FRDC FINAL REPORT (DEVELOPMENT AWARD)

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ACTIVITY UNDERTAKEN

The Award recipient participated in the annual ICES-FAO Fishing Technology and Fish Behaviour Working Group (ICES-FAO WGFTFB) meeting on April 8 - 12, 2019. This meeting was hosted by Shanghai Ocean University, Shanghai, China, although each year the meeting is held in a different location. The theme of this meeting was, *Responsible Fishing Technology for Healthy Ecosystems and Clean Environment*. This report presents a summary of this meeting and suggestions for future research in the Australian fishing industry. The meeting agenda is provided in Attachment 1 and presentation abstracts are provided in Attachment 2.

OUTPUTS AND OUTCOMES ACHIEVED TO DATE

The major output from this Award is the summary report (below) describing meeting presentations and findings by day and session theme. From the perspective of the Award recipient, important outputs and outcomes include:

- The use of artificial lights attached to fishing gear to reduce bycatch is gaining momentum globally. LED technology in particular is increasingly being adapted for underwater use and attachment to fishing gear. Already there have been some notable successes, although some seemingly the result of good fortune rather than good planning. However, as evidence is growing that lights of different colour (wavelength) may elicit different fish responses, greater consideration of their ability to improve fishing gear selectivity in Australian fisheries is suggested.
- From the few presentations describing efforts to reduce bycatch in tropical shrimp trawl fisheries it is clear that Australian efforts are well advanced and relatively successful. The

experimental design used to evaluate BRD performance in other countries is often lacking and adoption by industry is usually poor. No new TED or BRD designs were presented at the meeting that might improve bycatch reduction in Australian fisheries beyond current levels.

- The United States is poised to leverage the US Marine Mammal Protection Act and reject imports from countries where the impact on marine mammals is in excess of US standards. This will be enforced in 2020. This was news to the Award recipient and it is unclear if this knowledge is widespread in Australia and how it may impact local fisheries.
- As result of the EU discard ban there are several initiatives involving production of information data sheets describing gear selectivity research. The objective of these initiatives is to provide fishers and others a useful information source, where information related to modifying fishing gear to avoid select species can be found. The level of interest by fishers in such information and their rate of enquiry does not seem to have been evaluated and remains unclear.
- A presentation describing the SeSAFE project (FRDC 2017-174) was delivered by the Award recipient, including how modularised online training is being adopted (or not) by the fishing industry. The presentation also explored how the modularised approach can be extended to provide other training, such as fish behaviour to fishing gear and the ABC's of selectivity curves.
- A country report summarising two Australian fishing gear research projects was provided by the Award recipient. Country reports are designed to inform the WGFTFB of recent fishing technology research in each country represented at the meeting. As Australia is not an ICES member country there is no formal requirement for such a report; it was provided for informative purposes only. The two projects summarised were: *Reducing the environmental impacts and improving the profitability of prawn trawling through a structured framework of anterior gear modifications* (FRDC Project No. 2011/010) and the AFMA funded project, *Evaluation of three new BRDs for Australia's Northern Prawn Fishery*.
- The Award recipient also provided a summary of outcomes from his doctoral research understanding fisher behaviour, challenges facilitating behavioural change, and encouraging fisher uptake of research outcomes. This research included leading a three-year WGFTFB topic group on the subject. This request was made on the day by the Passive Gear topic group, and highlights ongoing challenges by WGFTFB members in facilitating the widespread voluntary adoption of gear research outcomes by fishers.
- The Award recipient delivered a brief presentation describing the timing and location of the 2020 World Fisheries Congress. It was suggested that WGFTFB could make use of this opportunity by supporting a session or satellite workshop on a topic of interest. The recipient left it to the WGFTB to follow this up if interested.
- While not specifically discussed at the meeting, there is merit in considering a future WGFTFB meeting hosted in Australia. This working group has not previously met in Australia, although several years ago it did so in New Zealand. This would be a serious undertaking and require a submission to the WGFTB several years in advance. An early

step prior to any submission would be to consider outcomes and benefits to Australian researchers and the fishing industry, as well as an estimation of costs.

Summary Report of the 2019 ICES-FAO Fishing Technology and Fish Behaviour Annual Working Group (ICES-FAO WGFTFB) Meeting

Shanghai Ocean University
Shanghai, China

March 8 – 12, 2019

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Executive Summary

This report provides a summary of the joint ICES-FAO Working Group on Fishing Technology and Fish Behaviour (ICES-FAO WGFTFB) annual meeting at Shanghai Ocean University, Shanghai, China on March 8 - 12, 2019. This meeting was attended by 138 fishing technologists, scientists, and others representing 23 countries around the globe, and was comprised of the following theme sessions (see Attachment 1 for the full agenda and Attachment 2 for abstracts):

- Abandoned, lost, or otherwise discarded fishing gear (ALDFG): Assessment of quantity and measures to prevent ALDFG and its impact
- Interactions of protected species in capture fisheries
- Light, fish behaviour, and fishing
- Technology and management to reduce bycatch and discards
- Selectivity of fishing gear: Means and methods
- New technologies for fisheries research and education
- Energy, technology, analysis, and simulation
- Chinese fisheries - status, challenges, and the future

The annual meeting also included topic group break-out sessions and summary reports, presentation of country activity reports, and a general business session. At this meeting topic group meetings were held on the following:

- Passive fishing gears
- Evaluating the application of artificial light by bycatch mitigation
- Evaluation of trawl ground gear for efficiency

As topic group sessions are held concurrently, the Award recipient was only able to attend the light topic group meeting (see Attachment 3 for agenda). However, a brief summary of the remaining topic groups is also provided.

Contents

Introduction

This report provides a summary of the joint ICES-FAO Working Group on Fishing Technology and Fish Behaviour annual meeting at Shanghai Ocean University, Shanghai, China on March 8 - 12, 2019. This meeting was attended by 138 fishing technologists, scientists, and others representing 23 countries around the globe.

The ICES-FAO Working Group on Fishing Technology and Fish Behaviour (ICES-FAO WGFTFB) was established in 2002. Prior to this it was known as the ICES Working Group on Fishing Technology and Fish Behaviour (WGFTFB) and was comprised primarily of individuals from ICES member countries in Europe and North America. After many years of collaboration between ICES and FAO, the forging of a combined working group with a mandate extending to developing countries was viewed as an important global development and extension of this relationship. A primary objective of this combined group is to foster dialogue and collaboration between member countries with regard to fishing technology and fish capture and contribute to the sustainable exploitation of global fisheries resources. Subsequently, FAO determines the location of the annual meeting every third year, usually in a developing country. Previously, these meetings have been held in Thailand and Mexico, with China being the most recent example of this collaboration.

This meeting was comprised of the following sessions (see Attachments 1 and 2 for the full agenda, presentation titles, speaker names, abstracts, and contact details for further information, including poster presenters):

- Abandoned, lost, or otherwise discarded fishing gear (ALDFG): Assessment of quantity and measures to prevent ALDFG and its impact
- Interactions of protected species in capture fisheries
- Light, fish behaviour, and fishing
- Technology and management to reduce bycatch and discards
- Selectivity of fishing gear: Means and methods
- New technologies for fisheries research and education
- Energy, technology, analysis, and simulation
- Chinese fisheries - status, challenges, and the future

This meeting also included topic group break-out sessions and summary reports, presentation of country activity reports, and a general business session. Topic groups are an opportunity for participants to focus on a particular issue, deliver and hear related presentations, and contribute to a report that synthesises latest developments and status of knowledge. Topic groups usually carry a theme across multiple meetings, and some participants work on a theme inter-sessionally. At this meeting topic group meetings were held on the following topics:

- Passive fishing gears
- Evaluating the application of artificial light by bycatch mitigation
- Evaluation of trawl ground gear for efficiency

As these meetings are held concurrently it was only possible for the Award recipient to attend the artificial light topic group. Country reports are an opportunity for individuals representing participating countries to provide a summary of national research related to fishing technology and fish behaviour. The general business section is an opportunity for individuals to learn of topic group

outcomes, raise any issue including forthcoming conferences or meetings, and other developments such as identification of the host country the following year.

The Award recipient has a history of involvement with this working group extending approximately 20 years. This includes presentation delivery, hosting a topic group on change management in fisheries, and reports to FAO on a contractual basis summarising presentations and outcomes of the meetings in Thailand and Mexico

Meeting summary

Day 1.

Opening and Welcome, Keynote presentation

- The meeting was opened and participants welcomed to Shanghai Ocean University.
- The keynote presentation described the status of global marine fish stocks, including that the most recent assessment of bycatch and discards is 9.1 million tonnes annually. Problems in fisheries were discussed including bycatch and capture of marine mammals, fishing gear loss, and plastic. An interesting suggestion was life cycle analysis of fishing gear and associated materials and ability to trace this material through its entire life cycle. The FAO Code of Conduct for Responsible Fisheries is now 25 years old, and still remains a guiding document underpinning sustainable fisheries. The publication, *Voluntary guidelines on the marking of fishing gear*, has recently been published by FAO and aims to guide efforts to reduce gear loss and combat ALDFG.

Session 1: Abandoned, lost or otherwise discarded fishing gear (ALDFG): Assessment of quantity and measures to prevent ALDGF and its impact

- The focus of this session was ALDFG including:
  - Global assessment and estimation of gear losses
  - International responses
  - Icelandic efforts to overcome ALDFG
  - Efficacy of side scan sonar to detect derelict lobster pots
  - Codend modification to reduce twine loss
- A meta-analysis of scientific publications describing fishing gear losses is being reviewed in a global assessment of fishing gear losses. A major challenge is that reporting gear loss is challenged by inconsistent reporting metrics. While acknowledging the limitations of this study, the loss rate of nets (purse seine, gillnet, trawl) was 5.7% or 26 nets (fragments or entire loss) per vessel per year. Pot loss rate was 3.6%, or 260 (entire pots) per vessel per year.
- FAO has recently published, *Voluntary guidelines on the marking of fishing gear* to provide guidance with respect to marking fishing gear and facilitate tracking of sources ALDFG.
- Iceland has imposed a USD 0.20 per kg tax on all fishing gear sold in Iceland to fund recycling of fishing gear and reduce the problem of marine litter.
- A study to test the efficacy of a relatively cheap and unsophisticated side scan sonar to detect derelict lobster traps was only moderately successful.
- Fragments of fayed ropes used as chaffing gear on trawl codends can break off and contribute to ALDFG. Modifications to trawl gear are being tested to reduce codend contact with the seabed and avoid loss of these fragments.

Session 2: Interactions of protected species in capture fisheries.

- The focus of this session was:

- Gear modifications to avoid marine mammals
- Update on US Marine Mammal Protection Act and implications on fishery imports
- Sea turtle releasing device in Japanese set nets
- Mesh size modifications to avoid cetaceans

- Marine mammals are increasingly under threat in North American fisheries due to rope and mesh entanglement. Options to mitigate these impacts include rigging modifications, pingers, reducing vertical lights, colour enhancements to ropes, although empirical evidence that these and other options work (evidence-based solutions) is lacking. Joining two ropes in a sleeve to provide a 'weak link' has proven promising. Rope-less fishing is being investigated, including specialised acoustic release and buoyant pop-up arrangements to release rope and allow retrieval at the surface. Alternatives to gillnets are being tested, including handlines, but are yet to prove to be a suitable replacement.
- A provision in the US Marine Mammal Protection Act allows the US to reject imports from countries where the impact on marine mammals is in excess of US standards. Countries have until 2022 to introduce comparable standards to the US.
- The Japanese have developed a turtle releasing device (TRD) for their set net fishery.
- Icelandic researchers are investigating options to avoid cetacean capture in gillnets.

Session 3: Light, fish behaviour and fishing

- The focus of this session was the response of mesopelagic fish to artificial light.
- There is renewed interest in these stocks in Norway and elsewhere, although the actual biomass of these stocks is highly uncertain.
- Historical catches have been highly variable, and the use of red, infrared, blue, green, and white light to aggregate these species has to date proven of limited effectiveness.

Session 4: Technology and management to reduce bycatch and discards (1)

- The focus of this session was:
  - Shrimp selectivity and behaviour to light
  - Reducing undersized whiting in fly shooting fisheries
- An experimental and theoretical approach was applied to identify the most selective codends based on evaluation of more than 30 different codends. An economic model was then developed to evaluate the impact of these codends, and a matrix was developed that combined economic and selective codend performance. This was then used to identify best performing codends.
- Several gear modifications have been tested to improve shrimp selectivity including vertical compartments inside a trawl, the efficacy of a guiding panel ahead of a grid, and a sieve net to block entry of large fish.
- Several modifications have also been tested to improve the selectivity of fly shooting gear, akin to Danish seining in Australia. One modification included a square-mesh panel plus white and multi-coloured LED lights, although the effectiveness of lights was unclear.

Day 2.

Keynote presentation

- The keynote presenter, Asmund Bjordal, has a history of fishing technology research extending more than 30 years. He described his upbringing and early interest in fishing. He then described highlights of his career and concluded with a few key points, a need to improve fuel conservation, and a need to innovate and reduce waste.

Session 4: Technology and management to reduce bycatch and discards (2)

- The focus of this session was:
  - New approaches and technologies to reduce unwanted catches in the European Union (EU)
  - Update of global discards
  - FAO Latin American shrimp bycatch project summary
  - Square-mesh panels
- The EU discard ban has significantly increased a need to improve fishing gear selectivity. A related initiative is the Gear-up program, which includes a searchable online database, www.gearingup.eu. This provides fishers and others a summary of recent gear selectivity research. This multi-lingual tool is designed to help fishers understand what has been done in the past and stimulate new ideas to improve selectivity. Research can be filtered by target group and species of interest, location, gear type, and selectivity device. This work compliments EU's discardless project (www.discardless.eu). The increased interest in artificial light was also mentioned, focusing on developing appropriate light technology and understanding behaviour to trawl. The smartfish project (www.smartfishh2020.eu) is investigating the potential of acoustics and infra-red illumination to observe fish behaviour and optimise gear performance. It is also exploring the potential to use 3D scanning from smartphones to analyse catches (http://smartfishh2020.eu/catchsnap-can-3d-analysis-of-fish-catch-be-done-using-mobile-phones/?fbclid=IwAR3vLl7CG4TLp6e8WS7pgNekhlItttVvkT4l_oAZtUtzgIzCTIakdFVDhzQ).
- The FAO's more recent publication, *Discards in global marine capture fisheries* has estimated that 9 million tonnes of seafood are discarded annually, which equates to around 10% of global landings.
- An FAO project is working with individuals in six Latin American countries to reduce bycatch in tropical shrimp fisheries. A variety of gear options are being tested including new otter boards, trawl designs, codend modification including TEDs and BRDs, and ground gear modifications. Substantial challenges are being experienced. Despite this there are some positive signs and improvement in bycatch reduction, including strengthening of partnerships and awareness raising by all stakeholders. A proposed global bycatch reduction project was discussed that also included efforts in African countries.
- An example of this project was presenting, with a focus on efforts to reduce bycatch in Brazil. Several BRDS tested included a square-mesh panel, a Nordmore grid, and a fisheye modified with square-mesh netting over the escape opening in a shrimp trawl, although these devices also lose shrimp while reducing fish bycatch by around 40%.
- Several presentations focused in local efforts to reduce bycatch and discards using square-mesh panels, grids, and other modifications.

- Another presentation focused on the limitations of piecemeal bycatch management, citing unintended consequence, and argued for an ecosystem approach.

Session 5: Selectivity of fishing gear: Means and methods

- The focus of this session was:
  - Trawl codend selectivity in Iceland, Mexico, Ireland, and the Netherlands
  - Stow net selectivity in China
- Various codend modifications and other modifications have been made to shirmp trawls and stow nets to reduce bycatch. Trawl modifications include replacement of the tickler chain, and use of steel hydrodynamic otter boards instead of traditional, rectangular flat otter boards. While some bycatch is reduced, problems remain and further improvements are necessary. Mexican research in a shrimp fishery were characterised by poor experimental design rendering the results little more than a snapshot of BRD performance.
- A codend comparision between 80 and 88 mm codends was described using a pulse trawl but results proved equivocal.

Session 6: New technologies for fisheries research and education

- The focus of this session was:
  - Acoustic catch monitoring methods
  - Open source software for statistical models
  - Electronic monitoring boards
  - Use of infrared to observe fish
  - SeSAFE presentation
- While acoustic methods can be used to evaluate a fish school by size and species before setting a purse seine, this approach is not exact. This is prompting renewed efforts to better understand how seiners can be better positioned during a set to improve acoustic evaluation of schools. The use of a drone equipped with sonar equipment is also being tested.
- R is now the dominated statistical package being used to analyse experimental data. A recently developed refined and improved package has been developed that is more flexible and accommodating of different experimental methods.
- The efficacy of a new electronic fish measuring board was discussed, with claims it is superior compared to previous designs.
- The pros and cons of using infrared illumination to observe fish behaviour was discussed.
- The SeSAFE project was presented, and how the modularised approach to training delivery can be adapted to suit other training needs and build capacity.

Day 3.

Session 7: Energy, technology, analysis, and simulation

- The focus of this session was:
  - Energy conservation in fisheries
  - Innovative fishing gear
  - Numerical modeling of floats, ropes, and flow around a beam trawl
- A process to audit the energy consumption of fishing boat is available although energy saving options typically reduce fuel consumption by only 10-30%.
- The CRISP project in Norway is developing several innovative devices to improve selectivity and reduce unintended mortality during fish capture. This includes a probe that can be deployed during hauling of a purse seine to transmit video and oxygen level data to the seiner. This allows monitoring of fish stress levels which is important for the survival of slipped fish. It includes a stereo camera system that identifies fish number, species, and size and transmits this information to the wheelhouse.
- A pontoon trap has been developed that includes the application of compressed air to lift the trap to the sea surface. This gear is designed to replace traditional gillnet gear and avoid seal mortality.
- Numerical simulation of trawl floats and twisted ropes is attempting to understand the hydrodynamic properties of these components. This understanding can help design fuel efficient gears, and perhaps reduce the need for large otter boards to spread open the gear.

Day 4.

Session 8: Chinese fisheries - status, challenges, and future

- The focus of this session was to provide an overview of Chines fisheries, including research on fishing gear selectivity, management, and IUU challenges.
- Despite significant growth in Chinese landings over recent years, effective management, control, and surveillance is limited and struggling to catch up. Research evaluating fishing gear performance and gear selectivity is limited, and recruitment of crew in the Chinese fleet is increasingly difficult. IUU fishing remains a significant challenge and obstacle to sustainable fisheries.
- A notable development is the establishment of a Fishery Improvement Project (FIP) by a local fishing company with pelagic longline vessels operatings in the Pacific Ocean.

Day 4 and 5.

Topic Group meetings - Light

- The agenda and abstract to both keynote presentations in the light topic group session are provided in Attachment 3.
- The objectives of the light topic group are:
  - Create a community of researchers using (or interested) in using light as a fisheries selective tool
  - Aggregate and synthesise known information
  - Workshop common challenges (experimental, technological, and analytical)
  - Exchange ideas, support, and stimulate innovation
- The topic group focused on several important questions related to the use of illumination, the following points and conclusions were made:
  - How confident are we that artificial light can reliably be used to manipulate fish behavour?
    - There is some evidence that different behavioural responses can be manipulated
    - The light stimuli to elicit given responses
    - The effect of light on fish responses in an environment characterised by other stimuli such as visual, aural, and tactile stimuli
    - We have a long way to go. A variety of responses may be present, we have difficulty describing and interpreting responses, there are no recognised guidelines, and we are unsure if we know what research we need to be doing.
  - What are the unintended issues associated with using light, and do we need to mitigate some or all of them?
    - If lights were mandated, how do we verify they are working as intended, how do we ensure they are not used for the wrong reason (e.g. IUU fishing), how do we respond if they are too efficienct, and do we monitor uptake and behaviour of fishers?
    - What are the implications for 'blinding' fish? Does it occur? Is it temporary? Does it increase catching efficiency or risk of predation?
    - Is light pollution an issue? Unintended consequences?
    - How does efficiency vary, e.g. by time of day, season, depth, etc.?
  - How do we differentiate response to an illuminated gear from response to a standard gear?
  - Are there waste or toxicity issues associated with the discard of lights? How should they be discarded responsibly?
  - What variables need to be considered and what data should be collected during research?
    - Environmental variables
    - Light placement and number
    - Light levels in other parts of the gear
    - Biological attribtes of each species
    - Impact of noise, soak time, and variation in ambient and artificial light sources
- The above questions highlight just how little is known about the use of artificial light and the scope of future research needs.

- Several case study experiments using lights attached to fishing gear were described. Research of Alaska Pollock suggests that short wavelengths of 360-400 nm (violet and blue) elicit ihibitory responses while long wavelengths of 550-630 nm (green and orange) elicity excitory responses. In several gillnet fisheries in the USA and Peru, off-the-shelf Lingren-Pitman lights transmiting in the green, orange and UV light spectrum have reduced the incidence of turtle entanglement. In an Indonesian study turtle entanglement rates were reduced by 50% and the catch increased by 20%. These lights apparently have been tested attached to longlines to reduce seabird capture. LED tubing has been tested attached to excluder grids, although the results are equivocal at this stage. Australian efforts using white light attached to prawn trawls was referenced, and held up as an example of a study with well documents results and discussion. Illumination in snow crab pots has improved CPUE by 77% in Newfoundland, and in Indonesia red lights attached to gillnets have proven to reduce catches of mobulid (manta rays) bycatch.
- Light studies often inherently assume that light is a dominant influence responsible for fish behaviour. It remains unclear if this is true or otherwise. In additional it is often assumed that fish are responding to a near-field stimulus, when in reality this is a far-field stimulus and fish may have been modifying their behaviour for some time before encountering the illuminated fishing gear.

Topic Group meetings - Groundgear

- The objectives of the groundgear topic group are:
  - Create factsheets describing commonly used groundgear
  - Describe methods to reduce bottom contact and fuel use and improve gear efficiency and selectivity
  - Recommend future theoretical and experimental research
  - Discuss implications e.g trade-offs and legislative requirements, regarding design and operation of groundgear to reduce bottom contact and fuel consumption
- During the topic group meeting the following recommendations were identified:
  - Understanding of i) fish reaction to groundgear, ii) environmental impact, iii) energy efficiency, and iv) survival of fish following groundgear contact and escape, is poor and additional research is required
  - New groundgear is required to reduce bottom contact and impact on benthic species
  - The weight of groundgear should be reduced whenever possible, to reduce bottom impact and fuel consumption
  - Improved steps are required documenting groundgear specifications. Inconsistent standards and reporting criteria hamper evaluation of groundgear impacts.

Topic Group meetings - Passive fishing gear

- The objectives of the passive fishing gear topic group are:
  - Aggregate and synthesise known information in relation to pots, traps, gillnets, and longlines
  - Document catching efficiency and selectivity issues, including depredation
  - Recommend potential improvements to these gears
- An overview of passive gear use globally was presented, as was steps to introduce passive gears as replacement gear in a fishery

- The Award recipient provided a summary of his change management research, particularly that associated with the voluntary adoption of research outcomes by fishers
- The challenges of replacing active gear with passive gear were discussed, and industry driven initiatives found to be more likely to succeed. Scientists need to get better at presenting information to fishers, policy-makers, public, etc in order to facilitate change.

General business

- It was agreed that the location of the 2020 meeting would be Bergen, Norway.
- The Award recipient provided a brief presentation describing the location and timing of the World Fisheries Congress in Adelaide in 2020. Mention was made that the WGFTFB might want to organise a satelite workshop or theme session related to a topic of interest, particularly as the timing coincided with a proposed ICES fishing technology symposium.