. We also trialled a method for estimating the small bycatch by using a series of markers positioned up the side of codends. (See Chapter 7 for details -estimating small bycatch).

We eventually returned to the previously proven method of weighing lug baskets of small bycatch, or filling them to the same level each time using a levelling device and multiplying the number of lug baskets by the average weight per basket. This method, although very laborious, proved to be the most viable and accurate.

Objective 2 - To assess the equipment requirements for Observers

A list of sampling equipment that we needed to construct ourselves was developed. It included items like the small bycatch plywood levelling devices and the hand scoop nets needed to retrieve small sharks and rays from the trash chutes. All other sampling equipment items were available for purchase off the shelf.

Objective 3 - To assess the Occupational Health and Safety concerns of the Observer Program

In particular, this objective focussed on ways to identify risks, and promote techniques to eliminate or reduce the chances of injury by the Observers.

Many issues were identified including:

- Observers would need to lift and weigh heavy baskets of bycatch (approx 40kg each), then tip them over the side of vessel;
- Observers would need to handle large sharks, rays and seasnakes (often alive);
- Observers need to work every night with little chance of taking a night off;
- Observers would be at sea for 3 months without a break on shore;
- NPF vessels work every night irrespective of the weather conditions;
- Observers would need to transfer to a new vessel every fortnight and encounter a new vessel layout; just when they had become used to the old vessel's layout;
- Observers risk of being injured during transfers from trawler to motherships or trawler to trawler on the fishing grounds;
- Observers risk of encountering a breakdown of personal relations with crew on trawlers.

9.2.2 Constraints on sampling design

A well-designed sampling program should include data collected throughout the entire tiger prawn season, cover as many different regions as possible, represent all vessel sizes, and as many different TED and BRD types as possible- while sampling under 'normal' fishing conditions.

In practice, the fleet characteristics, regional and local dynamics of vessel movements, the very nature of commercial fishing practices, and OH and S issues, all constrained the sample design in some way. For example –

The sample design avoided the vessels working the Joseph Bonaparte Gulf

These vessels usually work banana prawns on the neap tides and tiger prawns at other times. Vessels working west of Darwin were not used because there would be down time for Observers not working tiger prawns. Furthermore, coordinating observer movements with other tiger prawn vessels would be restricted by the remoteness of this region.

The sample design avoided vessels with hoppers

NPF vessels are twin-rigged and the Observer sampling program relied on recording differences in catches between the two different trawl gear configurations in the port and starboard nets. In the NPF, vessels generally use two very different on-deck systems for holding the spilled catches and the subsequent sorting of the catches.

Around 70% of vessels use a split sorting tray and the catches from the two codends are separated on the tray by a divider. The catch from each side can then be easily kept separate throughout the sorting process for the eight catch categories to be measured.

The remaining 30% of vessels use a sea-water hopper system (Heales et al., 2003). Here the catches from both codends are spilled into a sea-water tank where a conveyor belt extracts the catch from the bottom of the tank. Prawns usually sink to the bottom and are extracted first. Although catches can be kept separate occasionally by placing a tray on top of the hopper after the first catch is spilled inside, to do this every trawl for two weeks would severely interfere with commercial practice.

Consequently we avoided using vessels with hoppers. This biased the representation of fleet size because mostly the larger vessels use hoppers due to the high installation costs and the large deck needed.

The sample design avoided the smallest vessels in the fleet

We avoided using the smaller vessels due to concerns about Observer safety, especially when handling and weighing large quantities of bycatch in confined deck spaces in rough weather. Accommodation facilities can also be a constraint on board smaller vessels

The sample design was based on Observers staying approximately two weeks on each vessel

NPF vessels stay at sea for the entire 3 months tiger prawn season unless major breakdowns occur. They rely on supplies (for example fuel, water, victuals, spare parts, mail etc) delivered by mothership at around 2 week intervals (See Figure 9-7). They unload their frozen product and refuse, and crew changes often occur at the same time. In order to coordinate the movements of Observers from vessel to vessel via mothership, a pattern of spending approx. two weeks on each vessel was used.

Figure 9-7. Mothership "Pacific Pioneer" unloading and servicing NPF trawlers. (Photo- G. Day)

Table 9-1. Proposed catch categories to be sampled by Observers, and the feasibility of sampling each category.

No.	Catch category	Feasibility of sampling	Expected difficulties
1	Chelonidae -- turtles	Easy	Few- High crew awareness of turtle welfare
2	Large Elasmobranchs -sharks and rays > 30cm, mostly too big to pass through bars of TEDs or are easily separated from the catch on sorting trays	Possible	Requires collection by deckhand during sorting-- Time bottleneck can means interferes with collection of other data
3	Sponges >30cm - mostly too big to pass through bars of TEDs	Easy	Requires collection by deckhand during sorting
4	Seasnakes	Possible	Requires collection by deckhand during sorting
5	Prawn species (includes Bananas, Endeavours, Kings, Tigers) - - mostly pass through bars of TEDs	Easy on most vessels	Most vessels separate catch from each net - but not all, particularly vessels with hoppers
	Prawns species --Damaged- A subset of 5	Not easy- but possible	Hard to keep separate in processing rooms due to small quantities
6	Byproduct (includes bugs, squid, scallops - mostly pass through bars of TEDs	Not easy- but possible	Small weights to work with- and smaller sizes are discarded
7	Small Elasmobranchs -sharks and rays, - mostly pass through bars of TEDs	Possible	Requires dedicated scanning of discards for entire sorting process, both codends, by Observer
8	Small bycatch species (trash chute teleosts -fish, and invertebrates - crabs, small bugs etc) - mostly pass through bars of TEDs	Extremely difficult	Requires Observer to collect bycatch in lug baskets, weigh or estimate weight- then discard over side --Time bottleneck means interferes with collection of other data- many OH and S concerns

The sample design was influenced by the nature of commercial fishing

It is important to understand that the sample design used to assess differences between catches was often compromised by the nature of commercial fishing. For example:

- Fishers need to continually make adjustments to trawl gear in order to maximise catch rates of prawns. In direct contrast, Observers need to sample as many trawl comparisons as possible using the same unaltered fishing gear.
- Fishers will adjust their trawl gear to try to catch the same quantities of target species (prawns) but they do not normally make any gear adjustments if the amount of small bycatch differs from side to side. Ideally Observers needed to have the trawl gear evenly matched for capturing both target species and the small bycatch species.

The sampling design was influenced by OH and S issues

The NPF fleet is unusual in that, although the vessels fish continuously for three months or more, the vessels are quite small in comparison with other world fisheries where vessels remain at sea for long periods.

This situation led to the development of detailed Safety Notes in the Observers manuals (See Appendix 4. OH and S notes) in order to address the particular and peculiar demands caused by extended periods working at sea.

9.2.3 Final sample design

Changes to the original sample design

Due to input from the Northern Prawn Fishery Stock Assessment Group (NPFSAG) the original proposal to use 5 Observers at sea for 4 weeks (approx 280 Observer nights) between mid September to mid-October (based on CSIRO Report No CMIS 2000/190), was modified to 5 Observers at sea for the entire tiger prawn season (4 August to 9 November 2001) and approximately 450 Observer nights. This change was made to ensure a wider spatial and temporal coverage by the Observer fleet.

Sampling design planned for each vessel

The final design was based on an Observer spending two weeks (approx) on each vessel (See Figure 9-8).

- Night 1-- calibrations of either (a) Standard (the old style nets NOT fitted with either a TED or BRD) versus another Standard net; or (b) Treatment net (TED + BRD) versus another same Treatment net (TED + BRD).
- Night 2-7 inclusive - comparisons between a Treatment net (TED and BRD) and a Standard net.
- Night 8-13 inclusive - comparisons between a Treatment net (TED only net i.e. TED but no BRD) with a Standard net.
- Night 14-- calibrations (similar to first night) of either (a) Standard (the old style nets NOT fitted with either a TED or BRD) versus another Standard net; or (b) Treatment net (TED + BRD) versus another same Treatment net (TED + BRD).

- In some cases a Treatment net (BRD only) replaced the Treatment net (TED only) option on nights 8-13 inclusive, or in cases where the Observer was able to remain on board for three weeks.

In theory, whenever an Observer arrived onboard a new vessel, a decision needed to be made as to which side was to become the Standard net (have TED and BRD removed), and which net was to be the Treatment net. To randomise this decision, this choice was to be made using the toss of a coin. However, in practice, the skippers had often made those decisions before the Observer arrived and had gone ahead and removed the TED from a net.

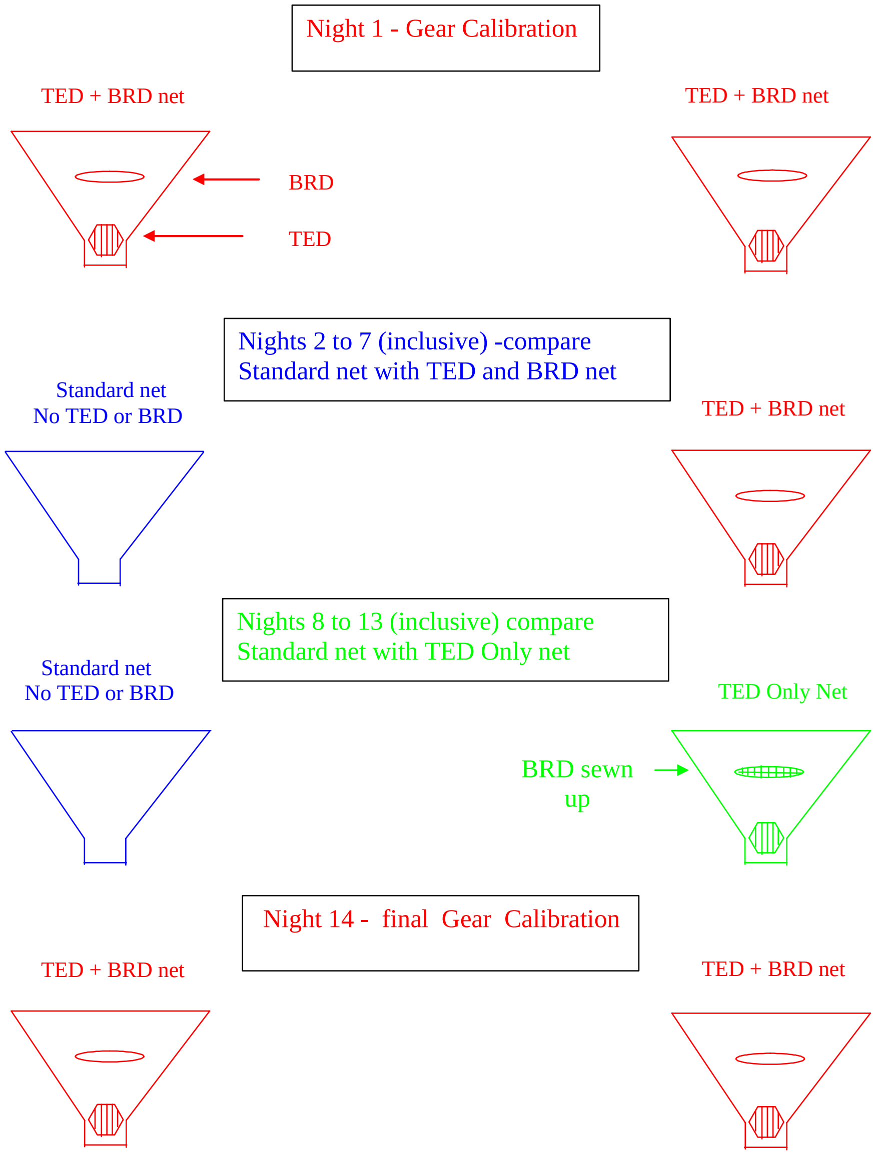


Figure 9-8. Diagrammatic representation of the experimental gear configurations over a 2 week sampling period for a twin- rigged Observer vessel (See Figure 9-6). In some cases, a BRD Only was used in nights 8-13.

Hypothetical sorting procedure for a catch

The flow chart (Figure 9-9) shows the order in which different catch categories needed to be sampled so as to minimise interference with commercial practice. A complete description of sampling methods is included in the Observer Manual (Appendix 4).

The codends from nets without TEDs commonly contained much larger sharks, rays and sponges than codends in nets fitted with TEDs (Figure 9-10).

Immediately the codends were spilled, the larger animals including turtles (Figure 9-11), sharks and rays (Figures 9-12, 9-13 and 9-14), sponges (Figure 9-15), snakes (Figure 9-16), were separated from the catch. These were identified, measured and weighed - then released alive wherever possible.

The remainder of the catch was then sorted by the crew. They remove the target species prawns (including damaged) (Figure 9-17), as well as the byproduct including squid, bugs, scallops etc (Figure 9-18).

The unwanted small bycatch is what remains after the prawns and byproduct have been removed, and is washed directly back to sea via a trash chute.

Small sharks (mostly less than 30cm in length) and rays (mostly less than 30cm disc width) are mixed in with the small bycatch. On some trawls, the Observers were asked to collect every small shark and ray from each side as the bycatch was washed down the trash chute. These animals were identified, measured and weighed (Figures 9-19, 9-20).

In order to record differences in the weight of small bycatch between different nets, the Observers collected the entire small bycatch from each codend in lug baskets. The full lug baskets were then weighed to give a total small bycatch from each side. Periodically, the lug baskets from each side were levelled to the same height in order to standardise the average weight of a full basket. The count of the total number of full lug baskets from each side was then multiplied by the average weight of the bycatch per lug basket (plus the weight of any half full baskets) (Figures 9-21, 9-22).

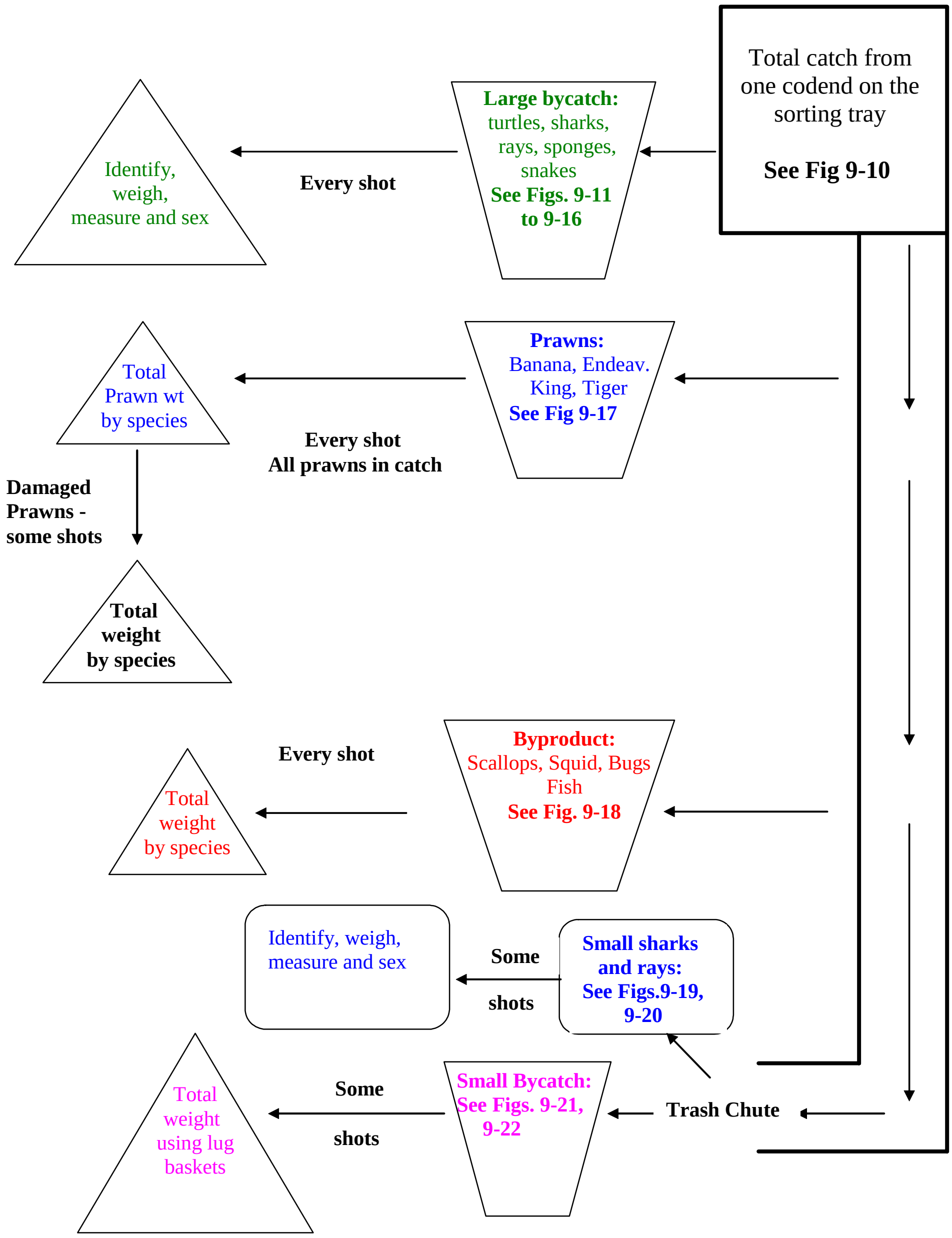


Figure 9-9. Schematic diagram of the on-board sorting process to collect all eight different catch categories - from one of the two codends from each vessel.

Figure 9-10. Spilled catch from a Standard net (no TED or BRD installed), on the sorting tray. Note the number of large animals normally excluded by the TED. (*Photo- G. Day)*

Figure 9-11. Flatback Turtle (*Natator depressa*) from the Standard net (no TED or BRD installed), on sorting tray before being released alive. *(Photo- B. Bird)*

Figure 9-12. Large Carcharhinid shark and Shark Ray (*Rhina ancylostoma*) taken from a Standard net (no TED or BRD installed). *(Photo- C. Gough)*

Figure 9-13. Large Shark Ray (*Rhina ancylostoma*) on sorting tray before being released alive - taken from the Standard net (no TED or BRD installed). *(Photo- B. Bird)*

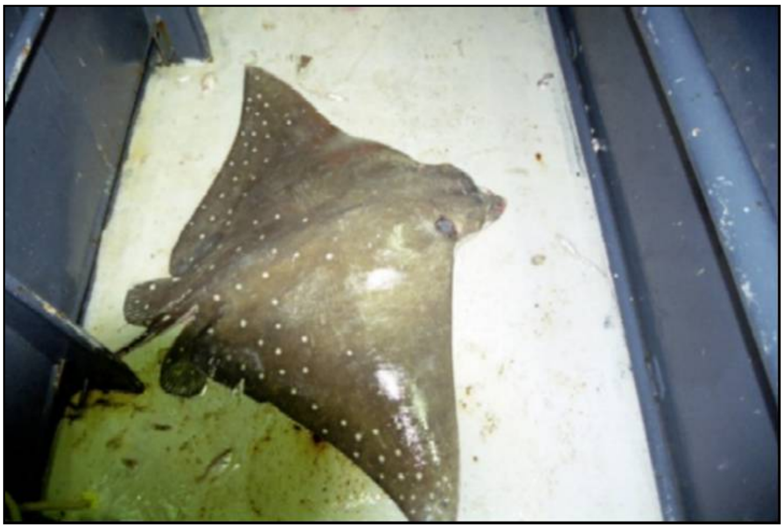


Figure 9-14. Large White Spotted Ray (*Aetobatus narinari*) before being released alive - taken from the Standard net (no TED or BRD installed). *(Photo- B. Bird)*

Figure 9-15. Examples of large sponges caught in the Standard net (no TED or BRD installed). *(Photo G. Day)*

Figure 9-16. Large sea snake (*Hydrophis elegans*) before release. *(Photo- B.Bird)*

Figure 9-17. Typical mix of unsorted catch showing target species of prawns, mixed with small bycatch fish. *(Photo B.Bird)*

Figure 9-18. Byproduct (squid and cuttlefish) awaiting packing after sorting, *(Photo- C. Gough)*

Figure 9-19. Small ray (*Dasyatis leylandi*) (collected from the trash chute) - on top of 28cm wide upturned bucket to demonstrate size. *(Photo- B. Bird)*

Figure 9-20. Small rays (*Himantura toshi*) (collected from the trash chute) on top of upturned lug basket to demonstrate size. *(Photo- B. Bird)*

Figure 9-21. Observer, Quinton Dell weighing small bycatch after levelling the volume in the lug baskets. *(Photo- Q. Dell)*

Figure 9-22. Observer, Ben Bird, weighing small bycatch in lug baskets. *(Photo B. Bird)*

9.3 Pre Season planning and observer training

9.3.1 Selection of observers and vessels

Selection of observers

The five Observers were chosen on selection criteria that reflected their ability to:

a) Collect high quality data for a wide range of catch categories;
b) Work in harmony with commercial fishers;
c) Remain functional at sea for the entire Tiger prawn season 2001;

The Observers selected (See Figures 9-23(a), (b) and (c) were (in alphabetical order):

Ben Bird	(AMC graduate and an experienced NPF Observer)
Garry Day	(AMC graduate in gear technologist and an experienced NPF Observer)
Quinton Dell	(CSIRO Fisheries biologist and an experienced NPF Observer)
Chris Gough	(former NPF crew member, experienced NPF Observer, and net maker)
Reuben Gregor	(AMC graduate and an experienced NPF Observer)

All five Observers had previously completed Observer duties during the first two weeks of the banana season in the NPF in April, 2001.

The Observers were advised that they would attend a three day Observer Training and OH and S Program at Cleveland Marine Laboratories (Qld) -from 21st to 23rd July 2001

Copies of both the Observer at-sea Sampling Manual and the Species Identification Manual were posted to each Observer 2 weeks before they were due at the Observer Training Course.

Selection of observer vessels

Project staff visited Cairns and Darwin at the end of the banana prawn season 2001 to seek expressions of interest from owners and skippers prepared to take an Observer on board for a period of 2 weeks sometime during the next tiger prawn season (4 August - 9 November 2001).

A standardised interview questionnaire was used to help ensure that the skippers understood the nature of the duties of the Observers. Some aspects of Observer duties could potentially affect the smooth running of the fishing deck operations - and these duties needed to be emphasized and clearly understood before agreement was reached. Consequently, project staff emphasised the following operational requirements:

- Observers needed to keep the catch categories from both nets separate wherever possible. This necessitated asking for help from the deck crew on many vessels.
- Removing the TEDs from one or both nets would lead to more dangerous animals on the sorting trays. This could increase the quantity of damaged product due to the increased presence of large animals crushing the prawns.
- Adequate work space on deck and accommodation space needed to be available on the prospective vessels.
- In some cases vessels would need to steam to motherships or other vessels in order to allow the Observers to board their next vessel.
- In some cases, vessels may not get sufficient lead time to order extra stores before Observers boarded their vessel. This could potentially cause some stores shortages.
- The process of collecting small bycatch weights required that the trash chutes could be dismantled and diverted (See Figure 9-21) into the top of a standard lug basket (holds around 40kg of bycatch). Consequently, the vessels were closely inspected to ensure that this was possible, and that this configuration could be maintained for a period of 2 weeks or more.

Figure 9-23(a). Observers and Training Staff at Cleveland Observer Training Course, July 2001.
Back Row: Brian Taylor (CSIRO), Don Heales (CSIRO), Reuben Gregor (Observer), Quinton Dell (Observer), Ben Bird (Observer).
Front Row: Gary Day (AMC - Observer), Chris Gough (Observer) and Dave Brewer (CSIRO).

We tended to select skippers that were known personally to project staff, or who were recommended by others well respected in the industry. We hoped that this process would reduce the chances of lost Observer time or other difficulties, such as personality clashes between Observers and crew.

Project staff also used these port visits to raise the public profile of the proposed Observer Program. We hoped that the transferring of Observers throughout the fleet during the season would be facilitated better by a greater understanding of the program objectives by the fleet. Therefore, flyers describing the program were handed out during these visits (See Chapter 15).

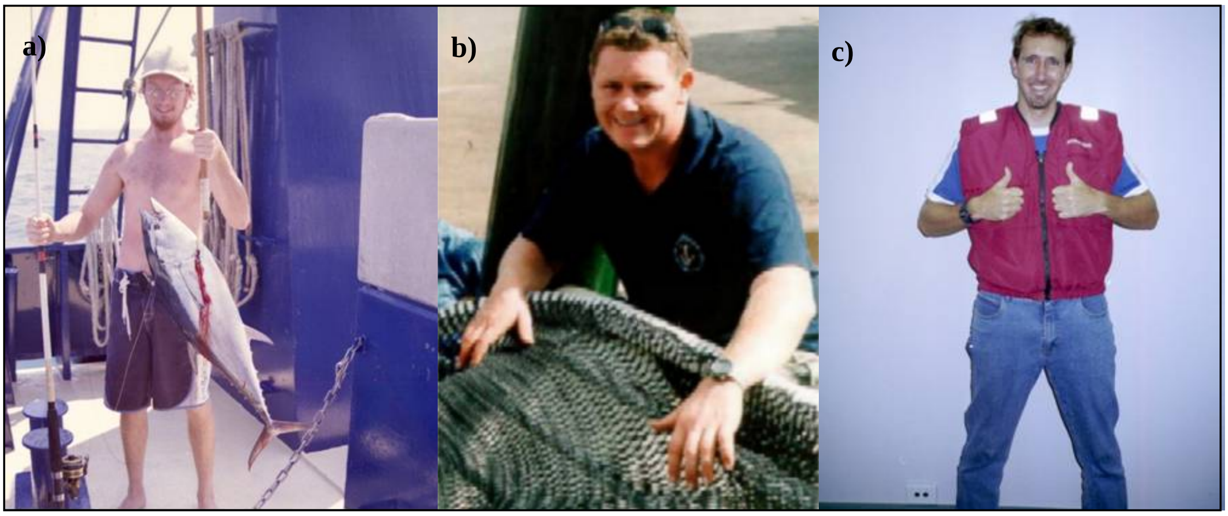


Figure 9-23(b). NPF Observers: a) Ben Bird, b) Gary Day, c) Quinton Dell

Figure 9-23(c). NPF Observers: d) Chris Gough, e) Reuben Gregor

9.3.2 Preparation of sampling gear and field manuals

Preparation of sampling gear

Unique sampling equipment

Some sampling equipment was designed and constructed at the Cleveland Marine Research laboratory. For example, in order to maintain consistency in the weight of bycatch in lug baskets, we constructed plywood levellers that were inserted into the baskets as they approached the right level. Similarly, the small scoop nets to sample small sharks and rays that were mixed up with the small bycatch, were designed and constructed locally so they could fit easily into the trash chutes.

Waterproof sample sheets sheets were designed and printed. This included 2000 Master sheets and 400 Trawl Gear /Gear change sheets (See Appendix 4 for examples of both).

In order to encourage participation by skippers and crew in the Observer process, we produced special project T Shirts and caps to outfit the entire crew on each Observer vessel, as well as mothership crews (See Figures 9-24(a), (b), (c)).

Figure 9-24(a). Project T-Shirt distributed by Observers to crews of Observer vessels and Motherships.

Figure 9-24(b). Close up view of T-Shirt distributed by Observers to crews of Observer vessels and Motherships.

Figure 9-24(c). Project cap that was distributed by Observers to crews from Observer vessels and Motherships

Standard sampling equipment

Other "off the shelf" items were purchased and collected around one month before the 10th July; the date when the kits needed to be road freighted to Cairns or Darwin. A complete list of sampling equipment taken to sea by each Observer is shown in Table 9-2. Similarly a list of personal items is shown in Table 9-3.

Observers needed to be self sufficient in terms of their sampling equipment and carry multiple spares. Replacing lost or damaged measuring equipment for example, can take up to one month if spares are not already aboard their normal mothership.

Pre-season logistics and planning

To ensure that the Observer kits were ready for loading on board vessels in both ports by the 25th July, the kits were pallettised (each kit fitted neatly onto a pallett) and road freighted to both ports (4 kits to Cairns, 2 to Darwin) two weeks prior to this date. GNM Chandlery stored the Cairns kits, and NT Fisheries (courtesy of Rik Buckworth) stored the Darwin kits.

A complete spare kit was also freighted so that it coud be stowed onboard one of the motherships to provide a backup for lost or damaged sampling equipment during the season.

Observer at-sea manuals

1. Observer Sampling Manual

NPF vessels stay at sea for the entire 3 month Tiger season (unless major breakdowns occur) and they rely on supplies delivered by mothership at 2 week intervals. Because Observers were to be isolated at sea for the entire 3 month tiger prawn season, they also needed to be self sufficient as much as possible in terms of sampling methodology. To meet this need, we produced a field manual so that Observers would have reference material for all aspects of their extended time at sea (See Appendix 4).

Table 9-2. List of field sampling equipment that Observers took to sea.

Item description	Number
Observers sampling manual	1
Observer Species Identification manual	1
List of 400 unique station numbers	1
Waterproof Master sample sheets	400
Waterproof Gear Description sheets	50
Waterproof Sample Labels	100
Waterproof paper for deck notes	40
Diary	1
PrePaid Post-Pak bags	8
Pencils	24
Pencil sharpeners	4
Rubbers	6
Folders	2
Plastic bags- Small to store data sheets in	100
Plastic bags- Large for freighting large frozen animals for IDs	50
Plastic buckets	3
Waxed fish cartons (10 kg capacity)	40
Bin liners for waxed cartons usage	200
Tape measures 8 metres steel	2
Spring balances 10 kg	2
Scales 50 kg (Figures 9-21, 9-22)	2
Rope and hooks for weighing baskets of bycatch (Figures 9-21, 9-22)	1 set
CRC- cans of, Masking tape, duct tape	6 of each
Lug baskets (Figures 9-21, 9-22)	9
Nally bins	2
Cable ties	100
VB cord, roll of	1
Levellers ((Figures 9-21, 9-22 ply catch levelling devices)	2 sizes
Numbered tablets (in sets of 20)	2
Scoop net to collect small sharks and rays from trash chute	2
Catch movers and scrapers	2 of each
Wooden drain supports	4
Project T-Shirts (Figure 9-24(a), (b) to promote co-operation)	40
Project Hats (Figure 9-24(c) to promote co-operation)	10

Table 9-3. List of personal equipment that Observers took to sea.

Item description	Supplied by	
	CSIRO	Personal
Personal safety inflatable V200 vest, Epirb, safety torch etc	Y	
Wet weather gear ie. jacket, trousers with bib	Y	
Waterproof aprons	Y	
Deck shoes (either runners or gumboots)	Y	
Overalls	Y	
Cotton gloves (12 prs), rubber gloves (6 prs)	Y	
Hat		Y
Sunglasses		Y
Good waterproof watch		Y
4 small hand towels	Y	
Clothes like shorts, t shirts		Y
Seasickness tablets, earplugs	Y	
Personal hygiene items toothpaste brush comb etc		Y
Medical supplies (Panadol, antibiotics, sea sickness tablets, sunburn cream, bandages, bandaids etc	Y	
Personal foods eg.cartons of soft drink, chocolate		Y
Camera		Y
Videos		Y
Sleeping bag	Y	

The **Observer Sampling Manual** included sections addressing:

1. What gear to take.
2. A list of contacts, with phone and fax numbers.
3. A brief summary of the project proposal.
4. The sampling methods.
5. A description of the Northern Prawn Fishery.
6. NPF Trawling Procedures.
7. Trawl Gear Requirements and Permits.
8. A Guide to Bycatch Reduction in Australian Prawn Trawl Fisheries (Eayrs et al., 1997).
9. Commercial Vessel Procedures Manual (Courtesy of Newfishing P/L).
10. OH and S Issues, First Aid, Survival at Sea.

2. Species Identification Manual

The Observers needed to identify all turtles, and at least the most common sharks and rays. Consequently, the **Species Identification Manual** included:

1. Shark identification keys.
2. Sawfish identification keys.
3. Rays identification keys.
4. Colour plates for : Sharks, Sawfish and Rays.
5. Turtle identification keys and Turtle Handling (AFMA).

6. Large Fish.
7. Hazardous Animals and Appropriate First Aid.

(See Appendix 4)

9.3.3 Training of observers and pre-embarqation procedures at ports

Training of observers

Training course structure

The Observers - see Figures 9-23(a), (b) and (c) were flown to the CSIRO Marine Laboratory in Cleveland, on the day before the training commenced (21st July, 2002). They were due to leave for sea duty within seven days of completion of the course. Full details of the course structure and timetable are shown in Table 9-4 (a), (b) and (c).

The main objectives of the Training Course were:

1. *Observer sampling methods*
   To ensure that Observers clearly understood the need for collecting this data; they were fully trained to sample all eight catch categories; they could identify all the species that needed to be identified at sea, and they were trained in the methods of transferring data to Cleveland.

2. *Observer sampling equipment*
   To ensure that Observers were equipped with all the sampling gear needed to complete the sampling and knew how to use this equipment.

3. *OH and S awareness*
   To ensure that Observers were fully aware of all OH and S dangers that they may encounter and how to eliminate or reduce the inherent OH and S risks involved in the sampling program.

4. *Personal safety equipment*
   To ensure that Observers were fully equipped with all personal safety equipment they may need during their time at sea.

1. Observer sampling methods

In order to ensure that the Observers understood the need for collecting data on the impacts of TEDs and BRDs, we organised speakers to address the history of the fishery as well as the history of the introduction of TEDs and BRDs. We also addressed the question of ecological sustainability in terms of the project aims and in particular with respect to sharks and rays. Other topics covered included project experimental design, sampling methods, communications, confidentiality of the data and the importance of maintaining good public relations. We also conducted sessions on sea snakes and sawfish.

In order to ensure that Observers were fully trained to record data on all catch categories, we ‘walked’ them through a hypothetical sampling schedule for a single trawl. In this exercise, the hypothetical 'crew' dealt with each catch category in the same order that they would at sea. So, for example, when the codends were winched aboard and spilt on the sorting trays, the large sharks and rays would normally be returned directly to sea. However, the Observers needed to identify these animals to species, and record lengths and weights where possible. So strategies were discussed to ensure that this happened with minimum disruption to the crew and to reduce the dangers involved in identifying measuring or weighing live sharks and rays. In this manner, each catch category was considered in the time sequence that it would be take to sample it.

We also discussed the reality that not every catch category could be sampled on every trawl, and how to deal with that (See Table 9-1 catch categories and feasibility of sampling). We discussed the need for the crew as well as the skipper to be fully informed of what the Observer would need to do to sample each trawl.

Species identification

In order to ensure that Observers could correctly identify certain species of the most common sharks and rays, we tested their ability using specimens stored (frozen) from earlier work.

Data recording

We discussed the type of fishing gear information that was to be recorded including trawl board types and dimensions, TED and BRD descriptions and dimensions as well as trawl net size and style. A completed Gear Sample sheet was supplied as an example in each Observer Manual so that Observers could refer to it at sea if they were in doubt about what data to record (See Appendix 4-Observer Manual).

We discussed the actual data that was to be recorded using the sample sheets provided in the Observers kits. We worked through each sample sheet in turn and discussed the type and quality of environmental data to be recorded, and the catch data (the large sharks and rays, large sponges, sea snakes, target species of prawns and damaged prawns, byproduct, small sharks and rays, and small bycatch). A completed Master Sample sheet was supplied as an example in each Observer Manual so that Observers could refer to it at sea, if they were in doubt (See Appendix 4-Observer Manual).

Data transfer

We discussed the two methods of transferring data back to the Cleveland Laboratories at the end of each sampling period on individual vessels. The first was a backup system of faxing a summary sheet of basic essential data before leaving the vessel. This was done to ensure that if the original data sheets were lost, we retained important information on position, prawn and small bycatch differences. The second method involved using pre-paid data envelopes that were posted via the mothership when the Observer boarded, before transferring to the next vessel.

2. Observer sampling equipment

To ensure that Observers were fully equipped and knew how to use all the sampling equipment and spares needed to complete the sampling, we provided a complete Observer Kit at the training so that each item could be discussed in context before going to sea (See Table 9-2).

For example, we demonstrated:

- using steel tape measures or cloth tapes for measuring animals;
- using spring balances for weighing sharks and rays;
- using the plywood catch leveller (Figures 9-21, 9-22) to maintaining consistency in weighing the lug baskets of small bycatch;
- using the 50kg dial scales to weigh lug baskets of bycatch to get average weights as multiplying factors, or for weighing large sharks and rays too heavy for the 10kg spring balances.

Field maintenance of all these items was discussed. The backup system of having one complete spare Observer kit on board one of the motherships ensured that items lost or damaged could be relaced within 2 weeks or earlier.

Table 9-4(a). Structure and content of Observer Training Course -- Day 1.

Section	Time	Person	Content
Introduction	0900	Dave Brewer	Welcome • House-keeping (phone numbers, messages, computers, email, facilities etc)
			Accommodation/transport/travel/bills/who pays for food at sea/ salaries
			Course outline/diligence/ data importance/ambassadors for CSIRO
Fishery History -	0930	Burke Hill	Fishery history/tiger fishery emphasis
TED's and BRD's	1000	Garry Day	Introduction of TED's -Research results so far - Published results etc Results of Banana season Observer work 2001
Morning tea	1030-1100		
Project aims	1100	Dave Brewer	Proposal/benefits to fishery
Ecological Sustainability	1120	Dave Brewer	Doctrine and its effect on NPF target and bycatch species
Project experimental design	1130	Dave Brewer	Random sampling with bias eg - vessel selection-skipper selection/then region selection/type of TED/BRD selection/permits required
Expected Observer protocols	1140	Dave Brewer/Don Heales	Time spent on each vessel/ time on motherships/changing vessels/time off
Methods Part A	1200	Don Heales	Outline of Methods/Gear configuration/permits/Sorting process each shot/Different catch categories/OH and S issues for each catch category
Lunch	1230-1400		
Methods Part B	1400	Don Heales	Sequence of data collection events within each shot/associated OH and S issues
Seasnakes	1430	Dave Milton	History/Why collect them?/How many to collect/ Identification/Permits to collect
Afternoon tea	1500-1530		
Methods Part C	1530	Don Heales	Sequence of data collection events within each shot/associated OH and S issues

Table 9-4 (b) Structure and content of Observer Training Course -- Day 2.

Section	Time	Person	Content
Methods Part D	0830	Don Heales	Sequence of data collection events within each shot/associated OH and S issues
Sawfish and sustainability	0900	Burke Hill	History/distribution./ identification/ sustainability/
Observer communications	0930	Brian Taylor	With skippers/crew-with supervisors by Sat Phones/ Fax/Who to ring/codes
Methods Part E	1000	Don Heales/Garry Day	Sequence of data collection events within each shot/associated OH and S issues
Morning tea	1030-1100		
Confidentiality -- Ambassadors for CSIRO	1100	Brian Taylor	Most important Never discuss other vessels, catches, skippers, crew, observers, supervisors etc
What to take on board	1130	Garry Day	What works for me!!
Methods Part F	1200	Don Heales/Garry Day	Hypothermia, inflatable vests, EPIRBs, planning for dangerous situations.
Lunch	1230-1400		
First Aid	1400	Dave Brewer	Up to date Treatment for Trawler/bycatch type injuries
OH and S What's left?	1430	Don Heales/Garry Day	Motherships/Swapping vessels/ OH and S issues from Observer Sampling Manual
Afternoon tea	1500-1530		
Record keeping/Transfer of data to Cleveland	1600	Brian Taylor	Faxed vessel summaries, posting data back, overall cruise reports
Bycatch videos of interest	1630	Dave Brewer	Turtle testing of TEDs in US /also new BRD design from US

Table 9-4(c). Structure and content of Observer Training Course -- Day 3.

Section	Time	Person	Content
Vulnerability and susceptibility of Elasmobranchs to trawling	0900	Dave Brewer	Needs for data, selection by TED's, low fecundity problems
Practical-- Identification of sharks/rays/ turtles/ seasnakes, /sponges/fish	0930-1230	John Salini/Don Heales	Hands on elasmobranch species identification using real animals/testing of knowledge in I/D's - discussion of other species
Personal Protective Equipment Refresher	1230-1300	Don Heales	When to wear safety vest, apron, shoes, gloves, overalls, hats, sunburn cream etc - lifting lug baskets of bycatch/manual handling video (10 mins)
Lunch	1300-1400		
What we havent already covered?	1400-1530	Open Discussion	Flexible-- What the Observers themselves wanted more info on!!
Last Minute Shopping	1530-1700		Local Cleveland -Buy seasickness pills, sunburn cream, earplugs, overalls etc

3. O H and S awareness

To ensure that Observers were fully aware of all OH and S dangers they may encounter, we addressed in detail the comprehensive safety section in the Observer Manual (See -Appendix 4). We concentrated on working alone on back decks at night, transferring from vessel to vessel on trawl grounds, and identifying hazards likely to be encountered on each new vessel (hazards to both Observers and other crew alike).

We discussed the dangers associated with each of the eight catch categories to be sampled. These dangers ranged from falling overboard while tipping 40kg baskets of bycatch over the side, back injuries from lifting heavy weights on rolling decks, to measuring large live sharks, and handling live sea snakes.

We covered the importance of handling relations with crew who were isolated at sea for three months continuously. We discussed the importance of communications and the use of phone cards and mobile satellite phone calls to maintain contacts with the outside world.

We discussed at great length the process for relaying messages to the shore supervisor if personal relations on board had deteriorated to the stage where code was needed to signify and identify the problems and solutions.

Through social contacts such as barbecues etc, we encouraged the Observers to form a self support group so that they felt they could contact one another for advice etc during the season.

4. Personal safety equipment

We ensured that each Observer was equipped with a personal flotation device that was self activated in water, and included small EPIRB and a small waterproof torch ('Stormy Seas' Vest). We discussed the use of these devices and strongly encouraged their use. We also provided other protective clothing as selected personally by each Observer. This list included overalls, wet weather jackets and pants, work aprons, gum boots, runners, cotton and rubber gloves, sunburn cream and hats. We also purchased a range of First Aid items that Observers felt would be needed at sea. These included bandaids, bandages, hand creams, antibiotic tablets and powders, antiseptic creams, sea sickness tablets etc (Table 9-3).

Permits

Observers required two types of permits in order to complete their work:

a) Permits to use any combination of TEDs and BRDs or Standard nets;

b) Permits to retain a range of animals needed for identification purposes, or required for other projects. This list included sharks and rays (identification), some teleosts and small invertebrate bycatch species on state schedules of legal sizes (requests from other projects), bugs (requests from other projects) and sea snakes (identification and biological sampling).

We applied to AFMA for permits to change gear on the vessels that each Observer was expected to sample from, and to allow the taking of bugs (CSIRO Research Project), and some Lutjanids (CSIRO Research Project).

We applied to NT Fisheries for permits to collect *Carangid* samples (NT Fisheries Research Project) and *Stolephorus* samples (CSIRO Research Project).

We applied to EA for permits to retain sea snakes (See Figure 9-16) on the vessels that each Observer was expected to sample (CSIRO Research Project).

Pre-embarqation procedures at ports

Objectives

- To ensure that each Observer kit was complete before heading off to sea.

Project staff accompanied three Observers to Cairns and two to Darwin. Upon arrival each Observer was issued with his own kit. The kit was duly checked against the supplied list of contents. Project staff accompanied the Observers on last minute shopping trips if other items were deemed to be necessary. Completed kits were then delivered to the first vessel that each Observer was due to board.

- To introduce Observers to trawler skippers and crew of first trawler that they would board, as well as to other likely trawlers/skippers they would encounter over the season.

Observers were introduced to the skipper and crew of their first vessel and the kits were stowed on board. They were also introduced to skippers and crew of any other vessels that they had on their proposed list of sampling vessels. Each Observer already had a list of vessels most likely to be sampled by them. The list revolved around mothership company lines because it would be easier to transfer to vessels that unloaded to the same mothership.

Project staff also took this opportunity to further identify obvious OH and S hazards on any of likely sampling vessels and point them out to the Observer.

- To encourage bonding between Observers

Project staff encouraged social interaction both during and after hours in the days leading up to embarkation- so that the Observers would feel they could contact each other by either radio or Satellite phone whilst at sea.

- To liase with the skippers and staff of the Mothership companies

Project staff visited offices of the four mothership companies (Cairns and Darwin) and sought help in organising transfers at sea, collection of frozen samples and subsequent storing of them on shore. A spare Observer kit was also placed in long term storage on a mothership to reduce the time lag when replacing lost or broken items of sampling equipment at sea.

9.4 At sea execution

9.4.1 Day to day communications and planning

Satellite phone communications

(a) Communications with Observers

Each Observer was usually contacted around 3 times each week (from 1st August to 9th November 2001) by the Observer Program manager using the Satellite phone.

The main questions asked of Observers were:

- their current position for safety reasons (latitude and longitude of the vessel);

- the current status of sampling schedule (eg. 3rd night into TED plus BRD versus Standard net);
- the current health status of Observer (for example, What injuries are you carrying? What treatments etc);
- any OH and S issues (for example, Any incidents near misses etc that need to be relayed to other Observers);
- the current status of Observer -crew relations if likely problems;
- the current sampling equipment deficiencies and requirements;
- the status of collection of frozen samples,and their transfers to motherships etc;
- the faxing of vessel summaries and posting of original data sheets to Cleveland.

The main information relayed back to Observers was**:**

- the next likely vessel to be sampled, its present position and tentative details of The transfer;
- the relaying of messages from supervisors, outside or other Observers;
- the relaying of safety alerts and general OH and S information as required;
- the details of delivery and mode of transport for equipment requests from previous conversations;
- the details of permits recently applied for;
- the requests for specimens (eg. sharks, rays, sea horses, bugs etc) to be collected for identification and other associated project requirements.

The most convenient time to call Observers was around 0700h to 0900h, either just before the morning trawl was winched in, or well after the processing of that trawl had finished. All matters discussed and requests for equipment were documented by the Observer Program manager, for each Observer, on the standard questionaire form completed during each call. In most cases, this daily working document formed the basis for the next phone call discussion.

(b) Communication with sampling vessels and motherships

Satellite phone was also used to keep in contact with the skippers of the most likely vessels to take an Observer on board. These skippers had already been approached before the season and had agreed to help our sampling. The geographic position of the vessel dictated whether they were next in line for taking an Observer.

Similarly, the Satellite phone was also used to keep in contact with the skippers of all four motherships. These skippers were extremely helpful in locating given vessels, and most often organised the timing of transfers for Observers because they knew when and where the next unloading or contact would occur.

(c) Communications prior to observer transfers

In the week leading up to an expected change in vessels, the frequency of phone contact increased to almost daily with:

a) the Observer involved in a transfer;
b) one or more vessels that were expecting to collect an Observer in the near future;
c) the motherships involved in the transfer arrangements.

The increased number of phone calls became necessary due to the constantly changing schedules. For example, motherships often only travel in one direction on their circuits around the fleet. So the next sampling vessel needs to be ahead of the mothership after the Observer is picked up from the completed vessel. But if the next sampling vessel decides to shift back to a position already serviced by the mothership, project staff needed to find another vessel ahead of the mothership and organise permits for that vessel instead. As the number of available vessels to sample becomes smaller, the complexity of organising transfers increases enormously. Weather conditions also changed the likelihood of motherships unloading on trawl grounds, with rough conditions forcing both vessels and mothership to seek shelter in the lee of islands to unload safely.

Due to OH and S concerns, we did not encourage direct trawler to trawler transfers if they could at all be avoided. This policy often extended Observer time on individual vessels to more than two weeks.

Applications for permits

There was considerable time spent coordinating the permits required for changing fishing gear because often, it was unclear which vessel was the next to be sampled. NPF vessels move often when catches drop and coordinating Observer movements with mothership movements was a major logistic problem.

In some cases where Observers changed vessels at very short notice, we advised AFMA Compliance Section of the proposed moves at the same time as we applied for Permits. We did this to ensure that Observers were not placed in situations where permits were either not supplied or that AFMA had not been notified that short notice changes were likely outcomes.

Copies of Permits for Gear changes to vessels were faxed to those vessels once it became clear that the correct vessel was listed and an Observer transfer to that vessel was imminent.

The transfer of data and confidentiality

The data transfer system worked extremely well. Faxing of the summary for each of the 24 vessels sampled caused a few problems, mostly due to the Satellite phones dropping out during faxing, either inwards or outwards. We lost no original sample sheets in the postal system. The first data sets although completed on the first vessels around 20th of August, did not arrrive in Cleveland until early September. The raw data sheets were stored securely in the laboratory safe until editing commenced after the season finished.

Maintaining the confidentiality of the data was constantly brought to the attention of the Observers. They were instructed not to leave data collected from another vessel anywhere where it could be accessed easily by crew from the present vessel. They were instructed never to discuss catch rates recorded on other vessels or to discuss crew problems from other vessels. The raw data sheets were placed in sealed pre-paid post paks before they were handed over to the mothership postage system.

The transfer of frozen samples

In those cases when Observers were transferring to motherships in order to travel to their next sampling vessel, they helped unload their frozen samples (ie. sea snakes, small bycatch sharks and rays for identification etc) to the mothership. The loading information was then faxed or relayed by phone to the Cleveland laboratory.

In cases where Observers transferred to another vessel (not a mothership) the frozen samples remained on board until that vessel unloaded to the mothership. The loading information referring to these samples was usually relayed to project staff by the skippers of the motherships during normal communications with them.

Frozen samples were stored in freezers in Cairns, Townsville or Darwin, until project staff organised road freighting of samples to the Cleveland laboratory.

Maintenance of observer equipment at sea

We organised for the replacement of all equipment that was damaged or lost overboard as soon as possible. We achieved this objective by maintaining a complete Observer kit on one of the motherships, and smaller quantities of expendables on the others. This system ensured that a stock of commonly used and/or lost sampling items such as lug baskets, plastic bags, waxed cartons, wood runners and medical supplies were in transit around the Gulf on the motherships at any given time. This system enabled the Observers to replace items much quicker than project staff purchasing replacement equipment, road freighting it to either Cairns or Darwin and waiting for the mothership connections to occur. This involved process could mean Observers waited up to one month before replacements arrived.

There were also some instances where swapping of spare equipment occurred between Observer vessels.

Some lug baskets were lost over the side and other smaller items were washed over or thrown over by mistake. However, none of the Observers was unable to complete their tasks due to the loss of critical sampling equipment.

Record keeping

We maintained separately, the electronic file records of phone call interactions with the Observers, the Motherships, and the 30 plus other trawlers contacted during the season. Keeping these records up to date on a daily basis was critical if control of the program needed to change hands between project staff.

Electronic records of the following interactions were updated on almost a daily basis:

a) phone calls to Observers;
b) phone calls to motherships;
c) phone calls to past and prospective sampling vessels;
d) lists of payments to skippers of sampled vessels for Observer board;
e) OH and S incidents and reports;
f) dates when Observers posted raw data sets from trawlers, and the dates of subsequent receival at Cleveland laboratory;
g) dates and details of unloadings to motherships of all freight including frozen sea snakes, bugs, Carangids, small bycatch samples etc;
h) details of freighting by road of all freight from Observers back to Cleveland laboratory;
i) details of arrival of all freight from Observers back at Cleveland laboratory;

The Observers were also encouraged to complete a daily diary (supplied).

Changes to sampling methods at sea

We encountered many instances where changes had to be made to methods in order to best fit in with commercial practice. Some deviations from the expected fortnight schedule occurred because of changes in mothership movements (for example, some sampling treatments were extended others shortened). At times, some extra sampling was instituted in order to quantify whether some particular BRD device was working successfully. Some prioritisation of sorting procedures became necessary on vessels that had different handling procedures or capacities to assist Observers.

Checks on species identification

We asked each Observer to collect one specimen from the most common species of sharks and rays and send them to Cleveland so we could verify their field identification.

Four of the Observers did so and their identifications were checked and we updated their data sheets accordingly where necessary.

9.4.2 Occupational health and safety issues at sea

Control of OH and S issues was extremely important. We could ill afford to lose an Observer through injury or sickness. Consequently, we instituted a series of wide ranging objectives in our OH and S policy whilst Observers were at sea. The Observer Program Manager (OPM) was responsible for achieving the following Objectives:

Objective 1 *To constantly assess all OH and S issues in every interaction with the Observers and the skippers of the sampling vessels.*

Objective 2 *To constantly update all Observers on OH and S concerns, in order to reduce chance of similar incidents.*

Objective 3 *To maintain accurate records of accident rates, near misses and relevant Incident Reports.*

Objective 4 *To ensure that the OPM was able to be contacted by phone 24 hours every day of the three months tiger prawn season in order to be able to respond immediately to any crises that may arise.*

Objective 5 *To provide a source of encouragement and positive feedback to Observers with respect to the quality of their data collection and provide a constant point of contact with the outside world.*

Summary of OH and S issues

Overall, the five Observers survived the three months at sea with minimal injuries. There was some time lost due to minor back injuries, and from injuries sustained from airborne objects and there were a few near misses that were potentially dangerous. The Observers were happy with the level of contact with the OPM and the assistance and encouragement provided.

In general, we discussed likely problems that could be encountered, on every phone call, and made sure that the importance of these issues was a matter of constant concern for project staff. We encouraged Observers to take respite from the constant sampling regime, and wherever it was possible, the OPM tried to select a replacement vessel at least 2 days steam away on the mothership.

We constantly kept all Observers updated on injuries incurred on other vesels by Observers as well as by other crew. Similarly, near misses were discussed so that they were made more aware of the likely consequences of hastily-thought out actions.

Records were kept of all injuries incurred by Observers as well as completing incident report forms where necessary. We organised the restocking of antibiotics tablets and powders during the season, as well as extra first aid supplies to replace those borrowed from the sampling vessels.

The OPM remained in phone contact 24 hours each day of the season and fielded many out of hours queries and facilitated Observer transfers. The cost of Satellite phone calls to Observers and other vessels was in the order of $4000 over the season.

We also provided encouragement and positive feedback to Observers and provided a constant point of contact with the outside world.

9.4.3 End of season debriefing

At the end of the season, two Observers arrived in Darwin on sampling vessels and one flew from Gove to Darwin a few days prior to the end of season due to a back problem. The remaining two Observers arrived in Cairns on their respective sampling vessels. Project staff met and debriefed all three Observers in Darwin, and one Observer in Cairns (one had to leave immediately for overseas upon arrival at port).

Debriefs included the following:

- Project staff documented information and feedback from all Observers as to what sections of the project worked well and what sections needed refinement;

- All outstanding data questions were resolved and the last sets of sample sheetsb collected;

- OH and S incidents were reviewed and near misses discussed with a view to reducing risks of future incidents in similar projects;

- Project staff congratulated the Observers on their great achievements during the program. The Observers were flown home shortly afterwards.

9.5 Post season accounting and data processing

9.5.1 Payments of accounts

Payments needed to be finalised for outstanding accounts incurred during the Observer Program, including:

a) payments to skippers (for board by Observers @ $20 /night)
b) payments to mothership companies for frozen or dry freight handling, board for Observers
c) payments to Coldstores for freight handling and pallett packing
d) payments to road freight Companies for transporting both dry and frozen freight to Cleveland.

9.5.2 Data base

Raw data handling

(a) We examined each raw data sheet to try to reduce the chance of wrong coding and obvious mistakes in recording the data. One of the biggest problems occurred when no information was recorded for a given catch category. In many cases it wasn’t clear whether the Observer had actually searched for that category of catch. For example, if no large sharks or rays were recorded, we needed to know whether (a) no large sharks and rays were actually in the catch, or (b) for some reason unexplained, the Observer was unable to check for and record the presence of the large sharks and rays in that catch.

(b) The system of using a unique set of consecutive station numbers for each Observer worked well. We had one instance where the same station number was used twice, on the shot immediately before and immediately after, changing vessels.

Database design and data entry procedures

A complex database structure, designed by Malcolm Austin (CSIRO), was required because the Observers collected a wide range of data opportunistically, as well as the core data (Figure 9-25).

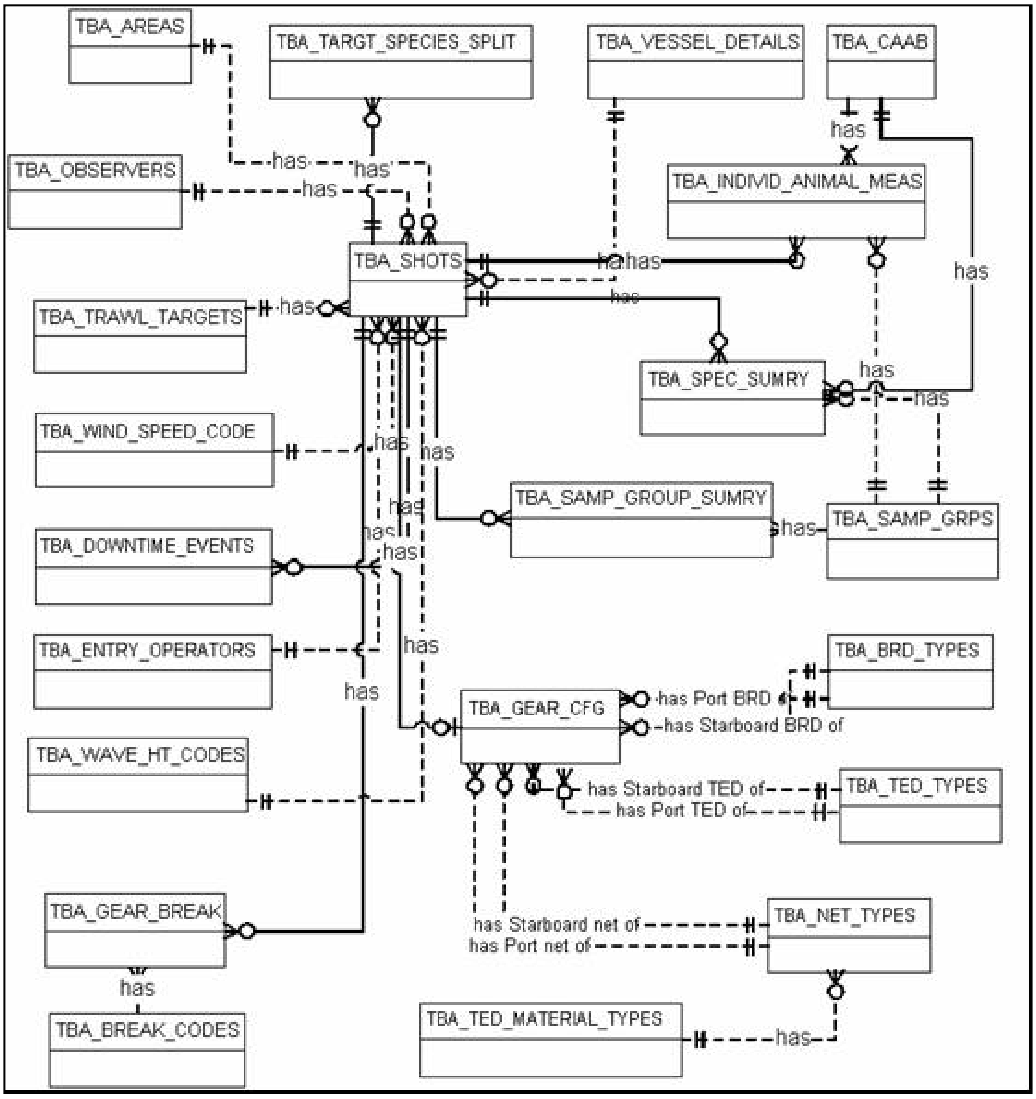


Figure 9-25. Schematic diagram of Observer database design. (TBA = TED and BRD Assessment-- for further explanation of the database, please contact the authors).

To facilitate the data entry process, we created a custom software application (see Figures 9-26 (a), (b), (c)). All data entered was stored directly into an Oracle database where it was automatically backed up nightly. The data entry supported simultaneous data entry and checking by a number of operators (normally two) in order to save time. This process took around 3 weeks.

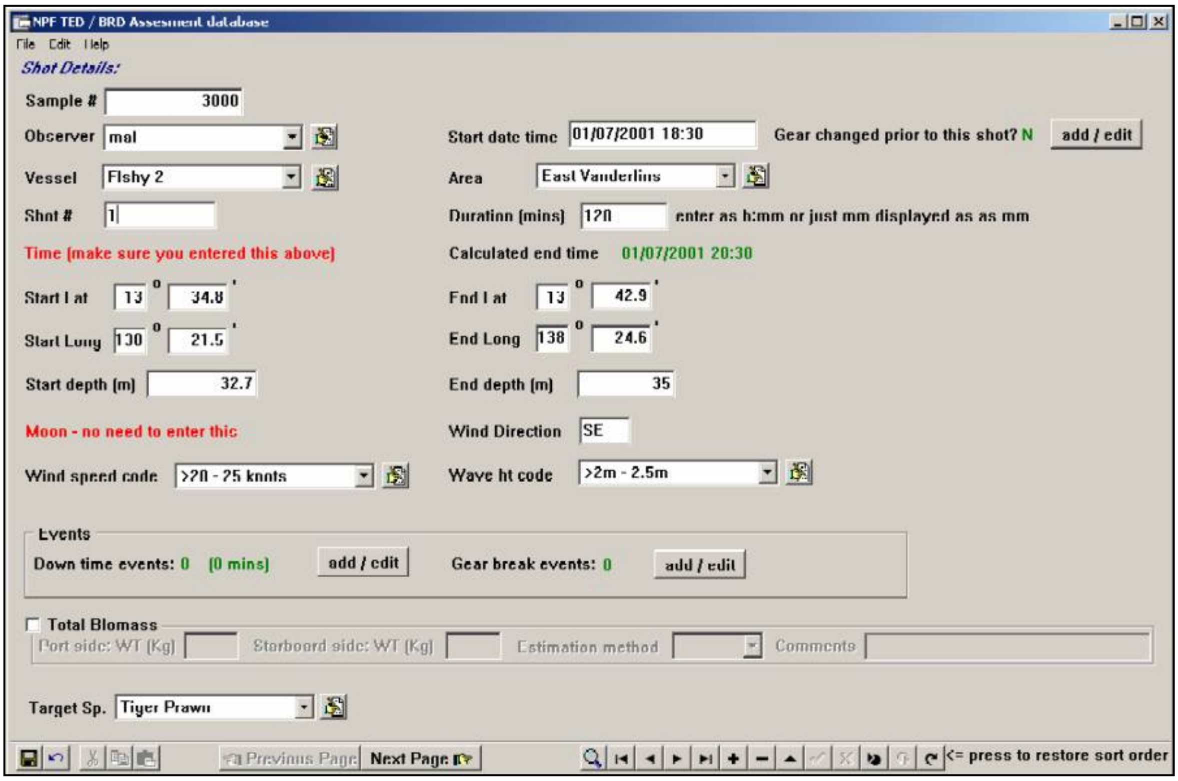


Figure 9-26(a). Example of sample data entry screen for the Observers shot details.

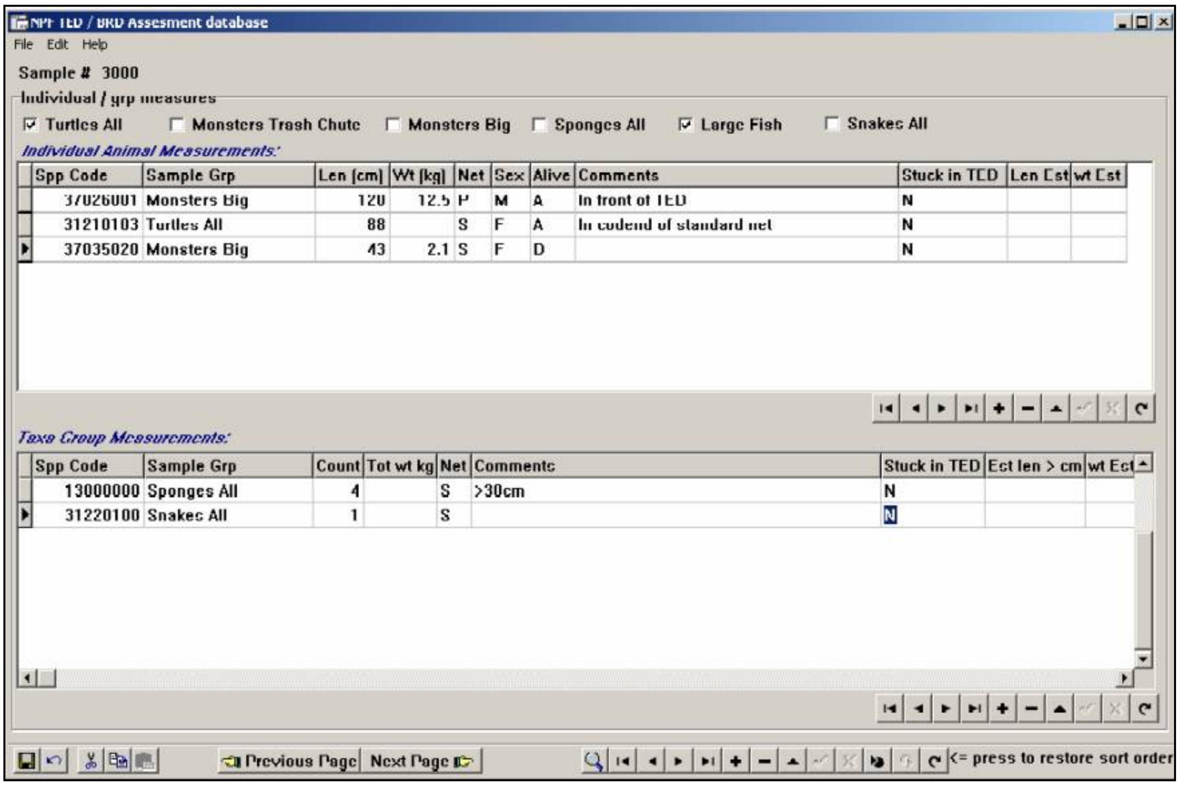


Figure 9-26(b). Example of sample data entry screen for Observer individual species and group details.

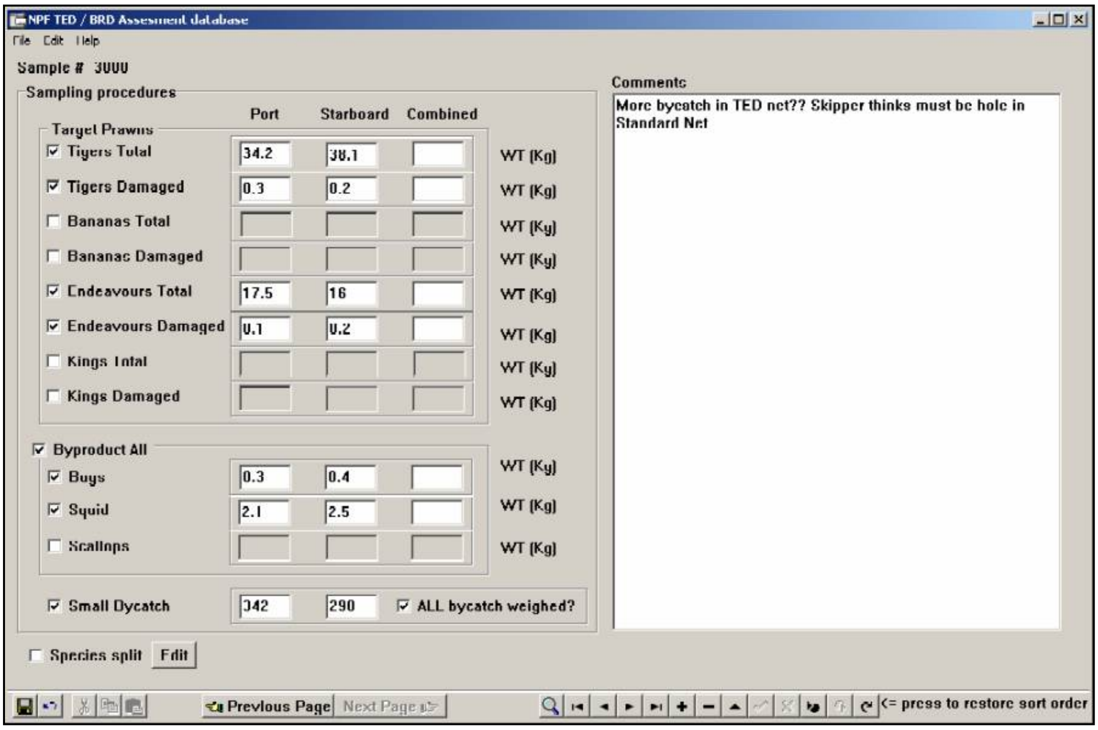


Figure 9-26 (c). Example of sample data entry screen for the Observer prawns, byproduct and small bycatch detail.

Editing of data in database

- We designed and ran automatic checks on the data to detect outlying entries in date, time of trawl start, duration of trawl, latitude and longitude, or depth.

- We also hand checked every entry of small bycatch and prawns to ensure that the data for each net was recorded against the correct gear combination. We did this by comparing computer printouts of the data with the original raw data sheets.

- We also hand checked a proportion (2/7th) of the completed data set for entries of large sharks and rays, turtles, sea snakes, small trash chute sharks and rays and sponges.

Wherever the Observer had commented that there had been something different about the fishing ability of one of the nets, we assigned a 'Gear Break' flag to the relevent data. For example, if a large ray was stuck across the face of the TED when the net was winched up, a 'Gear Break' was recorded for that net on that station (See Figure 9-27). At the same time, we flagged the different catch categories that may have been affected by the blockage. In the case above, we flagged the prawn catch, the small bycatch and the small trash chute sharks and rays as all possibly affected by the 'Gear Break'.

The list of possible 'Gear Breaks' is shown in Table 9-5. A total of 169 instances of 'Gear Breaks' were recorded in the 1637 trawls observed.

It should be noted that the Gear Break flags were only indicators of the potential of some event to affect any one or more of the different catch categories. It was not possible to make the list exhaustive. For example, there would be many times during the 3-4 hour trawls when large animals might temporarily block part of the TED. However, eventually the animal escapes and there is no evidence of its effect on the different catch categories.

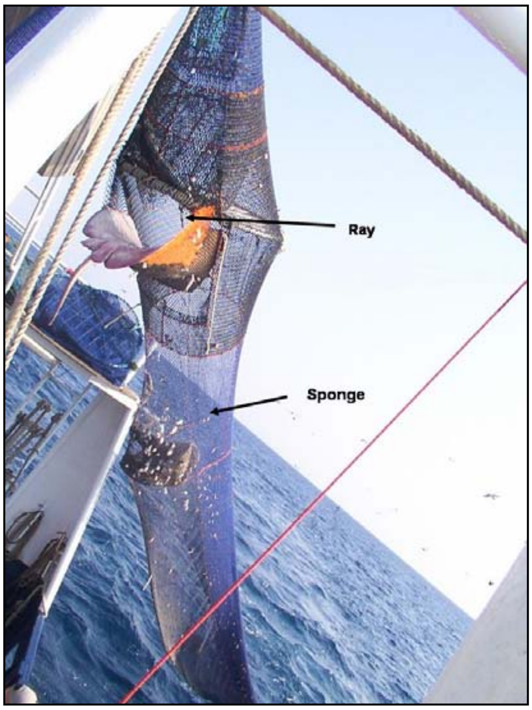


Figure 9-27. Large ray stuck in the TED exit hole and a sponge stuck in the throat of net. *(Photo-G. Day)*

Extraction of data for analyses

Data for analysis was extracted from Oracle tables using SQL plus.

Table 9-5. The types of gear breaks (gear related incidents with the potential to affect catches from an individual net) recorded by Observers and the frequency of occurrence of each type.

Count	Gear Break Codes
1	Bridle wires tangled
1	Codend not tied properly
1	Large shell stuck in TED
1	Large fish ahead of TED
1	Lazyline around TED
1	Some catch ahead of TED
1	Starfish ahead of TED
2	Black coral stuck TED
3	Strange TED blockage
3	Hit fish mark 1 side only
4	Catch spilt on both trays
4	Sawfish stuck in TED
4	TED broken
6	Different small bycatch
6	Mud bag in codend

Count	Gear Break Codes
7	Flywires crossed
7	Coral slabs ahead of TED
8	Large ray stuck in TED
8	Ground chain cut middle
9	Shark stuck in TED
9	Bogged one side
11	Hole in net
71	Sponge ahead of TED
169	

9.6 Results

9.6.1 Was sampling representative of NPF fleet?

Size structure of the NPF fleet throughout the tiger prawn season

The sampled Observer fleet (n=23) was reasonably representative (Figure 9-28), given that there was a need to avoid vessels that:

a) used hoppers;
b) were too small to sample safely from;
c) worked Joseph Bonaparte Gulf (See Section 9.2.2);

At any given time during the season, Observer vessels made up around 4.3% of the fleet. The Observer vessels sampled, along with their respective skippers and Observers, are shown in Table 9-6.

Spatial distribution of NPF fleet effort throughout the tiger prawn season

The log of nominal boat days rather than the actual, is shown, because we are interested more in the spatial pattern of coverage than the ratio between the Observer fleet and the Non-Observer fleet (Figure 9-29). The Observer fleet concentrated its effort from East of Mornington Island through to the Wessels. As expected, no Observer vessels sampled Joseph Bonaparte Gulf (JBG), and across the Top End. Also no Observer vessels sampled in the Weipa to Bold Point region.

Gear types (eg TED's and BRD's) used by the NPF fleet throughout the tiger prawn season

The Observer fleet had a lower proportion of upward to downward directed TEDs (See Figure 9-30) than that recorded by the fleet interviewed in the phone survey of gear types (See Chapter 8). For BRDs, the Observer fleet was representative of usage by the phone survey fleet, for the Bigeye, Square mesh panel and the Fisheye (See Figure 9-31) (See Chapter 8).

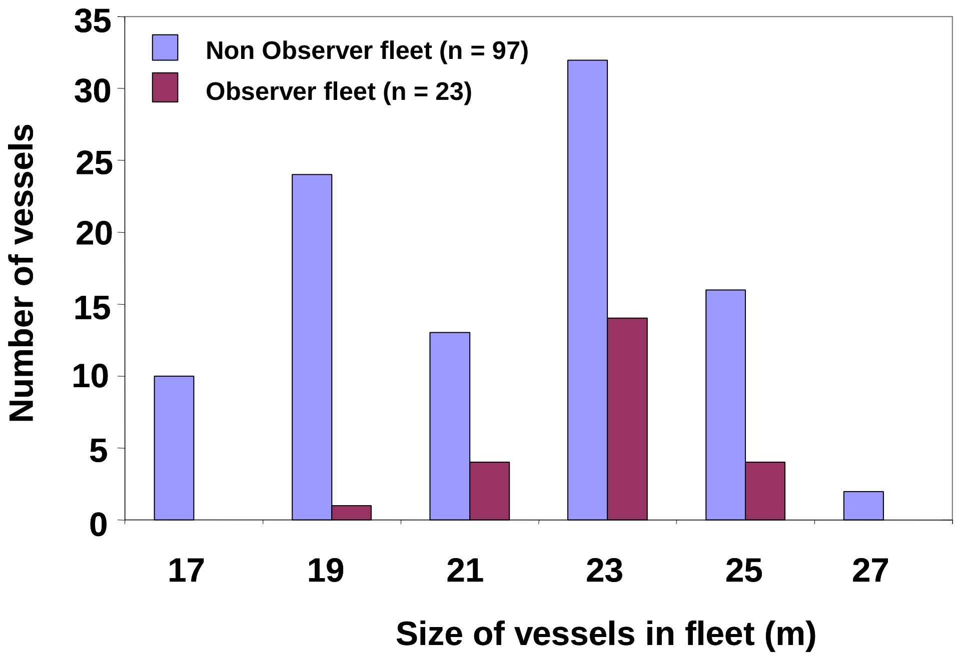


Figure 9-28. The distribution of vessel size in the Observer fleet compared with the remainder of the fleet.

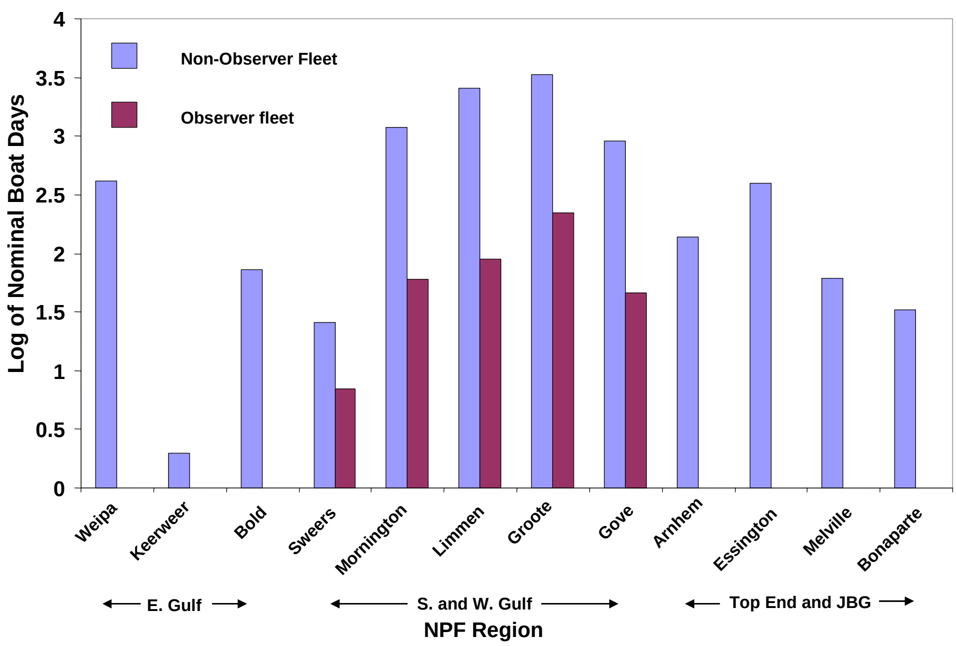


Figure 9-29. The log of boat days (nominal) in each major region of the NPF for Observer vessels- compared with the remainder of the NPF fleet. Boat days were recorded for the tiger prawn fishery from August to November 2001.

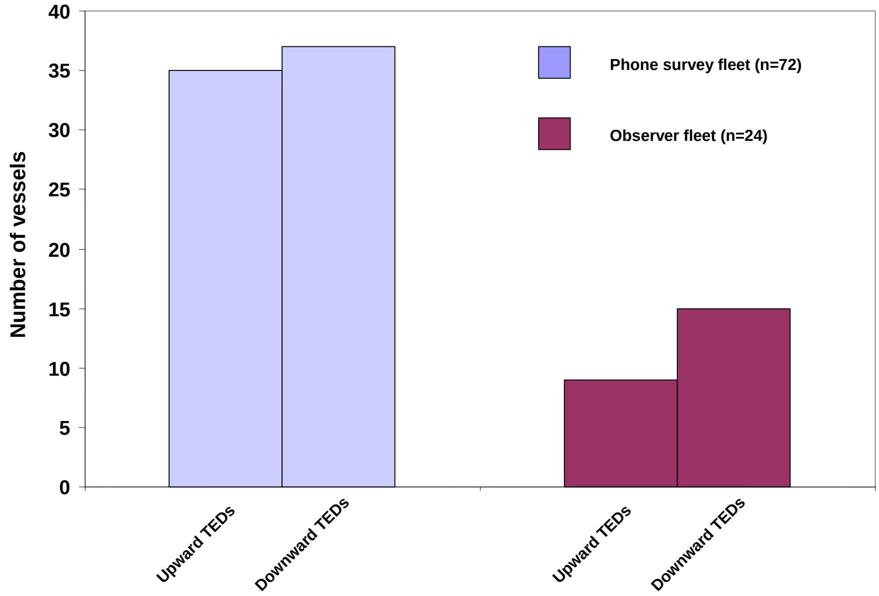


Figure 9-30. A comparison of use of upward excluding TEDs versus downward excluding TEDs by the NPF phone surveyed fleet (Chapter 8) and the Observer fleet.

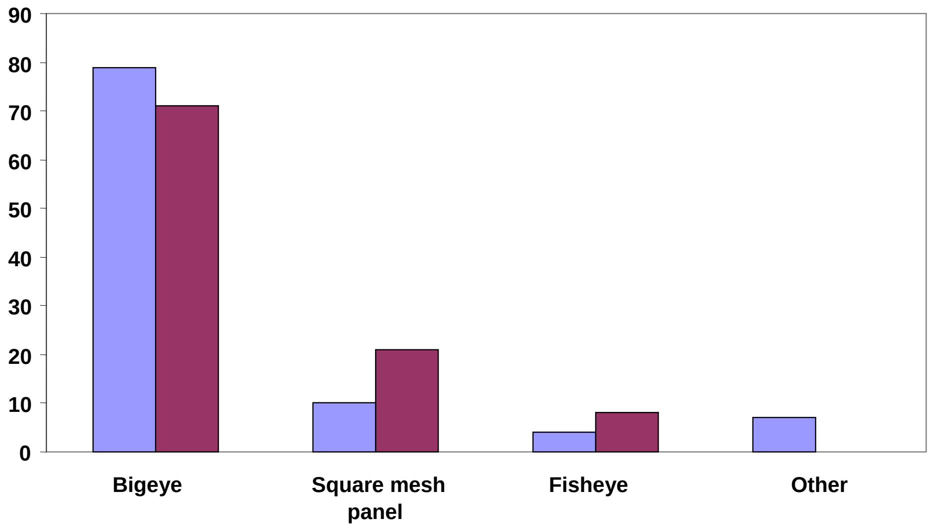


Figure 9-31. A comparison of use (percent) of different BRD types between the NPF phone surveyed fleet (Chapter 8) and the Observer fleet. The legend from Figure 9-30 also applies to this figure.

Table 9-6. Alphabetical list of 23 Trawlers, skippers and Observers. Note- 'Angelina C' was sampled on two separate occasions by different Observers.

Vessel name	Skipper	Observer
Amelia C	John Correia	Ben Bird
Angelina C	Richard Richter	Chris Gough, Reuben Gregor
Austral	Stephanie Bell	Quinton Dell
Bounty Hunter	Lester Sharpe	Quinton Dell
Brianna Rene Adele	Brian Bienke Jnr	Ben Bird
Caledon Pearl	Michael Coombes	Garry Day
Carlisle	Chris Orchard	Reuben Gregor
Cindy Ann	Rob Hoschke	Quinton Dell
Comac Endeavour	Dwayne Klinkhammer	Garry Day
Emserve	Alan Read	Ben Bird
Hayman	Darren ("Tractor") Towns	Chris Gough
Heron	Brian ("Jack") Gleeson	Ben Bird
Newfish 2	Greg Patrick	Reuben Gregor
Ocean Thief	Anthony Gofton	Garry Day
Perpetua	Neil ("Mouse") Clifford	Garry Day
Point Moore	Russel ("Mouse") Caravias	Ben Bird
Providence	Stuart Carter	Reuben Gregor
Rosen C	Jim Yarrow	Quinton Dell
Sandpiper	Rod ("Rocket") Annabel	Chris Gough
Sea Fever	Neil ("Chainsaw") McCulloch	Chris Gough
Sea Thief	Brad Allen	Garry Day
Ventura	Percy Hoschke	Quinton Dell
Xanadu	Jeff Nicholls	Reuben Gregor

9.6.2 Summary of data collected

How many trawls were sampled for each of the possible gear combinations?

The Table 9-7 shows the breakdown of numbers of trawls conducted using 6 possible gear combinations. Recorded were:

- 292 tiger prawn trawl calibrations and 57 banana prawn calibrations;
- 618 tiger prawn trawls and 25 banana prawn trawls compared a TED and BRD net with the Standard net;
- 407 tiger prawn trawls compared a TED only with the Standard net;
- 190 tiger prawn trawls compared a BRD only with the Standard net;
- 31 tiger prawn trawls compared a TED and BRD combination with the Standard net.

How well was sampling distributed amongst the eight catch categories?

The Table 9-8 shows the numbers of trawls that were sampled for each catch category and for each vessel. It is clear from the table that the Observers on vessels 12, 13 and 14 had their crews well organised because they managed to sample every catch category on most trawls.

Table 9-7. The number and type of gear comparisons sampled on each Observer vessel during (a) tiger prawn fishing (n =1538 comparisons) and (b) banana prawn fishing (in red; n = 82 comparisons). Columns 2 and 3 represent trawl gear calibrations and columns 4 to 7, the experimental treatment trawl comparisons.

Vessel	TED + BRD V's TED + BRD	Std net V's Std net	TED + BRD V's Std net	TED Only V's Std net	BRD Only V's Std net	TED + BRD V's BRD Only
1	7	0	29	24	0	4
2	3	0	24	18	0	0
3	12	12	28	28	0	0
4	7	6	16	18	0	0
5	0	15	32	29	0	0
6	30 (13)	0	31 (15)	21	0	0
7	27	0	28	33	37	0
8	20	0	22	28	0	0
9	5	0	35	0	0	0
10	8	0	40	32	0	0
11	8	0	36	36	0	0
12	8	4	24	24	23	0
13	8	0	24	24	0	0
14	4	3	0	0	20	0
15	8 (41)	0	42	0	23	0
16	0	28	13	0	55	0
17	13	0	37	20	0	0
18	7	0	29	17	0	0
19	3 (3)	0	13 (10)	3	0	0
20	8	0	22	30	0	0
21	0	8	23	0	32	27
22	8	7	19	22	0	0
23	11	0	27	0	0	0
24	4	0	24	0	0	0
Totals	209 (57)	83	618 (25)	407	190	31

Table 9-8. The number (*n*) of paired trawls (for each Observer vessel) that were sampled for the eight catch categories. The number (*n*) includes both calibration trawls and treatment trawls. Numbers in brackets = Banana prawn trawls. (The order of vessels is randomised from the list in Table 9.6).

Vessel code	Observ. No.	Nights fished (*n*)	Turtles (*n*)	Sponges (*n*)	Large Sharks/rays (*n*)	Sea snakes (*n*)	Prawns (*n*)	Byproduct (*n*)	Small Sharks/rays (*n*)	Small bycatch (*n*)
1	1	18	73	73	73	73	71	10	73	53
2	1	15	45	45	45	45	45		45	36
3	1	20	80	80	80	80	79		78	75
4	1	15	47	47	47	47	42		46	40
5	1	22	76	73	73	73	73		55	60
6	2	33	82 (28)	79 (28)	79 (28)	80 (28)	81 (28)	79 (6)	4	53
7	2	33	125	125	121	125	117	24		89
8	2	18	70	70	67	70	70			35
9	2	12	40	38	34	38	38			
10	3	20	80	79	79	68	80	74	24	48
11	3	20	80	76	76	76	80	8	52	53
12	3	21	83	82	82	83	83	74	73	60
13	3	14	56	56	56	56	56	56	55	39
14	3	8	31	30	30	30	31	31	27	26
15	4	28	73 (41)	56 (4)	56 (11)	56 (3)	72 (34)	12 (3)		15 (4)
16	4	24	77	77	77	77	92	28		44
17	4	18	74	44	43	43	71	1		34
18	4	18	53	22	22	25	48			11
19	5	11	19 (13)	17 (11)	16 (11)	16	14 (11)	17 (12)	5	8 (7)
20	5	18	60	55	57	58	60	49	6	25
21	5	25	90	80	76	80	84	68	5	45
22	5	12	56	47	47	48	51	49	4	8
23	5	11	38	26	26	26	22	1		22
24	5	8	22	22	22	23	22	10		6
Totals		442	1530 (82)	1399 (43)	1384 (50)	1396 (31)	1482 (73)	591 (21)	552	885 (11)

How well did the observers identify the large Elasmobranchs?

Observers were requested to send back to Cleveland, a frozen labelled specimen as an example of the common elasmobranchs encountered during the season. This was done to verify their field identifications. There were some identifications problems early in the program but soon after the start, 4 of the 5 Observers identified correctly the common species including *Carcharhinus dussumieri, Ca. tilstoni, Rhizoprionid acutus, Hemigaleus microstoma, Stegostoma fasciatum, Nebrius ferrugineus, Chiloscyllium punctata, Rhynchobatus djiddensis, Rhinobatus typus, Himantura toshi, Pastinachus sephen, Dasyatis leylandi, Da. kuhlii, Gymnura australis* and all of the sawfishes encountered (mostly *Anoxypristis cuspidata).*

Where positive identifications were not possible, photos were taken and identification attempted in the laboratory.

9.6.3 Feedback from industry and observers

How well did Industry accept the Observer Program?

The pre-Observer Program feedback we received from talking with skippers of possible Observer vessels was that they were very interested and looked forward to the chance to assess the performance of their own TEDs and BRDs. This was something they couldn’t do legally without permits and the small bycatch category was very difficult for fishers to assess accurately. Feedback from mothership skippers was also encouraging during the season. Comments included "it’s good to see some field work being done that benefits the industry" (Anon). Some crew on Observer vessels were starting to get unhappy after two weeks of having to deal with large live sharks and rays on the sorting tray again. One Observer was greatly in demand after taking over cooking duties.

What did the observers say about the project?

Generally the feedback from Observers on vessels was positive. They enjoyed their time at sea and gained much expertise in how this fishery operates.

What things should be changed?

The observers generally felt that their rate of pay was too low for the extended time at sea with the crew generally earning more on most vessels over the season. Observers were paid at an increasing but stepped rate. The pay increased by 20% after the first month and a further 20% in the last month (based on the first month pay rate). This was done purposely to try to ensure that motivation remained high towards the end of the program.

9.7 Conclusions

This program was designed to capture a snapshot in time (across a whole season), of the impact of TEDs and BRDs on catches by NPF trawlers. The five Observers recorded data while on board 24 individual trawlers over the season. In general, the Observer Program was competed successfully, collecting data to assess the performance of the use of TEDs and BRDs in the tiger prawn season of 2001.

Fishermen are continually making changes to how their gear fishes, especially to TEDs and BRDs. In the NPF mid season meetings in Cairns and Darwin in 2001, NPF fishers as a group were very much against the use of TEDs. It is fair to say that the situation has turned around, and most crew these days wouldn’t want to work without them in their nets. However there are still some areas of the NPF where TEDs continue to cause problems.

Nevertheless, the turnaround by NPF fishers on the TED issue is a credit to all parties concerned including the NPF skippers, owners and crew, the staff from AMC, CSIRO and QDPI, FRDC, and the netmakers including Popeye, Norm McDonald, GNM Chandlery, Swede, Tony La Macchia and Chris Gough.

9.8 References

Eayrs, S., Buxton, C., McDonald, B., 1997. A Guide to Bycatch Reduction in Australian Prawn Trawl Fisheries. AMC.

Heales, D.S.; Brewer, D. T.; Jones, P. N. 2003. Subsampling trawl catches from vessels using seawater hoppers: are catch composition estimates biased? Fish. Res. 63:1 pp 113-120.

CHAPTER 10

CHANGE IN CATCHES DUE TO TEDS AND BRDS

Chapter Authors:

David Brewer, Don Heales, Peter Jones, Dave Milton, Ilona Stobutzki,
Gary Fry, You-gan Wang

CHAPTER 10

CHAPTER 10

CHANGE IN NPF CATCHES DUE TO TEDS AND BRDS

David Brewer, Don Heales, Peter Jones, Dave Milton, Ilona Stobutzki, Gary Fry, William Venables and You-Gan Wang

Scientific Observers: Ben Bird, Garry Day, Quinton Dell, Chris Gough, Reuben Gregor

Summary

The catch data from each bycatch group were analysed differently depending on whether weights, counts or lengths were measured or if the group was rarely caught.

Total catch weights were collected for commercially important groups (i.e. prawns and byproduct species) and for the Small Bycatch species (i.e. small teleosts and small invertebrates). These weight data were log transformed and analysed using a linear model assuming a normal distribution. Sub-models were also fitted to test for the difference between downward and upward excluding TEDs, or differences between the two types of BRDs; the Bigeye or Square-mesh panel.

Counts of individual animals were recorded for turtles, sea snakes, sharks, rays, sawfish and sponges. Most of the groups with count data were rarely caught and were analysed using a binomial model with a fixed probability of capture.

Lengths of Elasmobranchs were analysed with a repeated measures Analyses of Variance and assumed to be normally distributed.

The introduction of TEDs and BRDs in all NPF nets has had a widely varying impact on the different species taken by the fishery. Catches of commercially important prawns have been reduced by 3% to 6%, depending on the ability of fishers to use their TEDs effectively. It is likely that this figure will shift from the higher to the lower value in the few years following the 2001 assessment. Most of the prawn losses appear to be attributable to the effects of TEDs, although there was also a significant loss of tiger prawns from the use of the Bigeye BRD. The other BRD tested, the Square-mesh panel showed no loss of prawns. The loss of prawns due to TEDs+BRDs has been partially offset by a significant reduction (~40%) in the weight of prawns that were damaged by heavy animals that are now rare in these catches. Three groups of byproduct species were also assessed. The use of TEDs and/or BRDs made no measurable impact on catches of Moreton Bay bugs, squid or scallops in this study.

The Small Bycatch received little benefit from the introduction of TEDs and BRDs. This group comprises hundreds of species of small fish and invertebrates and accounts for the vast majority by weight or volume of the bycatch taken in the NPF. The combination of TEDs and BRDs reduced the Small Bycatch by 8%. This result also appears to be almost entirely attributable to the influence of TEDs. The BRDs trailed in this study (mostly the Bigeye, with fewer Square-mesh panels) had no effect on catches of Small Bycatch. This is a poor result compared to similar studies and may be due to the BRD types, and the method by which BRDs have been used in the fleet. A significant shift in impact would require a change from the Bigeye to other BRDs, and improved use of some BRDs (e.g. use Square-mesh panels and Fisheye installed within 70 – 100 meshes of the codend drawstrings).

Catches of sharks and rays have been reduced in TED and BRD nets by 17.7% and 36.3%, respectively, since the introduction of these devices in the NPF. Any nets with TEDs reduced catches by 13.3% for sharks and 31.3% for rays, However, nets with BRDs only did not affect

Summary

catches of rays, but reduced shark catches by 16.7%. Despite this reduction for sharks, only one species, *Carcharhinus tilstoni*, demonstrated a significant difference (23.8%) between nets with a BRD only and the Standard net. Large sharks and rays (>1 m) were more effectively excluded by nets with TEDs (86% and 94%, respectively) compared to smaller animals (≤1 m) (4.9% and 25%, respectively). However, individual species differed from no change for 13 shark and eight ray species to >90% exclusion for two shark and seven ray species. Of the species showing no change, almost half (five shark and four rays species) were only caught in standard nets and may have demonstrated highly significant exclusion rates through TEDs if their sample sizes had been larger. The effectiveness of upward and downward excluding TEDs was about the same for rays (26.9% and 34.8% exclusion, respectively). However, upward excluding TEDs were more effective for sharks (20.4% exclusion) compared to downward excluding TEDs (8.8% exclusion). Five species (three shark and two ray species) showed differential exclusion between upward and downward excluding TEDs. None of the six highest risk Elasmobranch species (Stobutzki *et al.,* 2002) were encountered by observers in this study. However, the results from this study indicate that at least one of those species, *Dasyatis brevicaudata,* is likely to have a high exclusion rate in nets with TEDs, based on its large size. The results from this study are likely to cause a significant reduction in the level of risk from trawling for many of the Elasmobranch species caught in the NPF. The catches of the most commonly caught sawfish in the NPF, *Anoxypristis cuspidata* (narrow sawfish), have been reduced by 73% due to the introduction of TEDs. However the impact of TEDs on other, more rarely caught species of sawfish is unknown. Scaled results from this study estimate that 18120 elasmobranchs (12898 rays, 4980 sharks, and 242 narrow sawfish) were excluded from NPF trawls due to TEDs during the 2001 tiger prawn season.

TEDs had a significant impact on Large Sponges with >85% exclusion from NPF catches. Upward excluding TEDs removed 81.6% of Large Sponges from the trawl net, and downward excluding TEDs were more effective excluding 95.9%. However, exclusion from trawls does not necessarily mean that these species can re-attach to the substrate, and/or survive the trawling process. However, their removal, along with the other large animals has transformed trawl catches in the NPF to a 'cleaner' and easier operation for the crew. Processing and sorting catches is now easier, and most skippers and crews assert that they would leave TEDs in their nets if they were given a choice. BRDs had no impact on Large Sponge catches, and sponge catches had no impact on catches of most other groups (e.g. by blocking the TED and redirecting animals out the escape opening).

One of the biggest effects was on turtles where the introduction of TEDs has reduced the fishery's impact to almost zero. All species of turtles appear to be very effectively excluded from trawls and a hidden impact on turtle survival is highly unlikely. This translates to a reduction in impact from about 0.05 per trawl in 1989/90 (~5300 per year for the entire fleet) (Poiner and Harris, 1996) to 0.0006 per trawl (30 per year) after the introduction of TEDs and BRDs in 2000. Of these only 3-5 turtles are likely to drown and another 15 may suffer some other adverse affects. This result is a credit to all NPF fishers, netmakers, owners, and researchers who have worked hard to ensure the success of this technology.

Sea snakes were also poorly excluded from catches during the 2001 tiger prawn season. There was a small difference (5%) only between catches from the legal nets (TED+BRD) and nets without these devices. Two species of sea snakes have been identified to be at a relatively high level of risk from prawn trawling by Stobutzki *et al.,* (2000) and the use of TEDs and BRDs in 2001 has done nothing to alter this assessment.

10.1 Introduction

Experimental trawl comparisons measured the change in catches due to the introduction in 2000 of TEDs and BRDs in the NPF (see Appendix 3 – Approved TED and BRD designs for the NPF). Data and other information provide a benchmark for assessing the effectiveness of TEDs and BRDs in reducing bycatch, as well as the impact of these devices on the catches of commercially valuable prawn species.

The only information to date detailing the effects of TEDs and BRDs on catches in the NPF has been based on:

Relatively small numbers of samples collected by Garry Day from a limited number of boats during his time assisting NPF vessels (1997-2001);
Comparison of lengths between TED and non-TED nets Stobutzki *et al., (*2002)
Anecdotal evidence from fishers based on varying degrees of rigour; and
Early scientific trials of a range of devices (Brewer *et al*., 1998).

These trials play an important part in the strategic assessment of the NPF against the guidelines stemming from the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). They also provide information on prawn catches that can be used to improve the accuracy of the annual stock assessment.

Catch data were collected for all of the main species groups. However, the level of species identification varied, based on the ecological or commercial importance of each group and the feasibility of collecting such a wide range of information by a single observer.

10.2 General methods

The formal assessment of TEDs and BRDs in the NPF was made by scientific observers collecting catch data during the 2001 NPF tiger prawn season. Scientific observers were used to:

1. Minimise the imposition on the commercial fishing operation of the data collection process;
2. Maximise the reliability of data collection; and
3. Ensure the acceptability of the data by the wide range of stakeholders from this process.

The Observer Program required a large and highly coordinated approach, including recruitment, broad-based training, at-sea coordination, and post-program debriefing and data integration. A detailed description of the process associated with the Observer Program is provided in Chapter 9 and the field sampling and species identification manuals used are attached to the report as Appendix 2**.**

The rationale for the timing of the Observer Program was based on finding a balance between representing the ongoing effect of using TEDs and BRDs, but without having to wait until the industry had maximised their potential. This is described more fully in 10.2.1 below.

10.2.1 Sample design

Experimental design

NPF vessels use a twin-rig configuration of fishing gear, usually with Florida Flyer prawn trawls during the tiger prawn season. These are towed from a boom on each side of the vessel. Vessels usually complete four trawls per night, 3–4 h in duration. A daytime closure exists during the tiger prawn season (August to November).

In order to measure the effect of TEDs and BRDs on catches, the experimental design compared catches between paired nets with different gear configurations, based on a preliminary power analysis. The null hypothesis for all comparisons was that there is no difference between catches from port and starboard nets regardless of the addition of TEDs and/or BRDs.

The Standard prawn trawl (without a TED or BRD installed) was used as the experimental control. The experimental treatment in the net towed from the opposite side of the boat was either:

A TED + BRD net (the current legal trawl) - to measure the effect of both devices in combination (Figure 10.1);
A TED only net - to measure the separate effect of the TED; or
A BRD only net - to measure the separate effect of the BRD.

Definitions for the trawl gear and experimental design for this study are:

Term	Definition
Trawl	The trawl operation including the towing of two prawn trawl nets, usually for 3–4hrs during the tiger prawn season.
Net	A net towed during each trawl, usually a 'Florida Flyer' design in the tiger prawn season in the NPF
Treatment net	The net rigged with a device being assessed by the project. Either the 'Legal net' (TED + BRD net), TED only net, or BRD only net.
Control net	Standard net.
Standard net	A prawn trawl net with no TED or BRD installed, usually containing 55 – 60mm stretched mesh in the body of the net and ~50 mm in the codend.
Legal net (TED + BRD net)	A prawn trawl net with both a TED and BRD installed.
TED only net	A prawn trawl net with only a TED installed.
BRD only net	A prawn trawl net with only a BRD installed.

Some comparisons were also made between a 'TED + BRD' net and a net containing only one of these devices. This occurred mainly where converting the vessels TED or BRD net to a Standard net was considered to be an unreasonable impediment to the commercial fishing operation at the time. However, these data were not included in any data analyses (other than turtles) due to the added uncertainty in interpreting the results.

Sampling power

Previous research on the effects of TEDs and BRDs indicated that the difference in catches between Treatment and Standard nets varied greatly, depending on the catch group. For example, catches of some groups (e.g. commercially valuable prawns) may vary by only a few percent between the Treatment and the Standard nets. In other cases, occurrences of some species of interest were known to be rare in trawl catches and require substantial trawl effort to adequately detect any changes in catches due to a TED or BRD treatment effect. Consequently, the sample design needed to ensure that an adequate numbers of paired comparisons would be made to detect differences in both these scenarios. The number of paired trawl comparisons planned for each treatment also depended on the priority of the result. Assessing the combination of the TED + BRD net (currently mandatory in the industry) was the highest priority and consequently was allocated a higher proportion of trawl comparisons.

In order to ensure the collection of adequate numbers of comparisons, a power analyses was used to calculate the sample sizes required to detect small changes in the catches of rarer species. Data from previous NPF catches was used for this analysis. A detailed report of the power analyses is presented in Appendix 3.

Representation of important factors

A range of factors were included in the experimental design to ensure that the data was as representative of NPF commercial operations as possible.

The Observer Program aimed to:

1. Maximise coverage of the NPF fleet in terms of the number of vessels boarded. This ensured that the data accurately represented the variability that occurred between vessels in the NPF fleet, including vessel size, trawl configuration, skipper's fishing ability, rigging of TED and BRD, and the type of TED and BRD; and

2. Maximise the coverage of Observer effort between the major fishing areas in the tiger prawn season. This included keeping in regular communication with participating vessels and using strategic placements of observers from vessel to vessel (see Chapter 9).

The sample design in the original project document proposed to use ten observers over a single month to minimise variability between months while obtaining the sample sizes required. However, this design was changed after presentation to the Northern Prawn Fishery Management Advisory Committee Fishery Assessment Group (NORMAC FAG) meeting, to include samples from the entire tiger prawn season, including months when weather conditions were less favourable and could significantly impact on TED and BRD performance. The final design used five scientific observers throughout the entire three-month 2001 tiger prawn season. There was an attempt to balance the need for adequate fleet coverage with obtaining adequate sample sizes on each vessel, by changing vessels approximately every two weeks.

Banana or tiger prawn trawling

The second half of the 2001 NPF fishing season was chosen for the current assessment for a range of reasons (see Chapter 4). In particular, this time of year is usually devoted to tiger prawn fishing, where most of the concerns about impacts on bycatch in the NPF originate. The first half of the season (April to June) is usually dedicated to targeting large schools of banana prawns (*Penaeus merguiensis* and *P. indicus*) using raised headropes (‘banana nets’), slow trawl speeds, short tows during the day or night, and often with very little associated bycatch. However, the second half (tiger prawn season – August to November) is usually associated with lower headropes, faster trawl speeds, longer tows (3–4 h), night-time trawling, catches dominated by tiger and endeavour prawns, and large amounts of bycatch (Brewer *et al.,* 1998). The longer tows in the tiger prawn season are responsible for the main bycatch issues in the NPF, including turtle deaths, large catches of small fish and invertebrates, and a wide variety of other groups that cannot survive being towed in a net for long periods. The current TED and BRD assessment was planned during the second season to coincide with these issues.

The 2001 banana prawn season was the 2^{nd} highest on record (Perdrau and Garvey, 2003) and targeted banana prawn fishing continued into the tiger prawn season. It was impossible to predict which skippers would begin the season with banana prawn fishing, or when they would switch to tiger prawn fishing. However, the observers collected data during all tows and consequently our data consists of both banana and tiger prawn catch comparisons, but dominated by the latter. These are treated as separate data sets, although only the catches from tiger prawn trawling are reported in this study.

Banana prawn catches are usually more targeted and catches can vary greatly from side to side within a single trawl operation due to the aggregating behaviour of the species. Furthermore, schools of banana prawns may attract associated bycatch species that are also aggregated and closely tied to the school. Both of these factors lead to very high variability in catches and this negated our ability to assess most species groups from this part of the Observer Program.

Figure 10-1. An example of a legal codend (TED + BRD) used in the NPF. Note the presence of both the TED (Nordmore grid), and behind it, the BRD (Square-mesh panel). Photo taken at the AMC flume tank.

10.2.2 Calibration of paired trawls

Previous studies of paired trawl comparisons have demonstrated the need to calibrate the catches from the identical port and starboard nets before making comparisons of catches between two treatments (e.g. Brewer *et al.,* 1998). The calibrations are designed to measure any pre-existing differences in fishing ability between the two identical nets. Any pre-existing differences in catches can be adjusted for during the data analyses so the impact of the experimental treatment can be more accurately assessed.

The need for net calibration data may be eliminated if:

a) The sampling design allowed swapping of treatment and control gears between port and starboard nets; and

b) There were no other alterations to the fishing gear during either experimental phase. However, this scenario was not feasible in our sample design because the Observers were working within the confines of the commercial operation of the vessel.

On each vessel, scientific observers aimed to collect calibration trawl data on the weight of tiger prawns and, where possible, on the weight of Small Bycatch in each net. The calibration trials for prawns and Small Bycatch required eight to ten paired comparisons of a Standard trawl (no TED or BRD installed) on both the port and starboard sides. Half of the comparisons were made before rigging the trawls for the experimental comparisons and half were at the end. These data would give a measure of any pre-existing bias in catches of prawns or Small Bycatch between the two identical trawl configurations. However, the use of calibration trawls was not meant to overly compromise either the time that could be allocated to collecting experimental data or the fishing operation. Consequently, the judgement of each observer was often an overriding factor. Calibration data for the rarer species groups (e.g. turtles, sea snakes, byproduct and Elasmobranchs) would have required a very large number of trawls to have any statistical power and was therefore not attempted.

Calibration data

Two types of net calibration data were collected on observer vessels. Most calibration data was collected from TED + BRD nets on both port and starboard sides. This occurred when an observer boarded a new vessel, but decided to minimise the impact of gear changes on the skipper, crew and fishing operation by not enforcing the removal of both TED and BRD from both nets. However, this form of calibration was not used for this assessment due to the unknown level of extra variability in catches that may have resulted from these devices.

The second form of calibration involved trawls using Standard nets (no TED or BRD). These were undertaken on some vessels, although in most cases the number of paired comparisons was too low to examine trends in catches between nets. Two vessels had 22 and 24 calibration trawls using Standard nets and these were examined to assess whether any adjustment of the port or starboard catch data was necessary for the subsequent experimental trawls. The comparisons of these calibration trawls were made using paired *t*-tests for both tiger prawn and Small Bycatch data. In both vessels, there were no statistically significant differences between port and starboard catches of tiger prawns or Small Bycatch and consequently, no adjustments were made for the data on either of these vessels.

Although no pre-existing differences between port and starboard trawls were measured, it does not discount the fact that there may have been some differences in the fishing ability between these nets on some vessels. On all except two vessels, the number of suitable calibration trawls was inadequate.

This uncertainty is partly tempered by the fact that most skippers constantly adjust their nets in order to even up and maximise the prawn catches from both port and starboard nets. Consequently, the chances are low that an observer could have boarded any vessel and encountered nets that were not fairly evenly matched for prawn catches. The skipper, however, does not necessarily match, or attempt to adjust the fishing gear for consistency in catches of the Small Bycatch from each net (see Chapter 9).

The large number of catches sampled for the main experimental comparisons (3224 nets from 23 different vessels) has greatly reduced the influence of any pre-existing bias between sides, on the data analyses. This design should have ensured that the distribution of any bias between nets not due to TEDs or BRDs, was fairly equally distributed between sides and experimental treatments.

10.2.3 On-board data collection

While on board each vessel the scientific observers collected a variety of integrated data sets including weights and/or numbers/lengths of a large range of prawns, byproduct and bycatch groups, TED and BRD descriptions and configurations, trawl gear configurations, trawl log data, abiotic data on weather and sea conditions. They also recorded unusual or irregular events such as net damage, TED blockages or changes to the normal fishing regime that may account for differences in catches between fishing gear on different sides of the vessel. A detailed description of the Observers' tasks is described and summarised in Chapter 9.

The complete range of data required from every shot was too great to be obtained by a single observer. The large range of data recorded was only achieved by having the assistance of the skipper and crew on most vessels, and by alternating some tasks between different trawls. For example, collecting data on the weight of soft or damaged prawns was alternated with collecting all individual trash chute Elasmobranchs from one catch. Similarly, measuring the total weight of Small Bycatch – weighing and dumping many 40 kg baskets by hand – was not achieved for all trawls. A summary of the data collection feasibility is detailed in Table 9-1, and a summary of the actual data collected is given in Tables 9-7 and 9-8.

All field data was hand written onto purpose-built waterproof data sheets (Appendix 2). After completing sampling on each vessel, the observers posted their data sheets back to the CSIRO Observer Program manager (Don Heales) using pre-paid and pre-addressed overnight postage bags. Before leaving each vessel, the observers also faxed a summary of the data collected from that vessel to the CSIRO Observer Program manager as insurance against the potential loss of data through the postal system (see Chapter 9 for details).

At the end of the NPF tiger prawn season, each observer (except one) was met in port by project staff. In the following days, data recording and accuracy issues were discussed while still fresh in the observer's minds. This helped to circumvent a range of potential data inaccuracies and improved the ability of project staff to interpret all aspects of the observers' data recording

The data was entered into an Oracle database specifically designed to integrate the data for this project (Figures 9-25 & 9-26). Special coding of certain fields and categories of data was undertaken to enhance the analyses. For example, trawls with some form of operational problem (e.g. holes in the net or codend not tied properly) were flagged so they could be selectively included in the analyses; and trawls with large animals or objects against the TED on retrieval of the gear, were noted. The entered data were then checked to remove as many inaccuracies in data entry as possible.

10.2.4 Data analyses

Statistical analyses

The catch data from each bycatch group were analysed differently depending on whether weights, counts or lengths were measured; or if the group was rarely caught.

Model 1– Weight data

Total catch weights were collected for commercially important prawn groups (Total prawns, tiger prawns - *Penaeus esculentus* and *P. semisulcatus*, and endeavour prawns - *Metapenaeus endeavouri* and *M. ensis*), some byproduct species (grouped Moreton Bay bugs - *Thenus* spp., grouped squid - *Teuthoidea* spp., and scallops - *Amusium pleuronectes*), and the Small Bycatch species (small teleosts and small invertebrates) (Table 10-1). For these data, a log transformation was carried out to achieve uniformity of variance over treatments and to allow the Normal distribution to be assumed for the error structure in the analyses. Each trawl comparison consisted of two nets towed simultaneously. The paired nature of the weights collected from the two nets of a vessel was used to eliminate trawl-to-trawl variation by performing analyses on the differences between the two log weights of the Treatment and Standard nets (D in Model 1). These differences were analysed using a linear model with vessels considered as a random effect.

Model 1 - for weight data:

Define D to be

D [Log(Treatment Net Wt) – Log(Standard Net Wt)],

Then we assume
$D \sim N(u_d, s_d^2)$

and the linear model for the mean expectation of D as

Log (E(D)) = comparison(i)+vessel(j)+covariates.

For the weight analyses, the least squares means for the differences, D, when multiplied by 100, gave approximate estimates of the percentage difference in weight between the Treatment net and the Standard net.

Model 2 – Count data

Only count data could be recorded consistently for species or species groups that were rarer, often large and more conspicuous, and/or of special interest or significance. These included turtles, sea snakes, sharks, rays, sawfish and sponges. For these (mostly rarer) groups, the capacity to establish and compare catch rates that depend on external covariates or random effects (such as treatment and vessel effects) is extremely limited, and not presented. However, an assessment of the effectiveness of TEDs and BRDs may be obtained by restricting the data set to those shots where at least one animal is caught in a paired comparison between a treatment and control net.

The larger species groups (Elasmobranchs, Turtles and Large sponges) are likely to have highest exclusion through TEDs. As many of these species were caught in relatively low numbers, a separate analyses was use to assess the impact of TEDs on their catches. This aimed to maximise the number of cases where the impact of TEDs could be assessed. This involved comparing any pairs of nets that had a TED in one side and no TED in the other, regardless of the presence of BRDs (i.e. TED+BRD v Standard net; and TED only v Standard net). This is further justified by a preliminary analysis that showed different BRD types having limited influence on catches of Elasmobranchs, Turtles and Large sponges. Furthermore, the different types of BRD were combined to provide an overall analysis of their effect on catches of these groups.

For species with counts, the data are analysed as frequencies of animals caught using a binomial model with a fixed probability of capture. Given that an animal is caught, we view the side on which it is caught as a binomial outcome, with probability p for the TED (respectively BRD) side and $1 - p$ for the fully unprotected side. A natural null hypothesis is then $p = \frac{1}{2}$, implying indifference or neutrality of the protection device. Since the counts are often quite low, this null hypothesis is then tested by an exact binomial test against a two-sided alternative. For cases where the counts were higher a simpler chi-squared test would have sufficed, but the exact test was available and used as a slightly better option.

This analysis was also applied to broader Elasmobranch groups to assess more general trends, including:
Sharks >1 m in length
Sharks ≤1 m in length
Rays > 1 m in breadth
Rays ≤1 m in breadth

If the null hypothesis is retained the treatment is not shown to be effective in changing the bycatch reduction. If the null hypothesis is rejected, it indicates that the treatment has an effect. Whether the effect is to increase or decrease the conditional probability of capture is then clear by inspection, and noted.

Model 3 – Length data

Lengths of Elasmobranch species were measured, but could not be considered in a paired type analysis, as they were not always observed in both nets. These data were analysed with a repeated measures Analyses of Variance and assumed to be normally distributed.

Model 3 - for length data:

L = Length of Elasmobranch Species in each trawl, $L \sim N(u_l, s_l^2)$

E(L) = treatment(i) + vessel(j) + side(k) + covariates

Models one and three follow a similar format to those used in Miller and Willis (1999). The vessel(j) affect was considered random for Model 1 and as a fixed effect in Model 3. As a result of the differencing over sides in the Model 1, the D values are assumed to be independently distributed across trawls, as evidenced in preliminary analyses. However, an exchangeable correlation structure is assumed for the two sides of a vessel across trawls in the second and third models.

In some of the catch groups where weight data was being compared (byproduct groups and damaged prawns), a small additive constant (0.1) was used when zero weights were observed for any net in a paired comparison for that catch group. The constant was added before logs were taken to form the differences D.

For the weight data analyses (Model 1), the comparison (i) term had three levels representing the paired comparisons, corresponding to TED + BRD v Standard, TED only v Standard and BRD only v Standard. In contrast, for the length data, which were not differences between paired nets, the four configurations that could have appeared on any given side form the four levels of treatment(i), being TED + BRD, TED only, BRD only or Standard.

Covariate terms

A ‘covariates’ term was used in Models 1 and 3. The covariates used for most bycatch groups (indicated in Table 10-2) were region, duration and sponge.

The region term is a categorization of the prawn target area into four distinct areas. The overall tiger prawn fishing effort patterns are presented in Figure 10-2. The data from this project was relatively well distributed within most of the high effort areas of the NPF as shown in Figure 10.3. A preliminary analysis used the eight separate regions (Figure 10-3), but were reduced to the following four regions based on their similarity in abundances for most species groups:

Region 1 – T1+T2;
Region 2 – T3+T4;
Region 3 – T5+T6; and
Region 4 – T7+T8.

Trawl duration was used as a continuous variable, called ‘duration’ and measured in minutes.

If sponges were observed in a net, then the sponge covariate was given the value 1 and the value 0 otherwise. This aimed to look at the possible effect of sponges being caught on the TED and increasing the exclusion of other groups. However, when analysing actual count data for sponges themselves, the Sponges covariate was dropped from the covariate list.

Weather was recorded but was not included as a covariate. This was due to the lack of useful contrast between sea heights in the data.

The most important terms in these analyses are the treatment factors (TED and BRD combinations). The vessel effect and covariates were included to assess their influence on capture rates and the effectiveness of the gear configurations, but are not reported in detail.

Sub-models

Within the framework of the Models 1, 2 and 3, instead of including either the comparison or treatment terms, more specific sub models were fitted representing:

1. A test of the difference between Downward and Upward excluding TEDs; or
2. A test of differences between the two most commonly used types of BRDs; the Bigeye or Square-mesh panel. This term was called BRD Type.

Logistic regression of length data

The data came from trials in which there was a TED on one side only. For each caught animal we recorded an appropriate size measure: length for sharks and disc width for rays. We then used a standard logistic regression model to relate the probability that the animal is caught in the TED net side to the size measure of the animal. Two separate models were fitted, one for all sharks combined and the other for all rays.

Let p be the probability that an animal is caught on the TED side. The logistic regression model expresses this probability as a function of size. Assuming both nets were equally exposed to incoming animals, let n be the expected number of animals to which the two nets were exposed and suppose e is the exclusion rate of the TED. The expected number of animals caught in each side is then

Non-TED	TED
n	$n(1 - e)$

Hence the probability that a caught animal was found in the TED net is

$$p = \frac{n(1 - e)}{n + n(1 - e)}$$

which, for example is 0.5 only if $e = 0$ and the TED is ineffective. Solving this equation for e gives

$$e = \frac{1 - 2p}{1 - p}$$

which then relates the exclusion rate of the TED to the probability of capture on the TED side, which the logistic regression model has, in turn, related to the size of the animal. The logistic regression fitting process also allows us to estimate pointwise confidence intervals, which can be transferred into pointwise confidence intervals for the exclusion rate.

Software

Model 1 (weight data) was fitted using PROC MIXED (SAS). For Model 2, the exact analyses of binomial frequencies were done using the standard S-PLUS function binom.test. PROC GENMOD (SAS) was used for analyses of sea snakes. Model 3 (length data) used PROC GENMOD (SAS). Logistic regression models were fitted using the S-PLUS functions, glm and predict.glm.

Other data manipulations

Trawls were excluded from the analyses where breakages, holes in the nets, or other issues that could have caused bias to a particular catch category were recorded.

A comprehensive data manipulation was carried out for Elasmobranch species which were sampled by two different methods depending on their size. The larger specimens (sharks longer than ~30 cm or rays wider than ~30 cm) were sampled directly from the sorting trays. But the smaller Elasmobranchs (< 30cm) were sampled from the trash chute, but not necessarily for the same trawls as the larger Elasmobranchs (see Chapter 9 for Field Sampling Methods). Wherever the sampling for Elasmobranchs in a trawl was done using both methods, the two subsets were merged.

Analyses were also performed separately for three groupings of Elasmobranchs:

1. The individual species level;
2. The higher group level (sharks and rays); and
3. Large animals only (sharks >1 m in length and rays >1 m wide)
4. Smaller animals only (sharks ≤1 m in length and rays ≤1 m wide)

10.3 General results

During the Observer Program, five scientific observers were at sea during the entire 14 weeks of the 2001 NPF tiger prawn season (4 August to 9 November). Data were collected from a total of 1612 trawl comparisons (3224 nets sampled over 442 observer nights of trawling) from 23 different NPF vessels (Figure 10-2). The sample sizes of trawl comparisons made for each experimental treatment and species group are shown in Tables 9-7 and 9-8, respectively.

This comprehensive data collection program allowed a robust assessment of the most widely used TED and BRD configurations, and for a wide range of catch groups and species. The success of the sampling effort was due mainly to the commitment of the observers, but also due to the co-operation of the skippers and crew of the NPF vessels and the motherships involved, especially given the constraints of fitting these activities in with their commercial operations.

The data used in this assessment were recorded from high effort tiger prawn trawl grounds in the NPF (Figure 9-29) and from a representation of vessel sizes, as shown in Figures 9-28 and described in Chapter 9. The data were evenly distributed throughout the fishing season. The results also represent a reasonably accurate mix of the different types of TEDs and BRDs used by the entire NPF fleet in the 2001 tiger prawn season (Figures 8-1 and 8-2).

Table 10-2 summarises the influence of five co-variates on catches of species groups analysed using a general linear model to compare catch rates between different net configurations. Significant results demonstrate differences in catches due to the variability within each co-variate, as follows:

- a significant result for the ‘Gear comparison’ covariate demonstrates that there are overall differences in catch rates between different gears in the comparisons, after taking the effects of other covariates into account;

- a significant result for ‘Duration’ demonstrates differences in the catch rates between trawls of different duration, after taking the effect of other covariates and the main gear effect into account;

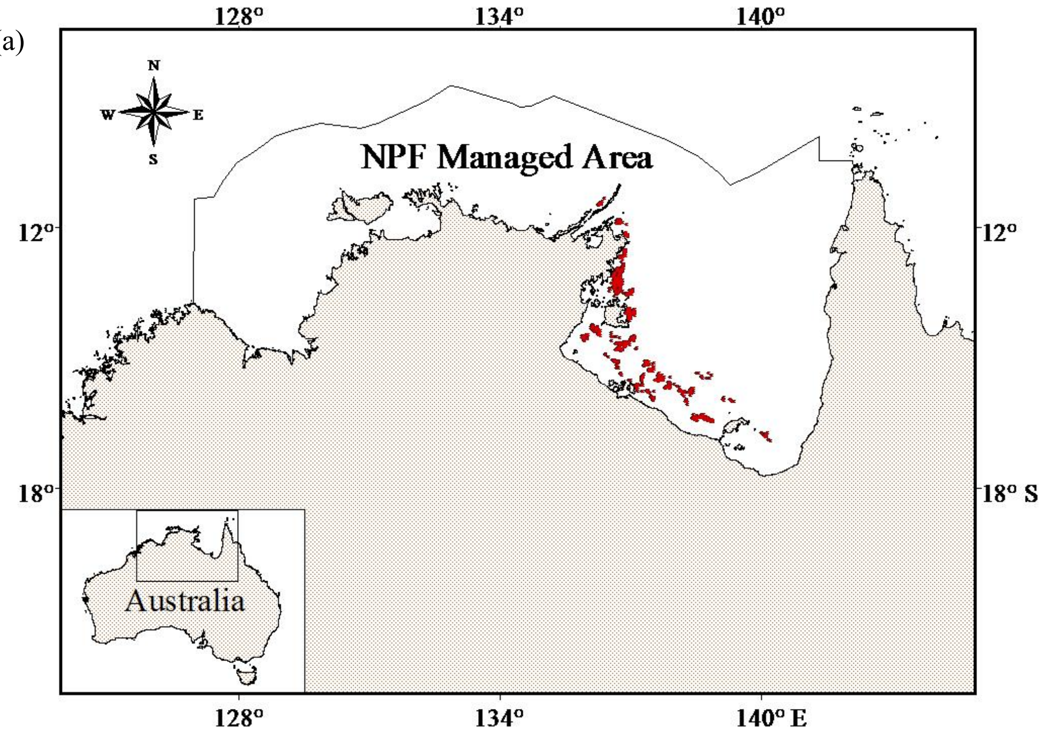
- a significant result for 'Region' demonstrates differences in the catch rates between trawls from different regions in the fishery (Figure 10-3), after taking the effect of other covariates and the main effect into account; and

- a significant result for 'Sponge' demonstrates differences in the catch rates between trawls where Large Sponges were recorded, after taking the effect of other covariates and the main gear effect into account, and possibly indicating a source of TED blockage and increased animal exclusion from the trawl (see 10.3.5 for more detailed explanation).

The most important interpretation of the results for these covariates is that (i) the influence of the covariate has been accurately quantified, and (ii) that their effect is taken into account in the analyses of the variables of most importance – the gear comparisons. The results below for each species group are presented in this context.

The data presented here refer to catch comparisons made while tiger prawn trawling only. Each catch group is treated separately and the level of detail varies depending on the feasibility of collecting the data and stakeholder interest in the group.

(a)



(b)

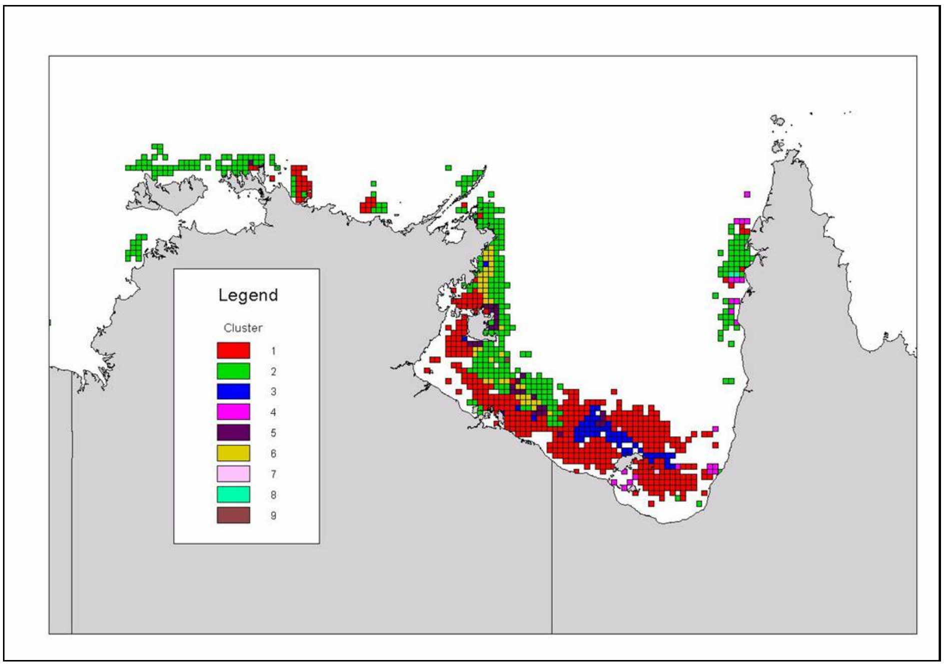


Figure 10-2. Northern Australia showing (a) the NPF managed area and the locations where the 1612 paired trawl comparisons were made (red dots); and (b) the distribution of trawl effort during recent seasons for vessels targeting tiger and endeavour prawns (brown are the highest effort grids and red the lowest).

Table 10-1. A guide to the different data analyses performed for each catch group**.**

Model type	Data distribution	Catch group	Data type	Model structure*	Analytical procedure
Model 1	Normal	• Prawns: total prawns, Tiger prawns Endeavour prawns, soft and damaged prawns; • Byproduct: Moreton Bay bugs, Squid and Scallops; • Small bycatch	Weights (kg)	• General linear model • Using continuous paired data • Random main effects: vessel • Fixed effects: region, sponges, weather • Continuous covariate: trawl duration • Separate analyses for each gear type	PROC MIXED (SAS)
Model 2	Binomial	• Total sharks and rays; • Individual shark, ray and sawfish species; • Large sharks > 1 m length; • Large rays >1 m disc width; • Small sharks ≤1 m length; • Small rays ≤1 m disc width; • Large sponges • Turtles • Sea snakes	Counts (Numbers)	• Binomial model with fixed probability of capture • Fisher's exact test • Tested among main gear effects only • Does not account for correlations between nets • Only uses paired trawls where animals caught in either treatment or control net	Binomial model (S PLUS)
Model 3	Normal	Individual shark and ray species	Length (cm)	• General linear model • Using raw data from each net • Random main effects: none • Fixed effects: region, vessel, sponges • Continuous covariate: trawl duration • Tested among main gear effects	PROC GENMOD (SAS)

* see the text for more details of the model structure

Table 10-2. Table showing the covariates used in the linear models to analyse the impact of TEDs and BRDs on catches from the bycatch groups where weight data were collected. Not all covariates were used for each catch group. An explanation of the different analytical models and a description of each covariate are given in general methods. Where the data was inadequate to provide a result, a dash '-' is used. Significance levels for covariate effects: * = p<0.05; ** = p<0.01; *** p<0.001; 'ns' = no significant effect. 'pc' denotes where paired comparisons were made eliminating the analyses for side effects.

Catch groups	Gear comparison	Side	Duration	Region	Sponge
Total prawns	ns	pc	ns	ns	ns
Tiger prawns	ns	pc	ns	ns	ns
Tiger prawns – soft and damaged	***	pc	*	ns	*
Endeavour prawns	ns	pc	ns	ns	ns
Endeavour prawns - soft and damaged	ns	pc	ns	ns	ns
Byproduct - Bugs	ns	pc	ns	ns	ns
Byproduct - Squid	ns	pc	ns	ns	ns
Byproduct – Scallops	ns	pc	ns	ns	-
Large Sponges	***	ns	ns	***	
Small bycatch	ns	pc	*	*	ns

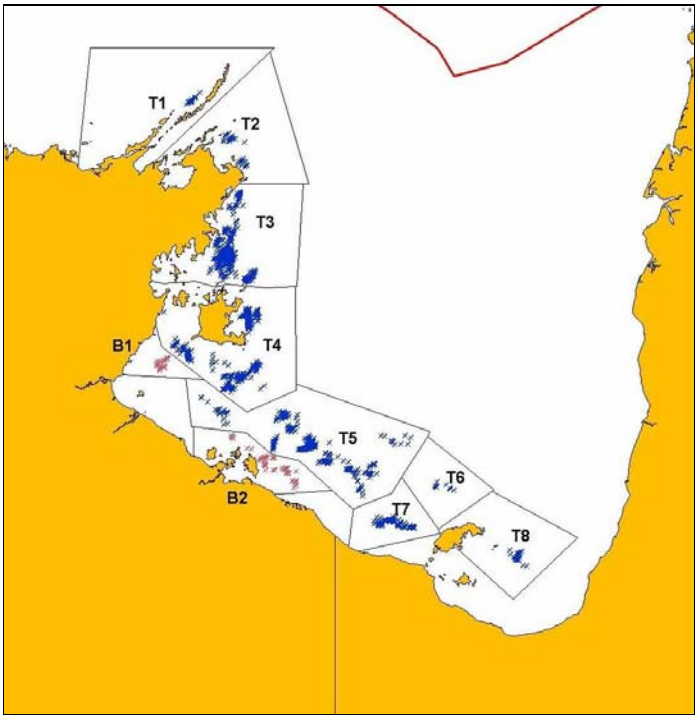


Figure 10-3. Map of the Gulf of Carpentaria showing the general regions used to account for geographical variability in the analyses to assess the performance of the main gear effects. Four regions were used in the analyses based on their similarity in abundances for most species groups: Region 1 – T1+T2; Region 2 – T3+T4; Region 3 – T5+T6; and Region 4 – T7+T8. Trawl sites in each region are indicated by blue crosses.

10.3.1 Commercially valuable prawns

David Brewer, Don Heales and Peter Jones

Introduction

Although TEDs and BRDs were introduced into the NPF to reduce the fisheries impact on bycatch species, there remains a strong focus on their impact on catches of the target species – commercially valuable prawns and, to a lesser extent, byproduct species. The ideal scenario for TEDs and BRDs performance would be significant reductions in all bycatch groups with no change in prawn catches. However, this is not easily achieved, as most TEDs and BRDs require additional openings in trawls to allow bycatch to escape. Excluding unwanted species through these openings without losing some prawns has proven to be a difficult task.

Methods

The methods used to collect the catch data are described in Chapter 9. The Model 1 data analyses described in 10.2.5 was used to assess differences in prawn species groups between treatment and control nets.

Results

Data was collected on commercially valuable prawns during most trawl comparisons and a large subset of that data analysed and presented here - 1063 of 1612 trawls**.** The number of comparisons for each species group varied depending mainly on time available to the observer during processing and the species priority. Commercially valuable prawns were treated at the same grouping level as seen in the commercial operation. The two tiger prawns (*Penaeus semisulcatus* and *P. esculentus*) were combined, as were the two endeavour prawns (*Metapenaeus endeavouri* and *M. ensis*). An exception to this is when all commercially valuable prawns are combined as 'Total prawns'. This group includes all tiger prawns, endeavour prawns, banana prawns (*P. merguiensis* and *P. indicus)* and king prawns (*P. latisulcatus* and *P. longistylus*). A small number of trawls that targeted banana prawn schools and caught very large quantities were not included in these data.

A total of 93.39 tonnes, mostly tiger prawns (62.5 tonnes) and endeavour prawns (30.6 tonnes) were processed during this study. A small portion of these were 'soft and damaged' prawns (referred to in the industry as 'soft and broken'; 3.82% - tiger prawns; 0.93% - endeavour prawns) and these were analysed as a separate category. Less than 0.3% (270 kg) of the prawn catches was other species. These data are not presented. The mean catch rates of tiger and endeavour prawns in the Standard nets are presented in Table 10-3, along with the numbers of nets sampled for each experimental trawl comparison.

The impact of using TEDs and BRDs on commercially valuable prawn catches varied greatly depending on the catch category (Table 10-4). The overall effect of using a TED + BRD in the 2001 tiger prawn season was a 6% reduction in the catch of Total prawns. This reduction was slightly higher for tiger prawns (6.5%) and slightly lower for endeavour prawns (5.0%).

However, there was a substantial impact on the proportion of soft and damaged prawns caught attributable to the combined use of TEDs and BRDs. There were 41.6% and 40.9% fewer soft and damaged prawns in the catches of tiger and endeavour prawns, respectively, in nets containing the TED+BRD combination (Figure 10-4).

Figure 10-4. The exclusion of large species such as turtles can reduce the amount of damaged prawns in trawl catches by more than 40%.

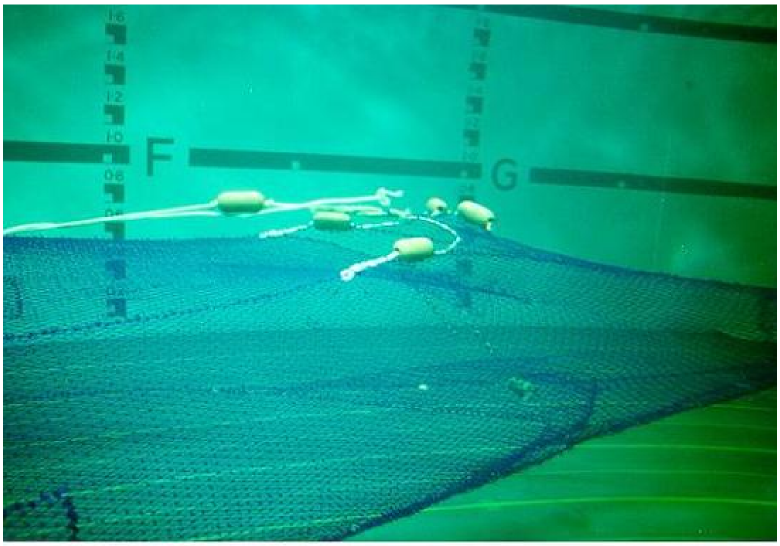


Figure 10-5. A Bigeye BRD being tested in the Australian Maritime College flume tank. It is constructed by cutting an opening (>1 m) across the width of the top of the net, with the forward edge of the cut weighted and the aft edge buoyed to keep the potential escape hole open.

For tiger prawns, the impact of using a TED + BRD net may be largely attributable to the effect of the TEDs used. The results from using both upward and downward TEDs on their own produced a change in prawn catch of -6.3% to -6.7%. This is very similar to the value demonstrated for TEDs and BRDs in combination. However, there were significant losses of tiger prawns when using the Bigeye BRD, the most commonly used BRD in the fleet at this time (Figure 10-5). The other BRD tested, the Square-mesh panel, showed no loss of prawns (see Figure 10-1).

For endeavour prawns, differences in catches appear to be less difficult to attribute to either the TED or BRD. Despite a demonstrated 5% loss of catch while using a TED and BRD together, there was no measured change in catches of endeavour prawns with either the TED only, or BRD only treatment configurations.

Catches of most prawn groups were not affected by the influence of the covariates described in Table 10-2. Soft and damaged tiger prawns were the exception having significantly larger catches from (i) shorter duration trawls, and (ii) the presence of Large Sponges. Although it is reasonable to expect higher catches of soft and damaged prawns with longer trawl durations, the slightly negative relationship (-1.1% change) may be explained by (i) the narrow range of trawl durations used in the tiger prawn fishery, and (ii) longer trawls are often used where catch rates are lower. Slightly negative relationships with duration were also were found for endeavour prawns, although these were not statistically significant. Reductions in the proportion of soft and damaged tiger prawns changed from a 28.1% to a 39.7% reduction due to the presence of Large Sponges in the Standard net, but not in the TED and BRD net.

Discussion

These data demonstrate that there was a commercial consequence of using TEDs and BRDs in the 2001 tiger prawn season when prawn catches were dominated by highly valuable tiger prawns and secondarily by endeavour prawns. The legal net (TED + BRD) lost significant amounts of both prawn groups.

The most likely explanation for the prawn losses include:

- Low level losses due to prawns either flicking, swimming or being deflected by the bars through openings in the net associated with normal TED and BRD function;

- Losses due to blockages on the TED (usually by large animals), causing an unusually high number of animals to be diverted through the TED escape opening instead of passing back into the codend (commonly referred to as being 'TEDDed'); and

- Losses due to poor construction, installation or tuning of the TED and/or BRD (see Chapter 12).

The percentage losses of prawns were higher than previous estimates taken from observer data in the seasons leading up to the 2001 Observer Program. Losses in prawn catches of around 3% (from 226 trawl comparisons - see Chapter 6) were measured from the earlier fieldwork. These differences of 2% or 3% translate into significant dollar amounts (Chapter 11).

Both estimates of the percentage of prawn loss also have an impact of the stock assessment evaluation in future years. Hence, it is important to describe the discrepancy in these figures.

There are several factors that have influenced the differences in prawn catches described in these studies. The 6% reduction in total prawns described in the 2001 Observer Program during the tiger prawn season is a statistically robust description of what happened in the fleet at this time. The smaller reductions in prawn catches (-2.8%) were measured by Day and Eayrs (2001) during the 2000 tiger prawn season (see Chapter 6 of this report). The latter results are a valid measure of improved catching performance of these gears, as a direct consequence of the gear technologist's (Garry Day's) activities on the vessels involved. His role was to assist fishers to improve performance of TEDs (and to a lesser extent, BRDs) by demonstrating the effect of modifications and tuning techniques.

It is reasonable to assume that the NPF fleet will improve their ability to retain prawns as they become more familiar with TEDs and BRDs; in the same way that smaller prawn losses were demonstrated on the vessels that worked with the gear technologist. However, without another snapshot assessment it is difficult to know exactly how the fleet performance will have changed from the 6% loss of prawns seen in this study (2001).

The work by the gear technologist also supports the result for soft and damaged prawns from the 2001 tiger prawn Observer Program. Day and Eayrs (2001) reported a change of -36.9% in soft and damaged tiger prawn catches due to TEDs and BRDs, compared to -41.6% from the 2001 Observer Program. These results and the similar impact shown for soft and damaged endeavour prawns (-40.9%, Table 10-4) demonstrate one of the most positive impacts of using TEDs (and to a lesser extent, BRDs). The reductions in soft and damaged prawns are almost certainly due to the removal of large animals from the codend (Chapter 10.3.4 - Elasmobranchs, 10.3.5 – Large Sponges and 10.3.6, - Turtles; Figure 10-4). These can break and squash prawns during the accumulation of catch in the codend, and when the weight of the animals caught are compressed as the codend is lifted from the water and spilled onto the sorting tray. This reduction in soft and damaged prawns translates to a greater proportion of the commercial catch in a high value category, compared to the lower value soft and broken portion of the catch. The economic repercussions of the reduction in damaged prawns was initially described in Salini *et al.,* (2000) and has been re-assessed in the current project Chapter 11.

An indication of the potential of TEDs and BRDs can also be taken from previous studies in the NPF and other prawn and shrimp trawl fisheries. Tables 10-5 and 10-6 summarises a range of results from the last 10 years. It is clear from these studies that TEDs and BRDs are capable of excluding bycatch with limited or no prawn loss. Most of these recorded no measurable prawn or shrimp loss (21 of 35 studies, 60%). However, this was not the case in the NPF tiger prawn season of 2001 for (i) TED and BRD combinations, (ii) downward excluding TEDs, or (iii) the most commonly used BRD, the Bigeye. There appears to be a significant potential for NPF operators to improve the prawn retention performance of both TEDs and BRDs. Chapter 11 describes the financial costs of the underperformance of these devices in the 2001 tiger prawn season, and Chapter 12 describes a range of methods and behaviours that can be used to improve this performance.

Table 10-3. Sample sizes used for analysing the effects of TEDs and BRDs on commercially important prawn catches in the NPF. The number of nets (n) represents the number of individual catches processed; the sample size describes the total weight of commercially important prawn groups processed and the mean catch rate is the average weight per trawl, in kilograms, of commercially important prawns caught in the Standard net (no TED or BRD).

Catch group	Total nets (n)	Sample size (kgs)	Mean catch rate (kgs ± se)	No. nets per treatment			
				TED+BRD	TED only	BRD only	Standard net
Total prawns*	2126	93,389 kg	44.8 (0.77)	538	351	174	1063
Tiger prawns	2108	60,125 kg	29.1 (0.49)	530	351	173	1054
Tiger prawns – soft and damaged	1396	2385 kg	2.0 (0.07)	325	216	157	698
Endeavour prawns	1938	30,325 kg	15.9 (0.56)	483	320	166	969
Endeavour prawns - soft and damaged	336	284 kg	1.0 (0.12)	92	44	32	168
				Upward TED	Downward TED	Bigeye BRD	Square-mesh panel BRD
Total prawns*				143	208	100	74
Tiger prawns				143	208	99	74
Tiger prawns – soft and damaged				108	108	88	69
Endeavour prawns				129	191	16	16
Endeavour prawns - soft and damaged				23	21	17	15

* Total prawns includes Banana and King prawns

Table 10-4. The percentage change and significance levels in catches of commercially important prawns due to the effects of TEDs and BRDs during the 2001 NPF tiger prawn season. The percentages are based on the weight differences between catches in the treatment nets (TED and/or BRD) and catches from the Standard nets (no TED or BRD). Negative values indicate lower catches than the Standard nets and positive values indicate larger catches. ns = no significant difference between comparisons; significance levels: * = p<0.05; **=p<0.01; ***=p<0.001. # denotes total prawns includes Banana and King prawns; ♠ denotes taken from Day and Eayrs (2001), also reported in Chapter 8.

Catch group	TED+BRD	TED only	Upward TED	Downward TED	BRD only	Bigeye BRD	Square-mesh panel BRD
Total prawns#	-6.0 ***	-5.8 ***	ns	-5.7*	-4.4 *	-4.2**	ns
Tiger prawns	-6.5 ***	-6.7 ***	-6.3*	-6.3*	-3.8 *	-3.9*	ns
Tiger prawns – soft and damaged	-41.6 ***	-55.1 ***	-35.8**	-63.2***	ns	ns	ns
Endeavour prawns	-5.0 **	ns	ns	ns	ns	ns	ns
Endeavour prawns – soft and damaged	-40.9 **	-44.4 **	ns	ns	ns	-	-
Tiger prawns (2000)♠	-2.8%						
Tiger prawns – soft and damaged (2000)♠	-36.9						

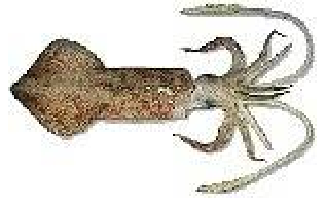
Table 10-5. Summary of previous TED and BRD performance results from the NPF. ns = no significant difference in catch compared to a control net.

Study	Device	Prawn catch	Fish bycatch
Brewer *et al.*, (1997)	Square-mesh codend (BRD)	ns	-33%
Brewer *et al.*, (1998)	AusTED (TED)	-24.8%	-26.6%
	Super Shooter + Fisheye 1 (TED+BRD)	ns	-16.3%
	Super Shooter + Fisheye 2 (TED+BRD)	-10.6%	-13.5%
	Nordmore grid + Fisheye 1 (TED+ BRD)	-16.7%	-30.9%
	Nordmore grid + Fisheye 2 (TED+BRD)	-13.9%	-27.5%
	Nordmore grid + Square-mesh panel 1 (TED+BRD)	-37.7%	-38.9%
	Nordmore grid + Square-mesh panel 2 (TED+ BRD)	-15.6%	-28.4%
	Fisheye (BRD)	ns	ns
Day and Eayrs (2001)	Various TED and BRD combinations	-2.8%	-5.6%
Gregor *et al* (Appendix 6)	Modified Fisheye (BRD)	ns	-17.86%

Table 10-6. Summary of TED and BRD performance results from other prawn trawl fisheries. ns = no significant difference in catch compared to a control net. RES = Radial Escape Section BRD; Fisheye = may include different versions or orientations of Fisheye BRDs.

Study	Location	Device	Prawn catch	Fish bycatch
Branstetter (1997)	South Atlantic	Super Shooter TED	ns	ns
		Morrison TED	-13%	-37%
		Andrews 5 TED	-16%	-57%
	South Atlantic	Fisheye (BRD)	ns	ns to -12%
		RES* (BRD)	ns	-18%
	Gulf of Mexico	Super Shooter TED	-3%	-22%
		Fisheyes(BRD)	ns to -16%	ns to -46%
		RES* (BRD)	ns	-21% to -32%
Broadhurst *et al.*, (1996)	Aust.-NSW estuary	Nordmore grid (TED)	ns	-77%
		Square-mesh panel(BRD)	ns	-70%
Broadhurst and Kennelly (1996)	Aust.-NSW Oceanic	Square-mesh panel(BRD)	ns	-35% to -40%
Courtney and Campbell (2002)	Aust.-Queensland east coast	Wicks TED + RES	ns	-28.33%
	Aust.- Qld east coast	Wicks TED	ns	-28.33%
	Aust.-Qld east coast	RES (BRD)	ns	-28.33%
Courtney and Campbell (2003 a and b)	Aust.-Qld east coast	Modified Wicks TED + Square-mesh codend (BRD)	ns	-28.33%
	Aust.-Qld east coast	Square-mesh codend (BRD)	ns	-18.06%
	Aust.-Qld east coast	Modifies Wicks TED	ns	ns
Garcia-Caudillo *et al.*, (2000)	Gulf of California	RES*(BRD)	-7%	-37%
Steele *et al.*, (2002)	Tampa Bay	RES* + Fish eye (BRD)	ns	-20% to -60%
Robins-Troeger *et al.*, 1995	Aust.-South-east Qld	AusTED	ns	-11 to -59%
Watson *et al.*, 1993	Gulf of Mexico	Super Shooter TED	-1%	-4%
		RES* (BRD)	ns	-37% to -46%
		Super Shooter TED + RES*	ns	-23%

* referred to as a 'large mesh extended funnel BRD'



10.3.2 Commercially valuable byproduct

David Brewer, Don Heales and Peter Jones

Introduction

The species group categorised as byproduct are the commercially valuable part of the NPF catch, other than prawns. However, their value to the fishery is small compared to prawns (Chapter 11). The most valuable species in this group are (i) Moreton Bay bugs, *Thenus indicus* and *T. orientalis*, also referred to as 'bugs' (Yearsley *et al.,* 1999); (ii) Squid (Teuthoidea) of several species (Dunning *et al.,* 1994; Yearsley *et al*., 1999**)** and (iii) Scallops, *Amusium pleuronectes* (Yearsley *et al*., 1999) (Figure 10-6). Other species of byproduct are retained less commonly and were not included in this study. There are no previous studies on the impacts of TEDs and BRDs on these byproduct species in the NPF.

Methods

The methods used to collect the catch data are described in Chapter 9. The Model 1 data analyses described in 10.2.5 was used to assess differences in Moreton Bay bugs, squid, and scallops between treatment and control nets.

Results

Data was collected on commercially valuable byproduct during approximately 18% of all trawl comparisons: 281 of 1612 trawl comparisons for Moreton Bay bugs (17.4%); 134 trawl comparisons for squid (8.3%); and 33 trawl comparisons for scallops (2%). Byproduct data was only recorded when data for the higher priority catch groups was completed and time permitted (Table 10-7).

A total of 444 kg of bugs, 520 kg of squid and 28 kg of scallops were processed during this study. The mean catch rates of bugs, squid and scallops from the Standard nets are presented in Table 10-7, along with the numbers of nets sampled for each experimental trawl comparison.

The use of TEDs and BRDs made no measurable impact on catches of bugs, squid or scallops (Table 10-8). The results were the same for both TEDs and BRDs trialled separately.

Catches of all three byproduct groups did not vary significantly for any of the covariates described in Table 10-2.

Discussion

This study is the first assessment of the impacts of TEDs or BRDs on catches of these byproduct species in the NPF. It demonstrates no negative consequences for byproduct catches by using TEDs and BRDs in the tiger prawns season of 2001. There were no measurable reductions in catches of bugs, squid or scallops.

The ability of TEDs and BRDs to maintain catches of commercially valuable byproduct is likely to be unintentional as the focus of most fishers has largely been on maintaining catches of prawns. There are no data from other fisheries to indicate the potential for changes in byproduct catches with improved TED and BRD performance. These scenarios are difficult to predict without information on how these species react to trawls, TEDs and BRDs, or without a replication of this study once fishers have learned to fish more effectively with these devices.

The only other studies of the impacts of TEDs and BRDs on these or related byproduct species come from recent research on the Queensland East Coast prawn trawl fishery. Courtney and Campbell (2003 (a) and (b)) found that a Wicks TED marginally reduced catches of Balmain bugs (a close relative of Moreton Bay bugs), but there was no affect on their catches with a TED+Square-mesh codend combination or Square-mesh codend without a TED. They also found that all three of these gear combinations had no effect on the catch rate of cuttlefish.

(a) (b) (c)

Figure 10-6. Catches of the three main byproduct groups in the NPF showed very little change due to the use of TEDs and BRDs: (a) Scallops, (b) Moreton Bay bugs and (c) Squid.

Table 10-7. Sample sizes used for analysing the performance of TEDs and BRDs on byproduct catches in the NPF. The number of nets represents the number of individual catches processed; sample size describes the total weight of byproduct groups processed and the mean catch rate is the average weight per trawl, in kilograms, of byproduct caught in the Standard nets (no TED or BRD).

Catch group	Total No. nets	Sample size (kgs)	Mean catch (kgs ± se)	No. nets per treatment			
				TED+BRD	TED only	BRD only	Standard net
Byproduct – Bugs	562	444	0.79 (0.049)	135	100	46	281
Byproduct – Squid	268	520	1.81 (0.62)	65	43	26	134
Byproduct – Scallops	66	28	0.49 (0.12)	18	15	-	33
				Upward TED	**Downward TED**	**Bigeye BRD**	**Square-mesh panel BRD**
Byproduct – Bugs				45	55	27	19
Byproduct – Squid				31	12	16	10
Byproduct – Scallops				-	15	-	-

Table 10-8. Percentage change and significance levels in byproduct catches due to the performance of TEDs and BRDs during the 2001 NPF tiger prawn season. The percentages are based on differences between catches in the net with the TED and/or BRD compared to a Standard net (no TED or BRD). Negative values = lower catches than a Standard net and positive values, larger catches. ns = no significant difference between comparisons; significance levels: * = p<0.05; **=p<0.01; ***=p<0.001.

Catch group	TED+BRD	TED only	Upward TED	Downward TED	BRD only	Bigeye BRD	Square-mesh panel BRD
Byproduct – Bugs	ns	ns	ns	ns	ns	ns	ns
Byproduct – Squid	ns	ns	ns	ns	ns	-	-
Byproduct – Scallops	ns	ns	-	ns	-	-	-

10.3.3 Small bycatch

David Brewer, Don Heales and Peter Jones

Introduction

The component of the catch referred to as the 'Small Bycatch' comprises hundreds of species of small fish and small invertebrates. It accounts for the vast majority by weight or volume of the bycatch taken in the NPF (Brewer *et al.,* 1998; Stobutzki *et al.,* 2000) (Figure 10-7). These species have been categorised together based on the way they are sampled. They are a very numerous and diverse group that cannot normally be processed on board. If information on abundances of individual Small Bycatch species is required, a subsample is usually taken on board (usually 10% or more of the catch), frozen and transported to the laboratory where each species can be separated, identified and processed.

This large group of small species dominates most catches in the NPF. The total bycatch makes up between 87.5% and 95.2% of NPF catches (Blaber *et al.,* 1997; Pender, 1992) and the Small Bycatch component dominates the composition of total bycatch. For this reason it is seen as an important target group for bycatch reduction. However, most of these species are of a similar size to the commercial prawns targeted by NPF operations. This makes their exclusion from the trawl more difficult compared to species groups that can be excluded based on their differences (in size and shape) to the prawns that are being retained. BRDs were developed specifically to exclude this component of the catch, and have been successfully used in a range of similar fisheries (e.g. Broadhurst and Kennelly, 1996; Steele *et al.,* 2002, Table 10-6). Several BRDs have also previously been trialled in the NPF with mixed results (Table 10-5).

The current study aimed to assess the performance of BRDs (as well as TEDs) in the NPF primarily by making comparisons of a BRD in one net against a control net with no devices installed.

Methods

The methods used to collect the catch data are described in Chapter 9. Model 1, described in 10.2.5, was used to assess differences in Small Bycatch between treatment and control nets.

Results

A total of 373t of Small Bycatch was weighed and analysed during this study (Table 10-9). These data provided comparisons from 703 pairs of trawls (1406 nets), 43.6% of all trawls in the study. The average weight was 207.7 kg (± 4.91) in the Standard nets (no TED or BRD). The average weight of Small Bycatch for the entire season is likely to be higher, as a relatively low number of the larger 'dawn shots' were processed for this study.

The combination of TEDs and BRDs reduced the Small Bycatch by 8% (Table 10-10). This result appears to be almost entirely attributable to the influence of TEDs, which produced a similar result on their own (7.9% catch reduction). It also appears as though downward excluding TEDs are more effective at excluding Small Bycatch (8.9% catch reduction) than upward excluders. The latter made no measurable difference to Small Bycatch. The BRDs trialled in this study (Bigeye and Square-mesh panel) had no effect on catches of Small Bycatch.

The impacts of TEDs and BRDs on catches of Small Bycatch were affected by the influence of trawl duration and geographical region (Table 10-2). There were significantly larger catches of Small Bycatch with longer duration trawls and larger catches recorded in Region 4 (West and East Mornington – T7 and T8, Figure 10-3). However, Observers weighed catches of total

Small Bycatch from each net only when it was convenient and feasible and consequently both of these results may contain some unforeseen bias.

Discussion

TEDs and BRDs were introduced to the NPF in order to address the wide range of bycatch groups impacted by this fishery. TEDs were introduced to exclude large animals, especially turtles, and BRDs to minimise catches of small swimming species, especially small fish. However, the exclusion of Small Bycatch in the 2001 tiger prawn season can be attributable mainly to TEDs, and in particular, downward excluding TEDs. This may be at least partly due to a 'swimming down' response described anecdotally for many benthic fish species. This response would assist small fish to find an escape opening at the bottom of the net where the TED is encountered and positioned to exclude through the bottom of the net. Similarly, Small Bycatch species may also encounter or collide with the vertical bars of the TED and be deflected towards the exit flap. This result is similar in magnitude to that recorded for the tiger prawn loss through TEDs. It appears as though the Small Bycatch and Prawn groups may be impacted by TEDs in a similar way.

The main objective of BRDs is to increase escapement of Small Bycatch species, hence the relatively small escape openings used in most of these devices. Several of these devices are positioned to exclude species that orient to an area of disturbed water flow; then swim through an associated opening (e.g. Fisheye and Bigeye). Others (e.g. Square-mesh panel, Fisheye) are positioned in the top of the net to use the natural upward escape response of some species

The BRDs being assessed during the 2001 Observer Program were the Bigeye (65 paired comparisons) and the Square-mesh panel (47 comparisons). The Bigeye was the most commonly used BRD in the NPF in 2001, being used by 79% of vessels (Chapter 8). It is recognized within the fleet that the Bigeye is used because it is placed well away from the codend, and least likely to lose commercially valuable prawns. However, the results described for prawns above, demonstrate a significant prawn loss through this device.

The Square-mesh panel was used by a minority of skippers (10%, Chapter 8), but failed to exclude Small Bycatch. However, in other studies (Tables 10-5 and 10-6), Square-mesh panels have been shown to reduce Small Bycatch. The poor result in the current study may be due to its positioning in the codend, relative to the drawstrings and consequently, the catch. This is likely to be a critical factor in the effectiveness of this type of BRD in excluding Small Bycatch.

During the tiger prawn season 2000, the gear technician measured a 5.4% reduction in catches of Small Bycatch due to TEDs and BRDs (Table 10-10 and Chapter 6). This lower level of reduction compared with an 8% reduction from the 2001 Observer Program is likely to be a result of his intervention and ability to tune TEDs to minimise unwanted loss of prawns (as described for prawns in 10.3.1). Assuming that fishers have improved their ability to tune their TEDs to minimise prawn losses since 2001, the figure of 5.4% reduction is likely to be a more representative value of the Small Bycatch reduction in the NPF in subsequent years, rather than the 8% reduction reported by the Observer Program in the 2001 tiger prawn season.

Despite the poor performance of BRDs measured in the current study, there is evidence from other studies that several of the BRDs available to skippers in the NPF (Appendix 1) may be capable of reducing catches of Small Bycatch, without significant prawn loss. These include the Fisheye, Modified Fisheye, RES, Square-mesh panel, and Square-mesh codends (Table 10-5 and 10-6). Both the Modified Fisheye (Gregor *et al*., 2003, Appendix 6) and Square-mesh codends (Blaber *et al.,* 1997; Brewer *et al.,* 1997) have been trialled successfully in the NPF, reducing Small Bycatch by 18% and 33% respectively, without significant prawn loss. These devices have provided equal or better Small Bycatch exclusion from other prawn trawl fisheries, but none of these BRDs have been widely used by NPF fishers since the mandatory use of TEDs and BRDs in 2000.

The results for Small Bycatch reduction in this study reflect poorly on the NPF and highlight the need for a change in the way BRDs are managed. The most obvious first step is the removal of the Bigeye from the list of legal BRDs available to skippers, and this change was put in place from the start of the 2004 tiger prawn season. It is also well known that, following the introduction of TEDs and BRDs in 2000, the initial focus of skippers and fleet managers was on TEDs. There was little attention given to Small Bycatch reduction through BRDs. The results presented here reflect that scenario, and more effective Small Bycatch reduction could be expected from the fleet in the years following this study.

A significant change would require a shift from the Bigeye to other BRDs and improved use of other BRDs (e.g. use Square-mesh panels and Fisheye within 70 – 100 meshes of the codend drawstrings). The results of the current project will be communicated to fishers and other stakeholders in a range of forums (Chapter 15). However, a significant improvement in BRD performance will rely largely on the good will of fishers, fleet managers and owners to use BRDs in a way that will both maximize the escapement of Small Bycatch while minimizing prawn loss, rather than just the latter.

Figure 10-7. A typical view of a catch from the NPF tiger prawn season. The catch is dominated by Small Bycatch species, especially fish, with commercially valuable prawns scattered throughout.

Table 10-9. Sample sizes used for analysing the performance of TEDs and BRDs on catches of Small Bycatch in the NPF. The number of nets represents the number of individual catches processed; the sample size describes the total weight of Small Bycatch processed and the mean catch rate is the average weight per trawl, in kilograms, of Small Bycatch caught in the Standard nets (no TED or BRD).

Catch group	Total No. nets	Sample size (kgs)	Mean catch rate (kgs ± se)	No. nets per treatment			
				TED + BRD	**TED only**	**BRD only**	**Standard net**
Small Bycatch	1406	373,021	207.7 (4.9)	324	267	112	703
				Upward TED	**Downward TED**	**Bigeye BRD**	**Square-mesh panel BRD**
				108	159	65	47

Table 10-10. Percentage change in catches and significance levels for Small Bycatch from the Observer Program to assess the performance of TEDs and BRDs during the 2001 tiger prawn season in the NPF. The values are based on differences between catches in the net with the TED and/or BRD compared to a Standard net with no TED or BRD. Negative values = lower catches than a Standard net and positive values, larger catches. ns = no significant difference between comparisons; significance levels: * = p<0.05; **=p<0.01; ***=p<0.001.

Catch group	TED+BRD	TED only	Upward TED	Downward TED	BRD only	Bigeye BRD	Square-mesh panel BRD
Small Bycatch	-8.0***	-7.9***	ns	-8.9*	ns	ns	ns
Small Bycatch (from 2000)♠	-5.4♠						

♠ Data from Chapter 8 – Garry Day on NPF vessels in the 2000 tiger prawn season

10.3.4 Elasmobranchs

Ilona Stobutzki, David Brewer, Bill Venables and Peter Jones

Introduction

Worldwide, there is increasing concern over the impact of fishing on Elasmobranchs (sharks, rays and sawfish) and this is reflected in international legislation. Some Elasmobranch species have been listed in the IUCN Red list of threatened species (4 species listed as 'critically endangered', 16 as 'endangered' and 19 as 'vulnerable', IUCN, 2002). The Food and Agriculture Organisation (FAO) has produced an International Plan of Action for the Conservation and Management of Sharks (IPOA-*Sharks,* 1999). Australia has produced a National Plan of Action for the Conservation and Management of Sharks (NPOA-*Sharks*) in line with the IPOA-*Sharks* (AFFA, 2003). The NPOA-*Sharks* highlights the national concern over the potential impacts of fishing on Elasmobranchs, particularly fisheries in which they are bycatch.

Elasmobranchs are bycatch in numerous fisheries that target teleosts (fin fish) or invertebrates. They may be retained and sold (byproduct) or discarded at sea (bycatch/discards) depending on the fishery. However, the biology of Elasmobranchs (slow growth rates, low natural mortality and fecundity) means that their populations may not be able to sustain fishing regimes designed for the more productive teleosts and invertebrates (Stevens *et al.,* 2000). The current global Elasmobranch landings are recorded as 828,000 t (FAO, 2002), but a similar amount is estimated to be caught as unreported bycatch (Stevens *et al.,* 2000). Some species have declined significantly due to their capture as fishery bycatch (e.g. the common and barndoor skates, *Dipturus batis* and *D. laevis,* respectively (Brander, 1981; Casey and Myers, 1998)). Bycatch is unmanaged in most fisheries, often due to the lack of data. While these species are not retained and sold, they still may not survive the capture process and are therefore subject to fishing mortality.

Australia has one of the most diverse Elasmobranch faunas, comprising at least 296 species, over half of which are endemic (Last and Stevens, 1994). In the NPF, 56 Elasmobranch species (19 families) have been recorded in trawl catches (Stobutzki *et al.,* 2001).

Prior to 2001, NPF trawlers were permitted to retain shark products but were restricted in terms of the amount on a vessel at any one time. Fishers were required to record retained Elasmobranch catch in trawler logbooks. In 1999, 4177 kg of fillet, trunk and whole shark and 1531 fins were recorded (Sharp *et al.,* 1999). However, the records were not validated and therefore their accuracy is unknown. In 2001, NPF fishers voluntarily agreed to not retain any Elasmobranch products and so a total ban on retention was introduced.

The Elasmobranch bycatch in the NPF has previously been assessed to determine which species are most likely to be at highest risk of their populations not being sustainable under current levels of fishing effort (Stobutzki *et al.,* 2002). Several groups caught as bycatch in the NPF, including the sawfishes (*F. Pristidae*), caused international concern due to their declining populations worldwide (Simpfendorfer, 2000). A significant change in the gear configuration used by the fishery, such as the introduction of TEDs and BRDs, may change the impact of the fishery on Elasmobranch bycatch as a whole. However, it is also likely that the impact of the gear changes will not be uniform across the species.

Preliminary trials of TEDs on scientific research vessels have provided evidence that they can reduce the catch of Elasmobranchs in prawn trawls, particularly the larger individuals (Stobutzki *et al.,* 2001; Brewer *et al.,* 1998). However, the previous studies were limited by the fact they were based on research vessels.

This study examined the impact of the introduction of TEDs and BRDs in the NPF on the Elasmobranch catch of the fishery by conducting controlled experiments onboard industry vessels. It was the first study designed to examine the species-specific response to the bycatch mitigation devices by examining the number of individuals caught and their size range.

Methods

The descriptions of the Observer Program and data collection process are given in Chapter 9. The statistical analyses used in this section are described in 10.2.5.

All Elasmobranchs caught were identified and where possible the length and weight of individuals was recorded. Total length (TL) was recorded for sharks, sawfishes (*F. Pristidae*), guitarfish (*F. Rhynchobatidae*) and shovelnose rays (*F. Rhinobatidae*), and disc width (DW) for the remaining ray families. Individuals that were clearly newborns, likely to have been aborted from a female in the catch, were excluded from the analyses.

The number and mean length of individuals caught by the different gear configurations was examined using Models 2 and 3, respectively, as described in Chapter 10.2.5. A preliminary analysis showed that different BRD types had little influence on catches of Elasmobranchs. Consequently, the different types of BRD were combined to provide an overall analysis of their effect on Elasmobranch catches.

Results

A total of 2168 nets (from 1084 paired trawl shots) were sampled for Elasmobranchs. Information on 7573 individuals was recorded, 98% of which were identified to species.

Thirty-six species (14 families) were recorded in the catch (Tables 10-11 to 10-15). Overall, five species accounted for 64% of the individuals observed: *Carcharhinus dussumieri* (whitecheek shark), *C. tilstoni* (Australian blacktip shark), *Rhynchobatus djiddensis* (white-spotted guitarfish), *Gymnura australis* (Australian butterfly ray) and *Himantura toshi* (black-spotted whipray). *C. dussumieri* was the most common species regardless of the gear configuration.

Total rays (from both the Trash chute and sorting trays) showed a significant reduction in catch rate in TED + BRD nets (36.3%) and any nets with a TED (31.3%) (Table 10-11). BRD only nets, showed no significant difference from the Standard net for all rays combined or for any individual species. There was little difference between the exclusion rates of rays between upward and downward excluding TEDs (26.9% and 34.8%, respectively) (Table 10-13).

Total sharks (from both the Trash chute and sorting trays) also showed a significant reduction in catch rate in TED + BRD nets (17.7%), any nets with a TED (13.3%) and nets with only BRDs installed (16.7%) (Table 10-12). However, only one species, *C. tilstoni*, demonstrated a significant difference (23.8%) between nets with a BRD only and the Standard net. There appears to be a noticeable difference in the exclusion rates between upward and downward excluding TEDs (20.4% and 8.8%, respectively) (Table 10-14).

Overall the sawfishes were rare, only 33 records, 25 of which were *Anoxypristis cuspidata* (Narrow sawfish) (Table 10-11). There was no significant difference between the different gear comparisons in the number of individual sawfish caught and no difference between upward and downward TEDs. This result appears to have been influenced by the low samples sizes used in the analyses. However, a significant difference in catches was detected for the most common sawfish species, *A. cuspidata.* A 73.3% reduction in numbers can be demonstrated in nets with a TED compared to nets without a TED (Table 10-11).

The impact of TEDs on the larger species was demonstrated by analyses of large and small sharks and rays. Large rays (> 1 m wide) had a 94% reduction in catches in nets containing TEDs compared to nets without TEDs installed. Large sharks (> 1 m long) had an 86% reduction in TED nets. Much lower catch differences were seen for smaller animals, with 25% fewer small rays (less than 1 m) compared to nets containing TEDs, while only 4.9% fewer small sharks were caught in nets with TEDs compared to Standard nets. These differences in exclusion rates for different sized rays and sharks are also depicted by the curves fitted using a logistic regression model of animal lengths (Figure 10-10).

Ray species

A total of eight of the 18 ray species showed a significant difference in catches between the legal net (TED+BRD) and the Standard net (Table 10-11). Ten ray species showed significant differences between any net containing a TED versus a Standard net. This increase in species showing differences has resulted from the increased sample size by using both TED+BRD and TED only nets together in the latter comparison. Seven of the 18 ray species had greater than a 95% difference in catches between nets containing a TED and Standard nets. Four rarely caught ray species (*Dasyatis thetidis*, *H. granulata*, *Taeniura meyeni* and *Urogymnus asperrimus*) may also be effectively excluded by TEDs, but this could not be tested here due to the low sample sizes for these species. No ray species showed differences in catches between nets with BRDs and Standard nets.

Five ray species showed a significant difference in catches between nets with an upward excluding TED and the Standard net (Table 10-13). Another seven species showed no difference in catches between upward excluding TEDs and Standard nets but were only caught in the Standard nets. Seven species showed a difference in catches between nets with a downward excluding TED and the Standard net. Another six species showed no difference in catches between downward excluding TEDs and Standard nets but were only caught in the Standard nets. Only one species, *D. annotata,* appears to demonstrate a higher exclusion rate for a specific TED orientation. Almost twice the number of individuals of this species were caught in the Standard net compared to downward excluding TEDs (49.3% difference). In comparison, similar numbers of *D. annotata* were caught in nets containing upward excluding TEDs and Standard nets.

Only three of the 18 ray species (*D. leylandi, H. toshi* and *R. djiddensis*) demonstrated differences in lengths between net configurations (Table 10-15). All three were caught at smaller lengths in nets with a TED+BRD. Two of the species, *H. toshi* and *R. djiddensis,* also showed significant differences between nets containing a TED only versus the Standard net (Figure 10-9). *H. toshi* was caught at smaller sizes in nets containing BRDs.

Shark species

Two of the 17 shark species showed a significant difference in catches between the legal net (TED+BRD) and the Standard net (Table 10-12). Four shark species showed significant differences between any net containing a TED versus a Standard net. This increase in species showing differences has resulted from the increased sample size by using both TED+BRD and TED only nets together in the latter comparison. Only two of the 17 shark species had large (greater than a 50%) differences in catches between nets containing a TED and Standard nets. Six rarely caught shark species (*Galeocerda cuvier, Negaprion acutidens, Triaenodon obesus, Nebrius ferrugineus, Eucrossorhinus dasypogon* and *Eusphyra blochii*) may also be effectively excluded by TEDs, but this could not be tested here due to the low sample sizes for these species. Only one shark species, *C. tilstoni*, showed a difference in catches between nets with

BRDs and Standard nets, with 23.8% fewer animals caught in nets with BRDs compared to the Standard net.

Two shark species showed a significant difference in catches between nets with an upward excluding TED and the Standard net (Table 10-14). Another five species showed no difference in catches between upward excluding TEDs and Standard nets but were only caught in the Standard nets. Three species showed a difference in catches between nets with a downward excluding TED and the Standard net. Another five species showed no difference in catches between downward excluding TEDs and Standard nets but were only caught in the Standard nets. Three species demonstrated different exclusion rates for a specific TED orientation. *Stegastoma fasciatum* was very effectively excluded by TEDs with either orientation. *C. tilstoni* was found in lower numbers in nets with an upward excluding TED compared to the Standard net, but showed no difference in catches between nets with a downward excluding TED and Standard nets. *Chiloscyllium punctatum* was the opposite, demonstrating a 29.6% exclusion rate from nets with a downward excluding TED, but showing no difference between nets with upward excluding TEDs and Standard nets. *C. dussumieri* was caught in greater numbers in the nets with downward excluding TEDs, compared to the Standard net. However, there was no difference between its catches in nets with upwards excluding TEDs and Standard nets.

Only one of the 17 shark species (*C. tilstoni*) demonstrated differences in lengths between net configurations. This species was caught at smaller lengths in nets with a TED+BRD or nets containing a TED only compared to the Standard net (Figure 10-9).

Discussion

The use of TEDs and BRDs in the NPF has clearly reduced the catch of Elasmobranchs, primarily due to the presence of TEDs. This result is not unexpected given the design of the TED and BRDs. The TEDs were originally designed to prevent turtles from entering the codend. The grid is a substantial barrier to large animals and appears effective for most species of Elasmobranchs. The maximum legal spacing between adjacent vertical bars in TEDs is 120 mm. This means that sharks substantially wider than 120 mm, or rays thicker (dorso-ventrally higher) than 120 mm would have difficulty passing through the bars.

This positive impact of TEDs on Elasmobranchs is emphasised by the high exclusion rates for large rays (94%) and large sharks (86%), which include more than half of the species encountered by the NPF. This result is consistent with the data collected by Garry Day during TED and BRD trials in 2000 (Chapter 8), where a 77.8% reduction in large sharks and rays was recorded. Only two other studies have reported high exclusion rates of large Elasmobranchs due to the use of TEDs. During scientific trials of TEDs and BRDs in the NPF, Brewer *et al.,* (1997) found that nets with TEDs caught one large Elasmobranch (>5kg) every 12.5 trawls, compared to a Standard net which caught one every 1.5 trawls. This equates roughly to a reduction of around 88% which is similar to that recorded in this study. Robins *et al.,* (2000) found that nets with TEDs caught 252 large sharks (>45 cm total length) compared to 551 large sharks from the Standard nets, a reduction of 54.3%.

In contrast, BRDs are designed to enable smaller fish to actively escape. Some BRDs could potentially allow some Elasmobranchs to escape. For example, the Bigeye, with its one metre wide hole in the top of the net, could allow quite large Elasmobranchs to escape, and this is the most likely explanation for the partial exclusion of sharks and in particular, *C. tilstoni* from nets with BRDs. However, it is unlikely that devices such as the Square-mesh panel would enable many Elasmobranchs to escape, given the size of the mesh (usually close to the minimum of 101 mm mesh, 50.5 mm bar length, Appendix 3), and this is reflected in the results presented above.

The sawfishes as a group do not show a reduction in number of individuals caught, due to the presence of the TEDs. However, a relatively high exclusion rate (73.3%) was measured for the most commonly caught species in the NPF, *A. cuspidata.* The rarity of sawfish in catches (only

33 recorded in nearly 2000 nets sampled) may have restricted the statistical power to detect a significant exclusion for all sawfish combined. However, this combined group includes species that were unidentified and may be more difficult to exclude from trawls. Sawfish are known for becoming entangled in prawn trawl nets due to the numerous teeth along their rostrum, which may also become caught in the TED. In the current study, five individuals observed in the nets with TEDs were caught in the main net, before the TED. As this group is one of high international and national concern, the fishery may need to examine other methods to reduce its impact on sawfish. Modelling of sawfish population dynamics suggests that their populations may take decades to recover from large reductions (Simpfendorfer, 2000).

The species-specific responses of Elasmobranchs to TEDs varied (Table 10-11 to 10-15). About one-third of species showed no exclusion through TEDs, or no potential for exclusion (if sample sizes were larger). Almost half of the Elasmobranch species showed effective exclusion, with reductions in numbers ranging from 17% (*C. tilstoni*) to more than 90% for nine species. These highly excluded species include *H. uarnak, H. undulata, Pastinachus sephen, Aetobatus narinari, Aetomylaeus verpertilio, Rhinobatos typus, Rhina ancylostoma, N. ferrugineus,* and *S. fasciatum*. The positive impact of TEDs on these species has been as dramatic as the impact documented for turtles. The impact of the NPF on Elasmobranchs has changed, from imposing a relatively constant level of mortality, to the current situation (post-2000 when TEDs and BRDs were introduced into the fishery). Currently, TEDs are excluding almost all individuals of nine species (above) that are commonly caught in trawls. This same high impact is also likely for a range of other large species caught only in Standard nets, but were encountered too rarely to demonstrate statistical differences in catches between nets. These include *D. thetidis, H. granulata, G. cuvier, N. acutidens,* and *Eusphyra blochii.*

Three of the smaller species (≤ 1 m width or length), *D. annotata, H. toshi* and *Chiloscyllium punctatum* showed a reduction in catches in nets containing a TED (23%-43%), compared to about seven other smaller species that were caught in similar numbers between TED nets and Standard nets (*D. kuhlii, D. leylandi, Gymnura australis, Aetomylaeus nichofii, C. dussumieri, Rhizoprionodon acutus* and *Hemigaleus microstoma*). This suggests that the TEDs were effective at excluding some small species, even though they were small enough to fit through the TED. It may be that differences in the reaction of some of the smaller species to TEDs assist their exclusion compared to other species. This more active escape response is relied upon to remove the Small bycatch through BRDs. However, only 8% of these animals were excluded by TED+BRD nets. The higher exclusion rate of the smaller Elasmobranchs suggests that the physical exclusion by TEDs is still playing a role in eliminating these Elasmobranchs, or they are far better at actively escaping through TEDs than the small bycatch.

Some ray species showed differences in catchability between upward excluding TEDs and downward excluding TEDs. Catches of *D. annotata,* and *C. punctatum* were reduced through downward excluding TEDs, but not through upward excluding TEDs. These species may have a natural tendency to escape from a trawl in a downward direction, but this would need to be established in a behavioural study (e.g. recording video images of species behaviour in trawls). This pattern was the same for *H. uarnak* although it appears that larger sample sizes would demonstrate similar exclusion through upward excluding TEDs for this species.

Sharks were more effectively reduced by using upward excluding TEDs, than downward excluding TEDs. However, only one species, *C. tilstoni*, was effectively excluded by upward excluding TEDs, but not by downward excluding TEDs. This species is also the only Elasmobranch excluded by BRDs in this study, and these devices were also located in the dorsal side of the nets. These results suggest that sharks, and *C. tilstoni* in particular, may have a relatively strong upward escape response to trawls compared to other Elasmobranch species. An explanation of this result would also require the collection of behavioural information in trawls.

Catches of *C. dussumieri* were greater in nets with a downward excluding TED than in Standard nets. This result is not easily explained, although information on the reaction of this species to trawls and TEDs may be a useful first step towards resolving this dilemma.

The results show that the introduction of TEDs in the NPF has dramatically reduced the bycatch of Elasmobranchs. In combination with the ban on retention of Elasmobranch products, the impact of the fishery on Elasmobranch populations has been greatly reduced. The TEDs clearly exclude a high proportion of the larger individuals while some smaller species also show a reduction in numbers caught. However, the NPF is still likely to catch large numbers of the small species, which dominate the Elasmobranch bycatch, for example, *C. dussumieri.*

The results from this study are likely to have a significant impact on the risk assessment (Stobutzki *et al.,* 2002) for some species. Most concern may be directed towards the species that are least likely to be sustainable, but not excluded by TEDs or BRDs. Stobutzki *et al.,* (2002) reported that six species were least likely to be sustainable in the bycatch of the NPF (*D. brevicaudatus, H. jenkinsii, Pristis pectinata, P. clavata, P. microdon, and P. zijsron*). None of these were identified by any of the five observers in the current study, and hence there is no data on their potential exclusion from NPF trawls by TEDs or BRDs. However, *D. brevicaudatus* is a large species of ray, growing to >2 m disc width (Last and Stevens, 1994), and, based on results for other large species, is likely to be at least partially excluded by TEDs. The other ray, *H. jenkinsii,* is smaller, growing to just over 1 m (Last and Stevens, 1994), and may not be well excluded by TEDs. The other four potentially unsustainable species are sawfish. Two are smaller than *A. cuspidata* (*P. clavata* – to 1.4 m and *P. microdon* – to 2 m) and two are larger (*P. pectinata* – to 7.6 m and *P. zijsron* – to 5 m). It is not clear if size is an important factor influencing the exclusion of sawfish. However, if this is the case, TEDs may be excluding a proportion of two or more of these species. Exclusion devices may not be the most effective method for reducing sawfish catches. Given the morphology of sawfishes (a long, toothed rostrum) the best way to reduce their capture may be to avoid interactions with them altogether. Scaled results from this study estimate that 18120 Elasmobranchs (12898 rays, 4980 sharks, and 242 narrow sawfish) were excluded from NPF trawls due to TEDs during the 2001 tiger prawn season.

Five more of the "relatively high-risk" Elasmobranch species (*Anoxypristis cuspidata, H. uarnak*, *P. sephen, R. ancylostoma,* and *R. typus*) have had a demonstrated benefit from the introduction of TEDs. At least five other relatively high risk, large species (*D. thetidis, H. Fai, H. granulata, N. acutidens* and *U. asperrimus*) are likely to be impacted in a similar way. Given the different responses of the species to the TEDs, and the changes in catch rates, the assessment of the relative risk to the species from the fishery (Stobutzki *et al.,* 2002) should be re-examined.

Figure 10-8. Sawfish caught in a fish trawl net.

Table 10-11. Comparison of numbers caught and percentage exclusion of Rays (and Sawfish) from three treatment-control designs: (i) TED+BRD v Standard net; (ii) TED net v Standard net (see Section 10.2.5); and BRD only net v Standard net. 'TED net' refers to any net with a TED (either TED+BRD or TED only). The number of individuals, n, is given for each treatment and control comparison; p = the probability that the numbers are different; ns = not significant; '% diff' is the percentage difference between animals caught in the TED and/or BRD and the Standard net, where a significant difference in catches was measured (p<0.05).

Species (common name)	**TED+BRD**	**Standard net**	***p***	**% diff**	**TED net**	**Standard net**	***p***	**% diff**	**BRD only**	**Standard net**	***p***	**% diff**
	n	**n**			**n**	**n**			**n**	**n**		
All rays	666	1046	<0.001	-36.3%	1311	1907	<0.001	-31.3%	192	198	ns	
Dasyatididae												
Dasyatis annotata (Plain maskray)	96	160	<0.001	-40%	165	247	<0.001	-33.2%	8	8	ns	
Dasyatis kuhlii (Blue-spotted maskray)	20	14	ns		35	34	ns		9	6	ns	
Dasyatis leylandi (Painted maskray)	72	103	<0.05	-30.1%	213	231	ns		26	25	ns	
Dasyatis thetidis (Black stingray)	0	4	ns		0	5	ns		-	-		
Himantura granulata (Mangrove whipray)	0	1	ns		0	2	ns		-	-		
Himantura toshi (Black-spotted whipray)	132	229	<0.001	-42.3%	278	406	<0.001	-31.5%	27	22	ns	
Himantura uarnak (Reticulate whipray)	0	6	<0.05	-100%	0	13	<0.001	-100%	1	3	ns	
Himantura undulata (Leopard whipray)	2	21	<0.001	-90.5%	2	41	<0.001	-95.1%	5	4	ns	
Pastinachus sephen (Cowtail stingray)	1	41	<0.001	-97.6%	2	78	<0.001	-97.4%	6	9	ns	
Taeniura meyeni (Blotched fantail ray)	-	-			0	1	ns		-	-		
Urogymnus asperrimus (Porcupine ray)	0	1	ns		0	1	ns		0	1	ns	
Gymnuridae												
Gymnura australis (Australian butterfly ray)	185	193	ns		326	362	ns		43	37	ns	
Myliobatididae												
Aetobatus narinari (White-spotted eagle ray)	0	3	ns		0	6	<0.05	-100%	0	1	ns	
Aetomylaeus nichofii (Banded eagle ray)	19	20	ns		30	31	ns		5	4	ns	
Aetomylaeus verpertilio (Ornate eagle ray)	0	5	ns		0	6	<0.05	-100%	-	-		
Rhinobatidae												
Rhynchobatus djiddensis (White-spotted guitarfish)	128	211	<0.001	-39.3%	247	389	<0.001	-36.5%	53	67	ns	
Rhinobatos typus (Giant shovelnose ray)	0	5	ns		0	7	<0.05	-100%	0	3	ns	
Rhynchobatidae												
Rhina ancylostoma (Shark ray)	0	9	<0.01	-100%	0	14	<0.001	-100%	3	2	ns	
Pristidae	7	11	ns		9	18	ns		3	3	ns	
Anoxypristis cuspidata (Narrow sawfish)	4	9	ns		4	15	<0.05	-73.3%	3	3	ns	

Table 10-12. Comparison of numbers caught and percentage exclusion of Sharks from three treatment-control designs: (i) TED+BRD v Standard net; (ii) TED net v Standard net (see Section 10.2.5); and BRD only net v Standard net. 'TED net' refers to any net with a TED (either TED+BRD or TED only). The number of individuals, n, is given for each treatment and control comparison; p = the probability that the numbers are different; ns = not significant; '% diff' is the percentage difference between animals caught in the TED and/or BRD nets and the Standard nets, where a significant difference in catches was measured (p<0.05).

Species (common name)	TED+BRD	Standard net	*p*	% diff	TED net	Standard net	*p*	% ex	BRD only	Standard net	*p*	% diff
	n	n			n	n			n	n		
All sharks	765	929	<0.001	-17.7%	1419	1637	<0.001	-13.3%	413	496	<0.001	-16.7%
Carcharhinidae												
Carcharhinus dussumieri (Whitecheek shark)	272	282	ns		642	614	ns		183	211	ns	
Carcharhinus sorrah (Spot-tail shark)	7	10	ns		12	15	ns		2	2	ns	
Carcharhinus tilstoni (Australian blacktip shark)	183	216	ns		317	383	<0.05	-17.2%	112	147	<0.05	-23.8%
Galeocerdo cuvier (Tiger shark)	0	4	ns		0	4	ns		3	4	ns	
Negaprion acutidens (Lemon shark)	0	1	ns		0	2	ns		-	-		
Rhizoprionodon acutus (Milk shark)	93	78	ns		109	91	ns		11	15	ns	
Triaenodon obesus (Whitetip reef shark)	0	1	ns		0	1	ns		-	-		
Ginglymostomatidae												
Nebrius ferrugineus (Tawny shark)	0	5	ns		0	7	<0.05	-100%	1	2	ns	
Hemigaleidae												
Hemigaleus microstoma (Weasel shark)	73	96	ns		133	161	ns		52	64	ns	
Hemipristis elongata (Fossil shark)	3	3	ns		3	3	ns		0	1	ns	
Hemiscylliidae												
Chiloscyllium punctatum (Grey carpet shark)	126	172	<0.01	-26.7%	188	246	<0.01	-23.6%	32	33	ns	
Orectolobidae												
Eucrossorhinus dasypogon (Tasselled wobbegong)	0	1	ns		0	1	ns		-	-		
Sphyrnidae												
Eusphyra blochii (Winghead shark)	0	3	ns		0	3	ns		1	0	ns	
Sphyrna lewini (Scalloped hammerhead)	6	8	ns		12	19	ns		1	2	ns	
Sphyrna mokarran (Great hammerhead)	1	1	ns		1	2	ns		1	2	ns	
Stegastomatidae												
Stegastoma fasciatum (Zebra shark)	0	48	<0.001	-100%	1	85	<0.001	-98.8%	14	13	ns	
Scyliorhinidae												
Atelomycterus fasciatus (Banded catshark)	1	0	ns		1	0	ns		-	-		

Table 10-13. Comparison of numbers caught and percentage exclusion of Rays (and Sawfish) from two treatment-control designs: (i) Upward excluding TED v Standard net; (ii) Downward excluding TED net v Standard net (see Section 10.2.5); and BRD only net v Standard net. The number of individuals, n, is given for each treatment and control comparison; p = the probability that the numbers are different; ns = not significant; '% diff' is the percentage difference between animals caught in the TED and the Standard net, where a significant difference in catches was measured (*p*<0.05).

Species (common name)	**Upward TED**	**Standard net**	***p***	**% diff**	**Downward TED**	**Standard net**	***p***	**% diff**
	n	**n**			**n**	**n**		
All rays	623	852	<0.001	-26.9%	688	1055	<0.001	-34.8%
Dasyatididae								
Dasyatis annotata (Plain maskray)	90	99	ns		75	148	<0.001	-49.3%
Dasyatis kuhlii (Blue-spotted maskray)	18	22	ns		17	12	ns	
Dasyatis leylandi (Painted maskray)	117	120	ns		96	111	ns	
Dasyatis thetidis (Black stingray)	0	3	ns		0	2	ns	
Himantura granulata (Mangrove whipray)	0	1	ns		0	1	ns	
Himantura toshi (Black-spotted whipray)	143	201	<0.01	-28.8%	135	205	<0.001	-34.1%
Himantura uarnak (Reticulate whipray)	0	5	ns		0	8	<0.01	-100%
Himantura undulata (Leopard whipray)	0	23	<0.001	-100%	2	18	<0.001	-88.9%
Pastinachus sephen (Cowtail stingray)	1	37	<0.001	-97.3%	1	41	<0.001	-97.6%
Taeniura meyeni (Blotched fantail ray)	0	1	ns		-	-		
Urogymnus asperrimus (Porcupine ray)	-	-			0	1	ns	
Gymnuridae								
Gymnura australis (Australian butterfly ray)	134	134	ns		192	228	ns	
Myliobatididae								
Aetobatus narinari (White-spotted eagle ray)	0	2	ns		0	4	ns	
Aetomylaeus nichofii (Banded eagle ray)	10	12	ns		20	19	ns	
Aetomylaeus verpertilio (Ornate eagle ray)	0	1	ns		0	5	ns	
Rhinobatidae								
Rhynchobatus djiddensis (White-spotted guitarfish)	104	164	<0.001	-36.6%	143	225	<0.001	-36.4%
Rhinobatos typus (Giant shovelnose ray)	0	3	ns		0	4	ns	
Rhynchobatidae								
Rhina ancylostoma (Shark ray)	0	6	<0.05	-100%	0	8	<0.01	-100%
Pristidae	4	9	ns		5	9	ns	
Anoxypristis cuspidata (Narrow sawfish)	2	9	ns		2	6	ns	

Table 10-14. Comparison of numbers caught and percentage exclusion of Sharks from two treatment-control designs: (i) Upward excluding TED v Standard net; (ii) Downward excluding TED net v Standard net (see Section 10.2.5). The number of individuals, n, is given for each treatment and control comparison; p = the probability that the numbers are different; ns = not significant; '% diff' is the percentage difference between animals caught in the TED and the Standard net, where a significant difference in catches was measured ($p<0.05$).

Species (common name)	Upward TED	Standard net	*p*	% diff	Downward TED	Standard net	*p*	% diff
	n	n			n	n		
All sharks	506	636	<0.001	-20.4%	913	1001	<0.001	-8.8%
Carcharhinidae								
Carcharhinus dussumieri (Whitecheek shark)	191	222	ns		451	392	<0.05	+15.1%
Carcharhinus sorrah (Spot-tail shark)	7	10	ns		5	5	ns	
Carcharhinus tilstoni (Australian blacktip shark)	94	148	<0.001	-36.5%	223	235	ns	
Galeocerdo cuvier (Tiger shark)	0	1	ns		0	3	ns	
Negaprion acutidens (Lemon shark)	-	-			0	2	ns	
Rhizoprionodon acutus (Milk shark)	63	48	ns		46	43	ns	
Triaenodon obesus (Whitetip reef shark)	0	1	ns		-	-		
Ginglymostomatidae								
Nebrius ferrugineus (Tawny shark)	0	2	ns		0	5	ns	
Hemigaleidae								
Hemigaleus microstoma (Weasel shark)	34	39	ns		99	122	ns	
Hemipristis elongata (Fossil shark)	2	1	ns		1	2	ns	
Hemiscylliidae								
Chiloscyllium punctatum (Grey carpet shark)	112	138	ns		76	108	<0.05	-29.6%
Orectolobidae								
Eucrossorhinus dasypogon (Tasselled wobbegong)	-	-			0	1	ns	
Sphyrnidae								
Eusphyra blochii (Winghead shark)	0	2	ns		0	1	ns	
Sphyrna lewini (Scalloped hammerhead)	3	5	ns		9	14	ns	
Sphyrna mokarran (Great hammerhead)	0	1	ns		1	1	ns	
Stegastomatidae								
Stegastoma fasciatum (Zebra shark)	0	18	<0.001	-100%	1	67	<0.001	-98.5%
Scyliorhinidae								
Atelomycterus fasciatus (Banded catshark)	-	-			1	0	ns	

Table 10-15. The mean length (L, cm) of Elasmobranch species in the different gear configurations. The standard error (se) is given for each mean. For the catch rate information the total number of individuals is given (Total (n)) and for the length information the number of individuals measured (n) in each gear configuration is given. Significance levels are indicated as follows: * = $p < 0.05$.

Group	Species (common name)	TED+BRD			TED only			BRD only			Standard net		
		mean	se	n	mean	se	n	mean	se	n	mean	se	n
Rays	**Dasyatididae**												
	Dasyatis leylandi (Painted maskray)	16.1*	0.30	139	18.2	0.26	174	17.2*	0.38	67	17.5	0.19	377
	Himantura toshi (Black-spotted whipray)	38.2*	1.14	122	37.6*	1.12	157	41.8		28	42.2	0.75	412
	Rhinobatidae												
	Rhynchobatus djiddensis (White-spotted guitarfish)	64.9*	2.10	128	64.5*	2.45	113	86.3	8.47	52	87.8	2.83	441
Sharks	**Carcharhinidae**												
	Carcharhinus tilstoni (Australian blacktip shark)	79*	0.80	183	75*	0.88	125	85.7	1.57	109	83.7	0.73	510

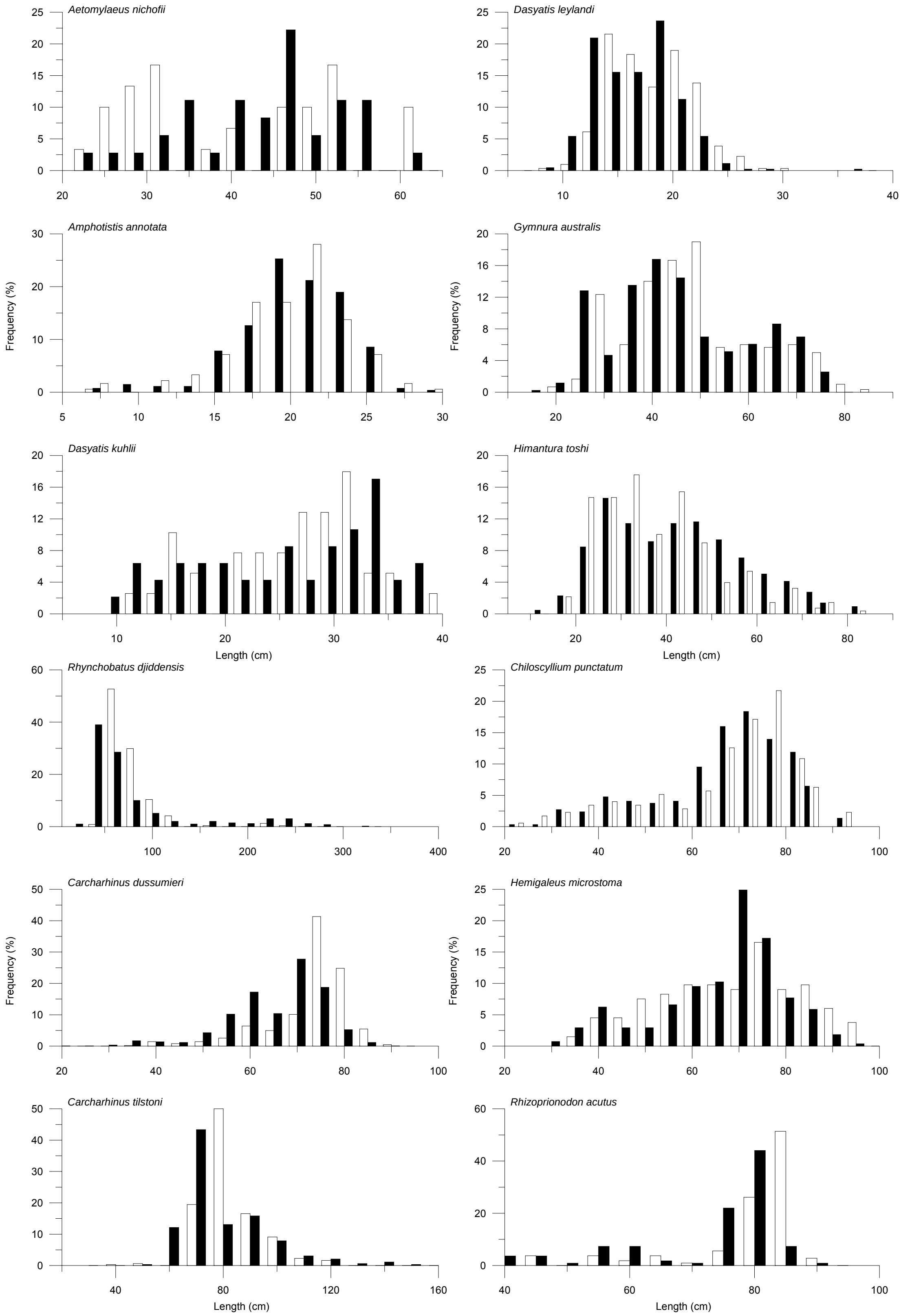


Figure 10-9. The frequency (%) of size classes of Elasmobranch species caught in TED + BRD or TED only nets (open bars) and Standard nets (solid bars). These data were taken from any of these gear configurations where these species were caught.

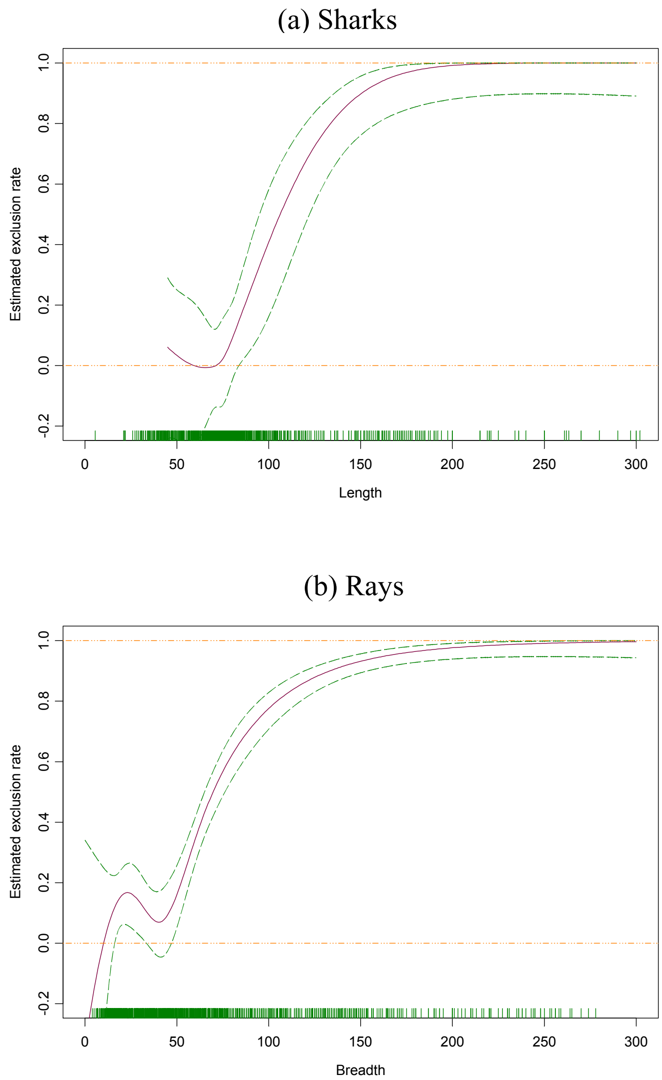


Figure 10-10. Logistic regression model outputs for (a) sharks and (b) rays showing the estimated exclusion rates for different sized animals (smooth curve) with 95% confidence intervals. The sizes at which observations were available for this analyses are indicate by small vertical lines, forming a 'rug' along the X axis, where a single line represents one animal.

10.3.5 Large sponges

David Brewer, Don Heales and Peter Jones

Introduction

Large Sponges (Phylum *Porifera*) were one of the projects target groups for data collection because of several unique characteristics. They are the most abundant group of the large sessile invertebrates caught in NPF prawn trawl catches. The large specimens usually don't pass through the TED and hence are not well sampled in the Small Bycatch component. They characterise catches in certain regions (e.g. large areas near the Bountiful Islands) and little is known about their catchability or ecological importance in the NPF. Their taxonomic identification is difficult and for this study all sponges greater than 30 cm in height or diameter were treated as one group.

Large sponge data were also collected to assess a hypothesis that reduced catches of other groups may be associated with interactions with Large Sponges while trawling. This hypothesis assumes that some Large Sponges get 'stuck' on the TED during trawling, and during that time, increase the loss of prawns and other species through the escape opening of the device (also described in methods, 10.2.5). The data for this covariate is presented in Table 10-2 for most groups.

Robins *et al.,* (2000) is the only other study to assess the impact of TEDs or BRDs on large sponge catches

Methods

The methods used to collect the catch data are described in Chapter 9. Model 2, described in 10.2.5, was used to assess differences in Large Sponge catches between treatment and control nets.

Results

A total of 1399 trawls were checked for Large Sponges and specimens were recorded during 24.2% of all trawl comparisons. A total of 1923 Large Sponges were recorded from 339 separate paired trawl comparisons (Table 10-16).

TEDs and BRDs reduced the catches of Large Sponges by 85.3% (Table 10-17). This result was totally attributable to TEDs, which, on their own gave a similar result (86.3% exclusion of sponges). BRDs had no impact on Large Sponge catches. Upward excluding TEDs removed 81.6% of Large Sponges from the trawl net, and downward excluding TEDs were more effective excluding 95.9%.

Sponge catches had no impact on catches of most other groups. Only soft and damaged tiger prawns showed any difference in exclusion due to the presence of Large Sponges in the catch. Catches of soft and damaged tiger prawns due to TEDs and BRDs changed from a 28.1% to a 39.7% reduction due to the presence of Large Sponges.

Discussion

This study is only the second assessment of the impacts of TEDs or BRDs on catches of Sponges. Robins *et al*., (2000) during Observer-based field trials in the Queensland East Coast Trawl Fishery and NPF, recorded an order of magnitude difference in the catches of Large Sponges in nets with TEDs (33 sponges) compared to control nets (342 sponges), a reduction of 90.3%. Observer work in the current project measured a 78.8% exclusion of Large Sponges on NPF vessels during the 2000 tiger prawn season. Both of these results are similar to the 85.3% exclusion measured during the 2001 Observer study and demonstrate the effectiveness of TEDs on this bycatch group.

Large Sponges are usually heavy, highly porous and negatively buoyant. It is reasonable to expect that downward excluding TEDs exclude Large Sponges more effectively than upward excluding TEDs. Robins *et al*., (2000) describes the sponge catching difference between a bottom opening TED and a control net on one vessel as zero versus 50 Large Sponges, respectively. The current study also found that downward excluding TEDs were more effective for Large Sponges than upward excluders, although both forms of TED were highly effective Large Sponge excluders.

Although TEDs were originally designed to exclude turtles from trawl catches, it is demonstrated here that Large Sponges are also effectively excluded from NPF catches by these devices. The study has also demonstrated that in almost all cases there is no relationship between catches of Large Sponges and exclusion rates of TEDs and BRDs, indicating that Large Sponges are likely to be excluded reasonably quickly having little chance to block the TED and affect exclusion rates of other species.

Although most Large Sponges are excluded by TEDs, the unresolved significant issues with this bycatch group are:

1. That small species of sponges are likely to pass through the bars of TEDs and consequently be poorly excluded (although not measured in this study); and
2. Little is known of the fate of the sponges that are excluded.

These species are usually attached to the substrate and filter feed on particulate organic matter and small plankton. It is not known whether sponges can survive their removal and immediate dumping back onto the sea bed. The potential impact of dislodging both the small and large sponge species on the demersal communities of the NPF is also unknown. There may also be little difference between returning a dislodged sponge to the seabed via TED exclusion or via a short stint on the trawler deck after being taken in the catch, although the difference in impact is likely to be greater for other species that have a commensal relationship with the sponge.

Table 10-16. Sample sizes used for analyzing the performance of TEDs and BRDs on catches of Large Sponges (>30 cm) in the NPF. The number of nets represents the number of individual nets from paired trawl comparisons that were analysed; the sample size (n) describes the total number of sponges caught in paired trawl comparisons. 'TED net' refers to any net with a TED (either TED+BRD or TED only).

Catch group	Total No. nets	Sample size (n)	No. nets per treatment			
			TED+BRD	TED net	BRD only	Standard net
Large Sponges	678	1923	150	242	97	339
			Upward TED	Downward TED		
			127	115		

Table 10-17. Percentage change in catches and significance levels for large sponges to assess the performance of TEDs and BRDs during the 2001 tiger prawn season in the NPF. The values are based on differences between catches in the net with the TED and/or BRD compared to a Standard net with no TED or BRD. Negative values = lower catches than a Standard net and positive values, larger catches. ns = no significant difference between comparisons; significance levels: * = $p<0.05$; **= $p<0.01$; ***= $p<0.001$.

Catch group	TED+BRD	TED net	Upward TED	Downward TED	BRD only
Large Sponges	-85.3***	-86.3***	-81.6***	-95.9***	ns
Sponge, rocks and shells (2000)♠	-78.8***				

♠ Data from Chapter 8 – Garry Day on NPF vessels in the 2000 tiger prawn season

10.3.6 Turtles

David Milton and Don Heales

Introduction

Sea turtles are one of the most widely impacted groups of marine vertebrates throughout the world. Consequently, they have been the focus of much attention in trawl fisheries where they are caught and often drowned. In Australia, the impetus for bycatch reduction included public concern about catches of rare and endangered species such as turtles (Robins-Troeger *et al.,* 1995) and a ban on the import of prawns to the US from fisheries that did not use TED. Several studies in northern Australia have trialled different TEDs that have been modified from designs developed for the American and European shrimp trawl fisheries (Watson *et al.,* 1986). These studies have demonstrated that inclined grids such as TEDs can exclude almost all turtles during research or limited commercial trials (Robins-Troeger *et al.,* 1995; Campbell, 1998, 1999; Brewer *et al.,* 1998; Day 1998; Day and Eayrs, 2001). None of these studies have examined the performance of TEDs under prolonged commercial trawling situations that would experience the full range of trawling conditions. However, a FRDC study from 1998 to 2002 has monitored the catch of sea turtles in the NPF, before and after the adoption of TEDs (Robins *et al.,* 2003)

Methods

All turtles caught in trawls were removed from the vessel sorting tray as soon as practicable. Healthy, vigorous animals were identified, measured (curved carapace length in cm) and returned to the water immediately. Species were identified from the key in the AFMA Observer Manual (see Appendix 4). Weak or distressed animals were identified, measured and placed in a 'recovery' position. When the turtle began to show signs of recovery (sometimes > 1 h), such as rapid movement of the flippers, they were returned to the sea.

The methods used to collect the catch data are described in Chapter 9. Model 2, described in 10.2.5, was used to assess differences in Turtle catches between treatment and control nets.

The proportion of turtles in trawls without a TED was compared to trawls with a TED by Fisher's Exact test.

Results

A total of 1240 trawls were checked for turtles and specimens were recorded during 6.8% of all trawl comparisons. A total of 84 turtles were recorded from 84 separate paired trawl comparisons (Table 10-18). No turtles were caught in nets with a TED + BRD gear combination (n = 643 trawls), and only one was caught in a net with a TED only (n = 407 trawls). In this case, a juvenile Flatback turtle (*Natator depressa* - 28 cm carapace length) was entangled in the net just ahead of the TED and released alive. The data suggests that TEDs are very effective and exclude 99%-100% of turtles from prawn trawl nets with TEDs and BRDs installed. The difference in the overall catch of turtles between TED and Standard nets was highly significant ($p<0.001$, Table 10.19).

A similar result was obtained by Robins *et al*., (2003). The study, based on 2821 fisher and Observer reporting days, estimated that sea turtle catch has fallen to around 120 individuals per year for the whole fleet. This is equivalent to a reduction of 95% from the estimated annual catch of around 5000 individuals in the years immediately before the adoption of TEDs.

Of the species identified, Olive Ridley (*Lepidochelys olivacea*) was the most commonly caught turtle species, followed by Flatback turtles (Table 10-20). Robins *et al*., (2003) reported a slightly different species composition of 60% Flatback turtles, 29% Olive Ridley turtles, and 11% of the other three species.

Discussion

All types of TEDs that were examined were extremely effective at excluding turtles. This is not surprising as there are a number of TEDs that have been effective at excluding turtles in certain fishing situations (Robins-Troeger *et al.,* 1995; Brewer *et al.,* 1997; Day, 1998; Campbell, 1998, 1999; Day and Eayrs, 2001; Table 10-21). This study extends the comparison across a range of TEDs and vessels, where the rigging of these devices vary. The results also demonstrate that they perform well in a range of different regions and under a variety of weather conditions. Turtles were excluded by all inclined grid devices and our data clearly demonstrate that they are very effective for these large animals.

Turtles have a hard carapace and are strong and vigorous swimmers and probably contribute to the damage to target species of prawns by large bycatch (Brewer *et al.,* 1998; Salini *et al.,* 2000; Day and Eayrs, 2001). Their effective exclusion is probably a significant contributor to the demonstrated reduction on soft and damaged prawns found by Salini *et al*., (2000) and Day and Eayrs (2001), and reported in 10.3.1. Given that all TEDs examined excluded turtles, including more than 10 different types of hard grids, future improvements to their performance can focus on reducing the catch of other bycatch groups or minimising prawn loss.

For turtle populations in northern Australia, prawn trawling is now an insignificant source of mortality (Table 10-19, 10-21). In 1989-90, Poiner and Harris (1996) estimated that 10 – 18% of 5000 to 6000 turtles caught in prawn trawls drowned and another 50% were damaged or in poor condition when landed. In recent years, but before the routine adoption of TEDs, total turtle catches were estimated to be around 5000 per year (Robins *et al.,* 2003). In addition sea turtle mortality rate due to NPF trawling operations was estimated at about 22%. This is assumed to be as a result of improved handling procedures publicised by Australian Fisheries Management Authority logbook officers and adopted by NPF fishers.

With the current range of TED devices in use, this level of undesirable impact reduces to less than 0.5% of the turtles previously caught. The incidence of capture in non-TED nets during this study was similar to that found by Poiner and Harris (1996) – 0.056 vs 0.051 turtles per trawl > 3 hrs. At the same time, the overall level of fishing effort has been reduced to about half that undertaken in 1989 – 90 (~100,000 trawls per year) to about 50,000 trawls, and the incidence of capture now 0.0006 per trawl > 3 hrs. Based on these data, the number of turtles caught by the entire fleet in 2002 would only be 30 turtles and of these, 3 – 5 are likely to drown and up to another 15 would be expected to suffer some other adverse effects.

Table 10-18. Sample sizes used for analysing the performance of TEDs and BRDs on catches of turtles in the NPF. The number of nets represents the number of individual nets from paired trawl comparisons that were analysed; the sample size (n) describes the total number of turtles caught in paired trawl comparisons. 'TED net' refers to any net with a TED (either TED+BRD or TED only).

Catch group	Total No. nets	Sample size (n)	No. nets per treatment			
			TED+BRD	TED net	BRD only	Standard net
Turtles	168	84	33	67	17	84
			Upward TED	Downward TED		
			22	45		

Table 10-19. Percentage change in catches and significance levels for Turtles to assess the performance of TEDs and BRDs during the 2001 tiger prawn season in the NPF. The values are based on differences between catches in the net with the TED and/or BRD compared to a Standard net with no TED or BRD. 'TED net' refers to any net with a TED (either TED+BRD or TED only). Negative values = lower catches than a Standard net. ns = no significant difference between comparisons; significance levels: ***=p<0.001.

Catch group	TED+BRD	TED net	Upward TED	Downward TED	BRD only
Turtles	-100.0***	-99.0***	-99.0***	-100.0***	ns
Turtles (from 2000)♠	-100.0***				

***The significance level is representative of the overall analyses

♠ Data from Chapter 8 – Garry Day on NPF vessels in the 2000 tiger prawn season

Table 10-20. The mean length of each species of turtle caught in the different gear configurations examined in the study. The number of nets sampled within each gear type (N) are shown in parentheses. n = number of turtles.

Gear type	Species	Carapace length (cm)	n
Standard net (N = 84)	Loggerhead (*Caretta caretta*)	84.0 ± 4.8	3
	Green (*Chelonia mydas*)	56.0 ± -	2
	Olive Ridley (*Lepidochelys olivacea*)	65.4 ± 2.6	23
	Flatback (*Natator depressa*)	75.1 ± 3.9	12
	Unidentified species	71.3 ± 2.3	33
BRD only (N = 17)	Loggerhead	74.0 ± -	1
	Olive Ridley	65.0 ± 5.1	4
	Flatback	27.0 ± -	1
	Unidentified species	76.2 ± 4.6	4
TED + BRD net (N=33)			-
TED only (N = 34)	Flatback	28.0 ± -	1
			84

Table 10-21. Comparison of the exclusion rates of turtles from studies in northern Australia measuring the impact of TEDs.

Study	Control net	TED net	Exclusion
This study (NPF Observers 2001)	84	1	99%
This study (Day and Eayrs, 2001)	6	0	100%
Brewer *et al.,* (1997)	11	0	100%
Robins *et al.,* (2000)	14	2	87.5%

Figure 10-8. Flatback Turtle, *Natator depressa*

10.3.7 Sea snakes

David Milton and Gary Fry

Introduction

Sea snakes are air-breathing reptiles that feed on bottom-dwelling fishes such as gobies and eels (Fry *et al.,* 2001). They have a life history similar to sharks and rays: all species are fairly long-lived (up to 11 yrs) (Ward, 2001), they have few, live young each year and are thus unlikely to be able to sustain much additional mortality from fishing. Most species are active mainly during the day, when they hunt for prey living in burrows and around rocks and reefs (Greer, 1997). Thus, many species of sea snake occur in higher abundance in structured habitats. These habitats are not normally trawled and so prawn trawlers are probably not catching species that occur in these habitats in proportion to their abundance. However, some species like *Hydrophis elegans* (Elegant sea snake) and *Disteira major* (Olive-headed sea snake) prefer habitats similar to prawns and are more likely to have a higher catch rate in prawn trawls (Ward, 2000). Consequently, sea snakes have received attention recently because their life cycle suggests they are potentially vulnerable to trawl impacts (Milton, 2001).

Sea snake catch rates in the Northern Prawn Fishery prior to the introduction of TEDs and BRDs were about one snake per three-hour trawl. (Stobutzki *et al.,* 2000). Of those caught, about half survived the effect of trawling when they were returned to the sea (Wassenberg *et al.,* 2001). These recent estimates of catch rates are much lower than that found in 1989 by Ward (2000), when the catch rate was about one snake per hour. However, since the study of Ward, the fishery has undergone major changes in their fishing patterns and has seen several reductions in the size of the fleet. Thus the catch rates calculated by Stobutzki *et al.,* (2000) are not comparable with the data from Ward because in the changes in effective fishing effort (Bishop *et al.,* 2002). The estimated declines in the catch rate may have been due to several factors besides a real decline in sea snake abundance, including different trawling patterns, different distribution of fishing intensity or a real impact of trawling.

Brewer *et al.,* (1998) compared four TED and three BRD types, including those now commonly used in the NPF. They found that a Square-mesh panel BRD could reduce the catch of sea snakes by up to 50%. Of the TEDs examined, the AusTED showed the greatest reduction in sea snake catch. Most TEDs, by themselves, are unlikely to significantly improve sea snake escape as they are long, thin animals and able to easily pass between the bars in the TED.

Methods

Sea snakes in each net were separated after each trawl, in a similar fashion to other large bycatch groups such as sharks, rays and turtles (Model 2, described in 10.2.5). However, sea snakes were returned to CSIRO for identification, measurement of length, weight, sex and reproductive status. In the laboratory, snakes were dissected, stomachs removed and the number and weight of eggs and developing young from pregnant females were recorded.

Few individual sea snakes were caught in each trawl and counts of each species were analysed rather than weights. Trawls were only analysed where there was a paired comparison between a treatment and control net and a sea snake was caught in at least one of the two nets.

The analysis of sea snakes was constrained by the low catch frequency, similar to many of the other rarer large bycatch species. The number of sea snakes in each treatment net (TED+BRD, TED only and BRD only) were summed and compared to the count from the paired standard net from the same trawls by a Fishers exact test.

Results

A total of 1427 trawls were checked for Seasnakes and specimens were recorded during 30.3% of all trawl comparisons. A total of 774 Seasnakes, of 12 species were recorded from 432 separate paired trawl comparisons (Table 10-22, 10-23). The highest catches was 11 snakes in one trawl (two nets), and six Seasnakes from a single net. Individuals from many of these trawls (713 sea snakes) were used to examine morphological aspects of the different species of sea snakes. *Hydrophis elegans* was the most abundant species caught, followed by *Lapemis hardwickii* (Short sea snake) (Table 10-22).

The rarest species was *Hydrophis mcdowelli* (McDowell's sea snake), with only one snake caught in one trawl. Most sea snakes caught were sexually mature, with the exception of the Olive Sea snake *Aipysurus laevis* whose mean size (caught) were less than the size at maturity (Table 10-22).

Gear effects

A total of 432 trawls were used in paired comparison to examine the impact of TEDs and BRDs on catches of sea snakes. The number of sea snakes analysed in these comparisons was 774 animals (Table 10-23).

There was a small overall difference in sea snake numbers for the TED+BRD gear combination compared with the Standard net (Table 10-24). The estimated mean reduction from the Standard net was 5 %. There was also no impact on sea snake numbers due to TED only and BRD only nets (Table 10-24).

Both the Bigeye BRD and Square mesh panel BRD show a reduction in their catch of sea snakes compared with the standard net, but neither was statistically significant due to the small number of trawls (Tables 10-23 and 10-24).

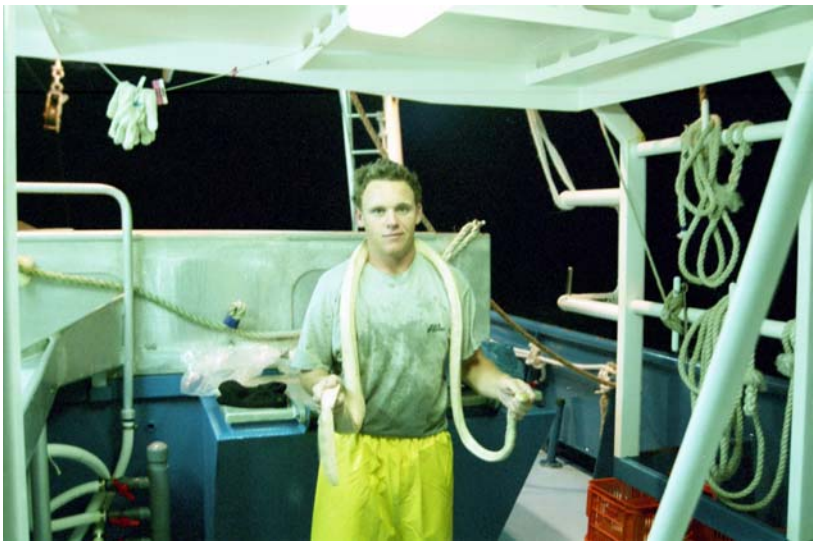


Figure 10-9. Live sea snakes make nice and interesting accessories too

Table 10-22. The number, mean snout-vent length ± standard error (mm) and mean weight ± se (in g) of males and females of each sea snake species caught by both experimental and calibration trawls during the study. (* Length at maturity data taken from Fry *et al.,* (2001)).

Species	Sex	Length at maturity (mm)*	Length ± se (mm)	Weight ± se (g)	N
Acalyptophis peronii	F	716	989 ± 35	681 ± 75	8
	M	890	1081 ± 27	886 ± 70	10
Aipysurus duboisii	F	910	970 ± 47	505 ± 101	3
	M	910	964 ± 22	473 ± 50	5
Aipysurus eydouxii	F	640	820 ± 22	501 ± 29	12
	M	472	669 ± 10	347 ± 14	11
Aipysurus laevis	F	1034	1010 ± 29	1573 ± 171	27
	M	1020	926 ± 18	908 ± 57	23
Astrotia stokesii	F	817	1143 ± 32	2134 ± 183	34
	M	720	1009 ± 20	1140 ± 93	27
Disteira kingii	F	823	1040 ± 180	228 ± 92	2
	M	1450	1225 ± 225	414 ± 185	2
Disteira major	F	710	1000 ± 15	642 ± 23	83
	M	840	974 ± 20	538 ± 24	41
Hydrophis elegans	F	1183	1672 ± 24	1403 ± 70	151
	M	890	1464 ± 15	862 ± 24	153
Hydrophis mcdowelli	F	635	710 ± -	215 ± -	1
Hydrophis ornatus	F	800	1050 ± 21	935 ± 61	21
	M	850	1085 ± 24	995 ± 53	32
Hydrophis pacificus	F	1410	1619 ± 28	1428 ± 70	21
	M	1410	1367 ± 52	924 ± 124	7
Lapemis hardwickii	F	677	902 ± 25	830 ± 48	56
	M	540	903 ± 11	824 ± 24	83

Table 10-23. Sample sizes used for analysing the performance of TEDs and BRDs on catches of Sea snakes in the NPF. The number of nets represents the number of individual nets from paired trawl comparisons that were analysed; the sample size (n) describes the total number of Sea snakes caught in paired trawl comparisons.

Catch group	Total No. nets	Sample size (n)	No. nets per treatment			
			TED+BRD	TED only	BRD only	Standard net
Sea snakes	864	774	214	172	46	432
					Big eye BRD	Square mesh panel BRD
					38	8

Table 10-24. Percentage change in catches and significance levels for Sea snakes to assess the performance of TEDs and BRDs during the 2001 tiger prawn season in the NPF. The values are based on differences between catches in the net with the TED and/or BRD compared to a Standard net with no TED or BRD. Negative values = lower catches than a Standard net and positive values, larger catches. ns = no significant difference between comparisons; significance levels: *=p<0.05.

Catch group	TED+BRD	TED only	BRD only	Square mesh panel BRD	Big eye BRD
Sea snakes	-5.0*	ns	ns	ns	ns

Discussion

The study has shown that the TEDs and BRDs used in the 2001 tiger prawn season did not reduce the catch rates of sea snakes. The number of sea snakes caught in a net with a TED and BRD was significantly lower than that of the Standard net, but the variation (5%) was only detectable due to the large number of trawls with snakes in them.

An earlier study by Brewer *et al.,* (1998) found that the Square-mesh panel BRD significantly reduced the catch of sea snakes. They found that the catch rate dropped from about one sea snake per two trawls to one sea snake per five (2-hr) trawls. They also obtained video footage of a sea snake escaping through the panel. The Square-mesh panel BRD was not widely used in the current study, but the number of trawls was similar to that of Brewer *et al.,* (1998) from Weipa, in north-eastern Gulf of Carpentaria. Catch rates from this study were similar or greater in the nets with a Square-mesh panel than even the Standard net catch of Brewer *et al.,* (1998). Sea snake catch rates vary widely between regions and this may contribute to the differences between the results of our study and that of Brewer *et al.,* (1998). It may be that the positioning of this BRD relative to the codend was not ideally suited to maximise sea snake escape. Clearly, more work is required if BRDs, including Square-mesh panels, are going to be effective at reducing the catch of sea snakes.

Two species, Pacific sea snake *Hydrophis pacificus* and Black-headed sea snake *Disteira kingii* were identified to be at highest risk compared to other species (Milton 2001). A significant improvement in the performance of BRDs may reduce the impact of the fishery on these species and consequently, provide a critical shift in the risk level for these species. Similar benefits of using BRDs effectively were described in Garcia-Caudillo *et al.,* (2000) where an 81% exclusion rate was achieved for an endangered Sciaenid fish (*Totoaba macdonaldii*) by using a RES BRD.

Recommendations from this study are described in Chapter 21.

10.4 References

AFFA 2003. Australian National Plan of Action for the Conservation and Management of Sharks, September 2003. Australian Government Department of Agriculture, Fisheries and Forestry. p94.

Blaber, S., Brewer, D., Burridge, C., Farmer, M., Milton, D., Salini, J., You-Gan Wang, Wassenberg, T., Buxton, C., Cartwright, I., Eayrs, S., Rawlinson, N., Buckworth, R., Gill, N., MacCartie, J., Mounsey, R., Ramm, D., 1997. Effects of Trawl Design on Bycatch and Benthos in Prawn and Finfish Fisheries. FRDC Project 93/179 Final Report. 190 p.

Brander, K., 1981. Disappearance of common skate *Raia batis* from Irish Sea. *Nature* 290, 48-49.

Branstetter, S. 1997. Bycatch and its reduction in the Gulf of Mexico and South Atlantic shrimp fisheries. Gulf and South Atlantic Fisheries Development Foundation, Inc. Florida USA.

Brewer, D.T., Eayrs, S.J., Rawlinson, N.J.F., Salini, J.P., Farmer, M., Blaber, S.J.M., Ramm, D.C., Cartwright, I., Poiner, I.R. 1997. Recent advancements in environmentally friendly trawl gear research in Australia. In: Hancock, D. A., Smith, D. C., Grant, A. and Beumer, J. P. (Eds.) Developing and sustaining world fisheries resources: the state of science and management: 2nd World Fisheries Congress Proceedings, 1996. Brisbane. Qld. pp 501-507

Brewer, D.T., Rawlinson, N., Eayrs, S., Burridge, C., 1998. An assessment of bycatch reduction devices in a tropical Australian prawn trawl fishery. *Fish. Res.* 36, 195-215.

Broadhurst, M.K., Kennelly, S.J., 1996. Effects of the circumference of codends and a new design of square-mesh panel in reducing unwanted by-catch in the New South Wales oceanic prawn-trawl fishery, Australia. *Fish. Res.* 27, 203-214.

Broadhurst, M.K., Kennelly, S.J., O'Doherty, G., 1996. Effects of square-mesh panels in codends and haulback delay on bycatch reduction in the oceanic prawn-trawl fishery of New South Wales, Australia. *Fish. Bull.* 94, 412-422.

Campbell, M., 1998. Industry trials of TEDs in the Northern Prawn Fishery. *Prof. Fish.* 19, 12-14.

Campbell, M., 1999. Another year of TED and BRD tests in the Northern Prawn Fishery. *Prof. Fish.* 20, 18-20.

Casey, J.M., Myers, R.A., 1998. Near extinction of a large, widely distributed fish. *Science* 281, 690-691.

Courtney, A.J., Campbell, M., 2002. Research results on the effects of bycatch reduction devices in the eastern king prawn fishery. *Qld. Fish.* 20(6), 20-23.

Courtney, A.J., Campbell, M., 2003 (a). Square mesh BRDs show good results. *Qld. Fish.* 21(1), 32-35.

Courtney, A.J., Campbell, M. 2003 (b). Square mesh BRDs show good results. *Prof. Fish.* 25(4), 12-16.

Day, G., 1998. Prawn industry continues to test BRDs in northern Australia. *Prof. Fish.* 19, 18-22.

Day, G., Eayrs, S., 2001. NPF operators make gains in bycatch reduction…but some problems remain! *Prof. Fish.* 23, 18-19.

Dunning, M., McKinnon, S., Lu, C.C., Yeatman, J., Cameron, D., 1994. Demersal cephalopods of the Gulf of Carpentaria, Australia. *Aust. J Mar. Freshw. Res.* 45 (3), 351-374.

FAO (United Nations Food and Agriculture Organisation), 2002 FAO Statistical Database http://apps.fao.org/default.htm.

Fry, G.C., Milton, D.A., Wassenberg, T.J., 2001. The reproductive biology and diet of sea snake bycatch of prawn trawling in northern Australia: characteristics important for assessing the impacts on populations. *Pac. Conserv. Biol.* 7, 55-73.

Garcia-Caudillo, J.M., Cisneros-Mata, M.A., Balmori-Ramirez, A. 2000. Performance of a bycatch reduction device in the shrimp fishery of the Gulf of California, Mexico. *Biological Conservation* 92(2), 199-205

Greer, A.E., 1997. The biology and evolution of Australian snakes. Surrey Beatty and Sons, Sydney. 358 p.

IPOA-Sharks., 1999. International Plan of Action for the Conservation and Management of Sharks. www.fao.org/fi/ipa/manage.asp. FAO.

IUCN (International Union for the Conservation of Nature), 2002. 2002 IUCN Red List of Threatened Species. http://www.redlist.org.

Last, P.R., Stevens, J.D., 1994. Sharks and rays of Australia. CSIRO Publishing, Australia, 513 p.

Miller, R.B., Willis, T.J., 1999. Estimating the relative density of snapper in and around a marine reserve using a log-linear mixed-effects model. *Austral. & New Zealand J. Statist.* 41(4), 383-394.

Milton, D.A., 2001. Assessing the susceptibility to fishing of populations of rare trawl bycatch: sea snakes caught by Australia's Northern Prawn Fishery. *Biol. Conserv.* 101, 281-290.

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

Perdrau, M.G., Garvey, J.R., 2003. Northern Prawn Fishery Data Summary 2002. Logbook Program, Australian Fisheries Management Authority, Canberra.

Poiner, I.R., Harris, A.N.M., 1996. Incidental capture, direct mortality and delayed mortality of sea turtles in Australia's Northern Prawn Fishery. *Mar. Biol.* 125, 813-825.

Robins, C.M., Goodspeed, A.M., Poiner, I., Harch, B.D., 2003. Monitoring the catch of turtles in the Northern Prawn Fishery. Fisheries Research and Development Corporation Final Report, Canberra.

Robins-Troeger, J.B., Buckworth, R.C., Dredge, M.C.L., 1995. Development of a trawl efficiency device (TED) for Australian prawn fisheries. II. Field evaluations of the AusTED. *Fish. Res.* 22, 107-117.

Robins, J., Eayrs, S., Campbell, M., Day, G., McGilvray, J., 2000. Commercialisation of bycatch reduction strategies and devices within northern Australian prawn trawl fisheries. Queensland Department of Primary Industries Report No QO00006. 40 p.

Salini, J.P., Brewer, D.T., Farmer, M., Rawlinson, N., 2000. Assessment and benefit of damage reduction in prawns due to use of different bycatch reduction devices in the Gulf of Carpentaria, Australia. *Fish. Res.* 45, 1-8.

SAS, 2001. Proc GENMOD. V 8.2. SAS Institute, Inc. Cary, North Carolina.

Sharp, A., Bishop, J., Harris D., 1999. Northern Prawn Fishery and Kimberley Prawn Fishery Data Summary 1998. Australian Fisheries Management Authority. Canberra Australia.

Simpfendorfer, C.A., 2000. Predicting population recovery rates for endangered western Atlantic sawfishes using demographic analysis. *Environ. Biol. Fish.* 58, 371-377.

Steele, P.B., Theresa. M., Johnston, Kristine H., Levett, S. 2002. Efficiency of bycatch reduction devices in small otter trawls used in the Florida shrimp fishery. *Fishery Bulletin* 100 (2), 338-350.

Stevens, J.D., Bonfil, R., Dulvy, N.K., Walker, P.A., 2000. The effects of fishing on sharks, rays, and chimaeras (chondrichthyans), and the implications for marine ecosystems. *ICES J. Mar. Sci.* 57(3), 476-494.

Stobutzki, I., Blaber, S., Brewer, D., Fry, G., Heales, D., Miller, M., Milton, D., Salini, J., Van der Velde, T., Wassenberg, T., Jones, P., Wang, Y., Dredge, M., Courtney, T., Chilcott, K., Eayrs, S. 2000. Ecological sustainability of bycatch and biodiversity in prawn trawl fisheries. FRDC Final Report 96/257 - 512pp.

Stobutzki, I., Farmer, M., and Brewer, D., 2001 (a). Sustainability of fisheries bycatch: a process for assessing highly diverse and numerous bycatch. *Env. Cons.* 28, 167-181.

Stobutzki, I.C., Miller, M.J., Jones, P., Salini, J.P., 2001 (b). Bycatch diversity and variation in a tropical Australian penaeid fishery; the implications for monitoring. *Fish. Res.* 53(3), 283-301.

Stobutzki, I.C., Miller, M.J., Heales, D.S., Brewer, D.T., 2002. Sustainability of elasmobranchs caught as bycatch in a tropical prawn (shrimp) trawl fishery. *Fish. Bull.* 100, 800-821.

Ward, T.M., 2000. Factors affecting the catch rates and relative abundance of sea snakes in the by-catch of trawlers targeting tiger and endeavour prawns on the northern Australian continental shelf. *Mar. Freshw. Res.* 51, 155-164.

Ward, T.M., 2001. Age structures and reproductive patterns of two species of sea snake, Lapemis hardwickii (Grey 1836) and Hydrophis elegans (Grey 1842), incidentally captured by prawn trawlers in northern Australia. *Marine and Freshwater Research.* 52, 193-203.

Wassenberg, T.J., Milton, D.A., Burridge, C., 2001. Survival rates of sea snakes caught by demersal trawlers in northern and eastern Australia. *Biol. Conserv.* 100, 271-280.

Watson, J.W., Mitchell, J.F., Shah, A.K., 1986. Trawling efficiency device: a new concept for selective shrimp trawling gear. *Mar. Fish. Rev.* 48, 1-9.

Watson, J., Workman, I., Foster, D., Taylor, C., Shah, A., Barbour, J., Hataway, D. 1993. Status Report on the Development of Gear Modifications to Reduce Finfish Bycatch in Shrimp Trawls in the Southeastern United States 1990-1992. NOAA Technical Memorandum, NMFS - SEFSC - 327, 131 p.

Yearsley, G.K., Last, P.R., Ward, R.D., 1999. Australian seafood handbook: an identification guide to domestic species. CSIRO Marine Research, Australia. 461 pp.

CHAPTER 11

ASSESSING ECONOMIC COSTS AND BENEFITS

Chapter Author:

Sevaly Sen

CHAPTER 11

CHAPTER 11

ASSESSING ECONOMIC COSTS AND BENEFITS

Sevaly Sen

Summary

An economic analysis was carried out to determine whether there is a net benefit or net economic loss from the use of TEDs and BRDs. The annual net gain or loss to the NPF fleet was calculated based on 2003 average prices of tiger and endeavour prawns and 2002 catches. The main impact of the use of TEDs and BRDs was a reduction in total prawn catch (a loss) and a decrease in the proportion of the catch which was damaged (a gain). The use of TEDs and BRDs had no discernible economic impact on the operating costs of the vessel such as fuel consumption, labour costs and gear wear and tear.

The economic analysis shows that overall, the use of a combined TED and BRD will result in an annual estimated loss of $2.4 million to the fleet, based on average 2003 tiger and endeavour prawn prices and the results of the 2001 Observer Program results. With 95 vessels currently operating in the fishery, this amounts to an annual cost per vessel of just over $25,000/year. However, estimates of cost/vessel should be treated with some caution as they may not accurately reflect any differing impacts of TEDs and BRDs by vessel size – data which was unable to be collected. These values would be approximately halved if Garry Day's Observer results were used (representing more experienced use of TEDs and BRDs).

11.1 Introduction

An economic analysis has been carried out to determine whether there is a net benefit or net economic loss from the use of TEDs and BRDs. It was carried out only on the statistically significant trials (for previous analysis see Chapter 10), namely:

- a net with a TED and BRD fitted compared to a standard net;
- a net with a TED only fitted compared to a standard net;
- a net with a BRD only fitted compared to a standard net; and
- a net with an upward excluding TED fitted compared to a net with a downward excluding TED fitted.

11.2 Assumptions

In order to estimate the economic gains or losses of using a net fitted with a TED and/or a BRD compared to a standard net, the assumptions used, based on discussions with stakeholders, were:

1. Two TEDs and BRDs are purchased annually for each vessel at a cost of $1300 per net. This estimate was derived from:

    - The average cost to manufacture and install a TED in a net of around $1,200;

- The average cost to install a BRD in a net of around $70; and
- A further $600/year is required to replace the part of the codend where the TED is installed.

It is anticipated that replacement of TEDs and BRDs will be less frequent as operators become more familiar with their use

2. The economic analysis has been based on total tiger prawn and endeavour prawn catches in the NPF in 2002. Although it was compulsory for vessels to use both TEDs and BRDs in 2002, this analysis, for simplicity, assumes that 2002 catches have been taken only using standard nets. Impacts on catches of TEDs and BRDs were based on the results of the project trials and are shown in Table 11-1 and 11-2 (taken from Chapter 10).

3. There are currently 95 vessels operating in the fishery (as at 14 May 2003, AFMA, pers. comm.).

4. The proportion of damaged endeavour prawns and tiger prawns in a standard net ranged from 3 – 10%. The analysis has assumed an average of 7%.

Table 11-1. Percentage change in catches of commercially important species groups due to the impact of TED + BRD combination, TED only and BRD only. Results are taken from the Chapter 10. Negative values = lower catches than a standard net and positive values = larger catches than the standard net. ns = no significant difference between comparisons; significance levels: * = p<0.05; **=p<0.01; ***=p<0.001.

	TED + BRD	TED only	BRD only
Total prawns	-6.0 ***	-5.6 ***	-4.4 *
Tiger prawns	-6.5 ***	-6.7 ***	-3.8 *
Tigers - damaged	-41.6 ***	-55.1 ***	ns
Endeavours	-5.0 **	ns	ns
Endeavours - damaged	-40.9 **	-44.4 **	ns
Byproduct - Bugs	ns	ns	ns
Byproduct - Squid	ns	40.4 *	ns
Byproduct - Scallops	ns	ns	-

Table 11-2. Percentage change in catches of commercially important species groups due to the impact of upward and downward excluding TEDs. Results are taken from Chapter 10. Negative values = lower catches than a standard net .ns = no significant difference between comparisons; significance levels: * = p<0.05; **=p<0.01; ***=p<0.001.

	Upward TED	Downward TED
Total prawns	-3.1 (ns)	-5.7 *
Tiger prawns	-6.3 *	-6.3 *
Tigers - damaged	-35.8 **	-63.2 ***
Endeavours	ns	ns
Endeavours - damaged	ns	ns
Byproduct - Bugs	ns	ns
Byproduct – Squid	ns	ns
Byproduct - Scallops	-	ns

5. Prices kg^{-1} for prawns and byproduct fluctuate substantially throughout the season. This analysis uses an average price/kg as described in Table 11-3.

6. Estimation of the value of total catch losses from the use of TEDs and BRDs, was based on a weighted price calculated on the proportion of the catch which was undamaged and damaged (i.e. catch *(0.93*undamaged price) (0.07 * damaged price)).

Table 11-3. Average prices per kilogram of the commercially valuable species groups used in the economic analyses of using TEDs and BRDs in the NPF.

Species group	Price kg^{-1}
Tiger prawns	$18.00
Damaged tiger prawns	$10.00
Endeavour prawns	$11.50
Damaged endeavour prawns	$ 7.25
Squid	$ 5.00

7. Savings made in a reduction of damaged prawns were calculated on the difference between the damaged and undamaged average prices for each species.

8. All vessels in the NPF fleet are subject to the same percentage savings and losses that result from the use of TEDs/BRDs. However, it should be noted that most of the trials were carried out on vessels between 19 and 23 metres because certain vessel attributes were required to collect data consistently (see Chapter 9). Smaller vessels in the fleet were not sampled adequately due to limited deck and accommodation space and many of the larger vessels were not sampled because they used seawater hoppers, which meant that catches from each trawl net could not easily be kept separate.

9. Where changes in catches of byproduct were significant, they were included in the analysis.

11.3 Potential costs and benefits excluded from the economic analysis

There are a number of potential costs from the use of TEDs and BRDs which were initially thought to have a potential impact, but on further investigation were excluded (Table 11-4).

Table 11-4. Variables excluded from the benefit cost analysis.

Variable	Impact on vessel costs of using a TED and BRD
Fuel use (due to changes in net drag)	No discernible change (O'Brien, pers. comm. and Carter, pers. comm.)
Labour use	No change in vessel crew (O'Brien, pers. comm.; Carter, pers. comm.; and Lowe, pers. comm.)
Gear wear and tear	Although more maintenance was required, crews are onboard so a change in workload but no change in cost. (O'Brien, pers. comm.; Carter, pers. comm.; Lowe, pers. comm.)
Impacts of fishing time	No discernible change.

11.4 Economic analysis comparing the use of a TED and BRD installed in a net with a standard net

The annual net cost of using TEDs and BRDs to the NPF fleet is estimated to be $2.415 million, based on 2002 catches. The average annual cost per vessel is estimated to be $25,430 (Table 11-5).

Table 11-5. Economic analysis comparing a net with a TED and BRD installed with a standard net. mt = metric tonnes.

Total tiger catch without TED/ BRD	mt	2017
Total tiger catch using TED/BRD	mt	1,896
Actual loss of total tiger catch from using TED/ BRD	mt	121
Reduction in catch of damaged tigers	mt	59
Total endeavour catch without TED/BRD	mt	1,132
Total endeavour catch using TED/BRD	mt	1,075
Actual loss of total endeavour catch from using TED/ BRD	mt	57
Reduction in catch of damaged endeavours	mt	32
Costs		
Manufacture and installation of TEDs/BRDs	$	304,000
Costs of lost tiger catches	$	2,110,240
Costs of lost endeavour catches	$	609,615
Total costs	**$**	**3,023,855**
Benefits		
Savings from reduced damaged tiger catches	$	472,000
Savings from reduced damaged endeavour catches	$	136,000
Total benefits	**$**	**608,000**
Benefit/cost	**$**	**(2,415,855)**
Benefit/cost per vessel	**$**	**(25,430)**

11.5 Economic analysis comparing a net with a TED or BRD installed with a standard net

The annual net cost of using a TED by itself or a BRD by itself in a net compared to a standard net in the NPF fleet is estimated to be $2.4 million and $1.7 million, respectively (Table 11-6). Therefore, the average annual cost per vessel is $25,074 for TED-only nets and $17,564 for BRD-only nets.

Table 11-6. Economic analysis comparing the use of a TED-only and BRD-only with a standard net. mt = metric tonnes.

		TED only	BRD only
Total tiger catch without TED/ BRD	mt	2017	2017
Total tiger catch using TED/BRD	mt	1,882	1,940
Actual loss of total tiger catch from using TED / BRD	mt	135	77
Reduction in catch of damaged tigers	mt	44	51
Total endeavour catch without TED/BRD	mt	1,132	1,132
Total endeavour catch using TED/BRD	mt	1,132	1,132
Actual loss of total endeavour catch from using TED/ BRD		-	-
Reduction in catch of damaged endeavours	mt	24	-
Total squid catches without TED/BRD	mt	177	177
Total squid catches with TED/BRD	mt	249	177
Gain in squid catches with TED/BRD	mt	72	-
Costs			
Manufacture and installation of TEDs/BRDs	$	342,000	13,300
Costs of lost tiger catches	$	3,112,425	1,775,235
Costs of lost endeavour catches	$	-	-
Total costs	**$**	**3,454,425**	**1,788,535**

		TED only	BRD only
Benefits			
Savings from reduced damaged tiger catches	$	594,000	-
Savings from reduced damaged endeavour catches	$	120,000	120000
Increase in squid catch		360,000	-
Total benefits	**$**	**1,074,000**	**120,000**
Benefit/cost	**$**	**(2,380,425)**	**(1,668,535)**
Benefit/cost per vessel	**$**	**(25,057)**	**(17,564)**

11.6 Economic analysis comparing a net with an upward or downward excluding TED installed, with a standard net

The annual net cost of using upward or downward excluding TEDs in compared to a standard net to the NPF fleet is estimated to be $2.09 million and $1.8 million, respectively (Table 11-7). Therefore, the use of upward excluding TEDs would cost around $300,000 more than the use of downward excluding TEDs. Average annual costs per vessel are $22,020 for an upward excluding TED and $18,820 for a downward excluding TED.

Table 11-7. Economic analysis comparing the use of an upward or downward excluding TED with a standard net. mt = metric tonnes.

		Upward TED	Downward TED
Total tiger catch without TED	mt	2,017	2,017
Actual loss of total tiger catches from using TED	mt	127	127
Total tiger catches using TED	mt	1,890	1,890
Reduction in damaged tigers	mt	51	89
Costs			
Manufacture and installation of TEDs	$	285,000	285,000
Costs of lost tiger catches	$	2,214,880	2,214,880
Total costs	**$**	2,499,880	2,499,880
Benefits			
Savings from reduced damaged tiger catches	$	408,000	712,000
Total Benefits	**$**	**408,000**	**712,000**
Benefit/cost	**$**	**(2,091,880)**	**(1,787,880)**
Costs/vessel		**(22,020)**	**(18,820)**

11.7 Conclusion

The economic analysis shows that overall, the use of a combined TED and BRD will result in an annual estimated loss of $2.4 million to the fleet, based on average 2003 tiger and endeavour prawn prices. With 95 vessels currently operating in the fishery, this amounts to an annual cost per vessel of just over $25,000/year. These estimated losses are obviously sensitive to the price of prawns. An increase or a decrease in price will either increase or decrease estimated losses. However, estimates of cost/vessel should be treated with some caution as they may not accurately reflect any differing impacts of TEDs and BRDs by vessel size – data which was unable to be collected.

Finally, it may be reasonable to assume that NPF fishers ability to fine tune TEDs and BRDs has improved since 2001 when the 6% prawn loss was measure in the industry. The 3% prawn loss achieved by Garry Day during his time spent on NPF vessels (see Chapters 6 and 10) should be achievable throughout the fleet (as fishers gain experience with these devices) and may be achieved already, halving estimated economic losses.

CHAPTER 12

FACTORS INFLUENCING TED AND BRD PERFORMANCE

Chapter Authors:

Garry Day and Steve Eayrs

CHAPTER 12

CHAPTER 12

FACTORS INFLUENCING TED AND BRD PERFORMANCE

Garry Day and Steve Eayrs

Summary

Between 1996 and 2001 an Australian Maritime College Fishing Technologist, Garry Day, spent long periods of time on NPF vessels assisting with and assessing TED and BRD performance. The knowledge and expertise gained from this time provides a valuable resource to help fishers maximise the performance from TEDs and BRDs. The information was gathered during a time when the NPF was mainly concerned with TED performance.

The efficiency of a well designed and maintained TED should ensure that large animals are quickly excluded from the trawl and prawn loss is minimal or non-existent. However, operators have usually found that new TEDs perform well but that performance deteriorates with time. This is usually due to stretching or wear of various TED components during the fishing season and ineffective maintenance of the TED. In response to this fishers often excessively modify or over-tune their TED in the hope of minimising prawn loss. These modifications normally have the opposite effect because they slow the escape of large animals which in turn provides increased opportunity for prawns to escape between the escape cover and codend.

Maintaining TED efficiency involves a range of factors, many of which should be managed by fishing crews, including the following:

- TED size – having a large enough grid (in total area) to exclude most or all animals encountered in catches.
- TED shape – the shape of the TED can affect the size of the escape opening, the exclusion ability of the TED and wear and tear on the trawl net.
- Bar spacing – smaller bar spacing allows exclusion of more bycatch species, although unfounded concerns over increased prawn losses have prevented fishers using less than 100-120 mm bar spacing.
- Bent bars – these can improve the speed by which TEDs can exclude large animals encountered on the TED and reduce prawn loss.
- TED orientation – can be altered to target the exclusion of particular species groups. For example downward excluding TEDs are thought to be best suited to excluding heavy, negatively buoyant items such as large sponges or rocks.
- TED angle – incorrect TED angle can result in prawn loss or poor bycatch reduction. Downward excluding TEDs are best at 50-55º, and upward TEDs at 40-50º.
- Escape openings – larger escape openings are best for excluding larger animals, although there are issues with maintaining the shape and strength of the net for larger openings.
- Escape covers – there are many misconceptions about these devices. They should be made of depth-stretched or heat set netting; not be too narrow or too long, and not have weight or flotation added. They need to be replaced regularly.
- Guiding panels or funnels – they are easily blocked and are best used for fishing on ‘clean’ grounds. Canvas may also be considered as an alternative to netting.

Summary

- Other gear modifications that should be addressed to help maximise TED performance include flotation, backwash funnels and position of lazy lines.

With this knowledge operators should be in a better position to identify suitable TEDs for a particular fishing ground and bycatch species. This will also improve TED performance through improved troubleshooting ability and provide fishers greater confidence in overcoming any problems with these devices.

12.1 Introduction

The development, testing and implementation of TEDs and BRDs in the NPF commenced in earnest in 1993. Since then a large range of these devices have been tested during various research programs, and over the last five years a gear technologist (Garry Day) has been introducing these devices to operators. During this time significant headway was made on improving the performance of TEDs and BRDs under commercial operating conditions.

During Garry's time in the fleet operators were mainly interested in optimising TED efficiency in order to minimise the loss of prawns often associated with the use of these devices, reduce the impact of fishing on endangered turtle populations, and remove the U.S. embargo on prawn imports. As a result of these efforts and the involvement of operators in this fishery, a detailed knowledge of the operational factors that affect TED efficiency has been developed. In contrast, relatively little effort has been expended developing effective BRDs. Even though some operational information exists, it is mainly directed towards minimizing prawn loss instead of reducing bycatch.

This section describes the operational factors that affect TED efficiency and provides related information to trouble-shoot problems with these devices, particularly those that are sources of prawn loss. Importantly, this section suggests ways to remedy these problems, as well as ways to improve the ability of TEDs to reduce bycatch.

12.2 Factors influencing TED efficiency

The efficiency of a TED is measured by two main factors:

1. The ease with which it can exclude large animals, rocks and other debris; and
2. The retention of commercially important prawn catch when:

    a. an escape cover is fitted; or
    b. an escape cover is not fitted.

These factors are influenced by the design, construction and operation of the various components that comprise a TED (Figure 12-1) under the range of operating conditions experienced on the fishing ground. How these interact to influence TED efficiency is illustrated in Figure 12-2.

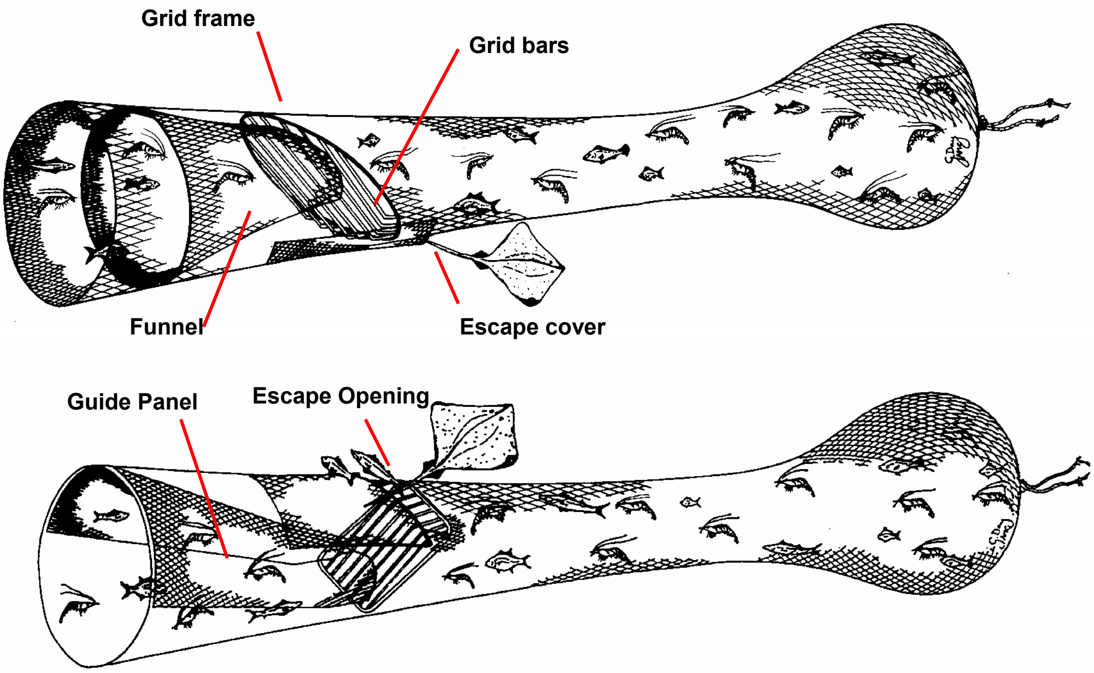


Figure 12-1 The various components typically incorporated in the design of a bottom excluding TED (top) and a top excluding TED (bottom).

12.2.1 Grid size (grid height and width)

Grid size relates to the total area of the grid that is available to filter large animals from the catch. All things being equal, a large grid is generally more effective in excluding large animals and retaining prawns than a small grid because it has a larger filtering area. For large grids fitted with an effective guiding panel or funnel, the catch passes through the grid and toward the codend at a relatively greater distance away from the escape opening; hence the chance of prawn loss is reduced. When describing grid size, net makers and operators often refer only to the height of the grid, but both grid height and width is important because they influence the overall grid area.

Grid height is one of the most important aspects of TED design. In addition to influencing grid size it also affects the angle of the grid and the sealing ability of the escape cover (or flap). There is a minimum effective grid height for any given codend size (circumference). This height is considered to be that required for the escape cover to seal snugly over the escape opening at a given grid angle. If grid height is inadequate the cover may flounder above the escape opening and not seal tightly (Figure 12-3). This will result in prawn loss through the escape opening. If grid height is greater than this minimum height, water pressure will hold the cover in contact with the grid resulting in a tight seal over the escape opening. As a general guide, when the grid is fitted at the desired angle it should distort the codend to a circumference greater than that without the TED (Figure 12-4). If a low grid angle is desired then the height of the grid should increase and vice versa. As a rough guide, the height of the grid should be no less than the diagonal distance between the top and bottom of the codend at the required angle of operation. For example, a 150 – 200 mesh round codend will have a working diameter of around 100cm. If a grid was to be fitted at an angle of 45° a grid with a height of at least 140cm should be used.

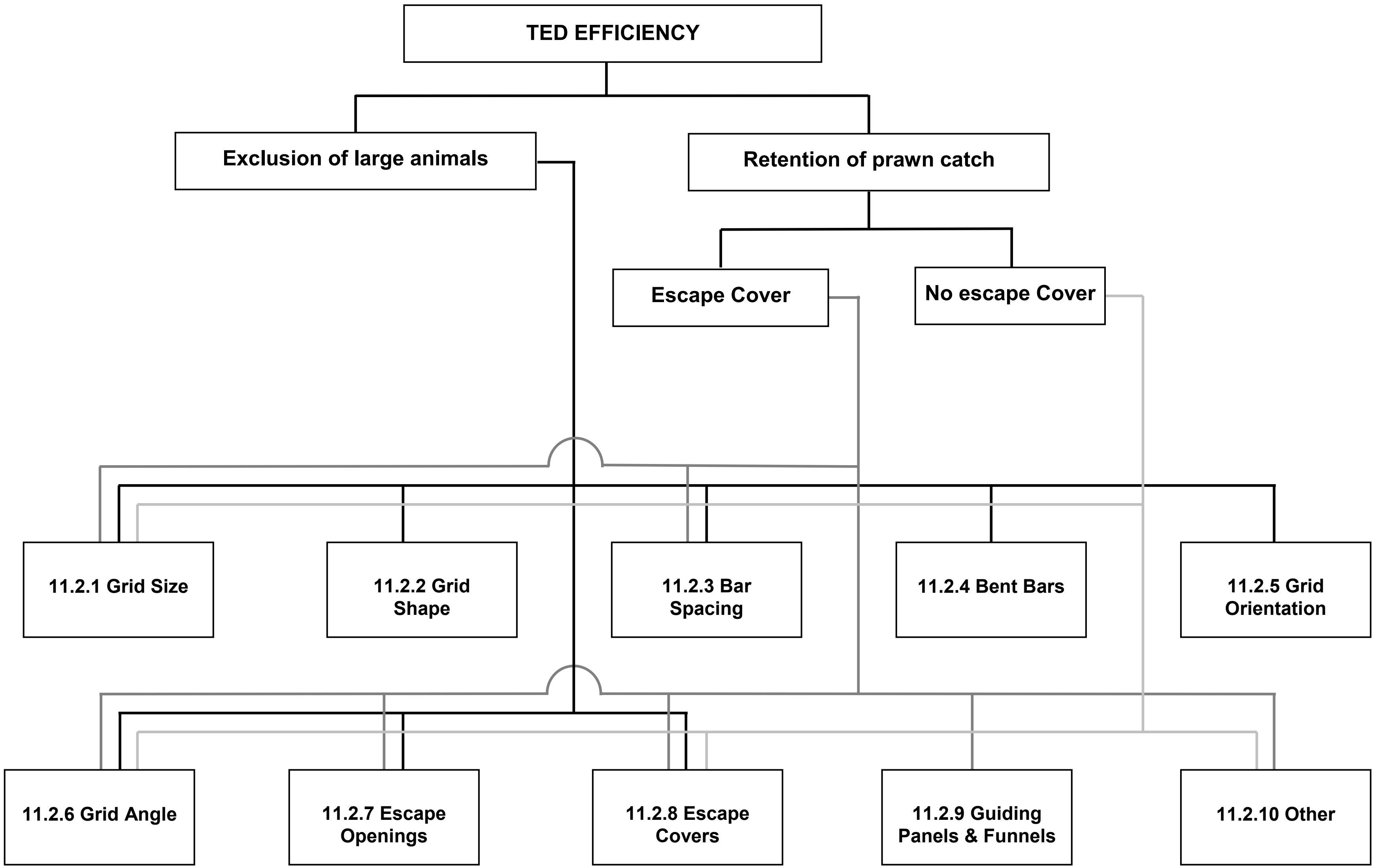


Figure 12-2. Relationship between the various design and construction parameters that effect TED performance.

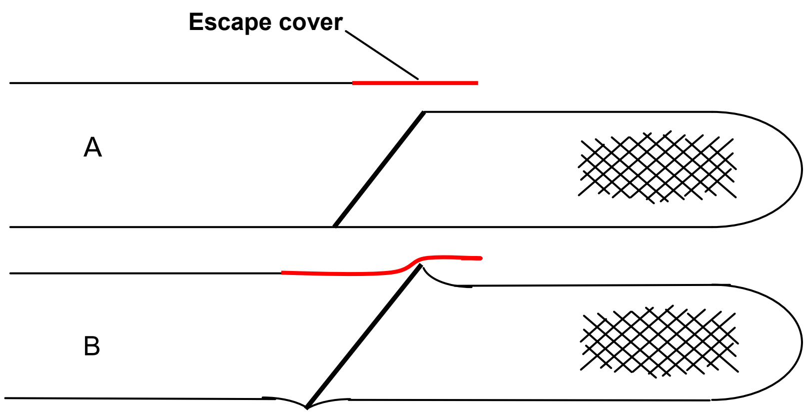


Figure 12-3. Effect of grid height on the ability of an escape cover (red) to seal tightly over the escape opening of identical codends at the same grid angle. A = short grid, B = high grid. Notice also how the size of the high grid stretches the shape of the codend and results in the escape cover fitting snugly over the opening.

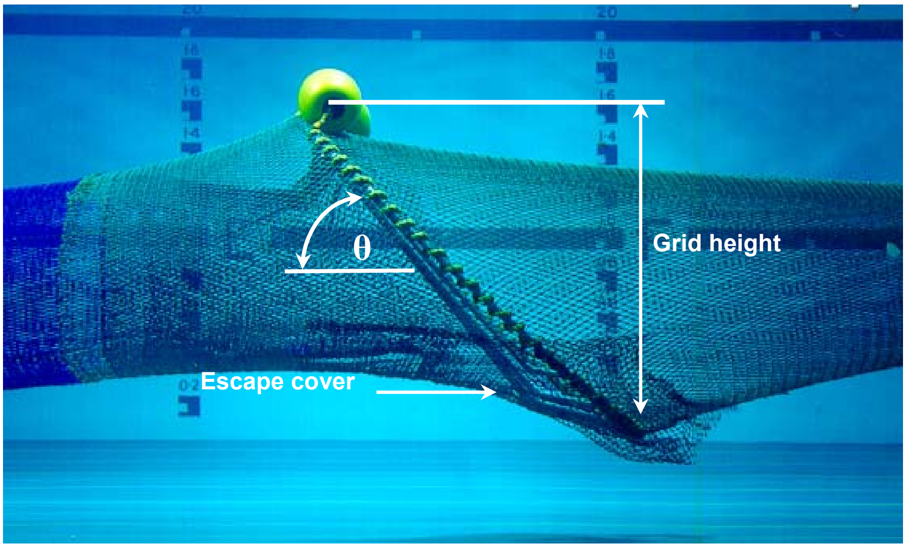


Figure 12-4. The Super shooter TED tested in the flume tank. The working or actual height of the grid is sufficient to distort the circumference of the codend so that the escape cover seals snugly against the TED and escape opening. Grid angle (θ) is the angle measured between the bars of the grid and the horizontal plane. Note the escape cover and its snug fit over the escape opening.

Operators and net makers typically refer to the height of a grid as the straight-line distance between the top and bottom edges of the grid frame. However, this is not the working or actual height of the grid during operation because it does not account for the angle of the grid in the net. The working height of the grid is therefore the vertical distance between the top and bottom edges of the grid frame during operation (see Figure 12-4). This height can be measured onboard the boat by lifting the codend vertically and measuring the distance between top and bottom edges of the frame.

Grid width is as important as grid height because it usually determines the size of the escape opening that can be cut into a codend. Generally the larger the escape opening the easier a large animal or object can be excluded from a TED, and the less prone it is to blocking and associated prawn loss. In the case of rectangular-shaped TEDs, the width of the escape opening is usually equivalent to the width of the grid frame. For oval-shaped TEDs, this opening is usually less than the maximum width of the frame. See 12.2.2 Grid shape for further details.

12.2.2 Grid shape

There are various shapes of grids used in the NPF, but the majority fit into one of three categories; rectangular, oval, or a combination of the two shapes. The latter is often referred to as a 'tombstone' shape.

The benefits of rectangular grids include simple construction and relatively large escape openings. The larger the escape opening, the easier a large animal can be excluded and the less prone the grid is to blockage. A blocked grid will prevent the passage of prawns into the codend and increase the possibility of their escape through the escape opening. The width of the escape opening is usually similar to the width of a rectangular grid (Figure 12-5). A major disadvantage of rectangular grids is the risk of netting abrasion at the corners of the grid due to contact with the seabed or the boat during deployment overboard and hauling. This can result in broken meshes and loss of grid angle, and in the worse case, reduced TED efficiency.

Figure 12-5. The AMC designed NAFTED shown here was a rectangular grid designed with a bar spacing of 60mm. Note that this version of the TED had no escape cover and the width of the escape opening was equivalent to the width of the grid.

Rounded, or oval, shaped grids better conform to the cross-sectional (circular) shape of the codend during the fishing operation, and they reduce the problem of net abrasion because any contact is spread over a greater area of the grid (Figure 12-6). Rounded grids can also increase the sealing ability of an escape cover. This is because the escape opening is cut partially down the sides of a rounded grid frame so that part of the grid protrudes above the escape opening. The escape cover then fits snugly against this raised section of grid in a similar fashion to that illustrated for a tall grid in Figure 12-3. A disadvantage of a rounded grid is that it may not allow as large an escape opening to be cut as for a similar sized rectangular grid, otherwise the escape opening will extend too far down the side of the codend.

Figure 12-6. Oval-shaped grids conform well to the shape of the codend during operation. Note that the escape opening extends part way down the sides of the grid frame.

Tombstone-shaped TEDs are a good compromise between rounded and rectangular TEDs. These TEDs were originally designed with the escape opening adjacent the square end of the grid frame. In this way the width of the escape opening is optimised without extending down the sides of the frame. This allows more codend meshes to support the grid and retards loss of grid angle due to stretched netting. Recently, an increasing number of fishers have used this TED with the escape opening adjacent to the opposing rounded end of the grid frame (Figure 12-7). This allows the escape cover to sit tightly against the rounded frame and prevent prawn loss.

Figure 12-7.

A tombstone shaped TED is a compromise between the rectangular- and oval-shaped grids. Note: the canvas section attached to the escape opening that is designed to assist the escape of animals from the trawl.

12.2.3 Bar spacing

The grid of a TED is usually constructed with an outer frame to which parallel bars are welded. These bars are spaced at intervals that allow large bycatch animals to be filtered from the prawn catch, and subsequently excluded from the trawl.

A TED with small bar spacing allows smaller animals and objects to be excluded from the trawl. There is some evidence that these TEDs more readily exclude large animals, in particular sponges, because they are less prone to becoming caught between the bars and have a greater surface area on which to slide towards the escape opening.

Legislation in the NPF prevents use of a grid with bar spacing greater than 120 mm. Most operators in this fishery use a bar spacing of 100 or 120 mm due to concerns for prawn loss using smaller bar spacing. However, bar spacing as low as 60 mm has been used with success in this fishery, particularly to exclude jellyfish. In relatively clean areas with few large bycatch animals present, larger bar spacing may be preferred so that large prawns can pass more easily into the codend.

12.2.4 Bent bars

The bars used to construct a grid can either be either flat or bent. Bent bars can assist the rapid removal of large objects, such as sponges, as they approach the escape opening. This is because on flat-bar grids, sponges and other heavy objects are prone to lodging against that part of a grid where the bars meet the outer frame of the grid. This can then block the passage of prawns into the codend and cause prawn loss through the escape opening. With bent-bar grids this problem is less likely to occur because the object is unable to lodge against the outer frame.

12.2.5 Grid orientation

Grid orientation refers to the direction in which a TED would guide or exclude a large animal from the trawl. The two most common grid orientations used in the NPF are bottom and top excluding TEDs. TEDs that incorporate grid inclines in both directions – known as pyramid TEDs - have been tested by some operators in the NPF with limited success (Figure 12-8).

The choice between the use of a bottom or top excluding TED often depends on the fishing grounds being trawled. The most effective exclusion of heavy objects (for example, rocks or debris), or animals with limited or no means of movement (for example, sponges), is expected from trawls using a bottom excluding TED. Top excluding TEDs are usually best suited for grounds where these animals or objects are seldom present.

If operators prefer a particular grid orientation they can make limited modifications to adapt them to exclude various animals or objects. For example, to improve the ability of both top and bottom excluding TEDs to exclude sponges and other heavy animals, the grid angle can be reduced. However, care must be taken that the angle is not so reduced that the escape cover no longer sits snugly over the escape opening. Canvas panels fitted immediately ahead of the grid can be used to reduce mesh fouling and facilitate the escape of large animals. To increase the escape of fish, the escape cover from a top-excluding TED could be removed to allow fish to freely swim from the trawl. Bar spacing could also be reduced to assist fish escape.

Figure 12-8. A pyramid TED with escape covers (black mesh) extending over both escape openings.

12.2.6 Grid angle

Grid angle is the angle measured from a line parallel to the codend extending to the bars of the grid (Figure 12-9). Grid angle is one of the most critical factors influencing TED efficiency and it is important to regularly check this angle. This is because the meshes attached to and adjacent the grid can become stretched and distorted over time. Moreover, the rope used to support and bind the TED frame to the codend may become loose, allowing the meshes greater potential to stretch.

If grid angle is too shallow, prawns can be lost through the escape opening due to the escape cover not sealing snugly against the escape opening (Figure 12-10). There will be a similar result if using a grid of inadequate height. If the angle is too high then large animals or objects may become lodged against the bars of the grid and block the passage of prawns into the codend. Operators in the NPF often refer to “steep” and “shallow” grid angles. A shallow angle would typically measure less than 40 degrees and a steep angle would measure 50 degrees or more.

Grid angle is easily checked by hanging the TED from the rigging using a lift (rope) tied around the throat of the codend (Figure 12-9). The TED will hang at the working angle of the grid and can then be measured using an angle meter. To measure the angle of bent-bar grids the angle of the bars is measured, not the frame. The range of grid angles that top and bottom excluding TEDs are typically set is different. As a general guide, bottom excluding TEDs can be set steeper (50 – 55°) than top excluding TEDs as objects tend to fall out easier under their own weight. Top excluders, on the other hand, may be set shallower (40 - 50°) to allow heavier objects to slide easily upward towards the escape hole. If a shallower angle is preferred for a top excluding TED, then grid height may need to increase (see 12.2.1 for details).

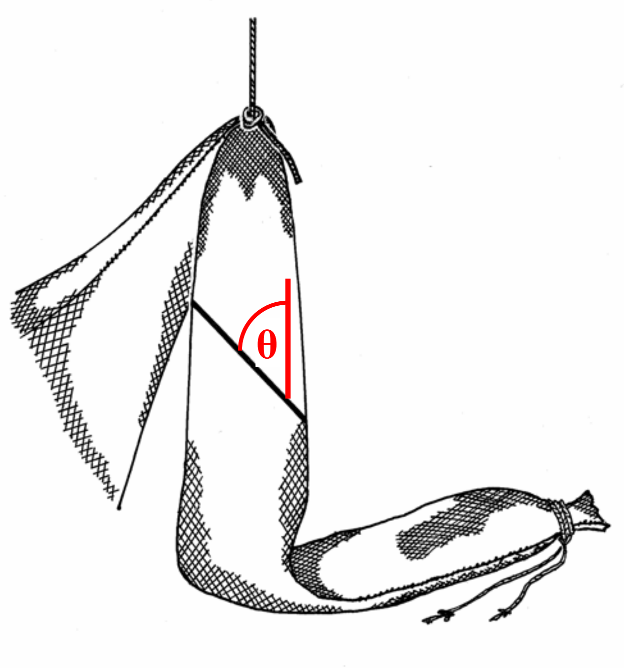


Figure 12-9. The angle (**θ**) of a grid fitted to a codend.

Figure 12-10. The grid on the left lost substantial amounts of prawn due to problems associated with a low grid angle (25°). The same grid (right) was re-hung at a greater angle (45 - 50°) and actually caught more prawn than a standard net. Note the poor contact of the escape cover (brown netting) with the grid at the low grid angle compared to the higher angle. Also note how the grid on the right expands the shape of the codend; this indicates an appropriate grid height for the set angle.

12.2.7 Escape openings

An escape opening is the hole cut into a TED directly ahead of the grid through which large animals are excluded from the trawl. As a general rule, the larger the escape opening the better a TED performs because large animals can be excluded quickly. If an escape opening is restricting the exclusion of large objects, the grid may become blocked and catch can be lost through the escape opening (Figure 12-11). It must be remembered that the width of a grid will ultimately determine the maximum width an escape hole can be cut into a TED.

Figure 12-11. Small escape openings can cause grid obstructions that often result in catch losses.

Another important consideration is that the larger the escape opening, the less netting there is to support the grid. If this netting stretches with use then the optimum grid angle may be lost. By selvedging the sides of escape openings with strong twine and adding a short belly rope to each side of the codend (extending about 1m either side of the grid), the grid is better supported to take the strain off the netting and prevent loss of grid angle. Cutting the sides of an escape opening on an all-bar taper can add more strength than if the sides were cut on all-points because they have less tendency to stretch. However, by doing this the escape opening has a triangular shape and the size of the escape may be too small. A good compromise is a combination of the two tapers to produce the desired size and shaped opening. One method to prevent stretched (or slipped meshes) around the escape opening this is to weld studs or eyelets at points on the outer frame of the grid to which the outer corners of the escape opening can be attached. Obviously care is required to prevent meshes becoming fouled on these attachment points.

12.2.8 Escape covers

Escape covers, or flaps, are sections of netting fitted over TED escape openings to prevent prawn loss. Escape covers are usually sewn to the codend at the leading edge of the escape opening and partially down each side while the trailing edge remains free. They are designed to operate much like a trap door, allowing only large animals and objects to move the cover aside and escape.

The knot orientation of an escape cover can be crucial to ensuring a snug fit and reduced prawn loss. The knots should be orientated so that water pressure forces the flap onto the escape opening when towing the net (Figures 12-12 & 12-4). When using TEDs with a large grid (and/or a rounded grid) knot orientation can be less critical as water pressure holds the cover against the bars of the grid (see Figure 12-3). However, it is still advisable to ensure knot orientation is correct.

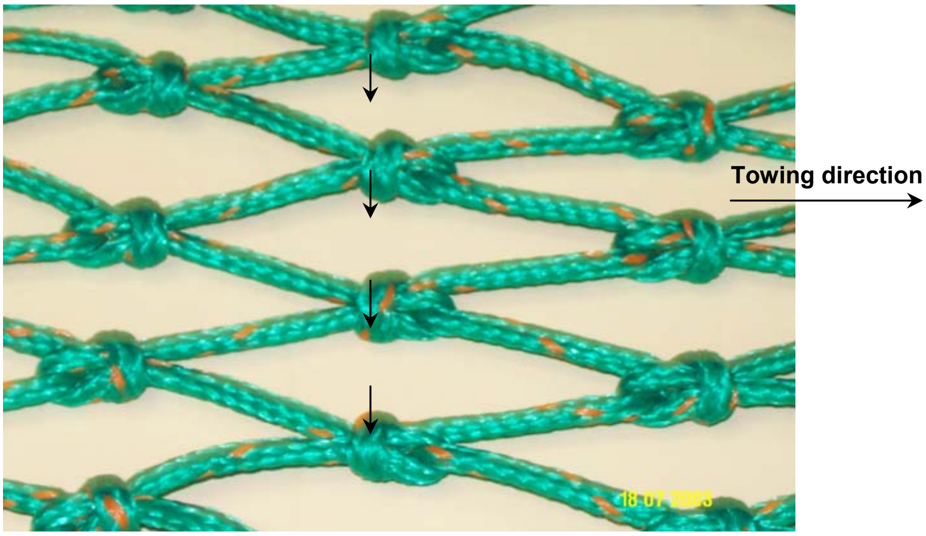


Figure 12-12. This sample of fish-trawl netting serves to highlight correct knot orientation. Note that if a panel of prawn netting is towed as indicated, water pressure on some of the knots will produce a downward force (indicated) sufficient to ensure an escape cover sits snugly over the escape opening. Water pressure on the remaining knots is insufficient to counter the downward force.

Escape covers tend to become stretched after prolonged use. The longevity of a cover largely depends on the number and size of large animals being excluded by the TED and how tightly it is attached to the codend. If fishing in areas with few large animals, escape covers will last longer because fewer animals are being excluded. The netting of old, stretched escape covers is less elastic than of new covers and will not seal as snugly, tending to flounder above the escape opening when under tow (Figure 12-13). Similarly, as the width of a cover increases through stretch, its length is reduced and its ability to effectively cover the escape opening may be compromised. A consistent problem is the use of escape covers that are sewn either tightly to the codend or too many meshes past the escape opening. This is usually done in response to fears of prawn loss, and usually retards or delays the escape of large animals from the trawl. As the animal struggles to escape the cover is pushed away from the escape opening for a longer period and the potential for massive prawn loss - commonly known as being 'TEDDed' – is a real possibility.

Figure 12-13. Both TEDs shown above are identical in construction, with the exception of the canvas section attached to the TED on the right. However, the TED on the right has lost grid angle and the escape cover is severely stretched (large gaping opening). Prawn loss was high from this TED and it requires substantial maintenance (i.e. re-set grid angle and replace escape cover). The TED on the left is new and ready for operation.

There are two options of prolonging the life of an escape flap. One option is choosing the most suitable material to construct escape flaps, such as depth-stretched, heat-set polyethylene prawn netting. This material has a high memory (spring/stretch action) and is less prone to stretch. Adding more meshes to the width of a flap can also help prevent the occurrence of excessive stretch. This will allow easier exclusion of large animals and objects and reduces the likelihood of the cover stretching. Escape covers sewn over an escape opening at a ratio of one cover-mesh to one codend-mesh are highly susceptible to stretch. Ideally the cover should be sewn to the codend using a ratio of no less than three cover meshes to two codend meshes, although a ratio of 2:1 has also been used successfully. Another advantage of wider covers is that the increased number of knots in the netting, if oriented correctly, can help seal the cover over the escape opening. Some operators from the Queensland east coast prawn fishery are using two escape covers that overlap along their length. This provides for greater coverage of the escape opening, particularly as animals escape from the trawl, and prevents the meshes from becoming stretched due to repeated exclusion of large animals.

It has often been considered that flaps can be extended in length and/or have weight or floatation added to help keep them closed over the escape hole. Through extensive testing, both locally and in the U.S., it has been found that flaps work best if kept to a length that extends no further than 6-10 meshes past the grid, with no weight or floatation added. Extra length can cause a cover to flap about during a tow and not seal efficiently. Similarly, adding weight or floatation (depending on grid orientation) can cause large animals and objects to block the grid and/or be excluded very slowly. In worst-case scenarios, the escape cover can be held open for long periods, resulting in large catch losses. The inclination, or perceived need, by fishers, to add weight, floatation or length to a flap to help it seal, is a general indication that there is a problem somewhere else with the TED. Usually incorrect grid angles, inadequately sized grid, incorrect knot orientation or excessively stretched flaps are responsible for such initial problems. It is recommended that these components are checked before modifying the flap.

12.2.9 Guiding panels and funnels

Guiding panels are sections of netting sewn into the codend to direct the catch away from the escape opening of the TED. As the name implies, funnels are tapered tubes designed to perform the same task as guiding funnels. Both of these components are fitted ahead of the grid and are critical in preventing catch loss from TEDs that use a short or no escape cover. When an effective escape cover is used, funnels have been removed from the TED with no loss of prawn catch.

Guide panels and funnels are most effective when fishing in clean grounds. In areas where high numbers of sponges and starfish are present, netting panels and funnels can become blocked with these animals. This may cause a build-up of catch ahead of the TED coinciding with the obvious risk of prawn loss. Other materials such as heavy canvas have proven to be a successful replacement for netting material. The advantage of canvas is that it provides a smooth surface over which sponges and other animals can pass easily towards the escape opening. The disadvantage of this material is that it does not stretch and can tear away from the codend if a sufficiently large animal enters the net. These torn panels have been known to cause substantial catch losses and must be carefully maintained.

12.2.10 Other

Secondary modifications available to operators that may make a substantial impact on TED efficiency include flotation, backwash funnels and lazy-lines.

Flotation

Floats are often attached to TEDs to compensate for the weight of the grid and provide stability when shooting the gear. The use of buoyant polyethylene netting and aluminium tubing to construct the TED negates the need for this additional buoyancy. However, stainless steel TEDs may require additional floatation to help counter their additional weight. Also, the bright colour of a float makes it relatively easy to see at night when the gear is streamed at the surface, and they make a useful reference point to check for a twisted codend and TED.

Floats should be attached to the upper half of the grid and inside the TED to prevent tangling with lazy-lines and hookups on rigging and gunwales. If they happen to come loose during a tow, they will also remain in the codend. Care should be taken to ensure that floats do not interfere with the escape cover, the passage of large animals from the trawl or the prawn catch from entering the codend. The amount of floatation required on a TED is easily estimated. Lower the TED into the water and add enough floats so that it is neutrally buoyant, neither floating nor sinking. Hard plastic floats are preferred over foam (expanded PVC) floats as they do not crush nor lose buoyancy if used in deeper waters greater than 25-30 m.

Backwash funnels

Backwash is a term used by NPF operators that refers to the forward movement of the catch arising from changes in trawl speed as the trawl is hauled from the seabed. Backwash funnels are cylindrical sections of netting fitted inside a codend aft of a TED or BRD. They are attached by their leading edge to the codend while the trailing edge remains free. While under constant trawl speed, the backwash funnel remains fully open allowing catch to enter the codend. When trawl speed slows, the funnel collapses and prevents forward movement of the catch in the codend, much like a non-return valve.

Backwash can also occur during sharp turns when the trawls are at the surface when targeting banana prawns. Similarly, large catches of banana prawns that fill codends may approach the escape opening of both TEDs and BRDs and substantial losses can occur without the installation of a backwash funnel.

Lazy-lines

Lazy-lines are ropes attached to the codend to enable them to be lifted onboard. There are two main methods of attaching lazy-lines to codends: ‘chokers’ or ‘lifting ears’. A choker is a loop in the end of a lazy-line that passes around the codend and ‘chokes’ the codend closed when pulled taught. Care should be taken when using choker lifts on codends because twists in the lazy-line rope, caused by winding the rope on a winch or capstan, can reduce the size of the loop around the codend and restrict catch from entering the codend. This will delay the passage of the catch into the codend and because the restriction is close to the escape opening, prawn loss may result. Lifting ears are pieces of netting sewn to the codend to which the lazy-line is then attached. Lifting ears usually do not ‘choke’ the codend closed and are therefore a preferred option for hauling the codend onboard.

Care must also be taken to ensure that the lazy-line is not too short. This may cause the TED to lay over on its side and may result in prawn loss.

12.3 “Over-tuning” and being 'TEDDed'

In the NPF the majority of catch loss observed has been related to the ‘over-tuning’ of TEDs. Over-tuning refers to excessive TED modifications made by operators in the mistaken belief that they will reduce or prevent prawn loss, and in particular incidences of massive prawn loss commonly referred to as being ‘TEDDed’. Examples of over-tuning including the use of excessive cover lengths, heavy weights attached to the trailing edge of an escape cover (Figure 12-12) or excessive flotation.

Catch loss typically arises from the poor design or operation of a TED in specific areas of the fishery. An example is the use of a top excluding TED with excessive grid angle in a location characterized by high numbers of sponges or other large animals. A well-tuned TED will rapidly exclude these animals from the trawl with minimal or no prawn loss. If these animals are not excluded quickly, they block or delay the passage of prawns into the codend, and the prawns could escape through the escape opening. If an escape cover is also being used, large animals will struggle to escape through the opening and increase the time that the cover is pushed aside. The potential for prawn loss is increased. In these instances, operators often incorrectly assume that making it more difficult for large animals to push the cover aside will lessen the loss of prawns. This leads to the use of excessive modification but instead of lessening the problem, has the reverse effect and exacerbates the problem.

The need to excessively modify a TED to retain the prawn catch is a general indication that there is a problem somewhere else with the TED. For example, if the escape cover is not sealing properly, then rather than add weight, grid angle may need to be increased or a larger grid used. Alternatively, the escape cover may be stretched and simply needs replacing.

It is important to note that while overtuning may actually solve the problem of prawn loss in clear grounds or areas with no large bycatch, when used in other regions prawn losses may be substantial. Prior to the catch results shown in Figure 12-15, the operator had overcome prawn loss in clean grounds from a small top excluding TED by adding weight to the trailing edge of the flap and increasing its length. However, when he moved to fishing grounds with high sponge numbers, prawn loss averaged 19% when compared to the standard net. Although the operator identified the initial problem as a poorly sealing escape cover, this was not the true cause of prawn loss. The grid was in fact too small and set at too low an angle (see Figure 12-10). This affected the ability of the escape cover to seal properly. The actual cause of the problem was identified and the grid re-rigged as a bottom excluder with a steeper grid angle of 55°.

Figure 12-14. This TED was losing substantial quantities of prawn when first installed by the crew. In an attempt to reduce this loss they lengthened the escape cover and added both chain and lead weights (right photo). These modifications only increased the problem of grid blockage with sponges, and prawn loss was further increased. The initial problem was not related to a poor escape flap, but to small a grid and a low grid angle (left photo). The grid was reinstalled at a higher angle by the author and an escape cover without weights was used extending only 6 meshes past the TED frame. Catch loss was eliminated and the incidence of grid blockage significantly reduced.

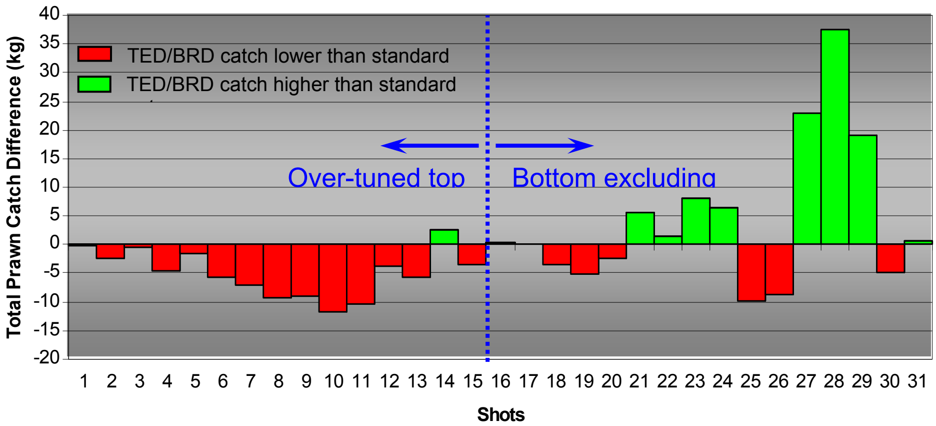


Figure 12-15. Difference in total prawn catch between a net fitted with a TED and BRD and a standard net (no TED or BRD). The dotted line indicates re-rigging of the TED and BRD net. Prior to this data, the operator had successfully overcome prawn losses in clean fishing grounds by modifying the escape flap. These modifications over-tuned the TED, which was not apparent until high sponge numbers were encountered, and prawn losses resulted (shots 1 – 15). The author identified the problem as incorrect grid size, angle and orientation and subsequently re-rigged the TED to a bottom excluding TED at a higher grid angle and removed the flap modifications. Catch losses were reduced and sponges were excluded successfully (shots 16 – 31).

The escape flap was replaced with new netting and no weights were used. The result was that sponges and heavy debris were excluded with relative ease. The higher grid angle allowed the escape cover to effectively seal over the escape opening and the prawn catch per shot was on average 1.4% greater than the standard net. This was an overall gain of over 20%.

Furthermore, because sponges were no longer a problem the catch of soft and broken tiger prawns was reduced by 13% in comparison to the over-tuned TED.

12.4 Conclusion

The efficiency of a well designed and maintained TED should ensure that large animals are quickly excluded from the trawl and prawn loss is minimal or non-existent. However, more often than not, operators have found that new TEDs perform well initially, but that performance deteriorates with time. This is usually due to stretching, or wear, of various TED components during the fishing season, and ineffective maintenance and overtuning of the TED. This section provides operators with a guide to maintaining TED efficiency, and options to avoid the problem of overtuning and associated prawn loss. With this knowledge operators should now be in a better position to identify suitable TEDs for a particular fishing ground and bycatch species, and to be able to successfully troubleshoot and remedy most of the problems associated with TED use in the NPF.

CHAPTER 13

AN INVESTIGATION INTO THE INFLUENCE OF THE SUPER-SHOOTER TED AND SEVERAL TYPES OF BYCATCH REDUCTION DEVICES ON WATER FLOW THROUGH A PRAWN TRAWL CODEND

Chapter Author:

John Wakeford

CHAPTER 13

CHAPTER 13

AN INVESTIGATION INTO THE INFLUENCE OF THE SUPER-SHOOTER TED AND SEVERAL TYPES OF BYCATCH REDUCTION DEVICES ON WATER FLOW THROUGH A PRAWN TRAWL CODEND

John Wakeford

Summary

A range of different Turtle Exclusion Devices (TEDs) and Bycatch Reduction Devices (BRDs) are currently used in Australian prawn trawl fisheries. It was argued that under certain environmental conditions some of these devices rely on water displacement as a primary motivator in guiding unwanted animals to escape openings. The Square-mesh window (SMW) and Fisheye (F/E) BRD were identified as two possible devices that could be enhanced through improved awareness of nearby water displacements. Measurement of water velocity in close proximity to these two devices and throughout the remainder of a codend containing a declined super-shooter (S/S) TED followed. Water velocity was measured using an electromagnetic log. The experiment was conducted in a flume tank with a full-scale codend and codend extension attached to a towing hoop. Findings included: F/E and SMW BRDs have quite different levels of flow disturbance when placed aft of a S/S TED in the upper panel; F/E BRD created a substantial wake that extended well downstream of the duct and resisted nearby water incursions; SMW BRD had negligible effect on codend shape and water flow; S/S TED caused quite a lot of disruption to the flow field, not so much because of the grid bars restricting water passage, but more so because of the oversize frame causing considerable netting expansion and constriction upstream and downstream of the grid respectively; flow disturbance associated with these BRDs seemed independent of catch amount in the codend, even though noticeable changes in velocity occurred elsewhere; catch induced water displacement was well aft of where the F/E or SMW currently reside (110 meshes anterior to end of codend) and consequently was unlikely to be of any benefit in the exclusion process. It was concluded that the SMW BRD in this position relies predominately on bycatch vision for escapement to occur, whereas the F/E offers additional stimuli in the form of velocity gradients and wake formation.

13.1 Introduction

Turtle Exclusion Devices (TEDs) and Bycatch Reduction Devices (BRDs) rely on non-voluntary and/or voluntary processes to expel unwanted animals from the confines of a trawl. With non-voluntary process, physical contact with netting or grid is required to direct animals to escape openings. Voluntary process, on the other hand, usually relies on a broader set of stimuli in order to create the desired result. In some circumstances, it has been shown, or can be deduced, that vision may play a minor role in this voluntary process, and that water displacement, for instance, may become a greater motivator.

Prawn trawling is conducted under a range of environmental conditions; shallow to deep water, night-time through daytime, clear to turbid water. Clearly there are going to be times where the visual range of animals entering a prawn trawl is going to be severely restricted. Under such circumstances, it may be more appropriate to use non-voluntary exclusion methods and incur the associated risk of injury to escapees, unless it can be demonstrated that the responsiveness of bycatch to water displacement and other stimuli (except tactile stimuli) can justify a voluntary approach. The paucity of data on water displacement fields around various types of TED/ BRDs has tended to stifle progress on this front to date. In the absence of this data though, progress has still been made by comparative gear trial methods (Brewer *et al.,* 1995) and by monitoring bycatch behaviour in clear water using underwater cameras or divers (Rogers *et al.,* 1997).

The influence of grid (grate) design and guiding funnel design on water displacement in a prawn trawl has been investigated (Riedel & DeAlteris, 1995). A noteworthy observation in regards to guiding funnels was that funnel configurations commonly used ahead of grids in prawn trawls have varying effect on gross movement of water through that section of the trawl. Previously there was some speculation that these funnels may cause water to be channelled towards the narrow end, giving rise to a localised increase in water flow in the region of the restriction, hence the term 'accelerator-funnel' being used. This report suggests that this is not always the case, and that the water approaching the netting actually passes through it, so the term 'guiding-funnel', which implies the funnel netting diverts objects by physical contact or presence, is the more appropriate term for these funnels under these circumstances. Similar studies on cones of netting have been undertaken with plankton nets (Hernroth, 1987; Tranter and Heron, 1967) and model mid-water trawls (Buxton and DeAlteris, 1993).

Another noteworthy observation in regards to grids/grates was that bar spacing and bar cross-sectional shape can influence water flow to the point where it is entrained behind the grid (Riedel and DeAlteris, 1995). In the case of Australian TEDs, the bar spacing is considerably greater (110mm compared to 32mm), despite rectangular sections being used, and one can speculate that the likelihood of observing entrainment downstream of say Northern Prawn Fishery (NPF) grids, is small.

The guiding funnel result reported by Riedel & DeAlteris (1995) also supported earlier work completed by Buxton & DeAlteris (1992) with model mid-water trawls. A field study where a speed log was inserted into a prawn trawl codend equipped with a Jones-Davis BRD also highlighted the ability of netting cones to disrupt water flow (Engaas *et al.,* 1999). In this instance there appeared to be a clear disturbance to the gross movement of water encountering the funnel. Lower water speeds posterior to the funnel walls, implied that some proportion of the water approaching the funnel was being diverted either inwards towards the longitudinal axis of the funnel, or outwards and leaving the trawl. Fish moving through the funnel were observed to quickly move outwards from this water jet as they left the funnel to take advantage of the water being drawn along behind the funnel at a closer speed to that of the trawl. Mention was also made in this report of water external to the codend extension being drawn along by the trawl, not to the same extent as that observed in the wings and underside of the trawl where netting incidence angle is higher, but drawn along nevertheless.

It would appear from the results of these two studies above that predicting water displacements around netting funnels located in the aft section of trawls in not a simple exercise. Differences in porosity and orientation of netting to the free stream may be the cause, although given the apparent similarity in guiding funnel properties used in these studies, it seems that some other influencing phenomena may be responsible. What we do know in regards to interaction between fluid and porous membranes is derived mainly from earlier investigations (Crewe and Arlotte, 1964) into air movement through wire gauze panels. These pioneering studies revealed that when air approaches a porous membrane below a critical solidity ratio and incident angle, that it passes through the membrane and in the process incurs some angle of deviation that is directly proportional to the associated pressure drop. In essence, more porous gauze (higher solidity netting) at lower incident angles (i.e. longer funnels) causes less deviation, a lower pressure drop, and hence a lower pressure drag.

The effect of catch quantity on water displacement in a prawn trawl codend was also investigated to establish an optimal position in the extension for a Square mesh window (Broadhurst *et al.,* 1999). Fish catch was simulated with water balloons and conducted in the same flume tank proposed for this experiment. Velocity measurements were taken in several locations down the centre line of the codend and codend extension, although the probe was only inserted some 5cms beyond the netting. It was suggested that a substantial amount of water was leaving the codend extension before reaching the codend, especially when the largest catch was present. This was not a startling observation considering the blockage effect caused by water balloons in the codend escalates as the quantity increases. Of more interest was the suggestion that at a distance of 2.2m (circa 55 mesh) ahead of the drawstrings, there was no significant difference between the 200 commercial codend and 100 commercial codend for all catch weights. Also of some relevance was the forward displacements observed underneath the composite Square mesh panel located between 1 – 2m upstream. Some of the inferences made about flow through the entire codend based on measurements along the inside edge were speculative to say the least. Slowed water flow near to boundaries, even porous ones, has been well documented and explained (Ferro and Stewart, 1987; Buxton and DeAlteris, 1993). Taking measurements in these boundaries to forecast what is going on further out in the flow is not the best approach. These boundaries certainly exist and have been described in a number of experiments (Hoerner, 1965; Engaas *et al.,* 1999). The only way to gain a more comprehensive picture of water displacements within a codend is to measure them or utilise a computational fluid dynamics package.

By conducting the experiment described above, the authors (Broadhurst *et al.,* 1999) also highlighted the importance of coinciding BRD placement with the position where a large amount of water was leaving the codend, in order to optimise finfish escapement. This recommendation and the basis behind it, recognises the need for inducing fish to leave the confines of a codend. Providing an escape window or opening without a substantial amount of water displacement out through it, may not be enough inducement to leave the codend for some species, especially if they are unable to see it due to limited visual range.

Recognition of additional stimuli to induce fish to leave voluntarily via escape windows has seen the emergence of a number of so-called fish-scarers (Engaas *et al.,* 1999). However, more effective use of water displacements to promote egress is being explored through the addition of various forms of water diverters. One novel idea is linked with the fish box TED (Engaas *et al.,* 1999), whereby a vortex created in the wake of a deflector is used to apply a downward velocity component to fish lingering behind the deflector. Interestingly, the species concerned remains horizontal despite water arriving from above. Consequently, the affected fish is unable to counter the hydrodynamic down-force created, and finds itself moving downwards and out through a nearby escape opening. Whether other species respond in similar fashion to this vortex is not widely reported. However, the author has observed a similar preference by fish to remain horizontal in an environment where it is beneficial not to do so; blue grenadier (and other species) have been observed passing by an u/w camera with their body in a horizontal position even when the trawl is travelling down a steep slope. In this instance the person looking through the camera towards the mouth of the net is left with the impression that fish are contemplating swimming upwards and through the top panel. In fact they are exhibiting a preference to swim horizontally, even though it proves to be less effective in terms of maintaining station in the trawl.

The primary aim of this investigation was to acquire water displacement data for three TED/BRD configurations that have been used extensively by the prawn-trawling sector in northern Australia over the last few years. These findings should prove useful to persons concerned with improving the performance of these selectivity devices in the future, as well as assist persons studying fluid dynamic phenomena in the aft section of trawls.

13.2 Methods

The Australian Maritime College flume tank facility (Figure 13-1) has been used on a number of occasions in the past to obtain measurements of water velocity in trawl codends (Broadhurst *et al.,* 1999; Waju, 2000; Wakeford, 2001; Piassante, 2001; Wakeford, 2002). It was used again in July and August 2003 for this purpose. Three prawn trawl codend configurations were tested

- standard codend (included super-shooter TED) (Figure 13-2)
- standard codend with Fisheye located aft of TED (Figure 13-3)
- standard codend with Square mesh window located aft of TED (Figure 13-4).

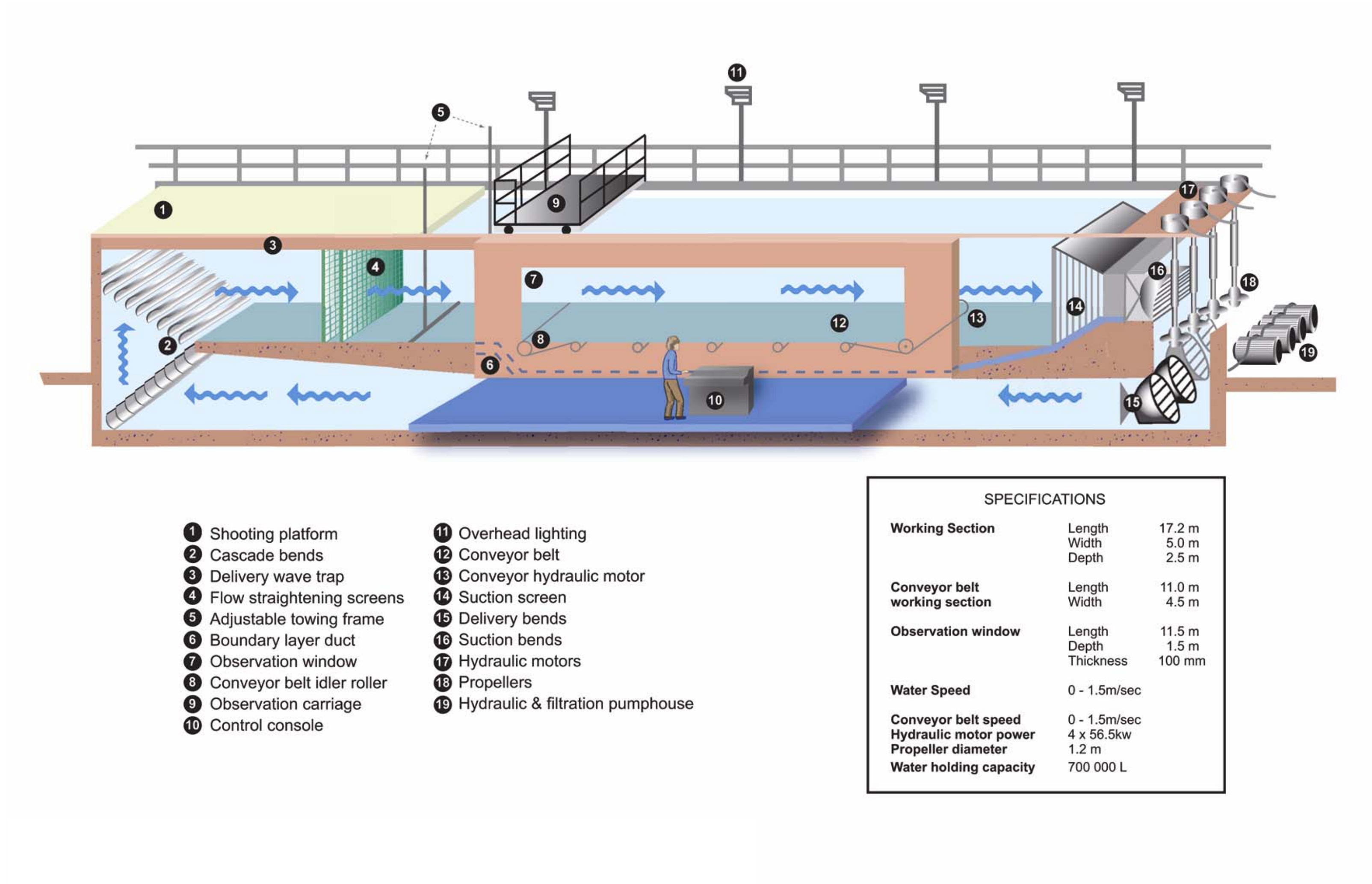
Each codend configuration was also tested with and without a simulated catch (350 x 2kg water balloon) present (Figure 13-5). Codend construction details are given in Figure 13-6.

Both internal and external water velocity were measured at numerous locations with a single-axis electromagnetic log (Figure 13-7). Codend shape was also determined with the aid of a specialised track and carriage arrangement that runs parallel to the observation window (Figure 13-8). During testing, still photographs of each codend were also taken.

Water velocity was measured at various heights down the centreline of each codend and extension piece. Positional data was also gathered and recorded at each location sampled. Velocity data and corresponding positional data were subsequently used to produce flow field plots for each codend arrangement tested. The following sections describe in more detail how the necessary data was firstly acquired and subsequently processed to produce these plots.

Sample positions
A two-dimensional grid of sampling positions was generated for each trawl codend by lowering a velocity meter on a vertical strut to a predetermined height at selected positions along the length of codend and extension. Lengthwise (longitudinal) and height displacements were termed x and y shifts respectively. X-coordinates corresponded with slots cut in the upper netting surface at 10 mesh intervals. The 10 mesh spacing used between adjacent slots originated at the last row of mesh in the codend and continued along the centre-line of codend and extension. In all there were 18 slots between towing hoop and codend drawstring, however the last two were never sampled because they were inaccessible from above. The length of these slots was made just long enough for a 100mm foil-shaped strut to penetrate inside the codend without resistance. Y-coordinates located inside the codend (internal y-coordinates) corresponded with some fraction of the vertical height of the netting funnel at that particular location (x-coordinate). External y-coordinates corresponded with a fixed distance above the upper netting surface and shared a similar x-coordinate as the internal y-coordinates.

Given both x and y-coordinates were linked to a flexible shaped structure meant that each codend arrangement was most likely to have a unique set of coordinates. These coordinates were recorded along with a few additional reference coordinates (upstream extension hoop), thus enabling a two-dimensional outline view (side view) of each codend arrangement to be produced.



.

Figure 13-1. Australian Maritime College flume tank facility. The test section measures 17m x 5m x 2.4m (L x B x D). Maximum flow speed 1.3 m/sec.

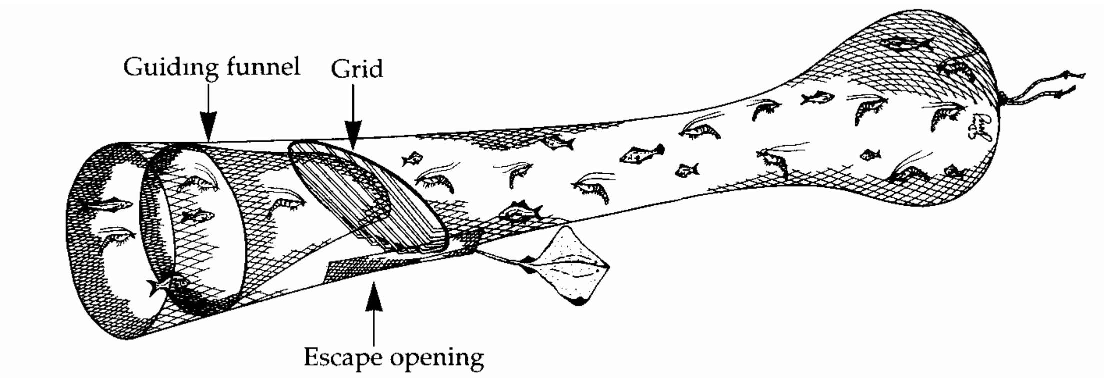


Figure 13-2. Photo (flume tank) and schematic of Super Shooter TED with downward excluding grid and guiding funnel. Note: Guiding funnel was removed from codend in this investigation (see photograph). Source: Eayrs *et al.,* (1997).

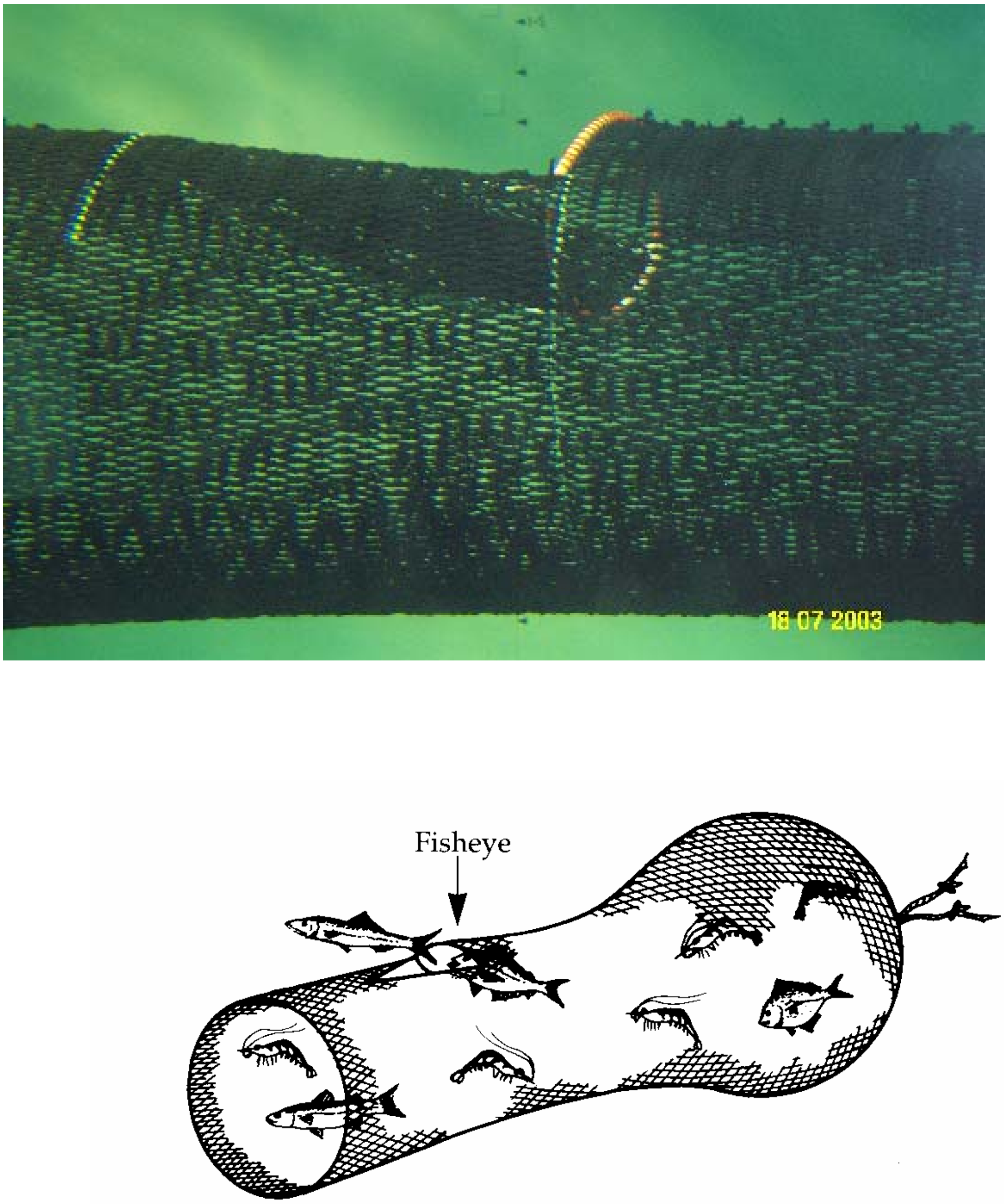


Figure 13-3. Photo (flume tank) and schematic of Fish-eye BRD in similar configuration to that used in this experiment (see photograph) Source: Eayrs *et al.,* (1997).

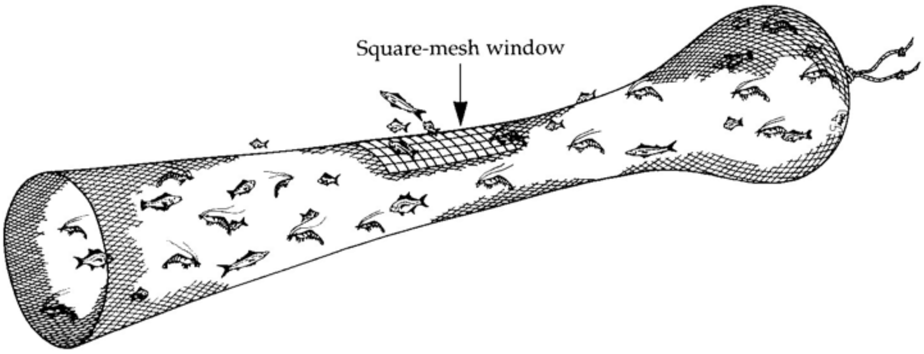


Figure 13-4. Schematic of Square mesh window BRD in similar configuration to that used in this experiment.

Source: Eayrs *et al.*, (1997).

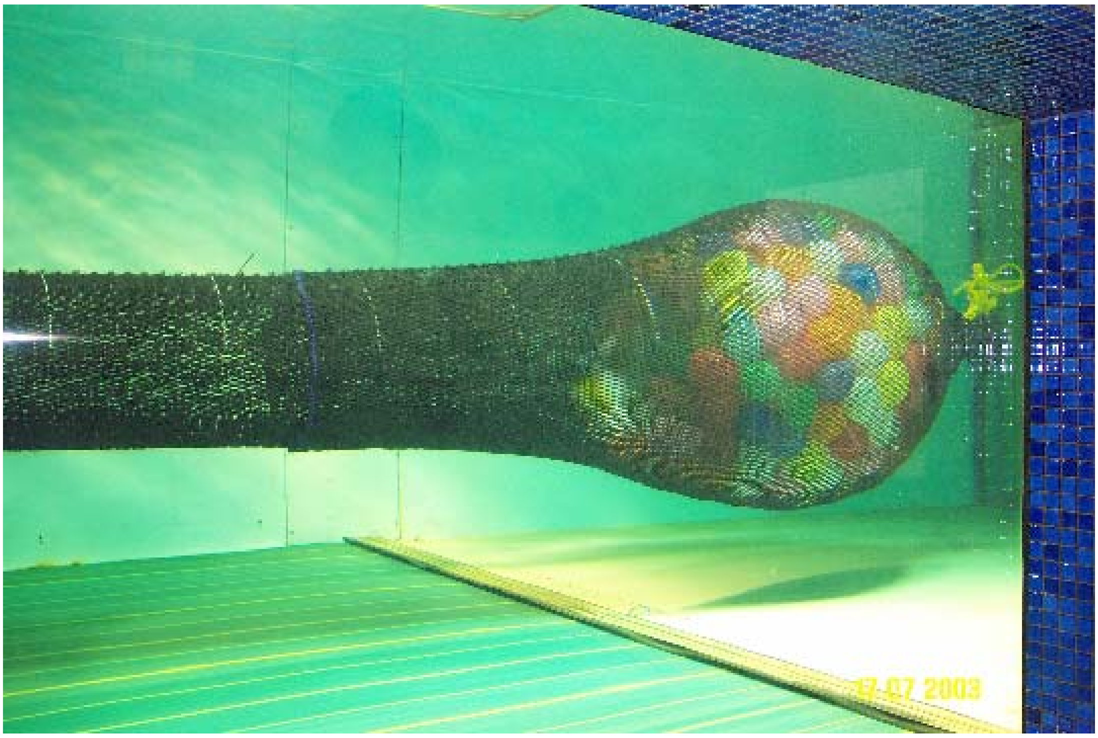


Figure 13-5. Catch was simulated with 350 x 2kg water filled balloons.

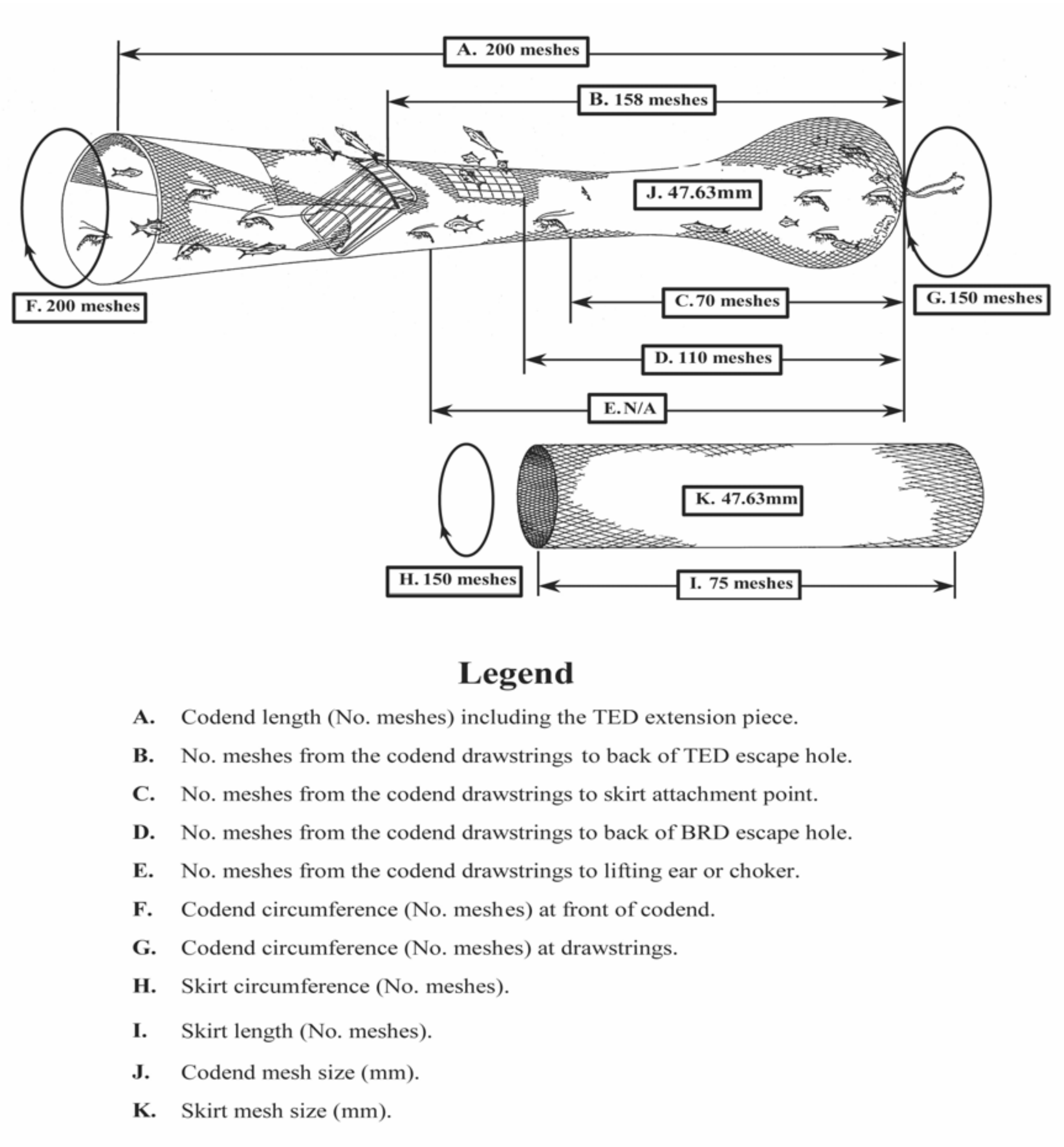


Figure 13-6. General construction details for standard Northern Prawn Fishery (NPF) codend featuring grid and square mesh window. Source: Eayrs *et al.,* (1997).

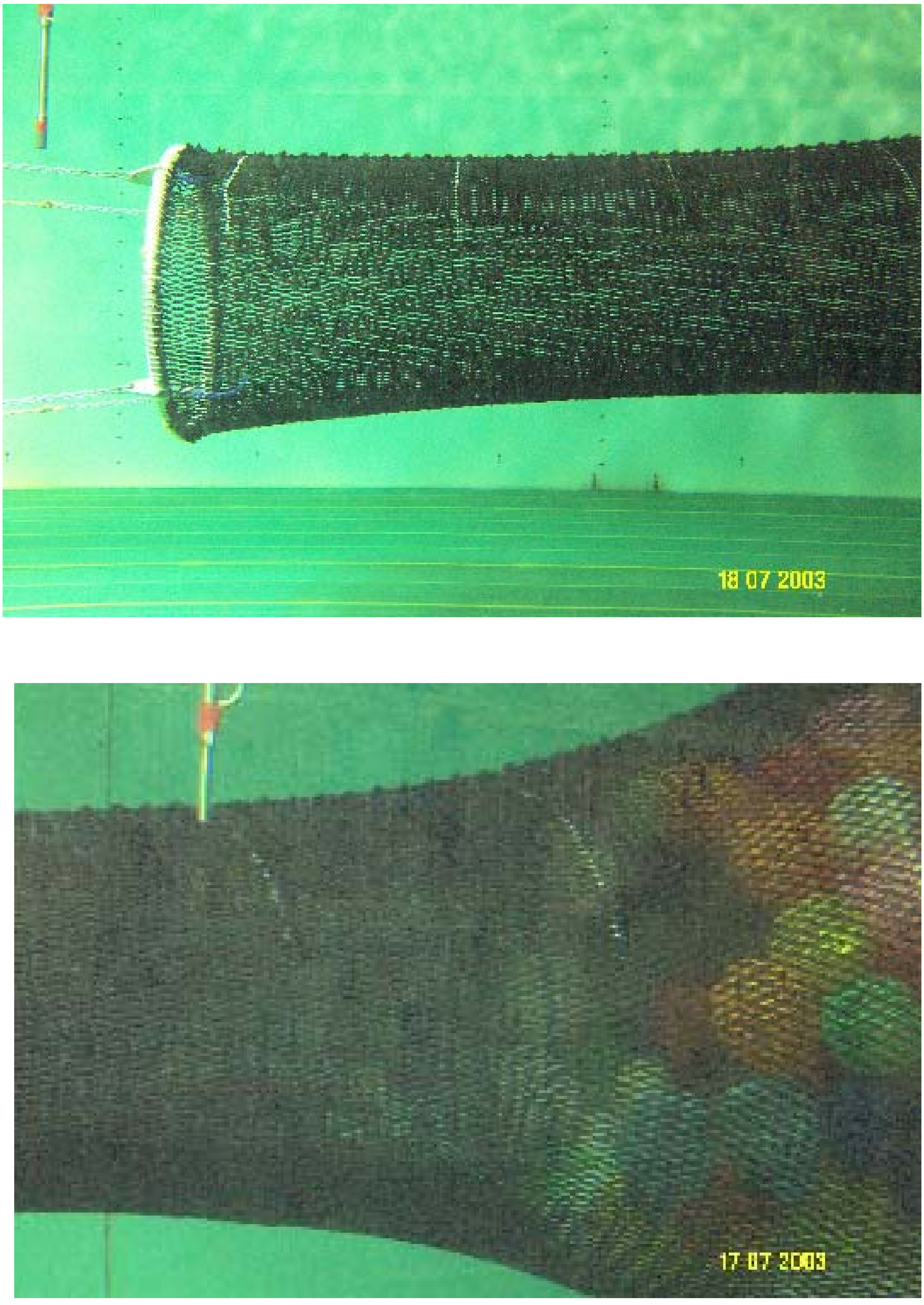


Figure 13-7(a,b). An electromagnetic log was used to take velocity measurements at numerous locations.

Figure 13-8. Positional coordinates were gathered with the aid of a scope and a track & carriage system that runs parallel to the observation window.

Codend towing hoop

In order to stream the aft section of prawn trawls in a flume tank it was necessary to truncate the trawl at some point and attach it to a towing hoop (Figure 13-9). Ideally, the dimension and shape of the towing hoop used will mimic the diametric plane occurring in a full-sized trawl in the field. Acquiring such data in the field is difficult. For this study, a number of experiments with a $1/7^{th}$ scale model of a common tiger-prawn trawl were conducted at different speeds and with varying simulated catch amounts (Day, 2003). Throat height measurements were gathered at the same position where the full-scale trawl would be truncated. This height data was averaged, analysed and what was considered a representative hoop diameter (0.62m) was chosen.

Water velocity measurement

Water velocity was measured with a pair of electromagnetic speed logs (Aquaprobe Flowmaster 2000). Each log was attached to the end of a foil-section strut (Figure 13-10). Each strut was mounted vertically and could be lowered to a desired depth from a moveable carriage located overhead of the water channel. Output data from these logs was displayed and recorded on a PC at 4 Hz over a 60 second period. One of the logs (labelled emlog1) was used to monitor water velocity in a centralised position upstream (approximately 3m) of the hoop to which the codend was attached.

The purpose of emlog1 was to monitor water velocity and ensure it remained constant (within a 1cm range from 0.914 to 0.924m/sec) whilst samples were being taken with a second emlog (labelled emlog2) located downstream. The position of emlog1 remained fixed throughout this experiment. Whenever a reading from emlog1 fell outside the required velocity range the reading from emlog2 was discarded and a repeat measurement was taken. Occasionally, a trend in repeat runs seemed evident and it was necessary to make a small adjustment (usually 0.2%) to the demand signal being sent to the motors driving the water in the test channel. A settling period of several minutes was imposed following such adjustments to ensure any small water accelerations caused by the adjustment were not recorded on the next run.

Emlog2 was used to take measurements concurrently with emlog1 at a point of interest in or around the codend. Emlog2 was positioned manually by at least two people. The first step involved positioning the strut overhead of the slot cut in the netting by moving the overhead carriage either upstream or downstream. The probe was then lowered through the netting-slot to a predetermined depth (referenced to a height above conveyor belt floor) under the guidance of a person looking from a side-on position through a scope (dumpy level) adjacent to the viewing window downstairs. An attempt was made to keep the line of sight through the dumpy level square to the observation window (forms part of the side of the channel) at all times. This was achieved by firstly levelling the scope, secondly, aligning the scope square to the window, and finally, wedging the rotating base to prevent the scope from rotating whilst measurements were being taken. Horizontal position shifts (x-direction) were achieved by sliding the carriage ('ladder') on which the scope was mounted along a track system running parallel to the sides of the water channel. Vertical adjustments to scope height were achieved by shifting a smaller carriage mounted to the side of the 'ladder' either upwards or downwards on a vertical track marked with a scale. By recording both horizontal and vertical displacements in scope position against a reference point, it was possible to gather both x and y-coordinates at selected points along the codend. X-coordinates corresponded with reference marks (a row of twine knots painted white to form a lateral band) located every ten meshes down the length of the codend, whereas y-coordinates corresponded with the lower edge of emlog2.

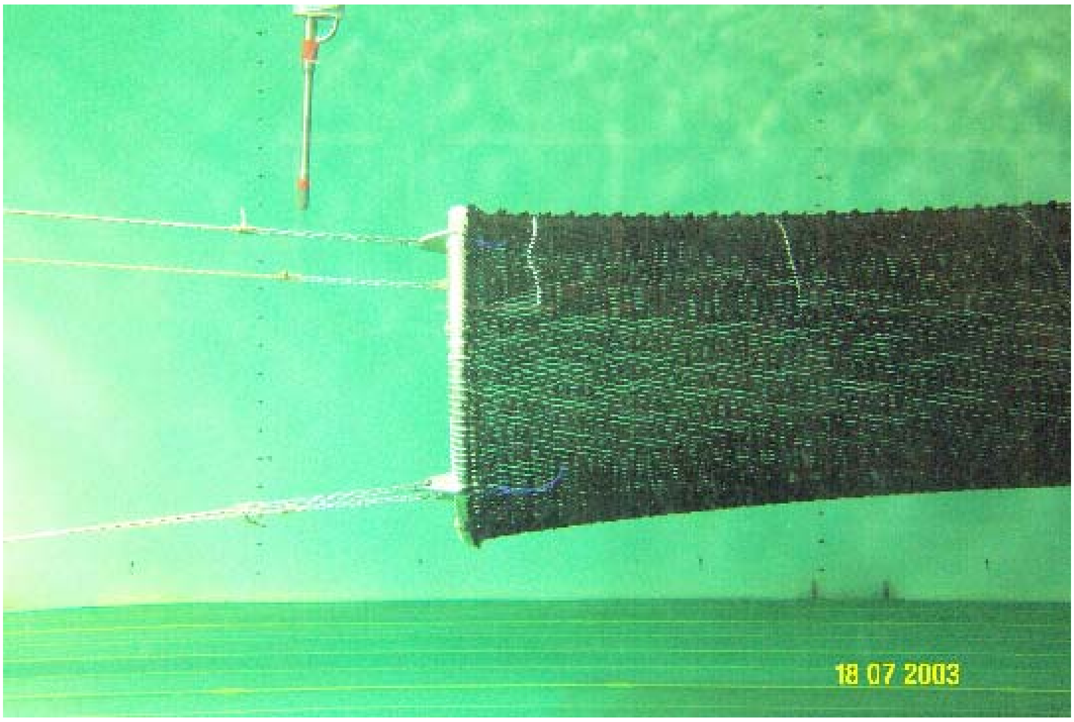


Figure 13-9. The codend extension was attached to a round towing hoop (0.62m in diameter). Hoop diameter was determined from measurements of codend extension heights on a model trawl over a range of speeds and with varying amounts of simulated catch in the codend.

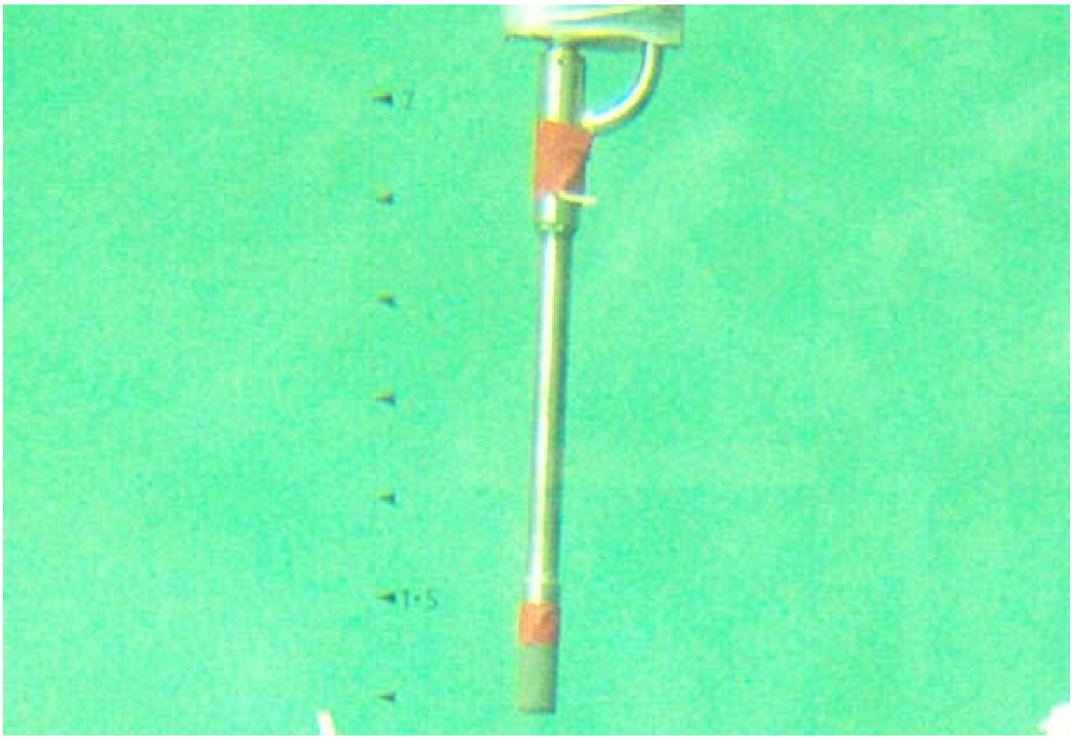


Figure 13-10. An Aquaprobe Flowmaster 2000 electromagnetic log mounted on a foil section strut was used to measure water velocity. Output data was recorded on PC.

Temporal, spatial and instrument variables

The following treatment was applied to all emlog2 water velocity measurements to address temporal, spatial and instrument variables that were possibly in effect whilst data was being gathered.

Temporal variations were addressed in several ways. Firstly by averaging data over a 60 second period for each run to minimise the effect of spikes in instantaneous water velocity associated with turbulence in the water channel. Secondly, by applying a reference velocity check with emlog1 in a fixed position upstream of the body being tested to ensure consistency between runs.

Instrument variations were addressed in several ways. Emlogs were checked for similarity before and after the experiment. This procedure involved taking long term velocity averages at similar locations and adjusting the scaling factor applied to output voltage from both meters to ensure they had similar displayed velocity values. Both emlogs were also calibrated at the conclusion of the experiment, and an adjustment for emlog drift, if present, was applied to the averaged velocity data. Given the velocity profiles in this report were presented as relative indexes, and then the need for accuracy in absolute velocity measurement was somewhat unnecessary. The suggestion that changes in absolute velocity upstream, result in proportionate velocity changes downstream, was verified by Ziembo (1976), and sounds reasonable as long as netting shape is not distorted excessively at different speeds.

Spatial water velocity variations in the test section of the water channel without bodies present were quantified at the time of commissioning (Smith 1984) and also on a number of occasions since. These velocity variations represent a real problem for testing relatively large sized objects, such as full-scale codends that stretch the length of the test section. One method of addressing these fluctuations, which takes considerable time, is to measure the velocity field down the centre of the channel without any body present, and then to use this data to derive a velocity adjustment factor for each position measured when the body was present. Such adjustments remain rather subjective though, as the influence of the body on the lengthwise flow in the channel cannot be isolated, so the adjustment made is really just an attempt to get a more representative indication of the water displacements that would be observed around trawl gear at sea or in a towing tank. An alternative approach is to ensure the body remains in similar positions between each test and concentrate on reporting relative differences between rigs, rather than differences observed across a single rig. The latter approach was adhered to in this experiment as much as possible; individual observations were made however, mindful of the maximum fluctuation across the area coinciding with the codend.

Data processing
Positional data corresponding to upper and lower edge of codend was plotted using Microsoft Autodesk software (2D version of Autocad). Overlay plots of codend shape were also created. The necessary reference point in this case was the fixed dimension and position of the upstream towing hoop. These overlay plots allowed the effect of external loading as well as addition of new objects (BRD's and simulated catch) to be visualised.

The aft section of the codend (position U-X inclusive) was partly plotted by extrapolation as only a y-coordinate was available after position S. The x-coordinate for positions U-X inclusive was derived using the average spacing between six positions (O-T inclusive) posterior to position U. This approach was acceptable for the unloaded codend where mesh-setting angle was relatively constant over this section, but would have exaggerated the length of the codend when the catch caused substantial amount of lateral expansion. For this reason the x-coordinate for position U only (using mean x-coordinate between positions 0-T inclusive) was derived for the loaded codend, and even then a degree of lateral expansion was evident.

13.3 Results

The positional and water velocity data gathered on three codend configurations (Super-shooter TED, S/S TED + Fisheye BRD, S/S TED + Square mesh window BRD) is presented in Figures 13-11 to 13-13.

Table 1 serves as a guide for relating water velocity index values* appearing in Figures 13-11 to 13-13 to likely water displacement outcomes in a trawl operating in the field (i.e. passing through water and over seabed).

<u>Super-shooter TED</u>
The following observations relate to the velocity and positional data contained in Figure 13-11.

Codend dimension and spatial position observations
The codend and codend extension adopted what has become a fairly common shape nowadays following the inclusion of oversize grid-frames; the netting-funnel posterior to towing hoop (position B to C) constricted slightly, then expanded at grid (position G to I) frame, and then narrowed again until position N, where it had a similar height as position A-B. Downstream of position N the funnel-height remained relatively constant in the unloaded codend until the gathering at the drawstrings (aft of position-X). The simulated catch in the loaded codend caused a familiar sight; netting began to expand aft of position r to form the recognisable bulbous shape.

Placing a simulated catch in the codend caused little change to netting-funnel height ahead of the grid, with the only apparent change being an upward shift of netting in this region causing it to adopt a slightly higher angle of incidence to the free-stream flow.

Loading the codend with catch caused slightly more constriction in the netting-funnel aft of the grid until position P was reached. Between position P and S the loaded and unloaded codend had similar funnel height. Increased netting constriction in the loaded codend also caused small elongations in mesh length in the same region.

Table 13-1. Relationship between water velocity index values (gathered using a codend in a flume tank) to likely water displacement outcomes in a trawl operating in the field.

Water velocity index value*	Water displacement in the field	Water velocity relative to seabed (water displacement /time)
1.00	zero	water remains stationary water is unaffected by the passing trawl
> 1.00	-ve displacement	-ve water velocity water is shifted in opposite direction to trawl motion
< 1.00 and > zero	+ve displacement	+ve water velocity water is shifted in same direction to trawl motion and approaches trawl speed when index value nears zero
≤ zero	+ve displacement	+ve water velocity water is shifted in same direction to trawl motion at ≥trawl speed

(*water velocity index = measured local velocity / reference water velocity taken ahead of codend towing hoop)

Position P also coincided with where the netting funnel of the loaded codend began a downward shift in position relative to the unloaded codend.

Water velocity observations

A similar variation (around 10%) in water velocity was observed upstream of the towing hoop irrespective of whether a simulated codend catch was present (loaded codend) or absent (unloaded codend). Peak water velocity occurred in a central position and diminished towards the perimeter.

Relatively high water velocities were evident in the central section of the netting-funnel at most positions along both unloaded and loaded codends.

Between positions A & G there was a noticeable variation in internal water velocity with both loaded and unloaded codends. Velocity indices ranged between 0.57 and 1.31 (0.74 difference), and between 0.50 and 1.13 (0.63 difference) for unloaded and loaded codends respectively. Lower velocity indices (i.e. higher positive water displacements) tended to occur in the upper section just ahead of the grid (position F & G), and to a lesser extent in the lower portion just ahead of the grid (position G & H).

Between positions A & E there was relatively higher water velocity in the lower half compared to the upper half of the netting funnel. This difference in water velocity escalated as the grid was approached, mainly because of a drop in velocity in the upper portion of the netting funnel.

External velocity indices along the top of the loaded codend extension were relatively constant from position A to F. At position G and moreover at position H, a small rise in external velocity occurred. Downstream of position H external velocities fell until a band of minimum velocities extending between positions l to R was reached. Position R marked the start of the codend skirt and this is where the netting funnel started to expand. External velocities in this region (position R to U) also crept higher.

At position H in the lowest portion of the netting funnel, just ahead of the grid bars, there was a large velocity gradient (0.8 and 0.77 difference in velocity indices between H-0.1 and H-0.25

for the unloaded and loaded codends respectively). This velocity gradient appeared to diminish at position I, just downstream of the grid bars, as a result of relatively higher velocities occurring at I-0.1 and I-0.25 compared to the low velocity index at H-0.1.

At positions J to K there seems to be more similarity in water velocity above and below the central position, unlike further upstream (C to H) and downstream (M to U), where there tends to be a bias towards higher velocities in the lower half of the netting funnel.

Velocity indexes along the central section of the netting funnel from position L to U and L to R showed a tendency to decrease gradually in both unloaded and loaded codends respectively. Downstream of position U (unloaded codend) and R (loaded codend) the water velocity decreased more rapidly.

A reasonable amount of water passed through the drawstring region of the empty codend despite the netting being gathered at this point. Water also showed a preference to pass through the lower section of the gathered netting. Negative velocity indices were recorded at position T and U in the upper portion of the loaded codend.

Super-shooter TED + Fisheye (F/E) BRD
The following observations relate to the velocity and positional data contained in Figure 13-12.

Codend dimension and spatial position observations
The addition of a Fisheye BRD at position N had very little affect on codend shape or spatial position either upstream or downstream of its location.

Placing a simulated catch of water balloons in the codend appeared to cause a small change in netting shape in the vicinity of position N, evident from the downstream shift in position N data points between loaded and unloaded codend.

Water velocity observations
The most noticeable change in water velocity following the addition of a F/E BRD was the appearance of very low velocities immediately downstream of it. These low velocities extended all the way back to position R, where the skirt was attached. Even at the half-height positions there was a noticeable drop in velocity index values from position O to R.

The blockage effect created at position N by the F/E in the netting funnel seems to have caused a localised increment in water velocity in the narrowed section below it.

External water velocity in close proximity to the F/E seemed to be unaffected by its presence, with the only minor change possibly being a small increase in external velocity at position M+10cm, which was just upstream of the netting scoop (i.e. start of F/E frame).

Super-shooter TED + Square mesh window (SMW) BRD
The following observations relate to the velocity and positional data contained in Figure 13-13.

Codend dimension and spatial position observations
The inclusion of a SMW BRD appeared to have very little affect on codend shape or spatial position, apart from a very minor depression (Position N* to O*) in the upper netting where the window of large mesh lost its curvature.

Placing a simulated catch of water balloons in the codend caused a similar downward shift in the funnel netting between position l to R as that observed without the SMW. Adding catch to the SMW codend also caused a distinct shift in spatial position downstream compared to the unloaded SMW codend, evidenced by the disparity in l sample locations.

Water velocity observations

The addition of a SMW BRD had minimal influence on the surrounding water velocity between positions l and R.

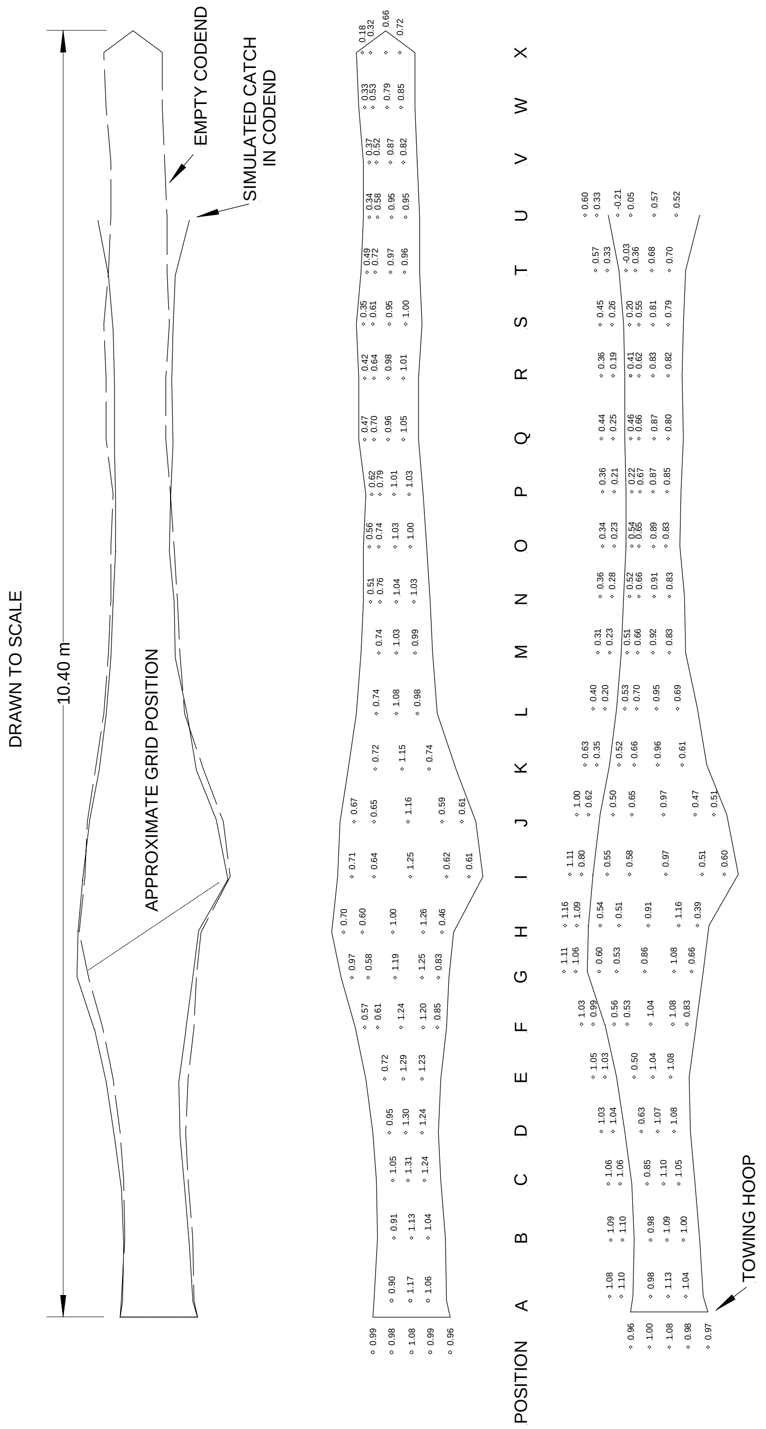


Figure 13-11. Water velocity indices at various locations through a prawn trawl codend equipped with a Super-shooter TED. Velocity and positional data were gathered with a full-scale codend (used on a 14 fathom headline trawl) in a flume tank. Aft portion of codend was enclosed in a netting skirt (starts at position R). Codend was tested with and without a simulated catch (350 x 2kg water balloons). Free stream velocity during experiment was circa 1.0m/sec. Water velocity was measured by electro-magnetic log.

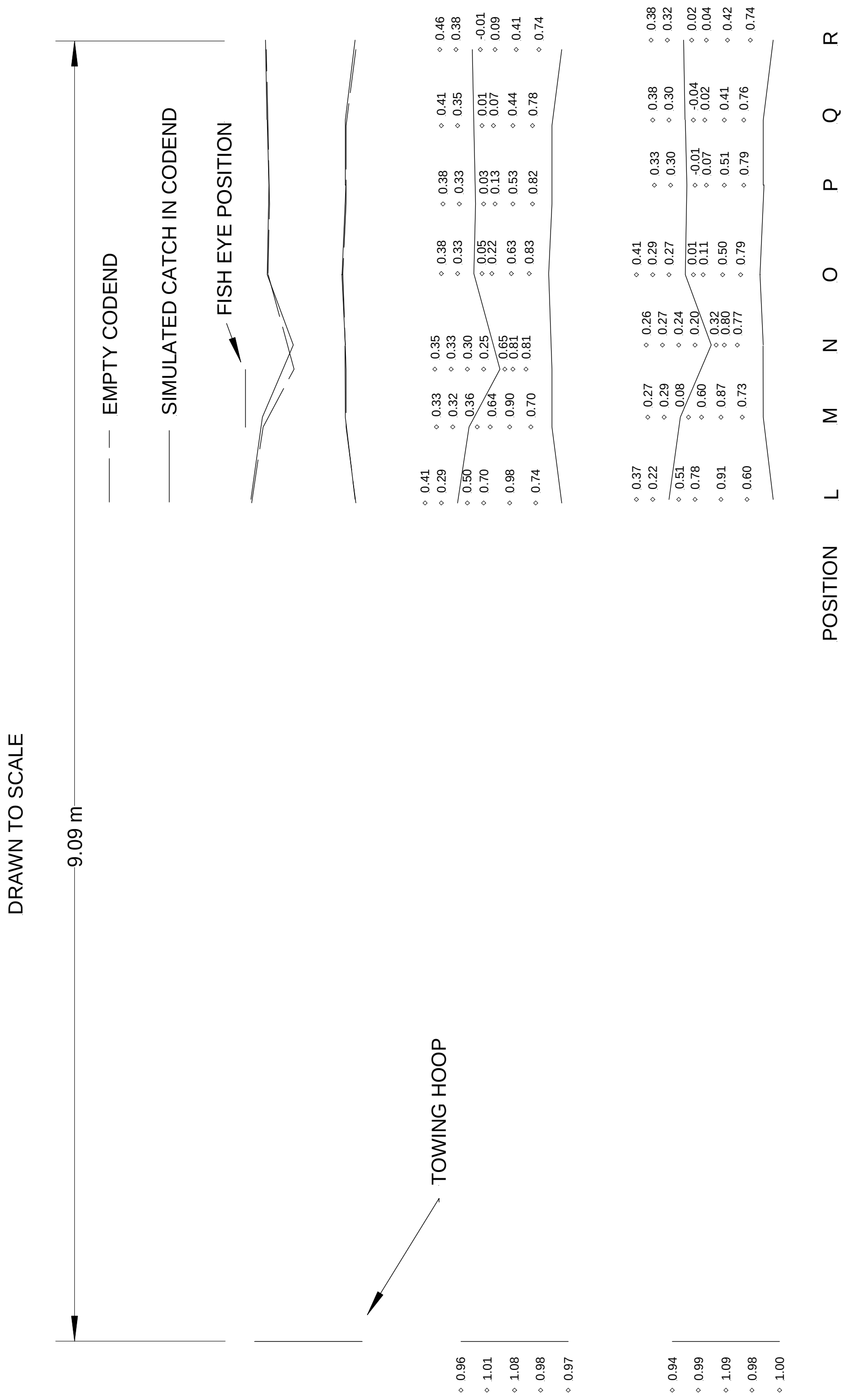


Figure 13-12. Water velocity indices at various locations through a prawn trawl codend equipped with a Super-shooter TED and Fisheye BRD. Velocity and positional data were gathered with a full-scale codend (used on a 14 fathom headline trawl) in a flume tank. Aft portion of codend was enclosed in a netting skirt (starts at position R). Codend was tested with and without a simulated catch (350 x 2kg water balloons). Free stream velocity during experiment was circa 1.0m/sec. Water velocity was measured by electro-magnetic log.

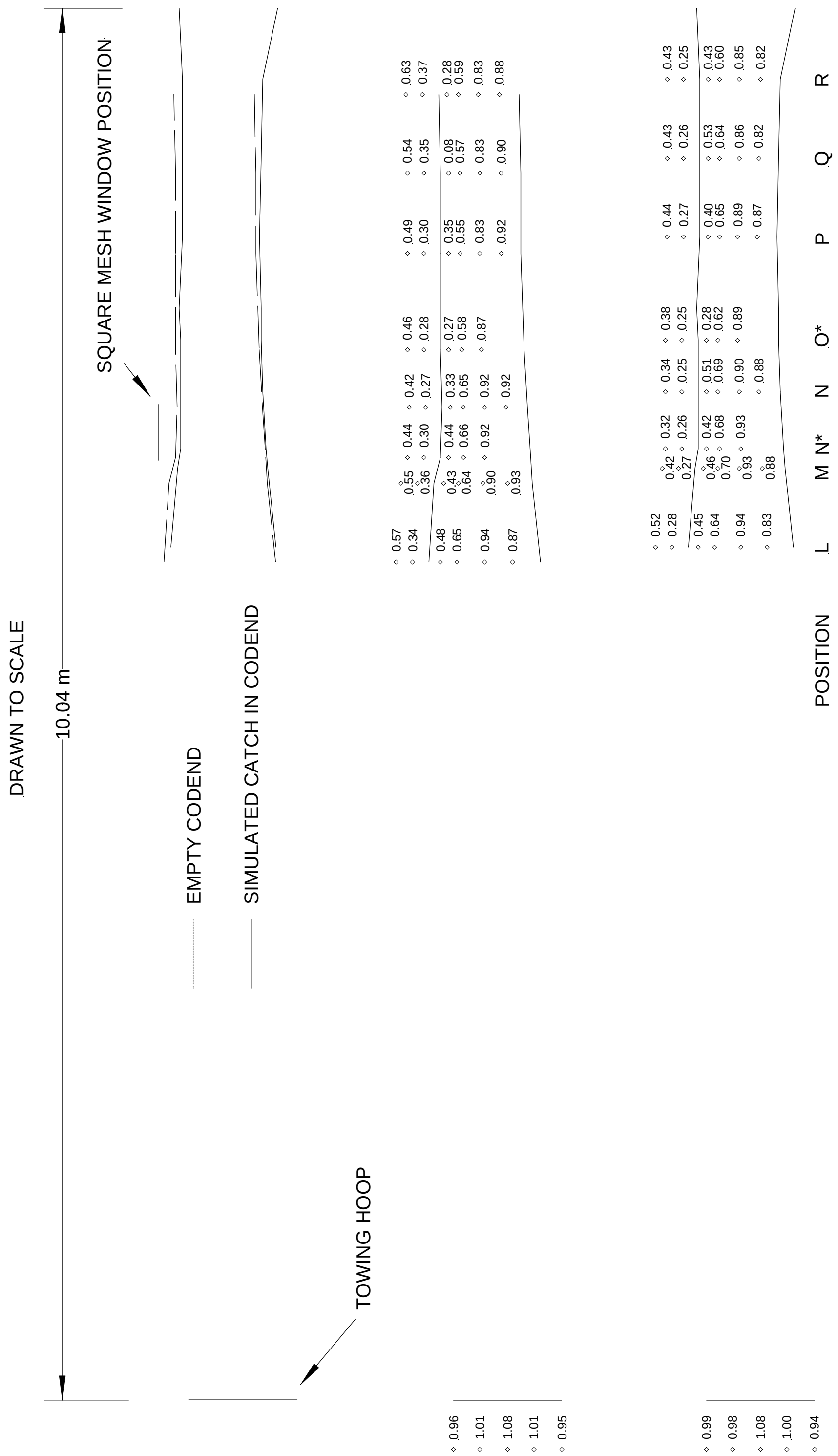


Figure 13-13. Water velocity indices at various locations through a prawn trawl codend equipped with a Super-shooter TED and a Square mesh window BRD. Velocity and positional data were gathered with a full-scale codend (used on a 14 fathom headline trawl) in a flume tank. Aft portion of codend was enclosed in a netting skirt (starts at position R). Codend was tested with and without a simulated catch (350 x 2kg water balloons). Free stream velocity during experiment was circa 1.0m/sec. Water velocity was measured by electro-magnetic log.

The addition of a simulated catch to a codend fitted with a SMW BRD had minimal influence on the surrounding water velocity between positions l and R, apart from a small rise in velocity just underneath the window meshes at position N-0.9, and marginally lower external velocities downstream of position M to position R.

13.4 Discussion

This investigation demonstrated that:

- there was considerable variation in water velocity through a prawn trawl codend equipped with a Super-shooter TED;
- the addition of a Fisheye BRD aft of a S/S TED caused a moderate reduction in water velocity for a considerable distance downstream of the Fisheye;
- the addition of a Square mesh window BRD at the same location as the Fisheye caused a minor change to the flow field; and
- the addition of a simulated codend catch caused some minor changes to the flow field upstream of the TED and below the Fisheye, with the largest changes being confined to the region just ahead of the catch.

<u>Super-shooter TED</u>
Remarks on external flow field ahead of towing hoop
The existence of a velocity gradient ahead of the towing hoop implied that some of the water flow was being diverted outwards and avoided entering the codend extension. Similar flow fields have been reported elsewhere for plankton nets (Hernroth, 1987; Tranter and Heron, 1967), and other forms of netting funnels (Buxton and DeAlteris, 1993) where relatively high solidity netting was combined with large entrance to exit area ratio. In this instance however, water may have actually been drawn into this netting funnel, rather than rejected from it. The codend extension did not exhibit much of a constriction ahead of the TED before it was forced to expand considerably to accommodate the TED frame, and relatively higher (up to 15%) water velocities coming concurrently from a position 3m further upstream of the hoop, suggest flow injection, rather than rejection, took place. One explanation is linked to the diverging nature of the high solidity netting ahead of the TED. There is a chance that this netting created a shielding-situation where dynamic pressure remains relatively constant down the central core of the netting funnel, like that observed with the J-D BRD funnel (Engaas *et al.,* 1999). Typically we observe the affects of an adverse pressure gradient diverting approaching water, which may not always be the case. Considerable effort was taken prior to testing to ensure hoop size matched trawl cross-sectional area. Intuitively, it seems reasonable to expect some form of funnelling in the throat section of a prawn trawl. High netting solidity (small mesh size drawn closed under load) combined with moderate angles of incidence has already been identified (Riedel and DeAlteris, 1995) as two of the necessary ingredients for such an occurrence.

Remarks on flow field upstream of S/S TED
The tendency for a central core of faster flowing water to extend down most of the extension piece and codend was somewhat similar to internal flows observed in pipes of changing diameter (Vennard and Street, 1982). Regions of low velocity just ahead of the grid and near to the netting walls coincided with an increase in funnel height. Such reductions in velocity would be expected in these locations to preserve mass flow rate (Buxton and DeAlteris, 1993), provided there are no additional sources of water. There was some evidence of water entering via netting just ahead of the bars at the base of the grid-frame, possibly because of the relatively high incident angle adopted by this netting. Consequently, local velocities in this region seemed slightly high, and tended to upset the trend of falling velocity with increased funnel diameter. In any case, these regions of reduced water velocity ahead of the grid represent real havens for fish trying to maintain station in the trawl codend with a minimum of effort. Having a declined grid

also meant the netting diverged away from the central core of faster flow in the upper section of the extension piece before it diverged away in the lower section. This difference in funnel symmetry combined with the slightly inclined netting funnel ahead of the grid, may provide fish entering the extension piece with lower velocity flow in the upper section of the extension before the lower section. If this was the case, then it can be speculated further that active swimming fish may initially congregate at this position, and subsequently be drawn up higher as they move aft and seek even lower velocities ahead of the grid bars. The upper panel ahead of the grid may therefore prove to be a suitable location for some kind of escape window/opening.

Remarks on external flow field
According to the pattern of external water velocity either side of the grid frame, water flow may have detached at the top edge of the grid. Flow reversal was not evident just downstream of this position though, suggesting a certain amount of water may have been injected there by filtering through the converging netting located aft of the grid frame. The presence of this wake-like region downstream of the grid and along the upper edge of the codend netting could prove useful in drawing fish out from inside the codend where the core velocity is considerably higher. Similar observations have also been made by scuba divers probing shrimp trawls with speed logs (Engaas *et al.,* 1999).

Remarks on asymmetrical, internal, velocity gradient
Water velocity in the lower half of the extension piece tended to be higher than that in the upper half at most of the positions sampled. Understandably, this trend may be worth highlighting in terms of the significance to fish movements within codend and extension piece. Fish with energy conservation in mind, and a preference to avoid suspended debris/sediment tracking through the lower half of the trawl, may therefore show an interest in this upper region. Relatively higher water velocities in the lower section of the trawl ahead of the grid also mean that prawns pass by the grid quickly, minimising the likelihood of downward escapement via grid escape opening. Higher water velocity ahead of the grid also implies that large animals receive maximum acceleration when they come into contact with the grid bars, increasing the chance of a successful exclusion.

Remarks on flow field downstream of S/S TED
Water flow downstream of the grid also held similarities to flow observed in pipes (Vennard and Street, 1982). Where a constant cross-section existed the flow field remained relatively constant, both internally and externally; mass flow rate was preserved. Only a slight lengthwise reduction in velocity was apparent along this section. It was not until a position was reached about 30 meshes (circa 1.5m) ahead of the drawstrings in the empty codend that the tell-tale signs of stagnating flow (Hoerner, 1965) became evident. It is likely that fish approaching the codend would detect this change as well, although whether it is enough of an inducement to leave the codend is debatable. Unfortunately, the proposed location for SMW and F/E at 110M anterior to the end of the codend, was well forward of where the flow really starts to stagnate. Furthermore, despite having a wall of gathered netting to pass through, some resemblance of flow was maintained even at the extremity of the codend when it was empty. In the absence of strong stagnation signals (i.e. corresponding forward water displacements in a trawling situation – see Table 1) catch is more likely to enter the confines of the codend bag, and subsequently become a wall feature.

Catch effects
The addition of 350 water balloons into the codend proved to be an appropriate way of simulating a neutrally buoyant, uniformly packed catch. The resultant flow field showed all the signs of full stagnation occurring upstream of the catch. A few balloons were even seen rotating around the perimeter of the central core of faster flowing water (Figure 13-5). However, the extent of the stagnation was confined mainly to a region some 1.5m (30 meshes) ahead of the catch, which is where the codend skirt was attached (position R). Broadhurst *et al.,* (1999) reported a similar shortcoming when they investigated water flow in codends to identify optimal

locations for a composite SMW; the preferred location for minimising prawn loss during haulback of trawl gear was also found to be well ahead of the preferred location where catch induced water displacement may encourage fish to utilise escape windows.

The downward shift observed in the codend position after being filled with neutrally buoyant balloons is almost certainly due to an imbalance in dynamic pressure between upper and lower sides of the codend. Lateral expansion of the codend as it fills with catch brings the underside closer to the boundary, in this case the floor of the flume tank. Consequently, water approaching the underside of the codend accelerates, and in doing so, disrupts flow symmetry. This alteration in flow symmetry manifests into a dynamic pressure imbalance (Hoerner, 1965) (relatively lower pressure below codend) and consequently we see the codend pushed downwards. The extent to which codend shifts downwards as catch quantity increases needs to be investigated further as it affects the downslope of the codend netting behind the grid. The presence of a downward sloping netting funnel aft of the TED creates a situation where fish experience the reversal of the inclined water flow effect described earlier and related to a trawl travelling downwards on a slope. In this instance, fish maintaining a horizontal body axis as they tire and move downstream behind the TED, would have a tendency to approach the upper edge of the codend extension, hopefully to encounter some form of BRD.

<u>Fisheye BRD</u>
The inclusion of an inward\facing F/E BRD with the opening slot facing aft, caused a wake to form and extend downstream to at least position R, where the codend skirt was attached. Interestingly, gross water flow in the wake was negligible, and there appeared to be very little incursion from water either above or below the wake. This result dispelled suggestion that a substantial amount of external water would be drawn into the codend via the F/E duct. In essence the F/E has created a passage in the upper half of the netting funnel that extends between codend and F/E, where fish can traverse along with little effort. The existence of such a dead zone should encourage fish to move into this region. However, whether these fish receive the right stimuli once they move into this wake region, and moreover, show enough initiative to leave via the F/E slot, can only really be speculated upon here. The presence of a slightly higher water velocity within and above the F/E is not going to encourage fish to depart, and even when they do, the lower water velocities extending forward and aft of this position, may induce escapees to remain close to the exterior netting surface for a period as well (Engaas *et al.,* 1999).

Other small changes in water velocity were also observed in the vicinity of the F/E BRD. However, there are a number of reasons why it is probably best at this stage to leave these results unexplained until a more detailed investigation of this region can be completed.

<u>Square Mesh Window BRD</u>
The addition of a SMW BRD had minimal influence on codend shape and water flow. A small rise in velocity index occurred just underneath the window following the addition of a simulated catch, but in the absence of any additional changes nearby to this location, looks very much like an experimental error. Broadhurst *et al.,* (1999) also reported a similar outcome, but this could be just coincidence. Irregular codend motions were one of the difficulties faced during water velocity measurement, especially with catch present and when the emlog-mast was drawn upwards and a level of dampening was lost. It is quite plausible that an upward codend movement caused a reading at position N-0.9 to be taken slightly too low, resulting in an exaggerated velocity being recorded. A similar but converse argument can be applied to the relatively low reading at position Q-0.9 (without simulated catch), despite the catch not being present. Taking velocity readings near moving netting walls where a reasonable velocity gradient exists is likely to introduce some errors when taking point measurements at the best of times. Inserting the foil shaped mast into the netting did help to dampen codend motions to some extent, but as it was drawn upwards to take higher measurements, especially when sampling well downstream, the swaying codend motion problem tended to resurface.

13.5 Conclusions

The results of this investigation into flow profiles through prawn trawl codends revealed that F/E and Square mesh window BRDs have quite different levels of flow disturbance associated with them when placed aft of a Super-shooter TED in the upper panel.

The S/S TED caused quite a lot of disruption to the flow field, not so much because of the grid bars restricting water passage, but moreover because of the oversize frame causing considerable netting expansion and constriction upstream and downstream of the grid respectively.

The level of flow disturbance associated with these BRDs seems to be independent of catch amount in the codend, even though noticeable changes in velocity occurred elsewhere.

The F/E BRD created a substantial wake that extended well downstream of the duct and resisted nearby water incursions. This wake is likely to attract active swimmers seeking refuge and escapement from the confines of the codend. Further investigation in terms of producing a more detailed flow field is warranted.

The Square mesh window BRD had negligible effect on codend shape and water flow. Evidently it relies predominately on bycatch vision for escapement to occur, whereas the Fisheye offers additional stimuli in the form of velocity gradients and wake formation.

There was a considerable amount of evidence to suggest that placement of escape windows in the upper section of codend and codend extension is probably as good a location as any. Although it is unlikely that catch induced water displacement is going to be of any benefit in the exclusion process where the F/E or SMW currently reside (110 meshes anterior to end of codend) as there was a disparity of about 40 meshes (circa 2m) between stagnating water flow and BRD position.

13.6 Acknowledgements

Special thanks to the 'tank-rats' Alan 'Porky' Faulkner, Hai and Steve Eayrs who participated in the testing phase. Garry Day and Steve Eayrs deserve special thanks for assistance in preparatory work and devising a suitable experimental design for this investigation.

13.7 References

Brewer, D., Eayrs, S.J., Rawlinson, N., 1995. Bycatch reduction devices show promise in the NPF. *Aus. Fish.* May 1995.

Broadhurst, M.K., Kennelly, S.J., and Eayrs, S.J. 1999. Flow-related effects in prawn trawl-codends: potential for increasing the escape of unwanted fish through square-mesh panels. *Fish. Bull.* 97: 1-8.

Buxton, N.G. and DeAlteris, J.T., 1992. Quantification of water flow and net drag in midwater trawls. *Fish. Res,* 16:165-178.

Crewe, P.R. and Arlotte, T.A., 1964. Results of a systematic series of tank tests on plane webbing pieces; comparisons with theory and earlier investigations. Westland Aircraft Ltd, Suanders Roe division H/O/181. Produced under contract to the White Fish Authority.

Eayrs, S.J., Buxton, C. McDonald, B., 1997. A guide to bycatch reduction in Australian prawn trawl fisheries. Richmon Printers, Devonport, Tasmania.

Eayrs, S.J., Rawlinson, N., Brewer, D., 1997. Reducing Bycatch in Australia's Northern Prawn Fishery. In: Asia-Pacific Fishing '97 – Conference Papers. Baird Publications.

Engaas, A., Foster, D., Hataway, B.D., Watson, J.W., Workman, I., (1999). The behavioural response of juvenile red snapper (*Lutjanus campechanus*) to shrimp trawls that utilise water flow modifications to induce escapement. *Marine Technology Society Journal* 33:2 43-50.

Ferro, R.S.T. and Stewart, P.A.M., 1987. The drag of nylon codends. *Fish. Res.,* 5: 331-347.

Hernroth, L., 1987. Sampling and filtration efficiency of two commonly used plankton nets. A comparative study of the Nansen net and the UNESCO WP 2 net. *J. Plankton Res.,* 9 (4): 719-728.

Hoerner, S.F. 1965. Fluid-Dynamic Drag. Published by author.

Piasente, M., (2001). The observed behaviour of selected fish species within demersal trawl nets in S.E. Fishery. MApSc (Fisheries) thesis (under review), Australian Maritime College, Tasmania, Australia.

Riedel, R., Dealteris, J. 1995. factors affecting hydrodynamic performance of the nordmore Grate system: a bycatch reduction device used in the Gulf of Maine shrimp fishery. *Fish. Res.,* 24: 181-198.

Rogers, D.N., Rogers, B.D., de Silva, J.A., Wright, V.L., Watson, J.W., 1997. Evaluation of shrimp trawls equipped with bycatch reduction devices in inshore waters of Louisiana. *Fish. Res.,* 33: 55-72.

Smith, D. 1984. Calibration and testing of the Australian Maritime College flume tank. Diploma Engineering (Marine) thesis, Australian Maritime College, Tasmania, Australia.

Tranter, D. and Heron, A., 1967. Experiments on filtration in plankton nets. *Aust. J. Mar. Freshwater Res.,* 18: 89-111.

Vennard, J.K. & Street, R.L. (1982). *Elementary Fluid Mechanics.* John Wiley & Sons.

Wahju, R.I., 2000. Codend selection of diamond and square mesh for Tiger flathead (*Platycephalus richardsoni*) and Thetis fish (*Neosebastes thetidis*) in the east Coast of Tasmania. MApSc (Fisheries) thesis (under review), Australian Maritime College, Tasmania, Australia.

Wakeford, J., (2001). Squid Fishery Management Co- SLED tests at the AMC flume tank. Proj. No. 01/G/01. AMC Search Ltd (internal publication), Tasmania, Australia.

Wakeford, J., (2002). Sea-lion exclusion device tests for the Hoki/Squid Fishery Management Co Ltd at the AMC flume tank facility. Proj. No. 02/F/04. AMC Search Ltd (internal publication), Tasmania, Australia.

Ziembo, Z., 1987. Correlations among velocities of water flow through the trawl. *Bull. Sea Fish. Inst.,* NR 5-6 (103-104): 14-19.

CHAPTER 14

TED AND BRD TESTING PROTOCOL

Chapter Author:

Steve Eayrs

CHAPTER 14

CHAPTER 14

TED AND BRD TESTING PROTOCOL

Steve Eayrs

Summary

The protocol for testing new TED and BRD designs has been developed by NORMAC's TED and BRD Subcommittee to promote the ongoing development of effective bycatch reduction devices. It has three assessment phases:

- an initial assessment phase;
- a visual assessment phase; and
- an at-sea testing phase.

The initial assessment phase involves members of the subcommittee assessing the potential of a new TED or BRD design based on information provided by the fisher, including diagrams and photographs. The visual assessment phase follows and involves the subcommittee physically viewing the device or testing in a flume tank. This phase is required only if some doubt about the claimed ability of the device exists or further clarification is required. It also provides a mechanism to assess complex or unusual BRD designs. The at-sea testing phase involves the fisher being provided a permit to test the new device under normal operating conditions for a pre-determined period. The subcommittee provides instruction to the fisher regarding testing conditions and data requirements. If the new device performs satisfactorily then an independent Observer may board the boat for a period of around two weeks to enable a more rigorous assessment of the device.

Currently a new TED is deemed to have performed satisfactorily if no more than two turtles are caught during the at-sea testing phase. This target now seems excessive given that the range of approved TEDs in this fishery is already excluding almost 100% of turtles and catch rates across the fleet are estimated at around 30 individuals annually. Reducing the allowable catch to zero is recommended. This is a responsible move and ensures that any new TED designs perform as well as those currently approved for the fishery.

In the case of a BRD there is no bycatch target at present; the codend with the device simply needs to retain less bycatch than a standard codend. The results of at-sea testing are then provided to the subcommittee for recommendation or otherwise as an approved Bycatch Reduction Device. However, the testing of new or modified BRDs requires a reasonable benchmark by which the performance of the device is to be assessed. A bycatch reduction target of 10% (by volume or weight) compared to catches from a standard trawl is a good starting point in a testing environment where the precise measurement of bycatch volume is not possible. This target sets the benchmark at a reasonable level and is commensurate with performance levels of the currently approved BRD designs. The target could be increased in the future if desired following assessment of the industry by key stakeholders.

The protocol is designed to provide sufficient rigor to demonstrate the achievement of reduced bycatch while accommodating the inherent difficulties of testing BRDs onboard commercial boats during the fishing season. It also provides fishers with a quick and simple means of developing and assessing these devices onboard their boat while attempting to satisfy the concerns of other stakeholders.

Further refinement of analytical techniques, including accurate assessment of required shot numbers for a given statistical power, will be possible in the future as the protocol becomes more heavily used. This may occur sooner then previously anticipated given the recent removal of the Bigeye from the list of approved BRDs and the need for fishers to adopt another design suitable to their fishing operation.

14.1 Introduction

In April 2000, the use of TEDs and BRDs became a mandatory requirement for all boats operating in the NPF. Prior to the introduction of these devices, the Northern Prawn Fishery Management Advisory Committee (NORMAC) established a TED and BRD subcommittee to identify a range of TEDs and BRDs suitable for the fishery and develop design specifications for each device to ensure appropriate use and effective bycatch reduction (Appendix 3 – TED & BRD design specifications).

The TED and BRD subcommittee recognised the possibility of new or modified Bycatch Reduction Devices being developed by NPF fishers. A TED and BRD testing protocol, to promote the ongoing development of effective Bycatch Reduction Devices, was designed. The protocol provides fishers with a quick and simple means of developing new devices and measuring their performance with sufficient rigor to determine if bycatch reduction targets can be met. Underpinning the design of the testing protocol was the desire to encourage and foster the development of innovative Bycatch Reduction Devices, and to provide flexible testing requirements that accommodate the inherent difficulties of testing these devices onboard commercial boats during the fishing season.

This section assesses the efficacy of the TED and BRD testing protocol and makes recommendations for fine-tuning and improvement based on catch data collected during this project.

14.2 The protocol

The TED and BRD testing protocol has three main assessment phases (Figure 14.1):

1. An initial assessment phase;
2. A visual assessment phase; and
3. An at-sea testing phase – Fisher assessment and Observer assessment.

14.2.1 Initial assessment phase

The initial assessment phase involves the operator providing AFMA with written details of the device to be tested, including technical details and specifications, and a description of how the device will reduce bycatch. Copies of the details are then forwarded to three members of the TED and BRD subcommittee (a commercial fisher, an AMC fishing technologist and the AFMA NPF Manager) for review and comment. This group reports back to AFMA, usually within 48 hours of receipt, indicating their initial approval, or otherwise, of the device and recommendations for the next phase of development and testing.

The criteria for initial approval of the device are based on:

1. the expected likelihood of reducing bycatch to a level at least commensurate with approved devices; and
2. the potential threat the device may pose to endangered or threatened species.

The judgment of this device and ability to meet these criteria relies almost exclusively on the collective experience of the three subcommittee members (although additional advice may be sought if warranted). The recommendation for the next phase of assessment may include a request for visual assessment of the device and/or at-sea testing.

14.2.2 Visual assessment phase

The visual assessment phase involves one or more of the three subcommittee members either physically viewing the device or briefly testing it in the AMC's flume tank (approximately one day). The aim of this phase is to gain a better appreciation of the device, its operation and the likelihood of it achieving the claimed reduction in bycatch. This phase is only expected to be required when an entirely new or complex bycatch reduction device is developed, or if the details submitted in the initial assessment phase are inadequate or inconclusive. In most instances a device will not require this assessment phase.

The criteria for visual approval of the device is similar to that for the initial assessment phase, but with the possible additional expectation that the shape and orientation of the device in the flume tank is as claimed. The cost of transportation and flume tank testing is borne by AFMA from the NPF budget.

At-sea testing phase – Fisher assessment

The final assessment of the device involves at-sea testing onboard a commercial fishing boat. The fisher is provided with a scientific permit from AFMA to test the device under normal commercial fishing conditions, but which may include specific requirements related to the location fished (e.g. region of relatively high bycatch density), data collection methodology and the period of assessment. Currently these requirements are dependent on the type of device being tested and the judgment of the three subcommittee members. In the case of a new TED being tested, a permit is initially granted for four to six weeks.

During this time the fisher operates as per normal commercial practice, but if more than two turtles are caught in the net with the new device, the permit is revoked, and the device fails the assessment. An allowance is made for the abnormal, or rare, capture of a turtle, such as when a turtle has had insufficient time to escape from a TED during haul-back, or when a turtle is small enough to fit through the bars of the TED. The fisher can be requested to operate in an area where turtle encounters are likely such as north of Groote Eylandt or near Weipa, although the final location is negotiated between the fisher and the three subcommittee members.

In the case of a BRD, similar testing conditions apply, however no bycatch target currently exists. The fisher is allowed to test the device for about four weeks and may be requested to operate in an area of high bycatch abundance. During this time a TED must be installed in both nets and an approved BRD must also be installed in the other net.

Following completion of the initial at-sea testing phase the fisher is required to provide a report with shot-by-shot catch details. If a new or modified TED is being tested, details of turtle catches in the net fitted with this device are required. If a new BRD is being tested, details of bycatch volume comparisons between the net fitted with the device (treatment net) and a net without a BRD (standard or control net) are required. This is achieved either by visually comparing catch volume in each codend prior to release onto the sorting trays, by visually comparing the catch released in each sorting tray, or by counting full lug baskets of bycatch during catch processing. The control net is usually fitted with an approved TED with the BRD removed so that turtles are still excluded from the net but all small bycatch is retained.

At-sea testing phase – Observer assessment

Following receipt of the fisher report, the subcommittee may decide to either approve the device, or request further testing and assessment. In most instances where a TED is tested a trained observer is required to independently assess the performance of the device over several weeks onboard the fishing vessel. If more than two turtles are caught during testing the TED fails the assessment.

In instances where a BRD is being tested the requirement for an observer may be waived. This may apply when there is little risk of encounter with protected or endangered bycatch species, or when the performance of the device is unlikely to differ substantially from that of already approved devices. However, in most instances, further testing will require an observer to board the boat for a pre-determined period. The observer collects relevant catch data from the treatment and the control, and will provide a detailed report analysing the performance of the device over the test period.

The observer will usually be onboard for one or two weeks depending on the device being assessed and the amount of bycatch caught. For example, the observer may be onboard for only several days if three turtles are caught in this time, or several weeks if fishing in a region of low bycatch density. Only in exceptional circumstances will the assessment extend beyond three weeks.

The three subcommittee members review the observer report and decide whether the device is acceptable for inclusion as an approved Bycatch Reduction Device. The criteria for accepting the device will be largely based on its ability to prevent the capture of endangered or threatened species, and its ability to reduce bycatch to a level at least commensurate with current TED and BRD designs. NORMAC and AFMA makes the final endorsement, and the results are promulgated to NPF fishers and other stakeholders. To maintain confidentiality all potentially sensitive information, such as prawn catch rates and fishing location, is not released. The costs of the assessment by the observer are met by AFMA.

14.2.3 Testing of turtle excluder devices

To date one fisher has used the testing protocol to test a TED. Mr. John Thomas, owner of the FV *Beachlands*, developed two versions of the Bigeye BRD (known as JT1 and JT2) and requested a scientific permit to test the ability of these devices to exclude turtles during the 2000 tiger prawn season. Both devices passed the initial assessment phase and a permit for one month was provided. The sub-committee decided that visual assessment was not required given the degree of modification

During the initial at-sea assessment phase the JT1 captured three turtles (in 72 shots), and therefore failed to meet the criteria for an approved TED. The scientific permit was revoked for that device.

The JT2 was a re-modified version of the JT1. A scientific permit was provided to test this device. It was tested over 111 shots and during this period one turtle was caught. An observer was then placed onboard to independently assess the device. After 39 shots the JT2 caught three turtles and the TED was deemed to have failed to meet the criteria of the scientific permit. Further details of this report can be found at www.afma.gov.au.

While both TEDs failed the at-sea assessment phase, this example highlights the ability of the protocol to provide an effective mechanism to assess the performance of a new Bycatch Reduction Device.

The provision of the scientific permit to the fisher occurred within two days of his initial application, and he was able to immediately commence at-sea testing of the device. An observer was already at sea involved in TED and BRD developmental work and was readily available to commence independent assessment of the new TED soon after completion of the initial at-sea assessment phase.

14.2.4 Testing of bycatch reduction devices

One fisher applied for a permit to test a Bycatch Reduction Device. Mr. Jim Yarrow, skipper of the FV *Rosen C*, was granted a permit to test a modified Fisheye during the 2002 tiger prawn season. This device was essentially identical to the Fisheye currently approved for the fishery with the addition of two steel bars inserted across the escape opening (Appendix 6). The bars were designed to prevent the escape opening from collapsing during haul-back, particularly following heavy contact with the vessel as the codend is hauled onboard. This device had earlier passed the initial assessment phase, and the sub-committee decided that visual assessment was not required given the degree of modification. An observer was placed onboard the boat to independently verify catching performance.

The November 2002 at-sea testing of the modified Fisheye by the observer occurred over 13 nights. A total of 51 trawls shots were completed and the fisheye excluded 20% of the small bycatch by weight compared to a control net ($p = 0.0024$, $df = 38$) (Appendix 6). Additionally, there was no significant difference in tiger prawn catch between control and treatment nets ($p = 0.2481$, $df = 42$). This device was recommended for use in the fishery and it is now referred to as the Yarrow Fisheye.

14.2.5 Proposed modifications to the at-sea testing phase of the protocol

Because only two fishers have taken the opportunity to apply for a permit and test a Bycatch Reduction Device it is difficult to critically assess the performance of the protocol. However, it is possible to make some general comments and recommendations regarding testing conditions for the future assessment of new or modified Bycatch Reduction Device.

At-sea testing phase – Fisher assessment

The initial phase of at-sea testing, whereby the fisher reports on the performance of a new or modified device, currently seems adequate. This period allows the fisher to assess the suitability of the device to exclude bycatch species and meet his operational needs, including ease of handling and robustness. There seems little point of going to the time and expense of placing an observer onboard at this time given that the device might be deemed unsuitable by the fisher and testing discontinued. Moreover, it gives the fisher time to modify the device if necessary and refine its performance.

At-sea testing phase – Observer assessment

The use of an observer to complete the at-sea testing phase is an essential part of the assessment process, but it is not without problems. The number of suitably qualified observers to assess TED or BRD performance is very limited, the logistics of transporting observers to and from the boat are considerable, and the methodology to test the device is not well defined and hampered by lack of control over the testing environment. The current options for sourcing a suitable observer is either from the pool of observers used by AFMA, from recent AMC fisheries graduates, or possibly unemployed fishers. In most instances the observer will also require specialised training in working effectively onboard a prawn trawler, including catch sampling techniques, TED and BRD specification and operation, and sea safety. The observer may also need to know how to sew trawl gear if transfer of the BRD and codend is required between port and starboard nets.

The logistics associated with placing an observer onboard a commercial boat are also considerable. The fishery is extremely isolated and identifying a suitable time and location to meet the boat requires considerable effort. Although it is possible to fly into the region bounded by the fishery there are a limited number of airfields scattered around the coastline, flights are infrequent and flying costs are high. Linking up with the boat is also difficult because it often requires the skipper to steam long distances to meet the observer and this may mean leaving productive fishing grounds or lost fishing time.

An alternative is for the observer to travel on a fuel barge to meet the boat. These barges usually depart from Cairns or Darwin and steam into the Gulf of Carpentaria, or other regions of the fishery, to meet individual boats at approximately fortnightly intervals. This option has the advantage that most boats periodically meet a barge to re-victual. The convenience and guarantee of meeting the boat means that this is probably the best option for placing the observer onboard, despite the possibility of spending up to one week steaming to and from a port.

Alternative at-sea testing phase

In the future it might be possible to undertake at-sea testing of TEDs and BRDs on an annual basis in the same location of the fishery. This is similar to that used by shrimp fishers in the Gulf of Mexico. These fishers seek certification of new devices by requesting the United States National Marine Fishery Service (NMFS) test their device using a small research boat. The testing of these devices by NMFS occurs annually under controlled conditions to satisfy strict assessment requirements and gauge their performance against bycatch targets. This option is currently not appropriate in the NPF given the lack of interest to test new devices, but could be considered in the future should interest increase substantially and a suitable boat is available on a regular basis.

14.2.6 Bycatch targets for TEDs

Currently a new TED is deemed to have performed satisfactorily if no more than two turtles are caught during the at-sea testing phase. This target was set several years ago when there was little information about the effectiveness of TEDs and to account for the rare capture of a turtle. In some cases a turtle can be caught in a net ahead of the TED, as it had insufficient time to escape before the commencement of haul-back.

The target of two turtles when testing a new or modified TED should be revised. This figure is excessive given that fishers have been using TEDs since 2000, the range of approved TEDs in this fishery is excluding almost 100% of turtles and catch rates across the fleet are estimated to be around 30 animals. Reducing this target to zero is an appropriate and responsible move in light of this data, and continued concerns over the impact of trawling on turtle populations. Moreover, such a target ensures that any new TED designs approved for the fishery are as effective as currently approved designs.

14.2.7 Bycatch targets for BRDs

It is currently difficult to apply a bycatch reduction target when testing a new BRD because of difficulties measuring the volume of bycatch retained in each codend. During the initial at-sea testing phase, the assessment of bycatch by fishers relies heavily upon their ability to visually estimate catch weight in the codend as the nets are hauled onboard, or following release of the catch onto the sorting tray (assuming that mixing of catch from each codend does not occur). In both instances the accuracy of bycatch estimates is poor because the catch contains both prawns and bycatch, and it relies on the subjective judgement of the fisher.

An alternative method for estimating bycatch weight is to process the catch from each codend separately and fill lug-baskets with bycatch as it enters the trash chute. The weight of bycatch caught in each net is then based on a count of full lug-baskets. This process is time consuming and can delay prawn processing, particularly if large volumes of bycatch are caught. Emptying the lug-baskets is also extremely heavy work, particularly on a moving boat in poor weather.

Another option for measuring bycatch weight is to measure total catch weight (prawn + small bycatch) as the codend is hauled onboard using electronic load-cells. This method avoids the need for heavy lifting but requires specialised equipment, and may also delay processing operations because codend weight can only be measured accurately when the codend is hanging steady from the rigging; a near impossible feat in heavy weather. This method also requires prawn weight from each codend to be subtracted from total catch weight, but it may be difficult to process the prawn catch from each codend separately if catches cannot be separated on the sorting tray.

Providing the catch from each net can be processed separately, using lug-baskets is likely to be the most accurate method of measuring small bycatch. A lug-basket filled to the handles with small bycatch typically weighs around 35 kg and it is simply a matter of counting the number of lug-baskets between nets. If fishers can be persuaded to undertake this heavy work during the initial at-sea assessment then this option should be pursued. However, it can pose a hardship on crew so if necessary this can wait until an observer is onboard.

There is presently no small bycatch target to be met by existing approved BRD designs. However, a bycatch reduction target of 10% (by weight) compared to a standard net is a good starting point. This target sets the benchmark at a reasonable level and is sufficiently high to be measurable in an environment where the precise measurement of bycatch volume is difficult. Importantly this target is commensurate with performance levels of the currently approved BRD designs and can readily be increased in future if desired.

14.2.8 Test location

Currently, there are no prescribed locations in this fishery to assess TED or BRD performance. This is because the protocol is designed to foster and encourage the development of efficient Bycatch Reduction Devices, and it is feared that such prescription would undermine this philosophy by forcing fishers to depart from productive fishing locations. However, it is clear that a device should be tested where bycatch is likely to be encountered. For example, a TED should be tested in a location where turtles are commonly encountered, such as near Weipa or north of Groote Eylandt. The testing of a BRD should occur where substantial volumes of small bycatch are caught, such as Weipa or the Vanderlin Islands. Attempts should therefore be made to ensure the timing of a test occurs when the boat is in one of these locations. No attempt has previously been made to rigidly impose this requirement upon the fishers.

14.2.9 Test timing

Given the protocol's current level of sophistication there is no prescribed timing for the testing to occur. Generally, the fisher assesses the device towards the end of the fishing season when catches are low as this lessens the financial impact of any loss of prawn catch. The availability of an observer and associated transport may influence when the observer can board the boat and the duration of the assessment phase. If the observer is reliant upon fuel barges for transport then usually a period of around two weeks is available for testing a device before the boat meets the barge.

14.2.10 Trawl design, rigging and operation

The assessment of a new or modified BRD requires the catch (prawns + small bycatch) to be compared between two trawl nets. Both trawl nets should be identical in size (headrope length), design and rigging. This ensures that the area of seabed swept by each net is similar and the response of prawns and bycatch to the stimulus of each net is identical. Fishers typically use nets of the same size and design so this will usually not be an issue, although each net should be measured and checked before the tests commence. The identical rigging of both nets is more problematic because fishers may have their nets or otter boards rigged differently to account for any differences in operation or catching performance. Examples of this include different otter board settings, ground chain attachment or sweep lengths between nets. It is also essential that all codend dimensions are checked for both nets, particularly if both the device and codend are swapped between nets during the assessment, because any difference may result in substantial catch bias between nets. A codend data sheet has been previously used with success to identify differences between nets.

If a TED is being tested then the design, rigging and operation of the trawl nets are generally not important, as they will have little impact on the ability or number of turtles that enter the trawl. However, it is important to record all TED dimensions, especially grid size (height and width), shape, orientation, bar spacing, grid angle and dimensions of the escape opening and cover.

14.2.11 Control net configuration – BRD assessment

When an observer is comparing the catching performance of a new or modified BRD it is important to consider the configuration and location of the TED both in the control net and the treatment net (the net with the new or modified BRD installed). In order for BRD performance to be compared between nets both TEDs must have a similar influence on the capture of small bycatch, thereby reducing the potential for catch bias in one net. It is essential that both TEDs are identical in every way including grid size, shape, orientation and bar spacing. It may also be necessary to replace the escape covers on both TEDs so that their ability to close and seal over the escape opening is similar. The size and location of the escape opening in the codend should also be identical between nets.

The testing of a new or modified BRD requires that its performance be assessed against a control. This control may take the form of either:

- a control BRD with a known level of performance (each will have a TED fitted); or
- a standard net without a BRD fitted.

Both options for a control net have inherent advantages and disadvantages (Table 14.1). The decision of which control to use has not been formally adopted, but to a large extent, depends on the aim and overall goals of the study.

During assessment of a new or modifed BRD by the fisher (prior to the observer boarding the boat) it does not seem necessary for either the control BRD or a standard net without a BRD configuration to be employed. In many instances the fisher may not have experience with the control BRD and it is more important for the fisher to focus on the performance of the new device against one that he is familiar with. In this way the fisher will be able to confidently compare catching performance between nets and readily identify the potential of the new device for further assessment by the observer. This also prevents the capture of additional bycatch by a standard net or poorly operated control BRD. The location of the new or modified BRD during the at-sea tests should be left to the discretion of the fisher.

Control BRD with a known level of performance

The selection of a control BRD with a known level of performance requires a device that has been tested extensively and rigorously, and found to perform well in excluding bycatch. In this way the bycatch reduction target, or benchmark, is high and the approval of a new device is based on its ability to reduce similar, or greater, amounts of bycatch. Over time, as more devices are developed, a new device can become the new benchmark, thus ensuring that even greater amounts of bycatch are excluded from the net. While all BRDs currently approved for this fishery (with the exception of the Bigeye) are known to exclude some bycatch (Appendix 3) the Yarrow Fisheye was found to catch around 20% less small bycatch than the control net (Appendix 6). It also caught the same weight of commercially important prawns as a codend with no BRD. This study is currently the most thorough and successful assessment of a BRD in the fishery thus far. The Yarrow Fisheye would therefore be the most likely candidate for selection as the control BRD.

Table 14-1. Advantages and disadvantages of using a standard net or a control BRD to compare the performance of a new or modified BRD.

	Advantages	Disadvantages
New BRD V standard net	• Standard net provides a suitable control (baseline) because the codend is assumed to be totally non-selective. • Overcomes problem of many uncontrolled variables e.g. bycatch volume and escape behaviour, and hence allows relative comparison between devices in different locations.	• Inability to directly determine if BRD is better (or worse) than other devices in excluding bycatch in a particular location.
New BRD V control BRD	• Allows immediate comparison between devices. • Relative performance promotes and accelerates development of improved BRD designs because benchmark continually increases.	• Inability to assess total amount of bycatch excluded. • Difficulty comparing results to similar tests elsewhere because performance of the control BRD may be different or unknown. • Complexities associated with monitoring the position of the benchmark, particularly if it is increasing regularly.

Standard net without a BRD fitted

Currently the performance of the approved BRDs has been quantified in very few regions of the fishery and under a limited range of operating conditions. Therefore a disadvantage of using a control BRD is that it is not known by how much performance will differ between locations and conditions. This device may perform well in some locations of the fishery but not in others. As factors influencing BRD performance have not yet been fully identified or measured, its use as a control may lead to the inappropriate approval or rejection of a new device. Additionally, the volume and type of bycatch that enters a net can have a substantial impact on the performance of the BRD, and because this information is not collected only the relative performance of the new device can be reported.

The only way to assess the total volume of bycatch excluded from a codend with a BRD is to compare retained catch rates against a standard codend (with BRD removed) that is assumed to be totally non-selective. In this way the volume of small bycatch retained by the standard net more accurately reflects the volume of small bycatch that entered the net with a BRD installed, and the likelihood of a correct assessment of the device is enhanced. For these reasons it is recommended that future assessment of a new or modified BRD be made against a standard net without a BRD fitted. This allows the setting of bycatch targets (by volume) against a control whose performance is less effected by the variables of time and space, and can provide a more accurate assessment of BRD performance for specific bycatch species including those that are endangered or protected.

14.2.12 Control net configuration – TED assessment

If a new or modified TED is being tested, then the design, rigging, location and operation of the TED in the control net is not important. This is because the assessment of a new TED does not require comparison with the other TED; the current target of two turtles is independent of the number caught in the control net. The design, size and location of the BRDs in either net will usually have no impact on the catch of turtles or the ability of TEDs to exclude these animals, so this information will usually not be required.

14.2.13 Location of the BRD

The location of the BRD in both nets is important. The current BRD regulations permit the device to be located anywhere in the codend provided it is no more than 120 meshes from the codend drawstring. Most fishers locate their devices as far as possible from the drawstring due to fears that prawns might escape, particularly during haul-back when the codend is on the sea surface. However, with the BRD in this location the ability of small bycatch to escape through the device is compromised. This is because small fish have limited swimming ability and are usually unable to attempt repeated escape attempts through the BRD. When small fish first enter the codend they may attempt escape as they approach the BRD. If they are unsuccessful they may then turn ahead of the accumulated catch, swim forward and re-attempt escape. In general, the closer the BRD is to the drawstrings and accumulated catch the greater the likelihood that small fish will successfully reach the BRD and escape.

In the study by Gregor *et al.,* (Appendix 6), the Yarrow Fisheye was located 68 meshes from the codend drawstring. This is the closest distance to the drawstring that a device has been tested in this fishery and it most likely contributed to the high rate of bycatch reduction. It was noted that some poor weather was experienced, an important fact because poor weather can cause the catch to surge forward when the codend is on the surface resulting in prawn loss. As there was no loss in prawn catch in this study, the fears related to prawn loss at the surface may be unfounded and additional assessment of BRDs in this position are recommended.

14.2.14 Tow direction, duration and timing

As the aim of the protocol is to assess the performance of a new or modified TED or BRD under commercial fishing conditions no attempts are made to impose limitations upon tow direction, duration and timing during the at-sea testing phase. There is no evidence suggesting that these factors influence catch rates of turtles, or the ability of TEDs to exclude these animals. It is likely that these factors affect the performance of a BRD, but this evidence is largely circumstantial. Towing direction is important because it influences trawl speed relative to the tidal stream, and hence the required swimming speed for a fish to escape from the trawl. Tow duration and timing are also important because they will influence the amount of small bycatch that is caught; longer tows generally catch more small bycatch than shorter tows, and a trawl shot at dawn or dusk usually catches more than those during the middle of the night. This is important because the distance between the BRD and accumulated catch is less if catch volume is large, making it easier for new arrivals to turn ahead of the catch, orientate towards the BRD and escape. It is for the same reason that BRDs closer to the drawstrings usually have higher rates of bycatch reduction. This will probably not be a problem if the performance of a new or modified BRD is compared to a control BRD located the same distance from the codend and both rely upon the swimming ability of bycatch to escape e.g. Fisheye or Radial Escape Section

(RES). However, if the BRD is being compared to a standard codend then it is possible that the performance of the device will be linked to tow duration. In other words, the longer the tow the higher the rate of bycatch reduction that may be recorded.

Tow direction is usually recorded by electronic plotter. However, as several directions are towed during a trawl-shot this information is of little use during assessment of a device. Taking note of turning direction may indicate a preference for turning in one direction or another - trawl performance differs substantially during a turn with the inside trawl coming almost to a stop while the outside trawl increases in speed (to the extent bottom contact may be lost during the turn) – but is unlikely to have a major influence on catches during a tow of several hours or more.

14.2.15 Performance assessment - analysis

If a new or modified TED is being tested, then performance assessment is simple and straightforward. There is no need to calibrate net performance between sides because catches of turtles are independent of net configuration (ie. the configuration of one net has no influence on the catch of turtles in the other net). The trawl simply needs to be rigged and operated as per normal commercial practice. The analysis of catch data is straightforward, being based on the number of turtles caught during the allocated testing period.

If a new or modified BRD is being tested then performance assessment is considerably more complex. This is because the catching performance of the new device must be compared against a control net but under commercial conditions it is not possible to control operational variables such as towing location or direction or environmental variables such as lunar or tidal periodicity. It is also usually not possible to prevent the fisher from modifying the gear at some stage during the testing process.

Performance assessment (Calibration)

There is some conjecture regarding the need or otherwise to undergo a calibration phase when measuring the performance of a new or modified BRD. The need for calibration usually occurs when it is not possible to change codends on a regular basis (i.e. after every shot or night fished) and the treatment BRD remains attached to the port or starboard net for several days. Calibration involves measuring catches of prawns and small bycatch from each net with the BRDs removed or sewn up (both nets must have identical TEDs to guard against turtle capture). In this way both codends are assumed to be non-selective and any difference in the catch of prawns and small bycatch is then assumed to be due to a difference in catching efficiency between the two nets. As the nets are considered to be independent and fish evenly for both prawns and small bycatch, any reported catch difference can then be accounted for in the analysis of catch data.

The study by Gregor *et al*., (2003) (Appendix 6) is one of the first attempts in the NPF to calibrate nets and compare catching performance. A calibration phase was conducted over the initial two nights and final two nights of their study. There was a significant reduction in small bycatch in the port net of 9.37% compared to the starboard net over the four nights ($p=0.0074$). All catches were adjusted for both nets by this amount.

Calibrating catches at both the beginning and end of the study assumes any subtle changes in the catching efficiency of the nets are taken into account, such as ground chains or net hangings becoming stretched. However, a problem with this technique is that it ignores any sudden, unsteady, infrequent or cyclic influences such as fishers tinkering with their gear, damaged nets or lunar influences on prawn emergence behaviour that occur between calibration phases. In the study by Gregor *et al.,* (2003) (Appendix 6) the calibration phases occurred two weeks apart - half a lunar phase - and the behaviour of prawns and small bycatch is likely to have been different between these periods. Therefore, by combining both calibration phases in their study the possible difference in behaviour between nets during the testing period was ignored. The catches of bycatch in the port and starboard nets during the initial calibration phase were on average 82% and 123% higher than respective catches in the second calibration phase. Moreover, during the second calibration phase 42% of shots recorded less than 2% difference in bycatch between nets, while no shots recorded less than 2% difference during the initial phase. Perhaps these results are circumstantial and influenced by low available shot numbers. However, it does serve to highlight the problems associated with net calibration.

Another problem with calibration is that any adjustment to the gear is based on a relatively low number of shots. Gregor *et al*., (2003) (Appendix 6) used catch data from just 13 shots (4 nights) to calibrate and adjust catches from 30 shots during the testing phase. It can be argued that providing some of these influences affect both nets equally then there is no need to account for them. Despite this, undertaking at least one calibration shot before assessing BRD performance can at least reassure the researcher that both nets are performing similarly.

The bycatch weight data recorded between treatment and control nets by Gregor *et al.,* (2003) (Appendix 6) reveals some interesting issues. When the BRD was located in the port net the average weight of bycatch per net was 160 kg whereas when the BRD was located in the starboard net the average weight per net was 240 kg, a 50% increase in bycatch. Also, the average difference in bycatch weight between the treatment net and control when the BRD was fitted to the port net was approximately 50% less than when fitted to the starboard net. This is perplexing given that the port net was already catching 9% less bycatch than the starboard net based on results of the calibration phases, and therefore should have recorded a higher average difference in bycatch between nets than when the BRD was located in the starboard net. These problems raise the issue that calibrating trawl nets is problematic, particularly when the available testing time is short.

Given that an observer is available to assess the performance of a BRD between barge trips, then approximately two weeks is available for testing the device. During this time it should be possible to collect catch data from 40 to 50 4-hour trawl shots. It is not possible to delay the fishing operation and swap the BRD between port and starboard nets after each shot. Attempts should be made, however, to regularly test the device on both sides during the trial period. If the crew is amenable to daily exchanges of the codend and BRD between nets then this should be pursued – it might even require the observer to undertake the task of additional net sewing. If this is not possible then the device should be tested on both nets and swapped every few days. By regularly swapping sides and collecting catch data it should be possible to obtain information about any catch bias between the nets, potentially negating the need for calibration testing.

A recommendation for the future at-sea testing of a BRD could be the addition to the fishing permit provided by AFMA that the device must be tested on both nets and exchanged every day or two for the duration of the trials.

14.2.16 Number of trawl shots

It is difficult to prescribe the number of trawl shots required to rigorously assess the performance of a new or modified TED or BRD. This because previous testing of these devices in the fishery has usually focused on the practical aspects their operation and usually over a short time period. Additionally, as there have been few attempts to control the testing environment or measure testing variables, quality data is scant.

In the study by Gregor *et al.*, (2003) (Appendix 6) the performance of the Yarrow Fisheye was assessed over a period of 13 nights. In this time catch data from a total of 51 trawl shots was collected. Based on this data the number of shots (n) required to detect a desired level of significance for both small bycatch and prawns was assessed using the following expression:

$$n = \frac{\left(Z_{\beta} + Z_{1-\alpha}\right)^2 \sigma^2}{\delta^2}$$

where Z = critical value, α = significance level (e.g. 0.05), β = required level of certainty (e.g. 80%), σ = standard deviation, δ = the desired difference to be detected (e.g. 5%). The outcome of this analysis indicated a total of 18 trawl shots (9 with the device on each side) were needed to be 80% certain of detecting a 10% change (reduction) in small bycatch between treatment net and control net. The number of shots with the device on each side increased to 36 to detect a 5% significant difference in small bycatch. In the case of tiger prawns only 7 shots per side were required to be 80% certain of detecting a significant difference of 10% and 26 shots per side for a 5% difference. These figures are based on catch data taken from a discrete area of the fishery. In other regions, where bycatch and prawn density is likely to be substantially different, the number of shots required to achieve the desired level of significance will not be the same. These figures should therefore be considered a guide only.

Despite a desire to produce statistically rigorous results the ability to realise such results will be largely determined by the available testing time and budget. Given that the observer is available between consecutive barge trips it is possible to use the entire available time. In most instances this will be several weeks and should be sufficient to allow for catch data to be collected from at least 40 shots. This equates to the estimates reported previously for a 5% level of significance. As additional fishers use the protocol, catch data can be similarly analysed to improve our estimates of shot number. Over time, knowledge of shot numbers for a particular testing location can be obtained. However, it should not be forgotten that the objective of the protocol is to test BRDs under normal commercial operating conditions and not under conditions that control all variables to produce a statistically robust result that does not reflect true operating performance.

14.3 Conclusion

The TED and BRD testing protocol is designed to provide an effective and flexible mechanism for fishers to develop innovative devices to reduce bycatch. Importantly it also provides a mechanism by which the performance of these devices can be scrutinised by other stakeholders.

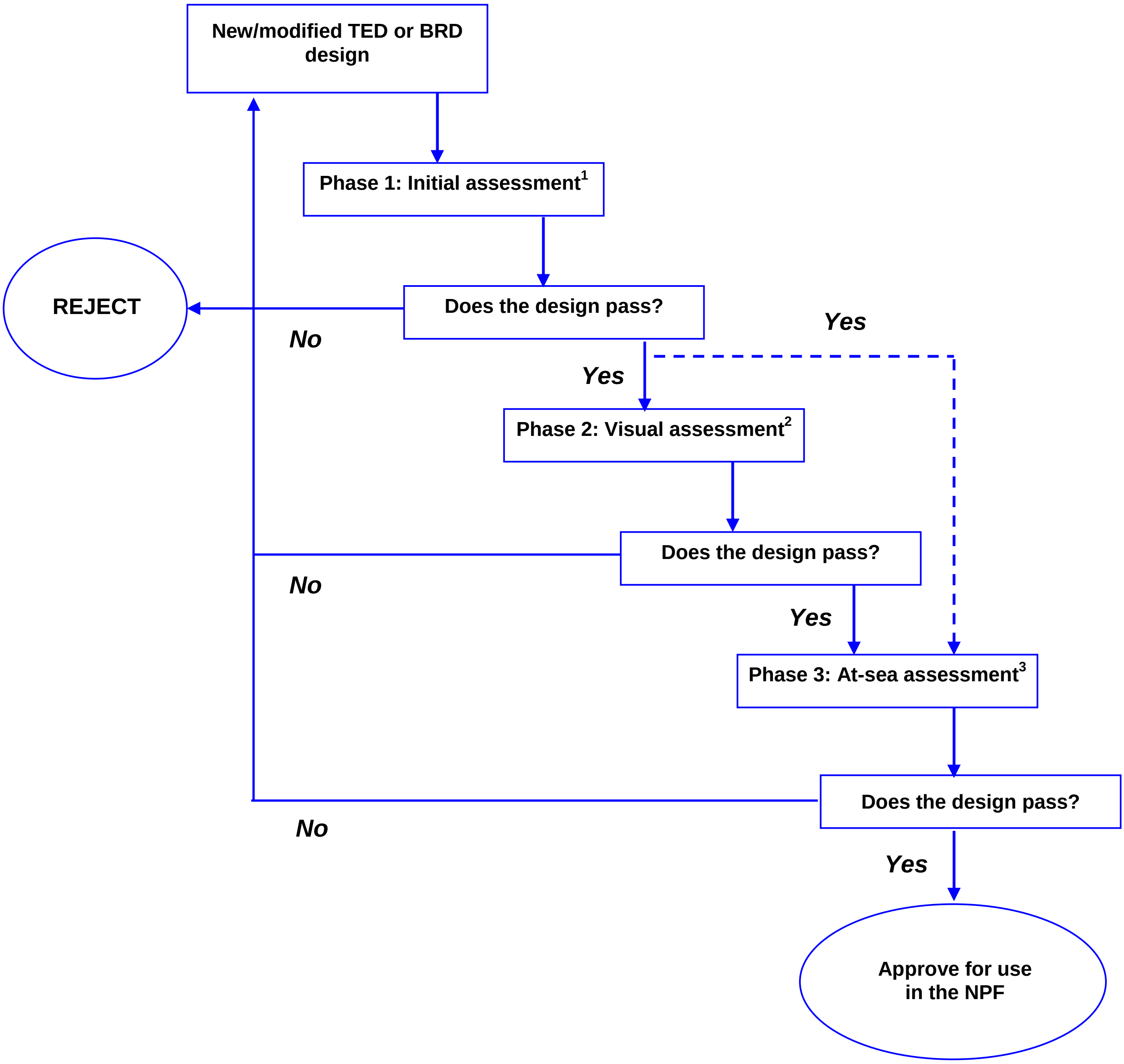
The low number of fishers that have used this protocol does not reflect a failure to deliver a suitable mechanism to test new Bycatch Reduction Devices. Instead it more likely reflects a low level of interest by fishers to develop and test new designs at this stage of the evolution of TED and BRD use. This may be attributable to fishers being reasonably happy with the current TEDs and BRDs used in the fishery and/or a lack of incentive to reduce small bycatch. Anecdotal reports indicate that most fishers are increasingly satisfied with the performance of their TEDs, and to a lesser extent their BRDs. Most fishers rate BRD performance in terms of prawn catch retention and not bycatch reduction, hence in an effort to reduce prawn loss they locate either their BRDs in the codend as far away from the accumulating catch as possible (around 120 meshes from the drawstrings) or use the Bigeye BRD in the main body of the trawl. In this position fishers are reasonably satisfied with their BRDs and therefore see little reason for further development, particularly given the limited fishing season and risk of prawn loss.

A recommendation is for future testing of new or modified TEDs to be conditional on a catch target of zero turtles. This target is easily measured and the testing process is relatively straightforward. Apart from reducing the catch target there seems little need to adjust the protocol in its current form.

On the other hand, the testing of new or modified BRDs is more problematic and complex, and modification to the protocol is recommended. There is currently no bycatch target with which to gauge the performance of a BRD. A target of 10% is recommended as an appropriate starting point because this figure is sufficiently high to be measured under normal commercial fishing conditions and is at a level commensurate with existing approved BRD designs. This target can also be increased if desired.

The existing testing criteria for an at-sea permit does not prescribe in detail the conditions for testing a TED or BRD as this is counter to the philosophy of encouraging fishers to develop and test new devices. However, there is currently provision for specifying where the tests should take place and the type of bycatch data to be collected. During future tests of new or modified BRDs it is recommended that the condition of regularly swapping the codend and BRD between nets also be introduced and that testing occur over at least two weeks. This is an attempt to remove the need for calibration trials; although one or two nights testing identical trawl nets could still be undertaken if desired. By regularly swapping the location of the BRD the main objective of the trials is not compromised, and any net or side effects can be accounted for in the analysis.

The establishment of the protocol by the TED and BRD subcommittee is an evolving process that will be refined as more experience is gained in the testing of these devices across the entire fishery. In the main, the protocol in its current form is generally appropriate and meets the expectations of most stakeholders. Fishers have the opportunity to test and develop a Bycatch Reduction Device under commercial conditions, the performance of the device is reported to the subcommittee and the costs of testing the device are kept to a minimum. Importantly the protocol provides a ‘snapshot’ of the performance of the device under test, and the results of such tests should be considered accordingly.



1. Initial assessment of TED or BRD design, including rigging details, specifications and location in the codend.

2. Visual assessment of actual device fitted to a codend.

3. At-sea assessment initially by fisher, then by TED/BRD observer if required.

Figure 14-1. The TED/BRD Testing Protocol.

CHAPTER 15

COMMUNICATIONS AND INDUSTRY LIAISON REPORT

Chapter Author:

Brian Taylor

CHAPTER 15

CHAPTER 15

COMMUNICATIONS AND INDUSTRY LIAISON REPORT

Brian Taylor

Summary

CSIRO and AMC staff maintained frequent and close communication and liaison with each other, with external collaborators and other NPF stakeholders throughout this project. It was recognized that this would, among other things, help maintain interest and co-operative enthusiasm.

Many forms of written media, personal verbal and group meetings were used to reach the key stakeholders. All communication included delivering current progress reports on the project and up-to-date results. Merchandise in the form of caps and shirts with unique project logos were also distributed to help maintain interest and co-operation. The effectiveness of the projects' communication program is illustrated by the high level of participation, enthusiasm and co-operation shown by commercial industry in this and other concurrent projects.

The communication activities of this project will continue beyond the final report by circulating summaries of the project results to the NPF and other stakeholders by way of industry workshops, face-to-face meetings in ports, industry magazine articles, media releases, Industry newsletters and brochures and scientific papers.

15.1 Introduction

Communication and liaison were recognised as key activities in this project because of the close involvement with industry and other stakeholders. It was important to keep industry and all other stakeholders fully informed of the objectives, activities, results and benefits of the project. This will encourage industry members to co-operate, provide answers to important questions posed by industry, and help researchers understand the industry perspective. It was also recognised that effective communication and liaison would demonstrate a strong commitment to the success of this project

15.2 Objectives

The following objectives are reworded from the original communication plan in the project document:

- to inform all TED/BRD project staff of project progress;
- to inform all collaborators (representing owners and managers of trawlers), other sectors of industry, and NPF stakeholders of the project and its progress;
- to encourage collaborators and other industry sectors to actively participate in the project.

15.3 Internal communication and liaison

CSIRO Marine Research and AMC staff members were present at meetings between the main project investigators. Throughout the life of the project, regular meetings were held at CSIRO and between CSIRO and AMC officers through phone conferencing. Also effective internal communications were maintained through the distribution of project newsletters (Appendix 7) to all project staff. Email, phone contacts and occasional face-to-face meetings were also used to discuss specific issues between CSIRO, AMC, FERM, Traffic Oceania and NPF collaborators.

15.4 External communication and liaison

Communication activities were varied, including many that arose opportunistically while meeting the objectives of other CSIRO and AMC projects in the NPF. CSIRO and AMC staff members delivered information and listened to industry views during a range of activities not necessarily associated with this project (including field sampling, meetings, and daily office activities). A description of the external communication and liaison activities used in the project are described below.

15.4.1 Planned activities

Project staff maintained personal interaction, had frequent phone contact and distributed written progress reports about the project to a range of stakeholders, especially NPF operators (skippers and crew, trawler owners, net makers, other involved companies and contract service people), other researchers and government managers (Table 15-1). Planned activities were as follows:

Personal contact and port visits

Personal contact with sea-going personnel was held during fishery closure periods, usually just before the start of the fishing seasons for the convenience of trawler skippers and crews. Opportunities to contact shore-based people, either in person or by phone were taken at various times throughout the year. All this contact ranged from casual informal one-on-one discussions to more formal meetings and workshops with small and large groups.

Project staff made regular visits to NPF ports (Table 15-1) to take advantage of the gathering of NPF operators just before the start, and at the end of each fishing season. A total of 20 port visits were made during the project and ports visited included Brisbane, Cairns, Weipa, Karumba, Darwin, Fremantle and Perth. The number of project staff involved in each of these visits varied depending on planned activities. These ranged from formal meetings at advertised venues and in company premises, to workshops and practical demonstrations, to informal discussions at wharf-side and on-board operator’s vessels. Visits at the start of the 2001 and 2002 banana prawn seasons were coordinated with the AFMA logbook officers’ visits.

Distribution of written material

Written material included project newsletters, circulars, notices and memos, articles in popular literature and formal scientific papers. Some materials were targeted at, and distributed to, NPF owners and operators. Others were distributed more widely, depending on the message and the relevance to that audience. All project staff distributed written project material during organised or opportunistic events in the field, at fishing ports or from the office.

After two years of the project (as at July 2002), five issues of a *TED/BRD newsletter* (Appendix 7) each approximately 4 pages, were prepared and distributed to all NPF operators and stakeholders, including project staff and government personnel. The *TED/BRD newsletters* included project objectives and methods, introduced staff and collaborator lists, detailed the proposed and completed activities, and presented project results and progress reports.

Five CSIRO written notices (17/7/2000, 6/2/2001, 25/5/2001, 20/6/2001 and 25/7/2001 – see example in Appendix 7) and one AFMA notice (1/2/2001) addressed to NPF operators were also distributed. These notices summarised progress results and advised operators of forthcoming port visits, workshops and practical demonstrations. Several notices were also devoted to the planned observer activities to take place during the second season of 2001. For example, to explain what changes to regular trawler deck procedures might be necessary to assist the observer operation.

An article entitled *"NPF operators make gains in bycatch reduction - but some problems remain"* was published in Professional Fishermen and reprints were distributed to NPF operators and other stakeholders. The project also prepared and distributed a five page AMC technical paper, *"Improving TED efficiency in the NPF"* and a four page coloured leaflet *"BRDs in the NPF"* (Appendix 7). Both of the latter leaflets aimed to improve NPF fishers' ability to chose and operate TEDs and BRDs by providing a wide range of up to date knowledge and performance results about these devices.

Vessel Monitoring System (VMS) broadcasts

VMS fleet broadcasts via AFMA were used on two occasions as a supplementary means of conveying specific project information about the Observer Program to the NPF fleet while the fleet was at sea (October 2000 and May 2001 - see example in Appendix 7).

15.5 Opportunistic activities

Data and general information on the use and performance of TEDs and BRDs in the NPF came mainly from the project's Observer Programs and by incorporating comments and advice from trawler skippers and mates, owners and agents, net makers and others. However, additional information was gathered during activities, as detailed below, that were not scheduled specifically as project liaison events.

- *Northern Prawn Fishery Assessment Group (NPFAG):* Project staff attended the NPFAG meetings in Cleveland in April 2001 and October 2001 where an update and progress report on the project was presented. Some of the data provided was later used by the NPFAG to refine the NPF stock assessments. These meetings also offered an opportunity for information exchange with researchers, managers and some industry representatives.

- *NORMAC's TED and BRD sub-committee:* Project staff attended meetings of NORMAC's TED and BRD sub-committee in 2000, 2001 and 2002. These meetings also provided further opportunities for information exchange with net makers, fishers and managers.

- *BRD workshop:* Project staff attended an NPF BRD workshop in Cairns in February 2002 to discuss the operation and performance of BRDs in the fishery and update fishers on other project results.

- *Non-observer staff at sea:* During 2000 and 2001 project staff, in addition to the scientific observers, were at-sea in the NPF. Specific activities included fitting, tuning and measuring TED and BRD performance and assessing sampling methods for recording data on total bycatch. The time at-sea onboard commercial vessels was valuable for general liaison with skippers and crew of trawlers and motherships.

Table 15-1. Schedule of port visits and other communication and liaison events with NPF industry.

Date	Port(s)	Events and Primary Objectives	Staff
July 2000	Cairns	Introduce project, request co-operation from fishers	Taylor, Heales, Eayrs
July 2000	Karumba	Introduce project, request co-operation from fishers	Taylor, Heales
July 2000	Darwin	Introduce project, request co-operation from fishers	Eayrs
November 2000	Darwin	Distribute progress reports & literature	Taylor, Day
November 2000	Fremantle	Distribute progress reports & literature	Taylor
November 2000	Cairns	Distribute progress reports & literature	Eayrs
February 2001	Cairns	Address NPF workshop, promote project	Eayrs
March 2001	Fremantle	TED & BRD demonstrations, meetings, AFMA briefing	Taylor, Eayrs, Day
March 2001	Brisbane	General liaison, AFMA briefing	Day, Heales, Brewer
March 2001	Darwin	TED & BRD demonstrations, meetings, AFMA briefing	Taylor, Eayrs, Day
March 2001	Cairns	Meetings, AFMA briefing	Eayrs
June 2001	Darwin	Encourage participation by fishers in Observer Program, general liaison, verbal progress reports	Taylor, Day
July 2001	Darwin	Arrange observer participation, introduce 2 observers to participating trawler skippers, general liaison	Taylor
August 2001	Cairns	Introduce 3 observers to participating trawler skippers	Heales
February 2002	Cairns	Attend NORMACs BRD workshop	Brewer, Day, Eayrs
March 2002	Brisbane, Cairns, Weipa, Darwin	General liaison, AFMA briefing	Day
August 2002	Darwin	Arrange species distribution sampling, general liaison, verbal progress reports	Taylor

- *Main Observer Program:* Observers were at-sea for the second half of the 2001 fishing season. They collected large amounts of informal information on TED/BRD use (observer training included advice about communication and liaison) from 23 NPF vessels.

- *Fleet phone survey:* Project staff collected information on the use of TEDs and BRDs during a phone poll conducted in October 2001. This poll included around 60% of the NPF fleet's skippers.

- *Deck layout surveys:* Communication between project staff and industry operators occurred while trawlers were being assessed in port for the suitability of their deck layout for the observer-based data collection. At these times skippers and owners were interviewed to ensure they fully understood the observer process and how some data collection on deck might interact with commercial practice.

- *Banana prawn observer survey:* For the first two weeks of the first season in 2001, AMC and AFMA undertook a joint project to examine the effect of TEDs on banana prawn fishing. They used observers at-sea and this provided another opportunity for liaison and communication.

15.6 Promotional material for the project

Caps and T-shirts: Caps and bucket hats with a unique TED and BRD logo (See Figure 9-24 c) were designed for this project and distributed to NPF operators and associates in the early stages of the project. T-shirts with a new design and the words "Turtles Love TEDs" were also distributed (See Figures 9-24 a & b).

Certificates of Appreciation: Certificates of appreciation were sent to the skippers and crew of all 23 trawlers who participated in the Observer Program during the second half of the 2001 season (Appendix 7). Additional certificates were also sent to two owners as a 'thank you' for their co-operation and help, both during the Observer Program and other at-sea data collection activities.

15.7 Indications of success

Although many researchers agree that effective communication is an essential part of any research that directly involves the fishing industry, the success and much of the benefit gained from these activities is often difficult to list and quantify. This section presents information to indicate the impact of the project's liaison and communication activities.

- *Participation in project activities:* There was a high level of interest, participation and co-operation from trawler owners, skippers, crew and other industry stakeholders (for example mothership companies) during the at-sea components of the project. Almost one-quarter of the fleet participated in the Observer Program – enough to completely fulfil this major component of the project data collection. Mothership operators were kept well informed of project activities and provided a high level of co-operation during the Observer Program. High levels of participation and co-operation were received from skippers during the October 2001 phone poll of TED and BRD types. Data on devices used was collected from over 80% of the fleet – 60% from the phone survey and the remainder from the Observer Program.

- *The attendance by operators at meetings and participation at workshops and practical demonstrations*: There were more than 40 NPF operators, for example, at the BRD workshop in Cairns in February 2001. Pre-season meetings, usually held by company operators, provided forums for effective information exchange with large numbers of skippers and crew.

- *The willingness of individuals to discuss the project on boats and wharf-side*: The timing of port visits maximised the ability of project staff to interact with a significant proportion of NPF operators at several times during each year (up to 90% of skippers and owners Darwin and Cairns).

- *Good industry awareness of relevant literature available and potential sources of information*: The awareness of members of the fishing industry was apparent during discussions and when distributing material. This was also reflected in their willingness to co-operate with CSIRO and other organisations in subsequent fishery dependent projects (for example, the AFMA funded tiger prawn species distribution project which started in 2002): The ongoing presence of CSIRO project staff at NPF ports, at industry forums and on vessels has played a part in the successful level of co-operation gained from NPF operators during this prawn sampling project.

It has been clearly demonstrated that the objectives of the project's liaison and communication activities were met. The collaborative relationships that have been established between CSIRO, AMC and NPF operators, provides an excellent platform for the large amount of fishery dependent data collection activities planned for the next few years.

Project staff will continue to provide information on the results of this project through industry workshops and port visits initiated in subsequent projects and through publication of results in fishing magazine articles and scientific papers.

15.7.1 Other literature distributed

Some of the articles distributed were prepared as a part of this project, whilst some were prepared from other work. Many overseas and other Australian articles and news snippets were considered useful reading and were distributed to NPF operators.

Anon. (2001) TED's earn extra $735 a week. R &D News April.

Anon. (2001) TED's tested on NPF bananas. The Queensland Fishermen, December.

Anon. (2000) Selective shrimp trawls. INFOFISH International 6.

Garry Day (2001). Improving TED efficiency in the NPF. AMC, February.

Garry Day and Mathew Campbell (1999). Another year of TED and BRD tests in the Northern Prawn Fishery. Professional Fisherman, September.

Garry Day and Steve Eayrs (2001) NPF operators make gains in bycatch reduction - but some problems remain. Professional Fishermen, February.

Steve Eayrs and Shekar Bose (2002) TED performance measured during NPF banana prawn season. Professional Fisherman, October.

Steve Eayrs (2000) Weekly TED and BRD logbook returns – NPF and Torres Strait Prawn Fishery, 2000. AMC.

John Watson (1999) Effect of knot orientation on TED flaps. National Marine Fisheries Service.

Lyndal Wilson (1991) Take a note of knots. Australian Fisheries.

Anon. (2001) Turtle excluder devices save fishers dollars. CSIRO Press Release, February.

CHAPTER 16

NPF INDUSTRY REPORT

Chapter Authors:

Industry Co-investigators

CHAPTER 16

CHAPTER 16

NPF INDUSTRY REPORT

Industry Co-investigators

Summary

Chapter 16 is made up of a series of short reports from four NPF fishing operators, summarising their impressions of the introduction of TEDs and BRDs in this fishery.

David Carter (CEO, Newfishing Australia)

In my view the NPF TED/BRD project is an absolute standout piece of results-focused FRDC sponsored research. There is no doubt that the project was critical to the NPF making a smooth transition to the mandated use of TED's and BRD's and that without this work the NPF would have been floundering with the new gear requirements.

The project was able to combine research with extension work in a way which aided in bringing a large part of the industry along with the project. These types of regulations can be onerous on operators and if introduced carelessly can result in compliance problems and at worst, pose a threat to the integrity of the management plan. By including such a broad base of industry players and by spending plenty of time in the field on a range of boats, the project was able to be a key part of delivering an award winning ++ result for the NPF and a role model for other fisheries to follow.

Tony Gofton (Skipper, *Ocean Thief*, ARJ Investments)

The introduction of TEDs and BRDs has not been an easy task.

Without the assistance of Garry Day, the Australian Maritime College, FRDC, CSIRO, Queensland DPI and the Gulf of Mexico shrimp fisherman, the process would certainly have taken a lot longer. Most NPF fishers found the larger frame TEDs/codends to be the most successful. Bigeye's have generally been used due to the ease of installation and most importantly, no loss of product.

Prawn loss, expense in manufacture, extra net maintenance and handling and the hazard to crew in rough weather, are ongoing problems with the use of TEDs and BRDs.

The positives are a big reduction in damaged product, cleaner shots and no injuries associated with handling sharks and rays etc.

The outlook on TEDs and BRDs and our environmental responsibilities are very encouraging. After all it's our livelihood we wish to preserve.

Clayton Nelson (Fleet Master, Tiger Fisheries Pty Ltd)

The logistics of fishing in the Northern Prawn Fishery are large because of its remoteness, therefore the effort and results that have been extracted from this study must be viewed as extremely successful.

As in all industries and in particular the fishing industry, change is difficult, and in particular, changes that in the short term impacts financially on the operator. The joint approach that was instigated by CSIRO and the fishing industry has overcome these obstacles and has led to an increased awareness by all operators on the need to be proactive in the development of methods to reduce the capture of all bycatch whilst maximizing economic efficiency.

A substantial and ongoing effort has been put into the development of TEDs and BRDs and this assessment will be vital for the future impact on bycatch species in the NPF.

The focus for the future needs to revolve around the methodical reduction of capture of all species of bycatch with a cooperative effort combining CSIRO and industry.

Special thanks must go to Garry Day for his tireless efforts in educating skippers and crews on the methods and benefits and bycatch reduction.

Jeff Nichols (Trawler operator with 16 years skippering)

When I first viewed the TEDs and BRDs in 1997, it was like a whack to the side of the head. My first impression was "why didn't we think of this before?" Then to be told they were in widespread use in other fisheries of the world, gave me the feeling we were like ostriches with our heads in the sand.

My views differed considerably from quite a number of fishermen in the early days. However, the concept must have seemed sound to quite a few, as a number of hands were raised to voluntarily test the devices.

Over the following years, the trials on my vessel were so impressive with regards to large species exclusion that I was looking forward to seeing the TEDs refined to a point where we would be seeing a majority of bycatch left on the sea bed.

The 2000 banana prawn season consisted of very poor prawn catches, and as fate would have it, this was the year the devices became compulsory.

Understandably, a fair percentage of fishermen attributed a considerable amount of their lack of catch, to losses through the devices. And I guess there would have been losses for a number as not a great percentage of fishermen had tested the TEDs prior to them becoming mandatory.

It was heartening to see how quickly the views of fishermen changed. Most of the initial problems and catch losses were overcome within a short period of time. So much so, that within a couple of years, I believe the devices would be voluntarily used by a majority of fishermen, even if not legally required to do so.

The improvements to the back deck to me are enormous. The most obvious being the lack of monster thrashing within the trays. No slashing shark teeth, no sting ray barbs, no smaller species of fish flying through the air searching out the nearest head or eye, as they are being flicked about the deck by some raging beast wondering what happened to its water.

We fishermen have had to make a few concessions though. The speed of deployment and retrieval of the nets, has been slowed and the process complicated by the large grids. Placement of the grids differs from vessel to vessel also and depends on rigging height, rear frame proximity to the rigging, and how far forward the outriggers are set. Therefore, there is no one rule for where to set the TEDs within the net. A certain amount of placing, then replacement sometimes takes place to set the grids just right. Then there is the constant need to be checking cover flaps and grid angles, as meshes stretch and distort. It is all extra work that older hands still find cause to grumble over.

The term ‘TEDDed’ has been added to the fisherman’s vocabulary, to explain catch losses, and variances.

It is a fact that catch losses occur, and when they begin to occur on a consistent basis, there is a handful of more possible causes which now need checking. Sometimes it becomes so confusing that the desire to remove a grid, to see whether it is in fact the net causing the problem, is very tempting. However, this cannot be done. I have personally changed complete rigs from side to side, and then swapped grids etc. just to find an exact cause of loss of catch. This can all be extremely frustrating for crew and skipper, who are sometimes lacking a little in sleep.

At the end of the day though, I feel that in my 20 years at sea, it is one of the most positive management inclusions we have seen. Certainly, as a fisherman with a green sensibility, I am heartened by the immediate positive impact upon the species were previously caught.

As for the future, I feel good gains in reduction of smaller bycatch can be possible if we get an experimentation plan up and running for BRDs. To expect gains to be made on vessel by fishermen alone, will be unrealistic though, as the fear of loss of catch during any trials is too great, and especially with fishing seasons being as short as they are.

CHAPTER 17

CONSERVATION REPORT

Chapter Author:

Eddie Hegerl

CHAPTER 17

CHAPTER 17

CONSERVATION REPORT

Eddie Hegerl

Summary

Chapter 17 is made up of a short report from conservationist, Eddie Hegerl, summarising his impressions of the introduction of TEDs and BRDs in this fishery.

The results from this project describe an important step in the evolution of the Northern Prawn Fishery (NPF). The introduction of TEDs and BRDs has probably been the most significant change to the NPF fishing operation aimed at reducing ecological impacts. The success of their introduction places this industry in a better light with the Australian and global community, and has played an important role in achieving a positive strategic assessment for this fishery.

The reduction in catches of protected and high risk species due to TEDs and BRDs has been an overdue and important step for trawl fisheries. The reduced impacts on sawfishes and other large vulnerable sharks and rays, and the almost total elimination of turtles from NPF catches may be critical to the long term survival of these species in this region. The NPF should be congratulated on this initiative and the example it has hopefully set for other similar fisheries around the world.

The results from this study have also demonstrated the need for the removal of the Big eye BRD from most NPF fishing operations. This will hopefully open the way for more effective BRDs and improved reductions in catches of the hundreds of species of small fish, sea snakes and other bycatch that are currently poorly excluded from trawls. An ongoing effort is needed by the fishery and its management to ensure that the process of bycatch reduction is one of continuous improvement. This will help regenerate the impacted marine communities in the NPF, and further insulate this industry from the pressures and expectations of the Australian community.

CHAPTER 18

BENEFITS

Chapter Author:

David Brewer

CHAPTER 18

CHAPTER 18

BENEFITS

David Brewer

There are two main beneficiaries of the results of this project: the Northern Prawn Fishery (NPF) and the general community. The NPF will benefit from the following main outputs:

- A formal, robust assessment of how the introduction of TEDs and BRDs has reduced the levels of bycatch taken by the fishery;
- A description of the factors that will help NPF fishers to tune these devices to help minimise prawn loss and maximise bycatch reduction;
- Knowledge of the financial implications of using TEDs and BRDs;
- A formal protocol that allows a path for the development and testing of new innovative devices for the reduction of bycatch in the fishery.

This knowledge will play an important role in the NPF's ability to demonstrate an intention to minimise impacts on non-target species, especially certain protected and high risk species such as turtles, sawfish and large sharks and rays. It also helps the industry demonstrate a move towards more ecologically sustainable practices.

The general community's concerns about the impact of prawn trawling will be alleviated by this new knowledge that TEDs and BRDs can cause a significant reduction in the impact on many of the species of greatest concern.

Other beneficiaries include other prawn trawl fisheries in northern Australia and research organisations. Other fisheries such as the Torres Strait, Queensland East Coast and Western Australian prawn trawl fisheries can also use the knowledge reported here to help improve their TED and BRD practices, as well as piggyback on some of the positive reporting that will flow from the NPF results into the general community.

Research organisations and other groups may benefit from some of the information contained in this report including:

- improved methods for sampling bycatch;
- running observer programs;
- assessing TEDs and BRDs performance, and
- providing mechanisms for fishers to develop new devices.

CHAPTER 19

FURTHER DEVELOPMENT

Chapter Author:

David Brewer and Don Heales

CHAPTER 19

CHAPTER 19

FURTHER DEVELOPMENT

David Brewer and Don Heales

The current project will be followed by a program of dissemination of results to stakeholders, although it is recommended that there be a separate, concerted effort to promote improved BRD performance to the industry. A project currently underway ('NPF Bycatch Monitoring and Risk Assessment Project', 2002/035) will re-evaluate the NPF bycatch risk assessment to include the impact of TEDs and BRDs.

Critical issues that the NPF will need to address in the short term include an investigation into methods to improve exclusion or minimise catches of sawfish, and an assessment of BRDs that may provide significant levels of sea snake exclusion. A repeat of the assessment of BRDs on bycatch reduction may also be needed in the future for the industry to demonstrate an improved level of performance from that measured in this study.

The data from the 'TED and BRD assessment project' can also be taken further through incorporation into the risk assessments for each bycatch species. This will translate the reduction in impacts on bycatch due to TEDs and BRDs, to reduced levels of risk from the fishery. It may also be feasible for these risk assessments to predict the levels of bycatch reduction that need to be achieved to remove the risk of unsustainable fishing by the NPF. This strategy is recommended for inclusion in the current 'NPF Bycatch Monitoring and Risk Assessment Project' being undertaken by CSIRO and AFMA.

The linking of changes in catches due to TEDs and BRDs and the revamped risk assessment for NPF bycatch species will be possible for the bycatch groups sampled to species level in this report. However, other groups, such as Small Bycatch will require a detailed study of the impact of BRDs on catches in order to provide this data for a new risk assessment. This could be collected during any future assessments of BRDs in the NPF once more effective devices have been adopted.

CHAPTER 20

PLANNED OUTCOMES

Chapter Author:

David Brewer and Don Heales

CHAPTER 20

CHAPTER 20

PLANNED OUTCOMES

David Brewer and Don Heales

1. **Effective compliance of TED and BRD use in the NPF**
   The efforts of Garry Day as an observer in the NPF, along with workshops and communications material, have played a significant role in sending the message that TEDs and BRDs can work effectively in the NPF (Chapters 6 and 12, Appendix 7). Although difficult to measure, these aspects of the project have almost certainly contributed to the very high level of compliance seen in the NPF regarding TED and BRD use.

2. **Improved levels of bycatch reduction for NPF fishers**
   The effective time Garry Day spent helping fishers improve TED and BRD performance, the workshops and the communications material, were also likely to have made an important contribution to the knowledge of effective TED and BRD use for many fishers in the NPF (Chapters 6, 12 and 13, Appendix 7). This knowledge along with their own increasing levels of experience have probably resulted in improved bycatch reduction, partly demonstrated by the greatly reduced levels of complaints about their introduction between 2000 and the end of 2001 (Chapters 8 and 16).

3. **Removal of pressure on the NPF from legislation that protects vulnerable and endangered species**
   The EPBC Act requires the fishery to minimise impacts on non-target species and that any impacts do not lead to an unsustainable decline in their populations. This project has provided the means by which the NPF can demonstrate major reductions in its impacts on a range of species considered to be at highest risk to fishing and/or trawling. These include exclusion of >99% of turtles and significant reductions in catches of many species of large sharks and rays. Although some catch groups require improved solutions to reduce the fisheries impact, the data provided by this project has helped the NPF take a large step towards demonstrating more sustainable practices and removing the pressure from the EPBC Act.

4. **Improved acceptance of NPF practices by concerned stakeholders such as conservation groups, recreational fishing groups and the general community**
   The demonstrated reduction in impacts on a range of charismatic and other species has also played an important role in reducing the concerns of potentially critical stakeholders of the NPF (Chapters 6, 10 and 17). The results from this project help demonstrate the continuing progressive attitude of the NPF towards these issues.

5. **Improved marketability for export prawns**
   The results from this project will also play an important role in any future bid by the NPF to obtain MSC accreditation (Chapters 6 and 10). They also validate the exemption from the ban placed on countries wishing to export prawns to the USA but not using TEDs.

6. **Improvement in accounting for variations in effort standardisation on prawn stocks**
The impact of TEDs and BRDs on prawn catches represents a significant variation to catches, and consequently levels of effort on prawn stocks. This study is the first robust analyses of the adjustment to catches resulting from the introduction of TEDs and BRDs (Chapters 6 and 10), and the study has provided relatively accurate data to current and future stock assessment processes.

7. **Demonstration of the cost-benefit implications to the NPF operators of using BRDs and TEDs**
The economics Chapter of the final report presents a detailed account of the financial repercussions of using TEDs and BRDs (Chapter 11). The benefits are a longer and more widely spread set of messages, but are clearly presented in the final reporting of this project. Although a net financial loss was recorded, most stakeholders would consider this to be outweighed by the reduction in ecological concerns for many bycatch species.

8. **Establishment of a practical and accessible means by which fishers can invent improved BRD and TED technology for use in the NPF**
The development of a protocol for testing new and innovative designs clearly provides this outcome for NPF fishers (Chapter 14).

9. **Demonstration of the NPF's intent to develop recognised environmental standards for incorporation into fishery certification processes that lead to world's best practice**
The results presented by this project demonstrate that the NPF is willing to introduce a major change in fishing practice solely to raise its environmental accountability, and despite some short-term loss in income. This project has also demonstrated that this change has had a major 'overnight' impact on some key species groups. Subsequent changes, such as the relatively prompt removal of the Bigeye BRD due to its ineffectiveness have also demonstrated the NPF's intent to continue to improve its environmental standards.

CHAPTER 21

CONCLUSIONS

Chapter Author:

David Brewer and Don Heales

CHAPTER 21

CHAPTER 21

CONCLUSIONS AND RECOMMENDATIONS

David Brewer and Don Heales

The NPF has taken the first major step towards minimising its impact on unwanted species by the introduction of TEDs and BRDs. This has removed the fishery's impact on turtles and reduced its impact on many of the highest risk sharks, rays and sawfish. The results of this study will play an important role in the fishery's ability to demonstrate ecologically sustainable practices, and ultimately its ability to receive a positive assessment under the EPBC Act 1999 and accreditation by international environmental auditors such as the Marine Stewardship Council.

Despite the largely positive outcomes of introducing TEDs and BRDs, there is still a significant step that needs to be taken by the NPF to demonstrate that the introduction of TEDs and BRDs has been a totally successful change to a more responsible fishing practice. This can be achieved by taking the very feasible step towards attaining a level of BRDs performance that produces significant bycatch reduction, but without loss of prawns. This is particularly true for the Small Bycatch and Seasnakes catch groups, and the future success of BRDs relies on the attitude of owners and operators towards this issue.

Other key outputs from the project also include (i) a formal and feasible protocol by which new and innovative devices can be trialed for inclusion on the list of approved TEDs and BRDs for this industry; and (ii) a comprehensive description of factors that affect TED and BRD performance. These factors include a range of practical solutions for at-sea handling and tuning of these devices to reduce prawn loss and maximise bycatch reduction. They also include a description of the water flow characteristics around TEDs and BRDs, based on flume tank trials. Both of these can allow NPF fishers to take another leap forward in their ability to understand and improve TED and BRD performance in the NPF. The project's communication strategy includes the dissemination of this critical information to fishers and other stakeholders in the months following the finalisation of the project reporting.

Recommendations

A number of activities should be given a high priority as a follow up to the assessment of TED and BRD performance conducted in the 2001 tiger prawn season. These are:

1. **Dissemination of results to major stakeholders**. This is a critical part of the educational step that will allow the NPF to understand the broader perception of using TEDs and BRDs effectively. This should assist a change in culture to a more proactive use of these devices for bycatch reduction. Summaries of the project results will be communicated to the NPF and other stakeholders as part of the project activities, by way of industry workshops, face-to-face meetings in ports, industry magazine articles, media releases, Industry newsletters and brochures and scientific papers.

2. **Concerted effort to promote improved BRD performance**. This study described the poor performance of BRDs in the 2001 season and the potential for higher bycatch reduction as seen in other studies. This potential should be promoted to the industry, especially in terms of the small fish and sea snake exclusion required by the NPF strategic assessment under the EPBC Act. Although this will be partly achieved by the post project communication strategy of the current project, is it recommended that AFMA and NORMAC provide the means for a more concerted and practical approach to improving BRD performance in the NPF as soon as possible. The Bigeye BRD was removed as an option for the fishery in 2004 and an improved use of other BRDs is an important next step in this process (e.g. use Square-mesh panels and Fisheye within 70 – 100 meshes of the codend drawstrings).

3. **Re-evaluate the NPF bycatch risk assessment**. Given the different responses of many species to TEDs (especially Elasmobranchs) the assessment of the relative risk to the species from the fishery (Stobutzki *et al.,* 2000, 2002) should be re-evaluated. This will be done as part of the 'Bycatch Monitoring Project' – FRDC 2002/035. When a significant reduction in the small bycatch (e.g. from effective BRDs) has been achieved it will be necessary to determine the impact of this on the risk assessment for individual species.

4. **Investigate methods to improve exclusion or minimise catches of sawfish**. This group is probably the highest risk of all the NPF bycatch. Although TEDs had an impact on one species of sawfish catches there is no information on four other high risk species. There may be relatively simple changes to the trawl net designs that can reduce sawfish entanglements. For example, use different material in the areas of the net where sawfish are most commonly entangled, as suggested in a recent workshop by an NPF skipper. The strategic assessment and the level of risk for these species demand that this issue be addressed as urgently as possible. It is recommend that NORMAC and AFMA provide a means whereby net makers, fishers and scientists can work together to design and test potential gear modification to address this issue**.**

5. **Assess BRDs that provide significant levels of sea snake exclusion**. There is some evidence that sea snakes can be excluded from trawls if an appropriate BRD is used. This should be investigated further by way of sea trials of appropriate BRDs, reported to the fleet, and appropriate recommendations made to industry.

6. **Investigate the fate of sponges impacted by prawn trawl nets**. Although sponges are largely excluded by TEDs it is not known whether they survive once returned to the sea bed or what the impact is on other species that have a commensal relationship with the sponge. A study to assess the medium and long term survival of large dislodged sponges would provide important information towards management of habitat and biodiversity in the NPF.

7. **Repeat the BRD performance assessment.** There may be a need to repeat the assessment for BRDs, following the poor performance reported here from the 2001 tiger prawn season. The NPF will be measured by the current result until an improved performance can be demonstrated. See earlier comments re selection of small bycatch species.

8. **Reconsider the use of BRDs during targeted trawling of banana prawn schools.** The assessment of TEDs and BRDs was not made for the banana prawn season due to the difficulty in collecting suitable data and in detecting differences between highly variable catches. Anecdotal evidence suggests that the Small Bycatch is less abundant and less diverse in catches that target banana prawn schools (usually in the first two weeks of the season). This bycatch is reported to be very different from the bycatch taken during pattern trawling (described in this report) used in the second half of the banana prawn season and the entire tiger season. The potential size of prawn catches when targeting banana prawn schools may also lead to significant losses of prawns through BRDs placed behind the TED. These issues warrant a re-assessment of the use of BRDs during the first weeks of the banana prawn season by NORMAC's TED and BRD subcommittee.

9. **Development of a cost-effective grid blockage detection device**. In larger scale shrimp fisheries in the North Sea trawlers use grid blockage detection devices to reduce shrimp losses. These devices detect when the inclined grid is covered by weed, large animals etc and send a signal to the bridge. This prompts the skipper to either haul in the fishing gear, or stop and restart the vessels momentum in an attempt to clear the blockage. This type of device could cut down prawn losses in the NPF. However, it would need to be specifically designed to suit the TEDs and financial limitations of this industry. Technicians at the CSIRO Cleveland laboratory have a basic design for such a device, but would require dedicated funding to develop this device for the NPF.

10. **Improve our knowledge of how bycatch species react to trawls**
    There is evidence that some species groups may react in a specific way when they encounter a trawl. However, this is largely known from circumstantial evidence, such as their direction of escapement via devices placed in different parts of the trawl. More data on how different species react to trawls (e.g. from video evidence or the positioning of meshing in the codend) would allow the design of TEDs and BRDs to be tailored to achieve more effective and targeted results.

APPENDIX 1

INTELLECTUAL PROPERTY

All components of this research are in the public domain.

APPENDIX 2

STAFF

CSIRO Marine Research

David Brewer (Project leader)
Don Heales
David Milton
Brian Taylor
Gary Fry
Quinton Dell
Malcolm Austin
Robert Pendrey

Australian Maritime College

Steve Eayrs
John Wakeford
Garry Day

CSIRO Mathematical and Information Sciences

Peter Jones
William Venables

Fisheries Economics, Research and Management Pty Ltd

Sevaly Sen

World Fish Centre

Ilona Stobutzki

National University of Singapore

You Gan Wang

Scientific Observers

Ben Bird
Garry Day
Quinton Dell
Chris Gough
Reuben Gregor

Northern Prawn Fishery Operators

David Carter
Clayton Nelson
Jeff Nichols
Tony Gofton

Conservation NGO

Eddie Hegerl

APPENDIX 3

Approved TED and BRD designs for the NPF

Who does the TED and BRD Direction apply to?

All prawn fishers in the NPF

What is a TED?

A TED is a device fitted to a net or modification that allows turtles to escape immediately after capture in the net.

What is a BRD?

A BRD is a device fitted to a net or modification that allows fish and other animals to escape immediately after capture in the net.

When do I have to use TEDs and BRDs?

From midnight, April 14th, 2000.

Do I have to use TEDs <u>and</u> BRDs in my nets at the same time?

Yes. You must use either:

1. an approved TED plus at least one of the approved BRD designs, or;
2. you can use a modified TED.

Do all my nets have to be fitted with a TED and BRD?

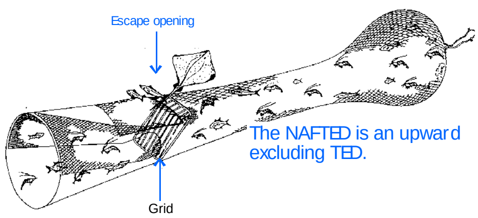
No. Only those nets that are rigged for fishing, ***excluding*** try nets. A net is rigged for fishing if any part of it is in the water or if it is connected in any way to a trawl board or warp wire, either onboard the boat or attached in any manner to the boat. Spare nets do ***not*** have to be fitted with a TED and BRD until rigged for fishing.

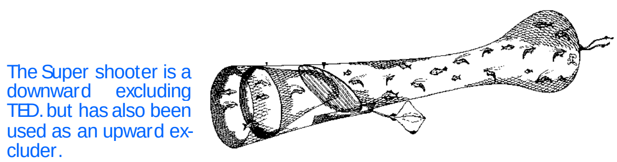
What TED designs can I use?

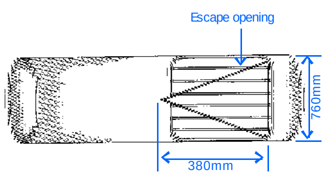
Any TED design you choose, providing it allows turtles to escape immediately after capture in the net ***and*** meets the following requirements:

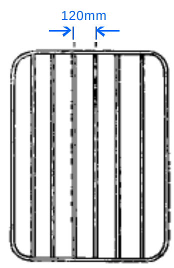
1. The TED must have a rigid or semi-rigid grid of inclined bars to guide turtles to an escape opening immediately forward of the grid.
2. The TED must be attached to the entire circumference of the net.
3. One or more escape openings that measures at least 760mm across the width of the net (when the net is pulled taut) ***and***, at the same time measures 380mm in a perpendicular direction from the midpoint of the width measurement.
4. A distance ***between*** the bars not exceeding 120mm. If the TED is made from wire or other semi-rigid material then the TED must be braced or designed so that this distance cannot be exceeded.

The orientation of the TED in the net is not specified as long as it meets the above requirements. This means that both upward and downward excluding TEDs are allowed in this fishery, such as the NAFTED and the Super shooter.









What BRD designs can I use?

Any one of the following BRD designs that have been approved for use in the NPF:

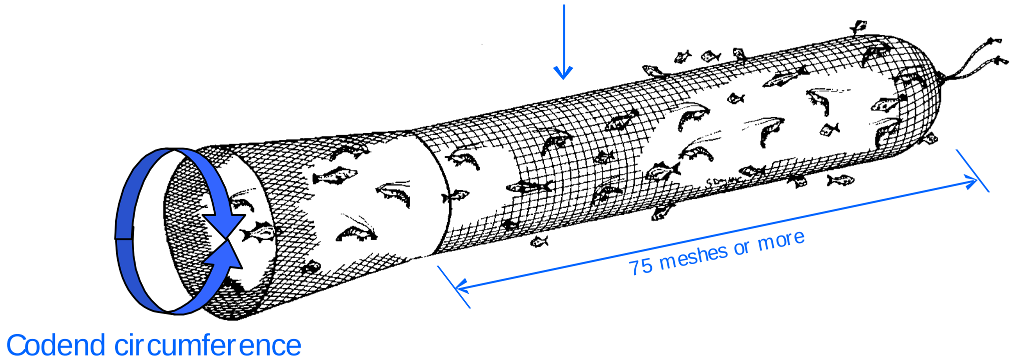
1. Square-mesh codend
2. Square-mesh panel or window
3. Fisheye
4. Bigeye
5. Radial Escape Section (RES)
6. Modified Turtle Excluder Device

1. Square-mesh codends

What are the Square-mesh codend specifications?

A Square-mesh codend has at least half the circumference of the codend with the following characteristics:

1. A nominal mesh size no less than 45mm (22.5mm bar length).
2. Netting orientated so that the direction of twine is longitudinal and transverse to the length of the codend.
3. An overall continuous length measuring at least 75 meshes (3.375m) long.
4. No pieces of netting or other material covering any square meshes during the fishing operation.



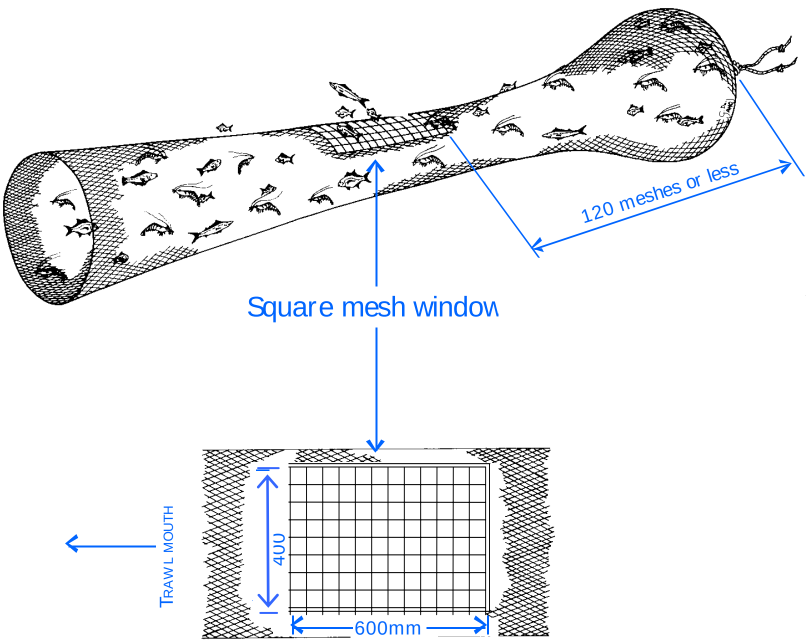
Note: The TED is not shown.

2. Square-mesh panel BRD

What are the Square-mesh panel specifications?

A Square-mesh panel or window is a continuous panel of netting that has the following characteristics:

1. A nominal mesh size no less than 101mm (50.5mm bar length).
2. An overall size measuring at least 400mm wide and 600mm long.
3. The aft edge of the panel located no further forward than 120 meshes of the codend drawstrings.
4. No pieces of netting or other material covering any square meshes during the fishing operation.



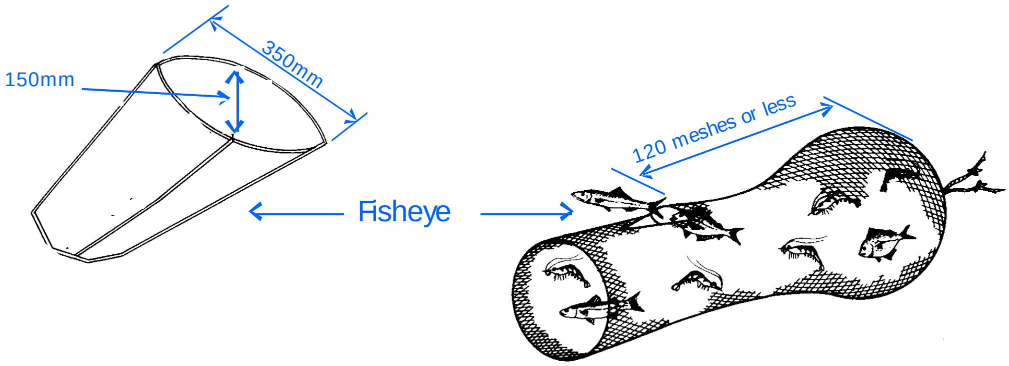
Note: The TED is not shown

3. Fisheye BRD

What are the Fisheye specifications?

A Fisheye is a device with the following characteristics:

1. A vertical escape opening held open by a rigid frame.
2. An escape opening measuring no less than 350mm wide x 150mm high.
3. The escape opening located no further forward than 120 meshes of the codend drawstrings.
4. No pieces of netting or other material covering the escape opening during the fishing operation.



Note: The TED is not shown

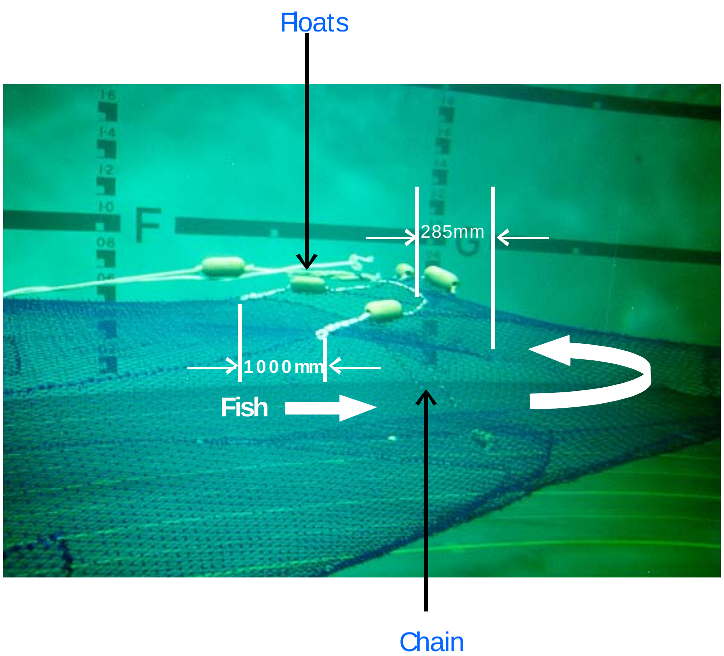
4. Bigeye BRD

What are the Bigeye specifications?

A Bigeye is a device with the following characteristics:

1. A non-rigid opening in the top panel of the net located no further forward than half the distance between the centre of the headline and the start of the codend.
2. An opening across the width of the net measuring no less than 1000mm.
3. The forward edge of the escape opening weighted with leads or chain and the aft edge of the escape opening buoyed to ensure a vertical escape opening is produced when fishing.
4. The edges of the escape opening overlapping by no more than 285mm (ie. 5 meshes x 2 $^{1}/_{4}$ inches).
5. No pieces of netting or other material covering the escape opening during the fishing operation.

N.B. This design will be removed from the list of approved BRDs from the 1st September 2004 (start of the 2004 tiger prawn season).



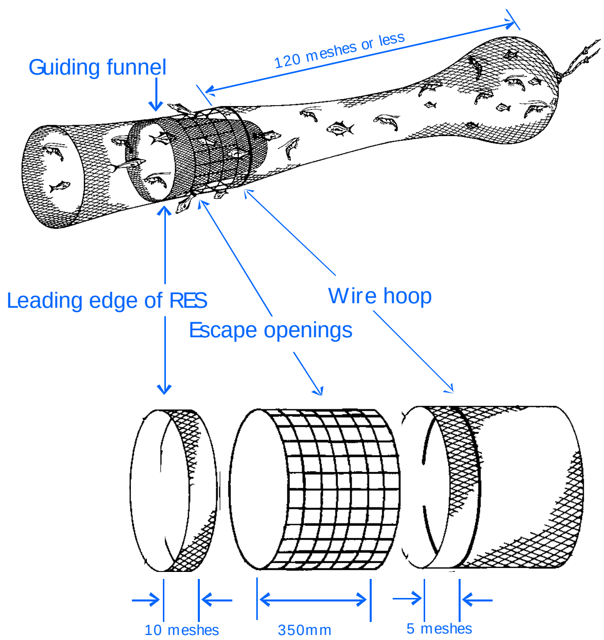
Note: The TED is not shown.

5. Radial escape section BRD (RES)

What are the RES specifications?

A Radial Escape Section (RES) is a device with the following characteristics:

1. A funnel of netting or other material located within the codend.
2. The circumference of the leading edge of the funnel must be of equal length to the circumference of the codend (the circumference of the codend is equal to the mesh size x the number of meshes around the codend).
3. The leading edge of the funnel must be attached to the codend no more than 10 codend meshes ahead of the escape openings.
4. The circumference of the trailing edge of the funnel is no more than 60% of the circumference of the codend.
5. Individual escape openings no less in size than a square mesh size of 100mm (50mm bar length).
6. Overall escape openings no less than a panel of netting measuring 350mm long (7 bar lengths) and at least half the circumference of the codend wide.
7. The trailing edge of the funnel extending no more than 500mm past the aft edge of the escape openings.
8. The aft edge of the escape openings located no further forward than 120 meshes from the codend drawstrings.
9. The forward edge of the RES located within 900mm of the TED grid or barrier, or if greater than 900mm from the grid, a wire hoop must be attached to the leading edge of the RES (where the funnel is attached to the codend).
10. A rigid or semi-rigid wire hoop with a minimum diameter of 650mm located no more than 5 meshes behind the escape openings.
11. No pieces of netting or other material covering any escape openings during the fishing operation.



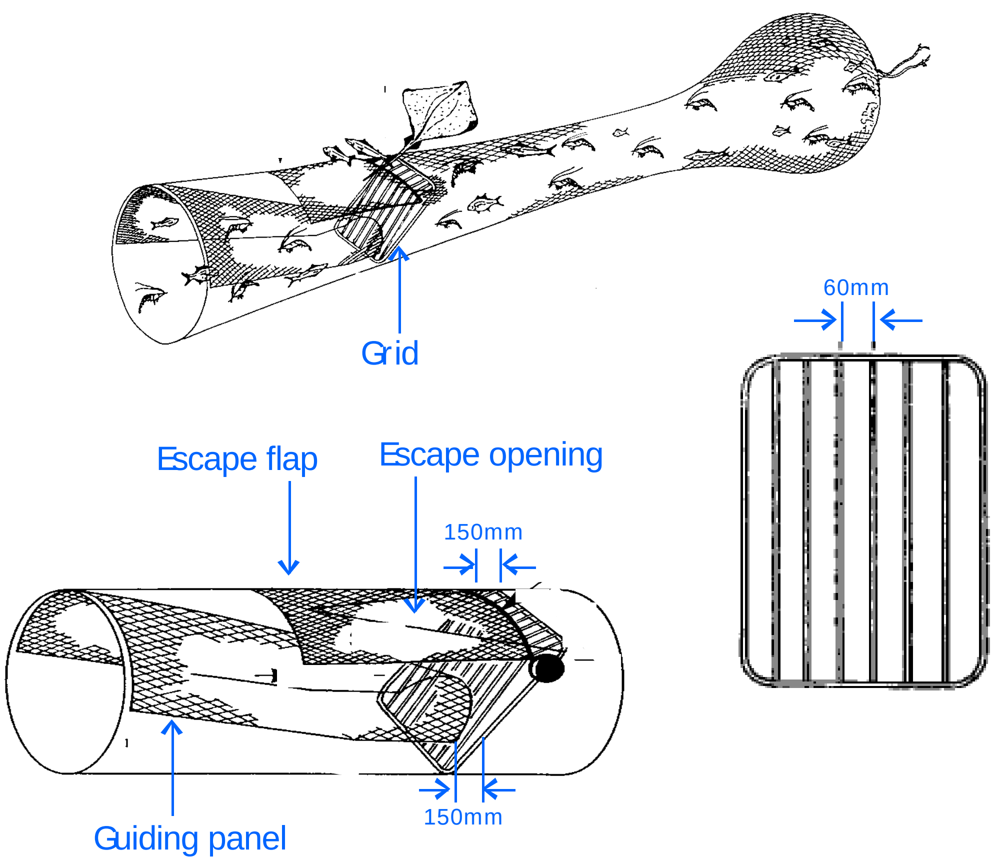
Note: The TED is not shown.

6. Modified TED (can be used as the TED <u>and</u> BRD)

What are the specifications for a modified TED?

A modified TED has the following characteristics:

1. An escape opening the same size as for a TED but located in the ***top*** of the codend.
2. A distance between the bars no more than 60mm.
3. An escape flap over the escape opening if required (no part of the flap may be closer than 150mm to any part of the grid or barrier, when the TED is fitted to a codend and hung vertically).
4. A guiding funnel or flap inside the codend if required (no part of the funnel or flap may be closer than 150mm to any part of the grid or barrier, when the TED is fitted to a codend and hung vertically).
5. No pieces of netting or other material covering the escape opening during the fishing operation.



APPENDIX 4

Abbreviated NPF Observer at Sea Manual
(NPF Tiger Prawn Season Aug - Nov 2001)

Occupational Health and Safety at Sea Observers manual

Don Heales and Quinton Dell

(reproduced here in black and white only)

ABBREVIATED NPF OBSERVER AT SEA MANUAL (NPF Tiger prawn season Aug- Nov 2001)

This Appendix is an abbreviated version of the Observer Manual that was taken to sea by Observers during the Tiger Season of 2001. A complete field version of the Observer Manual is available for viewing on request from FRDC.

The complete field version also included:

- Phone contact numbers for both Observers and Project staff on land and mobile phone numbers - 2 pages
- NPF commercial vessel procedures manual -39 pages (courtesy of Newfishing P/L)
- Selected sections from St John Ambulance First Aid Manual - 28 pages
- "Survival at Sea" - A Training and Instruction Manual - -Australian Maritime Safety Authority - 91 pages
- "A Guide to Bycatch Reduction in Australian Prawn Trawl Fisheries" S. Eayrs, C. Buxton, B. McDonald, G. Day. Publ. Australian Maritime College. 54 pp

Observers also took to sea an **Identification Manual** to help identify the large bycatch animals. It included keys to identifications and colour plates for

- sharks
- sawfish
- rays
- turtles

and included a list of the most common sharks and rays that Observers had been trained to identify (see Table 4 in this Appendix).

The complete field version of the **Identification Manual** is also very comprehensive and includes too many colour plates and identification keys to be reproduced as an Appendix for this report. However, a complete field version is available for viewing on request from FRDC or CSIRO.

Northern Prawn Fishery Observer Manual

- 2001 Tiger Prawn Season -

Assessment of TED's and BRD's by:

NPF Trawler Operators,

AMC, CSIRO, FRDC

Table of Contents

What do I need to take?

Below is a general list for you to follow when preparing for your Observer duties. Try to pack as lightly as possible as some flights are on light planes and weight limits of around 20kg per person can apply (eg Cairns - Bamaga). Similarly, living conditions may be a little cramped on board the trawler you work on.

A medium sized travel bag and small daypack is ideal.

Protective Gear

- Wet weather jacket, trousers - We will supply these.
- Protective footwear - preferably runners, 1 good pair for travelling and 1 old pair for deck work
- Hat, wide-brimmed, cap also
- Sunglasses
- Sunscreen
- Sea sickness tablets

Clothing

Expect to get dirty, so pack old comfortable clothing for onboard trawlers.

- Half a dozen pairs of board shorts are ideal
- Half a dozen cotton T shirts
- 2 Good pairs of socks for travelling, 3 old pairs if you wear them with runners
- Warm clothing e.g. trackies and a jumper (southerly winds off the desert can get cold).
- Some casual gear for travel to and from Brisbane, Cairns etc.

Personal

- Medical needs (ensure you carry minimum of 6 weeks worth, just in case
- Toiletries (Don't expect to have 'Hollywood showers', fresh water is very limited)
- Towel
- Sleeping bag (not all trawlers supply linen)
- Wrist watch for recording shot times
- $$$$ Cash to buy "Extras" from the mothership eg chocolates, coke etc

Other

- Personal camera, film and batteries
- Books and magazines (many hours are spent waiting for the next trawl to be winched in)

What we will give you

Table 1. General list of equipment in your kit

Personal Protective Equipment	**Number**	**Returnable to CSIRO**
Personal inflatable safety V200 vest, Epirb and torch	**1 of each**	**Yes**
Wet weather gear (jacket, trousers with bib,)	**1 of each**	**Yes**
Cotton gloves and Rubber gloves	**5 prs**	**No**
Seasickness tablets	**36**	**No**
Bycatch sampling kit		
Observers manual	**1**	**Y**
Identification kits (turtles, sharks, rays etc)	**1**	**Y**
Data sheets	**300**	**Y**
Pencils, Marking pens	**5, 2**	**N**
Rubbers	**2**	**N**
Folders (2 each)	**2**	**N**
Plastic bags to store data sheets in	**10**	**N**
Tape measures * 2	**2**	**Y**
Spring balances 5 kg	**2**	**Y**
Scales 50 kg	**1**	**Y**
Lug baskets	**9**	**Y**
Labels	**30**	**N**
Plastic bags for specimens -large heavy duty	**40**	**Y**
Rope and hooks for weighing baskets of bycatch	**1 set**	**Y**
Bycatch Levellers (use in lug baskets)	**2**	**Y**
Numbered tablets	**2 sets**	**Y**
Net to collect small rays from shit chute	**1**	**Y**
Catch mover and scraper	**2**	**N**
Wooden drain supports	**2 items**	**Y**
Give-aways		
Tshirts, hats	**25**	**N**

*************** **Warning** ***************

Please refrain from taking any prohibited drugs or alcohol onboard trawlers. All trawlers are 'dry boats' and we have gone to great lengths to establish good working relations and reputations with NPF operators. We do not want to jeopardize this relationship.

Check this List before leaving each vessel

It is absolutely critical that you try to avoid forgetting equipment because of the difficulty in getting replacement gear to you.

Have you packed the following:

A **3 packs lug baskets (9 in all) containing 2 catch levellers, 2 catch scrapers, plywood numbers**

B **1 bundle of wood (2 pieces of 3 by 2)**

C **2 Nally bins containing sample sheets, sample sheet marked with next sample number, safety vests, folders, identification manual, observer-at-sea-manual 50 kg scales and ropes, 2 spring balances, 2 steel tapes**

D **Checked the freezer for shark, snake and any other samples you may have collected**

E **Personal bags containing used sample sheets to be posted, cameras etc**

F **Waxed cartons unused**

G **Spare T shirts in carton**

H **Personal gear like washing hanging on lines, shoes/hand towels drying, books in wheel house, videos in galley etc**

I **Final check around back deck and processing area for any observer equipment you may have missed**

Maintaining contact with Supervisors

Project supervisors Don Heales, Dave Brewer and Steve Eayrs (on land) and Garry Day (at sea) will maintain contact with all observers on a regular basis to ensure that any problems that emerge can be sorted out as soon as possible (see Phone numbers on Contact List page). If you require assistance at any time, don't hesitate to call us.

We will ring you at frequent intervals to make sure that everything is going well. We will use a set of standard questions that we will ask of you in case you are having some difficulties but are unable to discuss them openly over the phone. Your answers to this series of questions will reveal to us whether you are able to speak freely, or not.

Each observer will be provided with a phone card, which can be used from satellite phones. Although these cards reduce call costs significantly, they should be used sparingly and for project purposes only. Observers may purchase their own phone cards for personal use if necessary. There is no mobile phone service in the NPF other than near Darwin and Gove.

We have provided a Fax cover sheet for use when faxing questions of lower priority to us at Cleveland so that we can reply to you (within 24h in most cases). Use this cover sheet whenever you Fax us at Cleveland (e.g. Observer Summary Data Sheets)

NOTE: Be courteous when intending to use the phone or fax on trawlers. Although it goes without saying, always obtain the skippers permission before using them. These communication devices are quite noisy/distracting and are often located in the wheelhouse and/or near the sleeping quarters of the skipper. Calls should be made at a time agreed to by the skipper. When fishing, they may be reliant upon incoming calls or they could be trying to get much needed sleep.

Brief Description of Project

The use of TED's (Turtle Excluder Devices) and BRD's (Bycatch Reduction Devices) has been compulsory in the Northern Prawn Fishery since April, 2000 (see Section 8 for description of devices). Previous research has shown that bycatch would be reduced significantly by the widespread use of these devices. However, the introduction of these devices does not give the NPF immunity from scrutiny of it's environmental management.

The concurrent use of both TED's and BRD's is still a relatively new concept, especially in Australian fisheries. Through the cooperation of NPF operators, fisheries technologists, scientists, economists and conservationists, this project will improve the performance of TED;s and BRD's, and will make a comprehensive assessment of the catching, engineering and economic performance of these devices.

The observer at sea section of this project will deliver an up-to-date assessment of the impact of TED's and BRD's on each category of catch and bycatch taken by NPF trawlers. This section of the project relies heavily on the support of NPF operators including owners, skippers, crew, and companies.

The six Objectives of this project are --

- To optimise the performance of approved TED's and BRD's on NPF trawlers
- To identify the factors influencing the performance of TED's and BRD's
- To measure any change in catch rates of total unwanted bycatch and in particular, selected charismatic or vulnerable bycatch species, due to the use of TED's and BRD's
- To measure any change in catches of commercially important prawns and retained byproduct species due to the use of TED's and BRD's
- To assess the economic costs and benefits to industry of the use of TED's and BRD's
- To establish a protocol for the ongoing development and testing of new TED's and BRD's

Overview of Sample Design

OBJECTIVE 1

To sample as many TED and BRD combinations on different vessels as possible over the 2001 Tiger prawn season

OBJECTIVE 2

To sample as many regions of the NPF as possible throughout the 2001 Tiger Prawn season, with the exception of the Joseph Bonaparte Gulf (a Banana Fishery).

In order to achieve both objectives, observers will need to change vessels at around 2 week intervals. This is mainly driven by frequency of mothership unloadings at around 2 week intervals. However, because only a subset of the fleet (around 20 vessels) are suitable for our data collection requirements, you may need to remain on the same vessel for up to 1 month.

A typical 2 week sampling period on board a vessel will involve the gear configurations as shown in Table 1 below and schematically in Fig. 1 next page.

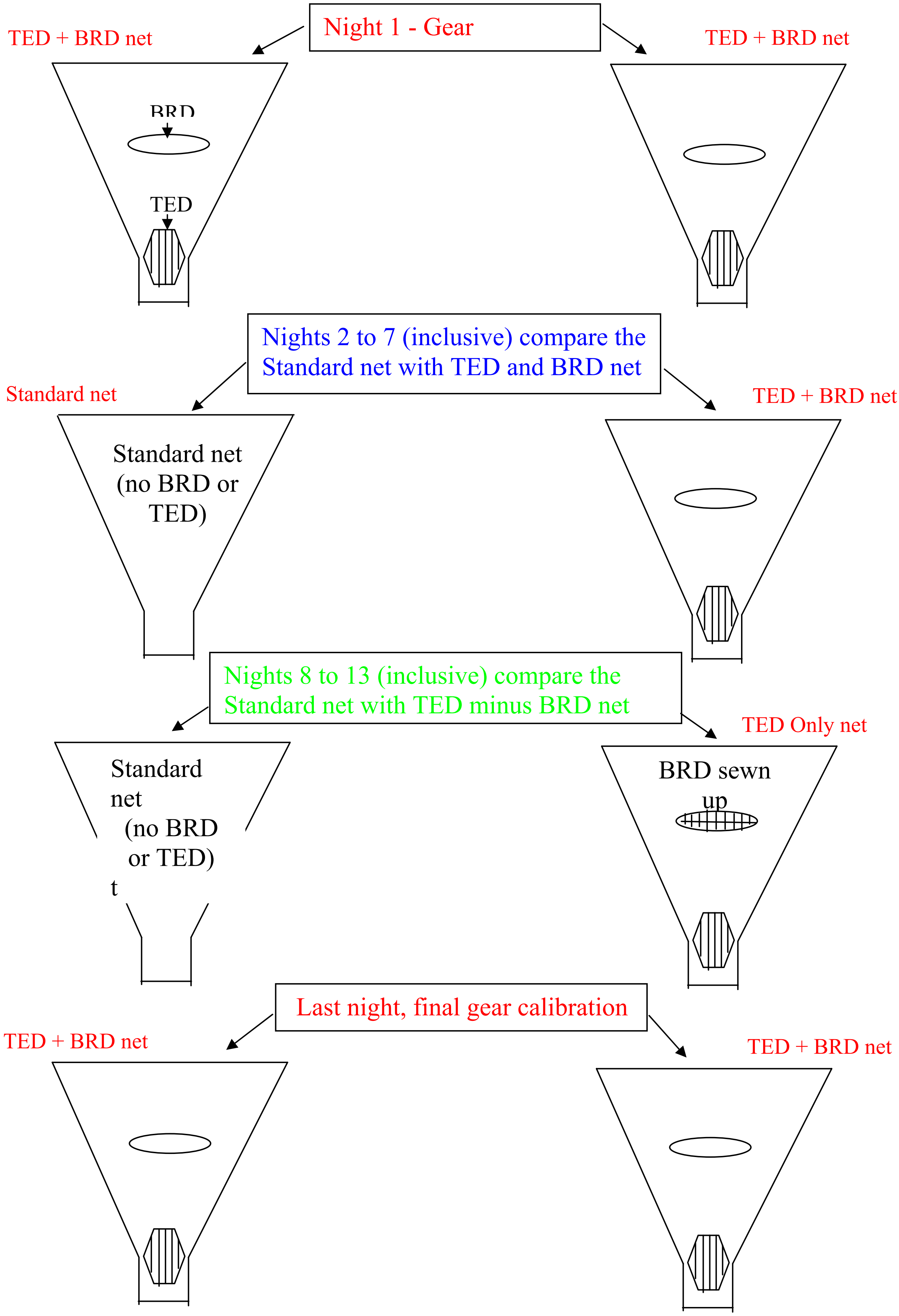
Table 1

Nights	Net changes to be made	Gear Comparison
1 -- Calibration	No change to any net	TED/BRD to TED/BRD
2 to 7 inclusive	Remove/sew up BRD on one net and remove TED from the same net. This becomes the Standard net	TED/BRD to Standard net
8 to 13 inclusive	Remove/sew up the BRD on the other net (it still has the TED installed)	TED only to Standard net
14 -- Calibration	Reinstall TED and BRD to Standard net. Un sew/replace BRD in other net. **A repeat of Night 1**	TED/BRD to TED/BRD

In order to achieve the sample Objectives, (i.e. as many TED/BRD combinations throughout both region and time), we will be coordinating your movements through the fleet, from Cleveland. We will be in constant contact with motherships as well as that subset of vessels in the fleet who are happy to have observers on board. We will keep you informed as to your next likely move as soon as possible.

NB. The process for collecting catch data from each net comparison (each shot) is detailed in **Methods Section 4**

Fig 1. Typical Gear configuration over a 2 week sampling period on one



Methods

Contents

4.1 The Role of Observers

The primary role of observers in any fishery is to record data and information on all aspects of that commercial fishing operation including the fishing gear, fishing methods, and catch information. The data recorded by observers is independent (hence called 'fishery independent data') compared with data recorded by operators in the fishery ('fishery dependent data'), which is usually recorded in logbooks. The 'fishery independent' data is used to validate 'fishery dependent' data when conducting an analysis on particular aspects of a fishery.

It is important to note that observers in this project are not compliance officers.

Your duties do not include any reporting of breaches of Fisheries Acts, Navigation Acts etc etc. It is well worth discussing this topic with the skipper of your trawler on the first day. This will allay any suspicions that may be held by either skippers or crew in that direction.

You will turn a blind eye to anything of this nature and leave that knowledge on board when you leave that trawler. Our assessment depends on good cooperation with skippers and crew. (Read 4.7.3 as well as OH and S Section on Confidentiality)

The most important role of an observer is to record information that is both true and accurate. Information must be recorded separately to that recorded by operators and records should not be influenced by the way operators perceive they should. Any pressure to record data in a specific way by operators should be reported to observer supervisors. If all else fails, record what the operator wants on a datasheet but note the true results elsewhere. Note on the data sheet that the information may be biased.

In addition to the recording of data, it is essential to maintain a trip diary where a more detailed record of events can be noted (there is a diary supplied in your kit). Maintenance of the daily diary also helps when preparing final reports. **You should always record information directly after it has been collected, rather than relying on memory**.

For those of you who take a personal camera on board, we would be happy to pay for the cost of processing 2 rolls of film (2 by 36 colour slide exposures). We would like to collect a series of shots showing things like differences between sorting trays before sorting, with many monsters on the Standard net side and few on the TED/BRD side, or any frames of general interest. Any shots of sawfish would be most welcome. As well, we would like to get some frames of each observer in action, as well as a portrait type frame or two, which we will incorporate into the final report to FRDC. Thus, you will be immortalised in NPF history! Get the cook to take a snap or two of you in action!!

4.2 Observer objectives

Each trawler participating in the observer project will be using two trawl nets, one fitted with a TED and BRD (as per regulations), and the other, the Standard net will have no TED or BRD installed (as per AFMA permit).

General objective
To measure the differences in catches attributable to the use of TED's and BRD's.

Specific objective
To measure the **differences in catches** of the following **catch categories**

1 Target species of prawns (including damaged prawns)
2 Retained byproduct
3 Large and small bycatch species

4.3 Observer Data Requirements

4.3.1 *What data -- and how often do I record it?*

(A) Record the following data**-- firstly when you go on board,** then again **every time the gear is changed,** e.g. a BRD is sewn up, or TED removed etc.

- Description of trawl gear, TED's, BRD's, and their size and position in the net. (see the **Example Sheet No 2** for further details)

(B) Record the following data**, for every shot:**

- **Station data** (eg. start time, end time, latitude, longitude, depth, weather etc)
- **Weight (kg) of prawn species** in each net (eg bananas prawns, endeavours, kings, tigers etc)
- **Weight (kg) of damaged prawn species** in each net (eg bananas prawns, endeavours, kings, tigers etc)
- **Weight (kg) of retained byproduct** in each net (eg bugs, scallops, squid, fish etc)
- **Species, length (mm), weight (kg) and sex of monsters** (and condition where possible). This includes the larger bycatch animals like sharks, rays, turtles, sea snakes and sponges)

(C) Record the following data**, for selected shots:**

- **Weight of small bycatch species** (usually discarded to sea). Collection will depend on sea conditions, size of catch in codend

- **Species lengths/weight of small sharks and rays from the trash chute bycatch.** Collection will depend on other higher priority tasks having already been fulfilled in a region.

The priority of sampling for the different catch categories is shown in **Table 2** below.

Table 2. The Field Sampling Priority list of the 8 categories of catch that possibly could be sampled on each trawl station

Sampling Priority	Catch Category
1	Changes in catches of whole prawns
1	Changes in catches of small bycatch
1	Changes in catches of large monsters
1	Changes in catches of sea snakes
2	Changes in catches of damaged prawns
2	Changes in catches of byproduct (bugs, squid, scallops etc)
3	Changes in catches of small sharks/ rays from the trash chutes
3	Changes in catches of sponges

4.3.2 In what time-sequence will I record this data?

(A) Data to be recorded only occasionally

- TED and BRD type, size, and position in net are recorded within the first 24h of boarding the trawler. Similarly, the size of trawl, type of trawl boards, etc are recorded at this time. **A Gear Sheet is supplied in your kit for this data. See the Example Sheet No 2 for further details.**

- However, every time during the survey, modifications are made to the trawl gear, the TED or BRD, then these changes affect the way that the gear fishes. Any such changes must be noted on a new gear description sheet, **especially noting the date and time of the modifications.**

(B) Data to be recorded every shot --- See Fig. 2.

4.3.2.1 **Station data** is recorded at the beginning of every shot, and towards the end of every shot, whilst the trawl is being winched in (winching usually takes 3-5 minutes depending on depth)

4.3.2.2 **Monsters - Live large sharks , sawfish, rays and turtles.** Species, estimated lengths and estimated weights and sex are recorded before live animals are returned to sea. This occurs as soon as the trawl gear is back on the sea floor bottom. Large live animals quickly damage the catch on the sorting tray so need to be returned to sea quickly.

4.3.2.3 **Weight of prawn species** is recorded after each individual net has been sorted. Usually, the crew weigh the prawns (by species) after the catch from the first net has been sorted. At this stage, you also need to record those weights. The process is repeated for the second net. Always request that the crew sort the same sorting tray side first on each shot (e.g always the Port side)

4.3.2.4 **Weight of damaged prawn species** is also recorded after each net has been sorted. The crew need to know to keep the damaged prawns by species from each net separately.

4.3.2.5 **Weight of retained byproduct** should also be recorded at the end of **sorting** the catch from the first net. You may need to weigh the byproduct yourself -- if time is available. If not, place it in a separate basket for weighing after the second catch has been sorted.

4.3.2.6 **Species, length, weight, and sex (where applicable) of the dead, medium-size sharks, rays, sawfish, sponges etc (less than 25kg)** is usually the last data recorded. Because these animals are already dead, this task is done when everything else is completed. This category may include some dead sea snakes which need to be bagged and placed in the freezer for transport to Cleveland Laboratories for biological examination.

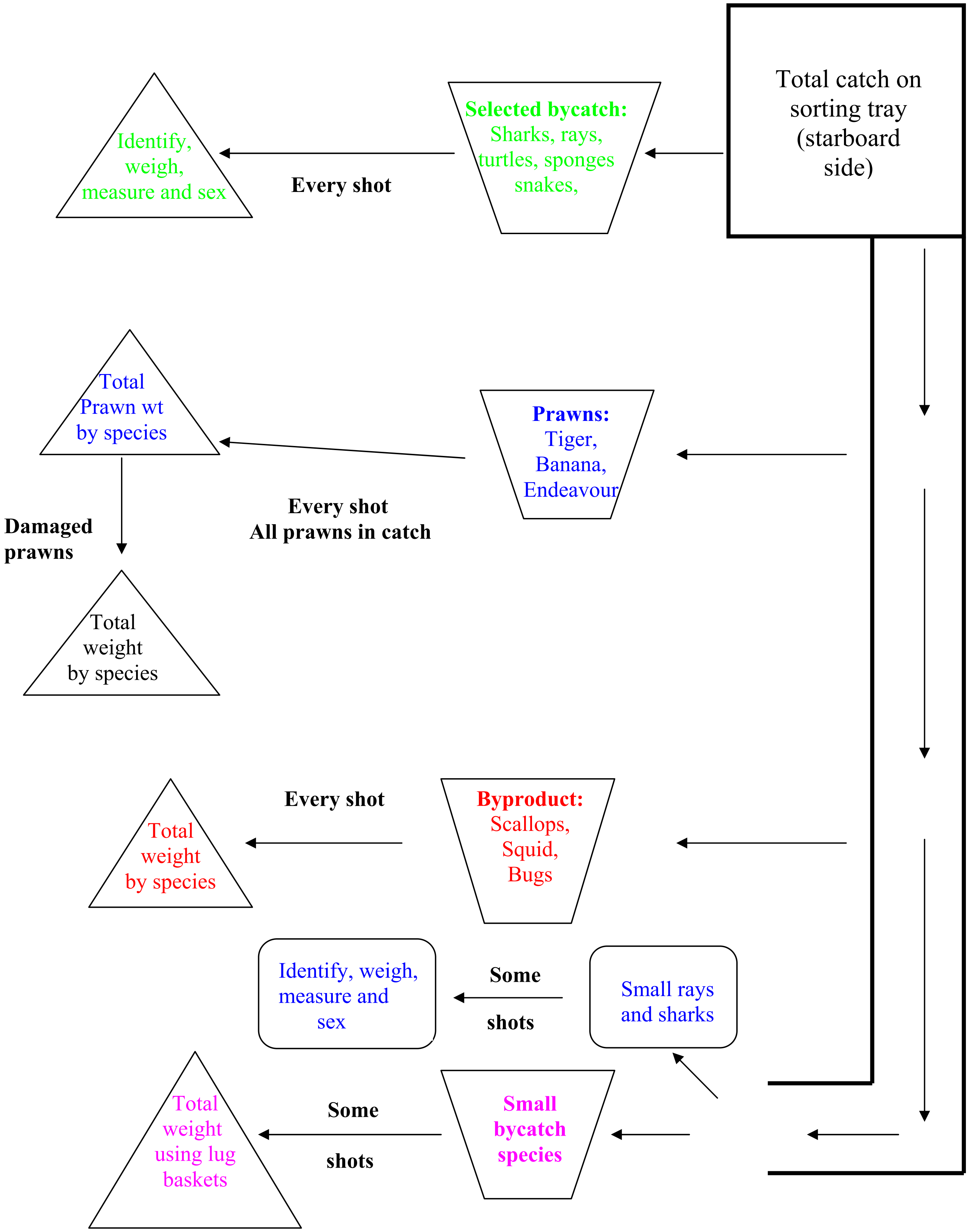
(C) Data to be recorded from selected shots. See Fig. 2.

4.3.2.7 **Weight of small bycatch** is recorded during the sorting of the catch from the first net. As the unwanted small bycatch is washed down the trash chute, you will collect and record the number of levelled lug baskets of bycatch, including the last 'Half basket'. You can then calculate the weight of small bycatch for that net. The process will be repeated for the catch from the second net.

NOTE : It will not be possible to weigh the small bycatch from every shot. Often when the ratio of bycatch to target species is very high, sorting is too fast for an observer to keep up with the flow of bycatch down the trash chute. It may be that in some regions, only catches taken at certain times of the night are suitable for observers to manage the weighing process. Furthermore, rough sea conditions will also make this work more risky, especially tipping full baskets of bycatch over the side. At these times, these comparisons should be dropped.

4.3.2.8 **The number of small rays that pass through the trash chute.** Collect and record the species, number, disc width, weight and sex (where possible) of the small rays that are not detected by the monster separation process on the sorting tray. Data must be collected for both nets.

Fig. 2. On-board sorting process and data collection (starboard net)



4.4 Detailed description of all data recording procedures

4.4.1 Recording Station data (abiotic)

At the start of each trawl, record the abiotic data including date, start time, latitude and longitude coordinates from GPS, depth, moon phase, weather (wind speed and direction, sea conditions). See Examples of completed Master Sample sheets and Gear Description sheets on pages 18 - 21

Each Observer has been allocated a unique set of Sample numbers before going to sea (See Table 3).

Each time that the trawl gear is shot away, allocate the next unused Sample number to that shot. This process continues for the whole season, irrespective of what vessel you are on.

Table 3. List of observers and their respective sample numbers for each shot

Observer	Sample numbers issued
Ben Bird	1 to 399 (inclusive)
Garry Day	400 to 799
Quinton Dell	800 to 1199
Chris Gough	1200 to 1599
Reuben Gregor	1600 to 1999

Check out the **Example Sheet No 1** to see where Sample No is recorded each shot.

At the end of each trawl just prior to or as the shot is being winched up, record the finish time, duration of trawl, and comment on any trawl irregularities (eg breakdowns, snagged or bogged trawl gear, or drastic changes in weather that might cause differences between catches. For example, one net may be fishing heavier and catching more mud than the other because the trawler is turning in the same direction over a small mud bank on each circuit. These types of observations need to be recorded while they are fresh in your mind - and not left until the following trawl, or day to be recalled.

CSIRO-AMC Assessment of TEDs and BRDs

Shot Description

Observer	Mal

Date at Start	3/09/02	Sample No	2014
Vessel	Fishy 2	Area	East of Webenger
Shot No	1	Duration	3.5h
Start Time	1830	End Time	2200
Start Lat	15Deg 56.9	End Lat	15 Deg 59.2
Start Long	137 Deg 33.2	End Long	137 Deg 36.0
Start Depth	13.2	End Depth	13.5
Moon	2 days after full	Wind Dir.	SE
Wind Speed	15-20k	Wave Ht	1.5
Down Time	Lost 5 mins at Start --- lazyline tangle		

Species Description --- Monsters

Species	Len (cm)	Wt (kg)	Which Net ? Either -- (a) TED only net (b) TED + BRD net (c) Standard net	Comments (photo?; dead or alive? etc)
Rh. djiddensis	58	2.6	(a) Port	Dead (F)
Ch. punctatum	51	2.38	(a) Port	Live (F) returned
Le olivacea	52*19	~ 20	(c) Starb	Live - Returned- Tag No 111
Epinephelus sp	80	45	(c) Starb	Live - Returned
W/glass Sponge	78	5	(c) Starb	-
Ball Sponge	115	~ 40	(c) Starb	-
Ball Sponge * 9	30-50	21	(c) Starb	Total Wt
				Snakes sampled Y
				Sponge sampled Y
				Monsters Big Y
				Monsters small N

Comparison of Catch composition

Catch Category	TED only net (Port) Wt in Kg	TED + BRD net Wt in Kg	Standard net (Starb) Wt in Kg	Comments (eg --Weighing methods etc)
Prawns				
Tigers	71.0		66.7	
Damaged	1.2		1.2	
Bananas	N/S		N/S	
Damaged				
Endeavours	7.8		5.5	
Damaged	N/S		N/S	
Kings	N/S		N/S	
Damaged				
Byproduct				
Bugs	0.85 (7)		1.3 (10)	
Squid	0		0.25	
Scallops	N/S		N/S	
Others				
***Smaller Bycatch	244 kg		258 kg	All weighed

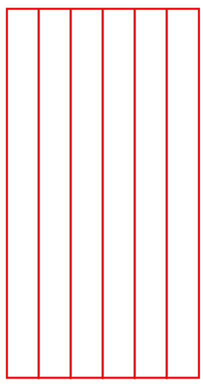
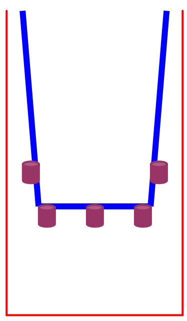
*** Example -- To calculate the Total Weight of Smaller Bycatch from a codend containing 7.5 baskets -- Multiply (the average weight of a lug basket of bycatch) by the number of lug baskets (7) filled to the same level --- then add the butt weight eg. (40kg * 7) + 16 kg = 280 kg + 16 kg = 296 kg (where the 16 kg is the butt weight--ie the weight of bycatch in the last basket - half filled only)

Vessel-Gear Information

Observer	Mal		
Date	03/09/02	Vessel	Fishy 2
Area	Vanderlins	Skipper	"Jello"
Trawl Board Type/Height	# 10 Bisons	Drop chain Ht	9mm = 260mm
Trawl speed (knots)	Av.= 3.2 kts		
Trawl design	Both Florida Flyer Tiger nets		
Trawl size headrope (m)	14 fthm Port 24.96m Stbd 25.05m		

COMMENTS

- Try Gear towed off stern
- Ground chains : Port : 3 links ahead - Star: 3 links ahead Star chain all stainless while port chain is mild steel Star chain greater in size at centre therefore an extra 200cm of small grade chain added to centre port. Both should be evn at this setting (Port @ top of board hinge, star 3 from top (foot rope))
- Sweeps :200 cm each net
- Headrope: Both set square
- Throat: 200mesh around
- Lifting ears: both codends
- Body taper 1P 4B - both nets
- Wash back funnels fitted in both codends between lift and TED.
- Codend extensions (100m long) fitted between TEDs and codend to keep TEDs out - board of lazylines

	TED/BRD net Port Net	Standard net Stbd Net
Body mesh size	50.8 mm	50.8 mm
Cod end size	200 round by 150 meshes long. 47.6 mm	same by meshes same. same mm
Cod end cover	75 by 200 round meshes. 47.6 mm by ply.	same by same meshes. same mm by ply.
TED description  	Large Nordmore Grid Top opening TED • Escape flap 10 mesh Post grid • Belly flaps • 40mm Alum tube outer • 25mm Inner bars • 100 mesh extension between TED and throat • TED angle 55 Deg • Bar spacing ~ 120mm	
BRD description  	Big Eye made by crew • 40 mesh wide selvedged to rope 2000 mm long • 90 meshes ahead of codend in top panel • floats along 2000 mm rope • weights - 5 * small chain links	

4.4.2 *Monster data - large bycatch animals*

Live large sharks, rays, sawfish, turtles and sea snakes are extremely dangerous.

The crew will handle these animals, often using the winch to lift them off the sorting tray.

DO NOT ATTEMPT TO WEIGH OR MEASURE LARGE LIVE ANIMALS

You should only attempt to identify, estimate length and estimate weights of these animals **from a safe distance**.

READ THE SAFETY NOTES IN SECTION 10

With permission from the Skipper, mark along the inside of each sorting tray (marking pen is supplied in your kit), a series of graduations (say at 0.3 metre intervals each) so that you have a reference scale to estimate lengths of live animals. If the animal is "dead", you can use the steel tape for measuring an approximate length of the animal. Never move down the side of a "dead" shark. Always extend the tape from well in front of its head, down to its tail for an estimate of its length. That way, if it lashes sideways, you will be safe. Watch out for "dead" stingrays, especially *Pa. sephen.* They have a particularly dangerous spine and a very agile tail to deliver it with.

Remember - Never trust a 'dead' monster

READ THE SAFETY NOTES IN SECTION 10

Weighing these large animals with the 50 kg scales is not possible. You will have to estimate their weight.

Length of sharks is measured as the total length in mm from the tip of the snout to the furthest extremity of the caudal fin (tail).

Table 4 The sharks and rays that could be most easily identified

List of Sharks, Rays, Sawfishes that can be identified by Observers			
Family	**Common Name**	**Species**	**Comments**
Carcharhinids	Whaler shark, Whitecheek Shark	*Carcharhinus dussumieri*	Second black dorsal only, sandy colour, all other fins almost colourless
	Common Blacktip Shark	*Carcharhinus tilstoni*	No interdorsal ridge, black tips/edges to most fins, strong muscular body,
			2nd dorsal almost directly above anal fin commencement
	Milk Shark	*Rhizoprionodon acutus*	Slender, small 2nd dorsal, position of 2nd dorsal to anal
Sphyrnids	Scalloped Hammerhead	*Sphyrna lewini*	
	Winghead Shark	*Eusphyra blochi*	
	Great Hammerhead	*Sphyrna mokarran*	
Ginglymostomatids	Tawny Shark, Tawny Nurse Shark	*Nebrius ferrugineus*	Sandy to greyish brown with 2 angular similar sized dorsal
			fins set well back on body
Stegastomatids	Zebra shark	*Stegastoma fasciatum*	Very long blade like caudal fin, ridges along upper surface & flanks
			Harmless, pavement teeth, small mouth bottom groveller
Hemiscylliids	Grey Carpet Shark, Brown Banded Cat Shark	*Chiloscyllium punctatum*	Live forever
Hemigaleids	Weasel Shark	*Hemigaleus microstoma*	Teeth do not noticeably protrude
	Fossil Shark or Snaggletooth Shark	*Hemipristis elongata*	Noticeably protruding teeth
Rhynchobatids	White spotted ray	*Rhynchobatus djiddensis*	
	Angel shark, Bow Mouthed Ray	*Rhina anclyostoma*	Large thorns on back, on horny ridges
Pristids	Wide Sawfish	*Pristis pectinata*	24-34 evenly spaced teeth
	Green Sawfish	*Pristis zijsron*	24 28 unevenly spaced teeth
	Narrow Sawfish	*Anoxypristis cuspidata*	Thin and no teeth on basal quarter of saw
Dasyatidids	Black Stingray	*Dasyatis thetidis*	Black, large, has thorns over head and back of adults.
	CowTail Ray	*Pastinachus sephen*	Black ventral skin fold on tail long and high
			(stinging spine long way back on the tail)
	Blackspotted Whipray	*Himantura toshi*	Black spots small, widely spaced and dark on dorsal surface.
			Banded black and white tail
	Painted Maskray	*Dasyatis leylandi*	Small dorsal spots, only grows to around 300mm disc width
	Reticulate Whipray	*Himantura uarnak*	Dense pattern of fine reticulations on dorsal surface
	Leopard Whipray	*Himantura undulata*	Leopard like spots
Myliobatidids	Eagle ray	*Aetomylaeus. nichofii*	Plain or faintly banded upper disc
Gymnurids	Australian Butterfly Ray	*Gymnura australis*	Rat tail ray. Very distinctive

Sawfish sometimes give birth on the sorting tray due to stress of capture. If you observe this event, record the number of pups, their sex, lengths and weights, as well as the normal data e.g. species, length and weight of the mother.

Rays are measured as disc width, i.e. the widest dimension of the animal.

Turtles are measured from the front of the carapace to the rear tip (except see Turtle section of ID manual for Hawksbills), allowing the steel tape to flex and follow the contours of the shell

Sponges are counted only if they measure 300mm or more in any dimension.

Sea snakes are to be counted only.

NB: Remember to record on the sample sheet when the weights and lengths are only estimations.

You need to talk to the deck crew so that they know to tell you when large animals (turtles, sharks or rays) are about to be removed/lifted from the sorting tray so that identification, length and weight estimates can be recorded before the animals are released into the sea. They are usually lifted by rope (via a winch) and lowered over the side in order to prevent further damage.

Handy Hints--

NB. It is a good game plan to carry a small sheet of waterproof paper and pencil in your pocket to record things whilst working on the deck. Your working master sample sheet folder should remain up on the winching deck in your "Office" -- otherwise you risk losing it to wind and waves and water.
Blanks sheets of waterproof paper have been included in your kit (60 each kit). The A4 sheets can be cut in half and at the end of each shot after data has been recorded on the master sample sheet, the pencilled deck notes can be rubbed out using the rubbers supplied. This way, the spare sheets will last for months.

4.4.3 Prawn species

Most trawler crews record the weight of each target species of prawns in each net separately. This allows them to identify when one net is fishing differently to the other and needs adjustment. You will need to organise with the deck crew who weigh the catch from each side, for them to notify you of the respective weights as soon as they become available. **Record the weights etc on your sheet of waterproof paper in your pocket.**

4.4.4 Weight of damaged prawn species

You will need to pre arrange with the deck crew in the processing room to keep separate the damaged prawns (from each net), and weigh them, and then notify you of the respective weights as soon as they become available. You must be careful that there is no carryover of damaged prawns from the first net sorted, to the second net sorted -- inside the processing room. **Record the weights etc on your sheet of waterproof paper in your pocket.**

4.4.5 Weight of byproduct

The crew may not separate the retained byproduct from each net and you will need to organise for one of the crew to do this. This means providing a different basket to separate the catch from the two nets. Use one of your plastic buckets to collect all the byproduct from the first side. Similarly after sorting the second side has finished, collect the remaining byproduct in another bucket. Remember the byproduct from each net must be recorded separately. You will not have time to weigh the byproduct during sorting. **Record the weights etc on your sheet of waterproof paper in your pocket.**

4.4.6 Recording the small bycatch species

In order to record the total weight of the small bycatch species from each net, you need to divert the trash chute that returns the bycatch to the sea. The trash chute often has two sections that lock together. By separating the last section, you can position the shortened chute so that the bycatch falls into a lug basket. As each basket is filled with bycatch and reaches the required level, you can adjust the unevenness of the bycatch in the basket by using the hand rake. Remove the basket, sliding an empty one in its place to catch the continuing stream of bycatch. Using the supplied levelling device, check that the basket is full to the required level, then drag it to the gunn'le and tip the contents over the side.

Select the next consecutive number from the pile of plywood tablets (supplied) to remind you how many baskets have been processed.

This is a critical step in the procedure.

You must get in the habit of doing this after tipping out a basket. Deck crew will be calling out weights of tigers (from the first side) to you that you need to record. It is very easy to lose count of how many baskets you have tipped over the side. When you are trying to detect a difference of maybe 10 kg between nets, under or over estimating by one whole basket because you have lost count causes serious data inaccuracies.

It is unlikely that the last basket in a catch will be full to the right level. You will end up with a "half basket". You must place the correct numbered tablet on the top of that basket. You need to weigh that "half basket" at the end of sorting the second catch, so put that basket somewhere safe and out of the way till then. Having the numbered tablet on top will remind you how many baskets were processed in that side.

It is very important that the deck crew, both sorters and those who shovel the unsorted catch (prawns, byproduct plus small bycatch) from the sorting tray through to the sorters, understood what procedures are needed for your data recording. In shots where you need to record separately the small bycatch from each net (in lug baskets), it is critical that the sorters cease (momentarily) after the first catch has been sorted. You need to replace the last "half basket" with an empty basket before the sorting process commences for the second net. At the same time, you must collect the byproduct in a bucket for later weighing.

Be extremely careful when tipping full baskets over the side. It is better to lose a basket, than follow it into the sea and be taken by a shark.
READ THE SAFETY NOTES IN SECTION 10

Record the numbers/weights on your sheet of waterproof paper in your pocket.

When you transfer the rough data to your Sample sheet, record the number of full baskets and the weight of the "half basket' for each net. **See Example Sheet No 1 for full details.**

In order to estimate the weight of small bycatch accurately, you need to know the average weight of a levelled basket of bycatch.

You will need to collect a series of baskets of small bycatch from both nets (around 6 from each side). Level them using the supplied leveller and allow them to drain for 1/2 hour using the wood supplied (with your kit) to keep them up from the deck.

Then proceed to weigh each basket and record the weights from each side separately. You can then calculate the average weight of a levelled basket from each net. The average weight from each side should be very similar. Record the individual basket weights on the sample sheet of the shot concerned.

You can then multiply the number of baskets (levelled ones) in future shots, by the average weight to arrive at the total (don't forget to add the 'half basket').

When the vessel moves to a new region and different bycatch species are taken, the average weight of a levelled basket needs to be recalibrated

Caution--Potential for Bias in average weight of baskets of bycatch

The objective behind using BRDs is to reduce the weight of small bycatch caught by the net. If a particular TED/BRD combination is excluding some small bycatch species successfully, then the average weight of a levelled basket may well differ between a Standard net and the TED/BRD net. This is most likely to occur if the excluded species is the dreaded light-weight Heart Urchin (Itsy Bitsy etc). A levelled basket of Heart Urchins will weigh considerably less than a levelled basket of normal fish and invertebrate bycatch.
You need to note these changes and act as soon as they develop. You will need to recalculate average basket weights if one net is obviously catching more Heart Urchins than the other.

Be extremely careful when tipping full baskets over the side. It is better to lose a basket, than follow it into the sea and be taken by a shark.

READ THE SAFETY NOTES IN SECTION 10

4.4.7 Medium-size dead sharks, rays, sponges etc (less than 25kg)

In every shot, the deck crew shovelling on the sorting tray need to keep separate the larger and the medium-sized bycatch from each net. This includes all the turtles, sharks and rays, sea snakes, and sponges that are greater than 1.5 - 2 kg. As a general rule of thumb, these animals would not fit easily into the standard waxed carton (the sea snake cartons).

You should keep one lug basket on each sorting tray so that the shoveller can then place these medium size animals into the appropriate baskets.

The larger of these dead animals can be weighed in a fishing basket suspended by 4 hooks from a set of 50 kg dial scales (attached to the shelter deck ceiling). There is a set of 50 kg scales and ropes/hooks supplied in your kit. However, you can use the existing ship scales on many trawlers as long as you do not interfere with whatever the crew are trying to do. **Talk to the crew and work out a compromise on scale useage.**

The smaller of these dead animals can be weighed with a 5 kg spring balance (supplied). In all but the calmest weather, you will need to hold the balance by hand in order to cushion the rolling of the trawler and reduce the error in weighing. **You will develop a feel and learn to compensate for the extra weight that the rolling or pitching of the vessel adds to the reading of the spring balance.**

Problems in identifying sharks or rays

You will encounter some small sharks (eg *Rh acutus* etc) or rays that are fairly common throughout the region you are working, but you may not be confident that you can identify them correctly. Even after discussing the identification with your supervisors, you may still be confused. In cases like this, carefully select 2 or 3 type specimens to keep frozen on board for your own reference. Be consistent in naming the unknown species and refer to your own frozen reference specimens, especially if any doubt exists that more than one species is included.

Some specimens of the species in question should be frozen and sent back to the laboratory for identification and subsequent biological examination. Before leaving your trawler, label the type specimens (sample labels are provided) and package them in a strong plastic bag (provided). Tie the plastic bag with VB cord around the neck and address the bag with the ink marking pen to:

CSIRO Marine Research, Middle St. Cleveland, Qld 4163.

Then **make sure that they are transferred to the mothership at unloading time** to be shipped to CSIRO, Cleveland to resolve the identification questions.

All species can be measured using a steel tape (supplied).

The data must be recorded separately for each codend.
Large sponges will be counted only. A sponge is counted only if it is larger than 300mm long, or wide in any direction.

4.5 Field identification of large/medium size bycatch species

- **Turtles** can be identified sing the QCFO leaflet "Sea Turtle Identification Chart". This leaflet also details a turtle recovery schedule. The crew are skilled at Turtle recovery processes**. Record the species and the length of the carapace (See Hawksbill).**

- **Sea snakes** are too dangerous to attempt identification. Some dead snakes may be frozen and transported back to the CSIRO laboratory for positive identification and/or biological examination. **Sea snakes are recorded by the numbers caught in each net, including any that are thrown over the side, and for every shot.**

- **Sharks, sawfish and rays** can be identified using the keys supplied (Identification manual). These keys are copied directly from "Sharks and Rays of Australia" by Last and Stevens, 1994. Any small sharks and rays that you are unsure of the identification, should be frozen, labelled and shipped back to Cleveland for positive identification as per **Section 4.4.7. Record species, length and weight where possible.**

- **Sponges** cannot be identified (except for a few species) so no keys are provided. **Record only the numbers of sponges larger than 300 mm in any dimension.**

4.6 Living/working conditions on NPF trawlers

4.6.1 Accommodation

Accommodation on board NPF trawlers ranges from a bunk in a twin share cabin to a separate cabin if the trawler is short-handed. Almost all trawlers are airconditioned, and often the temperature is so low in the galley downstairs that you will definitely need tracksuit pants and jackets and a jumper or two. The lack of storage space and the large volume of sampling equipment can create problems that needed to be addressed before going aboard any trawler. **Talk to the Skipper** about the best place to store items that may be used infrequently.

Effects of weather on sample recording

Weather influences the reliability of the data collected. In good conditions, weighing the small bycatch and monsters is much easier than when seas are rough. Weighing and measuring monsters in rough weather requires constant vigilance. Prolonged periods of rough weather also affect the general mood of crew and observers alike.

READ THE SAFETY NOTES IN SECTION 10

4.7 Relations between crew and observers

4.7.1 Briefing of skipper and crew before winching and sorting operations

For reasons of safety and morale, and to maximise the information gained from each trawl, it is important you keep the skipper and crew fully briefed about any likely changes to their normal fishing routines. Before winching up at the end of a trawl, discuss with the skipper your requirements for the trawl, what information you expect to be able to record and how. In turn, the skipper will instruct the crew in any changes to their duties. You can best maintain good relations with crews on the trawlers by giving them help where possible, yet staying out of their way as much as possible. The crews are restricted to working at sea every night for up to four months straight, **a major potential source of disharmony**.

4.7.2 Observers are ambassadors for CSIRO, FRDC, AMC, Fishing Companies and other project stakeholders

Whilst you are in the employ of this project, you are ambassadors for CSIRO, FRDC, AMC, Fishing Companies, net manufacturers. On your return journey whilst waiting for a flight home, you may be accommodated by the mining company GEMCO at Groote Eylandt for a night.

GEMCO is not required to permit anyone on their lease, and they do it as a favour for CSIRO.

We have developed good relations with such companies in Northern Australia over a long period of years. We don't want that reputation jeopardised.

Remember that you are a representative of these organisations. You are expected to honour the trust invested in you and behave in a civil manner at all times.

4.7.3 Confidentiality

You can best maintain relationships of trust with skippers and crews by not venturing opinions on the negative or positive attributes of other companies, trawlers, skippers or crew, or Government Research Organisations. You must respect the confidentiality of information that you are privy to eg. favourite fishing spots and good catches etc. You must also ensure that you never leave any confidential written information concerning any other trawler or fishermen, lying around in the wheel house or galley where it could have been accessed accidentally by those for whom it was never intended.

At some stage, a skipper or crew member will certainly question you about where the last vessel (you were on) was fishing, or what they caught, or was the skipper any good? etc etc.

Your reply must always be

"I'm sure you wouldn't like me to discuss your catches or favourite fishing spots with the skipper or crew of the next vessel that I'm on.

So I'm sure you can understand that I am not at liberty to disclose what happened on any other vessel."

READ SAFETY NOTES IN SECTION 10

4.8 How will I send my data back to CSIRO Cleveland??

Procedure to be followed at the end of the last nights work on a vessel.

4.8.1 **You must complete the data summary sheet (supplied in your kit).** This summary sheet is our insurance policy against losing any data in the transferral to Cleveland. It would make sense to fill in the summary sheet at the end of every nights work so that you have only to fill in the last nights work before jumping on to the mothership at the end of the 2 weeks (or whatever). **An Example Sheet No 3 is included to show how to complete this summary and explanation notes follow.**

4.8.2 **You must Fax this summary sheet (or sheets) to Cleveland in case your copy gets lost/damaged and your data gets lost. Fax the summary sheets before leaving the vessel on which the data was collected.** Store your summary sheet somewhere really safe. Place it inside one of the small plastic bags in your kit and seal the bag with tape (supplied). Then place the plastic bag on the bottom of your personal gear bag or somewhere equally safe.

4.8.3 **Before you leave every vessel -- follow the postage instructions (below) to send your data sheets to Cleveland.**

- In each observer kit, there are **6 Express post bags** for sending your data back to Cleveland. **These bags are pre numbered and prepaid.**

POSTAGE PROCEDURE

1) Use the postage bags in **their numbered order** .The hand-written numbers are located on the front, bottom left **e.g. No 1. USE THIS ONE (No 1) AFTER YOUR FIRST VESSEL.**

2) ***IMPORTANT: REMOVE** the 'sender **to keep**' tab on the front (bottom left corner of the Express Post bag). **Put this sticky tab in your diary** on the day you removed it.

3) **Place all data sheets (2 types --shot data and gear description) in postage bag and seal. Then staple at least 3-4 times along the seal** to ensure nothing can come loose.

4) **IF**, for any reason, the address we have already written on the Express Post bag is difficult to read (eg, effected by being in salt water), these are the address details that <u>must</u> be readable on the front of the Express Post Bag:

To: Company Name **CSIRO Marine Research**

For Urgent Attention of **Don Heales** *Telephone* **(07) 3826 7245**

PO Box Number or Street Address **PO Box 120**

Suburb or Town **Cleveland** *State* **QLD** *Postcode* **4163**

After boarding the mothership, discuss with the skipper what their postage system entails and the security of the system. The skipper will instruct you on where to place your sealed package of data so that it gets to Cleveland as soon as possible.

4.9 Concise dot – point summary of communication and confidentiality issues for observers to note

- To reinforce in a nutshell **the objective of the project** – to collect data to allow a comparison of catches of both prawns and by-catch caught with and without reduction devices
- You are an ambassador for CSIRO, AMC and the government in general and therefore you are expected to conform to some behavioural standards. You are not, however, a fisheries or any other sort of inspector (also section 4)
- The ship is the crew's home. Respect this and assist the crew whenever possible
- CONFIDENTIALITY. Be careful. Much of the information and the success of your data collection will depend on your demonstrated credibility (also section 4)
- COMMUNICATION. Don't assume any person knows about this project and your work. Talk about all aspects to the skipper and all the crew on your allocated vessels (also section 4)
- Be careful with submission of data sheets and be sure to keep accurate summary sheets. Data sheets have been mislaid and lost in the post in the past
- If in doubt about any aspect at all of your work or any other matter, or if you need help, don't hesitate to call us
- A preliminary summary of **results from all observers of your two-week banana prawn season stint** has been prepared by S. Eayrs and is available as a separate paper.

Glossary of sample sheet terms

(in the order that the terms appear on data sheets)

Section 1 Shot description

Sample No -- Each observer has been issued with 400 unique sample numbers for this project. If your allocated numbers are **400 to 799**, then the first sample sheet you fill out will have sample number **400** in the **Sample No** box. This number applies to everything related to this trawl shot, and that includes both nets. The second trawl shot becomes **Sample No 401** and so on, with numbers allocated consecutively to trawls in a time series.

Date at Start Date at the start of the trawl shot, **not** when the trawl is winched up.

Area Brief description like Nth Mornington Is. or Nth Groote Eylandt etc.

Shot no This only relates to the number of trawls undertaken on the **current vessel**. So it will revert to Shot No 1 when you shoot away for the first time on the **second vessel** you are aboard.

Duration This refers to the elapsed time between (a) when the trawl boards actually **enter** the water and (b) when the trawl boards **exit** the water. e.g. 3 h 12 mins. etc

Moon This refers to moon phase.

Phases	Days
New	1-7 (starts on day of new moon)
First Qtr	8-14
Full	15-21
Last Qtr	22-28

Wind Dir Direction wind comes from e.g. SE

Wind Sp. Wind speed in knots estimated e.g. 25-30 kts.

Wave Ht Height (in metres from peak to trough) e.g. 1.2m.

Down Time Describe and record the duration of any loss of **Trawling** Time due to any of the following --TED or BRD problems, mechanical breakdowns, hookups, foul weather conditions, steamimg to change trawl grounds, unloading to motherships.

Section 2 Monster data

Species	Latin name is the best -- if known from keys. Common names for the same species vary depending on who is telling the story.
TED only net	This is a net that has the BRD removed or sewn up, but retains the working TED. (See experimental design -should be used in week 2)
TED plus BRD	This is the net that has both the TED and BRD functional (see experimental design -should be used in week 1)
Standard net	This is the net that has both the TED and The BRD removed for the full duration of the comparisons. This net represents the standard net used before TEDs and BRDs were compulsory in this fishery.
Trash Chute Rays	**See Example Sheet No 1** at bottom of Monsters Section. The species, numbers and sex of the small rays are recorded here.

Section 3 Comparison of Catch composition

Damaged	Refers to the weight of target species that were separated because they were damaged, soft shelled etc (this may not occur on some vessels)
Byproduct	Refers to the retained (i.e. that which goes into the freezer) catch. Includes squid, bugs, scallops, fish, crabs etc)
Smaller bycatch	This term refers to the small fish crabs etc (everything unwanted) that normally is flushed down the trash chute and back to the sea. (You will be weighing this via the lug baskets.)

Cruise Summary (Observer Log) To be completed and Faxed before leaving each vessel

Observer: Garry Day	Start date: 3/9/01	TED Type	BRD Type
Vessel: Classic	End date: 16/9/01	Down Super Shooter (Popeye)	Big Eye 1/2 way (1m)
Gen. area trawled: Nth Gte	Sample Nos From: 400 To: 455		

Summary of Prawns and Small bycatch (e.g. 25-23-235 = 25 kg Tigers/**23**kg Endevs/**235** kg small bycatch**)**

Sample No	TED plus BRD (Port)	TED plus BRD (Stbd)	Standard net Port net	TED only net	BRD only net	Comments
400	23-4-0	24-6-0				No Small bycatch-Gear calibrate
401	30-9-0	35-12-0				Same
402	18-2-0	16-4-0				Same
403	12-4-0	14-3-0				Same
404		25-16-0	22-15-0			No TED or BRD (Port net)
405		28-12-321	29-10-234			Same
406		32-20-345	30-18-298			Same
407		26-9-0	28-12-0			Same
408		25-16-0	22-15-0			Same
409		28-12-321	29-10-234			Same
410		32-20-345	30-18-298			Same
411		26-9-0	28-12-0			Same

Sample No	TED plus BRD (Port)	TED plus BRD (Stbd)	Standard net Port	TED only net Stbd	BRD only net	Comments
412		25-16-0	22-15-0			Same
413		28-12-321	29-10-234			Same
414		32-20-345	30-18-298			Same
415		26-9-0	28-12-0			Same
416		25-16-0	22-15-0			Same - Gear bogged 1/2 h lost
417		28-12-321	29-10-234			Same
418		32-20-345	30-18-298			Same
419		26-9-0	28-12-0			Same
420		25-16-0	22-15-0			Same
421		28-12-321	29-10-234			Same
422		32-20-345	30-18-298			Same
423		26-9-0	28-12-0			Same
424		25-16-0	22-15-0			Same
425		28-12-321	29-10-234			Same
426		32-20-345	30-18-298			Same
427		26-9-0	28-12-0			Same
428			25-16-0	22-15-0		No BRD in Stbd net
429			28-12-321	29-10-234		Same
430			32-20-345	30-18-298		Same
431			26-9-0	28-12-0		Same
432			25-16-0	22-15-0		Same
433			28-12-321	29-10-234		Same
434			32-20-345	30-18-298		Same
435			26-9-0	28-12-0		Same

Sample No	TED plus BRD (Port)	TED plus BRD (Stbd)	Standard net Port	TED only net Stbd	BRD only net	Comments
436			25-16-0	22-15-0		Same
437			28-12-321	29-10-234		Same
438			32-20-345	30-18-298		Same
439			26-9-0	28-12-0		Same
440			25-16-0	22-15-0		Same
441			28-12-321	29-10-234		Same
442			32-20-345	30-18-298		Same
443			26-9-0	28-12-0		Same
444			25-16-0	22-15-0		Same
445			28-12-321	29-10-234		Same
446			32-20-345	30-18-298		Same
447			26-9-0	28-12-0		Same
448	23-4-0	24-6-0				No Small bycatch-Gear calibrate
449	30-9-0	35-12-0				Same
450	18-2-0	16-4-0				Same
451	12-4-0	14-3-0				Same

Easing in procedure on a new/first vessel

1 Introduce yourself to the Skipper and crew

2 ***It is important to note that observers in this project are not compliance officers.***

Your duties do not include any reporting of breaches of Fisheries Acts, Navigation Acts etc etc. It is well worth discussing this topic with the skipper of your trawler on the first day. This will allay any suspicions that may be held by either skippers or crew in that direction.

You will turn a blind eye to anything of this nature and leave that knowledge on board when you leave that trawler. Our assessment depends on good cooperation with skippers and crew.

3 ***Fit out the whole crew with T Shirts***

4 Explain to the skipper what data is needed and how you intend to collect it over the following 2 weeks on board.

General Objective --To assess the impact on catches of the use of TEDs and BRDs--

And specifically -- To measure the differences in catches of the following catch categories

(1) Target species of prawns (including damaged prawns)
(2) Retained byproduct
(3) Large and small bycatch animals

Step 1. You will need to establish that there is no pre-existing bias between Port and Starboard nets

- Explain to the skipper that the first night will be devoted to checking for bias between port and starboard nets (both still fitted with TEDs and BRDs)
- Explain to the skipper that you wish to randomly select a net to convert to standard. Then toss a coin in front of the skipper and select the net that will be converted to standard.
- Explain to the skipper that you will need to see the deck process in action before finalising your routines

5 The Objective for shots on your first working night will be Gear calibration--to detect bias in catches of primarily the target species of prawns.

So at the beginning of the first shot, fill in the sample sheet with start of trawl times, depth, lat, long, sea conditions. Talk to the mate who normally runs the deck process about collecting the weights of prawns from each side separately (both tigers and endeavours) and at the start of winching in, complete that section of the sample sheet.

As the catch is sorted, watch how the trash chute works- can it be stored somewhere easily and out of the way when you need to do the lug basket work. Record the weight of tigers from each net. Watch how the damaged tigers and endeavours from each net are handled. Are they kept separate -- because we need that information separately for each net.

After observing the first few shots, have a think about what is going to happen with the medium size monsters. The deckie needs to throw them into a lug basket, one basket for each side of the sorting tray. How will the snakes be handled before placement in sample bags with labels? And what about the large monsters. Tomorrow night, the TED and BRD will be removed from one net and you can expect large live monsters immediately.

How will you organise measuring them etc without getting too close?

Remember that sometime before the next nights trawling, the TED and BRD will be removed /sewn up.

What happens if one set of gear catches more prawn than the other, and consistently? Well, this shouldn't happen. The main reason for this will most likely be a hole in the net the lower catch. This can't be a contrived result because no one has prior knowledge of which net you are going to choose to convert to a standard net. If no successful alteration to the gear is made you should consult with your supervisor next morning to discuss the issue before allowing a TED and BRD to be removed from a net.

The second night on the first vessel that you board will be a case of working out a routine that works for you. Don't panic. The shark and ray identification will be slow. We don't expect you to get it right for the first few nights. We do expect you to be consistent in naming unidentified sharks and rays so that when you are confident of their names, you can backtrack and update your sample sheets correctly. We will be talking to you regularly for the first few nights to help with these teething problems. Get a routine going early, and then stick to it. You can modify it slightly on other vessels to suit new situations.

Northern Prawn Fishery

Occupational Health and Safety At Sea

OBSERVERS MANUAL

(Don Heales and Quinton Dell)

For use during the Tiger Prawn Season 2001

Contents

10.1 AIMS

This manual seeks to:

- identify and describe hazards likely to be encountered by observers.

  The hazards fall into two general categories:

  a) hazards likely to cause physical injury
  b) hazards likely to cause mental stress

- recommend actions that will eliminate or reduce interactions with these hazards

10.2 Hazards likely to cause physical injury - motherships

10.2.1 Hazard -Boarding and initial settling in period on motherships.

You may board a mothership at a port like Bamaga, Horn Island, Groote Eylandt, or at sea. Immediate awareness is required when boarding any new vessel (new to you) because every vessel has fittings on the deck to trip over, low ceiling heights in doorways, areas that are slippery when wet etc. None of these will be signposted - they are facts of live on commercial vessels.

Action

- Wear runners with good soles whilst boarding. The vessel may be unloading cargo when you board. Keep right away from containers being slung by the crane, especially when they are lifted up in the air.
- Firstly, find and introduce yourself to the Skipper/Mate.
- Ask the Skipper / Mate to show you things/hazards that he is aware of already e.g. no railing at stern or whatever.
- Ask where you are allowed to go on the vessel. For example, the engine room will always be out of bounds.
- Explore the layout of the vessel as soon as possible so that you are aware of things to avoid.
- Ask what is the emergency sound signal and where the muster point is in case of emergencies, either fire, sinking, etc.
- Make sure you find out where your lifejacket is stored, try it on so that you know it fits and is serviceable if needed. Find the liferafts and picture how they might be deployed in an emergency

- Place your personal inflatable vest in a position that is easily accessed in an emergency

- Find the Galley and introduce yourself to the cook. Ask where the tea, coffee etc is stored. Start reminding yourself that you do not leave things lying around on any vessel. Wash up, dry and put away after using cups, plates, towels, books whatever. Mothership crew don't have time to clean up after passengers.

- Keep your cabin tidy.

Day to day operations of motherships

10.2.2 Hazard - Steaming.

Sometimes whilst steaming, the decks may be awash. If someone falls overboard, it may not be noticed for 12 h or more. No-one does head counts on commercial vessels.

Action

- You must keep away from the decks, especially at night or any time when it is rough. Do not go out on deck alone at any time.

Unloading and transferring

Motherships supply fuel, dry freight, cold and frozen foods to trawlers. Trawlers unload product including prawns, byproduct (squid, bugs etc), as well as their accumulated rubbish (plastics, used engine oils, filters).

Unloading can occur at any hour of the day or night on the fishing grounds, but most unloadings occur from 0900h onwards provided the seas are calm. When seas are rough, unloading takes place behind shelter (also in the mornings), eg somewhere around Mornington Island, or Cape Vanderlin etc.

10.2.3 Hazard - Unloading trawlers on the fishing grounds

When trawlers are tying up to the mothership, or when they release their mooring lines when leaving, extremely large forces can be brought to bear on tie up ropes and bits on the deck.

Action

- You must not attempt to either place mooring lines on to bollards or lift them off. Stay right out of the way and leave these tasks to the crew of the mothership.

10.2.4 Hazard - Jumping from vessel to vessel

The trawlers bounce up and down at a completely different rate to the mothership. When an observer is jumping onto or off a trawler whilst on the fishing grounds, slipping between the two vessels, or getting jammed between parts of the two vessels travelling in opposite directions is easy to do. This always has the potential for serious crushing injuries.

Action

- You must be extremely careful when transferring to and from trawlers, either to motherships or to another trawler. If in doubt about the safety of the transfer, ask for help from either the trawler skipper or mothership skipper, or crew.

Do not get jammed between the 2 vessels

10.2.5 Hazard - Handling the prawn carton conveyor belt (used for unloading)

After the conveyor belt has been used inside the freezer room of the trawler for up to an hour, it will be frozen.

Action

- You must avoid handling the electric conveyor after it comes back on board the mothership. Your bare flesh will stick to it unless gloves are used.

10.2.6 Hazard - Unloading in shelter (behind an Island) is far less dangerous.

Action

- You must still observe all precautions discussed previously in **10.2.3, 10.2.4 and 10.2.5.**

10.3 Trawler hazards

Background

NPF trawlers remain on fishing grounds throughout the season. Mostly, after a night of trawling, the anchor is dropped close to where trawling will commence the next evening. Rarely will they seek shelter from bad weather. Most crew have little concept of days of the week except that "Barge Day" comes around every 2 weeks or so. All trawlers shoot the gear away at around dusk or 1830h. They commonly trawl for 3 to 4h before winching up to sort and process the catch. Most trawlers do 3 to 4 shots each night. They rarely breakdown. They carry spares of almost everything so that they do not lose a night's work.

10.3.1 Hazard - Boarding and initial settling in period on trawlers

Similar to the situation with motherships, immediate awareness is required when boarding any new vessel (new to you) because every vessel has fittings on the deck to trip over, low ceiling heights in doorways, areas that are slippery when wet etc. None of these will be signposted on commercial vessels.

Action

- When you board a trawler for the first time, you should make yourself known to the skipper and all the crew. Most trawlers will have a skipper, a mate, possibly an engineer, one or three deckhands and a cook. Similarly to the initial period on the mothership, ask about known hazards, muster points, emergency signals, and fire drills, presence of lifejackets (put it on as a test).

Fishing Operations

The hazards involved when fishing fall into 2 groups:

- shooting away and retrieving fishing gear
- sorting and catch processing

Shooting and retrieving fishing gear

10.3.2 Hazard - Fishing operations are dangerous

The trawl boards are very heavy and dangerous. You can be crushed when they drop into the racks. The nets when being fed away over the side are also dangerous. If you get part of your clothing caught in the net, it will lift you straight over the side. The full codends coming aboard are dangerous. You can be crushed between the codend and the sorting tray. Often live seasnakes hang out the side of the skirt. All the associated ropes and wire cables that link the fishing gear to winches etc are dangerous. When a wire cable or lazyline snaps under load, the parted ends fly back at great speed and cause severe injuries. When a lazyline block lets go, the block itself slams into the deck with tremendous force. It will kill you if you happen to be under it.

Action

Observers must keep away from all operations, including:

- where trawl boards are being winched on to or away from the deck of the trawler
- where nets are being shot away or retrieved over the gunn'le
- where codends are being winched in and spilled, or being returned to the sea empty
- all winches including the main winches, the try winches and lazyline winches when they are in use, and all anchor winches, anchor chains when they are in use

10.3.3 Hazard -Trawler rolling/pitching

You need to be aware that when the trawler turns, that the ship stays heeled until the turn is completed. You must be extra careful when moving around the decks during turns. The motion of the vessel also is much different during turns. Unsecured items on the deck will suddenly slide around the deck (eg baskets of bycatch). A 40kg basket sliding around can cause severe injury to your leg (or someone else's).

Be aware of any open hatches that you can fall into. Be aware of closed hatches that you can trip over.

Action

- Secure objects likely to shift with vessel movements. Keep the object weight low when lifting heavy objects so that if necessary, you can quickly lower the weight to the deck and secure it.

You have been provided with a personal inflatable life vest with EPIRB in the pocket. Wear it when working on the deck, especially in rough weather, or when working alone.

10.3.4 Hazard - Rough seas

You must take extra care when performing any tasks at all in rough seas. Remember that -

- More energy is needed to complete even simple tasks like walking around
- decks are likely to be constantly wet, and possibly slippery due to slime from large animals on the deck. Bycatch will be spilt on the decks during the TED Assessment. It is easy to slip on small fish covering the deck.
- there are many solid objects at head height on trawlers
- the trawler can lurch suddenly and if you are carrying a heavy weight at the time, you may well overbalance -
- all fishing gear is under increased strain and less controllable in rough weather

Action

- Be aware of increased risks described, use hand holds when walking around the deck
- Watch your head height and watch for fish and slime on decks.
- Don't walk close to the gunn'le when moving around the deck. Stay close to the sorting tray so that if the trawler rolls, and you overbalance, you will stay/fall inside the gunn'le, not over the side.
- When the vessel rolls, doors will slam and hatches close. Watch where you place your fingers in rough seas. Use every handhold possible but look before you place your hand on objects that may move suddenly.

You have been provided with a personal inflatable life vest with EPIRB in the pocket. Wear it when working on the deck, especially in rough weather, or when working alone.

10.3.5 Hazard - Falling overboard!!!!!!!!!!!

Similarly to conditions on motherships, there are no head counts on commercial trawlers. If a crew member goes overboard during the night, they may not be missed until the next trawl is winched up. If you go overboard, you may not be missed til next morning.

Observers need to note that during sorting operations, the bycatch is fed straight back into the sea. This attracts many sharks ranging from less than 1 metre long to whalers larger than 2 metres, and the occasional larger tiger shark. During sorting of most catches the trawler is followed by dozens of sharks of varying sizes. These animals follow the trawler even when no sorting is occurring, but are usually deeper and hard to see. When bycatch falls over the side, the sharks are in a feeding frenzy right at the surface and beside the trawler. If an observer falls over the side at this time, there is little prospect of survival.

Action

- You must understand that there is no one on board the trawler who will be responsible for your safety. The crew live with the described conditions daily and accept them. As an observer, taking precautions is finally your own responsibility. There will be times when you will be working by yourself on the deck whilst the crew are processing and hidden from your view. You can ask a crew member to be aware that you are working on deck alone, but the tired crew cannot be relied upon to note your comings and goings.

- You must be aware at all times of staying away from the gunn'le except where necessary. You must take account of the trawlers rolling motion and leave room so that a sudden roll will not place you overbalanced at the gunn'le.

- If you fall over the side, your only chance is to swim away from the side to the trawl wires and pull yourself up the wires and yell. If you try to swim to the rear of the trawler the prop wash will push you away. If you do happen to fall over the side at the transom, you may be able to grab on to the try winch cable. At least you know that someone will come on deck to winch it in within 1/2 hour usually.

- If you are not clear of the water within seconds, the sharks will demolish you.

You have been provided with a personal inflatable life vest with EPIRB in the pocket. Wear it when working on the deck, especially in rough weather, or when working alone.

If you survive falling in to the sea, and your lifevest has inflated correctly, immediately activate your EPIRB which is in one of the pockets. You can expect to survive in these waters for long periods especially later in the season when water temperatures are higher. Conserve your heat by crossing your arms and bringing your legs up. Remember that much heat loss is from the soles of your feet and the top of your head. You can reasonably expect for your EPIRB signal to be noticed and acted on within hours, especially if your absence from the vessel has been noticed and the skipper has contacted the rescue authorities.

Sorting and processing the catch

10.3.6 Hazards - NPF bycatch contains many animals that present hazards to the unwary.

For example, large live or dead animals on the sorting trays or decks can be dangerous. These include

- Sawfish (sharp teeth on blade)
- Sharks (sharp teeth in mouth)
- Large stingrays, especially the Cowtail ray (*Pa. sephen*-- large spine on tail)
- Turtles (strong beak)
- Shovelnose sharks (Rays *Rh. djiddensis* - strong body)
- Large fish gill rakers (sharp)

Small live or dead animals on the sorting trays or decks may be poisonous. These include

- Seasnakes (fangs - extremely poisonous)
- Stonefish (dorsal spines-extremely poisonous)
- Catfish (dorsal and pectoral spines -mildly poisonous)
- Black Trevally (Happy Moments) (dorsal spines -mildly poisonous)

Other animals that can cause bites, embedded spines, cuts or punctures to hands etc include:

- Large puffer fish (sharp cutting beak)
- Qld Halibut (sharp teeth and ambush feeder-can jump off sorting belt to bite)
- Heart Urchins (thousands of sharp fine spines)
- Sand Crabs, Mantis shrimp and other small crustaceans (usually sharp spines and claws)
- Fish in general

Action

- Avoid handling large live animals (sharks, rays, turtles, seasnakes) on the sorting tray, let the crew handle their removal.

- Wait until the smaller sharks and rays are dead before processing them.

- When weighing and measuring 'dead' sharks or rays, don’t assume that they are dead. Handle them as if they are alive. Always grasp the small sharks from above the head so that if they are still alive, your fingers are away from the slashing jaws. When handling stingrays, use a pair of sidecutters to clip off the spines on the tail. When handling large fish such as cod etc, never allow fingers to slip inside the gill rakers where they will be lacerated.

- Watch where you walk at all times - spines from catfish, or stonefish, or any other fish lying on the deck etc will go straight through the sole of a runner.

- When collecting small bycatch from the trash chute, use the small hand rake for levelling catch in the basket. When picking up or dragging the baskets around, check what animals are in close proximity to the handles where your fingers rest. Shift animals that could cause stings, cuts etc.

- **Never for any reason keep live seasnakes anywhere on deck**

10.4 Hazards likely to cause mental stress

10.4.1 Hazard - Constant tiredness

These hazards are mostly due to reduced sleep. Because trawls are winched up around 3-4 h intervals, during the night, you tend to sleep in short stretches of around 1-2 hr. The result of constantly sleeping in short amounts is that your sleep patterns become tuned to only sleeping that long. Even in the day, when it is possible to get longer periods of sleep, your body clock may force you to wake after 2 hours. Or other crew wandering around inside the cabins will wake you, or the banging of the trawler in the seas will awake you. Your body wakes because it thinks its time to winch up. So the bottom line is that you may end up constantly tired. This can cause mental stress.

Action

- Get on to a mother ship and rest for a period before setting up on a different vessel

10.4.2 Hazard - Tensions: crew to crew interactions, crew to observer interactions

The crew will have been dealing with stress for months by the time you arrive. Some may be very short tempered and flare-ups between crew are always possible. Sometimes a crew member has to leave the trawler for the sake of harmony. Rough weather, and the time of night exacerbate crew tension. Tempers get really tested around 0300h.

Action

- There are some rules that need to be observed. Don't take sides in arguments. Never try to intervene in hostile situations.

10.4.3 Hazard - Skipper to observer interactions

Be aware that the wheelhouse is the kingdom of the skipper. Don't wear out your welcome there. Some skippers have rules about what you can wear in the wheel house. Dirty clothes, no shoes or whatever. Ask the skipper what the local rules are.

Action

- Observers must acquaint themselves with these local rules and stick to them. Remember, observers will be relying on the skipper to supply station data for each trawl (Lat, Long, Start time depth etc)

10.4.4 Hazard - Asking for assistance in collecting observer data

When you need the crew to assist you, always approach the skipper/mate first to see if what you are asking for, is possible. If you do not follow this routine, the skipper may discover a crew member doing something instead of what they should be doing. The crew member may 'cop an earful' and indirectly, you will be to blame for their discomfort.

Action

- Observe the chain of command.

10.4.5 Hazard - Food unsatisfactory

Food is mostly of high quality. However, it takes a good cook to churn out top class meals when the trawler is standing on its ear. Be prepared for some less than average meals because either the weather is rough or the cook has 'snatched it' and is waiting for the next barge. Be aware that the 'fresh food (eg fruit and vegetables) ' that arrives on the mothership may have been travelling (on that plus another mothership) for over 2 weeks by time it is delivered.

Action

- Don't make disparaging comments about the food.

10.4.6 Hazard - Seasickness

Seasickness can be both a severe physical and mental stress. Many people find working at night and sorting moving targets (eg bycatch sliding across a sorting tray) can make them nauseous.

Action

- There are tablets that do work but everyone is different. 'Travacalm' is worth trying. However, it can make you drowsy and you need to take the tablet before you get sick. It's too late when you start feeling ill. Take 1 tablet 3 hours before leaving port if any doubt exists concerning seasickness.

10.4.7 Hazard - Living in confined quarters can cause stress.

There is no privacy. The best accommodation you can expect is a top bunk in a two bunk cabin. Your bag will probably remain unpacked on your bunk because there is little cupboard space spare. You can't leave it on the floor because you will trip over it in the middle of the night when you stagger out on deck blinking.

Action

- Keep everything tidy. No-one has time to tidy up after you. This will reduce mental stress for everyone.

10.4.8 Hazard - Using ship equipment

Observers will need to keep themselves and their clothes clean. They will need to uses the washing machine and drier.

Action

- Ask for instructions on how to use ship equipment. If you break it, there will be no replacement machine for at least 3 weeks. This causes much crew tension.

10.4.9 Hazard - Communications with people on shore or aboard other trawlers

This can be a problem. Because the satellite phone is in the wheelhouse, and someone is almost always present, it is very hard for example to explain problems you may be encountering on the trawler. Because the phone is in the wheelhouse and that is where the skipper lives, having people on shore ring to speak to you between the hours of say 0900 and 1700 hrs is likely to wake up the skipper. The cost of phone calls is around $1.80 per minute and being a satellite link, always has delays between talking and receiving. Use the phone card for work related calls only.

Action

- Your supervisor will ring you and ask leading questions that require a series of Yes/No responses. If things/relations on board are deteriorating, your supervisor will soon 'twig' to what's happening and responses to that situation can be rapidly organised.
- In general, ask people who ring you to select a set time outside 0900h to 1700h. Ask the skipper what the best time is for people on shore to ring you.

10.4.10 Hazard - Confidentiality

Observers are guests on these trawlers. Information collected during observer cruises is confidential, especially the catches being taken and the position or region where the vessel is fishing

Action

- Observers must not disclose any of this data over the phone except with their supervisor. Some observers will transfer to the mothership before boarding a second trawler. They must not discuss them with the crew of the mother ship, skippers or crew of trawlers unloading to the mothership during transit, or the skipper or crew of a second trawler that they may work on. For observers transferring to a second trawler via the mothership, all written data sheets collected from a first trawler must be placed in the special 'Post Bags' provided and sealed to ensure that no one can tamper with the package. The package should then be stored securely inside the observer's personal luggage bag until it can be paced in the postage system of the mothership.

- **Read Section 4.7 of Methods for further confidentiality information.**

10.5 General information

10.5.1 Crew Harmony

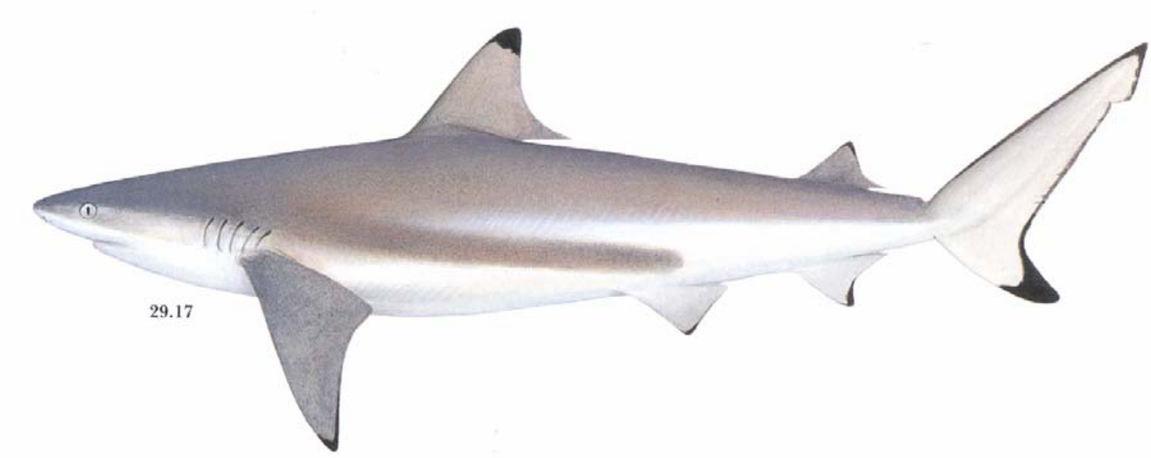
The best means of getting along with the crew is to pitch in and give a hand. You will be relying on their help for gathering some data. Even wiping the dishes makes a difference. If you can mend nets, offer to do so, or help to 'pull the snap'.

10.5.2 Sunburn

Sunburn is always a problem when working in the tropics. Even though most of the data collection occurs at night, always use the sun screen provided if you are exposed to the tropical sun for long periods.

Hazardous Marine Animals

SMALL SHARKS - Colour Plate: Blacktip reef shark as an example of small Whaler Sharks (Carcharhinidae)



<u>Hazard</u>: Small but very strong and agile sharks that thrash around with biting motions. While these sharks are only 70cm to a few metres in size, they have razor sharp teeth that can remove fingers and inflict deep wounds.

<u>Handling Procedure</u>: These sharks are strong, agile and have razor teeth. Handling live sharks should be avoided. If handling is necessary follow these steps (even if the shark is presumed dead):

- For removal from vessel – ensure no one is around you, stand behind shark, grab body just in front of caudal (tail) fin and very quickly throw overboard in one motion.
- For handling to measure, determine sex etc – First place one hand grasping over the gills (firm hold), then with the other hand quickly grab firmly on the body just in front of caudal (tail) fin

<u>1st Aid</u>: Wounds will vary in severity. Treat as for cuts and deep lacerations depending on the wound – IE: Place direct pressure on wound, place victim in comfortable position and elevate limb, apply pressure bandage, stay with victim, treat for shock, check circulation beyond pressure bandage. Loss of fingers is possible (treatment may require tourniquets, preservation of severed fingers that can later be re-attached –place finger in air tight bag, keep cool, note time of injury, ensure finger goes with victim to hospital-).

MEDIUM - LARGE SHARKS – Colour Plate: Shovelnose Ray (*Rhinobatidae*)

Hazard: These sharks are known for their excessive thrashing motions and are sometimes referred to as 'prawn sorters' due to this activity on the sorting tray. They pose a hazard to people walking near them, and anyone close to them is likely to be hit by flying bycatch (from crabs to spiny fish – including poisonous species).

Handling Procedure: DO NOT HANDLE. Measure and identify when they are dead.

1st Aid: Treat as per relevant injury (from cuts to bruising + sprains and strains if tripped for example).

LARGE SHARKS - Colour Plate: Tiger Shark, example of large Whaler Sharks (Carcharhinidae)

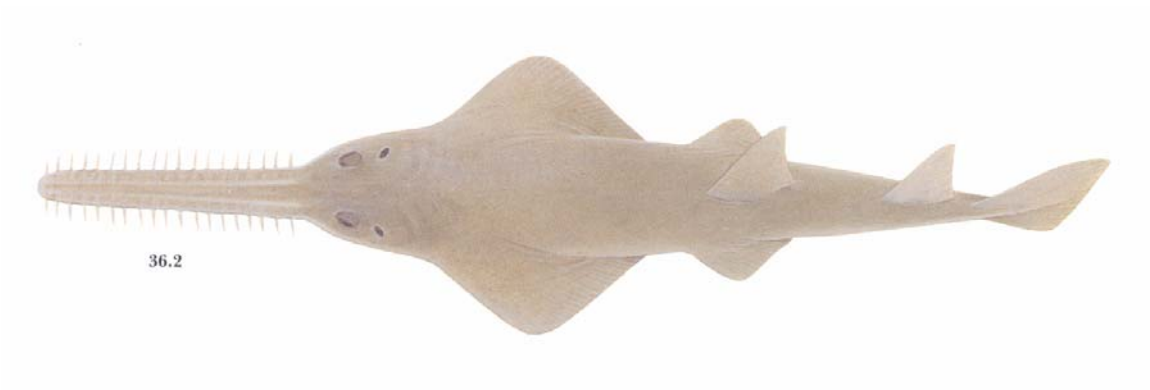
Hazard: Attains a length of up to 6m. It is a strong, large and dangerous shark with layers of razor sharp teeth.

Handling Procedure: DO NOT HANDLE, DO NOT APPROACH! For measurement, get deck hand to dump shark near the side of something you can later measure as a relative measurement once the shark is overboard. Do not attempt measurement if sea conditions are rough (IE stay away from the side of the boat in rough conditions rather then getting a measurement).

LARGE SHARKS - Colour Plate: Tiger Shark – Continued…

1st Aid: Expect sever lacerations, possible loss of limbs. First aid will require quick action. Control bleeding (pressure bandages, possibly tourniquets), treat for shock, get victim comfortable and keep conscious – do not leave victim unattended. Possible preservation of lost limbs that can later be re-attached may be required (keep limb in air tight bag and cool, label + note time of accident, ensure limb goes with victim to hospital!). Urgent medical attention may defiantly be required.

LARGE SHARKS - Colour Plate: Dwarf Sawfish as an example of Sawfishes (Pristidae)

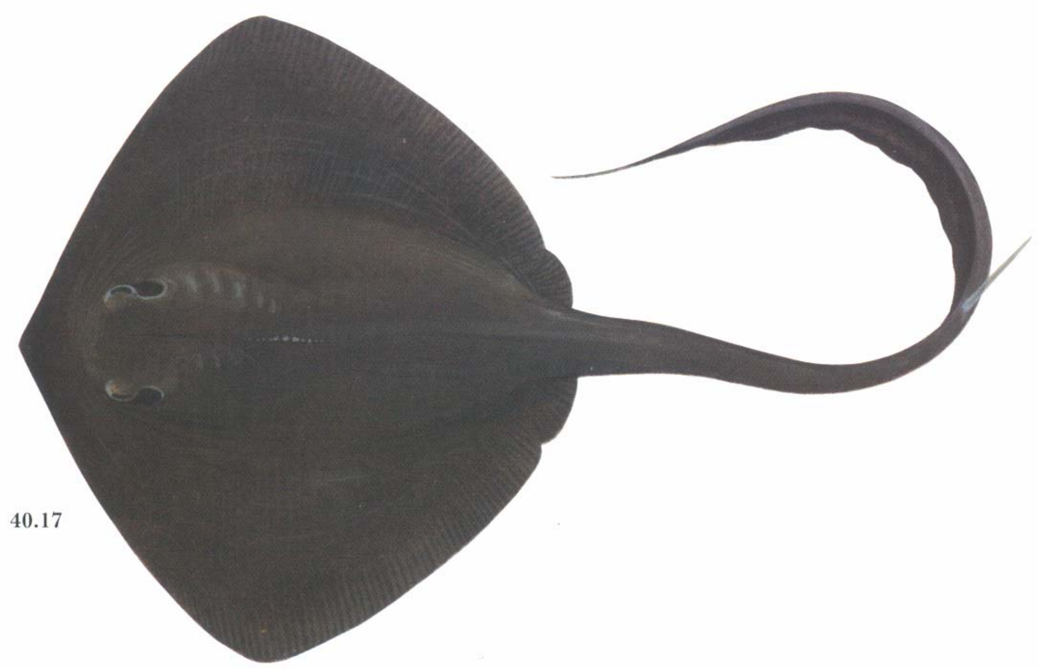


Hazard: These sharks are also known for their excessive thrashing motions. This combined with their toothed snout form an operational hazard. They pose a hazard to people walking near them, and anyone close to them is susceptible to being hit by flying bycatch (from crabs to spiny fish – including poisonous species).

Handling Procedure: DO NOT HANDLE. Measure and identify when they are dead.

1st Aid: Treat as per relevant injury (from cuts/lacerations to bruising + sprains and strains if tripped for example).

STINGRAYS - Colour Plate: Cowtail Ray as an example of hazardous Stingrays (Dasyatididae)



<u>Hazard</u>: One or more stinging spines on the tail. The Cowtail ray pictured above additionally has the ability to throw its tail forward and sting you.

<u>Handling Procedure</u>: DO NOT HANDLE UNLESS DEAD. Beware of the Cowtail ray's ability to throw tail (and stinger spine) forward.

<u>1st Aid</u>: Symptoms can range from severe pain to swelling, panic or irrational behaviour. Place injured area in hot water (as hot as can be tolerated, and until pain subsides). This will relieve pain and denature the enzymes of the poison. NOTE: do not let victim self-administer the heat of the water as they can loose feeling and burn themselves, someone else must monitor the water temperature. Do NOT use pressure bandages or ice on the wound.

SCORPION FISHES - Colour Plate: Stonefish as an example of deadly Scorpionfish (Dasyatididae)

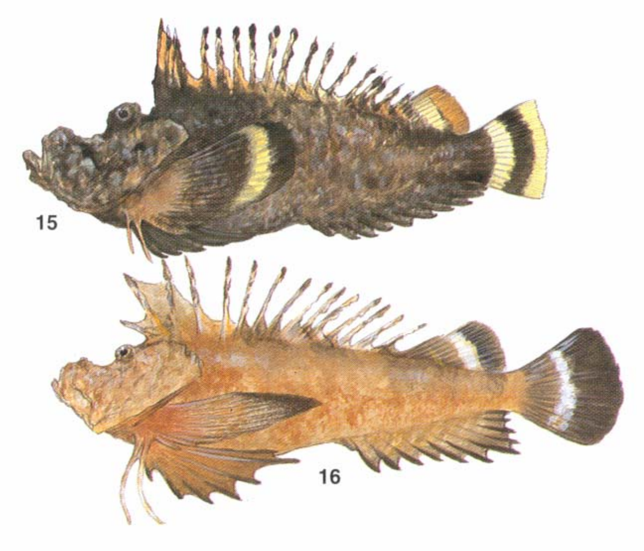
8

Hazard: This is an extremely venomous fish capable of causing death. Spines on these fish (particularly along the dorsal fin) contain venom, which is injected when the spine punctures the skin.

Handling Procedure: DO NOT HANDLE! Be cautious of this fish and use another object to move/remove it (handle by the caudal -tail- fin only if absolutely necessary).

1st Aid: Symptoms range from bee-sting sensation to violent pain and may lead to unconsciousness or extended coma. Immersing the wound in very hot water is an effective first aid treatment but medical treatment should be sought immediately. (NB: someone other than the victim must administer the heat of the water to avoid the victim burning themselves). Treat for stress, keep victim comfortable and conscious.

SCORPION FISHES - Colour Plate: Bearded Gouls as an example of severely painful Scorpionfish (Dasyatididae)



15

16

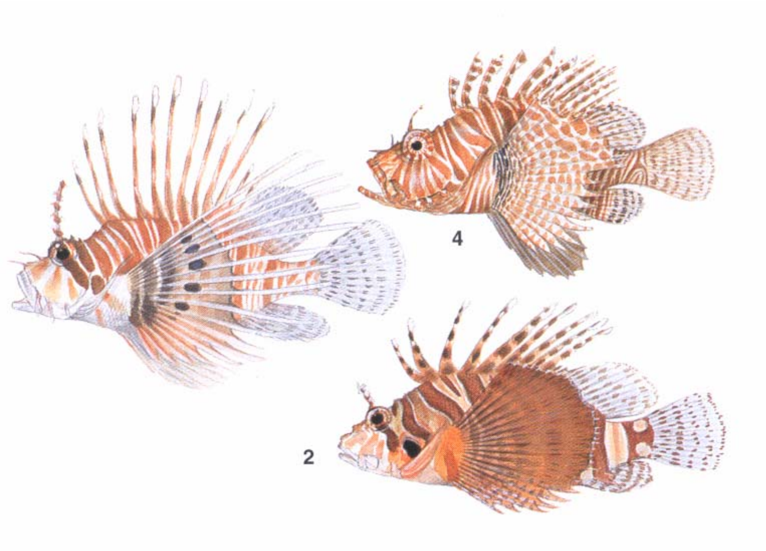
<u>Hazard</u>: These are venomous fish capable of causing mild - severe pain. Spines on these fish (particularly along the dorsal fin) contain venom. Scorpion fishes are generally identifiable by their raised dorsal fins and particularly ugly appearance.

SCORPION FISHES - Colour Plate: Bearded Gouls - Continued…

<u>Handling Procedure</u>: DO NOT HANDLE! Be cautious of these fish and use another object to move/remove it (handle by the caudal -tail- fin if necessary).

<u>1st Aid</u>: Symptoms range from bee-sting sensation to violent pain. Immersing the wound in hot water is an effective first aid treatment. <u>Note</u>: someone other than the victim must administer the heat of the water to avoid the victim burning themselves, the water should be as hot as possible without burning.

SCORPION FISHES - Colour Plate: Butterfly Cod as an example of severely painful Scorpionfish (Dasyatididae)



<u>Hazard</u>: These are venomous fish capable of causing mild - severe pain. Spines on these fish (particularly along the dorsal fin) contain venom. Scorpion fishes are generally identifiable by their raised dorsal fins and particularly ugly appearance.

<u>Handling Procedure</u>: DO NOT HANDLE! Be cautious of these fish and use another object to move/remove it (handle by the caudal -tail- fin only if absolutely necessary).

1st Aid: Symptoms range from bee-sting sensation to violent pain. Immersing the wound in hot water is an effective first aid treatment. Note: someone other than the victim must administer the heat of the water to avoid the victim burning themselves, the water should be as hot as possible without burning.

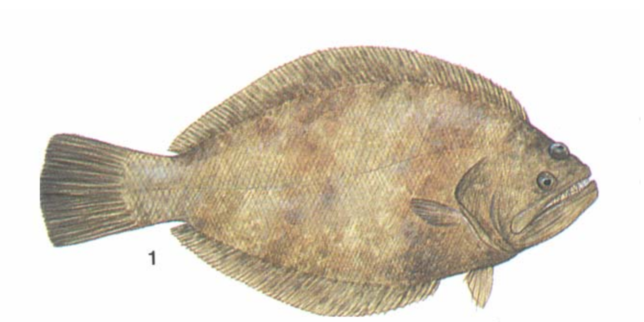
SPINEFOOT (aka: HAPPY MOMENT) - Colour Plate: Spinefoot, a painful stinger (Siganidae)

Hazard: Spinefoot have venomous spines on their dorsal and ventral fins capable of causing mid - severe pain.

Handling Procedure: be cautious of these fish, handle by the caudal (tail) fin if necessary.

1st Aid: Symptoms range from light to severe pain. Place injured area in hot water (as hot as can be tolerated, and until pain subsides). This will relieve pain and denature the enzymes of the poison. NOTE: do not let victim self-administer the heat of the water as they can loose feeling and burn themselves, someone else must monitor the water temperature. Do not use pressure bandages or ice on the wound.

QLD HALIBUT - Colour Plate: Queensland Halibut, aggressive fish (Psettodes erumeri)

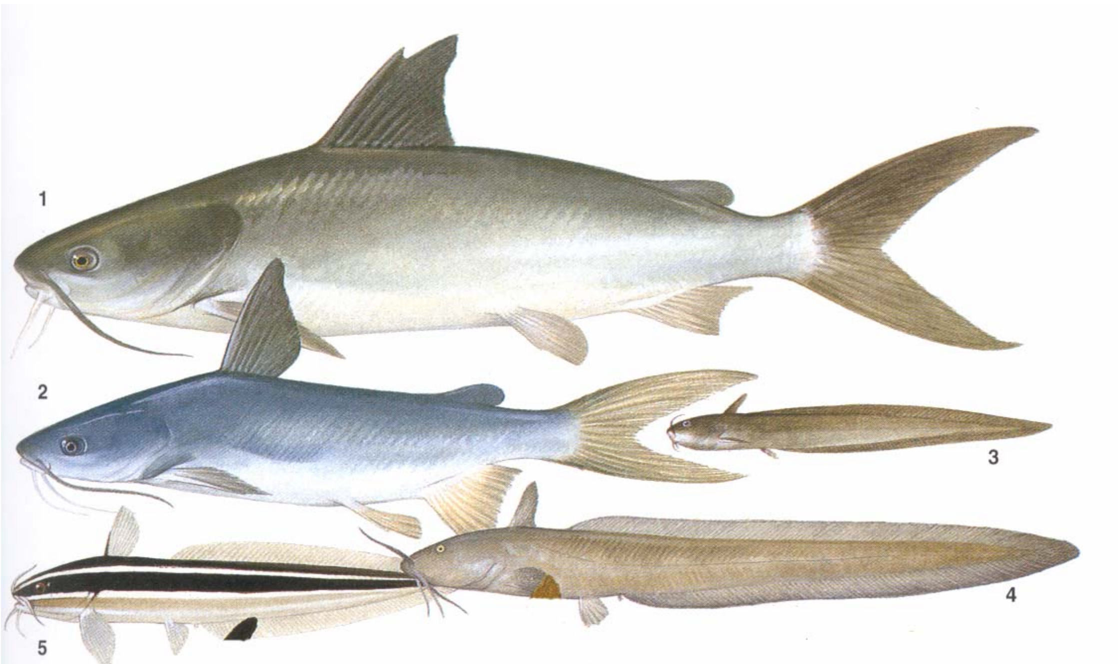


Hazard: These fish are renowned for their ability to lash out at fingers. They have a strong and largely extendable jaw (containing many sharp teeth) that is projected at hands when near this fish

Handling Procedure: Be cautious of this fish even if it appears dead. They often remain immobile then lash out unexpectantly. Handle as per normal, being aware of its behaviour.

1st Aid: Treat as per minor cuts. It is important to treat wounds early due to the bacterial load in fish slime and the tropical environment (plus other aliments such as sea ulcers developing if the wound is not addressed properly).

CATFISHES - Colour Plate: Range of Catfishes from painful – extremely painful stings (Ariidae & Plotosidae)



Hazard: Catfish have venomous spines capable of causing severe pain (numbers 1 and 2 above). Eel tail Catfish (numbers 3 – 5 above) are more venomous, causing severe and possibly long term pain.

Handling Procedure: Avoid handling, be cautious of these fish and use another object to move/remove it (handle by the caudal -tail- fin only if absolutely necessary).

1st Aid: Symptoms range from light to severe pain. Place injured area in hot water (as hot as can be tolerated, and until pain subsides). NB: do not let victim self-administer the heat of the water, someone else must monitor the water temperature. Do not use pressure bandages or ice on the wound.

TURTLES - Colour Plate: Ridley turtle as an example of turtles caught in the NPF

Hazard: The turtle's beak is very strong and sharp, easily capable of removing a hand or fingers.

Handling Procedure: Don't approach turtles from the front, always work from the side or behind.

1st Aid: Treat as for cuts / deep lacerations depending on the wound – IE: Place direct pressure on wound, place victim in comfortable position, elevate limb, apply pressure bandage, stay with victim, treat for shock, check circulation beyond pressure bandage. Loss of fingers is possible (treatment may require tourniquets, preservation of severed fingers that can later be re-attached –place finger in air tight bag, keep cool, note time of injury, ensure finger goes with victim to hospital-).

SEASNAKES - Colour Plate: Example of Sea Snakes caught in the NPF (Hydrophiidae)

Hazard: Sea Snakes in Australia's northern waters are one of the most venomous and deadly snakes in the world. These snakes can be very aggressive after being trawled.

Handling Procedure: DO NOT HANDLE. Let experienced deck hands deal with these snakes. Take extreme care even when handling dead and frozen snakes.

1st Aid: Seek urgent medical attention. Immediately apply pressure immobilization bandage IE: firm pressure bandage around snake bite –do not cut circulation- apply second firm bandage from the bite upwards as far as possible (eg, if there was a bite on the hand, bandage up to the elbow). Immobilize victim, bandage splint to the affected limb, monitor breathing/pulse-be prepared to resuscitate/start CPR

APPENDIX 5

NUMBER OF TRAWLS TO DETECT A SIGNIFICANT TED/BRD EFFECT ON PRAWN WEIGHT

November, 2000

Report Number:
CMIS 2000/190

P N Jones

1. Introduction

An investigation was to be carried out to examine the effect on prawn weight of nets from trawlers using various TED/BRD devices. The plan was to compare a standard net on one side of a trawler with a test net on the other side. The question that this report considers is what is the number of trawls needed to detect a given percentage change in the prawn weight between the test and standard nets. To answer this question information as to the variability of the difference between the prawn weights of two nets from a trawler using the same device on both sides is required.

Data in three files was available with prawn weights from the two nets on various trawls from three previous trials. This report calculates the variance of the required difference for these three data sets and the corresponding number of trawls required to detect a given set of percentage changes.

2. Methods

Data set one, called "ss1095", consisted of 88 trawls that had an incomplete "latin square" type arrangement of combinations of two of nine different types of trawl gear on either side of the trawlers. It was intended to have all possible combinations of the nine types in pairs, and to have the pairs in a sequence such that only one type needed to be changed between trawls. The prawn weight was recorded for each side of each trawl.

The second data set, called "moreps", involved 52 vessels with up to 5 shots each, totalling 169 trawls all together. Only one type of gear was used on all vessels and both sides of all the vessels. Again, prawn weight was recorded.

A recently acquired third data set, called "Data3", had a standard net on the starboard side and a TED device on the port side for all of the 42 trawls. Of these trawls, small bycatch weights for 20 trawls were recorded for the port and starboard sides.

To detect a change in mean prawn weight, let the mean of a standard net be $\overline{X}$ and the reduced mean weight of a test device be $p\overline{X}$, where for example a change of 5% corresponds to $p = 0.95$. By taking logs, the mean difference (δ) of the logs is approximately given by $\delta = -\log(p)$, independent of the standard net mean $\overline{X}$.

Analyses of variance of the log of prawn weight or small bycatch weight were carried out for the three data sets. For the case that gear or side effects were significant, the log weights were corrected for by subtracting the relevant significant effects.

The estimate of % Change associated with an estimate of a particular type of gear effect was obtained from the equation: %Change = 1 - exp(effect size) ≈ -effect*(1 + effect/2).

The variances of the log prawn weights (corrected if necessary) were calculated over both sides, as well as for the port and starboard sides separately, and also for the difference between the port and starboard sides. The correlation of the starboard side log prawn weight versus the port side was calculated and values of the two sides plotted. Similar analyses were carried out for the small bycatch weights for the third data set.

The variances of differences between log data from port and starboard sides, after correcting for any significant gear and/or p.s effects were used to calculate the number of trawls required to detect a range of mean differences for a significance level of 0.05 and a power 0.9. These were done using the equation: $N = 8.6(\sigma_{diff} / \delta)^2$.

3. Results

Details of the 88 trawls in the first data set, ss1095, are given in Tables 1 and 2. It is seen that the Standard net was used most often, and occurred in pairs with all the other eight types. There were roughly an equal numbers of nets of each type on the port and starboard sides. Not every possible pairing of the nine types occurred over the 88 trawls.

Analyses of variance for the four data sets are given in Tables 3 to 6, and the estimates of the fixed effects of gear and/or p.s are tabulated in Tables 7 to 10 (the trawl factor was modelled as being random). The vessel component of variance was not significant for the moreps data, and so that data was considered as comprising 169 distinct trawls. For data sets 1, 3 and 4, the gear effect was significant, and there was a significant p.s effect for data set 1. For data set 2, the p.s effect was not significant. The % Change for the gear types for data set 1 ranged from a reduction of 6% to 39%, and an increase of 4% for one gear type. From data set 3, the TED gear had a reduction of 5% for prawn weight, and from data set 4, the TED gear had a reduction of 8% for small bycatch weight.

The variances and correlations of the log data from port and starboard sides for the four data sets, after correcting for any significant gear and/or p.s effects, are given in Table 11. Plots of starboard log data versus port for the four data sets are given Figures 1 and 2. The number of trawls required to detect a range of mean differences (δ) for a significance level of 0.05 and a power 0.9 are given in Table 12.

4. Discussion

There was almost a doubling of the variance of a difference between sides of a trawler in log prawn weight, when estimated from data sets 1 and 3. The latter trawls were over a restricted trawl area and confined to a two-week period, whereas the former was over a wider range of space and time. It is also conceivable that the method of eliminating the gear and p.s effects in the first data set may still have resulted in an inflated estimate of the variance of the difference in log prawn weights between the two sides of a trawler. To plan for a comprehensive assessment of a test gear type, the number of trawls based on the first data set would be the most conservative option. Hence, if it were desired to be able to detect at least a 5% reduction in prawn weight with the use of a new device, then the number of trawls would need to be at least 107.

Table 1. Numbers of trawls with gear types used on Port, Starboard and overall for ss1095

Gear		P	S	Total
Standard	(1)	17	19	36
Austed	(2)	7	8	15
Fisheye	(3)	9	6	15
Nordmore Fisheye	(4)	10	5	15
Nordmore Fisheye2	(5)	11	11	22
Nordmore squ wind	(6)	6	9	15
Nordmore squ wind 2	(7)	11	11	22
S Shooter Fisheye	(8)	6	9	15
S Shooter Fisheye 2	(9)	11	10	22

Table 2. Numbers of trawls with gear combinations on Port and Starboard sides (row x column) for ss1095

P\S		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Standard	(1)	0	2	1	1	4	1	3	2	3
Austed	(2)	1	0	1	1	0	2	0	2	0
Fisheye	(3)	2	2	0	1	0	2	0	2	0
Nordmore Fisheye	(4)	2	2	2	0	0	2	0	2	0
Nordmore Fisheye2	(5)	3	0	0	0	0	0	4	0	4
Nordmore squ wind	(6)	2	1	1	1	0	0	0	1	0
Nordmore squ wind 2	(7)	4	0	0	0	4	0	0	0	3
S Shooter Fisheye	(8)	1	1	1	1	0	2	0	0	0
S Shooter Fisheye 2	(9)	4	0	0	0	3	0	4	0	0

Table 3. Analysis of Log Prawn Weight for ss1095

Source	DF	Value	p-value
Intercept	1	11463.91 (F)	<.0001
p.s	1	36.39 (F)	<.0001
Gear	8	16.08 (F)	<.0001
Residual	79	0.0161(MS)	

Table 4. Analysis of Log Prawn Weight for moreps

Source	DF	Value		p-value
Intercept	1	1768.886	(F)	<.0001
p.s	1	0.177	(F)	0.6744
Residual	168	0.0121	(MS)	

Table 5. Analysis of Log Prawn Weight for Data3

Source	DF	Value		p-value
Intercept	1	2228.560	(F)	<.0001
Gear	1	6.147	(F)	0.0174*
Residual	41	0.0084	(MS)	

Table 6. Analysis of Log Small Bycatch Weight

Source	DF	Value		p-value
Intercept	1	2707.403	(F)	<.0001
Gear	1	10.587	(F)	0.0042**
Residual	19	0.0064	(M)	

Table 7. Effect coefficients for ss1095

Effect	Value	Std.Error	t-value	p-value	% Change
Intercept	3.2885	0.0391	84.097	<.0001	
p.s	-0.1180	0.0200	-5.902	<.0001	
Austed	-0.2902	0.0545	-5.325	<.0001	25
Fisheye	-0.0920	0.0546	-1.684	0.0961	9
Nordmore Fisheye 1	-0.2541	0.0548	-4.634	<.0001	22
Nordmore Fisheye 2	-0.0981	0.0450	-2.183	0.0320	9
Nordmore squ wind 1	-0.4964	0.0545	-9.100	<.0001	39
Nordmore squ wind 2	-0.1298	0.0450	-2.887	0.0050	12
S Shooter Fisheye 1	0.0380	0.0545	0.697	0.4876	-4
S Shooter Fisheye 2	-0.0628	0.0455	-1.380	0.1714	6

Table 8. Effect coefficients for moreps

Effect	Value	Std.Error	t-value	p-value
Intercept	3.1275	0.0605	51.623	<.0001
p.s	0.0050	0.0120	0.421	0.6744

Table 9. Effect coefficients for Data3

Effect	Value	Std.Error	t-value	p-value	% Change
Intercept	3.4056	0.0723	47.091	<.0001	
TED	-0.0501	0.0202	-2.479	0.0174*	5

Table 10. Effect coefficients for Small Bycatch

Effect	Value	Std.Error	t-value	p-value	% Change
Intercept	5.1431	0.0989	52.011	<.0001	
TED	-0.0842	0.0259	-3.254	0.0042	8

Table 11. Variances and Correlations of the Log Data after correcting for gear and/or p.s effects for the four data sets

	ss1095	moreps	Data3	Small Bycatch
σ^2	0.0781	0.6185	0.2170	0.1905
σ^2_p	0.0768	0.6178	0.2104	0.2154
σ^2_s	0.0802	0.6228	0.2289	0.1757
ρ_{ps}	0.7934	0.9804	0.9619	0.9708
σ^2_{diff}	0.0325	0.0243	0.0171	0.0134

Table 12. Number of trawls to detect % changes for the four data sets with 5% significance and 90% power

p	% Change	δ	N (ss1095)	N (moreps)	N (Data3)	N (Sm.By.)
0.990	1.0	0.0101	2765	2068	1459	1139
0.975	2.5	0.0253	436	326	230	180
0.950	5.0	0.0513	107	80	56	44
0.925	7.5	0.0780	46	35	25	19
0.900	10.0	0.1054	26	19	14	11

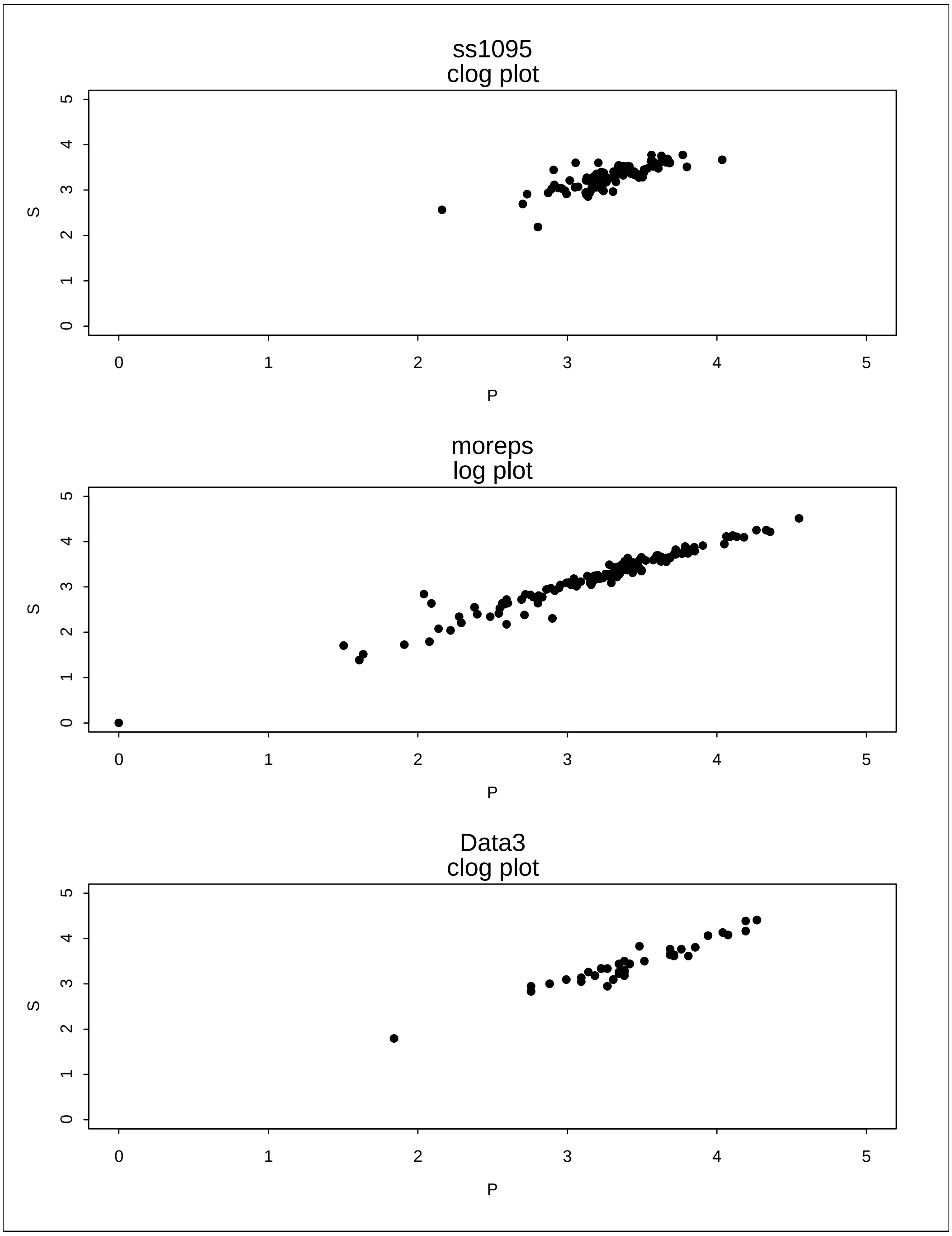


Figure 1. Log Prawn weight for Starboard side against Port side for ss1095, moreps and Data3 (the gear and p.s effects were removed from the first plot and the gear effect from the third).

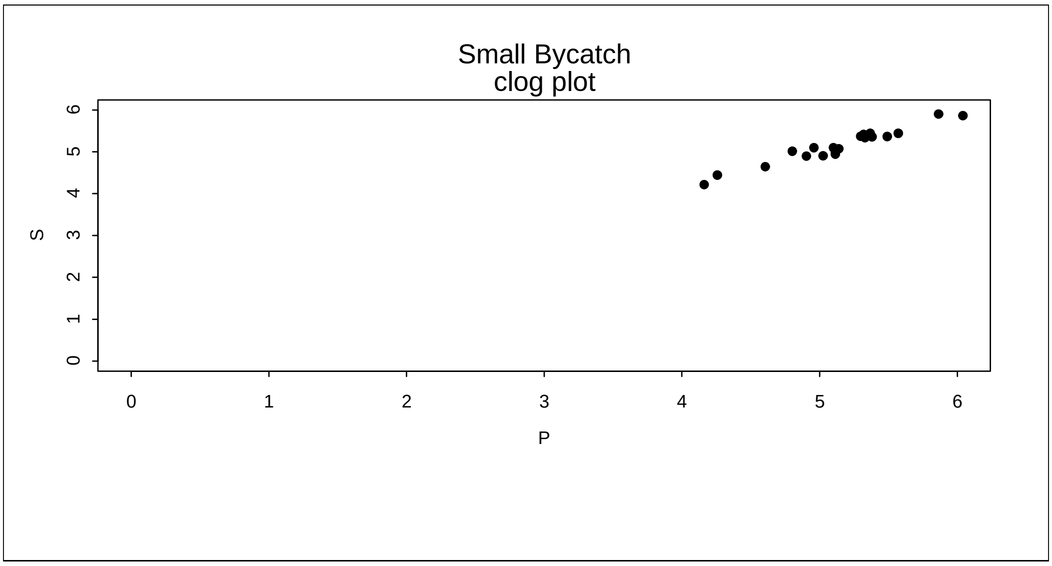


Figure 2. Log Small Bycatch weight for Starboard side against Port side (the gear effect was removed).

Appendix 6

Assessment of a Modified Fisheye Bycatch Reduction Device in Australia's Northern Prawn Fishery.

F.V. - "*Rosen C* " -- Skipper- Jim Yarrow

Reuben Gregor *, Don Heales ** and You-Gan Wang **

2003

* Australian Fishing Management Authority (AFMA), ACT

** CSIRO Marine Research, Cleveland, Q 4163

INTRODUCTION

The Northern Prawn Fishery (NPF) exports the majority of its product and is one of Australia's most valuable Commonwealth-managed fishery. This tropical penaeid prawn trawl fishery is categorised partly by its high bycatch volume and biodiversity. Pender and Willing (1992) estimated the bycatch from the NPF to be approximately 38,000 t each year. In recent survey's by Stobutzki *et al.* (2000), over 390 fish, 47 elasmobranch and 234 invertebrate species were identified in the bycatch of the NPF.

The management of the NPF falls within the jurisdiction of the Australian Fisheries Management Authority (AFMA). A key legislative objective of AFMA is to 'ensure that the exploitation of fisheries resources and any related activities are conducted in a manner consistent with the principles of ecologically sustainable development and exercise of the precautionary principle, in particular the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment' (Fisheries Management Act 1991, EPBC Act). This is consistent with the ongoing evolution of fisheries management towards incorporating an ecosystem approach as opposed to the traditional focus on sustaining maximum yields of target stocks.

The NPF has a Bycatch Action Plan (BAP, 2003) that strongly recommends reducing the volume of bycatch taken. This has partly been successful through the compulsory introduction of Turtle Excluder Devices (TEDs) and Bycatch Reduction Devices (BRDs) into the fishery in 2000. TEDs successfully exclude turtles and some other large animals including the larger elasmobranchs while BRDs aim at reducing the total amount of bycatch, particularly teleosts.

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

The skipper of the FV "Rosen C", Jim Yarrow, had made structural changes to his standard Fisheye (see Appendix 3 for definition) under a scientific permit. The main objective of the field work described in this report was to quantify the effectiveness of this BRD, a modified Fisheye, in excluding small bycatch species during commercial fishing. Depending on the results, this device may become an Approved BRD in this fishery. The field testing may also lead to further research in understanding the dynamics involved in excluding bycatch. A second objective was to assess the power of the sample design to detect reductions in the small bycatch species.

METHODS

Assessment of Fisheye performance

Description of the fishing gear and deployment

Both the Port and Starboard net had headrope lengths of 14.86 metres and footrope lengths of 16.60 metres. Size eight Bison Boards and a drop chain height of 7 links were common to both nets. Trawl speed over the sea floor was estimated to average approx 3.2 knots. With the exception of alternating the modified Fisheye, the nets were not altered over the assessment period.

The Port net was set up to fish square with the ground chains pulled up three links each side. The Starboard net had the headrope pulled up two links per side and the ground chains pulled up three links each side. A bubble was tied in the middle of the headrope to stop it from collapsing when fishing.

Description of the modified Fisheye

The skipper had strengthened the standard Approved Fisheye, by welding two new bars into the frame. One was attached vertically across the middle of the eye opening, effectively halving the maximum open width of the 'eye', the second running from the centre top exterior of the eye to the anterior apex of the support frame (see red lines in Fig. 1). These changes were not intended to alter the effectiveness of the BRD. Instead, they were designed to strengthen the frame and prevent collapse of the eye during hauling when the eye is often bounced against the net deck of the vessel.

Sample design

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

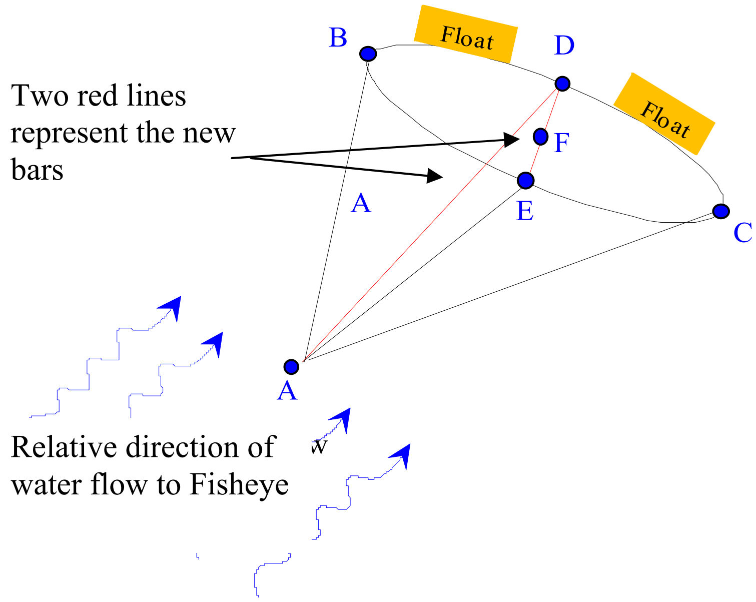


Figure 1. Diagrammatic representation of the modified Fisheye.

The objective of the sample design was to quantify the effectiveness of the modified Fisheye in excluding bycatch, and particularly, the small bycatch species. It was decided that the modified Fisheye would be best assessed while the Turtle Excluder Devices (TEDs) remained in place, hence best duplicating the commercial fishing operations. Assessment of the modified Fisheye took place through at-sea testing by an AFMA observer (the senior author), over 13 nights in the final two weeks of the commercial 2002 Tiger prawn season (late November).

For ease of reporting throughout the remainder of this report, we use the term Fisheye when referring to the modified Fisheye to be assessed.

Four phases of sampling were undertaken - (see Figure 2)

- Initial calibration
- Treatment 1 - Fisheye in Starboard net only
- Treatment 2 - Fisheye in Port net only
- Final calibration

The Initial calibrations (over the first two nights) were undertaken to estimate whether there were pre-existing bias between sides in catches of prawns, as well as small bycatch. If one net was fishing differently (e.g. 'heavier' or 'dirtier') during calibrations, then this difference could be accounted for in the analysis. A schematic diagram of the calibration 'TED only' nets (no Fisheyes installed) is shown in Figure 3.

The Treatment phases (See Fig. 2) included trialing the Fisheye firstly in the starboard net (See Fig. 4 for schematic diagram of installation position in codend), followed by the port net. Because the Fisheye was installed in only one of the paired nets, it acted as the sole Treatment device. This assumes that differences in bycatch between nets then reflected the impact of the Fisheye. The swapping of the Fisheye between nets was designed to further reduce sources of bias that may be derived from unmatched gear related factors, including whether the vessel made more turns to port than starboard over the Treatment phases.

The Final calibrations (over the last two nights) were undertaken to measure any changes (during the Treatment phases) to any pre-existing bias that was identified during the Initial calibrations. The Fisheye in each net was sewn up during both Initial and Final calibrations (Fig. 2).

Data collection

At the completion of each trawl, the two codends were spilled into separate sorting trays. Data was collected for two catch categories :-

(a) Target prawn species
(b) Small bycatch

(a) Target prawn species

Tiger prawn weights were mostly recorded by the crew and measured to the nearest kilogram. In some cases, the observer weighed the prawns to the nearest 100 grams.

(b) Small bycatch

The small bycatch from each of the two codends was collected separately in lug baskets, then weighed on a hanging 50kg spring scale to the nearest kilogram.

Effects of TED blockages

In some trawls, the size of the two codends was obviously very different, and implied that sometime during the trawl, there had been a blockage in front of the TED, commonly referred to by fishers as being 'TEDDed'[1]. Where a net was suspected to have been 'TEDDed', then this trawl was excluded from the assessment. A comparison of the tiger prawn catch between nets was also used as a measure of the possibility of being 'TEDDed'. Each trawl (mostly 3.5h duration) involved numerous runs over the same ground. Consequently the randomness of spatial and temporal catch distribution should become relatively evened out between the nets over the trawl and cases of being 'TEDDed' are usually obvious.

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

Figure 2. Diagrammatic representation of the experimental gear configurations over four testing phases: Initial calibration, Treatment 1 (Fisheye in Starboard net only), Treatment 2 (Fisheye in Port net only), and Final calibration.

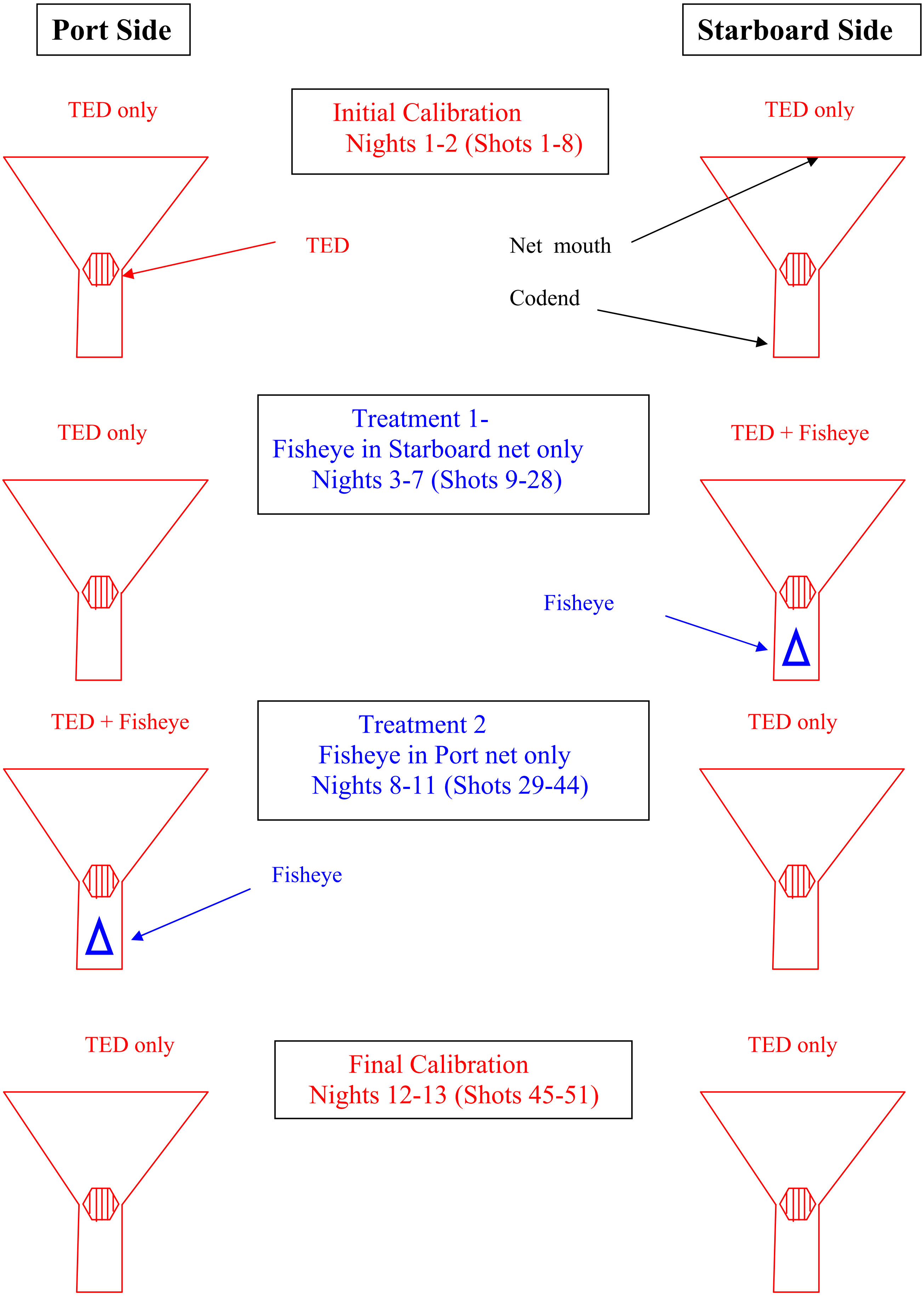
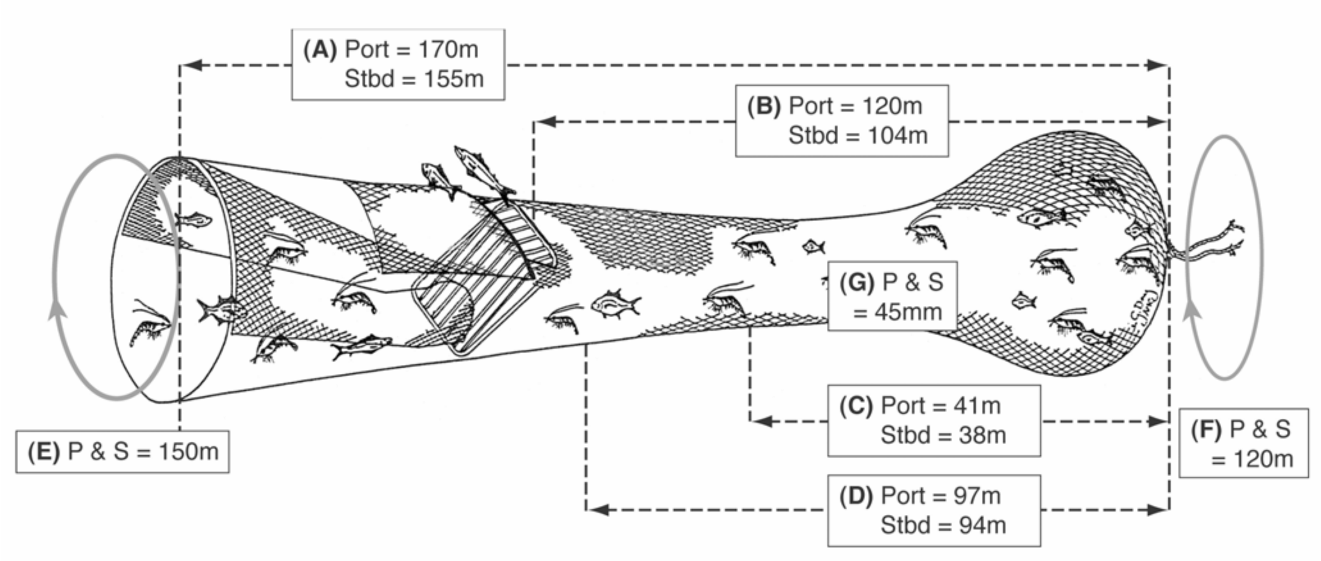


Figure 3. Schematic diagram of the Port and Starboard 'TED only' nets used during the Initial and Final calibrations. (m = meshes). Note- not drawn to scale.



Legend.

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

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

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

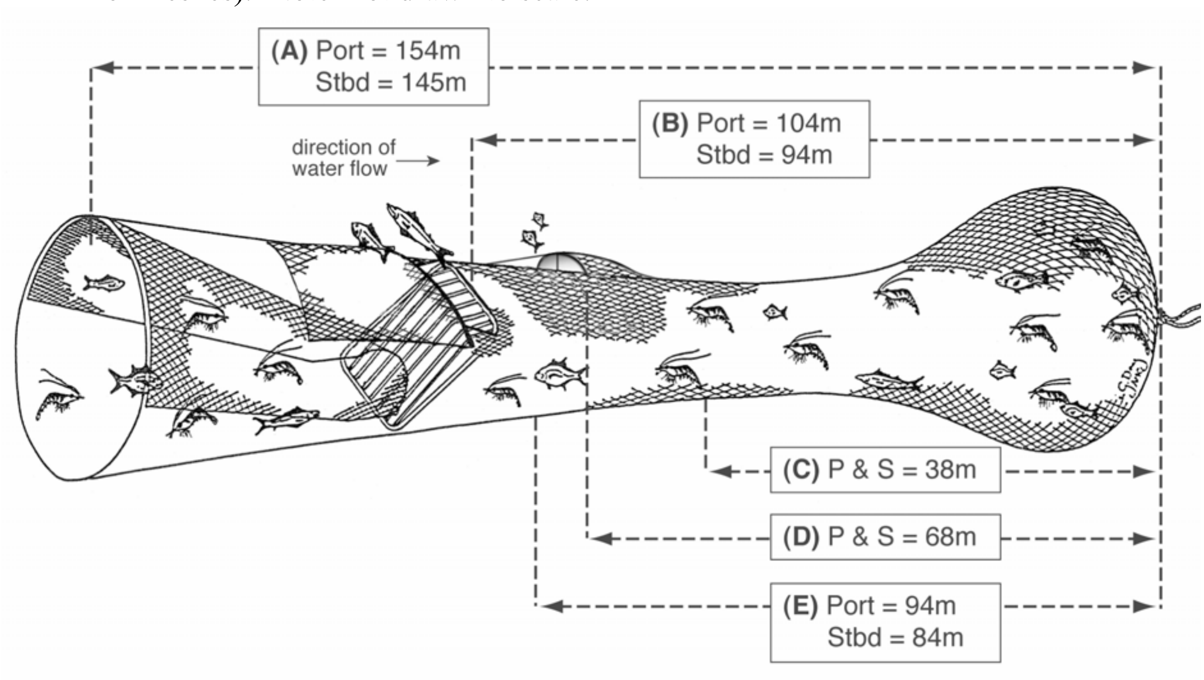
D. No. meshes from the codend drawstrings to lifting ear or choker.

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

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

G. Codend mesh size (mm).

Figure 4. Schematic diagram of the Port and Starboard codends (both fitted with TEDs) trialed during
the Treatment phases of Fisheye in Starboard net only, and Fisheye in Port net only. (m = no
of meshes). Note- not drawn to scale.



Legend.

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

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

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

D. No. meshes from the codend drawstrings to Fisheye escape hole.

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

Data Analyses

Any trawls where either codend appeared strongly biased (eg. 'TEDDed') for either tiger prawn catch or small bycatch, were excluded from the analysis. Not all trawls were sampled for both tiger prawn catch and small bycatch. Both data sets (tiger prawns and small bycatch) used weight as the measured variable and the data were assumed to be log-normally distributed.

Calibration analyses

The Initial and Final calibration data were analysed to test whether any bias identified before the Treatment phases, remained constant after the Treatment phases. If the two results were similar in magnitude and direction, then it could be assumed that there had been no changes in gear efficiency that could affect the Treatment phase results. If however, the Final calibration results were significantly different from the Initial results, then there would be cause to question the validity of the Treatment results.

A Mixed Procedure (SAS) was used to analyse the calibration data for both tiger prawns and small bycatch separately. Time (either Initial or Final) and Side (port or starboard) were used as fixed effects and the interaction between them was tested.

Fisheye performance analyses

The Treatment effect of the Fisheye was estimated with The Mixed Procedure (SAS), and separately for tiger prawns and the small bycatch. The effect of any pre-existing bias (eg. Side) was accounted for in the model.

Power of the sample design analyses

The objective of these analyses was to investigate the power of the sample design used in the 'Rosen C' assessment, to detect either a 5 or 10% reduction in the small bycatch.

We used the log of catch weight as the dependent variable and to reduce the effect of any extreme values, although these data (e.g. 'TEDDed') were not included. The model assumes that the calibration effect between nets (if any) is constant over time. So the difference, d1, between the weight of bycatch from the port and starboard nets in Treatment 1 is given by:-

$$d1 = (\text{'TED only' net}) - (\text{TED + BRD net}) \qquad \text{Equation 1}$$

Similarly for Treatment 2, after the BRD has been swapped to the other net

$$d2 = (\text{'TED only' net}) + (\text{TED + BRD}) \qquad \text{Equation 2}$$

The model also assumes that the BRD effect is the same, irrespective of the net in which it is installed, so the mean BRD effect (D), over both Treatment phases is given by:-

$$D = (d2-d1)/2$$

The estimate of D has a variance of $\sigma^2/(2n)$, where σ^2 is the variance of the error term *excluding* the shot-shot variations associated with log(catch), and n is the sample size for each gear-type. In our case, the total number of trawls is $2n$. Here $\mathbf{2\sigma^2}$ is the variance of the difference (d1-d2), $\boldsymbol{\sigma^2}$ is estimated as 0.01 for bycatch and 0.0007 for tiger catches from this study.

The sample size required to detect a difference of δ (eg. 5%) is given by the following equation-

$$n = \frac{(Z_\beta + Z_{1-\alpha})^2 \sigma^2}{\delta^2} \qquad \text{Equation 4}$$

where n is the number of trawls required in each treatment, Z_β is the value from the Z distribution for the chosen level of statistical power (0.8), $Z_{1-\alpha}$ is the value of the distribution at the chosen significance level ($\alpha = 0.05$).

RESULTS

The vessel completed four trawls per night over the 13 nights of the assessment, with 46 trawls sampled for tiger prawns and 42 trawls sampled for small bycatch (Tables 1, 2). A total of 16 trawls were used in the analyses when the Fisheye was installed only in the Starboard net, and 13 trawls used when the Fisheye was installed in the Port net (Table 1). In general, the mean catch weight per net of both tiger prawns and small bycatch declined over the assessment. The mean tiger prawn catch per net ranged from 14.4 to 46.3 kg and the mean small bycatch catch per net ranged from 136 kg to 327 kg (Tables 1,2).

Calibrations

Tiger prawns

There was no significant difference in catch rates between the paired 'TED only' nets in either the Initial or the Final calibrations (Table 3, P = 0.74,). This demonstrated that the catch rates of the port and starboard nets relative to each other did not change over the period of the project. Consequently, any observed difference in tiger prawn catch rates during the two Treatment phases could then be attributed to the presence/absence of the Fisheye.

However, catch rates did differ significantly between the Initial and the Final calibrations (Table 1, P = 0.0003) indicating much higher catch rates of tiger prawns where the vessel had fished at the beginning of the assessment compared with the end.

Small bycatch

A consistent difference was observed in the weight of small bycatch caught in the port and starboard 'TED only' nets during both calibration phases (Fig. 5). The analyses showed that there was a significant difference in catch rates between sides, in both the Initial and the Final calibrations (Table 3, P = 0.007). The port net catch rate was approx. 9.8 % lower than the starboard net. This difference was also consistent in both calibrations as the interactions between side (e.g. port or starboard) and time (Initial or Final) was not significant (Table 3, P = 0.93).

This showed that the catch rates of the port and starboard nets relative to each other did not change over the period of the project. Furthermore, any observed difference in catch rates of small bycatch could then be attributed to the presence/absence of the Fisheye.

Table 1. Unadjusted mean catch weights (± 1 SE) recorded for tiger prawns and small bycatch, from each net of paired trawls, during calibration phases used to assess the performance of a Fisheye. Note- (P) denotes Port net and (S) denotes Starboard net.

		Tiger Prawns (kgs)			Small Bycatch (kgs)		
Sample design phase	**No of nights**	**No of trawls**	**Ted only P**	**TED only S**	**No of trawls**	**Ted only P**	**TED only S**
Initial calibration	2	7	46.3 (± 7.0)	46.3 (± 8.1)	6	293 (± 51.7)	327 (± 61.8)
Final calibration	2	7	14.4 (± 2.6)	14.5 (± 2.7)	7	166 (± 16.5)	190 (± 27.9)

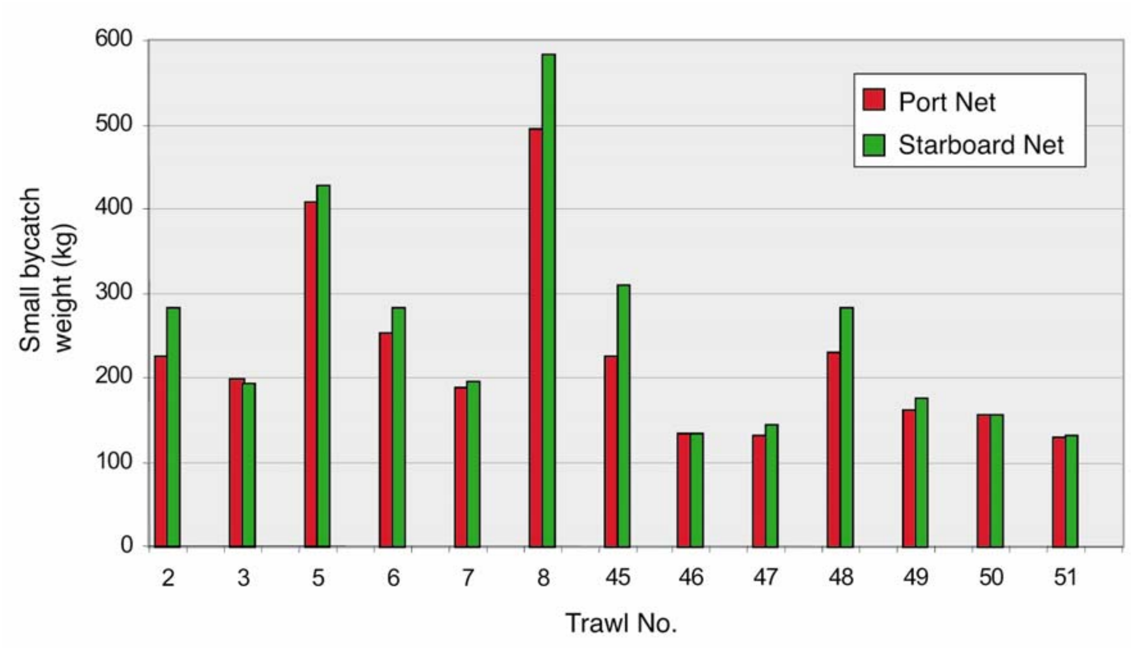
Table 2. Unadjusted mean catch weights (± 1 SE) recorded for tiger prawns and small bycatch, from each net of paired trawls, during treatment phases used to assess the performance of a Fisheye. Note- (P) denotes Port net and (S) denotes Starboard net.

		Tiger Prawns (kgs)			Small Bycatch (kgs)		
Sample design phase	**No of nights**	**No of trawls**	**Ted only**	**TED + Fisheye**	**No of trawls**	**Ted only**	**TED + Fisheye**
Fisheye in Starbd.net only	5	16	18.7 ± 3.2 (P)	17.8 ± 2.8 (S)	16	254 ± 14.7 (P)	219 ± 12.2 (S)
Fisheye in Port net only	4	16	12.5 ± 1.2 (S)	12.7 ± 1.1 (P)	13	183 ± 22.8 (S)	136 ± 16.7 (P)

Table 3. The Type Ш Fixed Effects and estimates of any significant side effects (in bold) for the tiger prawn and small bycatch from the Initial and Final calibration phases.

	Fixed effect	DF	F Value	Pr > ׀t׀	Estimate of side effect (%)
Tiger prawns	side	1	0.11	0.7411	
	time	1	26.06	**0.0003**	
	side * time	1	0.24	0.6332	
Small bycatch	side	1	10.71	**0.0074**	**9.8**
	time	1	3.83	0.0762	
	side * time	1	0.01	0.9277	

Figure. 5 Histogram comparing the unadjusted weight of small bycatch caught by each of the paired 'TED only' nets during the Initial and Final calibration phases.



Fisheye Performance

Tiger prawns

The analyses showed that there was no significant difference in the catch rates of tiger prawns between nets with TEDs and Fisheye installed, when compared with 'TED only' nets (Table 4, P = 0.68). There was also no significant interaction between side and the Fisheye (Table 4, P = 0.77), showing that the Fisheye lost no tiger prawns throughout the two Treatment phases, irrespective of whether it was installed in the port or starboard net.

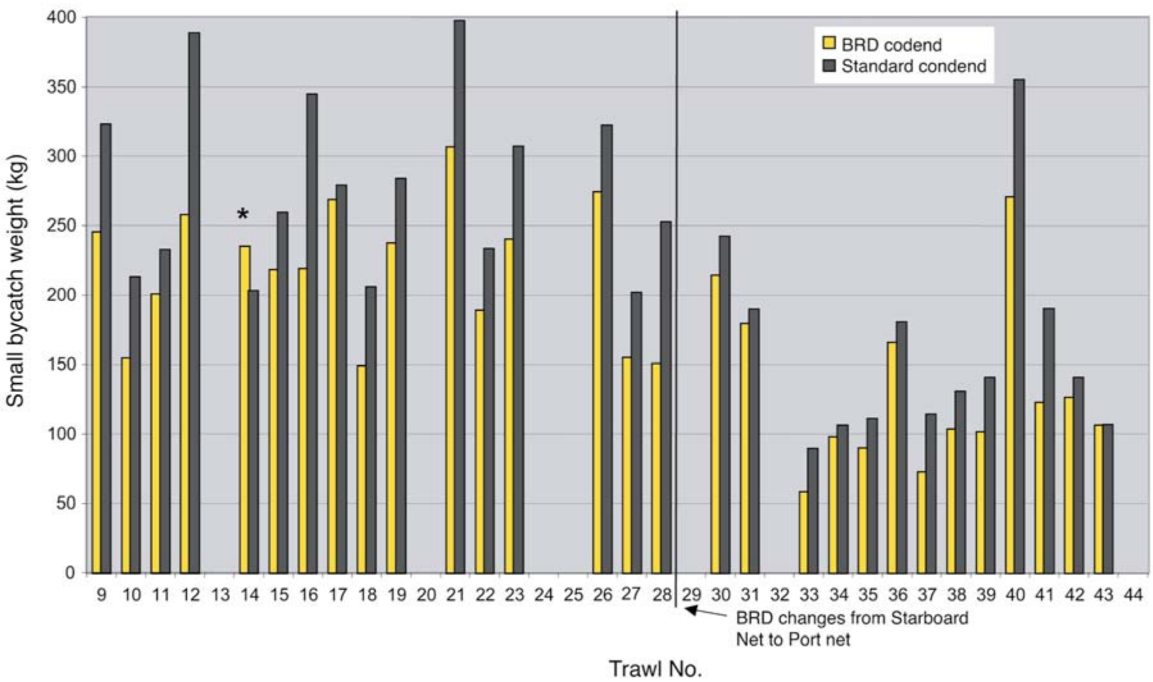
Table 4. The Type Ш Fixed Effects and estimates of any significant side effects (in bold) for the tiger prawn and small bycatch data from Treatment 1 (Fisheye in starboard net only) and Treatment 2 (Fisheye in port net only).

	Fixed effect	DF	F Value	Pr > !t!	Estimate of side effect (%)
Tiger prawns	Side	1	1.37	0.2481	
	Fisheye	1	0.17	0.6819	
	Side * Fisheye	1	0.12	0.7288	
Small bycatch	Side	1	0.11	0.0024	
	Fisheye	1	71.13	**<0.0001**	**-22.7**
	Side * Fisheye	1	0.09	0.7690	

Small bycatch
A consistent difference was observed in the weight of small bycatch caught in the net with both a TED and Fisheye installed, when compared with the 'TED only' net. This difference was consistent throughout both Treatment phases. Figure 6 shows the paired weights of small bycatch from each net, after adjustment for the pre-existing calibration bias of approx -9.8 % in the port net.

The analyses showed that the Fisheye significantly reduced the catch rate of small bycatch by 22.7% (Table 4) when compared with the 'TED only' net (P = 0.0024). This equated to an average 41 kg (per trawl) reduction in small bycatch over the Treatment phases. There was no significant interaction between side and the Fisheye (P = 0.7690), showing that the effectiveness of the Fisheye in excluding bycatch remained constant between the two Treatment phases, irrespective of whether it was installed in the port or starboard net (Table 4).

Fig 6. Histogram comparing the weight of small bycatch caught by the Treatment net, with the weight caught by the 'TED only' net. The weight of the 'TED only' nets has been adjusted to reflect the calibration difference between 'TED only' nets. Note that the BRD changes from the starboard net to the port net after shot 28.



Power of the sample design

For tiger prawns, the analyses showed that a minimum of 7 trawls per Treatment (e.g. 7 trawls with BRD in port net only, 7 trawls with BRD in starboard net) were needed to detect a 10% difference between sides attributable to the BRD, and 26 trawls per treatment to detect a 5% (Table 5). The significance level was chosen as 5% and the power set at β = 0 .8.

For small bycatch, the calculation showed that a minimum of 9 trawls per Treatment (e.g. BRD in port net only) were needed to detect a 10% significant difference between sides attributable to the BRD, and 36 trawls per Treatment to detect a 5% (Table 5). The significance level was chosen as 5% and the power set at β = 0 .8

Table 5. The number of trawls needed to detect either a 5 or 10% BRD effect for tiger prawns and for small bycatch. P = port , S = starboard (Calculations based on data set from Rosen C).

Percent reduction to be detected (β = 0.8)	No. of trawls required for tiger prawns	No. of trawls required for small bycatch
5	52 (26 P, 26 S)	72 (36 P, 36 S)
10	14 (7 P, 7 S)	18 (9 P, 9 S)

DISCUSSION

This is the first time a BRD has been assessed under commercial conditions in the NPF. Jim Yarrow's Fisheye reduced the small bycatch by 22.7% compared to the 'TED only' net. Furthermore, the loss of tiger prawns was non-significant. These positive results should encourage other NPF fishers to trial similar devices in order to reduce the impact of the fishery on the small bycatch species.

The success of this device may be attributable to a range of factors, including the distance between the Fisheye and (a) the drawstrings, (b) the choker lift and (c) the TED; the trawl speed of the "Rosen C", the species composition of the small bycatch in the area where the device was tested, and the strengthening modifications made by Jim to the standard approved Fisheye. The further these devices are placed away from the drawstrings, the less likely it is that small bycatch species can find the escape exits and use them. The Bigeye (See Section 10) is an example of the effect of distance from the drawstrings affecting the escapement of small bycatch. The Bigeye is positioned usually half way between the headrope and the TED, a long distance from the codend. The trawl speed on the 'Rosen C' was estimated at 3.2 knots approx. It is unclear whether the same reduction in small bycatch would occur if trawl speed was increased to 4 knots, a speed employed by some NPF vessels. Crude at-sea observations of differences in the bycatch composition pointed to big differences in the numbers of small Sea Pike retained by nets with and without the Fisheye. These species are pelagic and fast swimming, and may be well equipped to escape from the exit of the Fisheye. However, in areas with low numbers of Sphyraenids, the reduction in the small bycatch may well be much smaller than the 22.7 % recorded in this assessment.

The sample design employed in the assessment worked well. Assessing the performance of BRDs under commercial conditions is a cheaper option (when trialing such devices) than charter (either research vessel or commercial vessel). However, in the case of BRDs such as the Fisheye assessed in this report, other problems due to the nature of commercial fishing become obvious. For example, fishers constantly adjust their trawl gear on each side (paired nets) so that the prawn catch is equal from both nets. If one net is down in catch rates, that net will be adjusted until it catches at least as well as the net on the other side. However, this constant tuning and matching of fishing gear is not undertaken for the small bycatch component of the catch. If one net consistently catches more small bycatch than the other, but the prawn catch is equal between sides, then fishers will usually not make any gear adjustments.

The effect of being 'TEDDed' remains a cause for concern in the sample design. The decision as to whether a net has been affected by a blockage is often intuitive. It almost requires some prior knowledge of the level of small bycatch reduction that is likely to occur. This becomes obvious over the duration of the assessment but can present problems before a consistent pattern of reduction has been established.

The consequences of unmatched fishing gear (for the small bycatch) needs careful consideration when assessing whether a BRD is effective in reducing the small bycatch component. The need for calibrations increases, especially if alterations are made to gear during the course of the assessment (e.g. due to nets fouled on hard bottom, nets ripped/stretched etc). The alternative action may be to swap the device to be tested from side to side at least every couple of days. This assessment was fortunate to record a constant pre-existing bias between nets throughout the whole trial. The fact that the port net caught consistently around 9.8 % less than the starboard net was an ideal situation. If the pre-existing bias had changed between the Initial and the Final calibrations, the assessment would have been much less successful due to the relatively low numbers of calibration trawls that were undertaken in both calibration phases.

Obviously the larger the number of trawls that can be sampled, the more accurate will be the assessment result. The power analyses suggest that the number of trawls required in each Treatment phase could be lower than that undertaken during this assessment. However, caution should be adopted when attempting to reduce the number of trawls per Treatment to the bare minimum as the effect of gear alterations may change the base level required. For example, if a net is badly ripped, or major changes made to ground chain configurations, the variability increase will make detection of a significant reduction in bycatch much less likely. The power analyses also assume that the small bycatch populations are mostly randomly distributed in the path of the net. Therefore, chance encounters with aggregations of particular bycatch species are evened out between sides by the trawling behaviour of repeated runs back and forth over the same bottom ground during a trawl.

Further research into the performance of the Fisheye, and BRDs in general, is urgently needed. What makes them effective in excluding bycatch? How important is the distance between the exits of the BRDs and the drawstrings, and how does this distance interact with the size of the catch in the codend? And if they are effective, what species of bycatch are selectively excluded and does this selection have the potential to affect bycatch composition in the future?

CONCLUSIONS

To date, operators have generally avoided the use of BRDs that are located in the codend and behind the TED due to concerns over the potential for loss of prawn catch. The assessment of Jim Yarrow's Fisheye demonstrate that a significant weight of bycatch can be excluded without any associated loss of tiger prawns. We congratulate Jim Yarrow on his persistent efforts over a long period, to develop a BRD that works in the NPF.

Based on these results, the authors encourage the TED/BRD Subcommittee to recommend that NORMAC include the Fisheye as an approved BRD design under the relevant Direction.

Further research into the performance of the Fisheye and BRDs in general is urgently needed in order to reduce the impact of trawling on these bycatch species.

ACKNOWLEDGEMENTS

The authors would like to thank the skipper of the FV "Rosen C", Jim Yarrow, as well as all the crew. We also thank D. Milton for his comments on the manuscript.

REFERENCES

Stobutzki, I., Balber, S., Brewer, D., Fry, G., Heales, D., Miller, D., Miller, M., Milton, D., Salini, J., Van der Velde, T., Wassenberg, T., Jones, P., Wang, Y., Dredge, M., Courtney, T., Chilcott, K., and Eayrs, S. (2000). Ecological sustainability of bycatch and biodiversity in prawn trawl fisheries. FRDC Project 96/257.

Day, G. (2000). At-sea testing and assessment of the John Thomas Bigeye Turtle Excluder Device as an approved TED for Australia's Northern Prawn Fishery. Fishing Technology Unit, Australian Maritime College, Tasmania.

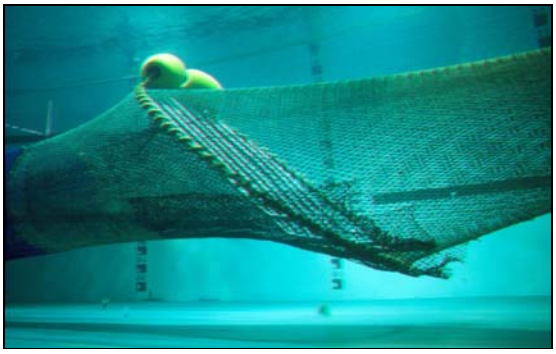
Pender, P.J., Willing, R.S., Cann, B., 1992. NPF bycatch a valuable resource? Aust. Fish. 51(2), 30-31.

Northern Prawn Fishery Bycatch Action Plan (2003). Publ. Australian Fisheries Management Authority. 26pp.

APPENDIX 7

Communications material

Contents



Newsletter No 1 - October 2000

NORTHERN PRAWN FISHERY - BRD and TED Project

Performance of BRDs and TEDs

In June 2000 a new industry/FRDC funded project began to assess the performance of BRDs and TEDs following their introduction in the NPF in April 2000. The project will run for 2 years and has the following main aims:

- Measure the performance of BRDs and TEDs (bycatch and prawn catches), using observers on NPF vessels in October 2001.
- Collect, summarise and provide feedback to NPF fishers on performance of BRDs and TEDs to enhance their progress for the benefit of the whole industry.
- Provide an economic assessment of the impact of using BRDs and TEDs for the industry.

Research at Sea

This project will see AMC and CSIRO staff at sea on NPF vessels for much of the 2000 (2nd half) and 2001 seasons.

Garry Day has re-joined our team and will be working at sea helping fishers improve the performance of their BRDs and TEDs.

Don Heales will also be at sea in October to conduct specific trials to decide the best way to measure differences in bycatch.

In October 2001, ten trained observers (mainly from AMC and CSIRO) will go to sea on NPF vessels for a month each to collect data that will tell us how well BRDs and TEDs are performing.

This will involve removing the BRD and TED from one side only and measuring the differences in catches between sides.

*** Please let us know if you would like to participate in this program. Call Don on 07 3826 7245.

BRD and TED information for NPF Fishers

During the project we will feedback information to NPF fishers so that all can benefit from the knowledge of others, with the aim of having only well performed BRDs and TEDs on all boats in the NPF. So far we can tell you that:

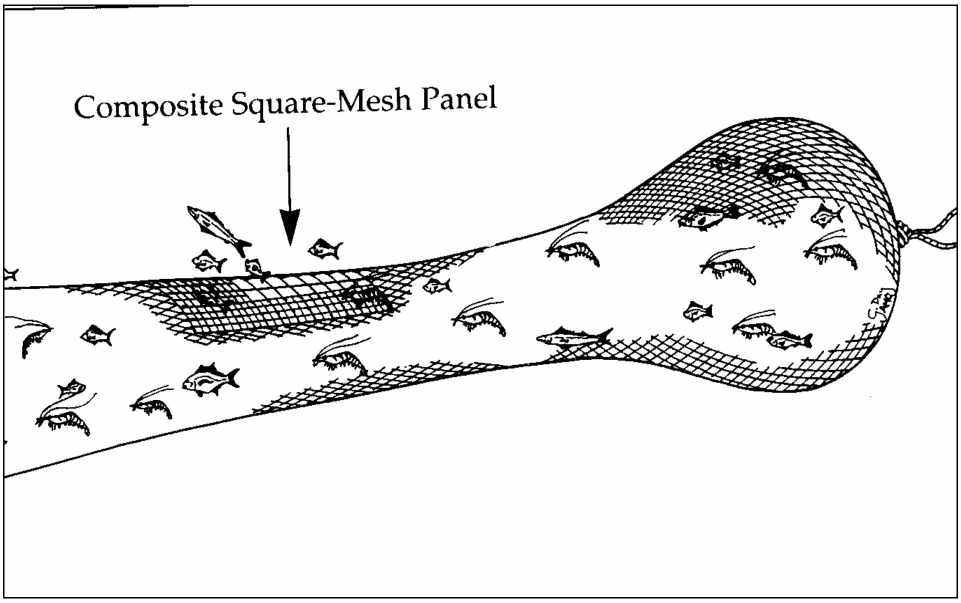
- Radial Escape Section (RES) BRDs have excluded about 25% of small fish with less than 3% loss of prawns (Tully/Bountiful).
- Square-mesh codends (45 mm) reduced small fish bycatch by 20-30% with about 3% prawn loss (Weipa).
- Composite square-mesh windows are being successfully used in the NSW and WA Shark Bay prawn trawl fisheries

Communication

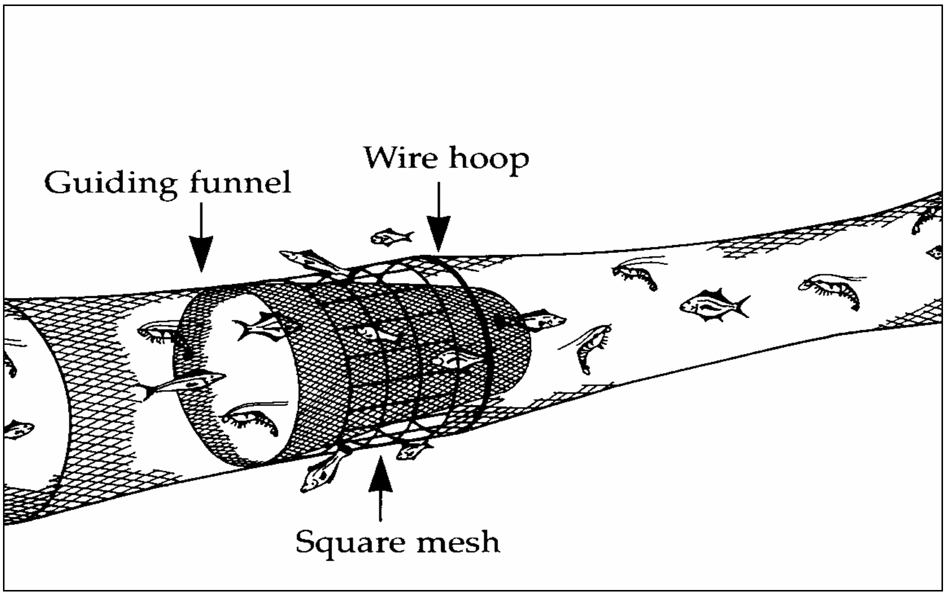
You can expect to be kept up to date with the progress of BRDs TEDs and other project related issues during personal contact with **Brian Taylor** and other project staff. They will be around the traps before and after you go to sea, as well as at other organised get-togethers. You can talk to Brian about project issues via 07 3826 7226

The Project is titled "Assessment and Improvement of BRDs and TEDs in the NPF: a co-operative approach by fishers, scientists, fisheries technologists, economists and conservationists" and is funded by the FRDC and Project Co-investigators including CSIRO Marine Research and Australian Maritime College, Fisheries Economics, Research and Management P/L, Traffic Oceania, A Raptis and Sons, ARJ Investments, Austfish Pty Ltd, Australian Trawl Net Co., Gulf Net Mending Co., Newfishing Australia Pty Ltd., Tiger fisheries Pty Ltd., Veejay Fisheries Pty Ltd.

The **Composite square-mesh panel BRD** is being used to exclude between 23-41% of fish from prawn trawls in the NSW Oceanic prawn trawl Fishery with minimal or no loss of prawns.



The **Radial Escape Section (RES) BRD** is being used to exclude about 25% of fish from prawn trawls in the NPF Fishery, with less than 3% loss of prawns.



Expanded square mesh

Newsletter No 2 – October 2000

To all NPF skippers & crews, operators & friends

In June 2000, an industry/FRDC funded research project to assess the performance of BRDs and TEDs following their introduction into the NPF in April 2000 began. This particular research work will run for 2 years. More details are being circulated and at the start of the 2nd season you may have spoken to Don Heales, Brian Taylor or Steve Eayrs about this work.

Collaboration with industry and other partners, and communications are key features. Both Don and Garry Day (a researcher from AMC) are at present at sea in the NPF as part of this project. Don is aboard the *Apolloair* where he will be for a few more days. Garry is presently on board the *Sea Thief* having been aboard *KFV Heron* and *Ocean Thief* earlier this season.

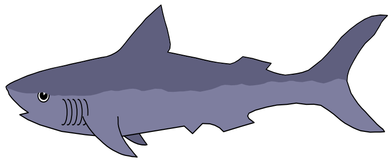
You are likely to run into Garry, Steve or Brian when in port at the end of the season. Please have a yarn to them. They will be keen to hear of your TED and BRD experiences from the 2nd half of the season and to record your ideas and suggestions.

Cheers……
BRD and TED project people

For further details or to comment, please contact:
David Brewer ph: 07 3826 7246
Marine Ecologist fax: 07 3826 7222
CSIRO Division of Marine Research
email:david.brewer@marine.csiro.au

Newsletter No 3 – February 2001

NORTHERN PRAWN FISHERY - TED and BRD Project



Project – assessment and improvement of TEDs and BRDs

A description of this project, its principal objectives and the staff involved has been detailed in previous newsletters. A key and immediate objective is to encourage optimisation of the design and use of TEDs and BRDs and this aspect is progressing well. Your own efforts and those of Garry Day (Australian Maritime College) with his at-sea tuning and general advice services are rapidly improving the design and performance of these devices.

- for more details refer to Garry's paper "Improving TED performance and efficiency" posted to operators during the end-of-season break. Extra copies of this paper are available from project staff.

Although considerable effort has been placed on TED performance in past seasons, BRDs also now require attention. Many operators are now confident in the operation of their TEDs but many have expressed a lack of confidence in some of the BRD designs currently in use. The forthcoming 2001 seasons will provide an opportunity for both operators and project staff to concentrate more on the development of BRDs for the NPF. Although several BRDs have provided good results with up to 20% reductions of small fish bycatch with minimal loss of prawn (see 2nd issue of this newsletter), more work is needed to improve and develop new devices. Any gains we can facilitate in this area are advantageous to all operators, and everyone is encouraged to be proactive in the testing and development of BRDs.

One of the other aims of the project is to assess the effectiveness of both TEDs and BRDs and this involves both intensive and extensive data collection and observations. Both Garry and Don Heales (CSIRO) were at sea on commercial trawlers during 2000 collecting data from both regular operations and special sampling activities.

- this was reported in the "TED and BRD article" prepared by Garry and Steve Eayrs (AMC) and published in the February 2001 edition of *Professional Fisherman*. Reprints and copies of this article are also available from project staff.

To hasten the accumulation and compilation of these sorts of data, fishermen have been asked (and are legally obliged) to contribute by completing accurate and comprehensive logbook details. Assessment and comparison of TED and BRD design and performance cannot be done without supporting data and as Garry and Don cannot be everywhere at once, your help is essential.

Pre-banana season 2001 port visits

To extend and continue our liaison and communication activities and to aid timely feedback of as much information to operators as possible, port visits to Fremantle, Darwin and Cairns are planned early in 2001.

Brian Taylor (CSIRO), Steve Eayrs and Garry Day (both AMC) will be in **Fremantle** for the week 5 to 9 March 2001. Informal opportunistic TED and BRD discussions and practical demonstrations with small groups and individuals will take place in commercial offices and refit sheds, boats and wharfside. Coinciding with these activities will be a brief semi-formal meeting on Tuesday 10 March at the WA Fisheries seminar and training room at 19 Mews Road, Fremantle. This meeting will start at 1530 hours and in addition to some brief details about the “assessment and improvement of TEDs and BRDs project”, Steve will describe and discuss the procedure for collecting data during the “TEDs/banana prawn project” during the first 2 weeks of the season this year (details below). Trysh Stone from AFMA will present some recent news and legislative requirements of her organisation.

A **Darwin** port visit is planned for the week commencing on 19 March and will follow much the same agenda. Brian, Steve and Garry will be around the duckpond and fishermens wharf in general for this week so please take the opportunity to speak to and question any or all of them. The semi-formal presentation by Steve and Trysh will be on the 22 March at 1630 hours in the AMC shed at the duckpond.

Similar meetings and discussions are planned for **Cairns** on February 20 – 22 and again on March 18 & 19. Further details of these visits were given in an AFMA circular in February this year.

All operators in each port are invited and encouraged to attend. It is only your active participation which encourages the arrangement of these types of informal information exchanges and practical demonstrations.

Any constructive thoughts or ideas on these port visits or any ways at all to improve NPF communication coverage are welcomed and should be raised with project staff.

TED/banana prawn operations in the first 2 weeks of the 2001 season

During the first 2 weeks of the 2001 banana season a special project to assess the impacts of TEDs on banana prawn catches will be in operation. This work will allow you to remove your TED from the net on one side (note that BRDs are compulsory on both sides) and in return you are asked to collect and record some observations and data in your logbook. It is important that the information you record is a true and reliable record of your activities, as it will provide the basis for a comparison of the net on one side with a TED and the net on the other side with no TED.

Some important points to consider:

- If you do not want to participate in this project then you must contact Trysh Stone or Mandy Goodspeed at AFMA. You must then use a TED in both nets.
- If you do participate then remove one TED. It is an AFMA requirement that all participants must not change their mind and pull out of the project before the two weeks are over.
- You do not need an observer onboard to participate. However, 6 observers will be at sea during this time collecting similar and additional information.

All results from this TED/banana prawn project will be collated and assessed by AMC. A report will be produced and presented to operators and boat owners by June, 2001.

Your help and cooperation is required!
Garry will be at sea again in 2001 collecting data and helping to tune TEDs and, more importantly, BRDs, but operators also need to provide as much information as possible.

The outcomes of the whole of this project, and the TED/banana work in the first 2 weeks of the 2001 season, rely heavily on at-sea industry operators recording their experiences and adding to the information base. This can be done by completing the relevant sections of the logbook, by personally passing on information and by taking observers on-board.

During the second season of 2001, some intensive data concerning the performance of TEDs and BRDs will be recorded by 10 observers at sea on NPF vessels. During port visits and at any other opportunistic time beforehand, project staff will be seeking owners and skippers willing to take onboard an observer for 2 - 4 weeks in September/October.

Observers will be measuring differences between a standard net (no TED or BRD) and a net fitted with both devices. Differences in prawn catch, damaged prawns, by-product, monster species and sizes, and the weight of small-sized bycatch are some of the details to be recorded during the assessment.

Many of the at-sea field trials last year showed little reduction in small-sized bycatch weight due to the type and the positioning of BRDs used. We encourage any skippers who feel confident that their TEDs are working effectively, to experiment with different BRD and TED combinations like a Radial Escape Section panel. Garry will have with him or have access to examples of RES devices that can be fitted and tuned to your gear.

If a substantial reduction in the small-sized bycatch can be demonstrated during the assessment in the second season, the whole fishery will benefit by being viewed as a sustainable fishery. It is therefore in your own interests to test some of these different BRD devices and one suggested way to do this is to speak to Garry now and arrange for him to help whilst he is at sea.

Keeping you informed
If you would like to but are not receiving notices, newsletters or any other TED and BRD literature direct from us, please advise Brian at

CSIRO Marine Laboratories
PO Box 120
Cleveland QLD 4163
Phone 07 3826 7226.

Advise him of address changes so a current communication network can be maintained.

If you have an email address advise brian.taylor@marine.csiro.au and we can place your name on this list as well.

Other reports and reading
BRD & TED project newsletters no1 (October 2000) and *no 2* (November 2000), CSIRO

NPF operators make gains in bycatch reduction_ _ _ but some problems remain. G Day and S Eayrs, Professional Fisherman, February 2001

Improving TED efficiency in the NPF. G Day, AMC, January 2001

Effect of knot orientation on TED flaps. US National Marine Fisheries, 2000

Take a note of knots. Australian Fisheries, June 1991

US delegation visits NPF. AFMA News, September 2000

Technical Q & A, Infofish International, 6/2000

Publicity notices re meetings and workshops, presentation notes. CSIRO 2000 & 2001

2000 NPF TED/BRD logbook summary, AMC

1999 NPF TED/BRD logbook summary, CSIRO

Reminder: *as mentioned many times, the whole of this project relies heavily on all skippers adding experiences with TEDs and BRDs to the information base by diligently completing the relevant sections of the logbook, by personally passing on information to project staff and by taking observers onboard.*

NOTICE TO: All NPF operators FROM: Brian Taylor DATE: 6 February 2001

Newsletter No 4 – February 2001

TEDs & BRDs: Assessment and Improvement

Port Visits, Pre-Banana Season, 2001

Staff involved in the current TED and BRD research project will be conducting port visits and informal industry get-togethers during the lead up to the 2001 banana prawn season. These gatherings and visits will enable NPF operators to obtain project feedback and provide an opportunity to **get tips on ways to improve TED and BRD performance**. Issues to discuss might include such things as information and data collection and communication, and TED and BRD design and fitting and techniques of use. The agenda will, however, be essentially driven by your particular interests and questions, so please give this some thought.

Fremantle

During the week commencing Monday 5 March 2001, Brian Taylor from CSIRO and Steve Eayrs and Garry Day from the Australian Maritime College will be in Fremantle. Informal meetings, discussions and demonstrations with small groups or individual crews are envisaged to take place on your boat, in your shed (a demo TED and BRD would be useful) or wharfside. Please contact Brian if you would like to set up a particular meeting with you or your staff or your crew.

Co-inciding with these arrangements is another meeting arranged for you. At 1530 hours on Tuesday 6 March 2001, Steve and Trysh Stone from AFMA will address a short semi-formal meeting at the WA Fisheries seminar/training room at 19 Mews Road, Fremantle. Both Steve and Trysh will discuss and explain the TED/banana prawn project procedures and requirements to take place in the first 2 weeks of this coming season. Trysh will also discuss some other recent AFMA requirements. Some refreshments will be provided at the conclusion of the meeting.

Darwin

Similar informal gatherings will take place in Darwin during the week commencing 19 March. TED and BRD project staff Taylor, Eayrs and Day will be in the duckpond/fishermens wharf area during this week to assist and speak with operators with regard to the above project and to help tune devices. Discussions about the TED/banana prawn issue and recent AFMA requirements are scheduled for 1630 hours on 22 March in the AMC shed at the duckpond. Refreshments will also be available here too.

Cairns

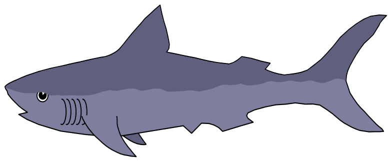
Meetings are also scheduled for Cairns in February and March. Steve will be around the pig pens on the morning of 20 February, and the afternoons of 21 and 22 February. In March, Trysh will present a pre-season briefing at the pens at 1630 hours on March 19 and Steve will talk about TEDs in the first 2 weeks of the banana season. Steve will also be available to discuss TEDs and BRDs with operators earlier in the day on 19 March and the morning of 20 March.

All operators are welcome and encouraged to attend. It is your active participation that encourages the arrangement of these informal information exchanges.

Newsletter No 5 – October 2001

NORTHERN PRAWN FISHERY

TED and BRD Project



We earlier called for volunteers to take 10 observers to sea during October in the second season of 2001. However, so we could cover more areas, more boats and more seasonal conditions, we decided to have five observers at sea for the whole of the second season. The observers will compare the catches of prawns and all by-catch in nets with and without TEDs and BRDs.

The importance and relevance of collecting comprehensive data on the performance of TEDs and BRDs this season cannot be over-emphasised. This is a once-only opportunity as conditions will probably change and the time window will pass. This “snapshot” will demonstrate the effect today.

We would like to thank the owners, skippers and crew of the following vessels for taking observers to-sea and for their valued help and assistance with our work: *Amelia C, Angelina C, Austral, Bounty Hunter, Brianna Rene Adele, Cindy Anne, Comac Endeavour, Emserve, Newfish II, Ocean Thief, Perpetua, Point Moore, Providence, Sandpiper, Sea Fever, Sea Thief, Ventura* and *Xanadu I*. More names will be added to the list in the future.

We realise that the passive description, “observer”, is somewhat misleading, given what these five people are expected to do. How would you like to be up to your armpits in trash chute by-catch weighing and counting? Not to mention “monster” identification and measuring – well done guys!

The field-work component of this major collaborative project (CSIRO, AMC, FRDC) concludes at the end of this current season when the observers finish their work at sea. There will still be oceans of data and information processing to do, however, and importantly, communication of the results.

Port visits, small-group discussions and practical demonstrations have been particularly useful throughout the project and we plan to hold a few more of these before the project finishes in June 2002. In the longer-term, it is expected that the results of this project will have lasting benefits for the NPF by demonstrating how effective these devices are in reducing the impacts of the fishery on the environment. We may need to collect some additional data, so please help if you are able.

CSIRO MARINE

Australian Maritime College

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

TED and BRD use phone survey

First two weeks of the banana season this year

AMC has prepared a summary of preliminary results from data submitted by the observers at sea during the first two weeks of the banana season in 2001. That preliminary report follows:

An assessment of TED performance in the NPF banana prawn fishery

A preliminary report by Steve Eayrs, Australian Maritime College

Aims of the study

1. To measure the impact of TEDs on catches of banana prawns
2. To measure the incidence of turtle capture during the banana prawn season and assess their condition and likely survival rates.

Methods

AMC observers recorded trawl and catch details on nine boats[1] during the first two weeks of the 2001 banana prawn season. The boats involved in this study (in alphabetical order) were the *Adelaide Pearl, Austral, Heron, Libertine, Ocean Exporter, Striker, Northern Pearl, Ventura* and *Xanadu I*. Each boat removed a TED from one net to allow catch comparisons between a standard net and TED-net. Estimated catch weights (boxes of known weights or kilograms) or catch volume estimated using coloured wires attached to each codend at five mesh intervals, (ten meshes for boats without observers), was recorded. Following is a preliminary report of the results:

[1] One observer spent time onboard two boats during the study period. The data from both have been grouped.

Results

Table 1: TED details for each boat and catch comparison between sides. Catch comparison shows the number of shots with even catches between sides and the number of shots that catches were higher in the TED-net or standard net. The higher number of shots with greater catches in the standard net is not necessarily a reflection of poor TED performance, but may indicate by-catch reduction by the TED.

Boat number	TED type	Bar spacing (mm)	Exclusion direction (↑/↓)	Catch comparison between sides (number of shots)		
				Even	TED up	Std. up
1	NAFTED	95	↓	35	21	27
2	Super Shooter	115	↑	16	9	11
3	Swede	120	↑	22	13	11
4	Swede	120	↓	22	7	11
5	Super Shooter	120	↑	7	2	27
6	Swede	120	↓	15	3	7
7	Swede	115	↓	11	4	17
8	Raptis	120	↑	10	14	18
			Total	138	73	129

Discussion

The TED details for each boat are shown in Table 1. To maintain confidentiality, each boat is numbered and listed in an order that does not reflect alphabetical order. Also shown are the number of recorded shots for each boat and the number of shots that the TED-net out fished the standard net (TED removed). For all but three boats, catches were mainly even between sides. Compared to the TED-net, catch (prawn + by-catch) volumes were more frequently higher in the standard net. This does not necessarily mean that the TED-net lost substantial amounts of prawns, but instead may reflect the exclusion ability of the TED and greater by-catch volume in the standard net. For boat number five the TED was attached to a larger codend, hence recorded catches were usually higher in the standard net. Only one boat recorded catch weights for all tows, and the TED-net caught five percent more prawns than the standard net.

Comparison of large animal catches is shown in Figure 1 (a-d). Where recorded, most animals were returned to the water alive and clearly the TEDs are effectively excluding this by-catch. A total of eight turtles were caught in this study, and all were released alive. Four turtles were caught in the TED-net ahead of the grid and released through the mouth of the net; these animals were lively and presumably had insufficient time to reach the TED and escape. Seventeen sponges were caught although only two were caught in a TED-net. There was clearly a reduction of saw shark catches in the TED-nets.

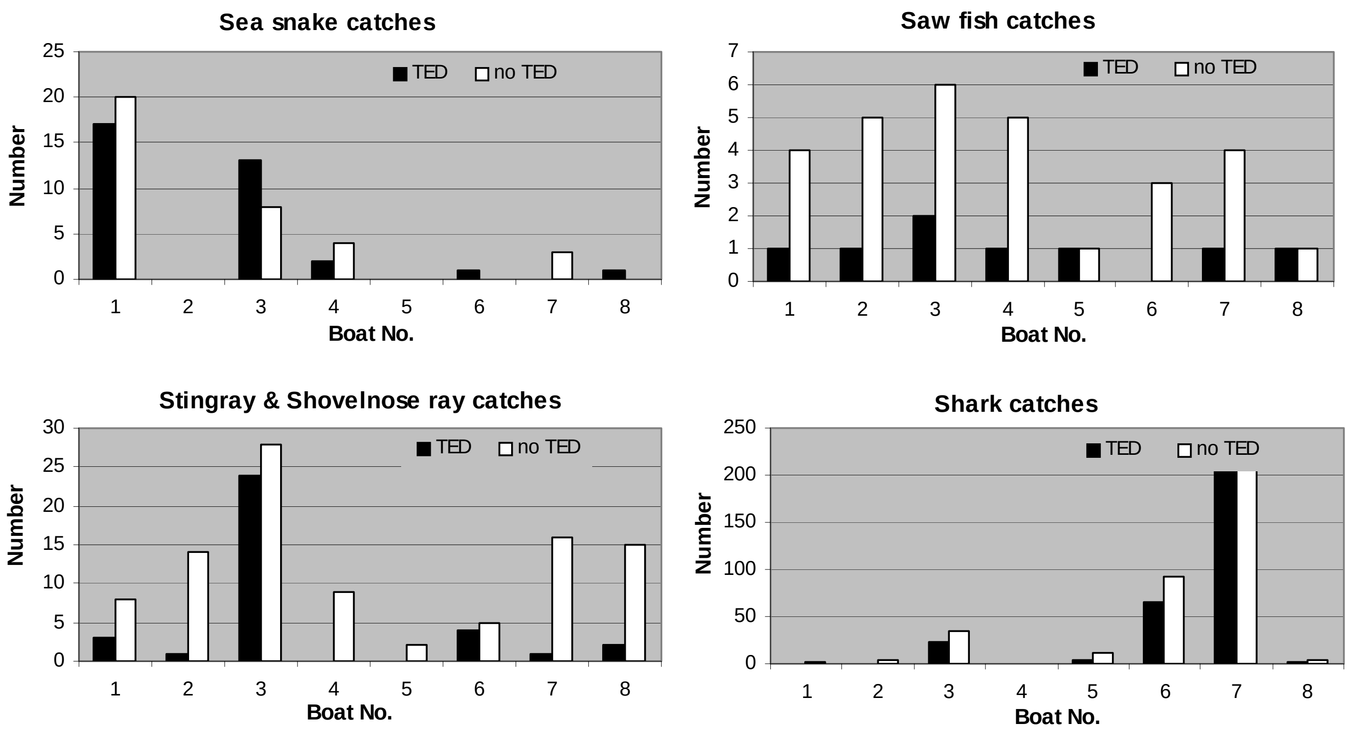


Figure 1: Catches of (a) sea snakes, (b) saw sharks, (c) stingrays and shovel-nose rays and, (d) sharks between sides. Most observers reported that many of the stingrays and sharks caught in the TED-net were small enough to pass through the bars of the grid.

Handling problems

Few handling problems were reported, although there was the occasional delay getting the TED over the side of the boat and correctly orientated. Prawn loss through TED escape openings was reported on most boats. Skippers reported that this was the result of full codends of prawns overflowing at the sea surface prior to hauling and was usually no more than a few kilograms in weight. Visual observations of the coloured wires were at times difficult but generally successful. All skippers reported being reasonably happy with the performance of their TEDs.

Conclusion

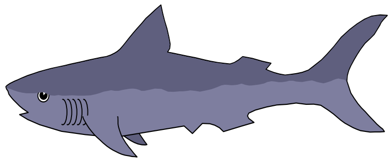
The preliminary results presented here are those from the nine boats that had AMC observers onboard and overall the results are positive. Log book returns and port meetings will indicate if they are indicative of fleet-wide results and experiences. Unfortunately given the nature of the fishery it was not possible to record catch weights between sides for all boats. Despite this limitation the results suggest that TEDs had little impact on prawn catches and effectively excluded large animal by-catch including turtles. Analysis of your log book data is ongoing and will be reported on shortly.

Acknowledgements

This project was funded by AFMA and NORMAC. Many thanks to the skippers and crew for their invaluable assistance and patience, and making their boat available for this study.

Newsletter No 6 – March 2002

NORTHERN PRAWN FISHERY



TED and BRD Project

In the previous TED and BRD newsletter number 4, we outlined the at-sea work proposal for Garry Day, Quinton Dell, Ben Bird, Chris Gough and Reuben Gregor, the 5 observers to work during the tiger season of 2001.

The broad objectives of this phase of the project were to examine the impacts of various TEDs and BRDs on:
- prawn catch and quality
- by-product catch
- monster catch
- sea snake and small sized by-catch
- general operations.

We also listed the boats that had participated at the time of that previous newsletter. The following list of 23 trawlers or about 20% of the fleet, is of all boats that participated in the entire project. Scientific observers on these trawlers covered and experienced a wide variety of vessels, fishing grounds, weather conditions, and TED and BRD types and techniques of use. They collected a huge amount of data from some 1600 trawl shots and recorded heaps of useful comments and observations. We have prepared a data-base from this information and we plan to have some preliminary results available at the start of the second season of 2002.

We sincerely thank the owners and skippers and crew for taking observers and assisting with deck and other activities. We also acknowledge and are most grateful for the assistance provided by the skippers and operators of the mother ships servicing the fleet. Without all your help and co-operation, the project would not have been possible.

Amelia C, Angelina C, Austral, Bounty Hunter, Brianna Rene Adele, Caledon Pearl, Cindy Anne, Comac Endeavour, Emserve, KFV Carlisle, KFV Hayman, KFV Heron, Newfish II, Ocean Thief, Perpetua, Point Moore, Providence, Rosen C, Sandpiper, Sea Fever, Sea Thief, Ventura and *Xanadu I*.

CSIRO MARINE **Australian Maritime College** FISHERIES RESEARCH & DEVELOPMENT CORPORATION

TED and BRD use phone survey

Brian Taylor conducted a brief phone survey of TED and BRD use in October 2001 to collect information about the types of devices in use across the whole fleet during the second season of 2001. The vast majority of people contacted responded to the survey and we can now be confident that the impacts of "observer boat" devices are generally representative of fleet-wide experience. Brian's phone survey and the CSIRO "observer boat" information covered over 80% of the fleet and some basic preliminary results follow.

All information about all devices is not always known and percentages given are for the numbers actually known for any particular criteria. Some rounding errors are nevertheless apparent. In many cases, confidentiality restricts publication in many categories.

TED's

Upward excluders totalled 47%. **Downward** excluders totalled 52%.

Essential shape (total all devices)**:**

Basically rectangular but curved one end	37%
Oval	28%
Rectangular or square	24%
Other	10%

Of all devices, 57% had **straight** bars, 42% had **bent** bars. 12% had an average **bar space less than 110 mm**, 88% had spaces **equal to or greater than 110 mm.**

BRD'S

Big eye	79%
Square mesh panel	10%
Fish eye	5%
Other	5%

NORMAC/AFMA workshop on BRDs – February 2002

About 35 fishermen and fishing company representatives, and 20 people from various government agencies participated in a workshop to look at the status of BRDs in the NPF. Dr. Chris Glass presented an interesting talk on fish behaviour (mainly their visual responses) and showed how these studies can be used to contribute to the design of more effective BRDs.

The meeting discussed the effectiveness of BRDs currently used in the fleet and examined other potential devices. It was agreed that the most commonly used BRD, the bigeye, is having little impact on bycatch reduction although prawn losses are minimised. A couple of skippers are using square mesh panels and think that they might be OK in some situations. It was agreed that more information was needed to assist skippers in choosing other BRDs to trial and the current "TED and BRD Assessment Project" will provide some summary information.

In November 2001, NORMAC's TED and BRD Subcommittee agreed to make no major changes to the BRD regulations pending the results of this "TED and BRD Assessment Project" due in mid 2002. However, we nevertheless encourage NPF operators to investigate and trial BRDs other than the bigeye in preparation for possible changes to the BRD regulations relating to that device. The 2002 fishing year is an ideal time to compare catches between nets with the different BRDs (e.g. bigeye versus square mesh panel or radial escape section). If you wish to discuss anything about BRDs in the NPF feel free to call or email project staff at CSIRO or AMC.

Improving TED Efficiency in the Northern Prawn Fishery

Garry Day*

Note: This paper is not to be reproduced without consent from the author.

The following information is a combination of specifications and modifications to TEDs that have helped to maximise catch retention and turtle exclusion.

TED efficiency relies on three main factors:

1. The ease with which it can exclude large animals, rocks and other debris
2. When using an escape cover, the ability to maintain an adequate seal over the escape opening when animals are not being excluded.
3. If no escape cover is being used, the ability to direct prawns away from the escape opening.

What Causes Prawn Loss?

Prawn loss through a TED is usually caused by:

1. Grid blockage by large animals, sponges, rocks and other debris that prevent prawns from passing through the grid efficiently
2. Associated prawn loss every time a large animal or object is excluded.

Trawls fitted with an upward excluding TED tend to suffer less from prawn loss. This is probably due to these grids being used on cleaner grounds where grid blockage is less of a problem. Bottom excluding TEDs have been shown to be more efficient in areas with high sponge and debris catches.

It should be noted, however, that both TEDs exclude large animals such as turtle, sharks and stingrays with equal efficiency.

TED and BRD Rigging and Handling:

Grid Size:

- Grid size is relative to the size of the net being used. A TED that is too small can cause prawn loss because there is less grid to filter the catch and large animals block a relatively larger area of the grid. Generally, the larger the grid the more efficient the TED.
- Grid height is the most critical dimension and it is recommended that a grid approximately 150 cm (5 feet) high be used in nets with a headline length of 12 – 14 fathoms. Although width is not as important it does determine the size of the escape

opening. Generally the larger the escape opening the easier a large animal or object can be excluded. A width of at least 100 cm (38 inches) is recommended for the net size of 12 - 14 fathoms.

**** Note: This paper is not to be reproduced without consent from the author.***

Grid Construction:

- Although there are various materials being used to construct TEDs, aluminium is preferred, at present, mainly due to its lightweight.
- For larger sized grids, aluminium tubing is recommended in preference to solid bar as it is stronger. Similarly, if welded correctly, tubing can provide some buoyancy to the TED and reduce the amount of flotation required. The outer frame of the TED should be constructed using tubing approximately 40 mm (1 ½ inches) in diameter while the grid bars should be approximately 25 mm (1 inch) in diameter. Wall thickness should be around schedule 40. If tubing is used, bar strength can be increase by flattening into an oval shape.
- When constructing the grid, TIG welding is the preferred method, as it does not weaken the aluminium around the weld as much as MIG welding methods. Good weld penetration is critical to prevent bars breaking free of the outer frame and to improve the overall longevity of the TED.

Bent Bars:

- It has been found that by bending grid bars slightly backward large objects such as sponges can be excluded with greater ease than with a standard flat grid. These bends should be approximately 35 degrees and extend for around 1/8th of the overall length of the grid.

Installation:

- When fitting a grid into an extension of netting, care must be taken to ensure it is installed evenly down both sides to prevent twisting during use.
- The grid should be first laced in tightly with strong twine before adding a protective rope over the top to reduce wear (mainly from the deck and rigging of the vessel) and provide longevity.
- Care must be taken when cutting the escape hole as this often reduces the angle of the grid by 5 – 10 degrees. When installing the TED it is a good idea to set the grid at least 5 degrees steeper than the angle you hope to achieve so that if the angle decreases when the escape is cut, the grid will be at the desired angle.
- Always selvedge the sides of the escape hole with a strong twine to prevent knot slippage and stretching of the meshes in that area which can also lead to angle loss.
- A belly or selvedge rope that is attached to the grid can be installed to the sides of the codend and throat of the net to help prevent angle loss. The rope should run from approximately 100 cm (3 feet) ahead and behind the grid and take some strain off the netting that the grid is attached to. This rope should be located as close to the escape opening as possible.

Grid Angle:

- Grid angle is one of the most critical factors influencing TED efficiency, and it is important to regularly check this angle. If grid angle is too shallow, prawns can be directed out through the escape hole. If the angle is too steep, the grid can become easily blocked by sponges and other debris, often resulting in catch losses.
- The preferred grid angle for a TED is 45 – 55 degrees. This is measured from a line parallel with the codend to the bars of the grid (not the outer frame of a bent-bar grid). not the frame.
- Grid angle is easily checked by hanging the TED from the rigging using a lift (rope) tied around the throat of the codend. The TED will hang at its working angle and can then be measured using an angle meter. 'Magnetic Angle Locators' are available from Blackwood stores.
- As a general guide, bottom excluding TEDs can be set steeper (50 – 55°) than top opening TEDs as objects tend to fall out easier under their own weight. Top excluders, on the other hand, may be set shallower (40 - 50°) to allow heavier objects to slide easily upward towards the escape hole. If a shallower angle is preferred for a top opening TED, make sure the largest possible sized grid is used for your net size, as grid height is critical in this situation.

Bar Spacing:

- Legislation prevents a bar spacing of greater than 120 mm being used. Bar spacings of between 120 mm and 60 mm have been used with success.
- Small bar spacings allow smaller animals and objects to be excluded from the trawl. Additionally, smaller bar spacing can allow for faster exclusion of larger objects, particularly sponges, as they are less prone to getting caught between the bars and have a greater surface area on which to slide towards the escape hole.
- In areas with less debris or during banana fishing, larger bar spacings may be preferred as less large sized bycatch is encountered and the catch can pass easily into the codend.

Flaps and Escape Covers:

- Together with grid angle, flaps or escape covers are the most critical components in maintaining TED performance.
- Correct knot direction is crucial to ensure that the flap over an escape opening is sealing and holding catch within the codend.
- Stretched escape flaps do not seal as well as new/springy flaps. Similarly, as the width of a flap increases through stretch, flap length is reduced. The best material to use in the construction of escape flaps is depth-stretched, heat-set polyethylene prawn netting. This material has a high memory (spring/stretch action).
- Adding more meshes to the width of a flap can also help prevent the occurrence of excessive stretch. A greater numbers of meshes in the width of the flap allows easier exclusion of large objects and reduces flap stretching. Similarly, greater width also increases the amount of knots that, if oriented correctly, can help seal the flap over the escape hole. The flap width should sufficiently cover the opening and it should be sewn to the codend using a ratio of 3 flap meshes to two codend meshes (3:2). A ratio of 2:1 has also been used successfully.

- It has often been considered that flaps can be extended and/or have weight or floatation added to help keep them closed over the escape hole. Through extensive testing (in the U.S. and locally), it has been found that flaps work best if kept to a length of approximately 6 meshes extending behind the grid with no weight or floatation added. Extra length can cause a flap to wallow during a tow and not seal efficiently. Similarly, adding weight and floatation can cause large animals and objects to block the grid ('TEDed') and/or be excluded very slowly. The escape cover is then held open for long periods, resulting in catch losses. If you feel there is a need to add weight, floatation or length to help seal a flap i.e 'Overtune the TED', it is a general indication that there is a problem somewhere else with the TED. Usually incorrect grid angles, too small a grid size, wrong knot orientation or excessively stretched flaps are to blame. Check these components before modifying the flap.

Escape Holes and Exits

- As a general rule, the larger the escape hole the better the TED performs. If an escape hole is restricting the exclusion of large objects, the grid may become blocked and catch can be lost. A large escape hole allows objects to be excluded quickly and reduces the length of time the escape hole is open to prawn loss.
- An important consideration, however, is that the larger the escape hole cut in a TED, the less netting there is to support grid angle. Always selvedge the sides of escape holes with strong twine and add a belly rope to the sides to help support the grid and take the strain off the netting to prevent stretch and angle loss.
- Cutting the sides of an escape hole on the bar can add more strength than if the sides were cut down a line of points. However, by cutting an escape on the bar (triangular hole) the size of the escape is reduced. A combination of the two may be best.
- Slipping and/or stretching of meshes around the escape opening can cause loss of grid angle. One method to prevent meshes sliding is to weld studs or eyelets at points on the outer frame of the TED to which the outer corners of escape opening can be attached.

Guiding Panels and Funnels:

- Funnels and guiding panels direct the catch away from the escape hole.
- These panels are most effective when fishing in clean grounds and are critical in preventing prawn loss from TEDs that use a short or no escape covers/flaps.
- In areas high in bottom debris such as sponges and starfish, funnels can become blocked and cause prawn loss.
- In TEDs that have a flap over the escape opening, funnels have been removed with no loss of prawn catch.

Floats:

- It is recommended that floats be added to TEDs as they provide both stability and floatation. As a general rule, large aluminium TEDs should have two 6 – 8 inch floats attached. Stainless steel TEDs will require more floatation to prevent contact with the bottom.
- The amount of floatation required on a TED is easily estimated by lowering the TED into the water (when it is not attached to the codend or net) and adding enough floats so that it is neutrally buoyant (neither floats nor sinks).

- Hard plastic floats are preferred over foam (expanded PVC) floats as they do not get crushed and lose buoyancy if used in deeper waters (greater than 25-30 metres).
- Floats should be attached to the upper half or the grid to provide stability, especially while streaming the nets to help prevent twisting.
- Attaching floats to the inside of the TED behind the grid prevents tangling with lazy-lines and hookups on rigging and gunwales. If they happen to come loose during a tow, they will remain in the codend. Care should be taken to ensure that floats do not interfere with the escape flap.

Lazy-lines:

- Care should be taken when using choker lifts on codends. Twist in the lazy-lines, due to winches and capstans, can reduce the size of the loop around the codend. This can restrict catch from entering the codend and hold it close to the escape opening in TEDs, which may result in catch losses.

Should anyone require further information or assistance with regard to improving the performance of TEDs and BRDs or the development of new designs please contact Garry Day or Steve Eayrs at the Australian Maritime College on 03 6335 4444 (mobile 0409 668 199) or 03 6335 4424 (mobile 0408 306 809) respectively.

**** Note: This paper is not to be reproduced without consent from the author.***

Professional Fisherman article - February 2001: "NPF operators make gains in bycatch reduction, but some problems remain!"

The year 2000 was the first that all operators in the Northern Prawn Fishery (NPF) used TEDs and BRDs. This is a major change in fishing practice, and in June 2000 a new FRDC funded project began to assess and improve the performance of TEDs and BRDs in this fishery. Garry Day and Steve Eayrs* report that while some operators are already reducing bycatch by more than 15% others are still experiencing substantial problems.

In the 2000 tiger prawn season, project researchers from the Australian Maritime College (AMC) and the CSIRO worked with five vessels to record the impact of TEDs (turtle excluder devices) and BRDs (bycatch reduction devices) on prawn catches and bycatch reduction. The devices assessed included both top and bottom opening TEDs such as the Super shooter and Swede, and BRDs such as the radial escape section (RES), fisheye and bigeye. The devices were tested over a range of seabed conditions, including clear grounds with low sponge bycatch to grounds with high numbers of sponges, rocks and other bottom debris. Skippers and crews were also provided with assistance in rigging and operation of TEDs and BRDs to improve performance.

Industry and researchers work together to optimise TED and BRD performance

During the fishing season five vessels were visited and the prawn catch compared between the TED/BRD net and a standard net (TED and BRD removed). Catch data from 226 paired shots was recorded, and there was less than 3% difference in tiger prawn catches between sides. No turtles were captured in a net fitted with a TED. Similarly, these nets reduced the number of large animals (sharks & rays) and sponges by 78% and 81%, respectively. The weight of fish bycatch was reduced by 5.6%, and the weight of soft and broken prawn was reduced by 37%, presumably due to the substantial reduction in total bycatch. On one vessel, a reduction in bycatch of 15% was recorded.

The bigeye was the most popular BRD used by the five vessels to reduce fish bycatch. This device is located in the top panel of the trawl well ahead of the codend, and its popularity is presumably due to concerns over perceived prawn losses from BRDs that are located in the codend. However, tests on one vessel indicated that this may not be entirely correct, with both the RES and fisheye (in combination with a TED) located in the codend and recording less than 2% prawn loss.

Table 1: Combined catch results for the five vessels visited during the 2000 tiger prawn season.

Catch Component	No. of Shots	TED & BRD Net	Standard Net	TED & BRD catch	TED & BRD catch (%)
Tiger prawns (kg)	226	10152	10450	-298	-2.8
Soft & broken tigers (kg)	73	77	122	-45	-36.9
Fin-fish bycatch (kg)	108	20570	21793	-1223	-5.6
Sharks and Rays (No.)	226	42	189	-147	-77.8
Turtles (No.)	226	0	6	-6	-100.0
Sponge, rocks and shells (No.)	226	89	470	-381	-81.1

Note: '-' denotes a smaller catch for the TED/BRD Net when compared to the Standard Net.

Over-tuned TEDs reduce prawn catches

When project researchers initially visited the vessels the performance of TEDs and BRDs was poor with most experiencing substantial prawn losses. These losses were commonly related to 'over-tuning' of the TED, which involved making excessive modifications to the TED to reduce prawn losses. This loss typically arises from the poor design or operation of the TED, including incorrect grid angle, orientation or escape flap design. The inappropriate selection of the TED for specific areas of the fishery including the use of small grids in grounds with high sponge numbers is another common cause of prawn loss.

The chances of prawn loss are determined by the ease and speed with which bycatch is excluded from a TED. A well-tuned TED will rapidly exclude large bycatch from the trawl, thereby reducing blockage of the grid or escape opening, and minimising prawn loss. Researchers have observed examples of over-tuning including the use of excessive flap lengths or heavy weights attached to trailing edge of the flap. While these may overcome prawn loss in clear grounds, in other grounds they can delay the exclusion of rocks, sponges and other large bycatch from the trawl and cause prawn loss.

An example of inappropriate TED selection and impact on prawn catch is shown in Figure 1. Prior to these results, the operator had successfully overcome prawn loss in clear grounds (arising from the use of a small grid at a low angle) by increasing the length of the escape flap and adding weight to the trailing edge of the flap. The initial 15 shots in Figure 1 demonstrate the impact of an over-tuned, upward excluding TED on prawn catches in grounds with high sponge numbers. This resulted in an average prawn loss of 19% compared to the standard net, and the TED was subsequently re-rigged as a bottom excluder (shots 16 – 31) with a steeper grid angle (55°) and the escape flap modifications removed. This substantially reduced prawn loss, and in fact average prawn catch increased by 1.4% when compared to the standard net. This is an overall gain in TED performance of just over 20%. Sponges were no longer a problem and the catch of soft and broken tiger prawns was reduced by 13% in comparison to the over-tuned TED.

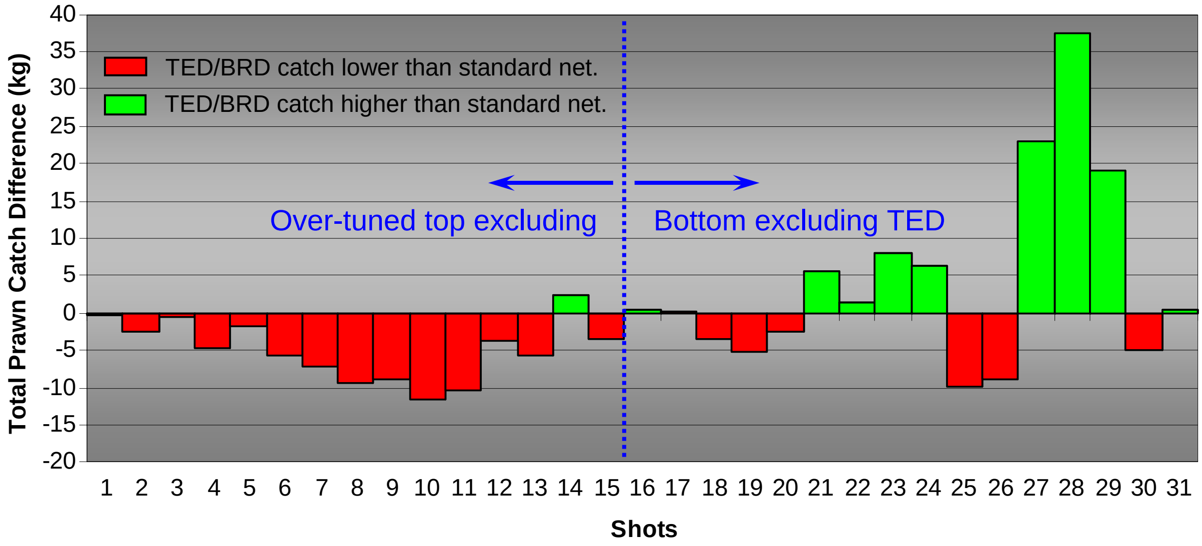


Figure 1: Differences in total prawn catch between the TED/BRD and standard net. The dotted line indicates re-rigging of TED/BRD net.

Industry comments on TEDs and BRDs.

A goal of this research project is to record comments and provide feedback to NPF operators on TED and BRD performance. Although some operators described massive prawn losses from individual tows, most noted much smaller losses (around 5%) on average for the season. However the general attitude of operators was that given time and experience the performance these devices will be improved and a small loss of catch was seen as inevitable given the relatively new fishing practice faced by the industry. Although operators acknowledged that this is partially compensated for by improved prawn quality (one company reported an average reduction in soft and broken prawns from 9% of total catch to less than 5%), reduced sorting times and hazards to crew by some bycatch animals (Figure 2).

Figure 2: The catch from a standard net (with TED and BRD removed) showing large black stingrays. Crew are usually keen to have the TED returned to avoid handling such hazardous animals.

Future project goals

Another goal of the project is to assess the performance of TEDs and BRDs. In October 10 observers will each spend up to a month at sea collecting catch information, thus enabling a detailed assessment of these devices to be achieved. A cost/benefit analysis of these devices will also be undertaken. Project researchers will continue to work on NPF vessels and help operators optimise TED and BRD performance. Project feedback and information about TED and BRD performance will be achieved by port visits, newsletters and magazine articles. Further information regarding the project can be obtained by contacting Brian Taylor (CSIRO) on Ph: 07 3826 7226 or Fax: 07 3826 7222

Acknowledgments.

Sincere thanks are extended to all the owners, skippers and crews for their willingness and enthusiasm to participate in this project and their hospitality while observers were onboard. Thanks also to Don Heales (CSIRO) for his contribution to the catch data in this report.

**Garry Day is a research officer with the Australian Maritime College, and Steve Eayrs is a fisheries technologist also at the AMC. This project is titled, "Assessment and improvement of BRDs and TEDs in the NPF: a co-operative approach by fishermen, scientists, fisheries technologists, economists and conservationists" and is funded by the FRDC and project co-investigators, including CSIRO Marine Research and Australian Maritime College, Fisheries Economics, Research & Management P/L, Traffic Oceania, A Raptis and Sons, ARJ Investments, Austfish P/L, Australian Trawl Net Company, Gulf Net Mending Co, Newfishing Australia P/L, Tiger Fisheries P/l, Veejay Fisheries P/L, WA Seafood Exporters, and Ocean Trawlers.*

Certificate of appreciation

CERTIFICATE *of* APPRECIATION

The staff of the TED and BRD research
group from CSIRO and AMC acknowledges
the invaluable help and assistance
provided during our work at sea in 2001
by the skipper and crew of the

We express our sincere thanks and appreciation.

FV *Caledon Pearl*

Northern Prawn Fishery
TED & BRD Project

CSIRO
MARINE RESEARCH

Article in AFMA NEWS, October 2003 – "Time to Say Goodbye to the Bigeye"

FISHERIES NEWS

Time to say goodbye to the Bigeye

THE 'BIGEYE' BYCATCH REDUCTION DEVICE (BRD) WILL NO LONGER BE PERMITTED IN THE NORTHERN PRAWN FISHERY (NPF) FROM THE START OF THE SECOND SEASON IN LATE 2004.

The bigeye is one of seven currently approved designs. However, a recent report by CSIRO and the Australian Maritime College identified that the bigeye is ineffective at reducing bycatch and it also reduces prawn catches by, on average, four per cent. AFMA and the Northern Prawn Fishery Management Advisory Committee (NORMAC) have therefore agreed to phase out its use.

Given that many NPF boats currently use the bigeye, this decision represents a major challenge to industry. Operators are therefore encouraged to take advantage of the 12 month phase-out period by experimenting with other approved designs, or even to come up with their own BRD designs. To promote this initiative, AFMA will provide observers to assess the effectiveness of new or improved BRD designs.

Turtle Exclusion Devices (TEDs) and BRDs became mandatory in the fishery in 2000. Since that date, operators in cooperation with AFMA and CSIRO have refined the use of these devices, which has seen a reduction in turtle interactions from approximately 5,000 in 1999, to just 18 reported interactions in 2002, with 16 turtles released alive. In the first half of 2003 there were just six interactions, with all six being returned to the water alive and well.

The research project "Assessment and improvement of BRDs and TEDs in the NPF" by the Maritime College and CSIRO concluded that TEDs were effective in preventing more than 99 per cent of turtle interactions. Given that TEDs are working well in the fishery and widely supported by industry, AFMA and NORMAC have now turned their attention to improving the effectiveness of BRDs.

Reducing bycatch increases the efficiency of operations, resulting in a better quality product with less effort, cost and risk to fishers. Just as importantly, minimising bycatch helps to maintain a healthy ecosystem, which in turn supports a healthy, profitable and sustainable prawn fishery.

Anyone wanting to find out more about approved BRD designs or who may be interested in designing their own BRDs should contact Alistair Bain in AFMA's NPF section on **(02) 6272 4834** or e-mail **Alistair.Bain@afma.gov.au**

New Code of Practice for Western tuna fishers

THE WESTERN TUNA AND BILLFISH FISHERY (WTBF) NOW HAS ITS OWN INDUSTRY CODE OF PRACTICE THANKS TO THE EFFORTS OF SEANET AND THE WEST AUSTRALIAN PELAGIC LONGLINE ASSOCIATION.

Released under the slogan, "Smarter, responsible, and sustainable fishing", the Code covers a range of topics including fishing practices, interactions with bycatch, food safety and industry participation with research and management.

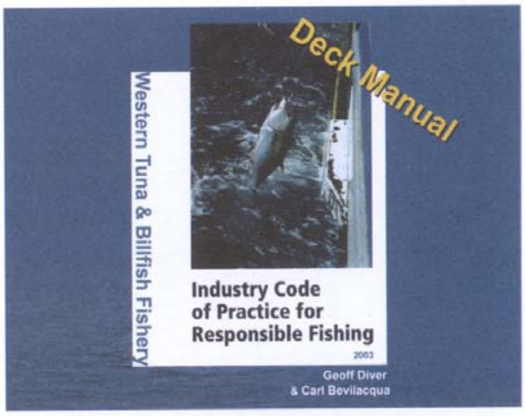
The Code is also accompanied by a Deck Manual (see cover below), which has species identification guides, tagging information, and handling protocols for protected species such as turtles and seabirds. The Deck Manual is waterproof.

It was launched by AFMA Chair Dr Wendy Craik at the Seafood Directions Conference in Perth in September and follows the release of a similar code for the Eastern Tuna and Billfish Fishery in May this year.

Geoff Diver (WAPLA) and Carl Bevilacqua (SeaNet) drafted the WTBF Code. Drafts were sent to all interested parties including state and Commonwealth fishery managers, recreational and environment groups, and industry members. Workshops were also held in Fremantle and Geraldton.

The Code has been well received since it was first launched and industry members are hopeful that it marks the beginning of a new era of cooperative co-management between AFMA and industry in this fishery.

For further information about the new Code, contact Geoff Diver at WAPLA on **(08) 9336 4840** or e-mail **geoff.diver@bigpond.com**



Article in AFMA NEWS, September 2003 – "Northern Prawn skipper develops new, improved Bycatch Reduction Device"

RESEARCH NEWS

Northern Prawn skipper develops new, improved Bycatch Reduction Device

THE NORTHERN PRAWN FISHERY MANAGEMENT ADVISORY COMMITTEE (NORMAC) HAS APPROVED A MODIFIED BYCATCH REDUCTION DEVICE (BRD) DEVELOPED BY SKIPPER JIM YARROW.

Mr Yarrow, skipper of the *Rosen C*, recently gained approval for his modifications to an existing BRD, the 'Fisheye'. He found that despite achieving substantial reductions in bycatch using the Fisheye, the frame regularly collapsed whilst lazy-lining.

Mr Yarrow decided to add two extra bars to increase the rigidity of the frame and reduce the risk of the device collapsing. Following AFMA approval of a scientific permit and initially positive results, a scientific observer formally assessed the BRD during fishing operations.

The observer collected data on the modified Fisheye during the end of the 2002 Tiger Prawn Season. A total of 51 shots were observed and analysed for differences in prawn and bycatch weights. The results showed a reduction of 20.3 per cent in bycatch weight compared with a standard net and a less than one-percent reduction in tiger prawn weight.

In June 2003, NORMAC's TED & BRD Subcommittee noted the ability of the modified Fisheye to exclude bycatch without

Bycatch sub-sample with use of reduction device (left) and without the device (right)

substantial prawn loss due to the structural enhancement of the frame. Following the Subcommittee's recommendation, NORMAC incorporated the modified fisheye design as an approved BRD.

The modified BRD has been named the "Yarrow Fisheye" in recognition of Mr Yarrow's innovation.

Operators in the NPF are required to use approved Turtle Exclusion Devices (TEDs) and BRDs when fishing. AFMA is keen to encourage operators to develop new, innovative and effective TEDs and BRDs, and grants scientific permits to operators wishing to trial new designs (**see accompanying flow chart**)

DESIGN YOUR OWN BRD

NPF fishers who wish to test their own design or modification can do so by obtaining a scientific permit from AFMA. There is no cost for a scientific permit.

There are four (4) steps to follow in order for you to have your own design included as an approved device.

Step 1: Contact AFMA

Provide a copy of your design and an explanation of how it operates to AFMA.

Step 2: Assessment

AFMA will arrange for your design to be assessed by a panel including a fishing gear technologist and a commercial fisherman. Depending on the design it may be necessary to supply the panel with further information at this stage.

Step 3: At-Sea Trials

If your design looks reasonable, AFMA will issue a scientific permit so that you can trial the device. If, after a month of trials you believe the device is effective, AFMA will arrange for a scientific observer to conduct further assessments aboard the vessel at no charge (the operator will need to provide on-board accommodation for the observer).

Step 4: Device Approval

Following successful trial and assessment of the device it may be included as an approved NPF design.

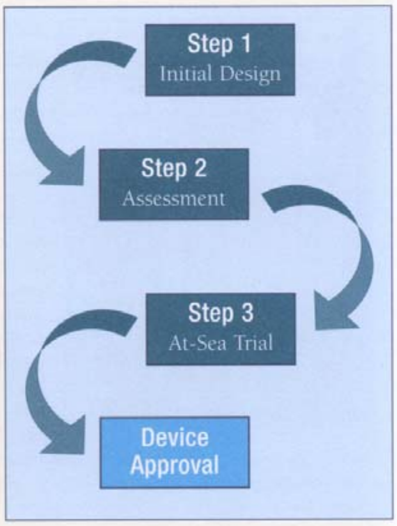
If you would like further information or assistance with the process or wish to submit a design please contact:

AFMA
Northern Prawn Fishery
Box 7051, Canberra Business Centre
Canberra ACT 2610
Ph (02) 6272 5039
Fax (02) 6272 4614

The Yarrow bycatch reduction device

Scientific Permit System

This system is designed to encourage development of new and innovative TED and BRD Designs. Simplicity is the key and depending on the design, not all steps may need to be followed in approving the device.



Eayrs and Day – Professional Fisherman, June 2004 "Optimising TED performance in tropical Prawn-trawl fisheries-a review part 1"

Optimising TED performance in tropical prawn-trawl

A well-designed and maintained Turtle Exclusion Device (TED) should ensure that turtles and other large animals are rapidly excluded from the trawl and prawn loss is minimal or non-existent. However, operators have found that TED performance is not consistent in all areas of a fishery and that performance can deteriorate with time. This has made the task of optimizing TED performance difficult, particularly when prawn loss and reduced income is the result of failure to correctly modify the device.

This article is in two parts and aims to provide operators in tropical prawn-trawl fisheries with a guide to maintaining optimum TED performance. Part 1 of this paper describes design and construction details relevant to the optimum performance of these devices. Part 2 describes secondary modifications that can influence performance and warns of the dangers of excessive modification, the so-called over-tuning of a TED. Importantly, options for minimising the effects of over-tuning are also discussed.

Background

The development and testing of TEDs in Australian tropical prawn fisheries commenced in earnest in the early 1990's. Over this time the fishing industry and various research organizations, including the Australian Maritime College (AMC), the CSIRO Marine Research (Cleveland), and Queensland and Northern Territory fisheries departments, have collaborated to test a wide range of devices to exclude turtles, fish bycatch and other animals from the trawl.

As part of this work the co-author, Garry Day, spent six consecutive years onboard commercial trawlers in the Northern Prawn Fishery (NPF) testing these devices and refining their performance under normal commercial operating conditions. This has resulted in detailed knowledge of factors that affect the operating performance and efficiency of various TED designs.

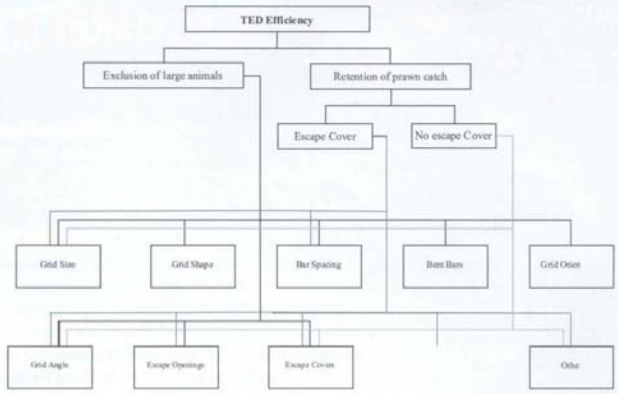


Figure 2: Relationship between the various design and construction parameters that effect TED efficiency

Factors Influencing TED Efficiency

The efficiency of a TED is a function of the ease with which it can exclude turtles and other large animals and objects from the trawl, and its ability to retain the prawn catch. The ability of a TED to perform these functions is influenced by the design, construction and rigging of the various TED components under the full range of operating conditions experienced in the fishery (Figure 1 & 2). The maintenance of these various components is also vitally important to ensure that TED efficiency is optimised.

PART 1: TED design, construction and rigging

Grid Size (grid height and width)

Grid size relates to the total area of the grid that is available to filter turtles and other large animals from the trawl. All things being equal, both large and small grids are similarly effective in excluding this bycatch, but the risk of prawn loss may be less with large grids. This is because the relatively larger filtering area of large grids means that prawns can still enter the codend when the grid is partially blocked by an animal or object, whereas the same animal or object may completely block a smaller grid and prevent prawn entry into the codend.

These prawns are then likely to respond to the blockage by swimming through the escape opening of the TED. Another reason for larger grids reducing

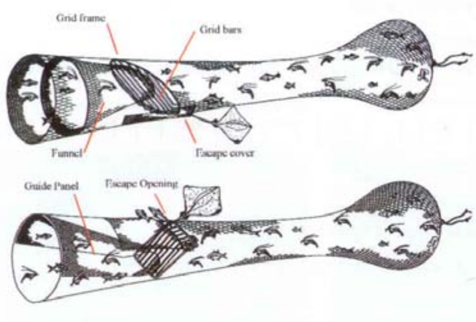


Figure 1: The various components typically incorporated into the design of a bottom opening TED (top) and a top opening TED (bottom)

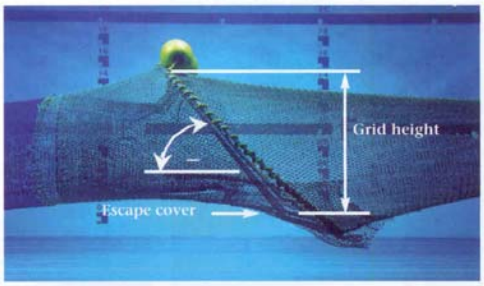


Figure 3: The Super shooter TED tested in the flume tank. The working height of the grid is sufficient to distort the circumference of the codend so that the escape cover seals snugly against the grid and escape opening. Note that grid height is measured from the bends in the bars of the grid. This slightly underestimates the true grid height but helps ensure the escape cover seals snugly against the grid

fisheries: a review – The first of a two part series to be continued next month

By Steve Eayrs and Garry Day*

prawn loss is that prawns have to swim a relatively greater distance to escape from the trawl, particularly if they enter the TED via a guiding panel. These grids also usually have a larger escape opening to facilitate the rapid exclusion of large animals from the trawl.

Grid size also affects grid angle and the ability of the escape cover (or flap) to seal over the escape opening. The correct grid size is that which slightly distorts or enlarges the circumference of the codend immediately around the grid (Figure 3). As the net is being towed, water pressure holds the cover firmly over the escape opening and against the grid, and the risk of prawn loss is low. If grid size is too small, the escape cover may flounder above the escape opening and not seal tightly. The risk of prawn loss will be increased considerably.

Grid Shape

There are various grid shapes that can be used in the construction of a TED but the majority fit into one of three categories; rectangular grids, oval grids, or a combination of the two grids (often referred to as a 'tombstone' grid). Rectangular grids are usually the simplest to construct and they have a relatively large escape opening because the width of the opening is usually similar to the width of the grid (Figure 4).

A disadvantage of these grids is the risk of netting abrasion at the corners of the grid. This can result in broken meshes, loss of grid angle and reduced TED efficiency. The attachment of a rectangular grid to a cylindrical codend will also distort and stretch codend meshes adjacent the corners of the grid. As these meshes stretch over time, grid angle may be reduced and compromise TED efficiency.

Oval or rounded grids better conform to the cylindrical shape of the codend and the problem of net abrasion is reduced because the grid has no angular corners – any abrasion is spread over a greater area of the grid (Figure 5). Oval grids may also increase the ability of an escape cover to seal tightly over the escape opening and prevent prawn loss.

Figure 4: The AMC designed NAFTED is an example of a rectangular bent-bar grid. Note that the width of the escape opening is equivalent to the width of the grid. This version of the NAFTED has no escape cover and was designed with a bar spacing of 60mm to exclude large jellyfish

This is because the escape opening extends partially around the sides of the grid and codend, resulting in a section of the grid protruding from the escape opening. The escape cover is then held firmly against this section of grid by water pressure as the net is towed through the water. The risk of prawn loss is reduced because the escape cover prevents their escape. A disadvantage of an oval grid is that the escape opening is usually not as wide as that for a similar-sized rectangular grid.

Figure 5: Oval-shaped grids conform well to the shape of the codend during operation. Note that the escape opening extends part way around the sides of the grid

Attempts to increase this width require the escape opening to be cut further around the sides of the codend, but it is unlikely the escape cover will now be able seal tightly over this part of the opening. Furthermore, as fewer codend meshes now support the grid, the remaining meshes are at increased risk of stretching and the potential for loss of grid angle is high. Increasing the overall size of the grid is one way to overcome this risk and enable a larger escape opening to be used.

Tombstone-shaped grids can be used so that the square end of the grid provides for a wide escape opening with the opposing rounded end of the grid better conforming to the shape of the codend. In this way, the grid provides a good compromise between rectangular and rounded grids.

Bar Spacing

A grid is usually constructed with an outer frame to which parallel bars are welded. These bars are spaced at an interval that allows large bycatch to be filtered from the catch and excluded from the trawl. Bar spacing is typically between 100 – 120mm, but 60 – 80mm has been successfully used in some fisheries. A grid with a small or narrow bar spacing will usually exclude smaller-sized bycatch than a grid with a large spacing.

These grids may also exclude bycatch such as sponges and jellyfish more readily because they have a greater surface area for the animal to slide towards the escape opening of the TED. The risk of these animals lodging between the bars of the grid may also be reduced when smaller bar spacing is used. However, in locations where few large bycatch animals are encountered, a larger bar spacing may be preferred so that large prawns can easily pass into the codend. This option, though, may reduce the exclusion rate of fish bycatch.

Straight – or Bent-Bar grids

The bars used to construct a grid can be either straight or bent. Straight-bar grids (sometimes called flat-bar grids) are simplest to construct, but sponges and other heavy objects may lodge against the grid adjacent the escape opening, where the bars meet the outer frame of the grid. This can block the passage of prawns into the codend and increase the risk of prawn loss through the escape opening.

Bent-bar grids overcome the problem of grid blockage in this location because the bycatch is unable to lodge against the outer frame of the grid. The bars of these grids are typically bent to about 135 degrees near the end of each bar at a position approximately 1/8th of total bar length. Similarly to an oval grid, these grids may protrude from the escape opening (where the bars meet the outer frame of the grid) allowing the escape cover to seal tightly and prevent prawn loss.

Grid Orientation

This refers to the direction that a grid excludes large animals and objects from the trawl. Two options for grid orientation are usually available; either upward (top) or downward (bottom) exclusion. A downward excluding grid is usually best to exclude heavy sponges, rocks and other debris because the escape opening is located in the bottom of the codend. Top excluding grids are usually best suited for fishing grounds where this bycatch is infrequently encountered. There is no evidence that either orientation is less effective in excluding turtles and other large animals from the trawl.

continued on following page

Optimising TED performance in tropical prawn-trawl fisheries

continued from previous page

Grid Angle

Grid angle is measured from a line parallel to the codend extending toward the bars of the grid. This measurement applies to both bent-bar and straight-bar grids and is one of the most critical factors influencing the efficiency of a TED. If grid angle is too shallow – irrespective of grid orientation – prawns can be lost because the escape cover will not seal tightly against the escape opening (Figure 6). If grid angle is too high, large animals or objects may become lodged against the bars of the grid and block the passage of prawns into the codend. Typically grid angle ranges from 45 to 60 degrees.

Figure 6: The grid at the top lost substantial amounts of prawn due to problems associated with a low grid angle (25°), including a loose fitting escape cover (brown netting). The same grid (lower) was re-hung at a greater angle (45 – 50°) and actually caught more prawns than a standard net. Note how the lower grid expands the shape of the codend (the codend has not yet been fitted to the TED); this indicates an appropriate grid height for the selected grid angle

Because netting adjacent to the grid can become stretched and distorted over time, it is important to regularly check that grid angle has not changed. The rope used to support and bind the grid to the codend may also become loose, allowing the meshes to stretch, and will need to be tightened on a regular basis. Another option to maintaining grid angle is to use short 'belly' ropes attached to the TED and codend either side of the escape opening. These ropes extend for a distance of approximately one metre ahead and behind the grid, and in this way support the grid and maintain grid angle.

If a low grid angle is desired then a larger grid may need to be used to sufficiently distort the circumference of the codend and ensure the escape cover fits tightly over the escape opening. If a high grid angle is desired then a smaller grid can be used but the risk of prawn loss is higher as previously outlined.

Escape Openings

An escape opening is a hole cut into the codend directly ahead of the grid through which large animals and objects are excluded from the trawl. As a general rule, the larger the escape opening the better a TED performs because the exclusion rate of this bycatch is increased. If a small escape opening is used, the exclusion of this bycatch may be delayed, resulting in blockage of the grid by other bycatch and prawn loss through the escape opening. All things being equal, larger or wider grids allow larger escape openings to be used.

Escape Covers

Escape covers (or flaps) are sections of netting fitted over the escape opening to help prevent prawn loss. They are usually sewn to the codend ahead of the escape opening and partially down each side, while the trailing edge of the cover remains free. In this way they operate much like a trap door, allowing large animals to move the cover aside and escape. Escape covers work best if they do not extend further than 6-10 meshes past the grid, with no weight or flotation added.

The knot orientation of an escape cover is crucial to ensuring a snug fit and reduced prawn loss. The knots should be orientated so that water pressure forces the cover to sit tightly over the escape opening when towing the net. If an oval or bent-bar grid is used, water pressure will hold the escape cover in contact with that part of the grid that protrudes slightly above the escape opening. However, if a rectangular or straight-bar grid is used, this pressure may not be sufficient to ensure contact with the grid or a tight seal over the escape opening. This explains why rectangular grids should be larger than oval grids for the same sized codend.

The escape cover may become distorted over time because the repeated exclusion of large animals tends to stretch the netting width-wise and reduce its elasticity (Figure 7). This can be a source of prawn loss because the cover can no longer return to its original shape and seal tightly against the escape opening. The length of the escape cover is also reduced as the cover netting becomes stretched, and it may not effectively cover of the escape opening. To overcome these problems it is best to regularly replace the escape cover with new netting, preferably depth-stretched, heat-set netting. If the distorted cover is replaced with a wider panel of netting, less stretching of the meshes will occur as animals are excluded from the trawl. Moreover, the effect of water pressure and the increased number of knots in the new panel will press the cover more firmly over the escape opening.

Some operators are using two smaller escape covers that overlap along their length over the escape opening. This provides for greater coverage of the escape opening and protection against prawn loss as animals escape from the trawl, and prevents the meshes from becoming stretched due to repeated exclusion of large animals.

Figure 7: A poorly fitting escape cover may allow prawns to escape because it does not sit snugly against the grid

Guiding Panels and Funnels

Guiding panels are sections of netting sewn into the codend to direct the catch away from the escape opening of the TED. As the name implies, funnels are tapered tubes of netting designed to perform the same task as guiding panels. Both are fitted ahead of the grid and are critical in preventing prawn loss from TEDs that use no escape cover. When an effective escape cover is used, funnels have been removed from the TED with no loss of prawn catch.

Care must be taken when using guiding panels and funnels in locations where the risk of encountering large starfish, sponges or other heavy objects is high because they may block the passage of prawns into the codend. Heavy canvas has proven to be a successful replacement for netting material as it eliminates the problem of starfish, fish and other animals from fouling the funnel and blocking the passage of prawns into the codend. However, because canvas does not stretch it can tear away from the codend if a sufficiently large animal enters the net.

**Steve Eayrs and Garry Day are Fishing Technologists at the Australian Maritime College. Additional details, including information on appropriate TED design and specification, can be obtained by calling Steve on 03 6335 4424 or Garry on 0409 668 199*

Eayrs and Day – Professional Fisherman, July 2004 "Optimising TED performance in tropical Prawn-trawl fisheries-a review part 2"

Optimising TED performance in tropical prawn-trawl fisheries: a review

– The second of a two part series

By Steve Eayrs and Garry Day*

PART 2: TED modifications and "over-tuning"

In Part 1 the major design and construction parameters that influence TED performance and efficiency were described. The information below outlines several secondary modifications that operators can make to further influence TED efficiency and examines the issue of "over-tuning" of TEDs.

Flotation

Floats are sometimes used to compensate for the weight of the grid and to ensure TED stability and correct orientation when deploying the trawl. A grid constructed from aluminium tubing will usually not require additional buoyancy if fitted to a codend of buoyant polyethylene netting.

In contrast, a heavier stainless steel grid will most likely require flotation to help counter its additional weight. The use of brightly colored floats can help with visual location of the TED when the trawl is streamed at the surface, and provide a useful reference point to check for twists in the codend and TED.

Floats should be attached to the upper half of the grid and inside the codend to prevent tangling with the lazy-line or fouling on rigging as the codend is hauled onboard. Floats should not interfere with the escape cover, the passage of large animals from the trawl or the passage of prawns into the codend. Hard plastic floats are preferred over foam or polystyrene floats as they do not crush nor lose buoyancy if used in deeper waters (greater than 25-30m).

Backwash funnels

Backwash is a term used by fishers to describe the forward movement of catch when towing speed is reduced and the trawl is hauled to the surface. Backwash can result in major loss of prawns as they are flushed forward from the codend and through the escape opening. To counter this some fishers are using so-called backwash funnels.

These are funnel-shaped sections of netting fitted inside the codend and aft of a TED (or BRD). They are attached by their leading edge to the codend while the trailing edge remains free. When fishing, backwash funnels remain open to allow the catch to enter the codend, but when the trawl slows or is hauled to the surface, the funnel collapses and prevents forward movement of the catch.

Backwash can also occur during sharp turns when the trawls are at the surface while targeting banana prawns. Similarly, large catches of banana prawns that fill codends may approach the escape opening of both TEDs and BRDs and substantial losses can occur without the installation of a backwash funnel. It is important to ensure that the trailing edge of a backwash funnel cannot surge forward and become fouled around the bars of the grid during trawl deployment.

Figure 8: The TED on the left was losing substantial amounts of prawns when first installed by the crew. In an attempt to reduce this loss they lengthened the escape cover and added chain and lead weights (right photo). These modifications only served to increase grid blockage by sponges with a resulting increase in prawn loss. The initial problem was not related to a poor escape cover, but to an under-sized grid and low grid angle (left photo). The grid was reinstalled at a higher angle by the author and an escape cover without weights was used extending only 6 meshes past the TED frame. Catch loss was eliminated and the incidence of grid blockage significantly reduced

Lazy-lines

Lazy-lines are ropes attached to the codend to enable them to be lifted onboard and the catch retrieved. Care must be taken that these ropes do not choke off the codend because this will prevent prawns from entering the codend and they may be lost through the escape opening of a TED (or BRD). This problem is commonly encountered when the lazy-line is designed to choke the codend closed as it is hauled onboard. The use of netting "lifting ears" usually does not choke the codend or result in prawn loss. The lazy-line should also be long enough that is does not pull the TED over on its side when fishing or streaming the net.

Canvas sheets ahead of the TED

In recent years the use of a canvas sheet attached to the codend immediately ahead of a bottom excluding TED has gained in popularity. This modification relies on the smooth surface of the canvas to facilitate the passage of large animals

Continued on page 18

Optimising TED performance in tropical prawn-trawl fisheries

Continued from page 16

towards the escape opening. In this way the risk of grid blockage is reduced and TED performance is optimized.

The problem of "over-tuning" and being TEDed

The majority of catch loss observed by the authors has been related to the over-tuning of TEDs. Over-tuning refers to excessive TED modifications made by fishers in an attempt to reduce or prevent prawn loss. Unfortunately these modifications usually only serve to increase this risk of loss, particularly where large animals or objects are present. These modifications may also result in the fisher being "TEDed", a term used when the TED is blamed for large-scale or massive prawn loss during a trawl shot.

In most instances, high prawn loss is the result of poor TED design or operation in a specific area of the fishery and subsequent over-tuning of the TED. An example of this is the use of a top excluding TED where heavy sponges or other large animals are encountered. In this circumstance fishers often assume that fitting the escape cover more tightly over the escape opening will prevent a loss of prawns.

A typical response is to add heavy weights to the escape cover and/or use an excessively long escape cover and increase the amount of cover sewn to the codend netting (Figure 8). The TED is now over-tuned because the exclusion of large animals is delayed or hampered. These animals now struggle to escape, and as the escape cover is pushed aside for a longer period the opportunity for prawn escape is now also increased.

Other examples of poor TED design include the use of small grids that do not distort the codend sufficiently for the escape cover to sit tightly over the escape opening, or grids rigged at excessively low grid angles. Escape openings that are too small to allow rapid exclusion of large animals, and the use of excessively stretched escape covers are other commonly observed examples of poor TED design. The desire to add floats to the escape cover of a bottom excluding TED is another example of over-tuning and is often an indication there is a problem elsewhere with the TED.

It is important to note that over-tuning a TED may solve the problem of prawn loss in locations where few large bycatch animals are encountered, particularly if the escape cover is stretched or grid angle is too low. However, when used in locations where large numbers of these animals are encountered, the risk of being "TEDed" is high.

The problem of overtuning clearly highlights the difficulties fishers face trying to optimise TED performance across the entire fishery, and the need for regular maintenance and replacement of worn or stretched components. An option not widely practiced at present, but which may go a long way to avoiding the problem of prawn loss, is for fishers to have available several different TED designs, such as a downward excluding grid for locations where large animals are commonly encountered and an upward excluding TED for locations where they are less common. In this way, a TED suited to specific conditions encountered in the fishery is used and optimal TED performance and efficiency can be maintained.

Ten tips for optimising TED performance

This article has described the major factors that affect TED efficiency and described options for maintaining optimum performance, both to exclude large animals and maintain the prawn catch. Based on these factors the table below provides 10 important tips for fishers to optimise TED performance.

Steve Eayrs and Garry Day are Fishing Technologists at the Australian Maritime College. Additional details, including information on appropriate TED design and specification, can be obtained by calling Steve on (03) 6335 4424 or Garry on 0409 668 199

TED factor	TED tip
1. Grid size	The grid needs to be large enough to exclude most or all animals encountered in catches.
2. Grid shape	The shape of the grid can affect the size of the escape opening, the exclusion of large animals, prawn retention and wear and tear on the codend.
3. Bar spacing	A smaller bar spacing allows exclusion of more bycatch species, although unfounded concerns over increased prawn losses has prevented fishers from using less than 100-120mm bar spacing.
4. Bent bars	Bent-bar grids can improve the speed of large animal exclusion and consequently reduce prawn loss.
5. Grid orientation	This can be altered to target the exclusion of particular species groups. For example downward excluding grids are thought to be best suited to excluding heavy, negatively buoyant items such as large sponges or rocks.
6. Grid angle	Incorrect grid angle can result in prawn loss or poor bycatch reduction. Downward excluding grids are best at 50-55º, and upward grids at 40-50º.
7. Escape openings	Larger escape openings improve the exclusion speed of large animals and reduce prawn loss, although there are issues with maintaining the shape and strength of the codend for larger openings.
8. Escape covers	There are many misconceptions about these devices and a major cause of over-tuning. They should be made of depth-stretched or heat set netting; not be too narrow or too long, and not have weight or flotation added. They need to be replaced regularly.
9. Guiding panels	They are easily blocked and are best used as funnels for fishing on "clean" grounds. Canvas may also be considered as an alternative to netting.
10. Other gear	Other modifications that can help modifications maximise TED performance include flotation, backwash funnels and position of lazy lines.