Investigating options to improve bycatch reduction in tropical prawn trawl fisheries – a workshop for fishers

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AUSTRALIAN MARITIME COLLEGE

Australian Government

Fisheries Research and Development Corporation

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OBJECTIVES:

1. Increase fishers' knowledge of latest developments in bycatch reduction
2. Assess a suite of innovative options to reduce bycatch and their potential application to the fishery
3. Engage fishers and others in the identification and uptake of suitable BRDs for tropical prawn trawl fisheries
4. Engage fishers and others in the development of a coordinated plan for future BRD R & D.

NON-TECHNICAL SUMMARY:

Since 2000 the use of bycatch reduction devices (BRDs) and turtle excluder devices (TEDs) has been a mandatory requirement in most tropical prawn trawl fisheries in Australia. Despite this period of mandatory use, the number of BRD designs has remained largely unchanged and their performance can, at best, be described as modest. In the Northern Prawn Fishery (NPF) tiger prawn fishery, these devices typically exclude less than 8% of small-fish bycatch (Brewer *et al.,* 2006), while in the Queensland's East Coast Trawl Fishery (ECTF) less than 20% of bycatch is excluded (Courtney and Campbell, 2002). Attempts in both fisheries to improve bycatch reduction have commonly been accompanied by prawn loss, and this acts as a disincentive for further BRD development.

In 2004 the need to develop more effective BRDs was discussed at the FRDC R&D workshop in Cairns. At this time it was suggested that a workshop should be convened for fishers to discuss ways to improve BRD performance and to develop new, innovative options to reduce bycatch. This notion received widespread support by participants at the workshop. Subsequent discussions with NPF and Queensland fishers have also confirmed a need to improve BRD performance, both to reduce prawn loss and improve bycatch reduction.

In November 2006 a two-day workshop was held in Cairns, Queensland. 58 people, including presenters from overseas as well as 21 fishers, net makers and fleet managers, attended this workshop.

The two-day workshop in Cairns was divided into four sessions:

1. Case study accounts of fishers and others of BRD design, performance and uptake
2. International progress in bycatch reduction and innovative options to reduce bycatch in tropical prawn fisheries
3. Innovative options to reduce bycatch
4. Options to improve fuel efficiency, and planning for the future.

Presentations covered the latest developments that have taken place in a number of fisheries from within Australia and overseas. The workshops allowed fishers to provide feedback on the bycatch options.

In July 2007 a short workshop was held in Darwin prior to the opening of the tiger prawn season. A total of 20 fishers attended this meeting plus representatives from the fishing companies based in Darwin.

This workshop included the pre-season briefing for the NPF by officers from the Australian Fisheries Management Authority (AFMA) and a summary of the options for bycatch reduction that were discussed at the Cairns workshop.

The proceedings of these two workshops have been compiled into a report entitled 'Options to improve bycatch reduction in tropical prawn trawl fisheries'. An associated CD containing an electronic copy of all the PowerPoint presentations that were presented at the workshops has also been produced.

The methods for bycatch reduction in prawn trawl fisheries presented and discussed at the workshop can be divided between the areas of influence, action and retention within the trawl. Options within the area of influence (ahead of the trawl) were alternative otterboard designs to reduce impacts on the seabed. Options within the area of action were aimed at reducing the non-target species which enter the trawl and include the use of lights, electrical fields, acoustic signals and the reduction of headline height. These options are all considered to be 'innovative' methods for reducing bycatch. Within the area of action, changes in ground gear configuration were also suggested as a means to reduce the impacts on the seabed. The majority of the efforts to reduce bycatch to date have concentrated on the inclusion of devices in the area of retention of the trawl. TEDs in the form of grids were already known to reduce the capture of turtles and other large bycatch animals such as sharks and rays. BRDs for reducing the capture of smaller bycatch animals have had limited success to date and suggestions to improve their performance included gaining a better understanding of the behaviour of non-target species in the vicinity of BRDs and designing BRDs to take advantage of these behavioural traits, improving the flow field around BRDs to produce a flow out through escape openings, and determining the optimum position of the BRD within the trawl in order to increase the likelihood of bycatch exiting through the escape opening of the BRD. From an industry perspective, future research should concentrate on options in the area of retention as this is the easiest area to incorporate changes from an operational perspective, although reducing bycatch within the area of influence or area of action is likely to be far more effective.

The workshops produced the following suggested pathways forward for further bycatch catch reduction in tropical prawn trawl fisheries:

- Provide opportunity for rigorous trials of current BRDs in more effective positions in the trawl
- Additional testing of the Popeye Fishbox incorporating modifications that will generate an improved flow-field around the escape opening. The testing of this device and the flow-field observations should be made in the Australian Maritime College (AMC) flume tank
- Trial the addition of a BRD enhancer, that will create a low-flow area in the vicinity of the escape opening, in conjunction with the use of the fisheye and the square mesh panel
- Incorporate the use of a black plastic tunnel behind the square mesh panel to stimulate an escape reaction through the escape opening
- Trial the use of T90 netting in prawn trawls.

The workshops produced the following suggested pathways for addressing bycatch issues in tropical prawn trawl fisheries:

- Improve the understanding of the behaviour of key bycatch species to acoustic signals
- Improve the understanding of research and management objectives through broader dissemination of research information throughout the industry
- Convert bycatch into byproduct to reduce discarding through improved marketing/processing of bycatch species
- Improve the public perception of the fishing industry and their approach to bycatch reduction through education programmes
- Bycatch reduction research needs to include industry knowledge of the fishery and therefore must be linked closely to commercial fisheries
- Trial new BRDs and methods out of season with options for keeping catch
- List the interested fishers and companies that are willing to trial innovative options
- Encourage greater industry participation in future workshops.

OUTCOMES ACHIEVED TO DATE

1. **A step improvement in the industry's and management's knowledge of how BRDs function, providing critical direction for improved performance.** The workshop provided evidence that the performance of bycatch reduction devices can be improved by changing the flow-fields around these devices. The results of research that were presented at the workshop demonstrated that the rigging and orientation of a BRD can be altered to generate a flow field that is conducive for the escape of bycatch. These findings led to further research between the AMC and AFMA in 2007 in a project that was funded by the National Heritage Trust. The research concentrated on several BRDs, namely the 'Popeye' Fishbox BRD, and a square-mesh window (SMW) BRD to which a BRD enhancing device was attached. Measurements of the flow around the Fishbox were conducted at the AMC flume tank. Design changes were made that created a more favourable flow field in the vicinity of the escape opening, and a clearer pathway between the codend and the BRD escape opening. These improvements were incorporated into the BRD that was used during the tiger prawn season in 2007. The Fishbox results are yet to be released. The flume tank was also used to improve the performance of the 'Witch-hat' BRD enhancer, which was positioned upstream of the SMW BRD. Anecdotal results from the trials that were conducted during the commercial operations of some NPF prawn trawlers showed the modified SMW BRD (i.e. the one equipped with a Witch-hat BRD enhancer) decreased bycatch by an additional 35%.

2. **Significant raising of awareness of what may be an important innovative BRD design for prawn trawl fisheries.** The workshop raised the use of light as an innovative option for the reduction of bycatch. This led to a research project entitled the 'Application of light stimuli to reduce bycatch in prawn trawl fisheries' that was conducted by the AMC and funded by the National Heritage Trust. The aim of the project was to attach lights to the headline of the trawl to stimulate an avoidance reaction and therefore reduce the number of non-target animals that entered the mouth of the trawl. The work was undertaken in June 2008 by a commercial trawler towing a quad rig net configuration in the Torres Strait Prawn Fishery. A total of 21 trawls (33.5 hours) were conducted over four nights. For each trawl the nets on one side of the vessel were illuminated using eight 3 Watt LED lights that were equidistantly attached along the headline. The lights produced a 50.4% reduction in the number of individual non-target animals and an 18.2% reduction in the weight of non-target species.

KEYWORDS: **Bycatch reduction, tropical prawn trawl fisheries**

ACKNOWLEDGMENTS

Mr. David Brewer, who was a co-investigator on this project, and contributed greatly to the coordination of the workshops and the finalisation of the proceedings from the workshops.

Dr. Wade Whitelaw, Miss Adrianne Burke and Mr. Mike Gerner, who were all working for AFMA at the time, made a large contribution towards the organisation of the workshops and arranging the participation of representatives from the fishing industry.

To all the speakers who made contributions at the workshops. The speakers and their contact details are listed in Appendix 2.

BACKGROUND

Since 2000 the use of BRDs (& TEDs) has been a mandatory requirement in most tropical prawn trawl fisheries. Despite this period of use, the number of BRD designs has remained largely unchanged and their performance can, at best, be described as modest. In the NPF tiger prawn fishery, these devices typically exclude less than 8% of small-fish bycatch (Brewer *et al*., 2006), while in the Queensland ECTF less than 20% of bycatch is excluded (Courtney and Campbell, 2002). Attempts in both fisheries to improve bycatch reduction are often accompanied by prawn loss, and this acts as a disincentive for further BRD development.

The definition of bycatch in Australia has been broadened to include not only ‘that part of a fisher’s catch which is returned to the sea either because it has no commercial value or because regulations preclude it being retained’ but also ‘the part of the catch that does not reach the deck of the fishing vessel but is affected by interactions with the fishing gear’ (Commonwealth of Australia, 2000). This therefore requires consideration of impacts of prawn trawling on the seabed and other unaccounted-mortalities of animals that interact with the prawn trawl, in addition to the catch that actually comes on board the fishing vessel.

NEED

In 2004, a need to develop more effective BRDs was discussed at the FRDC R&D workshop in Cairns. At this time it was suggested that a workshop should be convened for fishers to discuss ways to improve BRD performance or develop new, innovative options to reduce bycatch. This notion received widespread support by participants at the workshop. Subsequent discussions with the NPF and Queensland fishers have also confirmed a need to improve BRD performance, both to reduce prawn loss and improve bycatch reduction

OBJECTIVES

The objectives of the project were to:

1. Increase fishers’ knowledge of latest developments in bycatch reduction
2. Assess a suite of innovative options to reduce bycatch and their potential application to the fishery
3. Engage fishers and others in the identification and uptake of suitable BRDs for tropical prawn trawl fisheries
4. Engage fishers and others in the development of a coordinated plan for future BRD R & D.

METHODS

The aim of the project was to achieve the objectives through workshops that would bring together representatives from the fishing industry, management authorities and research institutions. The workshops would focus on discussions of BRD performance and would also provide the opportunity to explore new innovative solutions to bycatch reduction, and future directions for related research and development.

Two workshops were held during the project. The first workshop was held at the Cairns Yacht Squadron on 21st and 22nd November 2006. The timing of the workshop was based on optimising the number of fishers available to attend and coincided with the end of the NPF tiger prawn season. It was also a time when prawn and scallop catches were decreasing in Queensland’s East Coast Otter Trawl

(ECOT) fishery. A total of at least 58 delegates, including 21 fishers, net makers and fleet managers, attended the workshop.

The second workshop was held at the 'Duckpond' in Darwin on 25th July 2007. The workshop was arranged to coincide with AFMA's pre-season meeting for the NPF tiger prawn season. A total of 20 fishers attended this meeting.

RESULTS/DISCUSSION

The details of the proceedings made at the workshops are presented in the report 'Options to reduce bycatch reduction' shown in Appendix 3. The detailed results from this project are presented in that report and the associated CD**.**

In summary, the findings from this project for options for bycatch reduction within the trawl can be considered in terms of different areas of the prawn trawl over which the capture process for many of the bycatch species takes place (Figure 1). These are:

(a) Area of influence – the area in front of the mouth of the trawl that includes the warps, bridles and otter boards and also any influence created by the fishing vessel itself;

(b) Area of action – the area at the mouth of the trawl that includes the area around the headrope and the footrope; and

(c) Area of retention – the area behind the mouth of the trawl that includes the trawl netting and codend where the catch is retained.

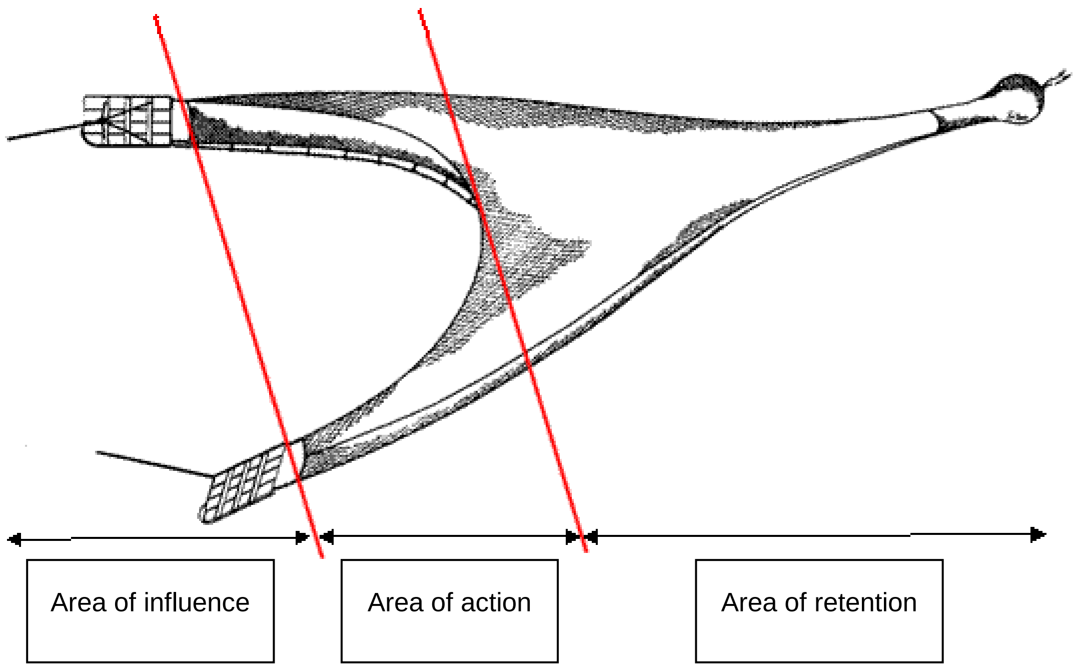

Figure 1: Areas within a prawn trawl that provide different options for bycatch reduction

During the workshops a range of methods for reducing bycatch from prawn trawls were presented and discussed. A summary of these methods are given in Table 1, with more thorough details in the proceedings given in Appendix 3.

Table 1: Summary of bycatch reduction methods for prawn trawls

Trawl zones	Potential impacts	Past activities / Current status	Latest developments / Future options
Area of influence	Reduction of impacts on the seabed	Minimal past activity but new developments are now being tested	**Alternative otter board designs** – otter boards which can be towed with lower angles of attack and therefore produce a reduced seabed footprint compared to traditional otter board designs - 'Batwing' otter boards have been trialled in Queensland.
Area of action	Reduction of bycatch entering trawl	Minimal past activity but new developments are now being tested	**Lights** – use of lights attached to the headline to promote an escape reaction away from the mouth of the trawl - Lights have been trialled in Queensland and initial results suggest a substantial reduction of certain bycatch species. **Electrical fields** – prawns jump when exposed to a pulsed direct electrical current but fish are repelled. Electrical fields could be used to promote an escape reaction away from the mouth of the trawl - Anecdotal evidence suggests that electrical fields using systems such as 'Shark Shield' attached to the headline can be successful in reducing the number of sharks and rays caught in a prawn trawl net. **Acoustic signals –** use of acoustic devices attached to otterboards, nets or headline to alert bycatch species to an oncoming net. Potentially an appropriate acoustic signal could be produced to repel certain species; however effective signals for fish have not been identified. (Acoustic trawl deterrents have been used in other fisheries to mitigate against the capture of marine mammals such as dolphins and seals). **Reduction in headline height** – allow some bycatch species to pass over the headline of the trawl - Research has shown that the majority of prawns enter the trawl close to the seabed so a reduced headline height of the trawl could be used. Some bycatch species would be able to pass over a trawl with a reduced headline height. No commercial trials have taken place to test the impacts of reduced headline height.

Trawl zones	Potential impacts	Past activities / .Current status	Latest developments / Future options
Area of action (continued)	Reduction of impacts on the seabed	Minimal past activity but new developments are now being tested	**Ground gear configurations –** reduce the use of heavy chain that scrapes the seabed just in front of the fishing line, and is designed to stimulate prawns that are on the seabed to rise up and over the fishing line into the mouth of the trawl. - 'Soft-brush' ground gear has been trialled in Queensland.
Area of retention	Reduction of non-target species that enter the trawl and are retained in the net	The majority of the effort to reduce bycatch to date has occurred in this area of the trawl. This has led to the use of approved TED and BRD designs in prawn trawls, including: TEDs – a rigid or semi-rigid grid barrier with escape opening BRDs – - square mesh codend - square mesh panel - fisheye - Yarrow fisheye - radial escape section - others	**Options for improving the performance of BRDs** - Gain a better understanding of the behaviour of non-target species in the vicinity of BRDs and design BRDs to take advantage of behavioural traits - Improve the flow field around BRDs to produce a flow out through escape openings - Determine optimum position of the BRD within the trawl in order to increase the likelihood of a successful reaction to exit through the escape opening of the BRD.

Due to the wide diversity of species that are present in prawn trawl fisheries, the most effective solution for bycatch reduction is most likely be produced by using a combination of the different options suggested in Table 1. However, the path to implementation of more effective BRDs has been hampered by a lack of funding of field programs that can run the appropriate sea trials required to determine effective BRD designs and configurations, as well as the industry's lack of willingness to undertake such trials themselves.

BENEFITS AND ADOPTION

Commercial fishers will be the main beneficiaries of this project. This will be achieved through greater awareness of methods to improve BRD performance and potential for innovative options to enhance bycatch reduction. Importantly this workshop provided fishers with an opportunity to contribute to the future direction of BRD research.

A number of commercial fishers committed themselves to trialling the some of the improved BRD designs during the 2007 tiger prawn season. The outcomes from these trails are not currently available.

FURTHER DEVELOPMENT

The workshops produced the following suggested pathways forward for further bycatch catch reduction in tropical prawn trawl fisheries:

- Provide opportunity for rigorous trials of current BRDs in more effective positions in the trawl
- Additional testing of the Popeye Fishbox incorporating modifications that will generate an improved the flow-field around the escape opening, with the flow-field observations being made in the AMC flume tank
- Trial the addition of a BRD enhancer, that will create a low-flow area in the vicinity of the escape opening, in conjunction with the use of the fisheye and the square mesh panel
- Incorporate the use of a black plastic tunnel behind the square mesh panel to stimulate an escape reaction through the escape opening
- Trial the use of T90 netting in prawn trawls.

The workshops produced the following suggested pathways for addressing bycatch issues in tropical prawn trawl fisheries:

- Improve the understanding of the behaviour of key bycatch species to acoustic signals
- Improve the understanding of research and management objectives through broader dissemination of research information throughout the industry
- Convert bycatch into byproduct to reduce discarding through improved marketing/processing of bycatch species
- Improve the public perception of the fishing industry and their approach to bycatch reduction through education programmes
- Bycatch reduction research needs to include industry knowledge of the fishery and therefore must be linked closely to commercial fisheries
- Trial new BRDs and methods out of season with options for keeping catch
- List the interested fishers and companies that are willing to trial innovative options
- Encourage greater industry participation in future workshops.

Recommendations

1. Information should be provided to members of the fishing industry on the correct methods of measuring and recording the position of bycatch reduction devices in the net in order to ensure that BRDs with the correct specifications are used and are positioned correctly within the net
2. Further research needs to be conducted on the specific behaviour of species in the different areas of the prawn trawl. This information could be used to identify appropriate solutions to exclude these species from being captured
3. Further research is required to understand the flow fields around different bycatch reduction devices
4. Further research into the use of lights attached to the headline to promote an escape response by bycatch species should be undertaken.

PLANNED OUTCOMES

The planned outcomes that were identified in the project application were:

1. Improved knowledge of options to improve BRD performance among fishers
2. Improved knowledge of innovative options to reduce bycatch and their applicability to tropical prawn trawl fisheries
3. Increased focus on the need for improved BRD performance in these fisheries
4. Reduced bycatch (especially small fish and invertebrates)
5. Improved ability by fishers to identify and apply suitable (effective) BRDs
6. The development of a handbook summarising workshop discussions
7. A prioritised description of recommendations by fishers for future BRD R & D, including suggested directions for the development and testing of new BRDs, and,
8. Improved ability to research and manage the development of improved BRD designs in these fisheries.

Those fishers who attended the workshops were exposed to a range of innovative options to reduce bycatch and some of the latest options to improve BRD performance. This information will have helped to improve the ability of fishers to identify and apply suitable and more effective BRD designs to their particular situations. The distribution of the proceedings from the workshops will allow a wider range of interested parties to be exposed to the latest options to improve BRD performance. If these options can be adopted by fishers, this will lead to reduced bycatch especially of small fish and invertebrates.

The fact that these workshops were held would have again highlighted the importance of bycatch issues and increased the focus on the need for improved BRD performance. These points were strongly reinforced by the fisheries managers and researchers, who made presentations at the workshops.

A list of recommendations for future research activities was produced from the workshops and included in the proceedings. These recommendations have also been summarised in this report. Some of these recommendations have been acted upon and further work has been conducted on flow-fields around the Fishbox and the square mesh window, as well as further research on the application of light. The challenge for all stakeholders will be to continue to work through the other recommendations that were made. This will lead to further improvements in BRD designs.

CONCLUSION

The workshops held in Cairns and Darwin provided an excellent opportunity for the sharing of the latest ideas regarding bycatch reduction in prawn trawl fisheries between representatives from industry, fisheries managers and researchers. The presentations highlighted the fact that although good progress had been made in addressing bycatch issues in tropical prawn-trawl fisheries, there is still a great deal of scope for improved performance of BRDs and the need for innovative options to address the problems.

Further options for bycatch reduction can be categorised into three broad areas on the prawn trawl; the area of influence, the area of action and the area of retention. From an industry and operational perspective, it is considered that future research should focus on options in the area of retention of the net and the improved performance of current BRD designs. The most important areas for future development include a greater understanding of the behaviour of bycatch species in the vicinity of BRDs and the subsequent changing of designs to increase escapement, improving the flow-fields around BRDs to produce greater flow out through the escape openings, and determining the optimum position for BRDs in the trawl.

In the area of action of the trawl, the use of lights, electrical fields and acoustic signals were all identified as possible artificial stimuli which could be used to discourage bycatch from entering the mouth of the prawn trawl. A reduction in headline height was also offered as a possible option to decrease the amount of bycatch entering the net.

In the area of influence of the trawl, the use of alternative otterboard designs that reduce the impact of prawn trawling on the seabed has been trialled and offers a possible solution for this problem. As the definition of bycatch broadens, there is likely to be greater focus on reducing seabed impacts in the future.

The workshops produced strong agreement between participants that future research efforts need to concentrate on a providing a better understanding of the behaviour of high risk bycatch species in the vicinity of the prawn trawl and bycatch reduction devices. Alterations to current BRD designs and the development of new designs would be based upon taking advantage of any particular behavioural traits.

The project has helped to focus attention on the need for continual improvement in the performance of BRDs. It provided options for future developments and research. Two of these options, improved flow fields producing greater flow through the escape opening s of BRDs and the use of light to promote an escape reaction away from the mouth of the trawl, have already been taken to commercial trials with encouraging results.

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APPENDIX 1:

INTELLECTUAL PROPERTY

All outputs will be available in the public domain.

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APPENDIX 3:

PROCEEDINGS FROM THE WORKSHOPS 'OPTIONS TO REDUCE BYCATCH IN TROPICAL PRAWN TRAWL FISHERIES'


Options to improve bycatch reduction in tropical prawn trawl fisheries

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Australian Government
Fisheries Research and Development Corporation

AMC
AUSTRALIAN MARITIME COLLEGE

CSIRO

FRDC Project No. 2006/308

Options to improve bycatch reduction in tropical prawn trawl fisheries

The proceedings of workshops held on

November 21 – 22, 2006

at the Cairns Yacht Squadron, Cairns, QLD

and

on July 25, 2007

at the Duckpond, Darwin, NT

Edited by

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and

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Introduction

This report provides information related to the application of new bycatch reduction devices, modifications to existing devices and the potential for innovative options to reduce bycatch in tropical prawn trawl fisheries that were discussed at two workshops. The objectives of the workshops were to:

- Increase fishers' knowledge of the latest developments in bycatch reduction
- Assess a suite of innovative options to reduce bycatch and assess their potential application to the fishery
- Engage fishers and others in the development of a coordinated plan for future bycatch research and development

The first workshop was held at the Cairns Yacht Squadron, on November 21 and 22, 2006. The timing of the workshop was based on optimising the number of fishers available to attend and coincided with the end of the Northern Prawn Fishery (NPF) tiger prawn season. It was also a time when prawn and scallop catches are historically decreasing in the East Coast Otter Trawl Fishery (ECOT). A total of at least 58 delegates attended the workshop including 21 fishers, net makers and fleet managers.

The second workshop was held at the 'Duckpond' in Darwin on July 25th, 2007. The workshop was arranged to coincide with the Australian Fisheries Management Authority (AFMA) pre-season meeting for the NPF tiger prawn season. A total of 20 fishers attended the meeting.

This report includes a description of the papers presented at the workshops and a copy of PowerPoint slides presented by the speakers. Also included is a summary of discussions associated with each presentation and group discussions. The outcomes of the workshop, including plans for future research and development in bycatch reduction, are also provided. Appendix 1 contains a copy of the workshop program including the names of speakers.

The workshop program including the title of each presentation, the name and affiliation of each presenter is listed in Appendix 1. The contact details for each of the presenters are provided in Appendix 5. A copy of the PowerPoint slides that were is presented at the workshops is provided in the accompanying CD. The CD should automatically run when placed in a CD drive of a computer. The user should then follow the instructions that are provided in the menus.

In some instances presenters have provided a recommendation for further research or development. These recommendations are for the consideration of the reader and their inclusion does not necessarily imply their support by FRDC, AFMA, AMC, or CSIRO.

This workshop was funded by the Fisheries Research and Development Corporation (FRDC Project No 2006.308) and the Australian Fisheries Management Authority.

List of Acronyms

AFMA	Australian Fisheries Management Authority
AMC	Australian Maritime College
BRD	Bycatch Reduction Device
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEH	Department of Environment and Heritage (now named Department of Environment, Water, Heritage and the Arts)
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
FE	Fisheye BRD
FRDC	Fisheries Research and Development Corporation
JTED	Juvenile and Trash Excluder Devices
MBT	Multi-level beam trawl
NPF	Northern Prawn Fishery
QDPI&F	Queensland Department of Primary Industries and Fisheries
SEAFDEC	Southeast Asian Fisheries Development Centre
SMW	Square Mesh Window BRD
TED	Turtle Excluder Devices

Cairns Workshop Welcome and Objectives

Steve Eayrs

PowerPoint Presentation: Investigating options to improve bycatch reduction in tropical prawn trawl fisheries – a workshop for fishers

Session 1: Drivers for improvement in bycatch reduction

- ***Drivers for improvement in bycatch reduction***

  Wade Whitelaw (Australian Fisheries Management Authority, Box 7051, Canberra Business Centre, Canberra, ACT 2610)

***PowerPoint Presentation*:** Drivers for improvement in bycatch reduction

The following is a brief summary of the presentation made by Wade Whitelaw.

1. Firstly what is bycatch? The official Commonwealth definition from the 'Commonwealth policy on fisheries bycatch' is:

'All material, living or non-living, which is caught while fishing, except for target species'.

This policy goes one step further and deals specifically with aspects of bycatch that are not currently subject to commercial management provisions, namely:

- That part of the catch which is returned to the sea either because it has no commercial value or because regulations preclude it being retained, and
- That part of the catch that does not reach the deck of the fishing vessel but is affected by interactions with the fishing gear. (Commonwealth of Australia, 2000)

A bycatch for one fisher is potentially a byproduct or target species for another.

2. Why reduce bycatch?

There are a number of drivers to reduce bycatch from prawn trawling operations. These are:

- Increased fishing costs through time spent sorting, damage to gear and increased fuel costs.
  - Potentially more 'soft and broken' prawns
- Discarding is wasteful and may pose a threat to marine systems.
  - Discards can include both target and non-target species e.g. small prawns

    - Ecological risk assessments are being carried out on all Commonwealth fisheries. These will help identify species potentially at risk to the effects of trawling.
- Reduction of bycatch species may ultimately affect the ecosystem on which target stocks rely. This is presently mostly unknown.

3. There are a number of regulations that address bycatch – a recent set of guidelines for Commonwealth fisheries, is the 'Guide to addressing bycatch in Commonwealth fisheries', which amongst others states that:

   (a) Appropriate programs are in place to establish the extent of discarding of all species

   (b) Measures will be assessed and implemented to significantly reduce discards of all non-target species in all Commonwealth fisheries with the goal to halve it by 2008.

4. Measures will be taken to reduce to an absolute minimum the interactions with all species listed under the Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act) as threatened, endangered or protected. This includes animals such as turtles, sea snakes and sea horses.

Reference

Commonwealth of Australia, 2000, *Commonwealth Policy on Fisheries Bycatch*, AFFA, Canberra

Session 1 (continued): Case study accounts by fishers and others of BRD design, performance and uptake

- ***Results of NPF BRD industry questionnaire***

  Steve Eayrs (Research Scientist, Gulf of Maine Research Institute, 350 Commercial Street, Portland, ME 04101, USA)

- ***Research and extension of TEDs and BRDs in the QLD trawl fishery since 2001***

  Tony Courtney, Matthew Campbell and Shane Gaddes (Southern Fisheries Centre, 13 Beach Road, Deception Bay, PO Box 76, Deception Bay, QLD 4508)

- ***Design, rigging and operation of the Popeye fish excluder***

  Robert Bennett aka Popeye (Popeye Netmaking, 415 Kamerunga Road, Redlynch, QLD 4870)

- ***The performance of the Popeye fish excluder in the NPF***

  Erik Raudzens (Australian Fisheries Management Authority, Box 7051, Canberra Business Centre, Canberra, ACT 2610)

- ***Design, rigging and performance of the T90 mesh panel***

  Andy Prendergast (Fleet Manager, Austral Fisheries Pty Ltd, PO Box 280, Mt Hawthorn, WA 6915)

- ***Design, rigging and performance of the Shark Shield in the NPF***

  Phil Robson (Fleet Manager, A. Raptis & Sons, PO Box 54
  Morningside, QLD 4170)

Results of NPF BRD industry questionnaire

Steve Eayrs

PowerPoint Presentation: Design and Rigging of BRDs in the NPF by Nick Rawlinson

Introduction

In 2006 a short questionnaire was presented to all NPF skippers. The questionnaire was prepared by Steve Eayrs and hand delivered by AFMA staff during pre-season visits to Darwin, Cairns and Karumba in July. The objective of the questionnaire was to gain an insight into the design, rigging and location of Bycatch Reduction Devices (BRD) currently used in the NPF.

A total of 77 questionnaires were delivered (see Appendix 2 for a copy). Many skippers immediately completed the questionnaire and handed them back to AFMA staff. A small number returned the questionnaire by mail. Whilst all measurements were requested to be recorded in metric units, many skippers reported dimensions in imperial units; this report therefore presents codend and BRD dimensions in both units.

Results

A total of 58 questionnaires were returned, equivalent to a 75% response rate. Thirty six respondents indicated they were using a square-mesh window (64%) and the remainder were using a fisheye (36%). One respondent indicated he/she was using a square-mesh codend. However the measurements that were provided indicated that a square-mesh window was being used. All but one respondent indicated he/she was using a double rigged trawl system; one respondent was using a quad rig trawl system

BRD dimensions

The most commonly cited width of square-mesh window was 8 bars and the most commonly cited length was 12 bars. Respondents reported that the minimum and maximum width of square-mesh window was 4 and 12 bars respectively and the minimum and maximum length was 4 and 18 bars respectively. Sixteen respondents (48% of respondents using this BRD) were using 4 inch mesh size; this was also the maximum cited mesh size, and the smallest mesh size was 2 inches. Fourteen respondents (42% of respondents using this BRD) were using a window measuring 8 bar lengths wide by 12 bar lengths long constructed from 4 inch netting; the remainder were using a smaller window and/or mesh size.

Twenty one respondents indicated they were using a fisheye BRD. Of the respondents using the fisheye, most reported a maximum escape opening width of 250 mm. The smallest reported width was 100 mm and the largest was 400 mm. The most commonly cited fisheye height was 500 mm. The smallest reported height was 50 mm and the largest was 600 mm. Eighteen respondents indicated that they were using a vertical or horizontal brace to support the escape opening. Only 8 (38%) of respondents using this BRD reported fisheye dimensions compliant with BRD specifications; the remainder perhaps incorrectly measured the dimensions of their BRD or are unaware of requirements for this fishery.

Codend design and dimension

The most commonly used codend length was 240 meshes; the smallest was 150 meshes and the largest was 290 meshes. Codends were most commonly constructed from 50 mm mesh material. The smallest reported mesh size was 1 ¼ inches and the largest was 2 ½ inches. The questionnaire did not attempt to link specific codend lengths and mesh size.

The most commonly cited location for the back of the Turtle Excluder Device (TED) escape opening was 200 meshes from the codend drawstrings. This dimension ranged from 110 meshes to 220 meshes. The most commonly cited location for the back of the BRD escape hole was 120 meshes from the drawstrings. Only a small number of skippers located the BRD closer to the drawstrings; the closest reported location was 50 meshes from the drawstrings. The skirt was most commonly attached 50 meshes from the drawstrings although some skippers attached the skirt as close as 35 meshes or as far as 75 meshes from the drawstrings.

Industry comments

Thirty seven respondents answered the question about using a different BRD (Q 8.c. in Appendix 2). Sixteen (60%) of these respondents indicated they would not change the BRD they are currently using, some indicating reasons for their reluctance to change including a low loss of prawns, ease of use and handling, and some reduction in the amount of bycatch. Others indicated they would change if something better came along. The majority of respondents suggesting they would change, indicated a preference for the fisheye – the questionnaire did not ask why these respondents had not moved towards using their preferred BRD – and several respondents indicated a preference towards using a square-mesh window or panel.

Seventeen respondents provided suggestions for further reducing bycatch. Nine (53%) indicated that reducing fishing time during dawn and dusk periods should be considered, but that only on an area-specific basis and that effort-credits will also need to be considered. Most of the remaining respondents indicated that they did not have any comments about improving bycatch reduction devices or reducing bycatch.

Conclusion and recommendations

The two BRDs being used in the NPF are the square-mesh window and the fisheye. With few exceptions these BRDs are typically located at or near the maximum permissible distance from the codend, which under current AFMA regulations is no further forward than 120 meshes of the codend drawstring. The dimensions given for the size of a fisheye suggest a misinterpretation of the measurements required for the height and width of the device (should be wider than higher, current regulations require a device measuring no less than 350mm wide x 150mm high). Many skippers seem reasonably happy with their BRD, understandably because they can be located in a position that is perceived to minimise prawn loss. There is also evidence of a preparedness to use improved BRD designs when and if they are developed.

A wide range of codend mesh sizes are currently being used in the fishery – there is no minimum mesh size regulation for the fishery. Given a range of permissible mesh sizes, this means that the distance from the drawstrings to the BRD may vary considerably from boat to boat. This variability also applies to the skirt attachment position on the codend. As BRD distance from the codend is likely to be a major variable influencing bycatch reduction. Consideration should be given to a minimum codend mesh regulation. This will also ensure that the location of a BRD and skirt meets minimum requirements.

The most disturbing finding from this questionnaire is that the majority of skippers are not using BRDS that are compliant with approved specifications. This could be because skippers either did not provide accurate BRD dimensions in response to the questionnaire, do not know how to correctly measure a BRD, or are using a BRD that does not comply with approved specifications (see Appendix 3 for details). Based on the dimensions reported in this questionnaire, it seems that confusion exists over the measurement of these BRDs, particularly the width and height of the fisheye. A recommendation is that training and literature be provided to skippers in 2007 during the pre-season to ensure that all are aware of the approved dimensions and location of BRDs. This will also aid consistency in measurement and use of metric dimensions.

Workshop questions/comments:

Question. Why can't we have different BRD specifications for each fishery within the NPF? We don't really target tiger prawns in the banana prawn season.
Response. This is a possibility that needs to be explored in the near future.

Comment. We need to have different requirements for each fishery because bycatch compositions changes between day and night.

Comment. Similar BRDs (to those used in the NPF) are used in the east coast, and we recently allowed two more designs to be used.

Question. If the BRD needs to be located no more than 120 meshes from the drawstrings, and skippers are using different mesh sizes, won't that mean the actual distance between BRD and drawstrings will vary for a given mesh size?
Response. Yes it will.

Question. The fisheye is designed to allow bigger, faster swimming fish escape from the codend, but what about the smaller fish?
Response. The square-mesh codend is the only device currently approved for the NPF dedicated to the exclusion of small fish from the codend.

Research and extension on TEDs and BRDs in the Queensland trawl fishery since 2001

Tony Courtney, Matthew Campbell and Shane Gaddes

PowerPoint Presentation: Research and extension on trawl bycatch reduction in Queensland

The following is a brief summary of research and extension on trawl bycatch reduction in the Queensland trawl fishery in the period 2001-2006.

The Problem

Queensland has the largest (by number of licensed vessels) prawn trawl fleet in Australia. The total tonnage of bycatch produced by the fishery is unknown, but likely to exceed 25 000 tonnes annually. Recent research has identified over 1 300 species or taxa in the bycatch, but the total number of species is likely to exceed this. Impacts from trawling are particularly contentious as about 70% of the catch and effort in the fishery occur in the Great Barrier Reef Marine Park.

TEDs and BRDs were made mandatory in the Queensland otter trawl fishery between 2000 and 2002. TEDs were introduced to reduce turtle catches but they also result in significant reductions in other bycatch, particularly sharks, rays and large sponges. BRDs were introduced to reduce other bycatch, particularly small finfish which comprise the bulk of the bycatch. The Queensland trawl fishery Management Plan specifies a 40% bycatch reduction Review Event, but measuring total bycatch production in the fishery is difficult, if not impossible, and therefore it remains unknown whether this targeted reduction has been achieved.

Currently, there are seven BRDs listed in the Plan that fishers can choose from and every otter trawl net must have both a TED and a BRD installed. Funding provided by the Fisheries Research and Development Corporation (FRDC) and the Queensland Department of Primary Industries and Fisheries (QDPI&F) has been used to measure the effects of different combinations of TEDs and BRDs in the major Queensland trawl sectors.

Assessing TEDs and BRDs under controlled research charters

A number of dedicated charters were designed and carried out in the major trawl fishery sectors to quantify the effects of TEDs and BRDs. Each charter took 8-10 nights and measured the effects on prawn, scallop and bycatch rates. BRDs that were examined were the ‘radial escape section’, ‘square mesh codend’, ‘fisheye’, ‘V cut’ and ‘Popeye Fishbox’.

The most promising results were obtained from a charter carried out in the scallop fishery where bycatch was reduced by an average of 77% by using nets with both TEDs and square mesh codend BRDs, compared to standard nets. Importantly, this reduction was achieved with no reduction in the catch rate of legal size scallops, and with 63% fewer undersize scallops being caught. If all scallop fishers used these devices, it would equate to a reduction in bycatch of over 10 000 tonnes annually, compared to pre-2000 levels (i.e., before TEDs and BRDs were introduced).

Another charter undertaken in the deep water eastern king prawn fishery showed that bycatch rates could be reduced by an average of 29% by using a square mesh codend BRD with a TED, with no loss of product, compared to a standard net. A further charter undertaken between Cairns and Cooktown on tiger/endeavour prawn fishing grounds demonstrated that the Popeye Fishbox reduced bycatch rates by 29%, with no effect on prawn catch rates.

Assessing the TEDs and BRDs that are being used by trawler operators

In addition to measuring the effects of TEDs and BRDs during controlled research charters, measurements from over 700 trawl shots were also obtained on trawlers during their normal fishing operations. These measurements are referred to as "opportunistic" measures and are not as reliable as those from the research charters, because there is little experimental control while working onboard commercial vessels during their normal operations. Nevertheless, the opportunistic measures indicate that, across the major prawn trawl sectors (north Queensland tiger/endeavour prawn, and shallow- and deep-water eastern king prawns sectors) the combined effects of TEDs and BRDs have lowered catch rates of bycatch by an average of 8%, compared to standard nets. In general, this reduction was low compared with the research charters. None of the devices being used by industry had any effect on prawn catch rates. No significant reductions in bycatch rates were detected for the TEDs and BRDs being used by fishermen in the shallow- and deep-water eastern king prawn sectors. In the saucer scallop fishery the TEDs and BRDs being used by fishermen resulted in an average reduction in bycatch catch rates by 68%. This large reduction was due mainly to the TEDs excluding large sponges which dominate the bycatch weight in the sector.

Recent research on sea snake bycatch

Recent research in Queensland has also focused on the impact of trawling on sea snakes, which are protected species in Australia under Schedule 1 of the National Parks and Wildlife Regulations 1994. The Department of Environment and Heritage (DEH) recommended that the Queensland Government undertake research designed to reduce the impact of trawling on sea snakes, as part of the DEH strategic assessment of the fishery. This research has focused on estimating the number of snakes being caught, the number that die annually from trawling, and assessing the effects of BRDs on snake catch rates.

The QDPI&F research vessel *Gwendoline May* was chartered to test different BRDs on sea snake catch rates in prawn trawl grounds between Cairns and Cape Upstart in May-June 2006. A total of 83 two nautical mile trawls were undertaken over 8 nights towing four nets (i.e., quad gear). Four different codend types were compared: 1) standard codend (i.e., no BRD), 2) fisheye BRD, 3) square mesh panel BRD and 4) square mesh codend. All of the nets were fitted with TEDs. Measurements of the number of snakes, bycatch and prawn catch were obtained from every net after every trawl.

A total of 70 snakes were caught in the codends from 35 of the 83 trawls. The fisheye BRD had the lowest catch rate of snakes at 0.286 snakes per trawl compared to the standard net codend (with no BRD) with a catch rate of 0.771 snakes per trawl. The square mesh panel had a catch rate of 0.629 snakes per trawl while the square mesh codend had a catch rate of 0.314 snakes per trawl.

The fisheye BRD also produced the lowest bycatch rate of 9.996 kg per trawl – a 43% reduction compared to the standard codend catch rate of 17.577 kg per trawl. The square mesh codend produced the second lowest mean bycatch rate of 10.616 kg per trawl, followed by the square mesh panel with a mean of 11.491 kg per trawl.

The effects of the BRDs on prawn catch rates are preliminary and based on weights obtained from the back deck immediately after the catches were landed and sorted. They include all size classes and all prawn species, including some small non-marketed species. The fisheye BRD produced the highest mean prawn catch rate of 1.605 kg prawns per trawl, followed by the standard codend with a catch rate of 1.378 kg prawns per trawl. The square mesh codend produced the lowest catch rate of 1.124 prawns per trawl.

The results from the charter indicate that the fisheye BRD is the most effective of the three devices trialled for reducing sea snake catches. The fisheye also had the largest bycatch reduction and the highest prawn catch rate. It is important to note that the fisheye and square mesh panel BRDs were located at 50 meshes from the drawstring, which is probably why the fisheye had such encouraging results (most fishers install BRDs 70-90 meshes forward of the drawstring, which appears to lower their effectiveness).

Extension and uptake of effective BRDs in the Queensland trawl fishery

In 2005 the QDPI&F and FRDC funded an extension project, in collaboration with SeaNet extension services, aimed at informing trawler operators about the design, installation and benefits of square mesh codends as a means of reducing bycatch and improving the selectivity of prawns and scallops in the Queensland trawl fishery.

To encourage fishermen to use square mesh codend BRDs, a "gear library" was established whereby square mesh codends were loaned out to fishermen free of charge. Thus far, 36 square mesh codends have been loaned out to Queensland fishermen in the deep water eastern king prawn, scallop and black tiger brood stock fisheries. Feedback from fishermen has been very positive, with about 75% of those fishers who were lent the device continuing to use them.

The extension project is also producing a DVD that shows how to construct square mesh codends, including a new innovative, simple and cheap method of construction, how to install the codends, research results from at sea trials and underwater video footage of the devices. The DVD will be sent to every prawn trawler operator in Queensland. The project is due to be completed in December 2006.

Editor's note: the Queensland's East Coast Otter Trawl (ECOT) fishery TED and BRD approved devices and specifications as prescribed in the Fisheries (East Coast Trawl) Management Plan 1999 are detailed in Appendix 4.

Workshop questions/comment:

Question. Why was the fisheye located 50 meshes from the drawstrings?

Response. No reason really, just moving it around. In NSW a square-mesh window was tested at 35 meshes from the drawstrings.

Comment. I used a second codend placed over the main codend to see what escaped. Had a 65% reduction in bycatch. This was back in the 1990's?

Comment. In the US there have been preliminary tests of magnets to deter sharks from the net with inconclusive results.

<u>The performance of the Popeye fish excluder in the NPF</u>

Erik Raudzens

PowerPoint Presentation: At sea testing of Popeye's fishbox in the NPF

Introduction

During the final three weeks of the 2006 NPF tiger prawn season the Popeye fishbox was assessed onboard the *FV Adelaide Pearl.* This report presents preliminary results based on these sea trials.

Methods

The Popeye fishbox was tested in two locations, 70 meshes (14.58ft) from the codend draw strings for 54 trawl shots and 100 meshes (20.83ft) from the drawstrings for a further 28 trawl shots. All trawling was conducted during night hours. Catch data was collected using a double rig trawl system under normal commercial fishing operations. Each net was fitted with a TED. One net contained the Popeye fishbox and the other net was not fitted with a BRD.

All small bycatch (including sharks and rays) from both nets was separated and weighed in lug baskets. All prawn catch was weighed separately to assess prawn escapement. The BRD was swapped from starboard to port side nets twice during the trial to account for potential differences in performance between nets.

Results

The following preliminary results are reported, with detailed analyses to be presented in a final report completed in January 2007.

With the Popeye fishbox located **70** meshes from the codend drawstring the net caught:

- **52.1%** less small bycatch;
- no significant difference in prawn catch;
- **85.7%** fewer sea snakes; and,
- **35%** fewer small sharks and rays than the standard net.

With the Popeye fishbox located **100** meshes from the codend drawstring the net caught:

- **28.7%** less small bycatch and
- no significant difference in prawn catch.
- Causes for a decreased reduction in the capture of small bycatch at 100 meshes are still being investigated.

Twilight versus night shots

- Twilight shots for nets with and without BRDs had a higher amount of small bycatch (approx. 50% higher) and smaller prawn catches (approx. 50% lower).

With the Popeye fishbox located 70 meshes from the codend drawstring, catch data from an additional 6 shots was recorded during shots for banana prawns. During these shots there was a 17.6% reduction in prawn catch and a 50.2% reduction in small bycatch. The reduction in prawn catch was probably due to prawns exiting through the escape opening of the device during haul back. Mitigation of this is being investigated.

Conclusions

- The Popeye fishbox substantially reduced the catch of small bycatch.
- Further analyses are required to determine whether the distance from the codend is crucial in reducing the amount of small bycatch.
- The 17.6% reduction in prawn catch when targeting banana prawns may suggest that the BRD is best applied during the tiger prawn season only, although current data is limited.

Acknowledgements: Thanks go to the skipper and crew of the *FV Adelaide Pearl* and A Raptis & Sons Pty Ltd for their efforts and the opportunity to trial the Popeye fishbox. Funding for the project was provided by the Natural Heritage Trust.

Workshop questions/comment:

Question. Have glow sticks been tried attached to the fishbox to further improve escape rates?

Response. No.

Comment. Flume tank testing would help to detect the eddies around the fishbox and how this could influence the behaviour for those species that are not excluded by the device.

Comment. On the east coast the trawl codend is smaller than the NPF, so it would be hard to put the fishbox in without losing prawns.

Response. A smaller version could perhaps be constructed to better suit the smaller codends.

Comment. I am concerned about the rigid frame of the fishbox and the large escape opening.

Response. This device is only new, and no doubt further modification can be made to improve the design of the device.

Comment. The fishbox will now be discussed by the NORMAC bycatch committee for approval as a device for use in the NPF.

Design, rigging and operation of the Popeye fish excluder (fishbox)

Robert Bennett aka 'Popeye'

A verbal presentation and demonstration of the Popeye fishbox was made by Popeye with the device attached to a full size prawn trawl.

Design, rigging and operation of the Yarrow fisheye.

Jim Yarrow

Jim Yarrow was unfortunately unavailable during the workshop. Details of the Yarrow Fisheye were discussed in the presentation by Tony Courtney.

Design, rigging and performance of the T90 codend

Andy Prendergast (Austral Fisheries Pty Ltd)

A verbal presentation was made briefly describing tests of a T90 panel of netting. T90 is the term given to diamond-mesh netting that is turned 90 degrees. In this way the meshes of the netting remain more-open than traditional diamond meshes, hence potentially allowing more small fish to escape.

Based only on observations, it appeared that by inserting a 50 mesh section of T90 forward of the TED that fast swimming fish (Yellow Tail) were able to swim against the reduced pressure in that section of the net. It would appear that T90 allows fish to orientate themselves toward the headrope, catch their fish breathe and if an effective BRD were to be installed in this T90 section, it may increase the BRD's effectiveness.

Comment. The AMC and SeaNet have recently been testing this device in a fish trawl in Tasmanian waters with encouraging results.

Comment. Not many people in the room had heard of the benefits of simply turning the mesh 90 degrees to the normal orientation to decrease water pressure.

Design, rigging and performance of the shark shield

Phil Robson (A Raptis & Sons Pty Ltd)

Introduction

The FV *Australian Pearl* tested the Shark Shield Mariner during 2004 and 2005 NPF tiger prawn season. The FV *Australian Pearl* is a 22 m prawn trawler and was using a twin trawl configuration consisting of No. 9 Bison Boards and 11 fathom Florida Flyer trawl nets.

The Shark Shield is a small unit consisting of an electronics module and battery pack to which is attached a 4 m antenna. The antenna houses two electrodes, which when immersed in water, projects an electrical field that supposedly repels sharks and rays.

2004 tests

Initially the Shark Shield was to be attached to a codend of one trawl when the boat was fishing in Joseph Bonaparte Gulf (JBG). In this location of the fishery sharks are a major problem as they bite holes in the codend during haul-back of the trawl. Unfortunately the boat did not get to JBG and while the Shark Shield was tested in the Gulf of Carpentaria with the same purpose in mind, the shark problem was not as bad. During this time the Shark Shield did not provide any observed benefit as shark numbers were low.

The Shark Shield was also tested on the headline of the trawl (near the trawl board) in an attempt to deter large sharks and rays from entering the trawl. Compared to the other trawl with no Shark Shield attached, there seemed to be a reduction in the numbers of sharks and rays caught.

2005 tests

The shark shield was attached to the headline of the trawl, approximately 3 m from the wingend with the antenna loosely bound along the headline. This trial indicated a large decrease in the number of sharks & rays caught in this trawl compared to the other.

Due to the haphazard nature of the tests and infrequent shark and ray encounter rate, few data were collected. Observations of sharks and rays caught was also restricted to those individuals small enough to pass though the TED or on rare occasions large individuals that remained in the net ahead of the TED (presumably having had had insufficient time to be excluded by the TED).

Conclusion

The concept of Shark Shield is good, but the main problems faced were:

1. Access to the Shark Shield for maintenance (ie. reattachment to the trawl, battery replacement). With the device attached to the trawl, access is only possible by

climbing out on the booms - near impossible in rough weather – or hauling the gear onboard; and,

2. The short battery life. The batteries typically lasted only for around 4 hours, which would necessitate their replacement several times during a nights fishing.

It is only because of these two problems that the use of Shark Shield has not been continued. Additional issues for consideration include potential risk of damage to the Shark Shield when catches are large and hauled onboard. Testing of this device was difficult during the fishing season as available fishing time was limited. Out-of-season trials should be considered/allowed so that the focus can be on the trials and not catching prawns.

Comment. There is some concern that the Shark Shield can cause shark mortality several days after the shark has encountered the electrical field. There is presently uncertainty with respect to the impact on sharks once they have swum away, and we need to be wary of this potential impact. Further research is required into the effect of the Shark Shield on sharks.

Editors note: Further details of the shark shield, including product description, function, uses, testimonials, video and photographic library, can be found at www.sharkshield.com

Session 2: International progress in bycatch reduction and innovative options to reduce bycatch in tropical prawn fisheries

- ***Bycatch reduction research in North American and European fisheries: a review***
  Chris Glass (Director of Northeast Consortium, Institute for the Study of Earth, Oceans and Space, University of New Hampshire, 142, Morse Hall, 39 College Road, Durham 03824, USA)

- ***Bycatch reduction research in the Gulf of Mexico***
  Daniel Foster (US National Marine Fisheries Service, Southeast Fisheries Science Centre, 75 Virginia Beach Drive, Miami, FL 33149, USA)

- ***Application of the Juvenile and Trash Excluder Device in S. E. Asia***
  Bundit Chokesanguan (Southeast Asian Fisheries Development Center, P.O. Box 1046, Kasetsart Post Office, Chatuchak, Bangkok, 10903, Thailand)

- ***Application of electricity to reduce bycatch in shrimp trawl fisheries***
  Daniel Foster (US National Marine Fisheries Service, Southeast Fisheries Science Centre, 75 Virginia Beach Drive, Miami, FL 33149, USA)

- ***Application of light stimuli to reduce bycatch in prawn trawl fisheries*** David Maynard (Australian Maritime College, Department of Fisheries & Marine Environment, PO Box 21, Beaconsfield, Tas 7270)

- ***Status of knowledge of fish behaviour in demersal trawl fisheries***
  Chris Glass (Director of Northeast Consortium, Institute for the Study of Earth, Oceans and Space, University of New Hampshire, 142, Morse Hall, 39 College Road, Durham 03824, USA)

Fish Behaviour, Bycatch Reduction and Species Separation

Chris Glass

Summary

Clear differences in reaction behaviours have been observed between different species of fish and also between fish and invertebrates and these have led to the separation of many species of fish and invertebrates in fishing gears. The same observations have led to extensive basic studies of the physiological limits that determine the ability of each species to react to a stimulus. A summary of publications on the thresholds and limits to behavioural response is presented. Recent examples of the applications of separation techniques involving differences in behaviour are reviewed. It is clear from these that where research effort has been applied there is a rapid development of existing ideas to meet the needs of particular fishery problems. It is noticeable how successful the developments have been when the research effort has been directed by effective teams to investigate and solve their local problems. This is particularly clear with the evolution of systems to separate shrimp or prawns from juvenile fish. One approach, and apparently the most successful, aims to exclude all active swimming fish; the other tries (less effectively) to compromise and retain the larger fish as part of the marketable catch. There has been much less research published on techniques to separate fish species yet there are many groups of fish species with potential for separation.

Introduction

Observations of species differences in reaction patterns of behaviour when stimulated by towed gears have been made over the past 35 years by many different methods, although the use of towed observation vehicles like the Aberdeen divers vehicle and remote controlled towed vehicles carrying TV and flash cameras have been the main source of observations since 1975 (Wardle and Hall, 1994). The diving observations by a large team at the Aberdeen Marine Laboratory between 1965 and 1970 of the Scottish seine net reported by Hemmings (1973) were the first to show clear examples of differences in the reaction behaviour of fish species. Flat fish being herded close to the sea bed by the ropes, exhausted in the mouth of the net and rising only enough to clear the ground rope when falling back. Haddock stacking high in the narrowing net mouth and surplus fish overflowing the headline as it closed and saithe diving under the raised ground rope when droppers were used. These studies were followed by many more diving and remote controlled towed vehicle (RCTV) observations from 1975 to the present and form a foundation for many of the recent practical developments (Wardle 1983, 1985, 1993). The observations, such as those above, have led to practical experiments where it was shown how fish species could be sent to different cod-ends depending on their reaction behaviour in the mouth of the trawl net (Main and Sangster, 1982a).

Fish behaviour was of course made use of in the evolution of species specific gears. Danish seines for flat fish had a low headline and great care was taken that the herding ropes and ground line pressed hard on the sea bed. Prawn trawls were made wide to sweep the sea bed, but with low headlines to leave out those fish that rise. Beam trawls towed fast catch mainly flats and other ground hugging species. Herring and haddock trawls need high headlines and even kites rigged above the net to drive the naturally rising fish down. Some of the separation issues are due to the economic need for the fishermen to catch more than just the target species so he used a high headline net for prawns that also caught the haddock. He then needs a system to let out the increased numbers of juveniles trapped and so on.

The issue of bycatch of both fish and turtles in the northern Gulf of Mexico penaeid shrimp fishery, where 70% of the discarded fish are important juveniles to the demersal fishery, has generated a long series of research projects summarised by Watson (1988). These included development of diving observations and experimental work and culminated in a status report in which some 51 conceptual designs for bycatch reduction have been evaluated (Watson *et al*. 1993). The objectives were to evaluate existing bycatch reduction techniques; collect data on the behaviour of fish and shrimp when encountering shrimp trawls, etc.; develop and evaluate new bycatch reduction techniques. It was found that reduction for individual fish species varied according to the designs. In some designs they achieved 50% reductions of fish bycatch while retaining 90% of the shrimp. Both in Norway and Australia major research efforts have been devoted to developing new approaches to separate species in trawl fisheries. Since publication of the Bergen ICES symposium on Fish Behaviour in relation to fishing operations in 1992 (Wardle and Hollingworth, 1993), which discussed a number of papers on both species and size separation, there have been many new developments and these publications lead the reader into various practical aspects of species separation and these are reviewed and their findings in this context briefly outlined below.

Species Differences in Reaction Behaviours and Their Limits

General principles

Observation of the differences in the behaviours observed in nets has led to basic research that looks into the reasons why. Most behaviour can be explained as a response to a stimulus where the response is limited by the abilities of the fish. It is important to realise that these responses have evolved within the evolution of each species of fish as part of its general biology in relation to its adaptations to its natural environment (see Ferno, 1992). The ability of the fish to respond is limited by performance thresholds that are in turn set by the physiological adaptations of the particular species. In poikilotherms, such as the teleosts and the invertebrates caught in commercial fisheries, change in sea temperature can raise or lower such thresholds. Some species can compensate for such changes; other do not.

Swimming ability

A simple example of species separation will occur in any trawl when similar sized pelagic and demersal fish are herded together in the mouth of the trawl. For example, a group of mackerel (*Scomber scombris*) might be seen out-swimming a group of saithe (*Pollachius virens*) of the same size which are being exhausted and dropping back to the cod-end. The saithe are caught and the mackerel swim away and the speed and size relationships are explained by studies of endurance swimming performance such as He and Wardle (1988). A survey of thresholds for swimming ability are published in a review by Videler and Wardle (1991).

Light and sound

Behavioural thresholds for some species for light level reactions have been demonstrated (Glass *et al*. 1986, Glass and Wardle, 1989, Cui *et al*., 1990, and Walsh and Hickey 1993). The role of sound in towed fishing gears has been discussed in Wardle (1993) and more recently the sensitivity of fish to infra sound seems to be species specific (Enger and Karlsen, 1993). There may be scope for careful application of sound. For example exploiting the very different hearing abilities of mackerel and herring but these do not yet appear to have been found in practice unless they occur unknowingly in purse seine or drift net fisheries. Local sound generated by humming wires attached to grids has been tried by Watson *et al*.(1993) to help deter fish from passing through shrimp grids.

A Review of Recent Published Findings

Shrimp, prawns and juvenile fish separation

A major worldwide problem is the capture of large quantities of juvenile fish in trawls constructed with small mesh cod-ends which are needed in order to capture the smaller shrimp and prawns. Many of the recently published studies are biased towards the assessment and development of methods to deal with shrimp fish separation. Some of these studies in experimenting with the various gear modifications have incidentally noticed changes in the range of fish species caught indicating some effects are species specific. The bycatch of a turbid water penaeid prawn fishery off South Africa showed 109 mainly juvenile species of teleost fish with a few species only dominating in weight and number. Slow towing speed was significant in avoiding capture of large pelagic fish species. A detailed study showed that season (as cool and warm samples) and depth (as shallow and deep samples) had significant influence on availability of some teleost species, but all were present in significant quantities throughout the year (Fennessy *et al*., 1994).

A detailed study looked at the species caught in shrimp trawls off Greenland. It shows the importance of the conflict between capture of shrimp, in this case *Pandalus borealis*, and the damage to juvenile commercial fish species growing up in the same area, such as redfish, Greenland halibut cod and 40 other species sampled in the 40 mm shrimp nets (Pedersen and Kanneworff, 1995).

A number of groups are tackling related problems in Australian shrimp fisheries and productive experimental work is being reported. Andrew *et al*. (1991) compared the catch composition of a variety of rigs of one size of trawl net. These ranged from single trawl with no sweeps to trawl with long sweeps and triple trawl rigs where three trawls are towed side by side with no sweeps. The experiments were carried out at around 30-40 m at night in the summer. The authors show that the herded reactive swimmers such as the larger finfish (red spot whiting, *Sillago bassensis*, and sand flathead, *Platycephalus caeruleopunctatus*) are increased relative to the prawns (*Penaeus plebejus* and *esculentus*) and shovelnose lobsters (*Ibacus* spp.) when long sweeps are used on the single trawl, whereas the triple trawl which is now used by many of the Australian fishermen catches more of the red spot whiting, but not sand flathead.

Light level was not measured during these tests, but by computing solar constants for these dates, at 40 metres depth, for 30° south, on 5 December through 12 December, it can be estimated that light level does not go below minus 4 Log lux and there was a moon raising this light level during the evening of the 5th but all night on the 12th (Kim, pers. comm.). The positive effect of sweep herding on the large finfish is discussed by Andrew *et al*. (1991) in relation to the findings of the few previously published studies made when the Vigneron Dahl gear was first introduced in the 1920s. The non reaction of the invertebrate species to the sweeps is discussed in relation to published work on *Nephrops* reactions. The authors point out that species specific differences in vulnerability to capture by trawls using long sweeps have clear implications in fisheries management confirming similar work such as that reported by Engas and West (1987), Engas and Godo (1989) and Mahon and Smith (1989). They conclude that long sweeps do effect the species composition of the trawl in this fishery and this feature could confidently be regulated to reduce fish catches.

A major problem in the Australian trawl fishery for prawn and shrimp species, as in many parts of the world, is the large part of the catch is made up of juvenile fish trapped by the small meshes needed to trap prawns (Robins-Troeger, 1994). In the Australian prawn fisheries these fish can weigh anything from six to 15 times the weight of the prawn catch (Robins-Troeger *et al*. 1995). Robins-Troeger (1994) describes how the Morrison soft turtle excluder, made from 150 mm monofilament mesh, when fitted eliminated catch of turtles and increased loss of unwanted juveniles of commercial species by 30% there were problems in losing prawns and marketable crabs.

Andrew et al. (1993) showed how in an offshore fishery the fitting of the Morrison soft TED did not reduce the prawn or invertebrate catch, but did reduce the discards by 32%. These contained 15-25 species of non-commercial benthic teleost fish and invertebrates, but also significant juveniles of commercial species as well. The very variable and conflicting findings of other studies are reviewed and discussed in Robins-Troeger (1994) and lead to the conclusion that these nets vary in their performance in different fisheries and conditions. The same research groups in Australia report the development of a more effective AusTED which when tested in a variety of fishing conditions did not lose any of the valuable prawn catch, but did reduce the turtle and juvenile fish catches. The device is described by Mounsey et al. (1995) and results from the test are in Robins-Troeger *et al*. (1995). More recent work by the Australians has looked at the use of the Nordmore grid (see below, Isaksen *et al*., 1992) in these fish shrimp fisheries and where the bycatch is not of value to the fishermen this system is now used in preference to the TED types mentioned above (Broadhurst, pers. comm., 1995).

In a fishery where the adult fish are needed to supplement the catch the difference in reactivity of Australian prawns and fish is made use of in an application developed by Broadhurst and Kennelly (1994).

Prawns (three species were studied) behaved quite differently from finfish in this study where 54% of the fish (mulloway) left the net via a square mesh panel ahead of the cod-end, whereas the prawns did not show any loss. Prawns were lost if the whole cod-end was square mesh. The author reviews observations of behaviour and concludes that the reactive swimming responses of fish cause these to leave in a size selective fashion, whereas the non-reactive behaviour of prawns lets these drift past the square mesh window to the cod-end. When square meshes are present in the rear most part of the cod-end, the prawns leak out through the open meshes during the haul or haul back. This finding was similar to that of Briggs (1992) where RCTV observations showed how the invertebrate *Nephrops* scuttle along the base of the trawl, whereas many of the small undersize whiting find their way up and through the top square mesh panel of this net. Comparative fishing with twin trawls showed the system to conserve the *Nephrops* within the net while losing most of the juvenile whiting.

The first studies in separation were those showing how Nephrops could be separated from finfish simply by introducing a horizontal separating panel 70 cm above the ground line in a high opening Boris dual purpose fish/prawn trawl (Main and Sangster, 1982b). In this case diving observations had concluded that Nephrops never rose more than 70 cm from the sea bed, whereas many of the small and large fish species tended to rise up over the ground line and the separating panel if this was staggered back from the ground line.

Use of net colour

It is interesting that the square mesh panel used by Briggs (1992; Fig. 7) is white, whereas the net is darker. The author describes the whiting trying to pass through the diamond meshes just ahead of the white panel and then emerging through the first lines of open square white meshes. However there is an indication that lights were used during the camera observations (p147) and presence of artificial light would modify the net colour pattern as seen by the fish from the inside. In natural light the behaviour might be different.

Both the last approaches involve retention of the large fish by the square mesh panels. The problem here has always been to make all the active fish attempt to leave via the selection panel whatever their size so that all are tested for size. The natural reaction of fish to panels is that they keep clear of them and pass along the central space. However recent findings investigating this behaviour have shown that the natural behaviour can be switched to trying to pass outside the cod-end tube if this is made to appear like an approaching predatory mouth to the fish funneled towards it from the net mouth. The illusion can be built into the net as a defined change in contrast of the net material. As mentioned above, this has been used unconsciously in a number of studies due to the random nature of the colour of available panels of different mesh sizes. The black mouth or black tunnel experiments and application in a cod-end are reported by Glass *et al*. (1995) and Glass and Wardle (1995) and have implications for both species and size selection devices of all sorts.

Total exclusion of swimming fish

A different approach for the separation of shrimp was taken in developments in Norway and is described by Isaksen *et al*. (1992). Here the inability of the shrimp to react and swim compared to the dynamic responses and avoidance behaviour of even the smallest teleost fish was observed by Karlsen (1976) when a rising net panel was angled upwards across the funnel of the shrimp trawl. The shrimp pass through the panel to the cod-end, whereas the majority of fish rise and pass out through an aperture at the top of the net. Following this finding fishermen in the Norwegian fishery were obliged to fit the panel whenever more than three cod or haddock were caught with each 10 kg of shrimp. One of the problems here was that certain sizes of red fish (*Sebastes marinus*) juveniles were meshed bursting the panel. In 1989 the Nordmore grid was developed and has now replaced this net panel, solving the problem with red fish. Many fishermen volunteered to use the grid even when not required by the law as they had less sorting of the catch. The results with this gear have been so convincing that there is now the compulsory use of the grid in this fishery (Isaksen *et al*., 1992).

Separation of fish species

There have also been reports on experiments looking at specific effects on the fish species by trawls gill nets and long lines. The subtle differences in capture by towed sampling gears were indicated by Engas and Godo (1989) when one of the species was being lost under the bobbin rig altering the ratios of species sampled. Engas and Soldal (1992) showed the numbers of small (L<30 cm) haddock and cod were greater during day hauls compared with night hauls, but the number of haddock were consistently greater when compared with cod in hauls made in daytime compared with hauls at night leading to a shift in the ratio of cod/haddock day and night. They were using a Campelen 1800 trawl with a 4 m headline height in autumn in the Barents Sea at 270-340 m deep. The same trend was not found in winter hauls, although the catch rates were lower. The authors concluded that such apparent differences in capture rate probably reflect small differences in the reaction behaviours of the species, for example at different light levels or temperatures. Interpreting these catch results as indices for 30 cm cod and haddock in October 1989, they suggested the daytime samples gave 3.3 and 21.5 times the night time value. Species specific reaction behaviour can lead to some species being easily sampled by a particular trawl rig, whereas other species seen by other techniques are absent from the trawl catch. A series of related papers on this issue are introduced and discussed by Engas (1991).

Adams *et al*. (1995) compared a survey made using TV camera transets with trawl survey samples from the same deep water grounds and they illustrate big differences in the assessment of species and their abundance. A similar approach comparing observation from a manned submersible and the trawl catch was reported by Kreiger (1993) where densities of Pacific ocean perch (*Sebastes alutus*) were estimated by a 400 mesh Eastern trawl with 14 m wing tip opening and <2 m headline height, with sweeps and board spread of 28 m and found to be about twice the numbers estimated by observation from the submersible. The difference was attributed by the authors to the herding of this species by the trawl sweeps. Densities of other species approached unity with submersible estimates indicating less herding of these species by the sweeps.

Small differences between behaviour of fish species result in numerous artisanal fishing devices being used to catch the fish from different niches of a complex fish community. In a multispecies fishery such as that described by Gobert (1994) in Martinique, out of 186 species identified in the area, 124 are identified in fishermen's catches. It is suggested that the diversity of methods of fishing used allows the fishermen to target any of the species and sizes of this demersal resource just by using the appropriate variations in gear which may involve variations in size, shape, mesh size, soak duration, fishing depths and baits, etc. This implies that single species or groups of species can be selected by application of an appropriate technique. Angling is well known for its specific aimed nature with specific tackle evolved throughout the world for specific fishing aims. A comprehensive review of species selectivity of long lining by Lokkeborg and Bjordal (1992) indicates that species can be selected by strategic fishing at specific depths or in layers of the right temperature; that baits are related to the foraging habits and preferences can be species specific; and that hook design can make the gear more appropriate for a particular species.

Although it might be concluded from some experiments that catch of drift nets would be light level dependent (Fujimori *et al*., 1990), Yatsu *et al*. (1995) conclude that diel activity patterns are more important in determining the catch rates for different species. However, one must admit that visibility of the net (Cui *et al*., 1991), animal activity (Collette and Talbot, 1972), and their distribution (Clark and Levi, 1988) are all controlled by light level and each affects the behaviour of the fish and so capture by static gears like drift nets with potentially complex results.

Some very similar species such a herring and sprat are found in closely mixed schools according to Torstensen and Gjosaeter (1995). In this case it seems to be due to overlap in need for the same size of food organisms, calanoid copepods. When caught by single small beach seine hauls, sprat can occur mixed with herring in any proportion when both species are between sizes 6 to 12 cm (Torstensen and Gjosaeter, 1995; Fig. 8). As the herring grow larger than the sprat quite rapidly their food changes and they are no longer found together.

Gill nets are highly selective gears where the use of appropriate mesh size avoids capture of the juveniles of the target species (Hamley, 1975). A careful study by Petrakis and Stergiou (1995) shows that there are also potentials for selecting single species where the net mesh matches the target and there is no other dominant species of the same size present.

Problems arise within large commercial fisheries where quotas impose pressures on fishermen to be more precise in their fishing techniques. In pelagic trawling, mackerel, herring, and horse mackerel can be found apparently in mixed schools of commercially sized fish. A recent study supported by the EU reports experiments both in aquarium and at sea where a search for differences between these species might be used to separate them in a pelagic trawl. Mackerel sink in sea water and must continue to swim to maintain depth; horse mackerel are usually neutrally buoyant; and herring may be neutral at the surface, but become heavy at depth. These three species will form mixed schools in an aquarium tank and will separate out by gentle chivying of the fish. In fast moving gears their swimming performance characteristics are very similar at the same size. In swimming experiments where they are made to react to netting panels, funnels, and barriers, all three species show identical responses. There is some indication at sea that if the species are different in size they will show different responses to the presence of selective grids (Marlen *et al*., 1994).

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Research Approaches to Shrimp Trawl Bycatch Reduction in the Gulf of Mexico, USA

Dan Foster

PowerPoint Presentation: Research Approaches to Shrimp Trawl Bycatch Reduction

Introduction

The Harvesting Systems and Engineering Division of NOAA[1] National Marine Fisheries Service (NOAA Fisheries) has been conducting research to reduce the take of unwanted finfish species from shrimp trawls since the mid 1980s. In 1998, BRDs became compulsory in the Gulf of Mexico, and the designs certified for use were the Fisheye and Jones-Davis BRDs. Between 1999 and 2002, NOAA Fisheries observers evaluated the performance of these BRDs in the fishery. The observers recorded that all but a few of the vessels in the Gulf of Mexico were using the Fisheye BRD. They also found that this BRD did not meet the requirement that BRDs reduce the fishing mortality of juvenile red snapper in the Gulf of Mexico by 44%. The Jones-Davis device was found to be effective in reducing the bycatch of juvenile snapper, but was considered impractical due to the complexity of design. Based on this information, NOAA Fisheries has been pursuing new and innovative approaches to improve shrimp trawl bycatch reduction technology.

Current Approaches to Bycatch Reduction

BRDs that have been developed for use in the Gulf of Mexico to utilise behavioural differences between fish and shrimp to achieve the exclusion of unwanted fish. Behavioural observations of finfish in trawls have shown that the TED alters the behaviour of fish as they pass through the trawl. Fish tend to take up station on the down-flow side of the TED for differing periods of time before dropping back into the codend. Many BRD designs have therefore been developed for the area just behind the TED to utilise this behavioural response, including the Extended Funnel and the Jones-Davis BRD. These, so-called funnel BRDs are designed to incorporate webbing funnels that direct the catch toward the codend, with escape openings in place in the extension piece around the funnel. Fish are able to detect the slow-flow areas created by the funnel, move towards the walls of the webbing, and take up station near the escape openings. Cable hoops placed in the extension piece maintain the space between the funnel and extension thus allowing clear passage through the escape openings.

NOAA Composite Panel BRD

In an attempt to reduce the complexity of funnel BRDs, research was conducted on a prototype BRD called a NOAA Composite Panel. This BRD differed from funnel BRDs in that the funnel was replaced by two composite webbing panels installed in the extension piece just behind the TED. Each composite panel was comprised of two overlapping panels, a diamond mesh panel (interior) and a square mesh panel (exterior). This design eliminated the need for cable hoops, and greatly decreased

[1] National Oceanic & Atmospheric Administration

material and labour costs. Field trials have shown this design to be comparable in performance to the more complex, funnel designs.

Finfish Stimulators

It has been demonstrated that fish will take up position in the slow-flow areas of a BRD close to the escape openings. However, escapement of these fish during the tow is limited because the fish are not induced or encouraged to escape. Fish stimulators have therefore been developed to deter fish from entering the codend, which causes crowding in the areas around the escape openings and increases fish escape rate. The first stimulator that was developed consisted of small, parallel steel cables stretched across an aluminium hoop. This device, called the hummer stimulator, was very effective in stimulating fish escapement, however, it was impractical due to heavy clogging with debris and grass (editors note: observations of this device in the NPF revealed that it also clogs with fish). A design developed by the shrimping industry, called the ‘spooker’ cone, utilises a cone made of webbing with a cable hoop attached near the base of the cone to maintain its conical shape. This design proved effective and is now typically incorporated in the Jones-Davis BRD.

Water Flow Modification

Harvesting Systems has conducted research into ways to eliminate the optomotor response in fish. A BRD called the fishbox was developed that generates water vertices near the escape opening of the device and inclined water flow out of the escape opening. Fish are unable to orient into the downward sloping water flow and are forced/stimulated to leave the trawl. This BRD demonstrated a high rate of continuous escapement during daylight trawling. However, when this device was tested during night trawling operations the escape rate was diminished.

Behaviour of Fish and Shrimp: Day vs Night

Shrimp trawling in the Gulf of Mexico occurs primarily at night. Until recent years, researchers lacked the technology to properly observe fish and shrimp behaviour in the trawl under dark conditions. Therefore, most of the development of bycatch reduction technology that is based of behavioural responses of fish has been based on observations made during daylight or twilight trawling. Examples of BRD designs that have been developed utilizing these behavioural observations are the Extended Funnel and the Fishbox. These designs have been shown to be effective under daytime trawling conditions. However, a decrease in finfish exclusion performance has been observed when towed during dark conditions.

In recent years infra-red LED technology has been developed that allows observations of fish behaviour under dark towing conditions. The Department of Biology at the University of Mississippi has also been conducting laboratory experiments to better understand how ambient light levels and introduced artificial light affects fish behaviour in the trawl. Research has shown a direct correlation between the ambient light level and the average time it takes a juvenile red snapper to escape from the Fishbox BRD, that is, at high light levels escapement occurs rapidly while at low light levels escapement is longer or not at all. Additional research has shown that dark adapted juvenile red snapper exhibit a negative phototactic response to introduced artificial lighting (i.e. they avoid areas in the trawl illuminated with artificial lighting), while the response of other finfish indicted that artificial lighting had no obvious benefit.

Experiments have also been conducted in an effort to utilize the negative phototactic response to deter fish from entering into the codend of the trawl. A prototype fish stimulator, which is a white tunnel constructed of tarpaulin was placed in the forward portion of the codend. White LED lights illuminated the interior of the tunnel. Initial trials showed that the illuminated tunnel was unsuccessful in deterring fish from entering the codend. However, additional experiments will be conducted using differing light levels and wave lengths of light. Another possible avenue that can be considered would be to utilize negative phototactic response to artificial light in finfish to develop a type of separator trawl.

Codend Modifications

With BRDs that utilize behavioural differences between fish and shrimp to achieve the exclusion of unwanted fish, individual escapement is greatly dependant on fish swimming ability. The bycatch of red snapper in shrimp trawls primarily consists of age zero (< 130 mm) and age one fish. Most BRD designs are relatively effective in excluding age one fish. However, the escape rate for age zero snapper is generally less than 10%. NOAA Fisheries has initiated research into codend mesh sizes and configurations to augment the escapement of age zero fish. Preliminary results have shown that an increase in codend mesh size from 44 cm to 51 cm results in a 38% reduction of zero year class snapper with no detectable loss in the targeted shrimp.

Application of the Juvenile and Trash Excluder Devices in Southeast Asia.

Bundit Chokesanguan

PowerPoint Presentation: Application of juvenile and trash excluder device in Southeast Asia

Introduction

The incidental catch of juvenile and trash fish is an acknowledged component of fisheries management. Its recent development into a major fisheries management issue can be attributed to increasing demand for fisheries resources and a growing recognition of the need to ensure that fisheries are conducted in a sustainable manner. Once considered as mostly a nuisance, catches of juvenile and trash fish are now recognized as having detrimental impacts on the health of fisheries systems. Similarly, the economic value of catches of commercially important fish species in the juvenile form are now viewed as being considerably lower than that for the same species at sizes more suited to market conditions.

In the development of sustainable fisheries, reducing the incidental catch of juvenile and trash fish is a key priority. In response to this, the Training Department (TD) of the Southeast Asian Fisheries Development Center (SEAFDEC) initiated research and development activities in 1998 aimed at providing a technical foundation for the adoption of Juvenile and Trash Excluder Devices (JTEDs) in regional trawl fisheries. Firstly, two JTED types were developed for installation into the upper part of the cod end. One device used a rectangular shaped window, whilst the other a semi-curved window. Both of them were constructed with stainless steel frames of 80 by 100 cm, with “soft” separator gratings made of 8 mm polyethylene rope.

The general effectiveness of these JTED types was tested during at-sea fishing trials and demonstrations. Their designs have been modified in response to more detailed testing of how JTED efficiency is influenced by factors including the separator spacing, “soft” versus “hard” separator gratings, and the fixture of the second cod end and the cover net. Investigations into the effect of trawl tow speed, catch loading and hydrodynamic drag on the deformation of trawl netting and the ultimate performance of JTEDs, has provided the research team with an insight into the operational considerations required to maximize the exclusion of juvenile and trash fish from trawl fishing operations. The rectangular rigid sorting grid and semi-curved rigid have been introduced, demonstrated and experimented at the later stage of the JTEDs implementation in the Southeast Asian Region.

Since 1998, TD has completed numerous experimental trials on the release of juveniles and trash fish from trawl fishing gear through the use of JTEDs in the Southeast Asian water. The work has been completed in the national waters off Thailand, Vietnam, Malaysia, Brunei Darussalam, Indonesia, the Philippines, Myanmar and Cambodia. TD has compiled all information data from the experiments on JTEDs in SEAFDEC member countries in order to present the efficiency of these devices. Besides the demonstration and experiment in the waters off member countries, the JTEDs have been trialled in the flume tank in the Marine Institute of

New Found land (MI), Canada, Tokyo University of Marine Science and Technology (TUMSAT), Japan, and Australian Maritime College (AMC), Australia, in order to improve its performance, especially the semi-curved rigid sorting grid.

The SEAFDEC member countries have continued their implementation of JTEDs in their home countries. The JTEDs have recently been adopted in waters of Calbayog City in the Philippines. A pilot project on their use has also been launched in waters of Kadah State, west Malaysia. SEAFDEC Training Department will continue to promote the use of JTEDs in Southeast Asian region and other non-member countries under the Project on Responsible Fishing Technologies and Practices with the support of Japanese Trust Fund and the fund provided by GEF/UNEP/FAO under an agreement on the support to activities which is part of the global project for the "Reduction of Environment Impact from Tropical Shrimp Trawling through the Introduction of By-catch Reduction Technologies and Change of Management".

Progress and results of implementation of JTED project in Southeast Asia

1. Brunei Darussalam

SEAFDEC/TD carried out activities to introduce JTED in the country in 2000 and 2002. Her Department of Fisheries has conducted a study of selectivity using various mesh sizes in square mesh and diamond configurations. During experiments on the use of JTED they brought their own JTED of various mesh sizes and mesh configurations to compare its effect with the rigid sorting grid JTED which was introduced by TD. The results from the experiments showed that JTED of 51 mm square-mesh worked better than that of rigid sorting grid type in terms of releasing the unwanted portion of the catch, which gave the Department of Fisheries an impetus to further its effort to improve its JTED of the square-mesh type. The purpose of the experiment was to generate information to be used as a reference for the possible amendment of the mesh size regulation on trawl nets to reduce the capture of unwanted catch. After they found out that the JTED of 51 mm square mesh gave the best performance, they introduced the device to fishers and trained them in building it and installing it on their fishing boats. The trawl boats were provided with free netting materials and a square mesh cod end and net but some operators resisted regulation enforcement since an approach was top down. They refused to go out fishing and raised complaints one day. Those operators who were misinformed and did not participate in the process of consultation and seminars sparked a protest against it. However, the regulation took effect. Some trawlers resorted to the use of JTED of diamond configuration and the use of thick twined cover nets that defeated the purpose of releasing unwanted catch.

2. Cambodia

In the year 2004, the Department of Fisheries of the country had close cooperation with SEAFDEC/TD in the introduction of JTED among local fishers through training. The training was conducted in Sihanouk Ville and focused on the theory of the use of JTED and practice on installation of JTED. However, there are many negative factors to hamper the promotion of the use of the device in Cambodia. On the side of its Government, they are lacking in understanding on the usefulness of JTED and in time and budget allowed for the introduction of JTED to fishers. As a

result, they can not well prepare an extension program for the dissemination of JTED technology to local fishers. On the side of fishers, their primary concern is to get as large a catch of all size of fish by their trawl and push nets for a larger income. That is why fishers are still reluctant to apply the devices to their gears.

3. Indonesia

Demonstrations and experiments to promote JTED were carried out many times in Indonesia. Experiments were conducted using different types of JTED such as Semi-curve Window, Rectangular Shape Window and Rigid Sorting Grid of 1, 1.5, 2, 2.5, 3 and 4 cm. Finally it was found that JTED of Semi-curve rigid sorting grid of 1.5 cm grid interval was the most applicable for trawls in the country. For the next activity, Indonesia will focus on the technology modification of JTED construction and mesh figure (diamond or square).

Based on the work plan of FAO-GEF Project (FAO Symbol EP/GLO/201/GEF) for Indonesia, the final outcome will be to standardise the BRD most appropriate to be used in Indonesia waters. For that purpose some measures will be taken, such as an adaptation of BRD technologies, field demonstrations of new technologies and the introduction of appropriate BRD technology to shrimp fishing fleets, training, a workshop of BRD, and legalisation of BRD standardization.

4. Malaysia

The 1st experiment was conducted at Kedah water to compare the effectiveness of the fishermen's net (cod-end of 25.4 mm), net with 38 mm of cod-end (following Fisheries Act), square mesh of 50 mm with 38 mm of cod-end and JTED (Sort-X) grill 15 mm with cod-end of 38 mm. It was found that the net with 38 mm cod-end performed well in selectivity and did not reduce the rate of commercial catch. However, the net of square-mesh window and other JTED need to be tested further. Malaysia is interested to introduce selective devices to the country, but existing devices are not fit for use in the country so their design should be modified as well as technical improvements.

5. Myanmar

JTED experiments were carried out twice in Myanmar. These experiments indicated that all types of JTED were effective in releasing juveniles. The devices, especially a window type JTED of 1 cm of bar spacing, can be applied to both fish and shrimp trawls. But most fishermen do not want to lose their profit by allowing fish to escape through the device so that they still do not use it in their trawls. However, The Government of Myanmar is willing to continue the experiment and research on the use of JTED in other areas and has requested some technical advice from SEAFDEC/TD or other relevant agencies for the demonstration and promotion of the use of JTED to fishers in the country.

6. The Philippines

Training/demonstrations and sea trials of JTED were done in the major trawling grounds of the country, namely, Manila Bay, San Miguel Bay, Lingayen Gulf, Visayan Sea and Maqueda Bay/ Samar Sea. Different types and variations of JTED were used and tested such as vertical bar sorting grid, square mesh sorting grid, horizontal bar sorting grid, semi-curve window, rectangular shape window and square mesh window. Cover nets were used to examine the composition, rate and measurement of escaping species. Consequent on the training/ demonstration of the JTED in Samar Sea and other fishing grounds, the JTED pilot project was proposed to the local government unit of Calbayog City to complement the ongoing Coastal Zoning Program in which locally based commercial fishing boats, including trawlers, were allocated to operate a specific area. Seminars and experiments to find the most applicable design of the device were carried out and activities to promote by-catch reduction technologies were broadcast through the local radio station in Daet, Camarines Norte. The outcome of meeting and consultation sessions held here showed that it was necessary for participating vessels to reduce fishing efforts. Accordingly, the implementation mechanism, guidelines which included fishing effort control, allocation, clearance system and enforcement/monitoring guidelines were reformulated and revised. The revised pilot project plan was approved by BFAR Directors and launched in March, 2006.

7. Thailand

JTED experiments and promotions were carried out twice in the Gulf of Thailand in cooperation between SEAFDEC/TD and the Department of Fisheries (DOF), Thailand. The experiments using window-shaped and Rigid Sorting Grid JTED were conducted in order to make a comparison in effectiveness between them. As a result, the Rigid Sorting Grid Device was recognized as an effective tool in order to release juveniles and trash from the trawl fishing. A technical report on those activities was submitted to DOF. However, it also depends on national policy whether the JTED promotion will be continued in Thailand.

8. Vietnam

The first experiment of JTED onboard a shrimp trawler was carried out in the Gulf of Tonkin in cooperation with SEAFDEC/TD. Vietnam has continued to conduct research into and experiments on JTED of square mesh of 20,25,30,35 and 40 mm and iron frame in order to make a comparison among them. The results proved that the JTED of square mesh of 20 mm showed the best performance in gear selectivity especially for squid, lizardfish and cuttlefish and had an economic advantage while JTED of iron frame of 12 and 20 mm was suitable for croaker and lizardfish groups. The Government of Vietnam considers that it is necessary to use a selective gear/device in coastal trawl fisheries and that they need further studies on the applicable selective gear in various water areas to assess the device more accurately. At the same time the fisheries sector and the Government of Vietnam were recommended to put forward specific measures, policies and regulations in order to apply the study results to trawl fishery operations in Vietnam.

Application of electricity to reduce bycatch in shrimp trawl fisheries

Daniel Foster

PowerPoint Presentation: Potential Application of Electrical Fields for Selective Shrimp/Prawn Fishing Gears

No written report available.

Application of Light Stimuli to Reduce Bycatch in Prawn Trawl Fisheries

David Maynard

PowerPoint Presentation: Application of Light Stimuli to Reduce Bycatch in Prawn Trawl Fisheries

Introduction

Bycatch and discards are recognised problems for fisheries globally. According to Kelleher (2005) global annual estimates for discards were 7.3 million tonnes for all fisheries. Tropical shrimp trawl fisheries are responsible for around 27% of the global estimate for discards. A variety of BRDs and TEDs have been designed and tested. These devices are used in prawn trawl fisheries around the world, and remove significant numbers of turtles, sharks, rays, and macro-invertebrates from the catch (Brewer *et al.* 2006; Eayrs, Buxton & McDonald 1997; Eayrs, 2005). The exclusion of small fish from the catch has, however, been less than impressive. Extensive testing of BRDs and TEDs in the NPF suggests a bycatch reduction rate between 5.4% and 8% (Brewer *et al*, 2006), falling well below the Commonwealth Government's target of 50%.

To date the focus of bycatch reduction presumes that small fish need to be removed after ingress, hence BRDs are located in or near the codend (Eayrs, Buxton and McDonald 1997). This is a less than optimal scenario, as little is known about escapee survival rates due to the effects of scale loss, skin damage and stress incurred during the capture process and subsequent exclusion (Farmer et al, 1998).

A more appropriate scenario would be to avoid the capture of small fish in the first place. A fish avoiding the capture process does not suffer the same injuries and/or stresses as a fish that passes through the trawl net and (hopefully) escapes through a BRD.

An area requiring further research is avoidance reactions in fish. The purpose of this paper is to describe a method that stimulates an avoidance reaction at the front, or ahead of, the net. In this case, underwater lights were used in night trawling to trigger a negative phototactic response in small fish, in turn reducing the number of fish entering the mouth of the trawl.

Background

The required escape speed for a fish to pass over the headline of an approaching trawl net is a function of the headline height, trawl velocity and the visible range. Wardle (1993) developed the following relationship to describe the required escape speed:

Required escape speed = Headline height x (trawl velocity ÷ visible range)

Any one of these three factors can be modified to improve the likelihood of fish escape. This paper concentrates on improving the visible range at which a fish observes the approaching trawl net. The work done by Wardle (1993) allows us to calculate the required escape speed, but how fast can a fish swim? Videler (1993) developed a relationship that allows us to calculate the possible escape speed for any given fish;

Escape speed = 0.4 + (Fish length x 7.4)

Effectively, the escape speed of any fish is a function of its length. Given that this speed is fixed, what can fishers do to increase the likelihood of a fish's escape from an approaching trawl net? This question takes us back to the work done by Wardle (1993). A doubling of the visible range of an approaching net essentially halves the necessary escape speed required for a fish to pass over the headline. This reduced required escape speed allows less proficient swimming fishes the opportunity of escape.

Can we increase the visible range of the trawl net using light? And if so, can we trigger an avoidance reaction in fish using light? These questions were put to the test in sea trials in July, 2004.

Materials and Method

Sea trials were conducted over two nights onboard the commercial trawler, FV *Santa Ana* during normal fishing operations on commercial fishing grounds adjacent to Bribie Island, Southeast Queensland. A four-fathom Florida Flyer trawl net with a headline height of 900 mm was used. The target trawl speed was 2.5 knots and the net had a spread ratio of 75%.

Four 50-Watt halogen underwater lights were attached equidistantly along the headline of the trawl. The lights were orientated normal to the top panel (effectively vertical, facing the seabed). The lights were powered from a battery pod mounted on the codend.

A total of 16 one-hour night-time trawl shots were completed and the catch assessed. Of these, eight were illuminated for the duration of the tow (experiment), and the remaining eight were not illuminated (control). The trawl sequence was one shot with lights on then one shot with lights off. The catch from each shot was sampled separately; all fish (excluding dangerous and toxic fishes) and small sharks were identified by species, then counted, weighed and measured for length. The target species (mixed prawns (family Penaeidae), and three-spot crabs (*Portunus sanguinolentus*) were measured for weight (kg) only to maximise commercial catch quality.

Results

Prawns

A total of 95.8 kg of commercial prawns were caught in this study. The eastern king prawn (*Penaeus plebejus*) was the dominant species. The prawn catch weight for the control shots and experimental shots was 41.3 kg and 54.5 kg respectively. This is a 32% increase in commercial prawn catch weight.

Three-spot crabs

A total of 57.6 kg of three-spot crabs (*Portunus sanguinolentus*) were caught in this study. The crab catch weight for the control shots and experimental shots was 24.3 kg and 33.3 kg. This is a 37% increase in crab catch weight.

Bycatch

A total of 2 494 fish, cephalopods and sharks/rays representing 26 species from 20 families were measured and recorded from the 16 trawl shots. Nine families accounted for over 90% of the bycatch numbers. Two families accounted for over half the bycatch numbers.

The number of fish captured in the control and the experiment was 1 465 and 1 029 respectively. This is a reduction in the overall number of bycatch of 29.8%.

Discussion

Lights offer industry and management another tool to tackle the bycatch issue. Industry and management should not be looking for a single *magic bullet* BRD design. Multiple BRD’s are needed to maximise the escape opportunity at each geographic location (and at differing times of the day, moon and season). Instead of looking for a panacea, in-depth knowledge of the fish assemblage susceptible to the gear is needed - for each fishery and in each region. This information will allow fishers to apply the right combination of BRD’s to specific segments of the fishery. Lights could be one of the tools utilised.

With an almost 30% bycatch reduction, lights offer an effective means of dealing with the bycatch issue as well as negating the post escape mortality problem – no interaction, no mortality. And for the fishers, an increase in target species of over 30% makes this BRD attractive – most other BRD tools have some level of prawn loss associated with their use.

The data from these sea trails was limited to 16 one-hour tows, in one fishery, over a very limited time frame. Lights need to be proven across entire fisheries, or more correctly across fish assemblages. Like other BRD designs, results will vary from location to location and throughout the season. But the main benefit of this method – avoidance instead of removal - makes lights an attractive tool to reduce bycatch. Combined with improved fish survival rates, this also translates to improved public perception of the prawn-trawl industry.

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Session 3: Innovative options to reduce bycatch

- ***Status of knowledge of prawn behaviour in prawn trawl fisheries***
  Steve Eayrs (Research Scientist, Gulf of Maine Research Institute, 350 Commercial Street, Portland, ME 04101, USA)

- ***Potential application of headline modification to reduce bycatch***
  Steve Eayrs (Research Scientist, Gulf of Maine Research Institute, 350 Commercial Street, Portland, ME 04101, USA)

- ***Performance of innovative otter boards and ground gear to reduce bycatch and seabed impact.***
  David Sterling (Sterling Trawl Gear Services, 27 Cobble Street, The Gap, Qld 4061)

- ***Application of acoustics to reduce bycatch in prawn trawl fisheries***
  Robert McCauley (Centre for Marine Science and Technology, Curtin University of Technology, GPO Box U1987, Perth, WA 6845)

- ***Flow field studies in and around TEDs and BRDs: potential to improve BRD performance***
  John Wakeford (Australian Maritime College, Department of Fisheries & Marine Environment, PO Box 21, Beaconsfield, Tas 7270)

Potential application of headline modification to reduce bycatch

Steve Eayrs

PowerPoint Presentation: Status of knowledge of prawn behaviour in prawn trawl fisheries/ Potential application of headline modification to reduce bycatch

Introduction

Despite a range of BRD designs being tested in the NPF over the past decade, current estimates suggest that these devices exclude less than 20% of fish bycatch from the trawl. A reason for this poor performance is that all rely to some extent on the behaviour of fish within the trawl to facilitate their exclusion from the trawl, yet the behaviour of both fish and prawns during the capture process is not well understood. To gain a better understanding of the behaviour of these animals, including their vertical distribution and response to the approaching trawl, a multi-level beam trawl (MBT) was developed at the AMC and tested in the NPF.

Materials and Methods

The design of the MBT consisted of a four-seam trawl net towed from an aluminium frame. The frame consisted of two triangular shaped shoes measuring 1.8 m high and 1.2 m long, connected together by a beam measuring 4.0 m in length. The design of the trawl was modelled on the Florida Flyer trawl and the headline length designed to provide a spread ratio of 0.75.

The mouth of the trawl was divided into three levels (compartments) by two horizontal separator panels extending the length of the trawl. Each level measured 600 mm high (0 – 600 mm, 600 mm – 1200 mm, 1200 mm – 1800 mm) and led to a separate codend. The top and bottom panels of the trawl and both separator panels were identical in design and construction to eliminate any lead-ahead (cover) that could hamper the vertical escape reactions of prawns and bycatch as they respond to the trawl. The trawl was constructed from 51.0 mm 210d/30ply twisted polyethylene (PE) netting and the codends from 45.0 mm 210d/60ply twisted PE netting. The ground gear consisted of a single 8.0 mm (diameter) galvanised steel ground chain.

The MBT was tested in three rigging configurations. In configuration one, a lead-ahead panel was attached to the headline of each horizontal separator panel and to the top panel of the trawl. Each lead-ahead panel extended directly between the wingends of the headline to prevent the migration of prawns and bycatch between levels, and in this way the catch in each codend provided information about the vertical distribution of these animals at the time of capture. In configuration two, the lowest lead-ahead panel (the panel separating the bottom and middle levels) was removed to allow animals in the trawl mouth the opportunity to respond vertically and migrate between the bottom and middle levels. In configuration three, the middle lead-ahead panel (the panel separating the middle and top levels) was removed in addition to the lowest lead-ahead panel. In this configuration, the catch in each codend was comprised of animals swimming ahead of each level at the time of capture plus those that reacted vertically to the trawl.

A total of 145 tows were completed at the commercial fishing grounds west of Weipa in the Gulf of Carpentaria. All tows were of half-hour duration and in a north-south direction. In configuration one, two and three, 43, 57 and 45 tows were completed respectively. All tows were made at night between 7:00 p.m. and 5:00 a.m. to prevent sunlight from influencing prawn and bycatch behaviour. To be consistent with industry practice, nominal towing speed was 1.5 m/s and warp to depth ratio was between 5.5 and 7 to 1. Water depth ranged between 14 - 22 m.

Results

A total of 2 220 commercial prawns were caught weighing an estimated 73 135 g. The grooved tiger prawn (*Penaeus semisulcatus*) was the dominant commercial prawn species in each configuration, accounting for 64% to 65% of the total prawn catch by numbers and 66% to 71% by weight.

A total of 55 772 fish, invertebrates and other bycatch species were caught weighing 1 570 321 g. Fish accounted for 75% to 88% of the bycatch by number and approximately 80% by weight. The catch composition varied little between configurations. Of the 25 most abundant species in each configuration, 17 were caught in all three configurations with a further 7 species caught in only two configurations. The black-tipped ponyfish (*Leiognathus splendens)* and the pearly-finned cardinal fish (*Apogon poecilopterus*) were the most frequently caught species, being recorded in 144 from a possible 145 tows. The black-tipped ponyfish was the dominant bycatch species in each configuration by weight and number, accounting for 21% to 36% and 34% to 52% of the catch respectively. The pearly-finned cardinal fish accounted for less than 10% of the total bycatch by weight and number in each configuration.

In configuration one almost 93% of commercial prawns (by number) entered the trawl within 600 mm of the seabed, and for the grooved tiger prawn this increased to 96%. In the remaining configurations up to 40% of grooved tiger prawns responded vertically to the trawl and entered the upper levels of the trawl. In configuration one almost 90% of the bycatch (by weight) entered the trawl within 600 mm of the seabed, but in configurations two and three this was reduced to 40% of the bycatch with the remaining fish entering the upper levels. In configuration three, removal of both lead-ahead panels resulted in an almost equal division of the catch between the upper and bottom levels, and approximately 20% of the catch entered the middle level of the trawl.

Over 90% of black-tipped ponyfish (by weight) entered the trawl within 600 mm of the seabed in configuration one, and less than 1% entered the upper-most level. In contrast, only 74% of pearly-finned cardinal fish entered the lowest level and 23% entered the middle level. In configurations two and three over 60% of black-tipped ponyfish responded vertically following removal of the lead-ahead panels and entered the upper levels of the trawl, while less than 40% of the pearly-finned cardinal responded in this way.

Discussion

The results of this study found that approximately 96% of grooved tiger prawns entered the trawl near the seabed (<600mm). The reaction of prawns to the trawl was then tested by sequential removal of the lower lead-ahead panels (configurations two and three), and the grooved tiger prawn clearly demonstrated a strong upward escape reaction in response to the trawl. The stimulus responsible for this response was most likely tactile contact with the ground chains.

The vertical distribution of fish and other bycatch as they entered the trawl was also close to the seabed, and sequential removal of the lead-ahead panels resulted in substantially increased proportions of the catch being retained in the upper levels. The dramatic change in bycatch proportions between levels indicates that many fish attempted to escape only when in close proximity to the trawl mouth, and this may be evidence of visually based responses in such conditions. Given the risks associated with reliance on tactile stimuli in low light conditions, it is not unreasonable to conclude that fish response to a trawl is principally visually based. Other research this notion, with evidence of daylight bycatch reduction rates being up to three times that recorded at night with the same BRD and at the same fishing ground.

Although most bycatch species were located on or near (<600 mm) the seabed at the time of capture, approximately 10% of bycatch entered the trawl between 600 mm - 1 800 mm above the seabed. Given the performance of current BRDs in the NPF, a substantial reduction in headline height has the potential to contribute greatly to improve bycatch reduction figures. Moreover, the results of this study suggest that the capture of some species, such as the pearly-finned cardinal fish, could be reduced by as much as 40% or more. A reduction in headline height may realise an increase in wingend spread, particularly if otter board size is maintained, resulting in increased catch of fish close to the seabed. A reduction in bycatch may therefore require additional trawl modifications that compliment a reduction in headline height and overcome any gain in bycatch. These include the use of BRDs that are more effective than those currently in use, or the use of novel modifications that alter the design or appearance of the trawl to elicit escape responses from the bycatch before they enter the trawl. The amount of lead-ahead built into the design of the trawl could also be altered to reduce bycatch. The effect of lead-ahead on bycatch has not been studied but may play a key role in the exclusion of these animals. Lead-ahead is principally used to prevent the escape of prawns over the headline over the trawl. Commercial prawn trawls are designed with lead-ahead that extends up to 1.2 m ahead of the trawl mouth, yet the exact amount of lead-ahead required to prevent prawn escape is unknown, this being a function of several parameters including headline height, towing speed, ground chain design and rigging, prawn behaviour and orientation to the trawl. The relationship between these parameters is complex, although presumably an optimum lead-ahead exists for a particular headline height. It may also be possible to further optimise lead-ahead so that strong swimming bycatch species can escape over the trawl whilst the poorer swimming prawns are retained. This would require a far greater understanding of the parameters that influence lead-ahead as well as knowledge of bycatch swimming performance, and future testing of the MBT with varying sized lead-ahead panels would go a long way to acquiring this knowledge.

Approximately 40% of the bycatch did not respond to removal of the lead-ahead panels, suggesting the absence of a vertical escape response by these species. On the strength of this result, the exclusion of these animals may be achieved by modifying the design or rigging of the ground chain, or the use of BRDs near the trawl mouth with escape openings in the bottom panel of the net. NPF fishers have a history of ground chain modification to exclude bottom dwelling bycatch including sponges, small sea urchins (sea eggs), rocks and other benthic debris, however, to date there have been no specific attempts to avoid the capture of bottom dwelling fish bycatch.

A further reduction in the amount of bycatch caught in tropical prawn fisheries could also be made if the trawl was more visible. This would potentially allow the bycatch more time to visually detect the trawl and swim over the headline to avoid capture. In the NPF tiger prawn fishery, fishing occurs in turbid waters and for much of the year only at night, and the use of artificial lighting such as glow netting or cyalume sticks may be required to make the trawl mouth more visible. The effect of trawl illumination has not been tested in the NPF, and if used in combination with reduced headline height, a substantially greater number of small or poor swimming bycatch species could avoid capture in the trawl.

Performance of innovative otter boards and ground gear to reduce bycatch and seabed impact

David Sterling

PowerPoint Presentation: Trawl gear to reduce seabed impact and bycatch of benthic material

Introduction

There is evidence that prawn trawling is destructive to sensitive ecosystems and causes unwanted seabed material to be retained in the codend. This has led to negative perceptions of the fishing industry that have been hard to manage. From the trawl gear perspective there are two components to this problem; large heavy otter boards that are operated at a high angle of attack and the use of ground chains that are purposefully intended to scrape the seabed to cause target animals to react and be caught.

A response to the problem was a research project to investigate ways to develop new trawl gear technologies that are not only more benthic friendly, but also more fuel efficient and, therefore, seek a win-win situation for both the fishing industry and the environment. The new trawl gear developed and tested in this project were a soft-brush ground gear and batwing otter boards.

The project was funded by the Australian Government's Fisheries Research and Development Corporation (FRDC) and undertaken by industry in collaboration with the AMC, the University of Queensland, and QDPI&F.

Details of the new trawl gear

The soft-brush ground gear consisted of a floated high-strength rope and short light-weight dangling chains. The soft-brush works differently from conventional ground gear because the ground rope is floated to pass above the seabed and prawns respond either to the approaching float/rope combination or to the dangling chains as they brush past. In this way, the chains ride over seabed objects rather than slice across the surface of the seabed.

The rope on which the floats and dangling chains were threaded was 6 mm 12-strand braided Supermax. This rope is made of Ultra High Molecular Weight Polyethylene (UHMWPE) fibres and is about 30% stronger than wire rope of the same diameter and about 87% lighter. The quoted breaking load of 6 mm Supermax is 3.8 tonnes. The floats used were QEL SDS oval floats, with a depth rating of 200 m and buoyancy of 94 gwt each. They measured 90 mm long by 60 mm in diameter. The dangling chains were made from 4 mm x 25 mm link 304 stainless steel chain with a linear density of 0.27kg/m. Each chain measured 250 mm in length. To achieve 2 dangling chains per float, one chain dangler was threaded on to the ground line between each float and a second dangling chain was attached at the centre of each float using two 300 mm zippy clips.

The flume tank at the AMC was employed to fine-tune the balance of forces acting on the new ground gear, set-up its correct height (~50 mm clearance under the floats) relative to the seabed and establish the effect of trawl speed on its geometry. The correct outcome was achieved when 3 floats out of 5 were drilled to remove excess buoyancy.

The batwing boards were designed to operate at a low angle of attack (20 degrees) and therefore have low hydrodynamic drag and reduced seabed contact. A novel feature of the batwing board was that the main contact shoe was aligned with the direction of tow, so that there was minimal scraping action which further reduces drag and benthic disturbance.

Most conventional otter boards used in prawn fisheries are operated at an angle of attack of around 40 degrees to ensure they remain stable at all phases of the fishing operation, including trawl deployment and retrieval. To achieve a low angle of attack and stability the towing wire (bridle) and the net were connected to the batwing board at the same longitudinal location – that is at a vertical pole; much like the "Sterling" sled. This makes the board operate like a kite (without a tail) and means that its angle of attack is not affected by the size of the net, catch loading in the net or the phase of gear operation i.e. shooting away or fishing.

The hydrodynamic wing of the batwing board was constructed from 20 mm polyethylene sheet cut into segments and welded together to form a curved shell with two vertical ventilation slots to reduce the separation of water flow. The wing has a geometric aspect ratio of 1 to produce maximum hydrodynamic spreading force at an angle of attack of 20 degrees. The dimensions of the wing were 1.425 m long x 1.325 m high, and the overall weight of the batwing board was 200 kgf in air and 144 kgf in water.

Engineering and catch trials

To test the new trawl gear, the FV *C-King* was double-rigged with two identical 4 fathom Florida Flyer nets. The batwing boards were on the port side and flat boards measuring 7' X 3' and weighing the same as the batwing boards were on the starboard side. From time to time the standard ground chain on either net was replaced by the soft-brush and the nets were also swapped at times to ensure that the net itself did not affect the results.

The drag of each net was measured using warp load cells and the spread of each net was measured using Scanmar spread sensors. Trawl data was collected at two engine RPM settings that nominally produce a trawl speed of 2.5 kts and 3.0 kts. The codends were left open during these trials so that large accumulated catches did not affect the results and data collection was not interrupted by the need to empty nets. These trials were conducted in Hervey Bay, either side of Sandy Cape and east of lower Fraser Island. AMC-designed underwater cameras were used during the sea trials to observe the operation and geometry of the ground gear and the otter boards.

Catch trials were also conducted, at a nominal trawl speed of 3.0 kts. A total of 64 trawl shots, each of 30 minutes duration were conducted on prawn and scallop grounds east of lower Fraser Island. The catches from each side were separately sorted into the following categories and the weight of each component was measured:

Target Species (King prawn, Tiger prawn, Scallops)
Byproduct species (Sand crabs, Bugs, Squid + Cuttlefish + Octopus)

Bycatch (Demersal fish, Pelagic fish, Crabs + prawns + other)
Sessile Benthic material (Starfish, Squirts, Shells)

Results

Based on the underwater observations, the soft-brush ground gear and the batwing otter boards appeared to be operating in the desired way. In both cases the intensity of direct contact between the gear and the seabed was observed to be substantially reduced. The operation and handling of this new gear was little different to standard ground gear and otter boards.

The engineering trials of the devices showed that the overall drag of a single net was reduced by 3.4% when the soft-brush ground gear was used and the spread of the net increased by 3.6%. The batwing boards increased trawl spread by 5.5% compared to the flat boards and an overall drag reduction of 13% was recorded. An estimation of otter board efficiency suggests that the lift to drag ratio for the batwing boards was about 100% higher than for the flat boards; that is for the same spreading force the new boards produced only half the drag as the flat boards.

From the catch trials the prawn catch was reduced by 10% when the soft-brush ground gear was used but the catch of scallops increased by 10%. The device also appeared to reduce the catch of starfish by about 35% but increased the catch of small-crab bycatch by about 10%. There was little difference in the catch of fish between ground gear.

When the batwing boards were used, on average there was a 10% reduction in prawn and scallop catch. Compared to the batwing boards, there was a 10 fold increase in the catch of sessile benthic material by the flat boards, although this was reduced by about 50% when 1.1 m long sweeps were inserted between the boards and the net. There was little difference in the catch of fish between otter boards, but there was a significant increase when the sweeps were inserted.

Conclusion

The new, innovative ground gear and otter board have both demonstrated good potential to reduce fishing impact on sensitive ecosystems. Underwater observations clearly indicated reduced disturbance to the seabed. The soft-brush reduced catches of sessile benthic material but further work is required to overcome loss of prawns and scallops. The batwing boards produced a relatively higher spreading force whilst generating less drag – this was a very good result considering the trawl net was being stretched to 85% of its headline length – and these otter boards are therefore substantially more fuel efficient than flat otter boards. The reduction in prawn and scallop catch associated with the batwing boards is hypothesised to be associated with reduced herding of these animals into the path of the net because the new boards have a lower angle of attack and much smaller lateral projection. Given that this explanation is true, the catch difference should be diminished for situations where higher order multi-net systems are used (e.g. triple or quad rig) because the lateral span of the otter boards would be a smaller proportion of the total (overall) span of the trawl gear (otter boards + nets).

Further testing and development of the gear is planned with the objective of gathering more detailed data on the impact of the new gear on commercial catch rates and establish the consistency of the gears performance across a range of operating conditions. It is anticipated that further refinements to the gear will continue to improve their performance.

For more information contact David Sterling on 07 33001105 or email djstgs@tpgi.com.au

Application of acoustics to reduce bycatch in prawn trawl fisheries

Robert McCauley

PowerPoint Presentations: (1) Marine mammal bycatch mitigation - Fish Trawls by Robert McCauley; (2) Trawl noise and bycatch reduction by Robert McCauley and Geoff McPherson

No written report available.

Flow field studies in and around TEDs & BRDs: potential to improve BRD performance

John Wakeford

PowerPoint Presentation: Flow field studies in and around TEDs & BRDs: potential to improve BRD performance

Since 2003 the flume tank facility at the AMC has been used to measure water flow through prawn trawl codends equipped with TEDs and various types of BRDs. A major objective of this work has been to evaluate the effect of these devices on the flow field in and around the codend. Knowledge of the flow field and fish behaviour has the potential to allow the development of TEDs and BRDs with higher rates of bycatch reduction.

2003

Initially, the work focussed on obtaining flow-field data to assist others assessing the performance of these devices to reduce bycatch. Water velocity in the downstream direction and codend outline shape were measured for three prawn trawl codend configurations; standard codend (included super-shooter turtle excluder device (S/S TED)), standard codend with fisheye (FE) located aft of TED, and standard codend with square mesh window (SMW) located aft of the TED. Each codend configuration was tested with and without a simulated catch (350 x 2kg water balloon) present. The experiment was conducted with a full-scale codend and codend extension attached to a towing hoop and streamed at 1m/sec in the flume tank.

Findings included: S/S TED and FE caused quite a lot of disruption to the flow field whereas the SMW had negligible effect on the flow field and codend shape; noticeable changes in shape and velocity occurred in the standard codend following the introduction of a simulated catch; and catch-induced water-displacement[2] was well aft of where the FE or SMW currently reside (110 meshes anterior to end of codend). It was concluded that whilst FE and SMW are located in this position they are unlikely to benefit much from catch-induced water-displacement. In this position the SMW relies predominately on bycatch vision for escapement to occur whereas the FE offers fish bycatch additional stimuli in the form of velocity gradients and wake formation. A more comprehensive coverage is contained in Brewer *et al*. (2006).

2004

A study involving more detailed measurements of the flow-field in the vicinity of several FE BRDs was undertaken to offer possible reasons for the success observed with the Yarrow FE during the 2004 Northern Prawn fishery season. Testing of these devices in the flume tank revealed that the Yarrow FE created a low flow region that extended over two metres downstream from its position in the net, and close to where the catch accumulates in the codend. It was suggested that finfish and sea snakes might be exploiting these low flow regions to escape via the eye. A more comprehensive coverage is contained in Heales *et al.*, (2008).

2006

In 2006, developmental work on a new composite BRD (SMW and FE hybrid) was undertaken, primarily to demonstrate that by careful manipulation of the design it is possible to create a flow-field that assists small bycatch in finding the window under low visibility

[2] As the trawl is towed forward the accumulated catch in the codend displaces water forward and sideways through the codend meshes. This is catch-induced water displacement, and fish have been observed using this displaced water to assist escape through a BRD.

conditions. Two key features in the modified flow-field were the creation of a wake region extending from the FE past the SMW, and the displacement of water out through the window. Previous flow-field measurements around SMWs located in prawn trawl codends have revealed very little, if any, water leaves the codend via the SMW, despite the clear difference in solidity ratio between the window netting and adjacent codend netting (setting angle of around 15°). Under a low-visibility condition, which is often the case in Australian prawn trawl fisheries, the need for small finfish to firstly see the escape opening, and then utilise it as they swiftly pass by, is possibly compromising this device's performance. In an attempt to address this apparent shortcoming, a modified form of FE was inserted directly upstream of a SMW. The modified FE had a circular shaped opening bisected by a horizontal bar (400mm long). The leading edge of the SMW was attached to this bar, which ensured about half of the four-legged apex frame (pointing upstream) of the FE resided outside the codend. A cone of PVC material (700 micron) was sewn over the entire apex frame. Three bean-shaped floats (buoyancy of 0.3kgf) were also attached at roughly even intervals across the upper portion of the eye framework. For comparative reasons, the initial test was done without the PVC cone in place. The resultant flow field results were very encouraging, as the modified FE, with flow dampening cone in place, not only strengthened the wake region downstream and caused the SMW to bisect it, but there was also an apparent exit of water via the SMW, and from inside the cone. Follow-up work in the form of at sea-trials during commercial fishing was therefore recommended.

References

Brewer, D., Heales, D., Milton, D., Dell, Q., Fry, G., Venables, B., and Jones, P., 2006, The impact of turtle excluder devices and bycatch reduction devices on diverse tropical marine communities in Australia's northern prawn trawl fishery, *Fisheries Research*, 81, 176-188

Heales D.S., Gregor, R., Wakeford, J., Wang, Y.-G., Yarrow, J. and Milton, D.A., 2008, Tropical prawn trawl byctach of fish and seasnakes reduced by Yarrow Fisheye Bycatch Reduction Device, *Fisheries Research*, 89, 76-73

Session 4: Options to improve fuel efficiency, and planning for the future

- ***Fishing gear modifications to improve fuel efficiency***
  David Sterling (Sterling Trawl Gear Services, 27 Cobble Street, The Gap, Qld 4061)

- ***Planning and prioritising for future efforts to reduce bycatch***
  Steve Eayrs (Chair), (Research Scientist, Gulf of Maine Research Institute, 350 Commercial Street, Portland, ME 04101, USA)

Fishing gear modifications to improve fuel efficiency

David Sterling

PowerPoint Presentation: The fuel crisis; improving the energy efficiency of trawling

No written report available

Planning and prioritising for future efforts to reduce bycatch

Steve Eayrs (Chair)

In this session of the workshop a range of issues were raised and discussed. The Chair opened the session by commenting on the need to move forward and develop new ways to reduce bycatch, given that existing approved devices and the manner in which they are currently used results in modest bycatch reduction. The Chair also commented that perhaps the best way forward was a focussed, coordinated effort that clearly defined objectives and who would do what. The alternative is to have little say in future bycatch reduction research. An example was cited with the fishbox, which has produced excellent results from preliminary testing, potentially being foisted upon the NPF whether fishers approve or otherwise.

Efforts were made to focus on planning and prioritising future efforts to reduce bycatch and to identify the group or institution responsible for taking on the identified issue. Table 1 below lists the ways forward that were identified during the discussion, how each option may be implemented and who will implement it. The table is by no means exhaustive, nor does it obligate the respective group or institution to take on the identified responsibility, but simply serves to represent the thoughts and suggestions of those in attendance.

In terms of future BRD development and testing, the Popeye fishbox and the AMC flow-field studies dominated discussion. It was suggested that the fishbox should be tested at the AMC flume tank to better understand how this device influences or generates water turbulence in and around the device and codend. This information could then be used to better predict how fish may escape from this device. The results from the flow-field studies presented at this workshop received special mention for dissemination to the industry.

One of the most concerning revelations from this workshop and the data provided from NPF fishers, was that many BRDs currently being used in the fishery do not comply with approved specifications. It seems clear that consistent measuring techniques are not applied across the fishery and that fishers are either unable to correctly measure their BRDs or are unaware of the approved specifications. Given that training in BRD measurement has not occurred since 1999-2000, it is perhaps timely and appropriate that consideration be given to providing such training. This could also be extended to compliance officers, as anecdotal evidence exists that they too are having difficulty understanding how to measure BRDs.

Table 1: Summary of discussions on ways forward to reduce bycatch in prawn trawl fisheries

Ways forward	***How to implement***	***Who to implement***	***Funding options***
Improved understanding of bycatch behaviour	Acoustic means – can be put on boat.		
Convert bycatch into byproduct rather than discard this component of the catch	Look at 'trash species' and change management rules that have a blanket ban on landing bycatch species. Improved marketing/processing of bycatch species.	Government and Industry Industry	
Improved public perception of the fishing industry and approach to bycatch and bycatch reduction	Industry bodies should respond to this challenge. Improved education to public/kids – better communication	Industry Industry and Government	
Research into the percentage of assemblage that ends up as bycatch and disseminate this information	GBRMPA is doing with AIMS/CSIRO	GBRMPA, AIMS and CSIRO	
Research needs to include industry knowledge of the fishery	Tie research to commercial fisheries	Government and Industry	
Develop and trial new or different BRDs or methods to reduce bycatch	Industry preference to test out of season with options of keeping catch, nights back (QLD), expenses, including fuel, covered. Government funded observer, improved education	Government and Industry	
Improved understanding of research and management objectives	Dissemination of research information to industry	Government and research	
Work done out of season to develop BRDS etc – combine b/w NPF TS, ECTF	Scientific permits Management changes	Government and Industry	
Further testing of Fishbox	Water flow/flume tank testing Testing in banana season	Industry and AFMA, AMC	Government and Industry NHT
List of interested parties (fishers and	Need scientific and industry rigor	Industry	

companies) willing to trial innovative options			
Composite fisheye (fisheye and square mesh panel with plastic film around the fisheye creating low-flow area)	Disseminate information to fishers Further testing	AMC and AFMA AMC	AMC and AFMA Government
Using a black plastic tunnel behind the Square Mesh Panel	Out of season testing with options of keeping catch, nights back (QLD), fuel payed for, Government funded observer, improved education	Industry, Government and AMC	Industry, Government
Encourage industry participation in future workshops	Forward information to fishers 2 months before the workshop then again 2 weeks before Incl. WA and SA trawl fisheries – Exmouth, Kimberley and Spencer Gulf fisheries	Government, Industry	
Testing of T90	Trialling in fisheries	Industry	US
Dissemination of final report	A hardcopy of papers and outcomes and a CD of presentations will be sent to workshop attendees, industry organisations, GBRMPA, QDPI&F, AFMA, DAFF, to SeaNet for dissemination and distributed at NPF pre-season briefings in 2007 Summary of workshop to: • FRDC • AFMA Fishing Future • Trade-a-boat magazine • MCCN – Waves (other green groups) • TS and NPF handbooks • Media releases	AMC, AFMA, QDPI&F, SeaNet, Industry	

Darwin Workshop

- ***Drivers for improvement in bycatch reduction***
  Wade Whitelaw (Australian Fisheries Management Authority, Box 7051, Canberra Business Centre, Canberra, ACT 2610)

- ***Bycatch reduction options for the Northern Prawn Fishery***
  Nick Rawlinson (Locked Bag 1396, National Centre for Marine Conservation and Resource Sustainability, Australian Maritime College, PO Box 986, Launceston,Tasmania, 7250)

- ***Improving BRD performance in the NPF***
  David Brewer, (Marine Ecologist, CSIRO Marine & Atmospheric Research, PO Box 120, Cleveland, Queensland, 4163)

Drivers for improvement in bycatch reduction

Wade Whitelaw

PowerPoint Presentation: Drivers for improvement in bycatch reduction

No written report available.

Bycatch reduction options for the Northern Prawn Fishery

Nick Rawlinson

PowerPoint Presentation: Bycatch reduction options for the Northern Prawn Fishery

This presentation provided an overview of all the options for bycatch reduction that were reviewed at the Cairns workshop.

Improving BRD performance in the NPF

David Brewer

PowerPoint Presentation: Improving BRD performance in the NPF

This presentation provided an overview of the bycatch reduction work that had been undertaken in the NPF and suggestions for the next steps for future developments.

A video of the flow-field work on the fishbox that had recently been completed in the Australian Maritime College flume tank was also shown at the workshop. The video showed different stages of experimental work to improve the flow-field around the fishbox.

Appendix 1: Workshop programme

Day 1 Session 1 – Case study accounts by fishers and others of BRD design, performance and uptake (Chair – Steve Eayrs; Rapporteurs – Adrianne Burke, John Wakeford)

	Session 1	Speakers
0830 - 0835	• Workshop welcome, objectives & proposed outcomes	Steve Eayrs (Australian Maritime College)
0835 - 0845	• Drivers for improvement in bycatch reduction	Wade Whitelaw (AFMA)
0845 - 0930	• Current status of existing BRDs including catching performance & uptake	• Steve Eayrs (Australian Maritime College) – *Results of NPF BRD industry questionnaire* • Tony Courtney & Matthew Campbell (QDPI) – *The performance of square mesh codends in the Qld otter trawl fishery* • Erik Raudzens (AMFA) – *The performance of the Popeye fish excluder (fishbox) in the NPF* • Others TBA
0930 - 1000	• Coffee break	
1000 - 1130	• Case-study accounts by fishers and others involved in BRD design, catching and handling performance	• Popeye (Popeye Netmaking) – *Design, rigging and operation of the Popeye fish excluder (fishbox)* • Jim Yarrow (NPF fisher) - *Design, rigging and operation of the Yarrow fisheye* • Andy Prendagast (Newfishing Aust.) – *Design, rigging and performance of the T90 codend* • Mike O'Brien (A. Raptis & Sons) – *Application of glow sticks to attract fish towards a BRD* • Phil Robson (A. Raptis & Sons) - *Design, rigging and performance of the shark shield* • Others TBA
1130 - 1230	• Open discussion of options to improve performance of existing BRD designs	• Group discussion
1230 - 1330	• Lunch	

Session 2 – International progress in bycatch reduction and innovative options to reduce bycatch in tropical prawn fisheries (Chair – Wade Whitelaw; Rapporteurs – David Sterling, Eric Raudzens)

1330 - 1430	• Presentation by international experts in progress in bycatch reduction	• Chris Glass (University of New Hampshire, USA) – *Bycatch reduction research in N. American & European fisheries: a review* • Dan Foster (National Marine Fisheries Service, USA) - *Bycatch reduction research in the Gulf of Mexico, USA* • Bundit Chokesanguan (SEAFDEC Thailand) - *Application of the Juvenile & Trash Excluder Device in S.E. Asia* • Others TBA

1430 - 1500	• Open discussion of outstanding issues and future goals to improve BRD performance	• Group discussion
1500 - 1530	• Coffee break	
1530 - 1630	• Application of innovative options to reduce bycatch in prawn trawl fisheries	• Dan Foster (National Marine Fisheries Service, USA) - *Application of electricity to reduce bycatch in shrimp trawl fisheries* • David Maynard (AMC) - *Application of light stimuli to reduce bycatch in prawn trawl fisheries* • Chris Glass (University of New Hampshire, USA) – *Status of knowledge of fish behaviour in demersal trawl fisheries*
1630 - 1645	• Electronic logbooks	• Dieter Bohm (Catchlog) – *Use & benefits of electronic logbooks in commercial fisheries*

Workshop program – Day 2

Session 3 – Innovative options to reduce bycatch (Chair – Tony Courtney; Rapporteurs – Matthew Campbell, David Maynard)

	Workshop program	**Speakers**
0830 - 1030	• Application of innovative options to reduce bycatch in prawn trawl fisheries	• Steve Eayrs (Australian Maritime College) - *Status of knowledge of prawn behaviour in prawn trawl fisheries* • Steve Eayrs (Australian Maritime College) – *Potential application of headline modification to reduce bycatch* • David Sterling (Director, Sterling Fisheries, QLD) – *Performance of innovative otter boards and ground gear to reduce bycatch and seabed impact* • Rob McCauley (Curtin University, W.A.) & Geoff McPherson (QDPI) - *Application of acoustics to reduce bycatch in prawn trawl fisheries* • John Wakeford (Australian Maritime College) – *Flow field studies in and around TEDs & BRDs: potential to improve BRD performance*
1030 - 1100	• Coffee break	
1100 - 1230	• Open discussion on the potential use and application of these options to reduce bycatch in Australian fisheries	• Group discussion
1230 - 1330	Lunch	

Session 4 - Options to improve fuel efficiency, and planning for the future (Chair – Steve Eayrs; Rapporteurs – Eric Raudzens, Adrianne Burke)

1330 - 1400	• Presentation on fuel efficiency options for prawn trawlers	• David Sterling (Director, Sterling Fisheries, QLD) – *Fishing gear modifications to improve fuel efficiency*
1400 - 1600	• Planning and prioritisation of future efforts to reduce bycatch for o Industry o Management o Research Organisations	• Group discussion
1600 - 1700	• Discussion on reporting and dissemination of information and outcomes from the workshop; description of future projects; future R&D; concluding remarks	• Group discussion

Appendix 2: NPF industry questionnaire

To: NPF Fishers Date: July, 2006

From: Steve Eayrs, Australian Maritime College

Subject: Questionnaire – Design and rigging of bycatch reduction devices in the NPF

Dear Fisher,

As you may be aware, the Commonwealth government is seeking a 50% reduction in bycatch in the NPF between 2005 and 2008. To help meet this target, a workshop is planned for November to i) evaluate the performance of existing BRD designs, ii) discuss options to modify these BRDs and further reduce bycatch, iii) evaluate the potential of new, innovative BRDs for the fishery, and iv) provide a venue for fishers to plan future BRD research for the following three years. All NPF fishers are invited to this workshop, and further details will be provided to you during the fishing season.

Before we hold the workshop it is important to collect information about the design and operation of BRDs currently in use in the NPF. This information will be used to identify the most common BRDs in the fishery and the preferred location, rigging and orientation of each type of BRD. (This information will be made public at the workshop.) To collect this information your input is sought to complete the attached questionnaire.

It is very important that you participate in this questionnaire and it should take only a few minutes to complete. Please note that the names of all fishers will remain confidential, and the information will not be used to identify specific individuals nor their specific fishing gear. Thankyou for you cooperation and I wish you a productive fishing season,

Steve Eayrs

Questionnaire - Design and rigging of BRDs in the NPF

Fisher/Operator name…………………………………

Question 1. Which BRD(s) are you currently using on your nets (tick appropriate box)?

1. Fisheye ☐ (go to question 2)
2. Square-mesh window ☐ (go to question 3)
3. Square-mesh codend ☐ (go to question 4)
4. Radial Escape Section (RES) ☐ (go to question 5)
5. Modified TED ☐ (go to question 6)
6. Other ☐ (go to question 7)

Question 2.

a) What is the maximum width of the fisheye escape opening? ……….mm

b) What is the maximum height of the fisheye escape opening? ……….mm

c) Is a vertical (or horizontal) brace used to support the escape opening? Yes/No

(go to question 8)

Question 3.

a) What is the width (number of bars) of your square-mesh window? ……….bars

b) What is the length (number of bars) of your square-mesh window? ……….bars

c) What is the mesh size of your square-mesh window? ……….inches

(go to question 8)

Question 4.

a) What is the width (number of bars) of your square-mesh codend? ……….bars

b) What is the length (number of bars) of your square-mesh codend? ……….bars

c) What is the mesh size of your square-mesh codend? ……….inches

d) What is the mesh size of your diamond-mesh net? ……….inches

e) What is the joining ratio between the diamond-mesh and the square-mesh codend? ……….diamond-meshes to ……….square-meshes

(go to question 8)

Question 5.

a) How many escape openings does your RES have? ……….escape openings

b) How many meshes wide is one escape opening? ……….meshes

c) How many meshes long is one escape opening? ……….meshes

(go to question 8)

Question 6.

a) What is the bar spacing of your modified TED? ……….mm

b) How many meshes wide is the escape opening? ……….meshes

c) How many meshes long is the escape opening? ……….meshes

(go to question 8)

Question 7.

a) If you use a different BRD or call it by another name, could you please describe it in a few sentences (or draw it on the reverse side of this page)?

____

____

____

(go to question 8)

Question 8.

a) Please complete the schematic diagram on the following page.

b) Are you using double rig (two nets) or quad rig (four nets)? ………………………….

c) If you had an opportunity to use a BRD different to those currently used in the fishery, what would you use? Please describe briefly.

____

____

____

____

d) Do you have any comments about improving bycatch reduction devices or ways to reduce bycatch?

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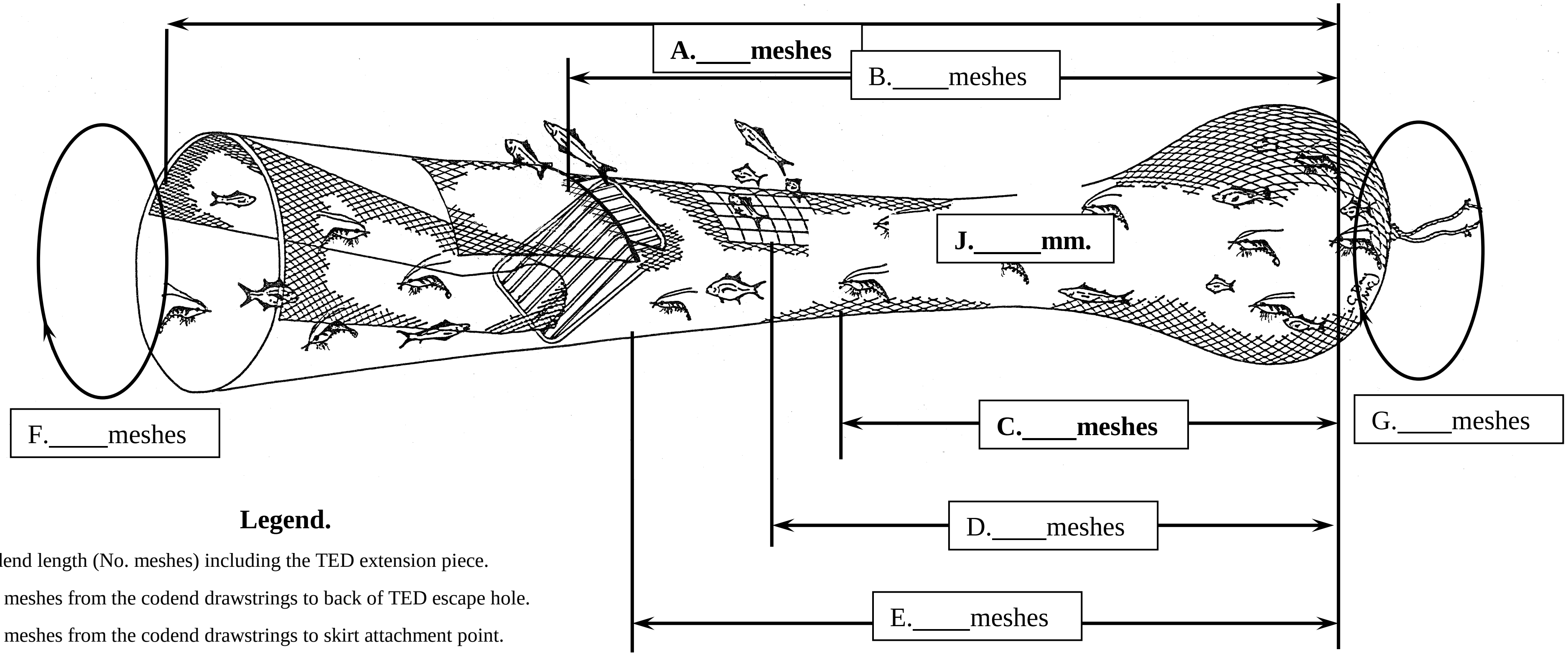
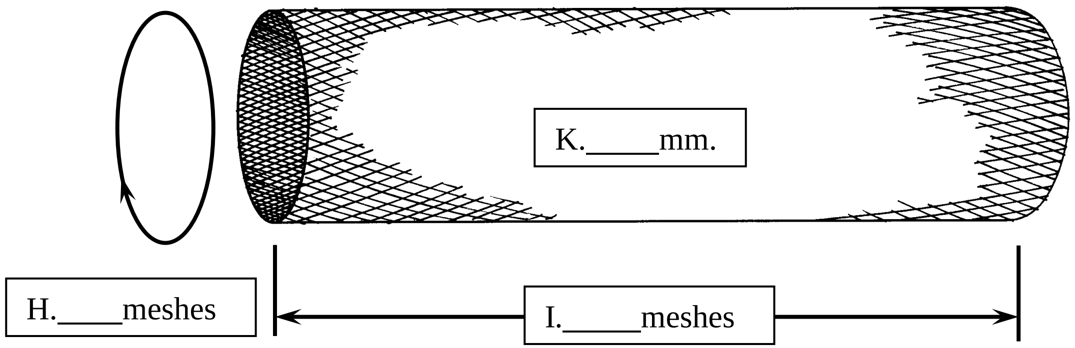
Thank you for your time.

Steve





Legend.

A. Codend length (No. meshes) including the TED extension piece.

B. No. meshes from the codend drawstrings to back of TED escape hole.

C. No. meshes from the codend drawstrings to skirt attachment point.

D. No. meshes from the codend drawstrings to back of BRD escape hole.

E. No. meshes from the codend drawstrings to lifting ear or choker.

F. Codend circumference (No. meshes) at front of codend.

G. Codend circumference (No. meshes) at drawstrings.

H. Skirt circumference (No. meshes).

I. Skirt length (No. meshes).

J. Codend mesh size (mm).

K. Skirt mesh size (mm).

Appendix 3: NPF TED and BRD approved devices and specification

FISHERIES MANAGEMENT ACT 1991
NORTHERN PRAWN FISHERY MANAGEMENT PLAN 1995

NPF DIRECTION No. 94
(revoking NPF Direction No. 81)
GEAR REQUIREMENTS

I, Richard McLoughlin, Managing Director of the Australian Fisheries Management Authority, as delegate, make the following Direction under sections 17(5A) and 17(5B) of the *Fisheries Management Act 1991* and section 25(1) of the *Northern Prawn Fishery Management Plan 1995*.

Dated March 2006

Managing Director,
Australian Fisheries Management Authority

Citation

1. This Direction may be cited as NPF Direction No.94.

Commencement

2. This Direction commences on day of registration.

Application

3.1 This Direction applies to a holder of statutory fishing rights in the Northern Prawn Fishery and to a person acting on behalf of the holder.

3.2 However, this Direction does not apply to the holder of a scientific permit that authorises the use of an alternative Turtle Excluder Device or By-catch Reduction Device.

Period of Application

4. This Direction applies for a period beginning on the date this Direction commences and ending on 31 March 2010.

Interpretation

5.1 In this Direction:

"**boat**" means a boat that is nominated on statutory fishing rights for the Northern Prawn Fishery, and includes carrier boats and fishing boats;

“**By-catch Reduction Device**” means a device that allows fish and other animals to escape immediately after being taken in the net and is constructed in accordance with Schedule 1;

“forward edge” is the edge of a By-catch Reduction Device where the funnel is attached to the codend;

“modified Turtle Excluder Device” means a device described in Schedule 2;

“**net**” means a net used for trawling except a try-net;

“**Turtle Excluder Device**” means a device fitted to a net, and modification made to a net, that allows turtles to escape immediately after being taken in the net, and which has:

a) a rigid or semi-rigid inclined barrier grid comprised of bars extending from the foot to the head of the net that is attached to the circumference of the net which must guide turtles towards an escape hole immediately forward of the grid. **The minimum dimensions of this grid to be at least 81cm by 81cm. This structure is to be set at a minimum angle of between 30 and 55 degrees in relation to the horizontal plane of water through the net;** and

b) an escape opening which must be:

- a double flap rectangular net opening where the cut immediately forward of the TED must be a minimum of 61 cm and the two forward cuts of the escape opening must not be less than 51 cm long from the points of the cut immediately forward of the TED frame. The resultant length of the leading edge of the escape opening cut must be no less than 142 cm stretched, or a double flap net triangular opening where the cut immediately forward of the TED must be a minimum of 102 cm with minimum forward cuts of 101 cm.The flaps must be composed of two equal size rectangular panels of mesh. Each panel must be a minimum of 147 cm wide and may overlap each other no more than 38 cm. The panels may only be sewn together along the leading edge of the cut. The trailing edge of each panel must not extend more than 61 cm past the posterior edge of the TED frame. Each panel may be sewn down the entire length of the outside edge of each panel, or;

- a single flap rectangular net opening where the cut immediately forward of the TED must be a minimum of 61 cm and the two forward cuts of the escape opening must not be less than 66 cm long from the points of the cut immediately forward of the TED frame. The resultant length of the leading edge of the escape opening cut must be no less than 181 cm stretched, or a single flap triangular net opening where the cut immediately forward of the TED must be a minimum of 102 cm with minimum forward cuts of 136 cm. The flap must be a minimum of 338cm by 132 cm piece of mesh. The 132 cm edge of the flap is attached to the forward edge of the opening 180 cm edge. The flap may extend no more than 61 cm behind the posterior edge of the TED frame.

c) a maximum bar spacing of 120mm.

d) Floats must be attached to the top one-half of all TEDs with bottom escape openings. The floats may be attached either outside or inside the net, but not to a flap. Floats of any size and in any combination must be attached such that the combined buoyancy of the floats, as marked on the floats, equals or exceeds the weight of the TED.

e) it is not permitted to attach any weights, meshing or other materials which may inhibit the opening of this escape flap.

5.2 For the purposes of this Direction, all net measurements refer to the measurement extending from the centre of opposing knots, when the mesh is pulled taut.

5.3 A term used in this Direction that is defined for the purposes of the Northern Prawn Fishery Management Plan 1995 has the same meaning in this Direction as it has in that plan.

[**Notes**: 1. Terms defined in the *Fisheries Management Act 1991* have the same meanings in this determination.

2. Terms defined in the Northern Prawn Fishery Management Plan 1995 include "Northern Prawn Fishery" and "Northern Prawn Fishery area".]

Nets to which devices must be fitted

6.1 The fishery is closed to a boat using a net unless each net used by that boat has:

(a) both a Turtle Excluder Device and a By-catch Reduction Device (as described in Schedule 1) installed in each net that is rigged for fishing; or

(b) a modified Turtle Excluder Device (as described in Schedule 2) installed in each net that is rigged for fishing; and

(c) the codend cover (skirt) attached no further than 60 meshes from the codend drawstrings.

6.2 A net is rigged for fishing if part or all of the net is in the water, or if it is shackled, tied or otherwise connected to any trawl door or trawl board, or to any tow rope or cable, either on board the boat or attached in any manner to the boat.

Revocation of NPF Direction No. 81

7. This Direction revokes NPF Direction No. 81 with effect from the day of commencement.

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SCHEDULE 1

Each of the following are by catch reduction devices:

1. "Square Mesh Codend" means a codend with at least half the circumference of the codend, and that has the following characteristics:

(i) a nominal mesh size no less that 45mm; and

(ii) netting orientated so that the Direction of twine is longitudinal and transverse to the length of the codend; and

(iii) an overall length no less than 75 meshes (3.375 metres); and

(iv) no pieces of netting or other material covering any escape openings of the square mesh, nor any opening closed by any other means, during fishing operations.

2. "Square Mesh panel" means a continuous panel of netting that has the following characteristics:

(i) a nominal mesh size no less than 101mm; and

(ii) an overall dimension no less than 400mm wide and 600mm long; and

(iii) the aft edge of the panel is located no further forward than 120 meshes of the codend drawstrings; and

(iv) no pieces of netting or other material covering any escape openings of the square mesh, nor any opening closed by any other means, during fishing operations.

3. "Fisheye" means a device that has the following characteristics:

(i) a vertical escape opening held open by a rigid frame; and

(ii) an escape opening measuring no less than 350mm wide x 150mm high; and

(iii) an escape opening located no further forward than 120 meshes of the codend drawstring; and

(iv) no pieces of netting or other material covering any escape openings, nor any opening closed by any other means, during fishing operations.

4. "Yarrow Fisheye" means a device that has the following characteristics:

(i) a vertical escape opening held open by a rigid frame; and

(ii) an escape opening measuring no less than 350mm wide x 150mm with the width of the escape opening divided in half by a solid bar; and

(iii) an additional rigid bar running from the apex of the frame to the top of the escape opening; and

(iv) the escape opening located no further forward than 120 meshes of the codend drawstring; and

(v) no pieces of netting or other material covering any escape openings, nor any opening closed by any other means, during fishing operations.

5. "Radial Escape Section" (RES) means a device that has the following characteristics:

(i) a funnel of netting or other material located within the codend; and

(ii) the circumference of the leading edge of the funnel must be of equivalent length to and attached to the circumference of the codend, where the circumference of the codend is equivalent to the product of the mesh size and the number of meshes around the codend; and

(iii) the leading edge of the funnel must be attached to the codend no less than 10 meshes from the leading edge of the escape openings; and

(iv) the circumference of the trailing edge of the funnel is less than or equal to 0.6 times the number of meshes in the circumference of the codend; and

(v) individual escape openings no less than a square mesh size of 100mm; and

(vi) overall escape openings no less than a panel of netting measuring 350mm long and extending radially around the codend for at least half the circumference of the codend; and

(vii) the trailing edge of the funnel extending no more than 500mm past the aft edge of the escape openings, and

(viii) the aft edge of the escape openings located no greater than 120 meshes of the codend drawstrings; and

(ix) the forward edge of the RES located no further forward than 900mm of the Turtle Excluder Device grid, or if located further forward than 900mm of the Turtle Excluder Device grid a wire hoop must be attached to the forward edge[1] of the RES; and

(x) a rigid or semi-rigid wire hoop with a minimum diameter of 650mm located no more than 5 meshes behind the escape openings; and

(xi) no pieces of netting or other material covering any escape openings, nor any opening closed by any other means, during fishing operations.

6. "Popeye Fishbox" means a device that has the following characteristics:

(i) a vertical escape opening held open by a rigid frame; and

(ii) an escape opening measuring no less than 375 mm wide x 375 mm; and

(iii) a rigid foil positioned at the forward edge of the BRD no less than 200 mm in depth; and

(iv) an escape opening located no further forward from the codend drawstrings than the number of meshes for a codend mesh size described in Schedule 3; and

(v) no pieces of netting or other material covering any escape openings, nor any opening closed by any other means, during fishing operations.

SCHEDULE 2

“Modified Turtle Excluder Device” means a device that:

(i) is a Turtle Excluder Device with the escape opening in the top of the codend; and

(ii) a bar spacing no more than 60mm; and

(iii) may have an escape flap over the escape opening (but no part of the escape flap may be closer than 150mm to any part of the grid, when the Turtle Excluder Device is fitted to a codend hung vertically); and

(iv) may have a guiding funnel or flap inside the codend ahead of the grid (but no part of the guiding funnel or flap may be closer than 150mm to any part of the grid, when the TED is fitted to a codend hung vertically

Appendix 4: Queensland's East Coast Otter Trawl (ECOT) fishery TED and BRD approved devices and specifications as prescribed in the Fisheries (East Coast Trawl) Management Plan 1999

Part 3 Use of BRDs
Division 1 Preliminary

40 Application and purpose of pt 3

This part—

(a) applies if, under chapter 4, a BRD must be used with a net used under a provision of that chapter; and

(b) prescribes an additional condition to which the licence under which the net is used is subject.

41 Purpose of BRD

The purpose of a BRD is to reduce the level of bycatch taken by the use of the net to the lowest level that allows the economically viable use of the net, having regard to the sustainability of the east coast trawl fishery's ecological systems.

Division 2 BRD use condition

42 Requirement to achieve purpose

(1) The licence under which the net is used is subject to a condition (the ***BRD use condition***) that the use of the net must achieve the purpose of a BRD.
(2) The BRD use condition also applies to anyone acting under the licence.

Division 3 Compliance with BRD use condition
Subdivision 1 Preliminary

42A Definition for div 3

In this division—***bar***, in relation to mesh in a trawl net, means—

(a) for a knotted trawl net—a side of a mesh of the net from 1 knot to the next knot on the same side of the mesh; or
(b) for a knotless trawl net—a side of a mesh of the net from 1 corner to the next corner.

Subdivision 2 General provision for compliance

43 How to comply

(1) The BRD use condition is taken to have been complied with if a recognised BRD is used with the net.
(2) In this section—

recognised BRD means a device that complies with—

(a) for an otter trawl net—subdivision 3; or
(b) for a beam trawl net—subdivision 4.

Subdivision 3 Recognised BRDs for otter trawl nets

43A Application of sdiv 3

This subdivision applies only to an otter trawl net.

44 Square mesh cod end

The net's cod end is a recognised BRD if—

(a) at least half the cod end's circumference is square mesh of at least 45mm; and
(b) the square mesh has at least 75 bars along each side of the mesh; and
(c) the square mesh net is no more than—
  (i) for a net used to take prawns—5 meshes from the cod end drawstrings of the net; or
  (ii) for a net used to take scallops—3 meshes from the cod end drawstrings of the net; and
(d) nothing covers any of the square meshes during trawling.

45 Square mesh panel

A panel of the net is a recognised BRD if—

(a) the panel—
  (i) is square mesh of at least 10.1cm; and
  (ii) is at least 60cm wide and 40cm long; and
(b) the entire panel is no more than—
  (i) for a net used to take prawns—100 meshes from the cod end drawstrings of the net; or
  (ii) for a net used to take scallops—50 meshes from the cod end drawstrings of the net; and
(c) nothing covers any of the square meshes during trawling.

46 Fisheye

An opening in the net is a recognised BRD if—

(a) the opening—
  (i) is held open by a rigid frame; and
  (ii) is at least 35cm wide and 15cm long; and
(b) the opening is no more than—
  (i) for a net used to take prawns—100 meshes from the cod end drawstrings of the net; or

(ii) for a net used to take scallops—50 meshes from the cod end drawstrings of the net; and

(c) nothing covers any part of the opening during trawling.

47 Bigeye

An opening in the net is a recognised BRD if—

(a) the opening—

(i) is in the top of the net; and

(ii) is at least 1m across the width of the net; and

(b) the opening is no more than—

(i) for a net used to take prawns—200 meshes from the cod end drawstrings of the net; or

(ii) for a net used to take scallops—100 meshes from the cod end drawstrings of the net; and

(c) the opening has, during trawling, a weighted forward section and a buoyed rear section; and

(d) the edges of the opening do not overlap by more than 28.5cm; and

(e) nothing covers any part of the opening during trawling.

48 Radial escape section

(1) A combination of a funnel, hoops and openings in the net is a recognised BRD if—

(a) they comply with subsections (2) to (4); and

(b) nothing covers any part of the openings during trawling.

(2) The funnel must—

(a) be attached to the net for all of the funnel's front edge circumference; and

(b) have a number of meshes in its rear edge circumference of no more than 60% of the number of meshes in the circumference of the net at its rear edge.

(3) The net must have—

(a) either—

(i) a hoop attached to it at the funnel's front edge that keeps the funnel fully open; or

(ii) a TED within 90cm of the funnel's front edge; and

(b) a hoop (the ***rear hoop***)—

(i) with a diameter of at least 65cm; and

(ii) no more than—

(A) for a net used to take prawns—105 meshes from the cod end drawstrings of the net; or

(B) for a net used to take scallops—53 meshes from the cod end drawstrings of the net.

(4) The openings must comply with the following—

(a) they must be forward of the rear hoop;
(b) the rear edge of the rear opening must be within 5 meshes of the rear hoop;
(c) they must extend for at least 35cm and cover at least half the net's circumference;
(d) they must be at least 10.1cm in each of their dimensions;
(e) they must be no more than 50cm forward of the funnel's rear edge.

V-cut and bell cod end

(1) A combination of the net's cod end and a V-cut opening in the cod end is a recognised BRD if—

(a) the last 33 meshes of the net from the cod end drawstrings of the net have a circumference of at least 150% of the rest of the cod end; and
(b) the opening complies with subsections (3) and (4); and
(c) nothing covers any part of the opening during trawling.

(2) However, subsection (1)(c) does not apply if—

(a) the meshes are left attached along the forward edge of the opening leaving a flap of net; and
(b) the edges of the flap do not extend wider than the opening during trawling.

(3) The opening must—

(a) be in the top of the net; and
(b) have 2 diagonal forward measurements of 10 bars of the net; and
(c) have a lateral measurement along its forward edge of 11 meshes of the net.

(4) The apex of the opening must not be more than 45 meshes of the net from the drawstrings.

48B Popeye fish excluder

(1) A combination of a funnel, frame and a rectangular opening in the net is a recognized BRD if—

(a) they comply with subsections (2) and (3); and
(b) nothing covers any part of the opening during trawling.

(2) The funnel must—

(a) be attached to the net for all of the funnel's front edge circumference; and
(b) be held open by—
    (i) a hoop attached to the net at the funnel's front edge; or
    (ii) a TED that is not more than 62cm from the funnel's front edge; and
(c) have a number of meshes in its rear edge circumference of no more than 60% of the number of meshes in the circumference of the net at the rear edge; and

(d) have a stretched length no longer than 2.25m; and
(e) be no more than 110 meshes of the net from the the cod end drawstrings of the net.

(3) The opening must be—

(a) no more than 95 meshes of the net from the drawstrings; and
(b) at least 40cm long and 38cm wide; and
(c) held open by a frame made of material that is rigid enough to ensure that, while the net is being used for trawling, the opening is at least 40cm long and 38cm wide.

Part 4 Use of TEDs

Division 1 Preliminary

51 Application and purpose of pt 4

This part—
(a) applies if, under chapter 4, a TED must be used with a net used under a provision of that chapter; and
(b) prescribes an additional condition to which the licence under which the net is used is subject.

52 Purpose of TED

The purpose of a TED is to allow turtles to escape immediately after being taken in the net.

Division 2 TED use condition

53 Requirement to achieve purpose

(1) The licence under which the net is used is subject to a condition (the ***TED use condition***) that the use of the net must achieve the purpose of a TED.
(2) The TED use condition also applies to anyone acting under the licence.

Division 3 Compliance with TED use condition

54 Compliance with TED use condition

The TED use condition is taken to have been complied with if a device that complies with section 55 (a ***recognised TED***) is used with the net.

55 Requirements for a recognised TED

(1) A recognised TED must consist of a barrier and an opening that allows turtles to escape immediately after being taken in the net.
(2) The barrier must consist of a rigid or semirigid inclined barrier of bars attached to the net's circumference that acts to steer turtles through the opening.

(3) The bars must be no more than 12cm apart.

(4) The opening must—

(a) be immediately forward of the edge of the barrier that is closest to the cod-end of the net; and

(b) have a minimum taut measurement across the widest part of the net of—

(i) for a net that is used in a beam trawl net no longer than 5m—50cm; or

(ii) for another net—60cm; and

(c) have a minimum taut measurement across any other part of the net of 50cm; and

(d) have at least 1 taut measurement of at least 76cm.

Appendix 5: Current contact details of presenters

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