Disseminating existing bycatch reduction and fuel efficiency technologies throughout Australia's prawn fisheries

FINAL REPORT

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Executive Summary

Prawn trawling is among the world's least selective fishing methods, the unintended consequence being large quantities of bycatch. It is also a method that can disturb benthic habitats and use large quantities of fuel—a significant running cost for many fisheries. Issues of bycatch and fuel efficiency are of significant concern to many stakeholders including prawn trawl operators, environmental groups, eco-labelling agencies and the general public.

For several decades, Australian gear technologists have been developing solutions to bycatch issues in prawn-trawl fisheries and, most recently, significant work has also occurred in designing prawn trawls that are more fuel efficient, reduce bycatch and/or have reduced benthic impacts (FRDC project 2011/010). The end-result of all this work is detailed information on a broad array of technologies that can ameliorate such problems. It was decided by the FRDC and ACPF that the next phase in progressing such solutions throughout Australia was to disseminate the available information to as many prawn fishers, net makers, jurisdictional scientists and managers as possible. Following an initial workshop of representatives from various fisheries around Australia (FRDC 2016/057), it was decided to extend the information to as many individual fisheries as possible so that they can be considered, trialled, modified, etc. to achieve optimal performance in each situation. The workshop therefore recommended the organisation of a "Prawn trawl roadshow", using the expertise of Australia's fishing gear technologists to explain and discuss these concepts with fishers in each fishery. The intention was that then, local fishers and jurisdictions would consider the various options and adopt them for trial/use in their own fisheries, leaning on the expertise of relevant gear technologists.

Following an initial examination of a risk/gap matrix developed by ACPF, a series of 12 workshops were held at some of the key prawn-trawl ports in Australia. These were in Darwin, Cairns, Townsville, Hervey Bay, Brisbane, Carnarvon, Yamba, Coffs Harbour, Newcastle, Adelaide, Port Lincoln and Lakes Entrance. At each, the PI and a fishing gear technologist gave presentations that summarized the information currently available on how to reduce bycatch, habitat-impacts and fuel use that have been developed in Australia and other countries, as well as recent work being done in Europe due to the implementation of its Discard Ban. During these workshops and

subsequent discussions at wharves, on boats, etc., various priority issues and potential solutions were identified for future examination.

The project resulted in a very significant increase in the number of stakeholders (particularly trawl skippers and crews) being made aware of the latest ways that bycatch and habitat impacts can be reduced while concomitantly increasing fuel efficiency. One-hundred-and-forty-six people participated in the workshops and/or on boats, at wharves, etc. (comprising120 fishers, 18 executive officers/facilitators, five fisheries managers, two scientists and one representative from Oceanwatch). As a result, this extension project has been able to reach a significant proportion of the total number of prawn trawl stakeholders in the country. In addition, the material presented has been made available as a stand-alone presentation with associated videos (at http://australianwildprawns.com.au/) so that anyone else interested in this work can obtain the information disseminated.

The workshops were successful in identifying the specific (and varied) issues each fleet has with bycatch and habitat-impact reduction and fuel-efficiency. Many of these issues and future work are specific to each fishery and should therefore form the focus of future industry and or scientifically based work in each. However, there were several issues that were common to more than one fishery and sometimes several. These more generic issues included:

- More streamlined permit-approval processes for fishers to trial modifications;
- A system where fishers could be trained in the use of, and get access to, FRDC's Notus portable acoustic net measurement sensors and load cells;
- Examine the utility of LED lights and other anterior modifications to elicit behavioural responses and reduce bycatch;
- Test the recently developed fisheyes (Kon's and the FishX 70) against the square mesh panel to reduce bycatch of small fish;
- Check and assess knot orientation to reduce bycatches and improve fuel efficiency;
- Designing retroactive modifications to otter boards that facilitate variations from approx. 35^0 when deploying to the critical 20^0 when fishing to reduce drag and fuel consumption;
- Examine anterior modifications to reduce sawfish bycatch including electromagnetic stimuli and/or LED lights;
- Using round/oval TEDs instead of rectangular TEDs; and
- Examine soft brush ground gear to reduce benthic impacts and drag.

The net result of all this work is a concrete set of agreed issues and potential solutions for each fleet that can be used by fishers, scientists, managers and funding agencies to conduct formal trials of modifications to deal with such issues in their prawn-trawl fleets. Fleet-wide reductions in bycatch, habitat impacts and drag will eventually produce low impact, fuel efficient (LIFE) Australian prawn-trawl fisheries over the next few years.

Keywords: Bycatch Reduction, Fuel Efficiency, Low Impact Fuel Efficient Fishing, Prawn Trawl, Anterior trawl modifications, Information Dissemination.

Introduction

Despite decades developing more selective fishing gears, bycatch and discarding remain major fisheries issues throughout the world with demersal prawn trawling still considered one of the least selective methods. In addition to large quantities of bycatch, demersal trawling can also disturb benthic habitats, upon which prawns and associated ecosystems depend. Not only can such disturbances affect these systems, they also contribute to the high energy needs (created by drag) of trawlers. Issues of bycatch, habitat impacts and fuel efficiency are now becoming uppermost in the concerns of many stakeholders including: prawn-trawl operators (who wish to reduce environmental impacts, running costs and avoid on-board discard handling), environmental groups (who are concerned about ecosystem disturbance and energy use), eco-labelling agencies (whose requirements include a focus on bycatch and habitat impacts), and the general public (who dictate the social licence to operate for such fisheries). These issues have therefore attracted the attention of many governments and international agencies including the UN's Food and Agriculture Organisation (FAO)—who first coined the term Low Impact Fuel Efficient (LIFE) gears encompassing methods that reduce bycatch, habitat impacts and drag.

For several decades Australian fishing gear technologists have developed solutions to such issues; the end-result of which is detailed information on a broad array of novel technologies. It was decided that the next phase in progressing such solutions throughout Australia is to disseminate the available information to as many prawn fishers, net makers, jurisdictional scientists and managers as possible. To this end, in February 2017, FRDC, the Australian Council of Prawn Fisheries (ACPF) and IC Independent Consulting hosted a workshop (FRDC 2016/057) of fishing-gear experts and representatives from Australian prawn-trawl fisheries to explore priorities for future work to develop ways to further reduce bycatch, habitat impacts and drag in prawn trawls. The workshop began by exploring the work recently done in this area. This included new developments by Broadhurst and Sterling in their recently completed FRDC project 2011/010 and some of the work undertaken in each state and overseas. The work presented showed that there now exists a broad ranging array of modifications to trawl gear that can significantly reduce bycatch, habitat impacts and drag — depending on the particular circumstances of each fishery.

The workshop concluded that these options now require full extension into individual fisheries so they can be considered, trialled, modified, etc. to achieve optimal regional performances. The workshop therefore recommended the organisation of a "Prawn Trawl Roadshow", using the expertise of Australian gear technologists to explain and discuss these concepts with fishers in each fishery. The intention was that then, local fishers and jurisdictions would ideally take the various options and adopt them for trial/use in their own situation, leaning on the expertise of relevant gear technologists.

Subsequent to the February workshop, the ACPF worked with individual fisheries and derived a bycatch and efficiency risk/gap matrix (see Table 1 in the Results section below). This provided an excellent starting point for extending existing information by focusing potential solutions to particular fisheries' issues. Some of the issues identified were quite generic (general reduction of discards of unwanted organisms like small fish and overall improvements in fuel efficiency),

whilst others were quite fishery-specific (reduction of catches of particular species like blue swimmer crabs, small mulloway and certain threatened, endangered protected (TEP) species like sea snakes, sawfish and turtles). The ACPF then sent a call for Expressions of Interest from relevant scientists around the country for a project that takes this next step – disseminating the relevant information to as many Australian prawn fisheries as possible and to plan the subsequent testing of gears that address each fishery's particular issue(s). The result of that Call is this dissemination project that involved a series of port visits and workshops. At these workshops, specific bycatch and efficiency issues for each fishery were identified and potential solution(s) developed.

Objectives

1. Review ACPF's risk/gap matrix and undertake a preliminary analysis of the types of technologies that would be beneficial for discussion/testing in each fishery
2. Identify the best locations and times for individual port visits in WA, Qld, NT, SA, VIC and NSW
3. Do the port visits at which: (i) the latest information on bycatch reduction and fuel efficiency technologies will be presented; and (ii) particular issue(s) identified for each fishery will be discussed and various technological solutions will be outlined and considered;
4. During and after these workshops, document a process for trials of appropriate technologies that arise;
5. Identify any other gaps (technological, administrative, etc) that may arise during the workshops; and
6. Provide a final report which describes the outcomes from each workshop and consequent actions for trials in each fishery.

During the project it was also agreed to add another objective (within the existing budget):

7. Provide a consolidated PowerPoint presentation with videos that contains the workshop material for the ACPF to distribute to prawn-trawl operators who could not make the workshops in person (and to any other people as appropriate).

Methods

A Steering Committee was established for the project to monitor progress and advise on any modifications that may be required. It met periodically and comprised the PI and representatives from FRDC and the ACPF. In addition, the Co-Investigators on this project were the Executive Officers of the main prawn-trawl industry associations throughout the country. Their role was to advise on the locations and timing of each workshop and also play a key role in ensuring local ownership of the results that arose.

The first objective required a review of the ACPF's risk/gap matrix and a preliminary analysis of the types of technologies that would be beneficial for discussion/testing in each fishery. This was done early in the project and reported in the first milestone report. Next, we (the ACPF, FRDC

and the PI) identified the best locations and times for individual port visits throughout the country.

The main part of this project involved these port visits which occurred throughout Queensland, the Northern Territory, Western Australia, South Australia, Victoria and New South Wales. These involved the PI and one of Australia's trawl gear experts (Drs Matt Broadhurst or Steve Eayrs). Each visit around the country's main prawn-trawl ports (i.e. Darwin, Cairns, Townsville, Hervey Bay, Brisbane, Carnarvon, Yamba, Coffs Harbour, Newcastle, Adelaide, Port Lincoln and Lakes Entrance) were done at times that tried to maximise the participation of relevant players. These include the skippers of each region's prawn fleet, netmakers, gear technicians, scientists and managers (the latter from the appropriate jurisdiction).

The workshops were collaborative events between the local industry, managers, researchers and the above trawl gear experts. Their main purpose was to map out a path forward for each fishery to deal with its particular bycatch, habitat impact and/or fuel efficiency issues. During each visit, presentations were delivered that summarized the information about technologies currently available to reduce bycatches, habitat impacts and improve fuel-efficiency that have been developed in Australia and other countries, as well as recent work being done in Europe as a result of the implementation of its Discard Ban.

The presentations were somewhat tailored to suit the particular bycatch/habitat/efficiency issue that the particular fishery has - based to some extent (but not exclusively) on the gap matrix provided by the ACPF (Table 1). During these workshops and subsequent discussions, various priority areas were identified as candidates for future examination. In addition, the PI identified potential owners/skippers/boats who might be appropriate for undertaking the work with an appropriate gear expert, subject to funding.

Results

Review of the ACPF's risk/gap matrix

As mentioned above, the first milestone for this project involved a review of the ACPF's risk/gap matrix (Table 1), identifying potential solutions to each fishery's priority issues.

Table 1 - Australian prawn fishery bycatch and efficiency risk/gap matrix

This risk/gap matrix is from ACPF and was designed to provide guidance on an appropriate model for extending known methods to reduce bycatch and/or improve fuel efficiency.

Fishery	**Bycatch risks** *"What are the bycatch related risks to your fishery's future? E.g. Endangered species, community perception, changing regulation,*	**Bycatch gaps** *"What information does your fishery need to address the bycatch risks?"*	**Trawl efficiency risks** *"What are the trawl efficiency related risks to your fishery's future? E.g. old gear, lack of new technology to address emerging issues?"*	**Trawl efficiency gaps** *"What information does your fishery need to address the trawl efficiency risks?"*
Spencer Gulf	Non permitted commercial species/incidental catch depending on management strategy (external to the fishery)	Information on gear modification options What percentage of the fishery is impacted. If significant, then look at needs which may include gear modification (and/or spatial management)	Fuel efficiency is good but could be improved further with update of equipment and configurations.	Information and calculated efficiencies for gear configuration that could be trialled to improve efficiency
Gulf St Vincent	Non permitted commercial species e.g. Crabs and other incidental species (leather jackets) that clog up nets and the BRDs	• Gear modification to better improve catch of target species • Ecosystem relationship study (populations of species and their impact on prawn population) a lesser concern	• Need to better develop gear not just the nets themselves to improve efficiency. • Net design. • Fuel efficiency	Information on net configuration, board design and improvements in BRD development (not just net design)
NSW	Small fish, esp listed species such as mulloway The inability to trial new bycatch reducing gear in reasonable timeframes	Information on and the assistance to trial, evaluate and monitor gear adaptations	Fishing efficiently around weed The inability to trial new gear in reasonable timeframes	Information on and the assistance to trial, evaluate and monitor gear adaptations
Queensland	Community perception Juvenile recreational fish species (e.g. snappers)	• Gear modification (eg BRDs) • Understand the species (spatial/temporal) so that it can be managed. Info on interaction of spatial/ temporal of target vs bycatch fish	Harvest strategy (as opposed to gear inefficiency) is far greater issue to be resolved to increase catch efficiency. Gear and trawl technique to fish around weed	Understanding environmental drivers so that trawl efficiency can be increased/ effort can be directed

Shark Bay	Sea snake & turtles	Assessment & reporting (via the MSC system)	• Optimising use of current equipment • With an aging fleet, the difficulty of updating vessels to efficiently cater for multispecies catch on vessels	Information about how to cost effectively set up new equipment and processes on board
Exmouth	Sawfish	Assessment & reporting (via the MSC system)	Use of equipment and fuel efficient configuration	Optimising use of equipment
Northern Prawn	• Community perceptions that all trawl fisheries are indiscriminate and destructive • Interactions with threatened species	• continued monitoring of threatened/at-risk species and impacts of trawling on these (we do this through our sustainability assessment and CMO program) • assessment of all bycatch and TEP species (done through ERA and MSC assessments) • new technologies to continue to reduce bycatch and interactions with threatened species • gear specialists to assist with the testing and/or implementation of new technologies/gear or modifications to current gear – just presenting information to operators doesn't help much, it needs to be more hands on.	• Old gear design – trawl net designs don't vary much and haven't really changed much over the decades. Some tweaking with twine and knot orientation, different materials for nets and boards etc over the years but overall no significant changes. • High fuel consumption - largest cost to the fishery	• New technologies/ modifications to improve trawl efficiency and reduce fuel consumption • As above- gear specialists to assist with the testing and/or implementation of new technologies/gear or modifications to current gear
Victoria	A multi-species catch fishery so bycatch in prawn catch isn't high priority		Use of equipment for mixed species catch	Information on cost effective gear modification/updates to improve general trawl efficiency

Taking each fishery in turn:

South Australia's **Spencer Gulf and West Coast** prawn-trawl fisheries identified that reducing the bycatch of non-permitted commercial species (which mainly includes blue swimmer crabs and various species of finfish), with minimal loss of target product, is an important step in self improvement. The fishery will continue to use spatial management and review new BRD technologies as they are developed.

We note that many previous studies in Australia and overseas have shown that particular grid designs successfully reduce the bycatch of crabs and finfish and, indeed several have been trialled in this particular fishery, which has invested in by-catch reduction devices since the 1980's. Clearly, these designs should be those that would form the early focus of any subsequent research if fine-tuning of such designs is required in particular areas of the fishery. However, there are also other concepts which we discussed at the workshop that may assist in this particular fishery (which tows its nets relatively fast) including tow speed, varying headline and foot rope heights and using alternative ground gears.

For fuel efficiency, the industry requested updates regarding the sorts of equipment and configurations that are available and their estimated efficiencies. Such information is now available as a result of the work by Broadhurst and Sterling and was delivered at the workshop. They involved a consideration of many different concepts including:

- Overall gear design (single-, double-, dual-, triple-, quad-,and penta-rigs, beam trawls, W trawls, and tongue trawls);
- Improved efficiencies associated with otter-board design including multi-foil doors, batwing boards, bisons, cambered doors, etc.;
- Effects of different ground gears including different sized chains, soft-brush gear, etc.;
- Improved performance by using fewer boards, and more sleds, etc.;
- The role of twine size, net length, sweep length, low-drag netting, etc. in reducing drag;
- Wing mesh height and orientation;
- Knot orientation; and
- Trawl body taper, mesh size, seam number, and hanging ratios.

From these options, at the workshop we identified which may be appropriate for initial testing in the fishery. For example, the West Coast prawn fishery showed some interest in reviewing gear design to improve efficiency and profitability.

The **Gulf St Vincent** fishery has very similar concerns as the Spencer Gulf fishery, with the reduction of crabs and other non-permitted species a priority. Similar solutions as the above regarding various grids and trawl modifications were discussed at the workshop. We noted that a study about ecosystem impacts of bycatches on the western king prawn population is also mentioned as an issue for this fishery, but is a lesser concern and falls outside this project's focus on gear-based solutions.

For **NSW**, the main issue concerns the bycatch of small fish and in particular species like mulloway. And we noted that a very large amount of work has been done (and indeed has been implemented) for small fish in relevant fisheries. A significant issue for this jurisdiction was raised at the Cronulla workshop and again in Table 1 and concerns the ease at which industry is able to fine-tune (for particular fisheries and vessels) the various modifications that Broadhurst and others have developed for NSW's oceanic and estuarine prawn-trawl fisheries. That is, a more streamlined system for industry-based testing of gears seems to be needed.

For the particular issues identified in NSW, relatively simple square-mesh panels and grid systems have been shown to work quite well and these were discussed further at the workshops. But in addition, various modifications anterior of the trawl such as the 'simple anterior fish excluder' (SAFE) also warrants attention. The capture of weed was also identified as a particular problem for NSW and solutions including raising footropes and using soft brush ground gear were discussed. For fuel efficiency, as for the other fisheries mentioned above, information about various modifications to trawl configurations to improve performance is required and were provided at the workshops.

Queensland's trawl sector noted public perception concerns related to bycatch, particularly in relation to small fish and, as they are known in Queensland, Species of Conservation Interest (SOCI) like turtles, sea snakes and sawfish. Fishers were looking for assistance to prioritise impacts so that they could focus on ways to ameliorate them. Depending on the species, we noted that there exist basic modifications that have proven to reduce bycatches of the species mentioned like grids (for larger animals like turtles – i.e. TEDs), square-mesh panels and especially fisheyes for sea snakes. With regard to reducing catch of, and injury to, sawfish the workshops discussed bar spacings on grids, but also the netting material used, particularly as the net contracts anterior to the grid. Such modifications were considered to identify particularly promising modifications to trial in subsequent work..

As for NSW, we also noted the desire in Queensland to deal with high catches of weed in nets and, as mentioned above, various modifications involving soft brush ground gear, grids and panels that alter water flow in the net may prove worthy of further examination.

For the Western Australian fisheries at **Exmouth and Shark Bay**, fishers prioritised the need to further reduce their TEP bycatches (turtles, sea snakes and sawfish) and the potential solutions outlined above (certain grids, panels and fisheyes) were discussed at the workshop. In addition, we noted their focus on monitoring of such bycatches for Marine Stewardship Council reporting and, while not part of this project regarding gear technology, we outlined various electronic reporting and monitoring options that are being developed throughout the world. For trawl-efficiency work, we noted the need for information about optimal ways to build and deploy existing and modified trawls. The above-mentioned options for improving trawl efficiency (like shorter nets, modified boards, etc.) were provided at the workshop in WA.

For the **Northern Prawn Fishery (NPF)**, we noted industry's concerns regarding community perceptions that all trawl fisheries are indiscriminate and destructive and have significant interactions with threatened species. As a result, the NPF continues to seek new technologies that build on previous work to reduce bycatch and SOCI interactions. Gears like various grids

(TEDs), square-mesh panels and fisheyes (especially the new Kon's Covered Fisheye) were discussed for possible refinement in subsequent work. The NPF also noted a specific need for the involvement of fishing gear specialists to assist with the testing and/or implementation of new technologies. That is, whilst these workshops were seen as a good first step, the NPF require on-the-ground gear experts to assist with future tests and refinements. We used our workshops to introduce the relevant fishing gear technologists to these fishers who had not been previously exposed to such expertise.

In terms of trawl efficiency, the NPF noted that its gear has remained relatively unchanged for decades and that fuel expenses are a major cost. Information on the latest ways to make and deploy trawl gears was required as well as the experts needed to test such options in the fishery. As mentioned above, a number of options regarding overall net configurations, otter board-types and ground gears were described that can reduce fuel consumption and were discussed as a pre-cursor to the identification of particular modifications to test.

For **Victoria**'s mixed-trawl fishery, bycatch issues are less of a concern, but we noted the desire for updated information on ways to enhance overall trawl efficiency, maximise catches of the mixed species assemblages landed, whilst reducing fuel usage. The various modifications mentioned above to assist with these issues were outlined at the workshop and future directions identified.

The Workshops

At each workshop, after introducing the project, we began with several presentations about: (i) various initiatives occurring in bycatch and habitat-impact reductions and fuel efficiency around the world, within Australia, and past and current work concerning gear modifications that reduce bycatch and habitat impacts and improve fuel efficiency. All talks, videos, etc. were left with the industry representatives at each location for distribution to interested fishers. In addition, we offered and supplied all materials to any fishers wanting them.

During and after the talks, as well as the next day, onboard vessels and dockside, significant discussion occurred among attendees; the key outcomes of which are summarized below.

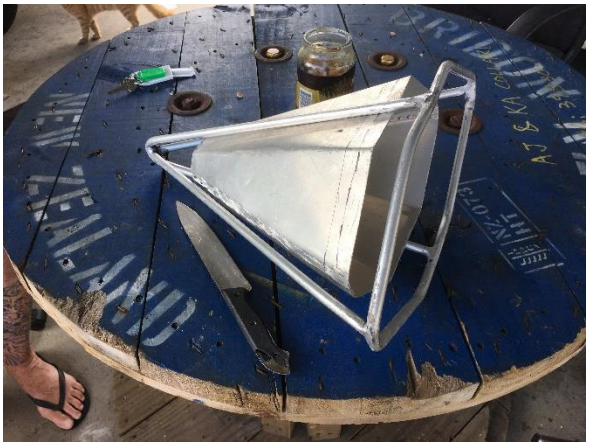
Townsville (Qld East Coast Trawl)

This was the first of the workshops and was held on 20 and 21 February 2018. Three fishers, one Exec Officer and the ACPF's Exec Officer attended the formal workshop and we also met with two other fishers the next day at the wharf. Matt Broadhurst was the attending gear expert. The main issues discussed concerned the need to reduce bycatches of certain species (particularly sea snakes). We discussed sawfish which were noted to not be a significant issue for these fishers as only one or two are caught per year.

One of the fishers was particularly interested in trying Kon's Covered Fisheye and had a prototype built which we examined and suggested some "tweaking" (Fig. 1). At the time of the workshop he noted frustration at the long process involved in getting the appropriate permit to test the gear. Fishers in general noted a need for a more streamlined permit-approval process so

that they can try modifications prior to formal experimental trials. In any case, the fisher's permit came through soon after the workshop. The intention is that, once he completes some preliminary testing, if it seems to be working well, a formal experimental trial involving scientific data collection may be required to implement the modification.

Fig. 1. Kon's Covered Fisheye developed by a Townsville fisher.



Adelaide (Gulf St. Vincent)

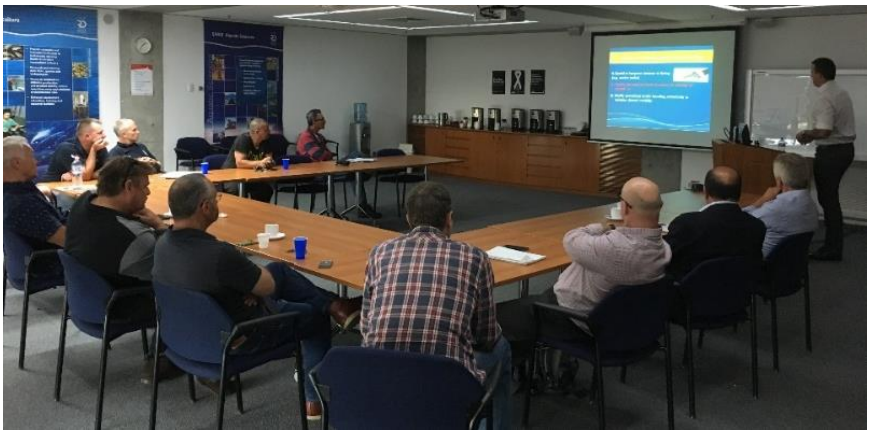
This workshop was held on 5 and 6 February 2018. Ten fishers attended, one Exec Officer, one manager from PIRSA and two scientists from SARDI (Fig. 2). Matt Broadhurst was the attending gear expert. As for the Townsville fishers, some frustration was expressed with a lack of legislative flexibility in allowing fishers to try various modifications. Significant discussion also concerned the use of grids to reduce bycatch, noting that they are used in Gulf St Vincent but not in Spencer Gulf.

Regarding particular bycatch issues, it was noted that leatherjackets can be a problem at times and there is also a desire to sort prawns better prior to capture. Kon's Covered Fisheye was discussed and relevant information regarding it was passed on.

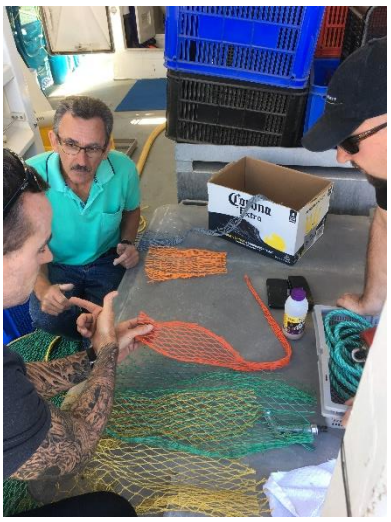
In addition, at least one fisher was interested in trying different knot orientations to reduce leatherjacket bycatch and trying different net types in the wings (T90 or T45) to improve size selection for prawns.

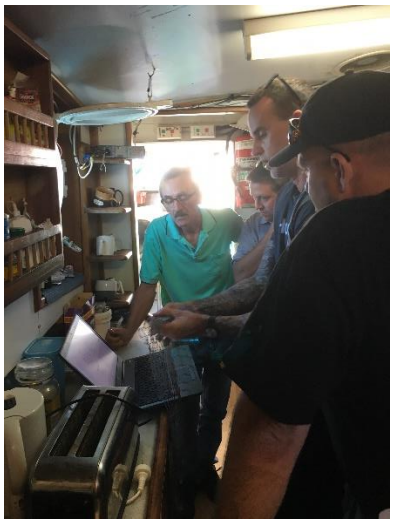
It was also noted by attendees that the workshop was successful in generally improving the knowledge of fishers regarding available options and how to do meaningful comparisons during their own testing.

Fig. 2 – Adelaide workshop



Figs. 3 and 4 – Meetings on boat in Gulf St. Vincent





Port Lincoln (Spencer Gulf)

This workshop was held on 7 and 8 February 2018 where seven fishers attended (plus their Exec Officer and the ACPF's Exec Officer). Matt Broadhurst was the attending gear expert. Attendees noted that there were few significant bycatch or efficiency issues that required attention. It was considered that blue crab bycatch issues are dealt with using crab bags and on deck sorting although there was acknowledgement that some work is needed to quantify their post-release mortality.

Other issues raised concerned the catch of King George Whiting in a certain area which is closed to fishing. It was considered that the square mesh panel and/or Kon's Covered Fisheye may prove useful to reduce King George Whiting catch so as to allow access.

Two fishers from the West Coast were interested in trialling quad gear as a means to improve efficiency. Others are examining the use of bison otter boards instead of the larger otter boards currently used which should reduce drag and habitat impacts. Relevant reports, papers, etc. regarding these issues were provided subsequently.

Lakes Entrance

This workshop was held on 3 and 4 May 2018. Matt Broadhurst was the attending gear expert. Three fishers and the Exec. Officer attended the scheduled workshop but we repeated the presentations the next day twice more on vessels at the wharf to 4 fishers and their facilitator.

This fishery currently uses no bycatch reduction devices, as it is a multi species fishery, and much of the material we presented was quite new to participants.

Some fishers were very interested in reducing the bycatch of small whiting and mackerel and were particularly keen to try the composite square mesh panel. We forwarded the relevant material.

Also of interest was the information on knot direction and how it may reduce bycatches. Further, at times, 2 spot crabs can be a nuisance and one fisher was interested in examining the utility of crab bags and drop chains on his ground gear to reduce such bycatch.

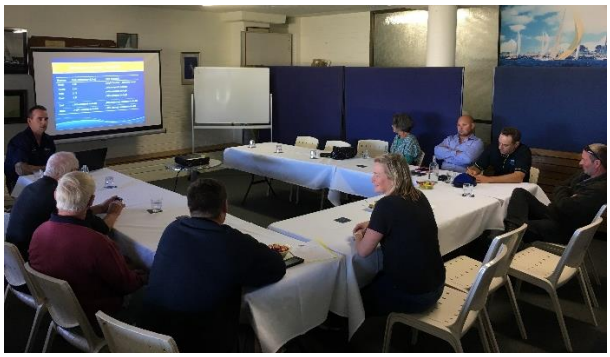
Coffs Harbour

The NSW Professional Fishermen's Association created a promotional video to advertise the NSW-based workshops. See:
https://www.facebook.com/professionalfishermensassociation/videos/vb.449730741845220/1014360425382246/?type=2&theater&notif_t=page_post_reaction&notif_id=1526513048519830

Within just a few days of posting, this fantastic initiative had achieved 225 views, one share and 10 likes on the PFA's Facebook page.

The Coffs Harbour workshop occurred on 21 and 22 May, 2018. It was attended by 4 fishers, 2 fisheries managers from NSW DPI, 1 person from Oceanwatch and 2 Exec Officers from the NSW PFA who facilitated the meeting (Fig. 5). Matt Broadhurst was the attending gear expert. We also met with another 4 fishers the following day on their boats and 2 at their factory where the workshop materials were presented again. We also met with the PFA Exec Officer and an NSW DPI fishery manager in a separate meeting to discuss permitting arrangements in order to facilitate a more streamlined process for fishers to test modifications.

Fig. 5 – The Coffs Harbour workshop



The key priorities for bycatch and/or habitat reduction and/or fuel efficiency for these fishers concerned two main issues. The first is reducing the bycatch of small mulloway to a sufficient level so that they can gain access to grounds that are closed after certain rainfall events (where the flood waters carry significant numbers of fish (and especially mulloway out to sea). It was

felt that if they could use a technique to exclude such fish, they could gain access to these Eastern King Prawn grounds (even if such modifications lost a few prawns. We discussed the merits of an appropriate grid and/or alteration of headline height to resolve this issue.

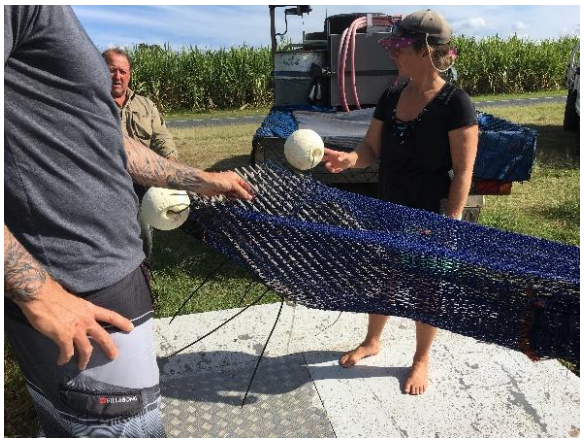
The second issue concerned the lack of a streamlined process for fishers to trial and use modifications. But we were pleased to see that NSW DPI have taken this issue very seriously and we were advised that they are apparently about to announce a "blanket" 12-month permit to allow fishers to test gears, following approval by the DPI FCTU (Broadhurst). Perhaps the timing of this permit so close to our workshops is co-incidental. Or perhaps it is because of the heightened attention to the permitting issue that our workshops is providing. But in any case, such a step is a very positive one for this jurisdiction.

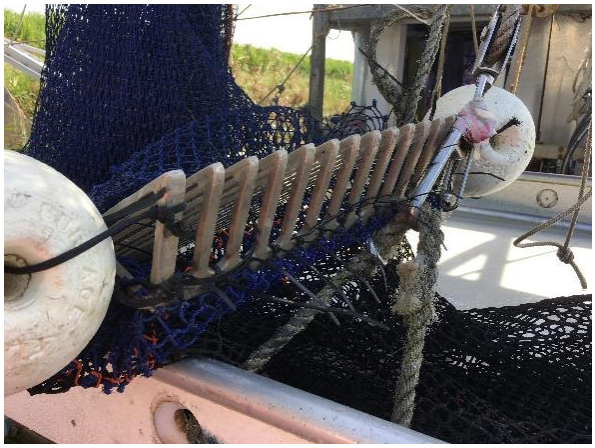
Yamba

The Yamba workshop was held on 23 and 24 May and was attended by 6 fishers and the PFA Exec Officer. Matt Broadhurst was the attending gear expert. We also met with some the next day on their boats. The relatively small attendance at this location was expected as most fishers in this area have been exposed to Broadhurst's work previously.

The main issues to arise concerned: the above mulloway issue; interest in trialling quad-rig trawls, using square mesh in the wings to reduce the bycatch of small Eastern King and Eastern School prawns; further "tweaking" of the grid that is used in the estuarine fishery (e.g. see Fig 6); designing an otter board that can go from 35^{o} when deploying to the critical 20^{o} when fishing to reduce drag; and the above need for a more streamlined permitting system to allow fishers to trial modifications.

Fig. 6 – A modified grid designed by a fisher to reduce weed in the Clarence River.





Another general issue (related to the latter permitting issue) that was raised by this group (who have been exposed to Broadhurst's new trawl technologies more than any other group of fishers in the country) concerned a feeling that the developments that have been made by Broadhurst were not reaching a 100% solution. That is, it was stated that much of the work done by Broadhurst over the years went very close to resolving many historical bycatch, habitat and fuel efficiency issues, but only a few (e.g. BRDs like grids, and square-mesh panels) reached a complete, ready-to-go solution (examples noted included more complex quad gear, headline-height modifications, otter board angle work, etc.). And that while some may say that such final

tweaking could (and should) be done by industry, fishers are reluctant to do that extra work as it would cost days of time in doing so. The solution suggested was more funding for the researchers to complete the work and address any ongoing dynamic issues which always eventuate (e.g. closures due to Mulloway bycatch in certain years or excessive weed following anoxic events).

Newcastle

The Newcastle workshop was held on 9 and 10 July and was attended by three fishers, the PFA Exec Officer, the ACPF Exec Officer and the Newcastle Co-op Manager. Matt Broadhurst was the attending gear expert. We also met with an additional four fishers the next day on their boats at the wharf.

A significant concept that one of the oceanic fishers was surprised to learn about concerned the effect that knot orientation in the top and bottom panels can have on bycatch and trawl performance. He then went to check his gear – which we also examined the next day.

The main concepts that the fishers wished to examine further were: the possibility of using grids to reduce bycatches when targeting royal red prawns, the design and utility of “weedless” grids to reduce bycatch, using square mesh in the wings to reduce the capture of small Eastern King Prawns, and alternative materials for constructing square-mesh codends. A particularly attractive concept that the fishers thought had utility was the quick and easy way to reduce fish bycatch by simply altering headline height.

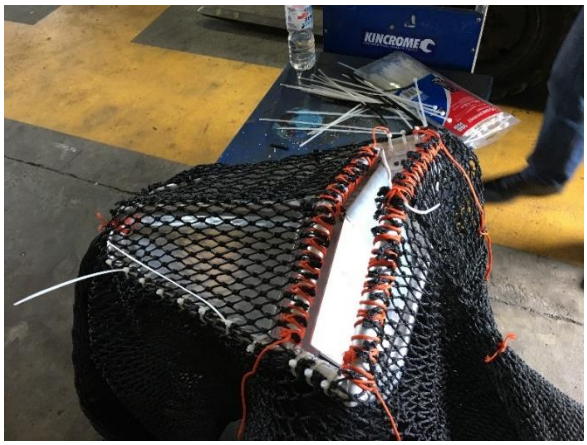
They also expressed a desire for assistance from Broadhurst to install grids and panels in their gear.

Cairns (NPF)

The Cairns workshop was held on 23 and 24 July and was attended by 10 fishers, the Northern Prawn Trawl Exec Officer, the ACPF Exec Officer, the AFMA Fisheries Manager and the Austral fleet Manager. We also met with an additional 2 fishers the next day on their boats at the wharf. Unlike the previous workshops, the gear expert presenting was Dr Steve Eayrs.

All the information presented was well-received and discussed at length. The main priority for this fleet concerned “fine-tuning” the latest fisheye concept being tested in the fishery – the “FishX 70” (see Fig. 7). In particular, it was noted that AFMA Observers had quantified a very satisfying 41% reduction in bycatch using this device, but more work was needed to reduce its weight (from 5kg to ideally 500g) and to see how the device behaved in a flume tank. Further testing this device, another fisheye version, and comparing it with the square mesh panel currently used is underway this season throughout the entire Northern Prawn trawl fleet.

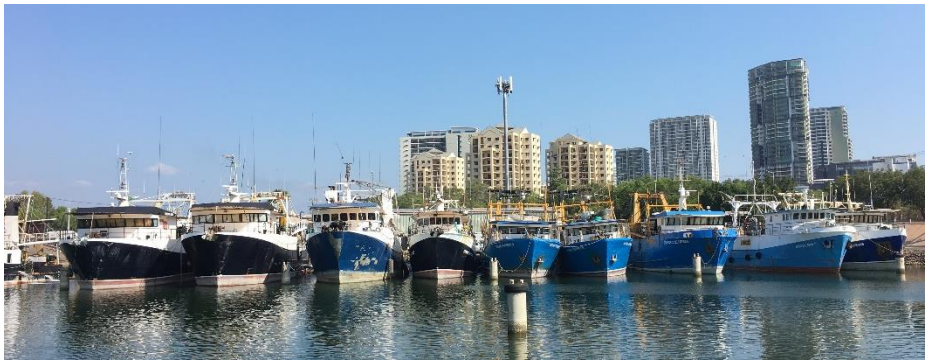
Fig. 7 – The new FishX 70 fisheye.



Darwin (NPF)

The Darwin workshop was held on 25 and 26 July and was attended by 8 fishers and the NPFI Exec Officer. We also met with an additional 8 fishers in the afternoon and the next day on their boats at the wharf. The gear expert attending was Dr Steve Eayrs.

Fig. 8 – The Darwin prawn trawl fleet preparing for the season.



All the information presented was well-received and discussed at length. Like the fleet in Cairns, many of the Darwin-based boats are testing the latest fisheye (the FishX70) this season in comparison with the square mesh panel currently used and/or Kon's Covered Fisheye from last season.

In addition to basic bycatch reduction, the main priority for this fleet concerned the bycatch of, and injury to, sawfish and possible ways to reduce them. We noted that because of their elongated, saw-like rostra, this group is at particular risk for accidental entanglement, and they are often difficult to free from gear without causing their injury or death. Indeed, even if a fish is successfully released, the loss or damage of the teeth protruding from the rostrum, or the wounding of the rostrum itself, can result in a decreased ability to feed. Numerous concepts were discussed regarding how to exclude this very difficult group and it was noted that measures should focus on the anterior part of the net because once sawfish enter the net, they are easily entangled in the netting and/or TED. Possible areas for research include using electro-magnetic stimuli to scare them from the mouth of the net and the new project to examine such concepts in aquaria was noted. We suggested incorporating permanent magnets and electropositive

metals such as neodymium, cerium and praseodymium into such experiments and information regarding such devices was provided.

Other issues concerned the shape of the TEDs used. Currently these are mostly rectangular which some fishers felt affects water displacement inside the net instead of an oval or round shape which is closer to the actual shape of the extension piece.

One interesting issue to arise from our discussions in Darwin was an unexpected source of concern regarding the bycatch of TEP species by the fishery – the crews. This was because travelling tourists, backpackers etc. from overseas often join crews for the season and these people often have quite environmental/conservationist attitudes.

Hervey Bay (Qld East Coast Trawl)

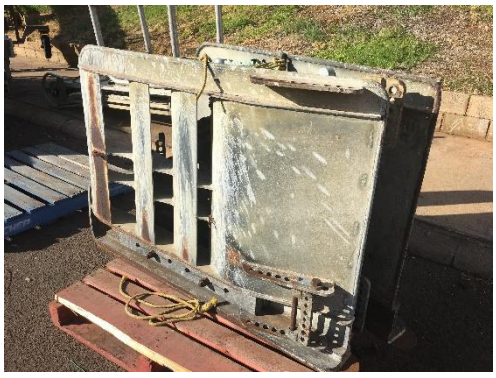
The Hervey Bay, Queensland workshop was held on 5 July, 2018 and was attended by 6 fishers (one of whom was Dave Sterling – a renowned gear technician himself). We also went to the wharf the next day to meet fishers but none were present. The gear expert attending was Dr Steve Eayrs.

All the information presented was well-received and discussed at great length, over many hours and well into the evening, to the point where this was probably the most interactive workshop held so far, with fishers contributing information constantly, drawing diagrams, feeding off each other, etc.

In terms of issues, one that was raised was the commonly stated issue (see above) regarding the streamlining of approvals to test alternative designs. Another was a concern that compliance officers required more training in trawl-gear technology and BRD performance, so they could better assess the legality/compliance of various modifications.

In terms of actual modifications that fishers would like to see developed, one priority was to test Thyboron boards as a way to reduce drag (see Fig. 9).

Fig. 9 – Side view of the Thyboron otter board.



Another was research into a mechanism to allow otter boards to be deployed at the appropriate wide angle (of 35-40^0 degrees) but then, once on the bottom, to change to the optimal towing angle of 20^0 (and so reduce drag). Another was the further development of W trawls as a mechanism to reduce drag - where most of the load is pulled from the centre of the gear through the central sled, allowing much smaller otter boards to be used (it was noted that the potential

reduction in drag could be well over 30%). Another was a new concept involving an alternative steering system using blocks sliding on tracks built on the arms to reduce sideways movement of the boat and the consequent twisting of triple gear (which increases drag). Another concerned the shape of the TEDs used. Currently these are mostly rectangular which fishers feel affects the displacement of water inside the net instead of an oval or round shape which is closer to the actual shape of the extension piece.

Finally, an overarching need that was identified was to organise a system where interested fishers could be trained in the use of, and get access to, FRDC's Notus net performance gear and load cells (currently based at Coffs Harbour).

Brisbane (Moreton Bay)

The Brisbane/Moreton Bay workshop was held in Shorncliffe on 30 November, 2018 and was attended by 8 fishers (one of whom was Dave Sterling) and the QDPI Fisheries Manager responsible for Queensland's Trawl Fishery (Fig. 10). We also went to the Shorncliffe and Scarborough wharves the next day to meet an additional three fishers (Fig. 11). The gear expert attending was Matt Broadhurst. Dr Eayrs also attended and contributed to the workshop as well as presenting his 'Sesafe work' (FRDC project 2017/194). After our workshop, the FRDC funded project 2017-012 took the opportunity to launch the SE Qld part of their social acceptance project.

All our BRD and LIFE information was well-received and discussed at great length, over many hours throughout the afternoon and the next day. In terms of general issues, these fishers would like to see the use of BRDs and TEDs used more to promote the industry - as they are clearly very positive initiatives. As was the case in other jurisdictions, they also would like to have a more streamlined process for testing various gears. Further, they questioned whether there was opportunity to provide financial incentives for fishers to test and/or use BRDs.

In terms of specific issues, fishers were quite comfortable with the TEDs they were using, but for other bycatch, small crabs, pigfish (leatherjackets) and dollarfish (liagnathidae) were the main concerns. Pigfish only at certain times, and dollarfish was an issue right along the coast.

Regarding actual things to test, it was agreed that an examination of groundgear (softbrush and other modifications) may assist with the reduction of crabs. For dollarfish and pigfish, an examination of panels and/or fisheyes in certain key parts of the nets may have potential.

Fig. 10 – Brisbane/Moreton Bay workshop.

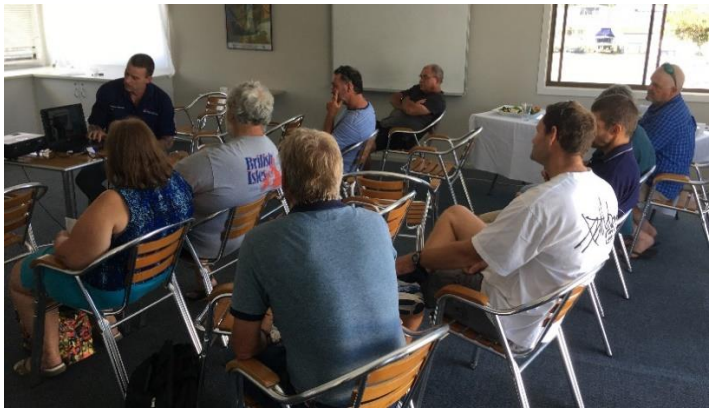
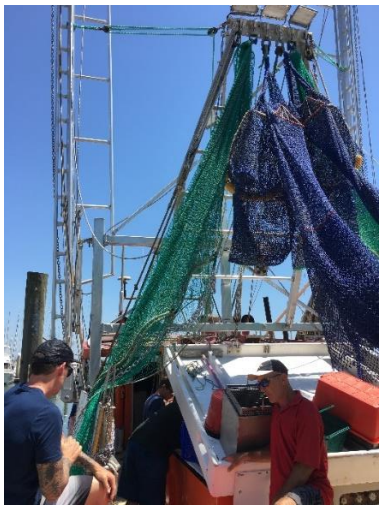


Fig. 11 – Meeting fishers at Scarborough wharf – note the TEDs and fisheye BRDs in the nets.



Carnarvon (Shark Bay)

The Carnarvon workshop was held on 11 March, 2019 and organised by Scott Razga. It was the best attended of any of the workshops (23 fishers – see Fig. 12). We also went to Mareterram's wharf to meet fishers and look at gears (Figs. 13 and 14). The gear expert attending was Dr Steve Eayrs who also presented his SeSafe work.

Fig. 12 – The final and best attended workshop at Carnarvon, WA.

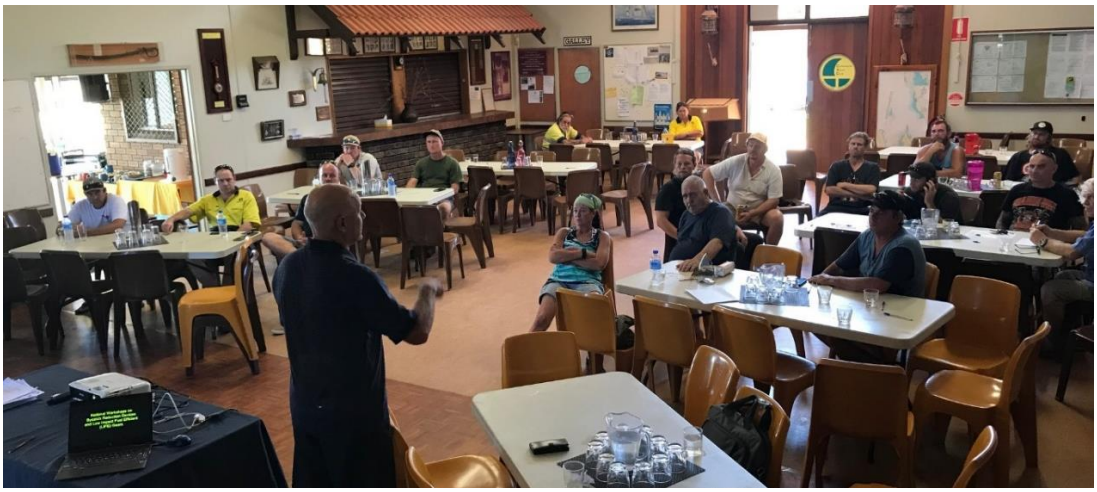


Fig. 13 – The Mareterram fleet in Carnarvon preparing for the season.

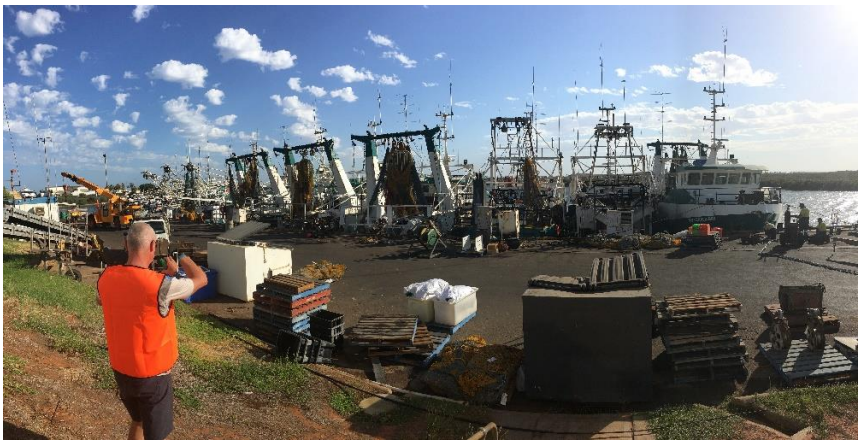
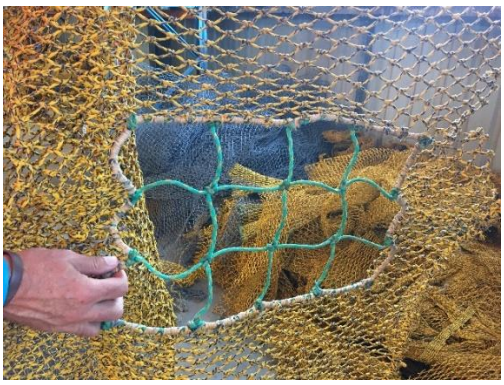


Fig. 14 – The square-mesh panel used in Shark Bay – which we felt was positioned too far from the drawstring, being located as far as possible from the codend drawstrings and immediately behind the grid..



All our BRD and LIFE information was very well absorbed and received by all skippers and mates.

In terms of main issues, these fishers would like to examine ways to reduce the bycatch of small fish (dollarfish in particular). They also have a significant issue with sea snakes and would like to reduce its bycatch. These issues are similar to those we've met elsewhere in Queensland and Darwin.

Regarding actual things to test, it was noted that an examination of square-mesh panels and/or fisheyes may have potential. In particular, we noted that the existing square- mesh panels used are set a very long way from the draw string and probably not doing much bycatch reduction, being located as far as possible from the codend drawstrings and immediately behind the grid. Also of interest was work to examine LED lights in nets to reduce bycatch and soft brush ground gear to reduce benthic impacts and improve fuel efficiency.

In addition, in terms of fuel efficiency, there was significant interest in exploring ways to alter the Angle of Attack of otter boards so that they can be deployed at 30^{o} to 40^{o} but towed at the optimal 20^{o} when on the bottom.

Summary of Outcomes from Workshops

A summary of information discussed and developed at each of the workshops held around the country is provided in Table 2.

Table 2 – Summary of attendance, issues and potential solutions that arose from each workshop

Fishery	Number of participants (workshop and on boats)	Key Issues	Potential solutions to be examined
Townsville	7	• Reducing bycatch in general and especially sea snakes • More streamlined permit-approval process for fishers to trial modifications	• Kon's Covered Fisheye to be tested • Permit for testing by a fisher came through soon after the workshop
Gulf St Vincent	14	• Leather jackets a problem at times • Reducing the catch of small prawns • More streamlined permit-approval process for fishers to trial modifications	• Kon's Covered Fisheye • Knot orientations to reduce leatherjackets • Different net types in the wings (T90 or square mesh) to improve size selection of prawns
Spencer Gulf	9	• Few bycatch issues • Mortality of discarded crabs • King George Whiting in a closed area • Fuel efficiency, drag and habitat impacts.	• quantify crab post-release mortalities • Square-mesh panels and Kon's Covered Fisheye to reduce whiting bycatch • quad gear to improve fuel efficiency • bison boards to reduce drag and habitat impacts
Lakes Entrance	9	• small whiting and mackerel at times • 2 spot crabs	• composite square mesh panel to reduce small whiting and mackerel. • knot direction to reduce bycatches • crab bags and drop chains to reduce crab issue

Coffs Harbour	15	• Closures due to small mulloway following significant rainfall events. • More streamlined permit-approval process for fishers to trial modifications.	• A grid and/or reducing headline height to exclude small mulloway • A new 12 month blanket permit is apparently to be provided by NSW DPI managers soon.
Yamba	7	• Closures due to small mulloway following significant rainfall events • More streamlined permit-approval process for fishers to trial modifications • Generally reduce bycatch and reduce fuel usage • Reducing the bycatch of small prawns • Reduce the capture of weed • Completion of the various concepts tested up to now to reach a complete, ready-to-go solution	• A grid and/or reducing headline height to exclude small mulloway • A new 12 month blanket permit is apparently to be provided by NSW DPI managers soon. • Quad-rig trawls to reduce bycatch and reduce fuel usage • designing an otter board that can go from 35^0 when deploying to the critical 20^0 when fishing to reduce drag • Refinement of the grids used to reduce bycatch • Using square mesh in the wings to reduce the bycatch of small prawns • Examine the use of soft brush ground gear to reduce weed • More funding to complete the various modifications tested to a complete, read-to-go solution
Newcastle	10	• Quick adjustments to reduce fish bycatch • Effect of knot orientation on performance	• Rapid headline height changes • Checking knot orientation in panels • Use of grids to reduce royal red prawn bycatch

		• Royal red prawn bycatch • Weed getting caught in grids • Reducing the capture of small school prawns in the Hawkesbury • Better materials for making square mesh panels and codends	• Examine use of weedless grids – as being developed in the Clarence River. • Examine utility of soft brush ground gear to reduce weed. • Using square mesh in the wings to reduce the capture of small prawns • Testing alternative materials for constructing square mesh codends.
Cairns	16	• Reduction of general discards including sea snakes	• Fine-tuning the FishX 70 to reduce its weight (from 5kg to ideally 500g) and to see how the device behaved in a flume tank • Comparing this and another fisheye with the square mesh panel currently used is underway throughout the Northern Prawn Fishery fleet.
Darwin	17	• Reduction of general discards including sea snakes • Reducing the bycatch of sawfish • The rectangular shape of TEDs damaging nets and disrupting water flow	• Comparing the FishX70, another fisheye with the square mesh panel currently used and Kon's Covered Fisheye is underway throughout the Northern Prawn Fishery fleet. • Examination of anterior modifications to reduce sawfish bycatch including electromagnetic stimuli. • Using round/oval TEDs instead of rectangular TEDs.
Hervey Bay	6	• More streamlined permit-approval process for fishers to trial modifications	• Source and trial the new Thyboron boards as a way to reduce drag.

		• Compliance officers required more training in gear technology, so they could better assess the legality/compliance of modifications. • Reduction of drag and therefore increased fuel efficiency • The rectangular shape of TEDs damaging nets and disrupting water flow • An overarching need that was identified was to organise a system where interested fishers could be trained in the use of, and get access to, FRDC's Nodus net performance gear and load cells (currently based at Coffs Harbour).	• Research into a mechanism to allow boards to be shot away at the appropriate wide angle (of 35-40^0 degrees) but then, once on the bottom, to change to the optimal towing angle of 20$^{0.}$ • Further development of W trawls as a mechanism to reduce drag - where most of the load is pulled from the centre of the gear through the central sled, allowing much smaller otter boards to be used. • An alternative steering system using blocks sliding on tracks on the arms to reduce the crabbing of the boat and the consequent twisting of triple gear • Using round/oval TEDs instead of rectangular TEDs. • A system where fishers could be trained in the use of, and get access to, FRDC's Nodus net performance gear and load cells.
Brisbane	12	• The use of BRDs and TEDs used to promote the industry • More streamlined permit-approval process for fishers to trial modifications • Financial incentives to test modifications. • Small crabs, pigfish (leatherjackets) at certain times and dollarfish	• An examination of groundgear (softbrush and other modifications) to reduce crabs. • For dollarfish and pigfish, an examination of panels and/or fisheyes in certain key parts of the nets identified using go-pro cameras

		(liagnathidae) right along the coast were the main concerns.	
Carnarvon	24	• Sea snakes and small fish in general (especially dollarfish) • Changing Otter Board Angle of Attack to be more fuel efficient.	• Examine position and size of square mesh panel (currently quite small and a long way from drawstring); utility of new fisheyes. • Examine the utility of LED lights to reduce bycatch. • Examine soft brush ground gear to reduce benthic impacts and improve fuel use. • Examine ways to vary Angle of Attack to be 30^{o} at deployment and 20^{o} when on bottom

Discussion and Conclusions

The Results described above show that this project has resulted in a significant increase in the number of stakeholders (particularly trawl skippers and crews) being made aware of the latest ways that bycatch and habitat impacts can be reduced and fuel efficiency increased. By holding 12 workshops around the country and engaging with 146 participants (comprised of 120 fishers, 18 executive officers/facilitators, 5 fisheries managers, 2 scientists and a representative from Oceanwatch), this extension project has been able to reach a significant proportion of the total number of prawn trawl stakeholders in the country. In addition, the availability of the material presented as a stand-alone PowerPoint presentation, and short extracts from it, means that anyone else interested in this work can obtain the information disseminated.

The workshops were also successful in identifying the specific (and varied) issues that each fleet has with bycatch reduction and fuel-efficiency. Table 2 in the Results summarises these issues and the potential work required to address them. Many of these issues and future work are specific to each fishery and should therefore form the focus of future industry and or scientifically based work in each. However, there were several issues that were common to more than one fishery and sometimes several. These are listed in Table 3 below.

Table 3 – Issues and potential solutions that were common to several fisheries

- More streamlined permit-approval processes for fishers to trial modifications;
- A system where fishers could be trained in the use of, and get access to, FRDC's Notus portable acoustic net measurement sensors and load cells;
- Examine the utility of LED lights and other anterior modifications to elicit behavioural responses and reduce bycatch;
- Test the recently developed fisheyes (Kon's Covered, the FishX 70, etc.) against the square mesh panel to reduce bycatch of small fish;
- Check and assess knot orientation to reduce bycatches and improve fuel efficiency;
- Designing retroactive modifications to otter boards that facilitate variations from approx. 35^0 when deploying to the critical 20^0 when fishing to reduce drag and fuel consumption;
- Examine anterior modifications to reduce sawfish bycatch including electromagnetic stimuli and/or LED lights;
- Using round/oval TEDs instead of rectangular TEDs; and
- Examine soft brush ground gear to reduce benthic impacts and drag.

The above list should be considered in any multi-jurisdictional initiatives to reduce bycatch, habitat impacts and/or improve fuel efficiency in prawn trawling

Implications

One of the implications from this project is that there are fewer prawn-trawl fishers in Australia who are unfamiliar with the latest modifications designed to reduce bycatch and habitat-impacts

and improve fuel efficiency. This, in itself, is a significant development and should, at a minimum, lead to significant informal testing of concepts by fishers.

Further, there now exists a concrete set of agreed issues and potential solutions for each fleet that can serve as a baseline and be used by fishers, scientists and managers as they seek to conduct formal trials of modifications. The overall outcome should therefore be improvements in bycatch reduction and fuel efficient fishing throughout Australia's prawn trawl fisheries over the next few years.

Recommendations

This project has yielded a series of recommendations for various prawn trawl stakeholders in Australia:

- Fishers unfamiliar with the latest ways to reduce by catch and habitat-impacts and fuel-efficient work should liaise with colleagues who attended the workshops and/or examine the PowerPoint presentation available at: http://australianwildprawns.com.au/.
- Management jurisdictions should try to develop more streamlined processes by which fishers can trial alternative gear designs.
- Researchers should consider the list of issues and potential solutions in Table 2 when developing projects designed to reduce bycatch and habitat impacts, or improve fuel efficiency in individual fisheries.
- When developing projects with a broader focus, researchers should consider those concepts listed in Table 3.
- For funding agencies (including state and federal fisheries jurisdictions and the FRDC), future applications in this field should at least have considered the concepts listed in Tables 2 and 3.

Further Development

The above recommendations detail the sorts of further technical developments that should come from this project. In particular, key developments should focus on those concepts that have potential application in several locations (see Tables 2 and 3 above).

We do not believe that there is a need to do any more workshops along the lines as those done in this project. Instead, more significant "on-boat" extension work would be appropriate where gear technologists actually assist fishers with the installation of modifications into nets. This is being done to some extent by AFMA in the NPF, a new extension project in NSW and concepts under discussion for Gulf St Vincent and in Queensland.

That is, the next steps in the implementation of the sorts of modifications described in this project throughout prawn-trawl fleets in Australia would see gear technicians working on multiple boats in multiple fisheries, showing as many fishers as possible how to use chosen modifications whilst also developing novel concepts. Such work should include scientifically rigorous trials that demonstrate the fleet-wide utility of modifications and so supply defensible evidence of the value of the modifications.

Extension and Adoption

This project was an extension project itself and, as noted above, we feel that, at the present time, there is little need for further workshop-type extension work in this area - other than the dissemination of the project's PowerPoint presentation to appropriate stakeholders.

Instead, ongoing extension and adoption work should focus on (i) developing solutions to the issues identified during the project (listed in Tables 2 and 3 of this report) and (ii) extending available solutions (and any new ones) via on-boat installation and scientifically defensible trials done by scientists and gear technicians on as many boats as possible - as described above.

This should eventually lead to a situation where the sharing of new developments throughout prawn-trawl stakeholders in the country will occur. And, as a consequence of the workshops done during this project, such dissemination should be relatively straightforward as most relevant stakeholders are now quite familiar with the field.

Project materials developed

The main outputs from this project are:

- the fleet specific and general list of issues and potential solutions provided in Tables 2 and 3, respectively; and
- the combined PowerPoint presentation with associated videos available at: http://australianwildprawns.com.au/