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# **Shark depredation in Australian fisheries**

**Understanding the scope of the issue: Workshop Summary**

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## **Shark depredation in Australian fisheries - Understanding the scope of the issue: Workshop Summary**

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# Contents

<b>Contents</b> .....	<b>iii</b>
<b>Acknowledgments</b> .....	<b>iv</b>
<b>Executive Summary</b> .....	<b>v</b>
<b>Introduction</b> .....	<b>1</b>
<b>Objectives</b> .....	<b>1</b>
Purpose of this document.....	2
<b>Method</b> .....	<b>2</b>
Discussion paper on shark depredation in Australian fisheries .....	2
Workshop 1: Understanding the scope of the shark depredation issue .....	3
Workshop 2: Identify and discuss potential mitigation options.....	3
<b>Results &amp; Discussion</b> .....	<b>4</b>
Discussion paper on Shark Depredation in Australian Fisheries .....	4
Workshop 1 synthesis: Understanding the scope of the shark depredation issue .....	4
Results from the survey prior to the second workshop .....	8
Workshop 2 synthesis: Identify and discuss potential mitigation options.....	9
<b>Recommendations</b> .....	<b>17</b>
<b>Extension and Adoption</b> .....	<b>20</b>
<b>Appendices</b> .....	<b>21</b>
Presenters at Workshop 1 .....	21
Presenters at Workshop 2 .....	21
<b>References</b> .....	<b>22</b>

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Thanks also to the various presenters across the series workshop (refer to the [Appendix](#)). Your contributions were fundamental in informing the subsequent discussions over the workshop series.

Finally, thanks to Robert Brennan for assistance in the planning and successful facilitation of the workshop series.

# Executive Summary

At the request of the Australian Fisheries Management Forum and in response to increasing stakeholder concern, FRDC held a series of workshops to explore the issue of shark depredation in Australian fisheries addressing two areas:

- Workshop 1: Developing a shared understanding of the nature and dimensions of the shark depredation issue, and
- Workshop 2: Identification of possible mitigation measures and pathways towards their development or adoption.

Workshops were held online due to persistent COVID-related travel issues. The online format enabled broad representation/attendance and involved stakeholders from all Australian states/territories as well as relevant Commonwealth-managed fisheries. Small working groups were used to discuss the information presented and then shared in plenary discussion sessions.

This document provides a synopsis of discussions, presentations, and attendee comments collated from the shark depredation workshops facilitated by FRDC through May and June 2022.

One of the main themes identified in Workshop 1 was the variability inherent in the issue, and in various user groups' experience of it. This variability extends across a range of spatial and temporal scales. For example, at the broadest scale, a general north/south divide in the rate and intensity of shark depredation was evident, with the northernmost parts of the country generally experiencing depredation as a pressing issue, while southern areas tend to identify depredation as a less pressing issue.

Through Workshop 2, participants identified a range of behaviours and technologies that fishers across various sectors and fisheries are using to mitigate depredation, noting that most of these are only partially successful. Opportunities may exist to refine some of these approaches to increase their effectiveness. Exertion of additional fishing mortality on shark populations to reduce depredation (either through reduction in shark abundance or by creation of negative associations with vessels) is of considerable interest to many fishers. Any further investigation of shark fishing as a mitigation tool would need to be based on a scientific understanding of shark population structure and dynamics, as well as the issue's economic and regulatory dimensions and wider social expectations.

Overall, it was noted that a successful pathway towards mitigation will involve a mix of behavioural change, technical solutions, and education, with these three components being strongly interlinked. Finally, it was noted that complete elimination of depredation is unlikely, and expectations for mitigation should be tempered accordingly. Consequently, understanding the magnitude of reductions that fishers would regard as successful (i.e. would a 10% reduction be viewed as success within a given fishery, or is 50% required?) is essential for measuring the impact of future mitigation pathways.

The workshop series identified important shared aspirations among stakeholder groups, as well as areas of divergent opinion. Both commonalities and differences made national-level prioritisation challenging, as different states and territories, and regions or fisheries within each jurisdiction, had different perspectives and priorities. Likewise, fishers' appetites for different mitigation measures will vary across operating and regulatory environments. Participants also noted that prioritisation of research objectives relating to depredation should be based on some form of cost-benefit analyses, noting that there is only a finite amount of funds available. Hence, subsequent research and development needs to be progressed in a collaborative manner focusing on areas of commonality (where possible) to ensure the greatest likelihood of developing positive impact.

Over the course of the workshop series, FRDC ensured that the participants were provided summaries of the outcomes of each session. At the conclusion of the workshop series, this synopsis of the discussions, presentations, and commentary from the shark depredation workshops was drafted and shared among the participants for feedback and finalisation.

**Keywords**

Shark; Depredation; Mitigation; Behaviour; Education; Innovation; Sustainable fisheries management

# Introduction

Anecdotal evidence of increasing shark depredation rates in a range of Australian fisheries, combined with recent scientific publications highlighting data deficiencies (e.g. Mitchell et al. 2018a,b; Mitchell et al. 2019; Ryan et al. 2019; Vardon et al. 2021) has created an impetus for further research on this issue.

Shark depredation is defined as the complete or partial consumption or injury by one or more sharks of an animal caught by fishing gear (modified from Mitchell et al. 2018a). In some contexts, this definition can usefully be broadened to include depredation that occurs following release from fishing gear (post-release predation). While noting that depredation by taxa other than sharks occurs in some Australian fisheries, in the interests of maintaining a manageable scope, the workshop(s) were limited to depredation by sharks.

Following reports of increasing shark depredation from numerous fisheries across many Australian jurisdictions (particularly those across the continent's northern half), the FRDC was tasked by the Australian Fisheries Management Forum (AFMF) with convening a workshop series on this issue.

In response, a series of two workshops were undertaken, involving all Australian states/territories as well as relevant Commonwealth-managed fisheries. The workshop series was planned in two parts, with part one focusing on the nature and dimensions of the shark depredation issue, and part two concentrating on potential mitigation options and pathways towards them.

To ensure that subsequent initiatives that may emerge from the workshop target key knowledge gaps, maximise the likelihood of identifying and developing effective mitigation measures, and create effective collaborative partnerships, the workshops were intended to bring together fisheries managers, researchers, and representatives from commercial and recreational fishing.

Importantly, these workshops did not focus on policy development. Rather, the first workshop provided opportunities for a coordinated and structured exploration of the issue to improve understanding of its scope and identify potential knowledge and data gaps. While the second workshop identified potentially fruitful mitigation options—both technical and behavioural.

While recommendations were anticipated to emerge from these workshops, the FRDC acknowledge that these do not circumvent or negate the need for standard jurisdictional policy processes. Similarly, any recommendations relating to R&D would need to pass through the standard processes of the relevant investment agencies/institutions as well as relevant FRDC structures, such as Research Advisory Committees.

## Objectives

Objectives of the project were to:

1. Define key dimensions of the shark depredation issue in Australian fisheries (across all relevant sectors) in terms of:
  - a. relevant characteristics of the shark species and populations involved,
  - b. relevant traits of the fisheries involved, and
  - c. potential impacts of shark depredation, from economic, ecological, stock assessment, and social perspectives
2. Clearly identify and discuss potential mitigation options
3. Facilitate a national approach to collaborate and share cross-jurisdictional knowledge and efforts to define the scope of shark depredation in Australia and potential next steps

## **Purpose of this document**

This document is intended to provide a synopsis of discussions, presentations, and attendee comments collated from the shark depredation workshops facilitated by FRDC through May and June 2022.

## **Method**

To understand key dimensions of the shark depredation issue in Australian fisheries, and potential mitigation options, FRDC facilitated a series of workshops:

- Workshop 1: Developing a shared understanding of the nature and dimensions of the shark depredation issue, and
- Workshop 2: Identification of possible mitigation measures and pathways towards their development or adoption.

## **Discussion paper on shark depredation in Australian fisheries**

To guide the workshops, FRDC commissioned Dr Jonathan Mitchell (Qld DAF) to draft a discussion paper exploring key issues in Australian shark depredation research. Given that at least one substantial global review on shark depredation had been published recently (Mitchell et al. 2018a), an exhaustive survey of the literature was not sought. Rather the discussion paper was intended to situate insights from the global experience of shark depredation in the context of Australian fisheries by reviewing the following elements:

- compile and evaluate the evidence underpinning claims of increasing shark depredation in Australian commercial and recreational fisheries,
- identify potential reasons for this increase, acknowledging that definitive identification of causal mechanisms is unlikely in a paper of this nature,
- consider depredation issues relevant to Threatened, Endangered, and Protected Species (TEPS), including where TEPS may be either the depredating taxa or the prey,
- identify measures of shark depredation that are most likely to be useful in quantifying the issue across Australian fisheries,
- identify key data and knowledge gaps for shark depredation research in Australia,
- identify potentially fruitful methodological approaches for addressing these gaps, with a focus on non-invasive solutions wherever possible,
- assess the potential role of shark depredation in generating intersectoral conflict,
- examine the implications of shark depredation for fisheries stock assessments in Australia, including approaches for more accurately estimating depredation rates for incorporation into stock assessments, and
- provide a high-level outline of mitigation approaches that could be useful across the range of affected fisheries in Australia.

Workshop 1 was structured around the content of the discussion paper, with presentations from the fisheries management agencies of Western Australia, the Northern Territory, Queensland, New South Wales, and the Torres Strait structured around key themes or issues identified through the paper, and small-group discussions focusing on data gaps and information priorities.



## **Workshop 1: Understanding the scope of the shark depredation issue**

The first workshop was structured around a series of jurisdiction-specific presentations. The discussion paper was used to guide development of these presentations and provide context, and to ensure the presentations formed a cohesive whole. Presentations were intended to improve understanding of the scope of the shark depredation issue and identify both commonalities and particularities across and among jurisdictions. Presentations addressed the following broad topic areas:

- monitoring and data collection relevant to participating jurisdictions,
- research and monitoring underway in participating jurisdictions,
- management issues,
- key challenges and knowledge gaps, and
- sector-specific perspectives on the issue.

The first workshop was focused on fishery managers, agency researchers, and representatives from the commercial and recreational sectors. The workshop's purpose was to scope the extent of the problem.

The workshop was held online due to persistent COVID-related travel issues. While the online format enables broader representation/attendance, it is acknowledged that this is not the ideal format to facilitate an open discussion forum. To combat this, the workshop regularly broke out into smaller (four to seven people) working groups to discuss the information presented to them.

## **Workshop 2: Identify and discuss potential mitigation options**

The second workshop concentrated on identifying potential mitigation options and pathways towards them. The second workshop's scope was informed by discussions during workshop one, with the following themes emerging as specific discussion topics for workshop two:

- exploration of possible mitigation approaches, spanning the broad categories of (i) gear and technology, and (ii) fisher behavioural change,
- communications and education approaches to underpin elements of fisher behavioural change as well as raising awareness of the shark depredation issue with the community, and
- the influence that possible changes in shark populations may be having on depredation and the question of whether sustainable shark fishing could be used to mitigate shark depredation.

Prior to the second workshop, FRDC circulated among the invitees a survey that aimed to collect stakeholders' views on potential approaches for mitigating shark depredation. Participation was voluntary and all responses were anonymous. The survey was not intended to be exhaustive and posed the following questions:

- What sector best describes you?
- What technical mitigation solutions do you know of that are effective at reducing the likelihood of fisher interactions with sharks?
- What changes to fishing behaviours do you consider effective at reducing the likelihood of fisher interactions with sharks?
- What data/information would you need to see to be convinced that mitigation approaches are effective?

FRDC collected and collated survey responses and reported summarised results back to the workshop participants to promote discussion.

# Results & Discussion

## Discussion paper on Shark Depredation in Australian Fisheries

This can be accessed [here](#).

## Workshop 1 synthesis: Understanding the scope of the shark depredation issue

### Session 1

Session 1 of workshop 1 began with a presentation from Dr Jonathan Mitchell summarising the discussion paper written to guide the workshops ([Appendix](#)). After a discussion of Jonathan's paper in plenary, jurisdictional presentations were delivered by fisheries management agency representatives from Western Australia, the Northern Territory, and Queensland. Refer to the [Appendix](#) to access the presentations from Session 1.

In addition to question time, these presentations were interspersed with small-group sessions ("breakout rooms") in which mixed groups comprising participants from different states/territories and sectors and professions/interests discussed the following topics:

- What data gaps are beginning to emerge for you (having seen the initial presentations)?
- What is the relative priority of research recommendations from the discussion paper?

The following synthesis has been developed from notes collected by rapporteurs from each of the small-group sessions, and from comments and questions made during the plenary sessions.

One of the main themes identified in this session was the variability inherent in the issue, and in various user groups' experience of it. This variability extends across a range of spatial and temporal scales. For example, at the broadest scale, a general north/south divide in the rate and intensity of shark depredation was evident, with the northernmost parts of the country (WA north of about Geraldton, the NT, Qld, and northern NSW) generally experiencing depredation as a pressing issue, while southern areas tend to identify depredation as a less pressing issue. Nonetheless, shark depredation does occur off the continent's southern coastline (e.g. in Victoria, seven-gill sharks depredate snapper, while the incidence of depredation south of Geraldton in WA may be increasing). Nonetheless, as a general statement, northern Australia from approximately Geraldton to South West Rocks in NSW appears most affected.

In northern areas, depredation occurs across a very wide range of species and fisheries (e.g. from gamefishers targeting billfish through to reef and estuary species), and fishers believe depredation has increased in recent years (approximately the last 4–5 years in many cases). In terms of gear types, there was general agreement that line fisheries are most affected, but there were important qualifications to this, with some net and trap fisheries (including those targeting crustaceans) also substantially affected. For tuna longline fisheries, toothed whales rather than sharks are the primary predators eating hooked fish. At finer temporal and spatial scales, the incidence of depredation can vary substantially between fishing spots, seasons, and times of the day.

Most groups identified the primarily anecdotal nature of our current understanding as a primary barrier to effective action and called for collection of more quantitative data. However, some breakout groups took an alternative view, noting "we have enough data to understand the problem, now we have to do something about it". To this end, there is substantial interest among fishers in opportunities or techniques for avoiding depredation. For these fishers, mitigating or avoiding depredation is a more immediately pressing issue than understanding shark numbers or quantifying depredation rates.

The willingness of fishers to participate in data collection is variable. Some fishers/sectors may be quite motivated to participate in data collection activities of this nature, particularly if user-friendly methods (e.g.

phone apps) are involved, whereas other sectors are already feeling overburdened by data collection and would need to be shown a clear value proposition for collecting additional data to ensure participation. A coordinated national approach to data collection could be useful, but probably isn't essential provided the data collected are usable at the jurisdictional level. Some stakeholders also noted that there is a need for rapid action, rather than an extended period of data collection.

All participants agreed that if additional monitoring or research is to occur, it should be carefully planned to ensure that it can directly inform management action. The suggested scenario was to imagine that you have one minute with the relevant fisheries minister—what would you tell him/her needed to be done? Then consider the data required to support this action. Early assessments of data requirements may also be enhanced by a temporarily reduced focus on methods; while researchers will need to ensure that methods are reliable, repeatable, and cost-effective, the initial effort may best be devoted to identifying data needs rather than focusing on applicable methods.

Some areas for which further information is required were identified as follows:

- more accurately and comprehensively identifying the depredating shark species,
- better baseline information on shark stock status,
- drivers of depredation (e.g. changes to marine foodwebs), and
- understanding trends in depredation through time.

In terms of the “two, one, or none” approach to ranking research recommendations from the discussion paper (and associated presentations), group responses were quite varied. However, research priorities associated with tracking sharks and vessels to better understand interactions, improving identification of depredating sharks, and various approaches for collecting data from fishers (e.g. apps, logbooks, surveys) tended to rate highly. Recreational fishing participants noted that, in terms of survey methods, app-based reporting may yield better results than boat-ramp surveys, as a proportion of the fishers who experience shark depredation (at least in NSW) are likely to be fishing from vessels that are kept in marinas or on permanent moorings, and therefore don't use boat ramps. However, in other locations such as north Queensland and northwest WA, many fishers do use boat ramps. Some breakout groups noted that the prioritisation process used in this session was less than ideal, and that they wouldn't want these rankings to be recorded as their ultimate choices.

An essential point to emerge from both breakout rooms and broader discussions is that societal attitudes towards sharks have changed substantially over the last decade or two (i.e. support for sustainable shark management practices is no longer simply a “green” or “eNGO” issue), and that discussions of future options will need to occur with these changes in mind. In many cases, these broader changes are also being reflected in various fisheries and sectors (e.g. the days of recreational fishers routinely retaining large sharks are more or less over). Similarly, as data collection approaches and subsequent mitigation measures are developed, there will be a clear need to actively engage with the broader public to communicate the views and needs of fisheries sectors.

Some final points at a finer level of detail are:

- Disentangling the respective roles of behavioural and abundance changes as drivers of depredation can be tricky.
- Isotope studies are useful for identifying the trophic level(s) at which study animals are feeding, but don't enable species-level identification.
- A useful example from WA—there are approximately 100 species of sharks and rays that regularly show up in catch returns, whereas about four species are regularly assessed. In other words, the shark species diversity present in each jurisdiction or region and the number of species for which a clearly defined stock status is available are usually very different (particularly in the tropics and sub-tropics).

## **Session 2**

Session 2 of Workshop 1 began with presentations from New South Wales Fisheries and the Australian Fisheries Management Authority (Torres Strait) before moving into two small-group discussion sessions (“breakout rooms”). Refer to the [Appendix](#) to access the presentations from Session 2.

The first small-group session brought together participants with varied sectoral and jurisdictional representation. This session aimed to identify any additional stakeholder groups who should be included in future discussions and to conceptualise their interests and needs. The second small-group session involved sector- or discipline-specific groups and aimed to refine priorities and information needs for relevant sectors or stakeholder groups. In each small group, rapporteurs took notes for subsequent verbal reporting in plenary and for dispatch to FRDC. Each presentation and break-out session were discussed in plenary, with opportunities for questions and comments. The following synthesis has been prepared using information collated from all sources described above.

This workshop revealed areas of both consensus and divergent opinion among attendees. The breakout sessions tasked with identifying groups who need to be included in further discussions and actions almost unanimously identified Indigenous people and conservation groups, including environmental non-government organisations (eNGOs). Other stakeholder groups identified as likely having interests in depredation and associated issues included:

- tourism operators (particularly those offering in-water activities such as snorkelling),
- charter fishing operators (a sub-set of tourism operators, but one that likely warrants special consideration in relation to shark depredation),
- tackle-shop owners,
- beachgoers/swimmers,
- environmental managers (e.g. those working with threatened, endangered, and protected species (TEPs), including TEP sharks),
- commercial and recreational fishers operating in the Indian Ocean Territories (Christmas Island and the Cocos-Keeling Islands), where depredation is a major issue affecting commercial pelagic and demersal fisheries, as well as the growing recreational fishery for bonefish,
- industry-focused non-government organisations (e.g. OceanWatch),
- new immigrant fishers (e.g. Chinese and Vietnamese fishers),
- animal welfare groups (e.g. National Aquatic Welfare Working Group), and
- commercial shark fishers.

While recreational fishers in a general sense were represented at the workshop, spearfishers were also identified as a user group who, by virtue of the specialised nature of their activities and their often-close interaction with sharks, will require specific engagement. While not a direct stakeholder group in Australia, valuable insights are likely also available from fishers, managers, and scientists from other countries with advanced fisheries management approaches that, like Australia, have been rebuilding shark stocks under international agreements for the last ~20 years. Some attendees also emphasised the importance of including individual fishers in discussions and consultation, rather than always communicating through peak bodies or other representative organisations.

Consistent with this diversity of relevant stakeholders, participants noted that, while the present workshops are focused on depredation, shark-related issues almost always have linkages to related topics such as bather protection and the sustainable management of sharks as fisheries resources. Fisheries management attendees noted that the latter topic (management of shark fisheries) and its associated policies, processes, and scientific and engagement activities must be clearly distinguished from policies or management actions intended to mitigate shark depredation. Indeed, while increasing catches in some shark fisheries may appear an obvious mitigation option (i.e. to “fish down” shark numbers), a range of bioeconomic, social, and regulatory factors, including lack of knowledge on the shark species responsible for depredation, low acceptability of shark products among many consumers, low profitability of shark

fishing and the varying levels of legislative protection afforded to different shark species, probably mean that implementation of such measures is unlikely.

The data, information, and (in some cases), communication and engagement needs envisioned for these varied stakeholder groups were diverse, and included the following points:

- Improved understanding of the relationships between shark population dynamics, depredation, and environmental change at a variety of scales. For example, some tropical or subtropical shark species are appearing in more southerly waters (e.g. Lemon Sharks are now encountered south of Geraldton in WA). At slightly finer scales, what impacts might events such as the 2022 floods have on shark populations and on depredation?
- Stock status and stock structure for depredating shark species.
- Fine-scale mapping of shark and fishing-vessel movements.
- A more comprehensive understanding of fishers' experiences through direct engagement.
- Mapping the extent of the issue across all affected sectors/fisheries.
- Understanding relationships between stock structure, abundance, aggregating behaviour, and depredation.
- Understanding the relationships between depredation and changes to ocean food webs (e.g. changes to the distribution and abundance of the fish stocks sharks rely on for food).
- Recognising mismatches between conservation narratives regarding shark abundance and fishers' experiences.
- Quantifying some of the variability in depredation at the scale of individual fisheries or regions in terms of the depredating species and seasonality.
- Interactions between depredation and shark diets (e.g. is depredation changing sharks' dietary composition? Do sharks feed to satiety? Does depredation constitute provisioning?).
- The role of learnt behaviour (by sharks) as a driver of depredation.
- Improved data on the economic and social impacts of shark depredation.
- An overall need for good education/communication materials based on sound science.

In addition to the largely quantitative information needs outlined above, two groups independently raised the prospect that oral histories and other modes of historical-ecology inquiry could be used to gain improved understanding of shark abundances and fishers' experience of depredation prior to the development of commercial shark fisheries in Australia. Opportunities to speak with fishers who may recollect pre-exploitation shark abundances are declining as this group ages.

Support for enhanced data collection was not, however, unanimous among all groups or participants. Some groups questioned whether additional data are a prerequisite for action on depredation; these groups argued that practical actions to reduce the incidence of depredation should be the primary focus of management action, and that baseline information on shark stock status and structure may not be required to support such actions.

These groups further argued that data-collection initiatives could, depending on the cost-recovery models involved, impose additional costs on commercial operators already overburdened in this area (the potential for image-recognition technologies to reduce this burden by automating data collection was also mentioned). Additionally, these groups advocated that, if additional data collection did proceed, such activities would need to acknowledge and incorporate the skills and knowledge of commercial fishers and be accompanied by sound business cases. Participants questioning the need for further data collection also asked whether research on the population status (i.e. abundance and structure) of other depredating taxa (e.g. seals, seabirds etc) had occurred prior to the implementation of mitigation measures for those groups.

Relationships between fishers (across varied sectors) and fisheries management agencies will also influence the success of initiatives to reduce depredation. The desire for immediate action on mitigation mentioned above probably reflects frustration at a long period of inaction (in terms of support for both direct

mitigation action and supporting research) on depredation. Groups noted that in some jurisdictions, trust between fishers on the one hand and managers and researchers on the other has eroded to an extent that could compromise cooperative efforts to address depredation. Rebuilding those relationships on a basis of transparent engagement will thus be a precondition for successful efforts in this area.

Sector-specific breakout groups identified numerous issues and information needs. However, some important commonalities emerged, including a shared desire for a higher-order process to set policy directions, encompassing identification of untenable policies. A policy-setting process of this nature would provide valuable direction for future exploration of mitigation options. Improved understanding of how depredation could be factored into stock assessments and TACC setting was also desired by several groups, as was a clearer understanding of the costs involved in assessing depredation on a fishery-specific basis; this information could go some way to addressing industry concerns regarding the financial implications of data collection and mitigation action.

Another striking area of commonality to emerge from the workshop was the recognition of shark depredation as a pressing issue in almost all fisheries (commercial and recreational) targeting Spanish Mackerel across that species' Australian distribution (including northern NSW). Spanish Mackerel is also one of few species for which reasonable data holdings on depredation exist in some jurisdictions (e.g. WA). These fisheries may thus offer opportunities to test and refine data collection (see Carmody et al. 2021) and mitigation approaches as case studies (acknowledging that fishery-specific issues may preclude general applicability).

The potential for expanded education initiatives to contribute positively to awareness and mitigation also emerged from the sector-specific discussions. These ideas were raised by the recreational fisher group, who suggested the following elements to a "best-practice" guide for avoiding sharks:

- where to fish,
- when to fish,
- how often to move,
- how to set a drift,
- identifying sharks on a sounder,
- how to use deterrents (if/when available), and
- adapting fishing methods.

Development of similar advice may also be applicable to other sectors.

In conclusion, this workshop session identified important shared aspirations among stakeholder groups, as well as areas of divergent opinion requiring further exploration and clarification. Both commonalities and differences could provide a basis for a high-level policy setting and prioritisation process as the focus of the next workshop series moves towards mitigation.

## **Results from the survey prior to the second workshop**

Prior to the second workshop, FRDC invited attendees to complete a survey that sought to gauge participants' views on potentially effective mitigation behaviours and/or technical solutions that they had used or were aware of. The survey was not intended to develop a comprehensive list of mitigation approaches, but rather highlight the range of options in use/available to promote discussion.

The information presented here was collated from the 34 responses submitted at survey closure (July 1<sup>st</sup> 2022). These responses were updated and shared with the participants of the second workshop. Survey results demonstrated the depth of respondents' experience and local knowledge.

Overall, respondents came from a range of stakeholder groups, with recreational fishers particularly proactive in providing feedback.

Survey responses included the following points/comments regarding technical mitigation methods:

- reducing vessel noise—including transmitter power on sounders,
- electric reels to enable rapid retrieval of hooked fish,
- comments that most currently available deterrents have been ineffective or only mildly effective – with deterrents including:
  - electric deterrents (albeit with a short effective range)
  - rare earth magnet (efficacy inconsistent across studies)
  - audio
  - chemical deterrents (including necromones),
- changing gear types where feasible (e.g. from line to trap for commercial fisheries),
- reduce bait use (i.e. use artificial lures where possible), and
- use of turtle exclusion devices in trawl fisheries.

Some respondents noted that effective mitigation would likely require a suite of measures, with technical solutions only one part of a broader strategy. With this in mind, a range of potential behaviours were highlighted by survey respondents in mitigating depredation. Overwhelmingly, moving on/moving spots frequently was the most reported fisher practice, with some respondents noting that this is only minimally effective in some areas (and adds to costs). A related measure involved avoiding shark ‘hotspots’, which has both a spatial and temporal (i.e. certain times of day and/or year) dimension.

Additional fisher behaviours identified included:

- adopting different fish handling/release approaches (e.g. sailfish off Broome)—including avoiding catch and release of some species in some areas,
- for longline gear, reduce soak times and set gear at depths less favoured by key depredating sharks,
- switch to bigger gear with heavy line and drag settings,
- spreading recreational fishing effort over broader spatial extents,
- avoid discarding offal or bait,
- avoid burleying if feasible to do so (noting this should be at discretion of the individual fisher), and
- diversify target species to include those less favoured by sharks.

The final element of the survey sought to better understand the information or data that might be required to promote adoption of mitigation behaviours and/or technical solutions. Overall, responses to this question mainly fell into two broad categories. The first class of responses stressed fishers’ day-to-day experience on the water as the primary measure of success—essentially, shark mitigation actions could be deemed successful if fishers perceived that they were experiencing fewer depredation events (or possibly seeing a reduction in some proxy, such as shark sightings) relative to the period prior to the intervention. The second class of responses stressed the need for well designed, robust scientific experimentation to test the efficacy of mitigation solutions.

Notably, several respondents also commented that shark depredation is so frequent and intense that no mitigation measures are effective (i.e. nothing works). These frequent and widespread nature of depredation was attributed in part to high shark abundances. Such comments were linked to suggestion that shark fishing—both within a sustainably managed fishery framework or as a targeted cull—is required to reduce shark numbers to reduce the likelihood of depredation events.

## **Workshop 2 synthesis: Identify and discuss potential mitigation options**

### **Session 1**

Workshop 2, beginning on Wednesday 22/06/2022, saw the discussion shift from a broad consideration of the nature and dimension of the issue to exploration of potential mitigation measures. After introductions by facilitator Rob Brennan, FRDC representative Chris Izzo summarised discussions at the workshop to date,

emphasising that, while fisheries and sectors around Australia have reported an increasing incidence of depredation, the issue is characterised by high level of variability among fisheries, sectors, gear types, and species, as well as through time and across geographic areas. At present, information on the issue is primarily anecdotal, except for Spanish Mackerel fisheries in several jurisdictions, where data collection tends to be more advanced. Chris noted that while earlier discussions had identified the need for improved data collection, there was a strong appetite for practical mitigation action across most sectors and fisheries. Refer to the [Appendix](#) to access the presentations.

Following Chris’s presentation, Daryl McPhee of Bond University delivered a presentation illustrating the lessons and insights that could be drawn from the bather-protection experience and applied to the depredation context. Refer to the [Appendix](#) to access the presentations.

Daryl noted that, in attempting to protect water users from shark bites, governments and other decision makers typically face “no-win” situations, in which some stakeholders will inevitably be unhappy with any decision or policy direction. Nevertheless, governments face considerable public pressure to respond when people are bitten by sharks and have consequently invested substantially in shark-bite mitigation. Reflecting demand for effective mitigation options from both governments and citizens following shark bites, numerous technical solutions, often with associated patents, have been explored by entrepreneurs. Most of these solutions have insufficient testing to validate claims of effectiveness.

The bather protection experience emphasises that the effectiveness of a given mitigation solution will depend on the extent to which it is matched to, and scaled with, relevant shark senses. For example, sharks can detect underwater sound from considerable distances, so a sound-based deterrent could be considered where the goal is to repel sharks over longer ranges. Conversely, sharks’ electro-receptors function at close range, so electrical deterrents are expected to work most effectively when the deterrent and shark are in close proximity. Thus, alignment between the deterrent type and shark senses, along with a range of other co-factors, should be considered when designing or implementing approaches for mitigating depredation. Daryl’s presentation also identified additional similarities (and differences) between shark bite and shark depredation mitigation (Table 1).

**Table 1.** Similarities and differences between mitigating shark depredation and shark bites on humans. These points have been assembled from Associate Professor Daryl McPhee’s presentation to the FRDC shark depredation workshop (see [Appendix](#)).

Similarities between mitigating shark bites and depredation	Differences between mitigating shark bites and depredation
<ul style="list-style-type: none"> <li>• Effective mitigation will require a mix of technical, behavioural, and education solutions.</li> <li>• The efficacy and suitability of mitigation solutions are variable and not always tested (many approaches “over-promise” regarding their effectiveness).</li> <li>• Lots of entrepreneurial activity.</li> <li>• Diversity of views on causes and solutions.</li> <li>• There is no “silver bullet” solution that will fix the problem.</li> </ul>	<ul style="list-style-type: none"> <li>• Shark bites on humans generally involves a narrower mix of shark species (typically White, Bull, and Tiger sharks) than depredation.</li> <li>• Incidence data and reporting for shark bites on humans are better/more comprehensive than for fisheries depredation.</li> <li>• The two types of interactions have very different likelihood and consequence profiles. In other words, shark bites on humans remain rare events, but are usually catastrophic for the people involved, whereas depredation is much more common, but, at least at the level of the individual depredation event, usually has less serious consequences (while noting that depredation has serious cumulative social, economic, and environmental impacts).</li> </ul>



Group discussion of Daryl’s presentation highlighted the challenges associated with testing various devices and deterrents in a robust manner. As noted in Table 1, depredation does not usually affect people in the sense of mortal injuries, but does have important social, economic, and environmental consequences, and governments may therefore want to recommend certain deterrent devices/approaches. Robust testing, preferably incorporating standards against which device performance could be benchmarked, is a critical prerequisite for endorsement of this nature. The Western Australian Government has attempted to test various shark deterrent/repellent devices that were either already available or close to market and found that obtaining robust results was more complicated than expected. Keeping track of the full range of devices available on the market (or approaching market) is also important for maintaining a comprehensive testing regime and providing useful and reliable advice to consumers. Additionally, while testing deterrent or mitigation devices is important, fishers will inevitably adapt the ways in which they use deterrents to suit their fishing styles, preferred gear types etc. Deterrent testing and selection advice therefore needs to account for this variation in end-use styles. Overall, recognition that shark deterrence is a rapidly evolving field, combined with an ongoing commitment to develop standardised and coordinated deterrent testing approaches, represents the best opportunity to quantitatively evaluate deterrent effectiveness.

Expectations for depredation deterrents need to be scaled accordingly (i.e. deterring sharks from behaviour that probably feels very natural to them—taking a hooked fish—is likely to be more difficult than deterring the less familiar behaviour of biting a person). Therefore, an important priority is understanding the extent to which depredation would need to be reduced for fishers to feel that a given mitigation measure had delivered success. For example, would a 10 per cent reduction in depredation constitute success, or is a 50 per cent reduction needed? Given the variability highlighted in workshop 1, the relevant scale for identifying quantitative mitigation goals would almost certainly be individual fisheries or regional sectors.

Improved understanding of the trade-offs that may be involved in mitigating depredation was also identified as a priority. While attendees broadly agreed that there is no single solution, and that effectively addressing depredation requires both technical and behavioural changes, the likelihood that some fishers will be unwilling to change fishing practices to accommodate mitigation measures was also acknowledged. Consequently, establishing fishers’ willingness to pay for solutions—both financially and in potentially reduced catching efficiency—will be essential to evaluating mitigation options and developing associated communications and extension materials. More broadly, the source of funds for any initiatives to mitigate depredation, whether research, management interventions, or development and trials of deterrents, was identified as a key concern, noting the burdens already faced by some sectors.

While discussions of depredation mitigation often focus on technical solutions, behavioural approaches may be equally important. For example, spearfishers in some areas have changed their practices from diving solo to working as a team (one person spears a fish and others protect it from sharks). Daryl agreed that effective mitigation will involve a mix of technical and behavioural change.

Following Daryl’s presentation, Chris Izzo presented an update of responses to the FRDC survey on shark depredation (see workshop 1 summary for details of survey responses). Following the presentations from Daryl and Chris, the first of two small-group sessions (“breakout rooms”) for this workshop began. The breakout groups were mixed, comprising people from different states/territories, sectors, and professions/interests. In the first breakout session, participants focused on ways in which fishers could adapt their practices to reduce mitigation, and addressed the following two questions:

- What existing and known behaviours and practices are people using to mitigate depredation?
- What are other possible practices and behaviours?

The following synthesis has been developed from notes collected by rapporteurs from each of the small-group sessions, and from comments and questions made during the plenary sessions.

Feedback from the breakout groups was consistent with the survey responses. A range of practices were identified as being used by fishers in attempts to reduce depredation. Most approaches were identified as only partially effective. Moving between fishing spots before sharks arrive was a frequently mentioned, but

usually impractical, approach to avoiding depredation. The effectiveness of moving between spots was considered in part dependent on knowing when and where the sharks are likely to appear, including knowledge of any seasonality in shark movements or behaviours. Once this knowledge is developed, fishers can enact strategies such as planning visits to favourite spots in a sequence that may reduce (but will not eliminate) depredation. Hence, local fishers are likely to be more effective at reducing depredation than are visitors.

Moving on was also acknowledged as an impractical option for commercial fishers given the cost and time burdens that this approach imposes. Moving frequently between locations to minimise depredation can also reduce fishing success when attempting to target some species. Alternative solutions are required and might include fishers switching or altering gear types to reduce the likelihood of depredation events. Examples provided by the participants included using gears (electric reels, heavy handlines etc) that land fish quickly, noting that this approach is also not always applicable and may not be palatable to sportfishers (although there is still potential to fish heavier to reduce fight times). However, using heavier gear can reduce catch rates for some species, as fish may be less likely to take a bait or lure fished on heavy line. Changes in gear type (e.g. from line to trap gear in some commercial fisheries), and exploration of chemical deterrents and necromones were also identified as avenues worthy of investigation. Attendees also noted that simpler measures, such as turning off electronics while over the fishing grounds and minimising vessel noise, could sometimes have benefits.

Communication and cooperation among fishers can also assist in avoiding sharks. For example, there is evidence that commercial fishing vessels in Indonesia work together to mitigate depredation. Similarly, Australian gamefishers tend to communicate well regarding shark-related incidents and other relevant information. One potential form of cooperation between fishers is the use of “decoy” vessels that deliberately draw sharks away from the rest of the fleet. The decoy-vessel approach would presumably necessitate some form of cost sharing among the fleet to compensate the decoy vessel for lost catch or opportunities to fish. Additionally, use of a decoy vessel raises other potential issues such as the possibility that the decoy would simply draw further sharks to the area without substantially reducing depredation. The exact nature (and potential impacts) of the practices used to decoy sharks away from actively fishing vessels would also need to be considered. Anecdotal evidence suggests that setting decoy nets may be partially effective. Similarly, demersal longline fishers in Western Australia sometimes take turns to set the first shot, which usually experiences the highest depredation rate. Thus, the cost of the “sacrificial” first shot is shared among the fleet. This approach is at best a partial measure, as it still involves lost catch.

Other behavioural approaches included avoiding shark-attracting practices (e.g. disposing of offal, fish frames, and unused bait on fishing grounds, allowing speared fish to struggle unduly in the water or playing line-caught fish for extended periods on light tackle, or using live or oily baits in preference to artificial lures, noting that lures aren't suitable for all target species). However, regulatory barriers may hinder broadscale adoption of these and other mitigating behaviours in some jurisdictions. For example, possession limits for some fish species may prevent fishers from stockpiling fish frames in freezers for crab bait and promote discarding at sea. Likewise, holiday accommodation often bans disposal of fish waste in bins, which again tends to result in increased discarding into the ocean (often in a concentrated, “point-source” manner), with associated risk of attracting sharks. Similarly, mandatory release of some fish (e.g. those under legal minimum size limits) could also exacerbate depredation issues if fish are released while suffering barotrauma or other injuries likely to increase vulnerability to sharks. Mandatory use of release weights could partially address this issue. The Northern Territory has taken a different approach to post-release survival by removing minimum size limits for most reef fish species, encouraging responsible retention of smaller reef fish that are good eating (e.g. Hussars, Stripey Snapper), and asking fishers to move on to other fishing pursuits (e.g. targeting pelagic fish) once they've caught sufficient reef fish for their immediate needs. This strategy recognises the realities of post-release survival in tropical waters, and places responsibility on fishers to act as resource custodians. However, for a range of reasons, removing minimum legal sizes or similar output controls is unlikely to be appropriate across all Australian jurisdictions. In a further comment on behavioural mitigation measures, breakout groups noted that adopting technical solutions and accepting management interventions also involves behavioural elements,

making the valuable point that use of technical deterrents, behavioural change, and management are not distinct and alternative domains, but should be viewed as components of an interlinked system.

Nor should consideration of behavioural issues be limited to human behaviour. Some groups noted that an improved understanding of shark behaviour could enable development of more effective mitigation options. For example, highly resident shark species or populations are likely to require different mitigation approaches to those that are mobile or migratory. Similarly, understanding the human dimension of fisher-shark interactions through social science provides useful opportunities for authentic engagement with stakeholders. This engagement might be facilitated by encouraging fishers to record depredation events, via logbooks (commercial) and app-based reporting (recreational).

The second breakout session focused on the following question:

- What information/data or other activities do we need to bring potentially useful behaviours or practices into common usage or to make them more effective?

The working groups outlined the range of potential data collection methods and/or approaches that could improve understanding of the behaviours fishers currently use to mitigate shark depredation (as well as understand rates of depredation) to inform behavioural change—these included:

- observers on board vessels to collect human dimension data (social science),
- boat ramp surveys where suitable (e.g. where landing points are limited),
- recreational fishing surveys could include questions about depredation,
- research vessels targeting sites where multiple vessels aggregate to gather data, and
- value adding to the onboard camera footage that are already in use for various commercial vessels.

Breakout groups unanimously agreed that future efforts should be inclusive of fishers—to find out which of their currently used methods are effective, acknowledge their stewardship, use their expertise and experience to involve them in citizen science, use social media to raise awareness and counter misinformation (noting that social media can also promote misinformation).

Among the groups (and consistent with the feedback from the workshop survey), it was suggested that consistent sustainable shark fishing activity could be a behavioural (and policy enabled) approach to mitigate shark depredation—even if indirectly rather than through a substantial reduction in shark numbers.

Increasing shark harvests (or re-opening shark fisheries where they have been closed) may be unlikely in some jurisdictions/regions. As such, position statements from relevant state/territory governments regarding shark fishing as a mitigation option would clarify the range of options available for consideration. Attendees clearly expressed a desire to discuss shark fishing as a mitigation option, noting that it was the “elephant in the room” at the workshop. Participants agreed that decision-making in this area should be based on sound science. With robust fisheries science and management frameworks, Australia is well placed to deal with this issue. A discussion of the potential role of shark fishing as a mitigation measure was identified as a priority for the next workshop session.

As the workshop session concluded, there was general agreement that disentangling behavioural and technical mitigation solutions was challenging, and in some respects creates an artificial distinction, because effective mitigation will inevitably require a combination of approaches. Promoting behavioural change (including adoption of technical solutions) will require effective engagement, communication, and education with both fishers and the broader Australian community. This engagement will need to encompass both the nature of the shark depredation issue (including shark behaviour and population dynamics), and potential approaches for reducing depredation. Complete elimination of depredation is also very unlikely, and expectations for mitigation should be tempered accordingly.

## Session 2

Workshop facilitator Rob Brennan introduced Session 2 of Workshop 2. FRDC representative Chris Izzo then summarised discussions from Session 1 regarding mitigation solutions and behaviours (see Session 1 synthesis above). Participants began a series of breakout sessions. The first of these focused on the question:

- What other mitigation measures (gear and technology) might work?

The following synthesis has been developed from notes collected by rapporteurs from each of the small-group sessions, and from comments and questions made during the plenary sessions.

Feedback from the groups suggested that previous discussions during the workshop had identified most mitigation options. Some additional potential options included:

- Physical protection devices may be more cost effective and targeted but not applicable to all fisheries. For example, hoods used in the Patagonian Toothfish fishery may be useful in Spanish Mackerel fisheries.
- Use lights (in particular colours) to repel sharks.
- Reducing engine and propeller sound (which may be difficult in areas used by numerous vessels), noting that in some cases noise may also repel sharks.
- Using black plastic bags as 'scarecrows' in demersal fisheries.
- Underwater drones may have potential to either repel sharks or to act as decoys.

This discussion session also raised the role of ecosystem changes in influencing the likelihood and nature of shark encounters. Ecosystem factors could include the effects of climate change, reduction in natural prey for sharks, and changes in dominant shark species. For example, anecdotal information indicates that large Tiger Sharks and Hammerheads have declined in abundance with Bull Sharks taking their place. In northern Australian waters, historical fishing patterns (including by international fleets under various joint-venture arrangements) may have changed marine ecosystems in ways that influence depredation rates. More recently, shark recovery plans and more stringent management may have enabled rebuilding in some shark stocks, with current abundances perhaps beginning to approach historical baselines not seen for several decades. For example, historical accounts from southwest WA indicate that sharks were less abundant relative to present-day levels from the 1960s to the 1980s.

Discussions of potential increases in shark abundance provided a good transition to the next agenda item, which focused on the following question:

- What would be needed for States and Territories to consider possible future sustainable harvest of some shark species?

This session began with a plenary discussion before moving to breakout groups. As noted in the Session 1 summary above, discussion of increased shark harvests as a mitigation option was prompted by numerous survey responses identifying shark fishing as a preferred—and for some respondents the only viable—mitigation measure, combined with similar in-session conversations with workshop participants. In summary, use of increased fishing mortality on sharks as a measure to mitigate depredation was, as noted in the Workshop 1 synthesis, the “elephant in the room”, at the workshops, and its discussion was much desired by many participants. A clear theme to emerge from this discussion was a disconnect between the experiences of fishers (both recreational and commercial) and the state of scientific understanding of shark populations and abundance. Specifically, fishers in many (though not all) regions report increased depredation over recent years, but science is lacking on whether this trend reflects a real increase in shark abundance, or some other phenomenon (e.g. learnt behaviour by sharks to target hooked fish, or complex changes to marine food webs triggered by exploitation of key prey species, climate change, or other ecological factors). Consequently, stock assessments and information on population structure and connectivity for the shark species implicated in depredation would necessarily underpin decisions regarding

any use of shark fishing as a mitigation measure. Other issues (identified both in the plenary discussion and breakout groups) requiring consideration as part of any attempt to use increased fishing mortality on sharks as a mitigation measure include:

- a) Identifying the fishing mortality rates that would be required to reduce depredation. During the workshop, the application of fishing pressure to reduce depredation was generally described in terms of “sustainable harvest”. In this context, there is an implicit assumption that “sustainable” implies fishing shark populations to around the level of Maximum Sustainable Yield (MSY), or some similar reference point intended to ensure shark population viability and entailing little or no risk of population collapse. However, whether “sustainable” harvest of this nature would be sufficient to substantially reduce depredation, or whether substantially greater fishing mortality rates (i.e. at levels that would drive ongoing declines in shark abundance through impaired recruitment) would be required, is unclear. Furthermore, some participants noted that even if intensive fishing removed all sharks from a given area, repopulation from surrounding areas could occur unless sharks were reduced to very low abundances across large geographical areas. As mentioned in Session 1, some workshop attendees felt that the aim of applying fishing pressure should not necessarily be to reduce abundance, but to create a negative association with vessels for sharks. For example, fishers have observed that shark blood in the water may temporarily repel other sharks.
- b) Markets and economic viability of shark fisheries. In general, most participants who supported the concept of applying fishing mortality on sharks as a mitigation measure favoured doing so as part of a commercial fishery, in which fishers could sell captured sharks for economic profit. Most participants did not favour exerting fishing mortality as a “cull”, in which sharks would be killed without any expectation of sale or other productive use of the carcasses. Commercial harvest obviously assumes that markets are available for captured product. Some participants expressed doubts regarding market demand for shark products, noting that existing shark quotas/Total Allowable Commercial Catches (TACCs) were not being filled in some jurisdictions. Various phenomena could potentially underpin reduced demand for shark products. Some participants felt that reduced demand reflected a widespread perception among seafood consumers that shark fishing is “unsustainable”, with associated avoidance of the product. Major retailers have responded to these consumer sentiments, with Woolworths and Coles no longer selling shark flesh. Similarly, participants noted likely low levels of public support for export of shark fins, even where trunks are retained, based on negative perceptions generated by media coverage of illegal and unsustainable shark finning internationally. Some groups further noted that public acceptance of shark fishing to mitigate depredation is likely to be lower than if bather protection (i.e. protection of human life) were the aim.

Some participants felt that barriers to broader market access for shark products were largely regulatory (though this is likely related to the species involved). Potential regulatory issues identified as potentially hindering sale of shark products included (i) poor market access for larger sharks based on food safety concerns (i.e. high mercury and PCB concentrations in the flesh), (ii) regulatory restraints on targeting the full range of shark species involved in depredation, (iii) capture of sharks by commercial fishers who are not primarily shark fishers, (iv) reporting requirements, and (v) length restrictions on retained sharks. As a related issue, some participants also noted that many recreational fishers are now less likely to retain sharks for consumption than was the case one or two decades ago.

- c) If fishing mortality were deployed as a mitigation measure, effort would need to be targeted at the sharks actively involved in depredation. In some areas, large sharks appear primarily responsible for depredation, and, due to food-safety issues such as heavy metal accumulation, are unlikely to be targeted for commercial harvest (at least for flesh). The sustainability of fisheries for some whaler (Carcharhinid) species is also premised on the concept of a “gauntlet” fishery, in which fishing effort is targeted primarily at juveniles, with the long-lived, late-maturing (e.g. maturity at >20 years for Dusky Whaler) adult portion of the population left largely intact to ensure a consistent

supply of recruits (2–18 pups produced every 2–3 years for Dusky Whaler). If these adult sharks are, as suspected, the individuals primarily responsible for depredation, applying fishing pressure to them would essentially involve a reversal of the mechanisms that currently ensure the long-term sustainability of these fisheries.

- d) Some depredating species (e.g. Grey Nurse Sharks, Bowmouth Guitarfish) may currently be listed as Threatened, Endangered, or Protected Species (TEPS), or otherwise listed in national or international conservation instruments (e.g. CITES), thereby limiting options for directed fishing mortality. Similar situations exist internationally. For example, Atlantic Goliath Grouper (*Epinephelus itajara*) have historically been protected off Florida, and often depredate hooked fish. The Florida Fish and Wildlife Commission have recently approved a limited harvest of Goliath Grouper, potentially beginning in 2023. Likewise, fishers in various locations globally have lobbied for control of seals and sea lions to reduce depredation.
- e) Some gear types used to target sharks are not very selective, so intensified shark fishing effort could lead to increased interactions with TEPS.

The day's final session involved a prioritisation exercise, in which participants reviewed the recommendations for (i) data collection, and (ii) mitigation from Jonathan Mitchell's presentation in Workshop 1 ([Appendix](#), slides 15 and 16) and aimed to refine and rank priority areas based on discussions and information presented over the course of the workshops. Points made because of this session largely reflected comments made throughout the workshops and included in this summary. Important messages emerging from the ranking and refinement discussion included the need to clearly explain the process underlying any policy or management recommendation to fishers. The premise for this recommendation is that fishers will ultimately be responsible for both adopting mitigation measures and assessing their success; therefore, understanding the underlying rationale may (i) encourage conversations among fishers regarding mitigation, and (ii) increase fishers' willingness to participate in/adopt measures. Participants also noted that there was support for research related to depredation, but some concern that this should not entail long timeframes before proactive steps are taken to implement mitigation measures. Similarly, concerns were expressed regarding the source of funds for both research and management activities, noting financial pressures already experienced by many sectors. Among the research needs identified as high priority were identification of the shark species primarily responsible for depredation in different regions and fisheries, and research (including satellite/acoustic tagging) aimed at understanding shark population structure and behaviour. App-based reporting was identified as being particularly applicable to recreational fishers. Noting the variability in depredation highlighted throughout the workshop series, participants emphasised the importance of identifying the sectors and fisheries most affected and concentrating efforts on them. As a general comment, participants noted that "any data are better than no data". Recommendations from this session are discussed in more detail in the next section of this report.

In conclusion, workshop two began the process of identifying potential mitigation measures and developing pathways towards them. Comparison of the depredation context with bather protection provided insights including the likely proliferation of entrepreneurial activity directed towards depredation mitigation, and the need for a rigorous standardised testing of the resulting solutions. The bather protection experience also highlighted the widely differing expectations that different stakeholder groups will have of management and policy decisions in the depredation area. Participants identified a range of behaviours and technologies that fishers across various sectors and fisheries are using to mitigate depredation, noting that most of these are only partially successful. Opportunities may exist to refine some of these approaches to increase their effectiveness. Exertion of additional fishing mortality on shark populations to reduce depredation (either through reduction in shark abundance or by creation of negative associations with vessels) is of considerable interest to many fishers. Any further investigation of shark fishing as a mitigation tool would need to be based on a scientific understanding of shark population structure and dynamics, as well as the economic and regulatory dimension issues and wider social expectations of the public. Developing a successful pathway towards mitigation will involve a mix of behavioural change, technical solutions, and education, with these three components being strongly interlinked. Finally, understanding

the reduction in mitigation that fishers would view as successful (i.e. would a 10% reduction be viewed as success within a given fishery, or is 50% required?) is essential for measuring the impact of future mitigation pathways.

## Recommendations

From the workshops on (i) understanding the scope of the shark depredation issue, and (ii) exploring potential mitigation options, a range of potential recommendations were identified. In the final session of the workshop, FRDC presented a collation of some of the key recommendations that were highlighted in Jonathan Mitchell's [discussion paper](#) as well as from the plenary discussions. Overall, the recommendations could be categorised under four general themes, each having their own elements or activities. Some of the elements are inter-linked and so can be progressed collectively. The four themes were:

1. Data collection
2. Shark research
3. Mitigation approaches
4. Communications and education

For the final small-group session, each group, focusing on two of the areas of further work, was asked to refine the area and its elements by adding, deleting, or modifying, and where possible prioritising (low, medium, high). In brief, the workshop attendees were relatively supportive of the recommendations that were identified throughout the workshop series (albeit with amendments in some areas – highlighted in **blue** in the text boxes below).

### 1. Data collection

*Participants were divided on the need for further data collection. Some highlighting that there had been a period of data collection and there was a need for (immediate) action to address the issue. Conversely, it was suggested that more precise (and consistent) measures of depredation are fundamental to understand the scale of the issue and to help determine how effective mitigation efforts are*

- a) Collate anecdotal/historical information on depredation experiences, 'hotspots' and times/seasons = **MEDIUM, given largely anecdotal it will be prone to errors/uncertainty**
- b) Develop consistent data collection methods across fisheries – e.g. logbook fields, app, observers, rec survey Qs = **MEDIUM, noting any data are better than no data. Suggested data on effectiveness of mitigation measures may not need be as robust as data collection for deterrent**
- c) Develop consistent metrics of shark depredation – e.g. data collection focused on interaction rate and gross depredation rate = **MEDIUM**
- d) Develop stock assessments that consider gross depredation rate (as another source of mortality) = **LOW**
- e) Investigate social and economic impacts of shark depredation = **MEDIUM/LOW (potentially linked to 3d)**

### 2. Shark research

- a) Identify depredating shark species – which species should be focus of R&D and interventions = **HIGH, potentially using DNA. Noted this will likely be easier to undertake in some fisheries relative to others**
- b) Assess depredating species behaviour and nature of interactions = **MEDIUM (combine with 2g), potentially through satellite tagging**

- c) Identify potential depredation 'hotspots' based on fisher–shark spatial overlap = **MEDIUM, being inclusive of all fishing sectors (combine with 1a)**
- d) Assess depredating species abundance &/or stock status – monitor trends = **MEDIUM/LOW, clarifying timescale, fishers want solutions now but changes to management need to be evidence based**
- e) Dietary analyses of depredating species to identify key target/prey species = **LOW**
- f) Explore drivers of depredation – e.g. changes to food webs, climate change = **LOW, likely ineffective as drivers for depredation will likely differ among regions – e.g. north Qld vs SA**
- g) Explore the potential for learnt behaviour (by sharks) as a driver for depredation = **LOW (combine with 2b)**

### 3. Mitigation

- a) Capture the range of solutions/methods fishers have tested in the past &/or currently using **and have a system for capturing new entries to the market or field**. Evaluate the efficacy of these methods for further testing in other fisheries = **HIGH, need to explain the process followed to come up with these methods and make information available (combine with 4a)**
- b) Robust experimental testing of physical protection devices and shark deterrents to determine products/solutions that are practical and effective for fishers **(across all sectors) = HIGH, involving fishers (recreational and commercial) to be involved in testing mitigation options (i.e. through partnership with innovators/developers)**. Should consider cost v. benefit
- c) Understand fishers' willingness to pay for reduced depredation rates – in terms of catch efficiency, impact on fishing experience, financial cost, etc. = **MEDIUM**
- d) Understand what successful mitigation looks like – e.g. 5% or 95% reduction in depredation = **MEDIUM (linked to 4c)**
- e) **Exploring increased take of sharks by commercial (testing economic viability) and recreational (understand perceptions and regulatory barriers)**. Requires engaging with conservation groups around alignment of sustainable shark fishing and conservation objectives (linked to 2d)

### 4. Communication / Education

- a) Share methods/experiences that fishers have used in the past, or are currently using, to reduce shark depredation – both positive and negative = **MEDIUM, considered to have minimal use given few successful approaches have been identified. Any efforts should focus on fishers talking to fishers, as this might improve credibility and improve the likelihood of adoption / behaviour change (combine with 3a)**
- b) Provide practical advice on techniques that can be used to reduce the likelihood of depredation events – a best-practice guide for avoiding sharks = **MEDIUM (combine with 4a)**
- c) Develop educational materials on shark depredation to inform fishers about the nature of depredation in Australia **(and globally)**, its causes, and impacts – noting depredation will likely not be completely **(satisfactorily)** resolved = **MEDIUM, less important until more successful measures developed. Messaging must be succinct, easy to follow and appropriately targeted to specific sectors (linked to 3d, 4a & 4b)**
- d) Inform the community on the nature and dimensions of the shark depredation issue **in Australia (and globally)** – recognising mismatches between conservation narratives regarding shark abundance and fishers' experiences = **HIGH, needs to be ongoing and potentially capture messaging around shark consumption. Acknowledge the uncertainty (causes are not clear), and**



that data are being gathered and mitigation methods trialled around the world, updating information as it becomes available. Highlight relevant research being undertaken

Yet, as previously highlighted, the issue of shark depredation in Australia is characterised by a high degree of variability among fisheries, sectors, gear types, and species. National-level prioritisation in the face of this variability is challenging, as different states and territories, and regions or fisheries within each jurisdiction, will have different perspectives and priorities. In the same manner, there will be different levels of appetite for different mitigation measures given differences in operating and regulatory environments. Participants also noted that prioritisation of research objectives should be based on some form of cost-benefit analyses, noting that there is only a finite amount of funds available.

As such, there is a need for subsequent research and development to be progressed in a collaborative manner focusing on areas of commonality (where possible) to ensure the greatest likelihood of developing positive impact. It is considered that this can be achieved by (i) undertaking research that spans multiple jurisdictions and, or (ii) explore partnerships with various organisations/agencies, businesses, technology developers, and funding bodies (i.e. The National Environmental Science Program or Marine Parks Australia) – for example:

- While this workshop series sought to develop a shared understanding of the shark depredation issue in Australian fisheries, there is likely a need for a more structured and methodical approach to the synthesis of available data. Such an approach might form the basis for identifying and mapping depredation “hotspots” or developing a “best-practice” guide for avoiding sharks
- Testing the efficacy of depredation mitigation approaches and, or behaviours might involve partnerships with private sector innovators/technology developers and entrepreneurs that occupy this space. This model has been successfully adopted in WA when testing beach safety technologies
  - At the time of publishing this report (December 2022) and following post-workshop feedback from some agency participants advocating that FRDC should lead further research in this area, applications are being sought to undertake a global review of solutions to reduce unwanted fisher interactions with elasmobranchs, building on the existing primary literature base by focusing on secondary and anecdotal/unpublished research. Such a review might also consider factors that influence the likelihood of adoption. Those solutions considered successful and are practical may then inform future industry co-designed trials to reduce the likelihood of interactions between fishers and depredating elasmobranchs
- It was acknowledged that there were continual developments in the mitigation of shark depredation, which required mechanisms to collect new information and make it readily available – e.g. through a community of practice type of approach
- In terms of depredated species, Spanish Mackerel were identified as a promising species on which to base the next steps towards developing mitigation pathways, because shark depredation is a key concern throughout much of the species’ Australian distribution and is already being monitored to some extent in several jurisdictions (meaning that mackerel fisheries are relatively “data rich” with respect to depredation)
  - FRDC has since funded project [2021-111 “Addressing uncertainties in the assessment and management of Queensland east coast Spanish Mackerel”](#) that includes an objective to: Quantify shark depredation rates (percentage of catch lost) across the fishery and provide an estimate of post-release survival.
- In terms of depredating shark species, Bull Sharks were identified as a common depredating species and might provide a suitable case study to investigate the factors and behaviours that influence patterns of depredation and might be exploited as the basis for mitigation approaches and solutions

Such case studies should be inclusive of relevant stakeholders from those jurisdictions as a means of remaining engaged and connected to further share their experiences and learnings. Potential case studies would likely cut across the four themes that were identified at the beginning of this section, leveraging on existing information and investment.

Finally, the value of establishing a national steering committee or community of practice in this space was discussed. Such an entity would provide a forum for all relevant stakeholders to keep abreast of developments in the field and remain connected to others across jurisdictions and sectors.

## Extension and Adoption

Over the course of the workshop series, FRDC ensured that the participants were provided summaries of the outputs of each session. At the conclusion of the workshop series, this synopsis of the discussions, presentations, and commentary from the shark depredation workshops was drafted and shared among the participants for feedback.

**FRDC welcomes the broad sharing of this document among interested parties, noting that it is currently in a draft format. The document will be updated accordingly and finalised.**

All workshop presentations and Jonathan Mitchell's discussion paper have been made available on the webpage for FRDC project [2021-038 "Shark depredation in Australian fisheries: understanding the scope of the issue and identify potential mitigation options"](#).

# Appendices

## Presenters at Workshop 1

- Jonathan Mitchell (Qld DAF)—Overview of discussion paper
- Peter Coulson (DPIRD WA)—Western Australia
- Michael Usher (NT Fisheries)—Northern Territory
- Sam Williams (Qld DAF)—Queensland
- Vic Peddermors (NSW DPI)—New South Wales
- Chris Boon (AFMA)—Torres Strait Fisheries

## Presenters at Workshop 2

- Daryl McPhee (Bond University)—Lessons from bather protection measures
- Chris Izzo (FRDC)—Workshop overview and summary of pre-workshop survey responses



# Shark depredation: A review of existing research

FRDC National Workshop on shark depredation  
April 2022

Dr. Jonathan Mitchell  
[jonathan.mitchell@daf.qld.gov.au](mailto:jonathan.mitchell@daf.qld.gov.au)



## Acknowledgement of First Nations peoples

I would like to respectfully acknowledge the Traditional Owners and Custodians of the land on which we meet today, and I pay my respects to their Elders past, present and emerging.

I extend that respect to all Aboriginal and Torres Strait Islander peoples here today.

# Importance

- ❖ Shark depredation occurs in many fisheries around Australia
- ❖ Causes economic losses for fishers
- ❖ Biological impacts on target species and sharks
- ❖ Social impacts and intersectoral conflicts
- ❖ Anecdotal information suggests depredation is increasing over time
- ❖ Complex issue that will require coordinated effort to manage



# Discussion paper

- ❖ Guides the national workshop being held by FRDC
- ❖ Provides detailed overview of existing research on shark depredation in Australia
- ❖ Identifies key gaps for research and management
- ❖ Discusses potential options for mitigation

Discussion paper for the Fisheries Research & Development Corporation National Workshop on Shark Depredation in Australian Fisheries

March 2022

Dr. Jonathan D. Mitchell

Queensland Government, Department of Agriculture and Fisheries, Animal Science





# Research published since 2018

- ❖ Key metrics for depredation in longline fisheries developed (Rabearisoa et al. 2018)
- ❖ Large scale survey of commercial, charter and recreational fishers in WA (Ryan et al. 2019)
- ❖ Video and genetic methods to identify depredating shark species (Fotedar et al. 2019, Mitchell et al. 2019, Vardon et al. 2021)
- ❖ Experimental study showed sharks can rapidly learn to associate fishing vessels with food (Mitchell et al. 2020)
- ❖ First study to quantify depredation in a commercial mackerel trolling fishery in Australia (Carmody et al. 2021)
- ❖ Using acoustic tracking and VMS to identify spatial overlaps in shark movements and fishing activity (Mitchell et al. 2021)
- ❖ First study of shark depredation in an invertebrate trap fishery (Qld spanner crabs) (Milburn 2021)
- ❖ Fishers workshops held in Qld to assess socio-economic impacts on fishers (Hoel et al. 2021)
- ❖ First study to test the effectiveness of three shark deterrents for reducing depredation (Coulson et al. in prep)

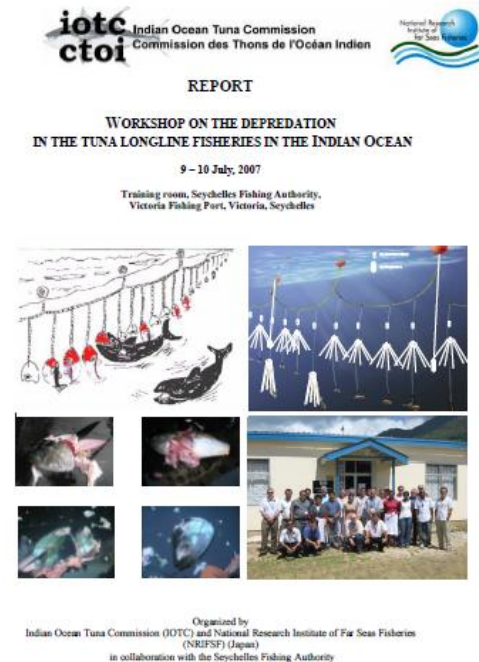


# International context

- ❖ Shark depredation primarily studied in large-scale tuna longline fisheries
- ❖ Numerous studies in Indian and Pacific Oceans (incl. IOTC workshop in 2007)
- ❖ Depredation rates range from 0.9 – 26% across global fisheries
- ❖ Depredation rates in Australian studies range from 1.7 – 13.7%
- ❖ Many line, net and trap fisheries impacted by depredation in Australia
- ❖ 27 shark species responsible for depredation
- ❖ Increasing focus on depredation in recreational fisheries in Australia and the USA
- ❖ Recent survey reported that shark depredation was regularly occurring during recreational fishing in southeastern USA



Credit: Sijo P. Varghese





# Metrics for quantifying depredation


- ❖ Interaction rate – proportion of sets or trips where depredation occurs
- ❖ Depredation rate per unit effort – e.g. per 1000 hooks in longline fishery
- ❖ Gross depredation rate – percentage of total number of hooked fish that were depredated
- ❖ Important to generate representative values across many fishing trips – i.e. calculate the mean, because depredation can be highly variable between trips
- ❖ Metric used will depend on fishing gear type
- ❖ Can be further divided into depredation rates for specific target species
- ❖ Also need to consider cryptic depredation

**PLOS ONE**

 OPEN ACCESS  PEER-REVIEWED

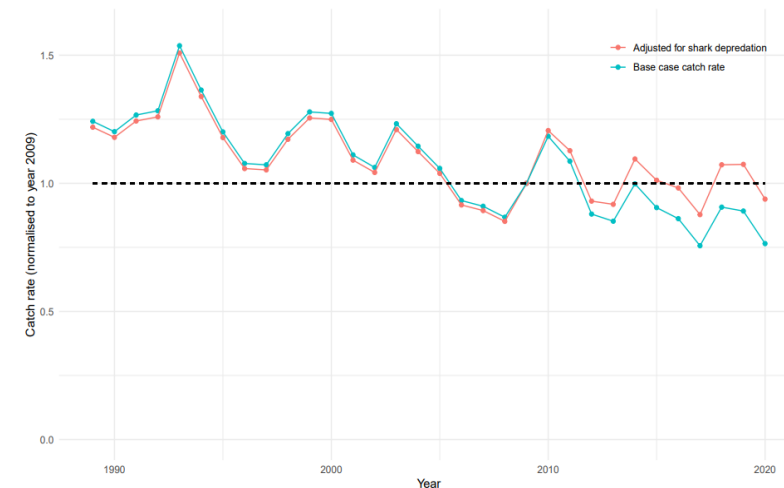
RESEARCH ARTICLE

**Toothed whale and shark depredation indicators: A case study from the Reunion Island and Seychelles pelagic longline fisheries**

Njaratiana Rabearisoa , Philippe S. Sabarros, Evgeny V. Romanov, Vincent Lucas, Pascal Bach

# Depredation and stock assessments

- ❖ Increased mortality from shark depredation is often not accounted for in stock assessments
- ❖ Can affect the robustness of stock assessments
- ❖ Can lead to inappropriate TACCs and bag limits
- ❖ Need to increase data collection to enable incorporation into assessments
- ❖ Recent Qld Spanish mackerel stock assessment simulated increasing shark depredation
- ❖ Alaska sablefish fishery have successfully incorporated depredation into assessments and adjust quota based on depredation rates



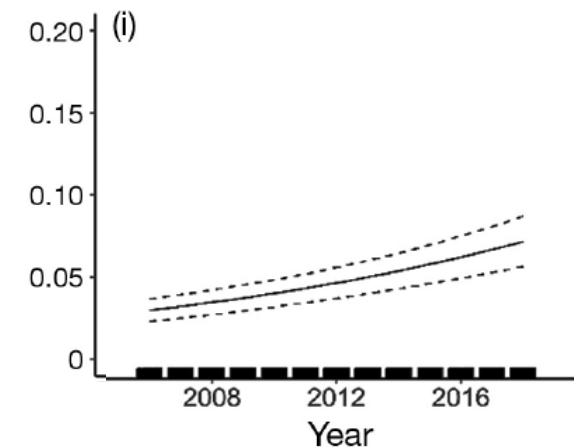
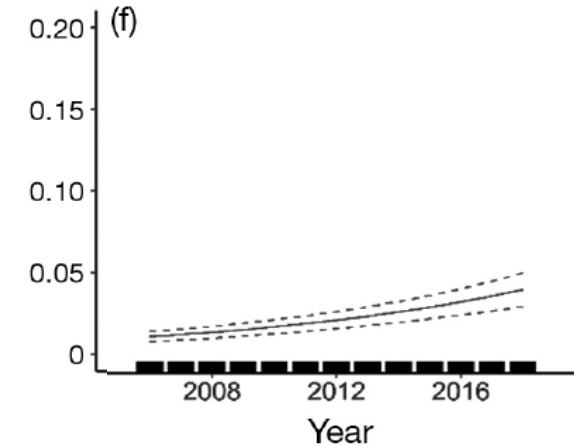
Tanimoto et al. (2021)

# Has shark depredation increased?

- ❖ Anecdotal reports of depredation since the 1800s
- ❖ Reports suggest increase in last 10-20 years in Australia
- ❖ Linked to changes in fishing dynamics, possible changes in shark abundance and shark behaviour
- ❖ Influence of increased reporting e.g. social media
- ❖ Scientific validation needed but little historical data
- ❖ Only long term study to date in WA mackerel fishery, where slight increase from 1 - 3% in Pilbara and 2 - 11% in Gascoyne occurred from 2006-2017 (Carmody et al. 2021)
- ❖ Ongoing data collection is a key priority



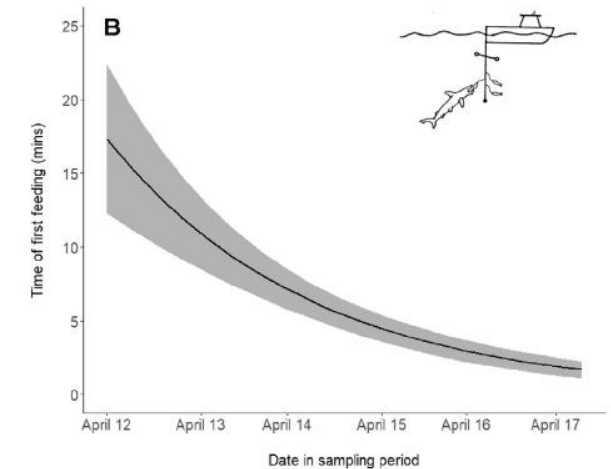
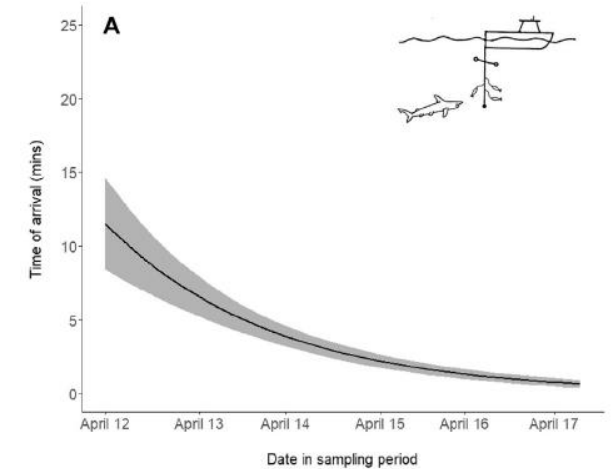
sharks ate my catch  
Public group · 6.4K members



Carmody et al. 2021

# Factors driving changes over time

- ❖ Sharks rapidly learn to associate fishing vessels with food
- ❖ Spatial changes in commercial fishing activity due to management
- ❖ Decrease in trawling in some areas led to loss of food source for sharks
- ❖ Increase in recreational fishing in remote areas where shark populations are healthier = more competition for resources
- ❖ Possible increases in shark abundance due to reduced commercial catch and bag/size limits but limited data to support this
- ❖ Anecdotal reports suggest increasing numbers
- ❖ Existing data shows stable shark population trends in WA
- ❖ Qld stock assessment of 12 whaler and hammerhead species shows mixed trends - stable in north Qld but increasing in SEQ (data only up to 2013)
- ❖ Most large whaler species take >8 years to mature and have <20 pups, so rapid increases in 10-20 years unlikely
- ❖ Environmental changes and prey abundance having an impact





# Social impacts of depredation

- ❖ Intersectoral conflict in the context of depredation
- ❖ Between fishers and conservation groups
- ❖ Commercial and recreational/charter sectors
- ❖ Relationships between fishers and managers/researchers need be improved
- ❖ Need to work together to set realistic goals that benefit all sectors
- ❖ Managing expectations is key – we can't stop depredation completely but we can identify realistic reduction targets
- ❖ Consideration of wider societal implications and expectations
- ❖ Transparency in research objectives and decision making
- ❖ Education and accurate messaging

# Impacts on threatened species

- ❖ Threatened, endangered and protected species (TEPS) can be predator or prey
- ❖ Qld groper, potato cod and/or black cod could be impacted
- ❖ Sharks depredating upon hooked sharks in some cases – could affect hammerheads, grey nurse and other TEPS
- ❖ 12 shark species identified as being responsible for depredation in Australia, includes grey nurse shark
- ❖ Bowmouth guitarfish and giant guitarfish (both endangered) depredated catch in Qld spanner crab fishery
- ❖ Sharks can become hooked and bycaught after depredating catch, causing sublethal impacts
- ❖ Retaliatory killing of sharks occurs in some cases
- ❖ A number of protected mammal species also cause depredation, e.g. fur seals, killer whales, sperm whales



# Post-release predation

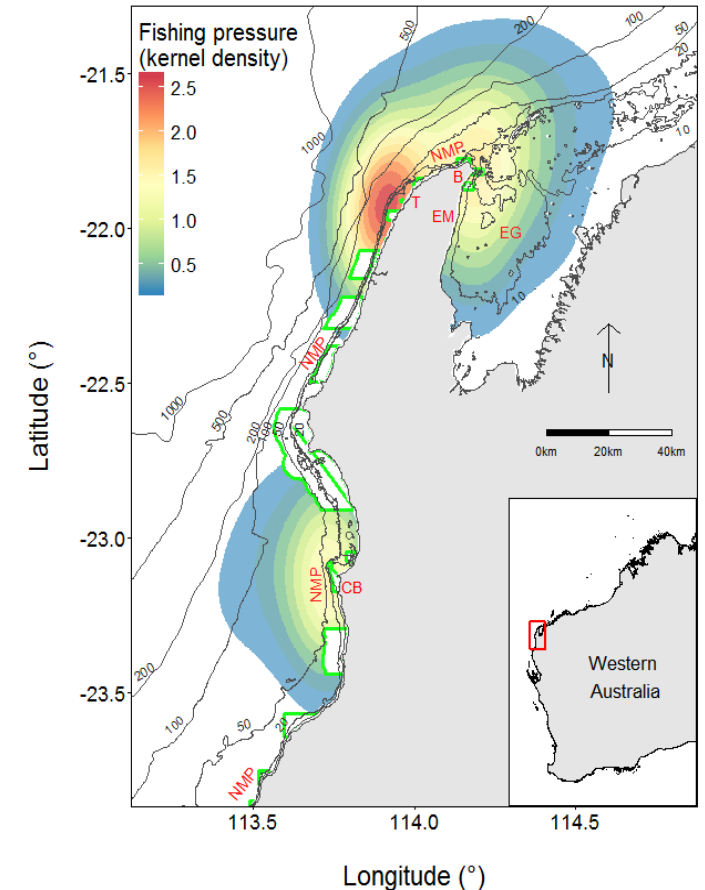
- ❖ Different to depredation but another important source of mortality
- ❖ In some cases may be as high or higher than depredation rate
- ❖ Catch and release fisheries especially vulnerable, e.g. billfish, bonefish
- ❖ Research in US using release weights showed zero post-release predation
- ❖ Tagging studies can help to quantify post-release mortality from different causes





# Key data and knowledge gaps

- ❖ Quantifying shark depredation – lack of data for many fisheries
- ❖ Environmental and ecological factors influencing depredation
- ❖ Understanding broader social and economic impacts
- ❖ Identifying shark species responsible in different areas/seasons
- ❖ Quantifying shark abundance over time
- ❖ Investigating ecological effects, e.g. changes in diet of sharks and knock-on effects in the food web
- ❖ Changes in shark movements and behaviour driven by depredation
- ❖ Identifying and testing a range of mitigation approaches



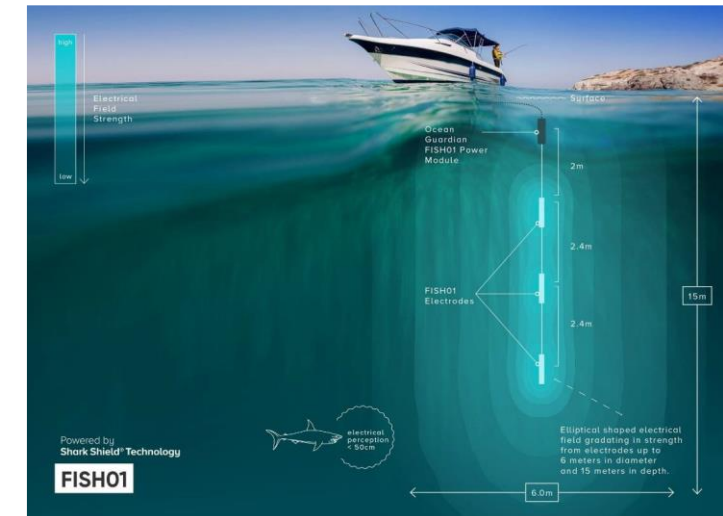
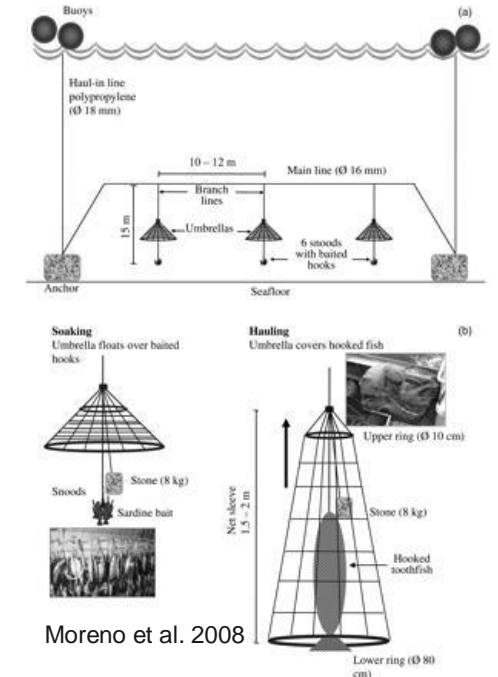
# Recommendations – data collection

- ❖ Logbook/app fields to quantify depredation in commercial and charter fisheries e.g. Carmody et al 2021
- ❖ Targeted boat ramp surveys
- ❖ Phone/online surveys e.g. those by WA DPIRD
- ❖ Fisher workshops and interviews to collect social impact data e.g. Hoel et al 2021
- ❖ Shark abundance studies – baited camera surveys, longline surveys, increased observer coverage and stock assessments
- ❖ Environmental datasets for investigating links to depredation
- ❖ Optimise video and genetic methods for shark identification
- ❖ Stable isotope analysis to determine shark diet
- ❖ Acoustic/satellite tracking of sharks combined with vessel tracking and/or sound recorders for vessels



# Recommendations – mitigation

- ❖ Stakeholder workshops to identify strategies for modifying fishing methods – what has been trialled and does it work?
- ❖ Developing educational material
- ❖ Physical protection devices to protect catch – have been trialled in some longline fisheries, with mixed results
- ❖ Electrical shark deterrent devices – first study to test these in Western Australia
- ❖ Follow-up workshops to evaluate progress



Credit: OceanGuardian



# Acknowledgements

- ❖ Dr. Sam Williams and Dr. Sian Breen (DAF Animal Science) provided input into the structure and content of the discussion paper



**Queensland Government**

**Department of Agriculture and Fisheries**

A photograph taken from the deck of a boat, looking out over the ocean at sunset. The sun is a bright, glowing orb in the upper right, casting a shimmering path of light across the dark, choppy water. The sky is filled with soft, golden light and scattered clouds. In the foreground, the white, padded deck of the boat is visible, along with a black outboard motor. The word "Questions?" is written in a large, white, sans-serif font across the center of the image.

Questions?



Department of  
**Primary Industries and  
Regional Development**

GOVERNMENT OF  
WESTERN AUSTRALIA

# Shark Depredation in Western Australia

Peter Coulson, Gary Jackson, Maddison Watt



# Fishing interactions & practices

## Fisheries

- Line-based fisheries – Recreational, charter and commercial
- Anecdotal reports - purse seine and beach seine fisheries
- No comprehensive assessment across all WA fisheries

## Fish species

- Emperors, Sparids, Snappers, Trevallies, Serranids and Scombrids<sup>1,2,3,4</sup>



# Fishing interactions & practices

## Depredation

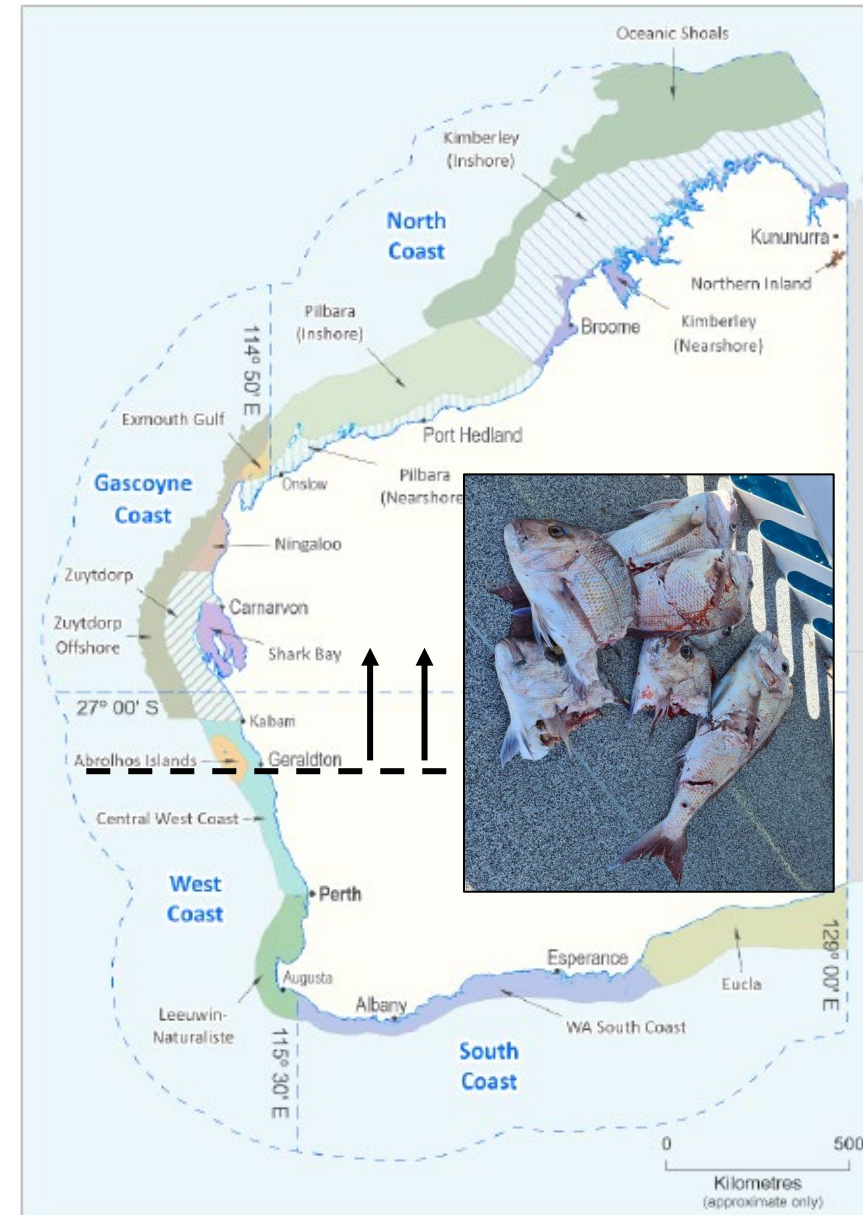
- Research in WA focused on line-based fisheries
- Depredation occurs after fish hooked

## Spatial and temporal dimensions

- Depredation most prevalent in subtropical and tropical regions<sup>1,2,3,5</sup> (north of Geraldton)

## Modification to fishing gear/behaviour

- Employing methods to retrieve fish quicker (electric reels, rapid retrieval, heavier lines)<sup>3</sup>
- Move spots or stop fishing<sup>3</sup>





# Species interactions

## Shark species

- Species identified by genetics (swabs)<sup>6</sup> and underwater video<sup>4,7</sup>
- Large individuals of some Serranid species<sup>4,7</sup>

## Threatened, Endangered and Protected (TEP) species

- Grey nurse *Carcharias taurus*<sup>6</sup>

## Post-release mortality (PRM)

- Information from fisher surveys indicate PRM is high<sup>1,3</sup>
- Anecdotal of PRD in the Pilbara commercial trap fishery, with the release of undersize target species and release of non-target species



# Research and monitoring

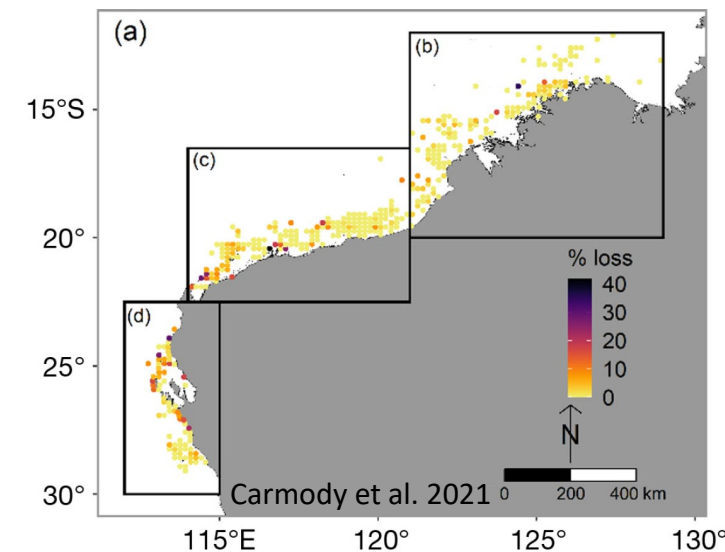
## Data type and regions

- Genetic identification – Gascoyne/Pilbara<sup>6</sup>
- Quantification through rec fisher surveys – State-wide, Exmouth, north-west<sup>1,3,5</sup>
- Time series from commercial mackerel fishery – north of Geraldton<sup>2</sup>
- At-sea quantification and visual identification – north-west<sup>4,7</sup>
- Effectiveness of shark deterrents – north-west<sup>4</sup>



## Magnitude of shark depredation

- Spatial/temporal data – limited and patchy
- 40% depredation rate - fishery independent<sup>4</sup>
- 9% depredation rate – fishery (Charter) dependent<sup>7</sup>
- 1.7-5.7% depredation rate – fishery (Comm mackerel) dependent<sup>2</sup>



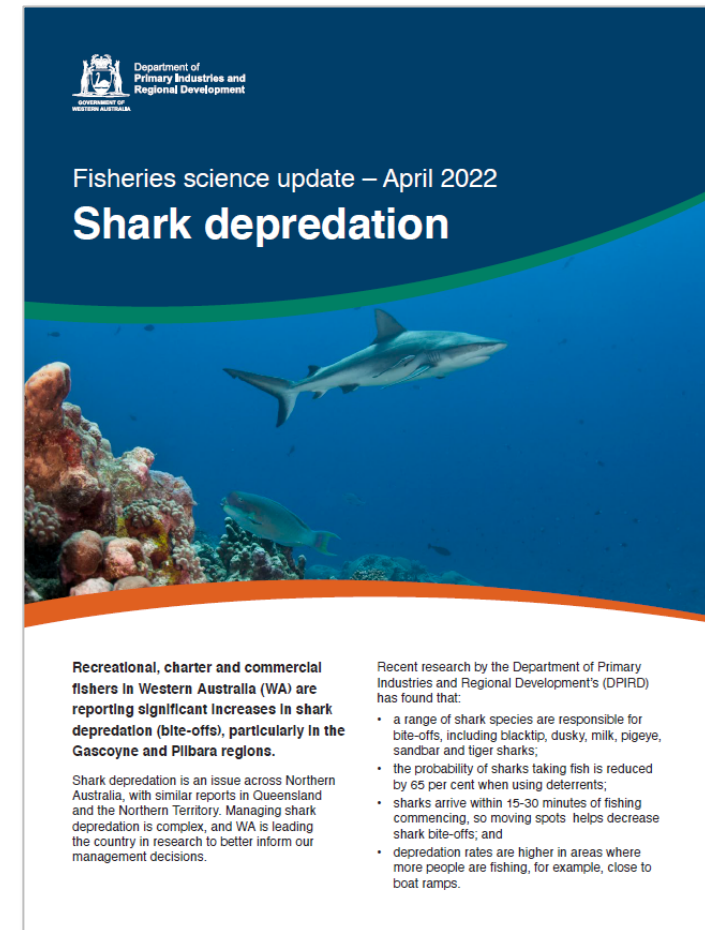
# Research and monitoring

## Temporal change in depredation

- Commercial mackerel fishery – depredation rates increased over 13 years<sup>2</sup>
- Answers in rec fisher survey indicate depredation increased over past 10 years<sup>3</sup>

## Research, monitoring and assessments

- Commercial mackerel fishery reports depredation via logbooks
- Questions asked as part of state-wide boat based recreational fishing diary-phone survey (every 3 years)
- Depredation and release mortality (barotrauma related) included in stock assessments
- Depredation accounted for in Gascoyne snapper assessment



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7. Mitchell, J. D., McLean, D. L., Collin, S. P., & Langlois, T. J. (2019). Shark depredation and behavioural interactions with fishing gear in a recreational fishery in Western Australia. *Marine Ecology Progress Series*, 616, 107-122.

# Thank you

Visit [dpird.wa.gov.au](http://dpird.wa.gov.au)

## **Important disclaimer**

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Department of Industry, Tourism and Trade

# FRDC shark depredation workshop

Michael Usher  
NT Fisheries



# Fishing interactions & practices

Depredation an issue for:

- **Line caught fisheries**
  - Fishing tourism and recreational anglers
  - Spanish Mackerel Fishery (troll lines)
  - Coastal Line Fishery (vertical lines, Black Jewfish)
  - Shark longlining
- **Gillnet fisheries**
  - Offshore Net and Line Fishery (pelagic gillnet, Grey Mackerel)
  - Barramundi Fishery (coastal gillnet, Barramundi and Threadfin Salmon)
- **Trawl fishery**
  - Offshore snapper fisheries (post release depredation)

# Fishing interactions & practices

## Spatial and temporal dimensions

- Fishing specific locations repeatedly
  - Aggregations and well known reefs
- Areas of high shark abundance and repeated effort (e.g. Wessel Islands)
- Diurnal patterns
- Barramundi Fishery possible increase in depredation during neap tides

## Modifications to fishing gear and practices

- Fishing tourism operators:
  - Move on
  - Trialled the use of shark deterrents (Sharkbanz - \$105)
- Using multiple gears (pelagic gillnet - purse seine)
- Avoiding areas of high depredation
- Retaining offal – dumping off fishing grounds



# Species interactions

Species responsible - on board observers have identified:

- Great Hammerhead, Tiger, Pigeye, Australian and Common Blacktip, Spot-tail, Bull, Lemon, Silky and Tawny sharks

Observed instances of net caught TEPS depredation (soak and post release)

River sharks occasionally captured by coastal fishers (recreational anglers and Barramundi Fishery)

Limited information regarding post release depredation, but likely high due to barotrauma, high shark abundance and learned behaviour

# Research & monitoring

Recorded by on board observers:

- Offshore Net and Line Fishery
- Fishing Tourism Operator

Reporting in logbooks

- Spanish Mackerel Fishery
- Coastal Line Fishery
- Fishing Tourism Operators

# Research & monitoring

Anecdotal evidence indicates that shark depredation has increased in recent years.

- Fisheries observers have noted an increase in depredation of Grey Mackerel in gillnets
- Commercial and tourism operators noting an increase

Depredation in stock assessments:

- Shark depredation rates included in discard estimates for Grey Mackerel stock assessment.
- NT reef fish assessment assume 100% mortality due to barotrauma and high depredation rates.

# Abundance

Stock assessments estimating increasing abundance in the NT.

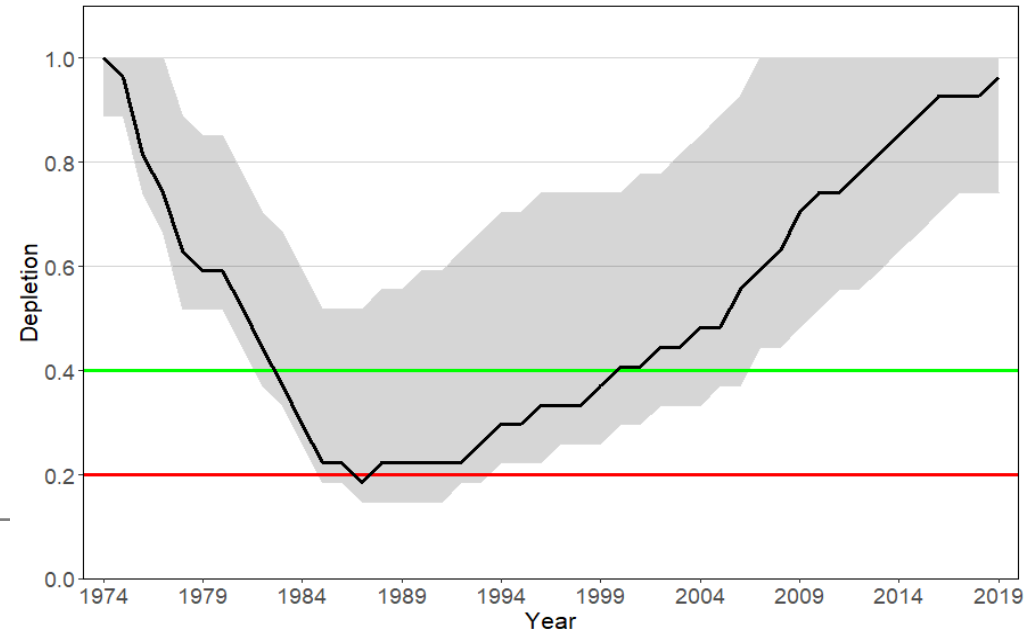
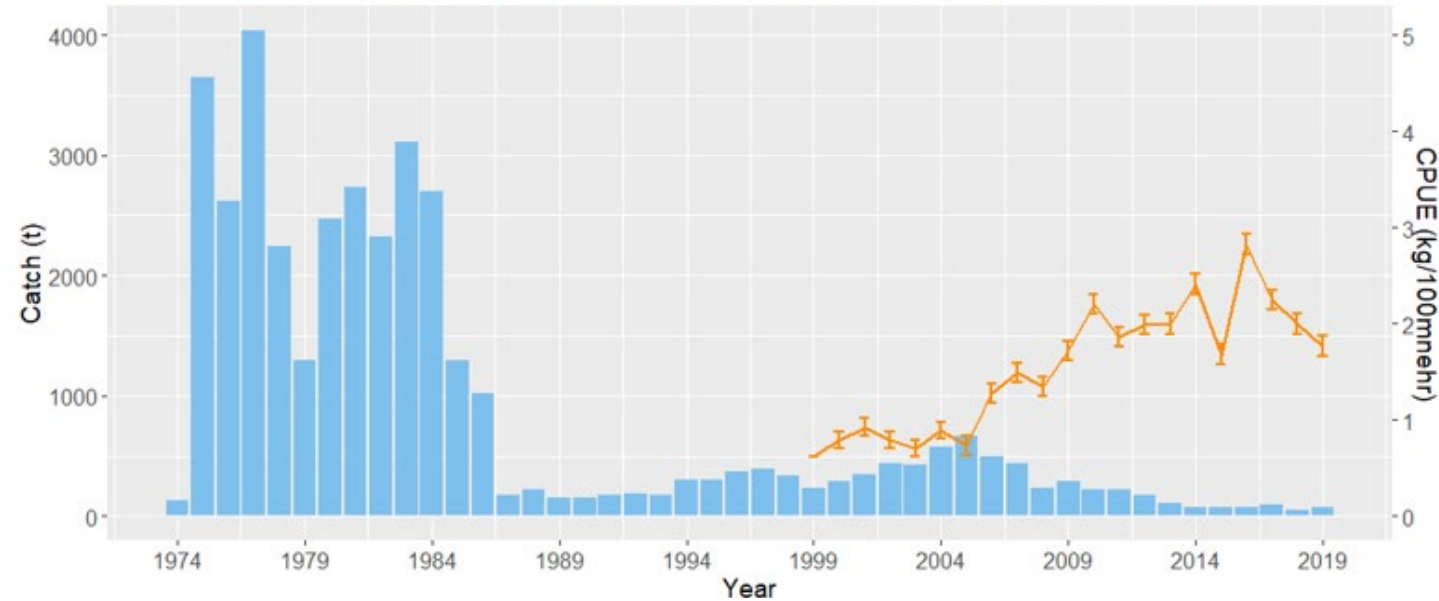
Catch histories for sharks in northern Australia show 35 years of recovery

Bradshaw, CJA, Field, IC, McMahon, CR, Johnson, GJ, Meekan, MG and Buckworth, RC (2013) More analytical bite in estimating targets for shark harvest. *Marine Ecology Progress Series*, 488: 221-232.

Grubert, M. A., Saunders, T. M., Martin, J. M., Lee, H. S. and Walters, C. J. (2013). *Stock Assessments of Selected Northern Territory Fishes*. Northern Territory Government, Australia. Fishery Report No. 110.

## Catch trends

Catch history and standardised CPUE for the North and West Coast stock of *C. tilstoni*



# Assessments

Single species assessments in Northern Australia:

*Carcharhinus tilstoni*, *C. sorrah*, *C. limbatus* and *Sphyrna lewini*

Survey abundance estimates need to properly assess data deficient species

Longline survey



# Queensland

## Depredation overview



Queensland  
Government



## Acknowledgement of First Nations peoples

I would like to respectfully acknowledge the Traditional Owners and Custodians of the land on which we meet today, and I pay my respects to their Elders past, present and emerging.

I extend that respect to all Aboriginal and Torres Strait Islander peoples here today.

# Fishing interactions

Fisheries interactions are diverse in Queensland, occurring in **recreational, traditional, charter and commercial fisheries** across the state.

The QLD fisheries where depredation is most commonly reported:

- Hook and line 'reef fishing' for demersal species (commercial/rec/charter) – widespread throughout the state, from coastal to deep water habitats.
- Spanish mackerel line fisheries (troll/live bait) – state wide
- Spanner crab commercial fishery (tangle net/dillies) – south east Queensland
- Large mesh net mackerel fishery – east coast.
- There are others including artisanal, trawl, inshore net and line.



The time of depredation varies based on fisheries. Generally speaking line based depredation occurs while a fish is being retrieved, while net fisheries occur during soaks.

Seasonality = peak in summer months (Oct – Feb/Mar), but this also varies regionally.



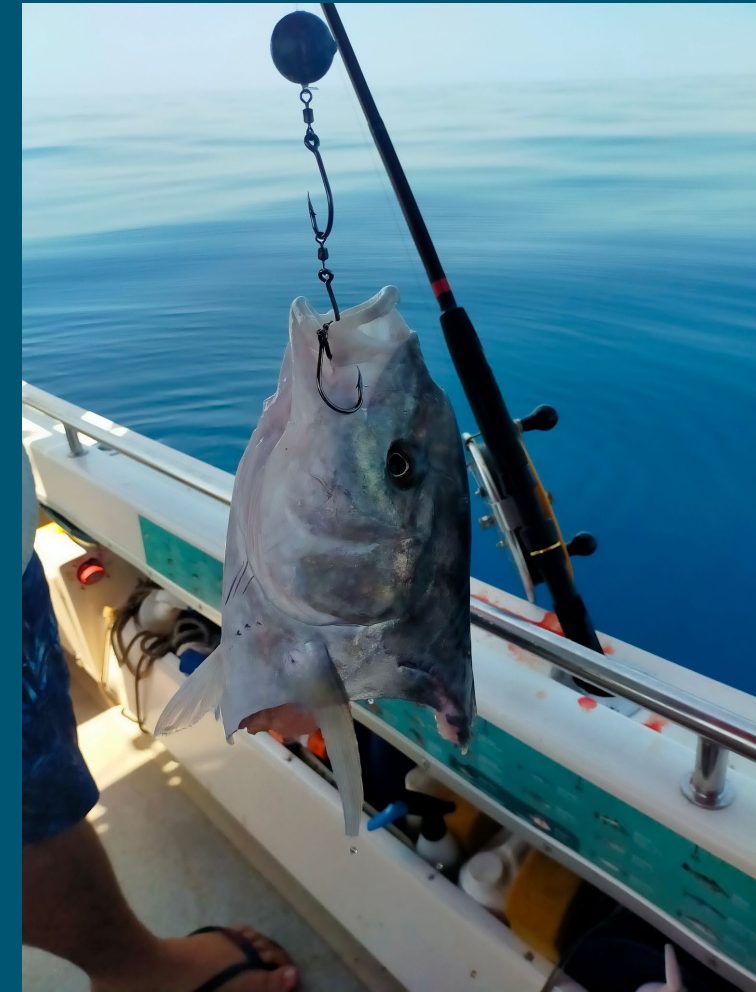
# Fishing interactions & practices

Modification to gear includes:

- use of electronic reels to retrieve fish faster
- provision of extra dillies/nets to replace destroyed ones
- use of electric motors.

Modifications to practices include:

- avoiding favourable fishing locations until key bite times
- no longer fishing at certain times of the year or locations
- ‘moving on’ after depredation occurs.



# Species interactions – depredation species

Preliminary results from genetic analysis on depredating species (Vardon et al - ongoing) are:

## South east Queensland (Vardon et al 2021)

**Major depredation species (multiple records):** bull sharks (offshore), dusky shark, sandbar sharks

**Minor depredating species (single records):** pigeye sharks, silky shark, spinner shark, spot-tail shark, blacktip shark

## North East Queensland (Work in progress)

**Major depredation species:** pigeye sharks

**Minor depredating species:** bull shark, trevally unspecified



Inshore/offshore change also detected (Vardon et al 2021).

# Species interactions – depredation species

Depredating species from camera observation in spanner crab fishery (Milburn et al in prep): Bowmouth guitarfish (shark ray) and giant guitarfish

-Globally, these species are both considered 'Critically Endangered' (IUCN)



Post-release depredation is often observed (i.e. photo on previous slide), but has only been quantified through satellite tagging on billfish in QLD.

- Five of 102 tagged black marlin tagged off eastern QLD were predated (5%), which contributed to an overall post-release mortality of 10% (Williams et al. 2015)

# Quantitative Research & monitoring



Current research and monitoring has occurred through university research students with Government co-supervisors and funding support.

Quantitative measures of shark depredation in Queensland are limited to the spanner crab fishery which was estimated at 3.68% of all crabs captured.

There are plans for quantitative monitoring of other fisheries (Spanish mackerel, east coast reef charters)

There is a need for more research into shark abundance and behaviour

Some influences remain difficult to quantify, such as influence of shark presence of fish catchability.



# Qualitative Research



## **South east Queensland (Vardon 2019)**

- Interviews of 14 commercial and 12 charter fishers in South East Queensland reported an average depredation rate between 40% and 60% of all fish hooked.
- The majority of fishers (95%) reported high variability in daily depredation occurrences, with some days resulting in a large proportion of catches being depredated, while on other days, no depredation was observed.

## **North Queensland (Hoel et al 2021)**

- Interviewed 12 stakeholders (commercial, recreational, charter, spearfishing, and managers) to better understand what's occurring and what drives frustrations.
- Participants expressed a notable increased frequency in shark interactions in past 5-10 years
- fishers agreed that shark populations seem to have either increased, or returned to levels that fishers haven't had to deal with for decades
- Fishers recognised that sharks are intelligent animals that follow their boats, and have learned that the sound of an anchor drop or generator starting is effectively a "dinner bell."

# Research & monitoring



## Research planned or underway

USC PhD research student Jaeden Vardon

- 1) genetic analysis to determine species of interest across the state
- 2) testing of deterrent devices as potential mitigation strategies
- 3) influence of fishing activity of shark presence (behavioural cues)
- 4) quantifying depredation rates in Queensland reef charter fisheries

## Apps

Infofish reporting app <https://sharkd.com.au/> – targeted at recreational fishers

JCU reporting app (in development) – targeted at commercial/charter fishers

## Planned research;

FRDC recent EOI focused on quantifying spanish mackerel depredation (observer program and post-release depredation/survival)

# Research & monitoring



## Stock assessments

### Spanish mackerel stock assessment – Methods

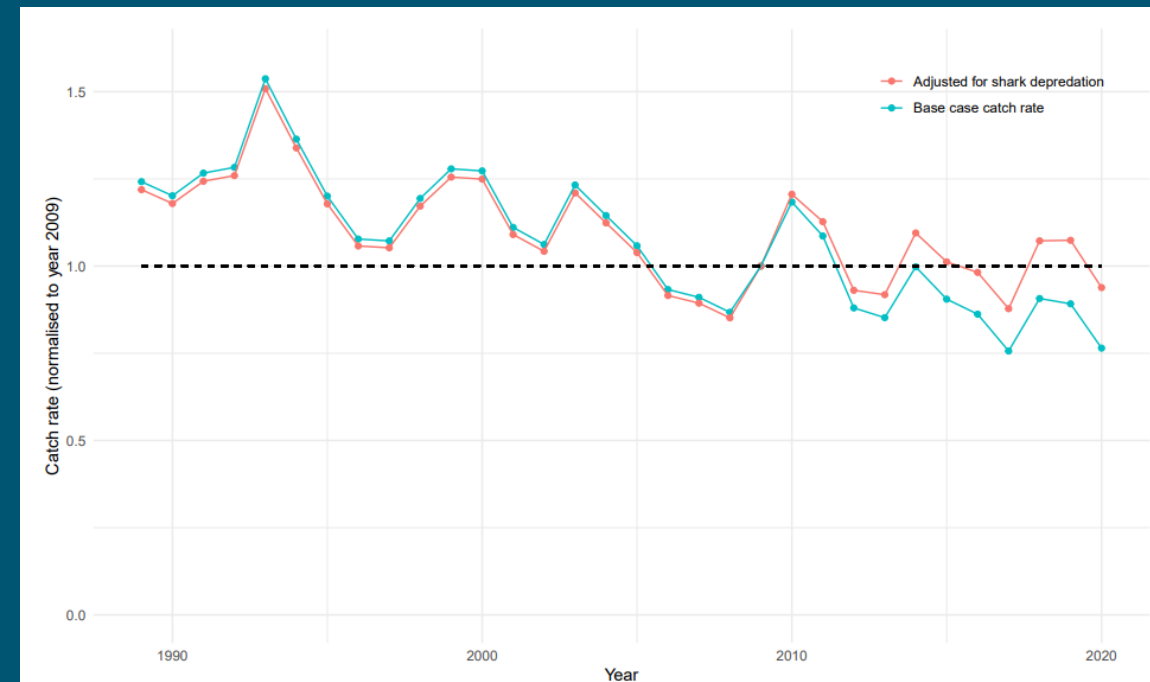
- Included as a offset term in the catch rate standardisation
- Rate of increase 1.84% over 12 years (2009-2020), with the rate at 1% prior to this period.
- Total rate of 20% reflected rates from commercial longline fisheries (gilman et al 2008)
- Also included in annual harvest estimates, by dividing harvest estimates by the shark offset

## Results

The estimated spawning biomass in 2020 was about 6% higher compared to assuming no shark effects, likely due to higher catch rate used as an index of abundance.

Potential use of spanner crab information through:

- adjustment to target reference points
- incorporation into standardisation





**Thank you for listening**

**Acknowledgements**

Jaeden Vardon for preliminary research results  
Jonathan Mitchell review of presentation content



**Queensland  
Government**





Department of  
Primary Industries

# NSW DPI Fisheries

## FRDC shark depredation workshop

# Fishing interactions & practices

- For which fisheries, target species, and gear types is shark depredation a serious issue?

Other than the charter boat fishery at Lord Howe Island, no commercial or recreational fishery in NSW waters is reporting a 'serious' issue, perhaps with the highest level of depredation occurring in the fisheries seasonally targeting Mackerel.

## NSW Commercial Fisheries:

Observer records in the NSW Ocean Trap & Line (OTL) fishery indicates approximately 3.5% of the 279 observed trips included depredation events, representing <1% of the total catch, however, fishing methods observed primarily focussed on demersal line fishing.

## NSW Charter Boat Fishery:

1 x depredation by a Shortfin Mako Shark reported in 172 observer trips between Swansea & Narooma 2017/18; Zero depredation events recorded in 245 observer trips during 2019/20. Anecdotal accounts of 'regular' depredation in the South West Rocks region.

At Lord Howe Island, substantial loss of Kingfish and baits to Galapagos Sharks occurs & has been the topic for an ongoing research program (Mitchell *et al.* 2021)

## Lobster fishery:

No reported depredation events

# Fishing interactions & practices

- For which fisheries, target species, and gear types is shark depredation a serious issue?

## Recreational fishing:

For the three NSW RFMP surveys conducted between (i) June 2013 to May 2014, (ii) October 2017 to September 2018 and (iii) November 2019 and October 2020, no recreational catch events (for either kept or released catch) reported incidents of depredation by shark/other species within the state's estuarine or oceanic waters. However, specific questions regarding depredation were not asked in the surveys.

Currently no formal data capture, however, anecdotal reports for shark depredation of catch from South West Rocks, Coffs Harbour, Yamba and Ballina, with anglers commenting that it appears to be getting more common, especially around popular reefs and islands (e.g. Solitary islands, Grassy Head).

## Offshore game fishing:

The NSW DPI Game Fish Tagging Program – few comments on post-release predation more commonly on the Sailfish grounds offshore of Weipa (York Peninsula, QLD), on inshore Black Marlin grounds on the Sunshine Coast & Gold Coast (SE QLD), and the Striped Marlin grounds on the south coast of NSW.

# Fishing interactions & practices

- For fishing gears with discrete phases of operation (e.g. soak and retrieval), can you identify the phase during which depredation is most likely to occur?

Troll fishing with live baits/surface lures for Mackerel report primarily fish are depredated when retrieving the fish.

Similarly, recreational fishers report depredation inevitably occurs when retrieving the caught fish, with few reports of bait depredation in coastal NSW waters (except out at Lord Howe Island where Galapagos Sharks will regularly depredate baits and up to 1,328 sharks are caught as bycatch per annum, of which >95% are released alive). Offshore game fishers report post-release depredation by “large whalers”, but prevalence unknown.

# Fishing interactions & practices

- What are the issue's spatial and temporal dimensions (noting this may be correlated with fishing activity)

It appears that depredation by sharks is primarily recorded for the region north of  $\sim 31^{\circ}30'S$  (Port Macquarie).

Within the NSW OTL, fishing for Mackerel is highly seasonal and represents a small component of this fishery (5 yr average catch: Spanish Mackerel = 11.2 t; Spotted Mackerel = 20.7 t)

Recreational boat fishers targeting Mackerel also report depredation by sharks when retrieving fish particularly north of Port Macquarie.

As a result, depredation within fishing activities for Mackerel is extremely seasonal & spatially restricted.

# Fishing interactions & practices

- What modifications to fishing gear and practices are fishers currently using to decrease the incidence of depredation?

OTL fishery – none

Lobster fishery – none

Charter fishery – none (Lord Howe Island charter fishers & recreational fishers currently do not employ changes to gear and/or fishing practices, but that may change following the research by Mitchell *et al.*)

Recreational fishers – none known

# Species interactions

- Acknowledging the difficulties associated with confidently identifying sharks in the water (beyond broad taxonomic groups such as “whaler” and “hammerhead”), do you have any indication of the shark species involved in depredation?

OTL fishery: Hammerhead, Bronze Whaler, Bull Shark, Common Blacktip Shark, ‘whaler’ sp.

Charter boat fishery: 1x Shortfin Mako recorded & anecdotal report for SW Rocks it is Bull Shark & Bronze Whaler; Lord Howe Island = Galapagos Shark

Recreational fishing for pelagics: caught fish depredation by Bull Sharks; Common Blacktip Shark; depredation of live slimy mackerel bait by Scalloped and Smooth Hammerhead Sharks – Feb to May (mainly north of Port Macquarie); Offshore game fishing = “large whaler sharks”

# Species interactions

- Are you aware of any interactions with Threatened, Endangered, or Protected Species (TEPS) during depredation events? Noting TEPS can be either the depredating shark or prey animal.

OTL fishery: Scalloped Hammerhead and Greynurse Shark (both released alive)

Recreational fishing: Greynurse Shark, White Shark depredation on snapper (released alive, however, post-release mortalities of internally-hooked Greynurse Shark is considered to impact the population).

- Do you have any knowledge of post-release depredation rates in your jurisdiction?

No



# Research & monitoring

- What are your jurisdiction's data holdings on shark depredation?

Data are restricted to observations made during periodic observer coverage.

- Do you have any measure (even anecdotal) of the magnitude of shark depredation in your jurisdiction?

No **fishery-wide** estimates of shark depredation, but overall considered to be low magnitude in NSW waters.

- Anecdotal evidence indicates that shark depredation has increased in recent years. Do you have a sense (either qualitative or quantitative) of whether depredation rates have changed through time?

Based on industry feedback, definitely increasing in OTL fishery.

# Research & monitoring

- Does your jurisdiction have research or monitoring related to shark depredation underway?

No – Monitoring of OTL fishery ends in May 2022

- Do any stock assessments in your jurisdiction include shark depredation as a source of mortality? If yes, what are the data, assumptions, and modelling techniques used to support this inclusion?

No stock assessments include depredation mortality

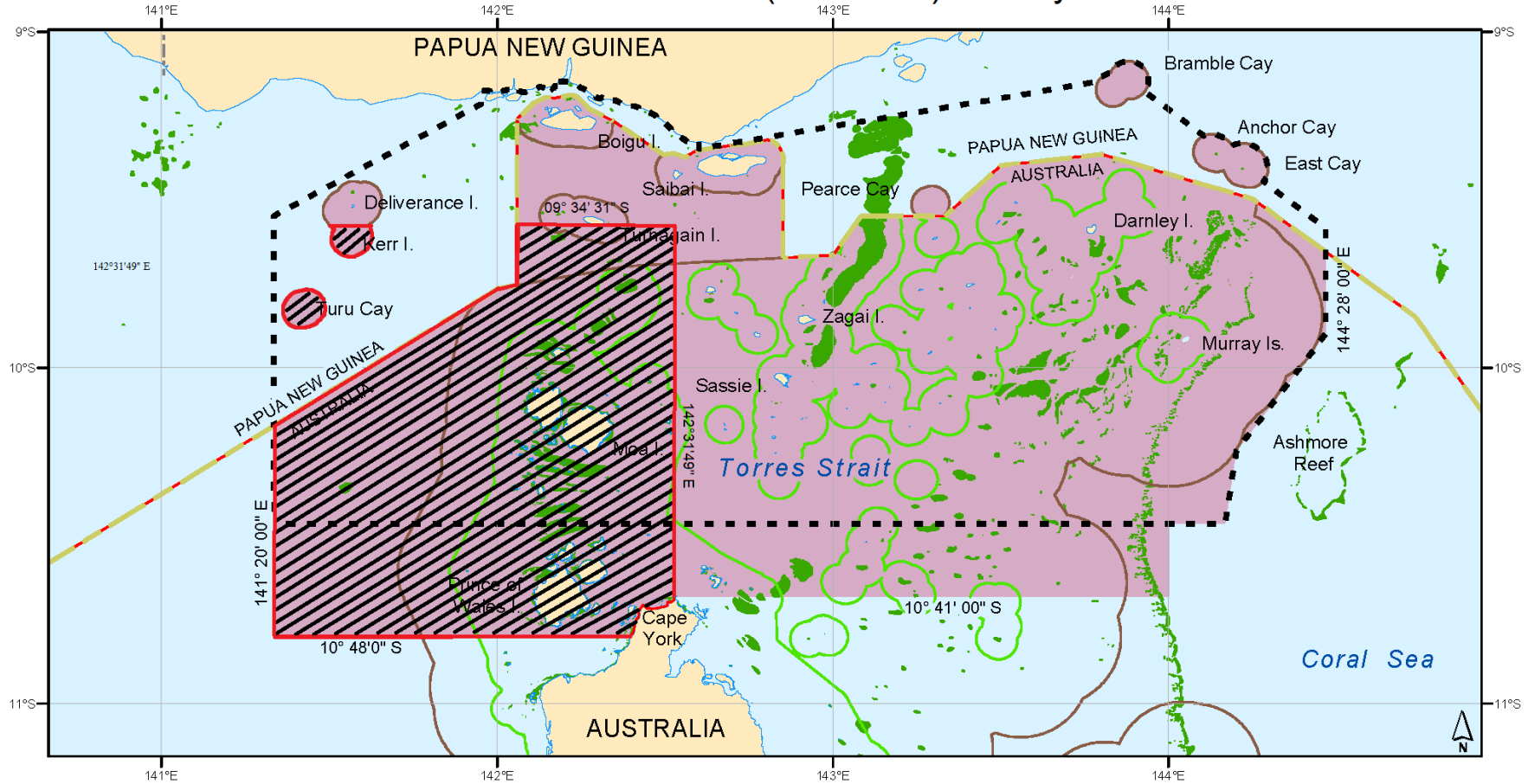


# Torres Strait Finfish Fishery

FRDC SHARK DEPREDATION WORKSHOP

# Torres Strait Fisheries

## Area of the Finfish (Reef Line) Fishery



- Coastal Waters limit (3nm)
- Exclusive Economic Zone limit (200nm)
- Fisheries Jurisdiction line
- Protected Zone Boundary
- Territorial Sea limit (12nm)
- Low tide elevations and reefs

### Torres Strait Fisheries

Finfish Fishery



Permanent Closure Area



Australian Government  
Australian Fisheries  
Management Authority

Produced by Geoscience Australia  
for the Australian Fisheries Management Authority, August 2006  
© Commonwealth of Australia 2006

Geographic  
Datum: WGS84

#### NOTES:

1. The area of the Fishery is sourced from the Torres Strait Fisheries Regulations 1985
2. Within this fishery, arrangements exist between the Commonwealth and QLD, whereby the Coastal Waters of that State are deemed part of the AFZ
3. The Fisheries Jurisdiction Line and Protected Zone shown on this map are established under the Treaty between Australia and the Independent State of Papua New Guinea. This Treaty entered into force on 15 February 1985
4. The maritime zone boundaries shown on this map are sourced from the "Australian Maritime Boundaries (AMB) v2.0"

GeoCat #: 64844

# Fishing interactions & practices

- ▶ Shark depredation impacts both the TS Spanish Mackerel and TS Reef Line fisheries.
- ▶ These are active hook & line fisheries – trolling and handlining.
- ▶ Anecdotal evidence indicates that shark depredation rates have significantly increased over the last 10 years.
- ▶ Sharks are known to locate and follow fishers – resulting in fishers having to periodically leave a fishing location when depredation rates become too high.
- ▶ Shark depredation for the Commonwealth tuna/longline fisheries is considered to be a secondary issue behind toothed whale depredation.
  - It is known that there is at least a low level of shark depredation occurring in these fisheries, but no data yet exist to quantify this.

# Ramifications for catchability

- When depredation rates are high, Spanish mackerel fishers have to run shorter lines (reportedly less effective), and will not utilise the method of leaving a mackerel on the line to attract other mackerel to the boat.
- Spanish mackerel are reported to jump and shake the hook more often when sharks are present – leading to increased losses of catch.
- Remaining school become spooked by the presence of sharks.

“We just don’t know how many we would have caught otherwise”

- How will changes in shark interactions affect CPUE? How can we track these changes over time and account for them in stock assessments?



# Species interactions

- ▶ Fishers have reported that the main species of sharks are 'reefies' (1m in length), bull sharks and whalers.
- ▶ Fishers report that TEP shark species such as tiger sharks and Hammerheads do not typically interact with the fishing gear – “Too slow”.
- ▶ Post-release depredation rates are unknown. The level of actual releases are presumed to be low, as most fish species are retained as by-product. It is assumed that the depredation rates of any released fish are high when sharks are in the area.



# Research & monitoring

- ▶ There is currently no data held on shark depredation rates.
- ▶ Shark depredation rates can reach up to 1/3 of the total catch (anecdotal reports). – Main issue for fishers is sharks then scare the remaining fish away.
- ▶ Currently no monitoring efforts, but this is an active area of development. It is intended to modify the current daily logbook to include a section to report depredation rates.
- ▶ Fishery-independent monitoring also a high priority.
- ▶ The Spanish mackerel stock assessment does not currently account for depredation rates. This is an established priority for future assessments.

# Shark Depredation: What Can We Learn from Mitigation of Shark Bite on People?

Daryl McPhee





No win-win

---

# Mitigating Unprovoked Shark Bite

- Requires understanding of sharks and various human dimensions.
- Large government investment in the challenge.
- Unprovoked shark bites are increasing at meaningful temporal scales.
- Fishing is increasingly blamed for the trend in bites through:
  - Decreasing shark prey species.
  - Undertaking practices that increase the overlap between sharks and water users.
- Large number of active patents nationally and globally for technical solutions.

# Conceptual Understanding of Mitigation

- ***Tier 1 - Perimeter.*** *Reduce spatial overlap between water users and target sharks.*

This is currently done in the using lethal or non-lethal approaches and with research, community education and engagement that results in shark smart human behaviour.

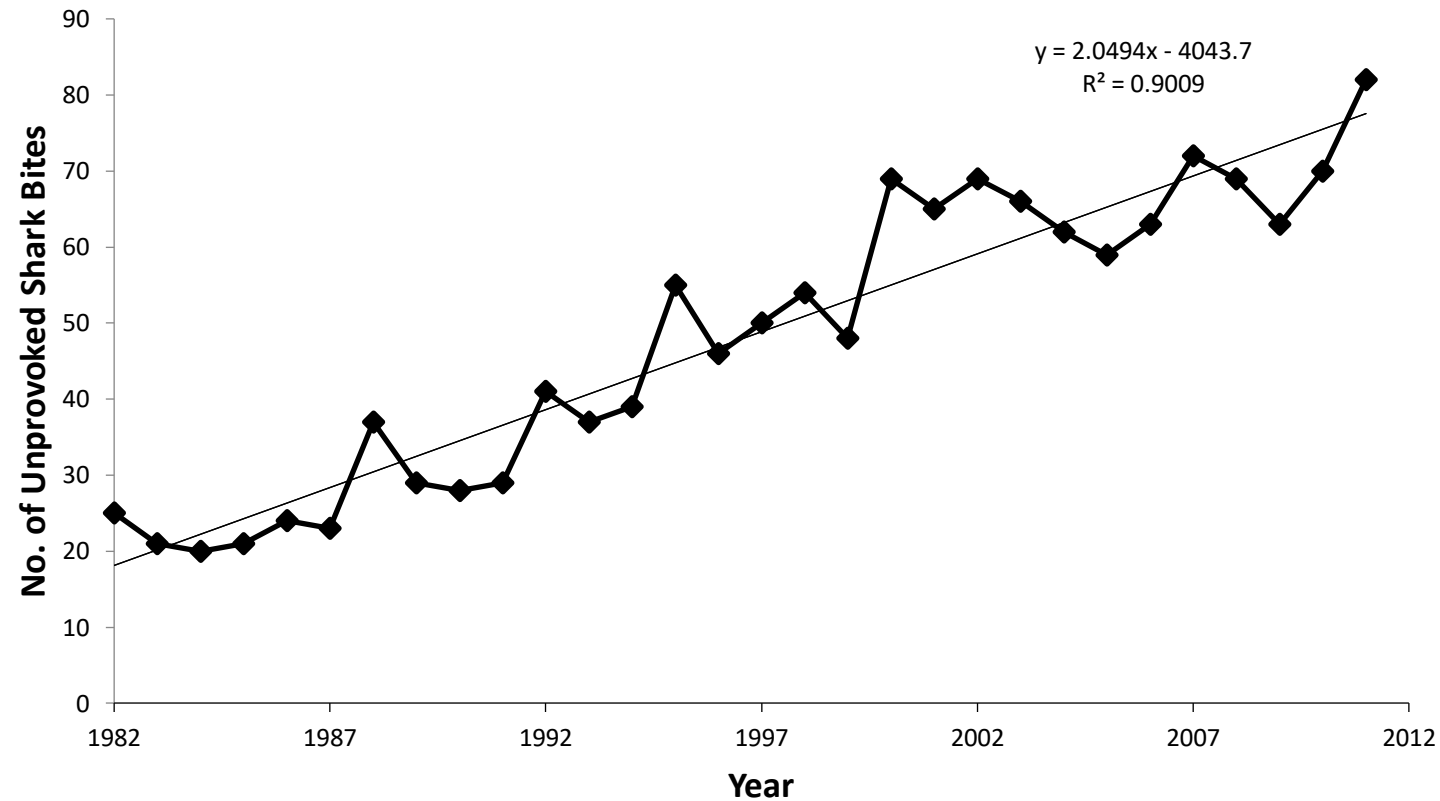
- ***Tier 2 - Proximity.*** *Reduce likelihood of shark bite when beach-based overlap between water users and target sharks cannot be avoided.*

This relies on product development, technology, education and community engagement resulting in greater uptake of existing, effective personal deterrent devices than is current.

- ***Tier 3 – Prevent bleeding.*** *Reduce the impacts of a shark bite when one has occurred.*

Better first aid and wetsuits

# Trends in Unprovoked Shark Bite



Source: McPhee (2014) Unprovoked Shark Bites: Are They Becoming More Prevalent? *Coastal Management* 42(5): 478-492.

**Australian Patents (Active)**

<b>Name</b>	<b>Date</b>	<b>Company/Contact</b>	<b>Type</b>	<b>Patent No</b>
<b>Shark Resistant Composite Fabric</b>	10/4/19	Haydon Burford	Personal protection	2019901237
<b>Shark Proof Swimming Enclosure</b>	9/4/19	Gregory Webber	Area Barrier (physical)	2019901221
<b>A Shark Barrier</b>	24/3/17	Stellenbosch University	Area Barrier (physical)	2017243768
<b>A Shark Self Defence Tool</b>	8/9/17	Eduardo Marquez	Personal protection	2017225122
<b>Radio Transmission Based Shark Alert System</b>	19/12/17	David Cave et al.	Shark Detection	2017101768
<b>Image Generating Shark Deterrent for watercraft</b>	30/11/17	Robert Carraro	Personal (visual) deterrent	2017101672
<b>Shark Deterrence Safety Modification</b>	17/11/17	Scott Beith	Personal (visual) deterrent	2017101617
<b>Marine predator repellent apparatus and system</b>	16/6/16	Ignatius Hartzenberg	Area Barrier (electric)	2016281201
<b>Shark Detection System, Apparatus, and Method</b>	26/10/16	Allen Bennetto	Shark Detection	2016250364
<b>Puncture and cut resistant material</b>	3/5/12	John Sundnes	Protective apparel	20063407892

# Similarities and Differences

- Mix of possible mitigation options including technical, behavioural and educational.
- Efficacy and suitability of mitigation options vary depending on location and environmental contexts and human dimensions.
  - Much entrepreneurial activity.
  - Efficacy of technical solutions not always tested.
    - Much focus on “Science by Youtube”.
  - Some technical solutions overpromise and underdeliver.
- Diversity of public views on the causes and solution to the “problem” and the value of sharks.
  - No one universal “magic bullet” solution is likely.



# Similarities and Differences

- Narrower mix of shark species to consider for human safety.
  - Very different likelihood and consequence profiles.
  - Better information over time on bites on people.
- Several entrepreneurs now see mitigating shark depredation as a richer field to plough than mitigating bites on people.

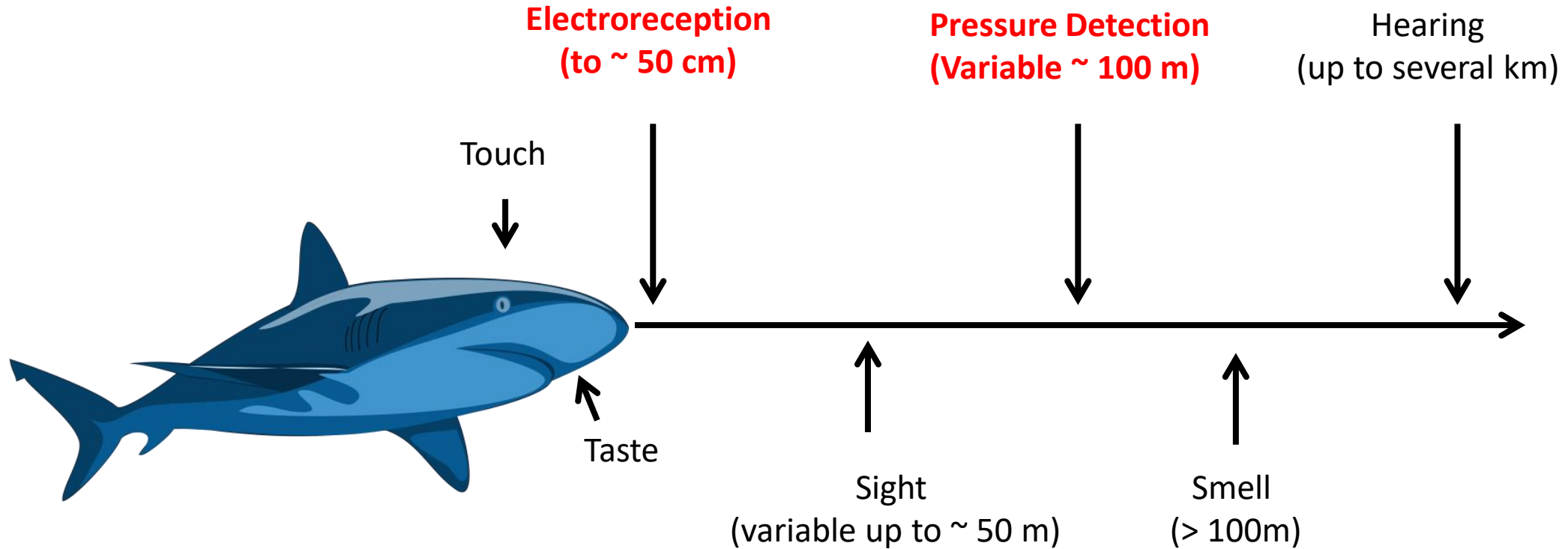
# Types of Approaches for Mitigating Shark Bites on People

- Shark Detection Methods
- Area-based Deterrents/Barriers
- Education to Enact Behavioural Change
  - Individual Deterrents
- Advances in Wetsuit Materials

McPhee, D.P., Blount, C, Peddemors, V. and Lincoln-Smith, M. (2021) A comparison of alternative systems to catch and kill for mitigating unprovoked shark bite on bathers or surfers at ocean beaches.

*Ocean and Coastal Management* 201,105492

# Sensory Biology of Sharks



**An eighth sense: Magnetoreception?**

# Types of Approaches for Mitigating Shark Bites on People

- Factors to consider:
  - Operating times
    - Location
    - Sea-state
    - Water clarity
    - Beach attributes
  - Potential human health impacts
- Potential impacts on species and coastal processes
- Independent testing including on relevant species
  - Commercial readiness
  - Comparative expense

# Types of Approaches for Mitigating Shark Bites on People

- **Shark Detection Methods**
  - Manned aerial
  - Unmanned aerial
    - Land-based
  - Detecting tagged sharks *in situ*
  - Detecting untagged sharks *in situ*

# Types of Approaches for Mitigating Shark Bites on People

- Area Based Deterrents/Barriers
  - Electric Barriers
- Magnetic/Visual Barriers (SharkSafe Barrier™)
  - Physical Barriers
  - Acoustic Deterrents
  - Chemical Deterrents

# Types of Approaches for Mitigating Shark Bites on People

- **Personal Deterrents**
  - Electrical
  - Magnetic
  - Visual

# Types of Approaches for Mitigating Shark Bites on People

- Education to Inform and Enact Behavioural Change
  - WA SharkSmart
  - [SharkSmart – Home](#)
  - Qld SharkSmart
  - [SharkSmart \(daf.qld.gov.au\)](http://daf.qld.gov.au)
  - NSW Be SharkSmart
  - [Home - SharkSmart \(nsw.gov.au\)](http://nsw.gov.au)



# Educational Elements

- Tips for various water users to take personal responsibility to reduce their risk and those around them.
  - Behavioural
  - Research on deterrents
- Information on riskier times and locations for interactions
  - After rain near river mouths.
- Information on shark activity.



# SHARK SPOTTING PROGRAMME

## HAAIKYKYPROGRAM / INKQUBO YOKUJONGWA KOOKREBE

The Shark Spotting Programme is an early warning initiative provided as a service to communities. Although effective, shark spotting can never guarantee your safety 100%. Sharks spotters are not responsible for your safety.

As 'n vroeëwaarskuwingsinisiatief lewer die haai kykyprogram 'n diens aan gemeenskappe. Hoewel doeltreffend, kan haai kyk nooit jou veiligheid 100% waarborg nie. Haai kykers is nie vir u veiligheid verantwoordelik nie.

Iinkqubo yokujongwa kookrebe liphula lokulumkisa abantu kwangexesha nebonolelwa njengenkono eluntwini. Nangona isebenza, ukujongwa kookrebe akunakho ukuqinisekisa ukuba ukhuseleke ngokugqibeleleyo (100%). Amagosa ajonga ookrebe awanaxandiva lokhuseleko lwakho.

## FLAG WARNING SYSTEM

### VLAWAARSKUWINGSTELSEL / INKQUBO YOKULUMKISA NGEEFLEGI



#### GREEN FLAG

- Spotting conditions good
- Haai kyktoestande goed
- Iimeko ezilungele ukujonga ookrebe



#### BLACK FLAG

- Spotting conditions poor
- Haai kyktoestande swak
- Iimeko ezingakulungelanga ukujonga ookrebe



#### RED FLAG

- High shark alert
- Ernstige haaiwaarskuwing
- Ixilumkiso sookrebe abaNinzi



#### WHITE FLAG

- A shark has been spotted - siren will sound. Leave the water immediately.
- 'n Haai is gesien - sirene sal loei. Verlaat die water onmiddellik.
- Kubonwe ukrebe - kuzo kukhaliswa ixilongo lokulumkisa. Phumani ngokukhawuleza emanzini.

**USE OF OCEAN AT OWN RISK**  
**GEBRUIK DIE OSEAAN OP EIE RISIKO**  
**ULWANDLE ULUSEBENZISA NGOBAKHO UBUTYALA**



**EMERGENCY NUMBERS / NOODNOMMERS / IINOMBOLO ZEXESHA LIKAXAKEKA**



Shark Repellent Cable in place at Glencairn Beach (South Africa)

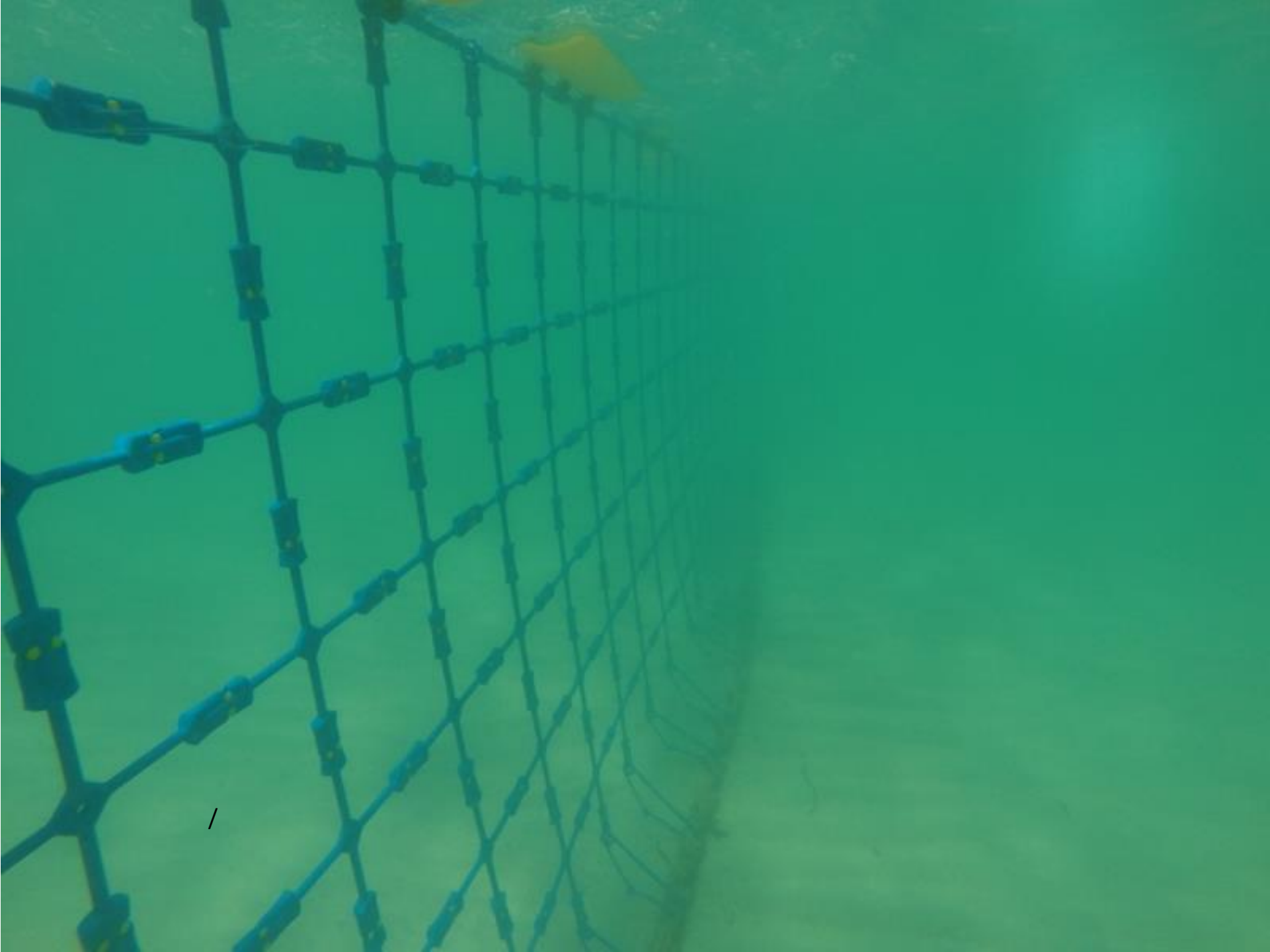
An underwater photograph showing a diver in a dark wetsuit and fins, swimming horizontally. The diver is surrounded by a large cloud of white bubbles. The water is a deep teal color. In the foreground, a thick, dark cable or rope runs vertically from the top left towards the bottom. The background shows a sandy seabed with some faint, dark markings.

Shark Repellent Cable in place at Glencairn Beach (South Africa)

2015. 4. 30 10:20



Shark – EcoBarrier in WA





Shark Barrier Fail – NSW North Coast



The SurfSAFE barrier in position

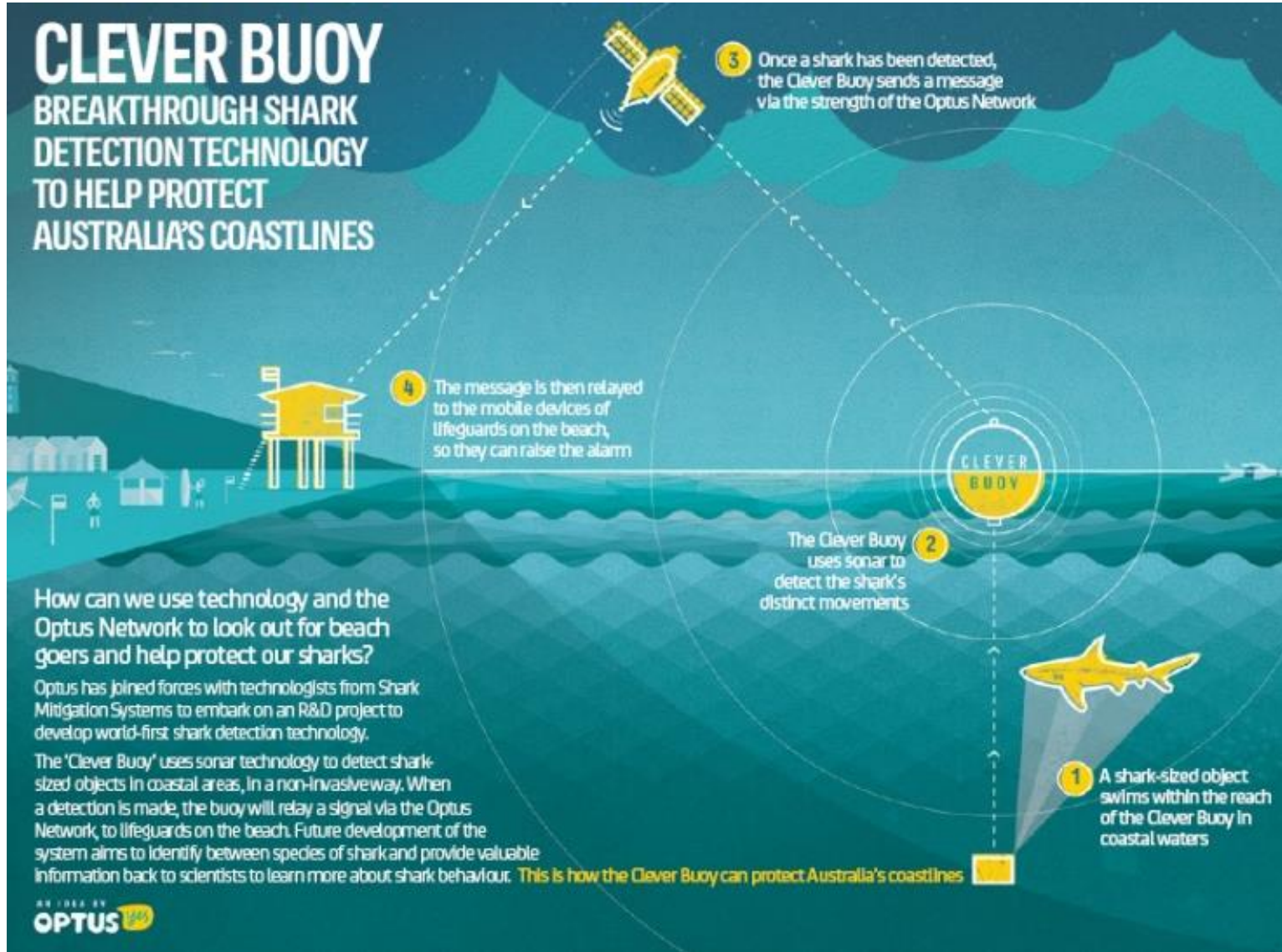
*Sara Andreotti*

© [www.sharkdivingunlimited.com](http://www.sharkdivingunlimited.com)



# CLEVER BUOY

## BREAKTHROUGH SHARK DETECTION TECHNOLOGY TO HELP PROTECT AUSTRALIA'S COASTLINES



How can we use technology and the Optus Network to look out for beachgoers and help protect our sharks?

Optus has joined forces with technologists from Shark Mitigation Systems to embark on an R&D project to develop world-first shark detection technology.

The 'Clever Buoy' uses sonar technology to detect shark-sized objects in coastal areas, in a non-invasive way. When a detection is made, the buoy will relay a signal via the Optus Network to lifeguards on the beach. Future development of the system aims to identify between species of shark and provide valuable information back to scientists to learn more about shark behaviour. **This is how the Clever Buoy can protect Australia's coastlines**

# Cleverbuoy Awards

- Optus' 'Cleverbuoy' campaign by M&C Saatchi Sydney won a Gold Lion at Cannes in the mobile category.
  - *"Clever Buoy was created to improve the perception of the Optus network."*
- Grand Prix and Gold at the WARC Prize for Innovation.
- 'Most Innovative Use of Digital' at the London International Awards.
- Numerous CLIO Awards.

# CLEVER BUOY.

HOW A SHARK DETECTION BUOY MADE WAVES FOR A TELECOMS NETWORK.

## Background.

Optus has Australia's second largest mobile network. Our brief was to **improve consumer awareness** and **brand perception** by shifting the focus from the (inferior) size of the Optus Network, to the amazing things it can do.

## Idea.

We created Clever Buoy. A smart ocean buoy that detects sharks and sends real-time alerts to lifeguards via the Optus Network. The PR campaign and earned media attention was our key platform in showcasing the project to the world, and a vital tool in transforming Optus' brand perception.

## PR Results.

- Social/PR reach of over 40 million – with an 84% positive sentiment towards the Optus brand.
- Featured in over 800 global news stories.
- Over 200 global broadcast news stories.
- Earned PR/Advertising value over \$7 million.
- Launch video had over 3.0 million online impressions.

## Product development.

- Commercial Clever Buoys now in development, with public rollout targeted for 2015.
- New innovations division created within Optus to oversee the product launch.
- The NSW government has committed \$100,000 to public testing.

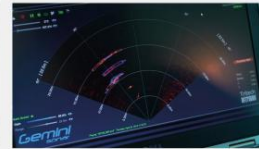
See case study film for more



Prototype Build.



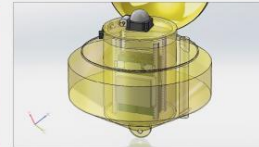
Shark Sonar Detection.



Wild Testing.



Commercial development.



Real Time Data Journey - Shark > Sonar Head > Clever Buoy > Satellite > Lifeguard Tower



PR & Social.

GIZMODO

Mashable

WIRED

The Sydney Morning Herald

BBC

MailOnline

NATIONAL GEOGRAPHIC

FORTUNE

BUSINESS INSIDER

sunrise NEWS

THE AUSTRALIAN

7NEWS

Daily Telegraph

sky NEWS



This is incredible! Clever Buoy by @Optus to detect sharks and alert lifeguards. cleverbuoy.com.au

@LeeMilton 3m ago



Wait. What? Is there a corporation out there that's ACTUALLY using their technology effectively and ethically?... cleverbuoy.com.au

@DoctorStu 45m ago



Clever Buoy was covered on every commercial television channel in Australia.



NSW Government pledge \$100,000 into public testing of the buoy.

# Cleverbuoy

- Approach relies on sonar arrays to detect sharks.
- The effective range of an individual Cleverbuoy in the surf zone needs to be determined, but is most probably very limited.
  - This influences the number that need to be deployed at a beach and hence the cost.
- Lots of advocates but ineffective.
- Similar hardware has been and the results published in the peer review literature are “not stellar” in terms of potential<sup>1</sup>

<sup>1</sup> Parsons, M.J.G., Parnum, I.M., Allen, K., McCauley, R. and Erbe, C. (2014). Detection of sharks with the Gemini imaging sonar. *Acoustics Australia* 42(3): 185-189.

# What to look for in an Individual Deterrent?

- Has it been **independently** tested and are the results publicly available?
  - <http://www.theaustralian.com.au/news/nation/experts-raise-alarm-bell-on-shark-repellents/news-story/3267244d83090907fd1e8c7b52dc7739>
- Is it suitable for the relevant shark species?
- What is the area over which the approach is likely to be effective?
- Does it suit your individual use?





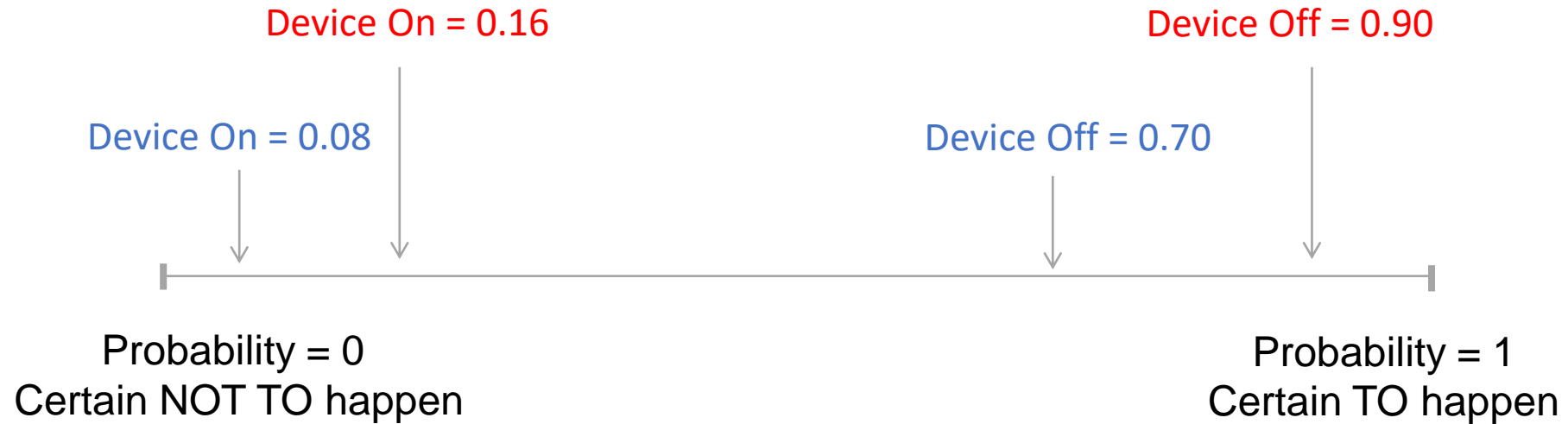
BRING BACK  
COMMON  
SENSE

CHILLAX  
organic surf wax  
MARKET  
Regular 85 \$10  
SPECIAL  
Retro Economy 180 \$18

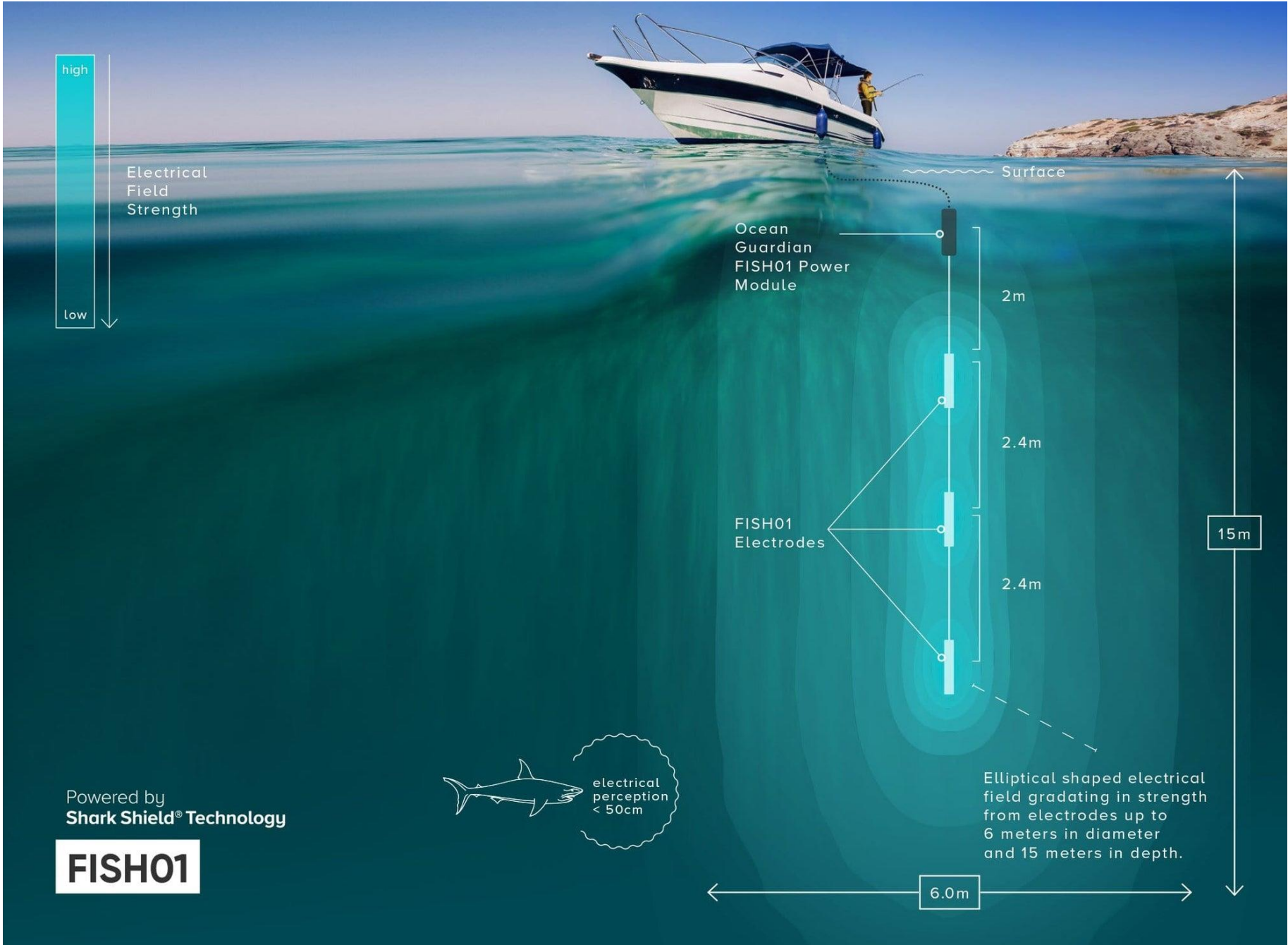




# Results of Independent Testing of the Shark Shield



Data from Huveneers et al. (2013)







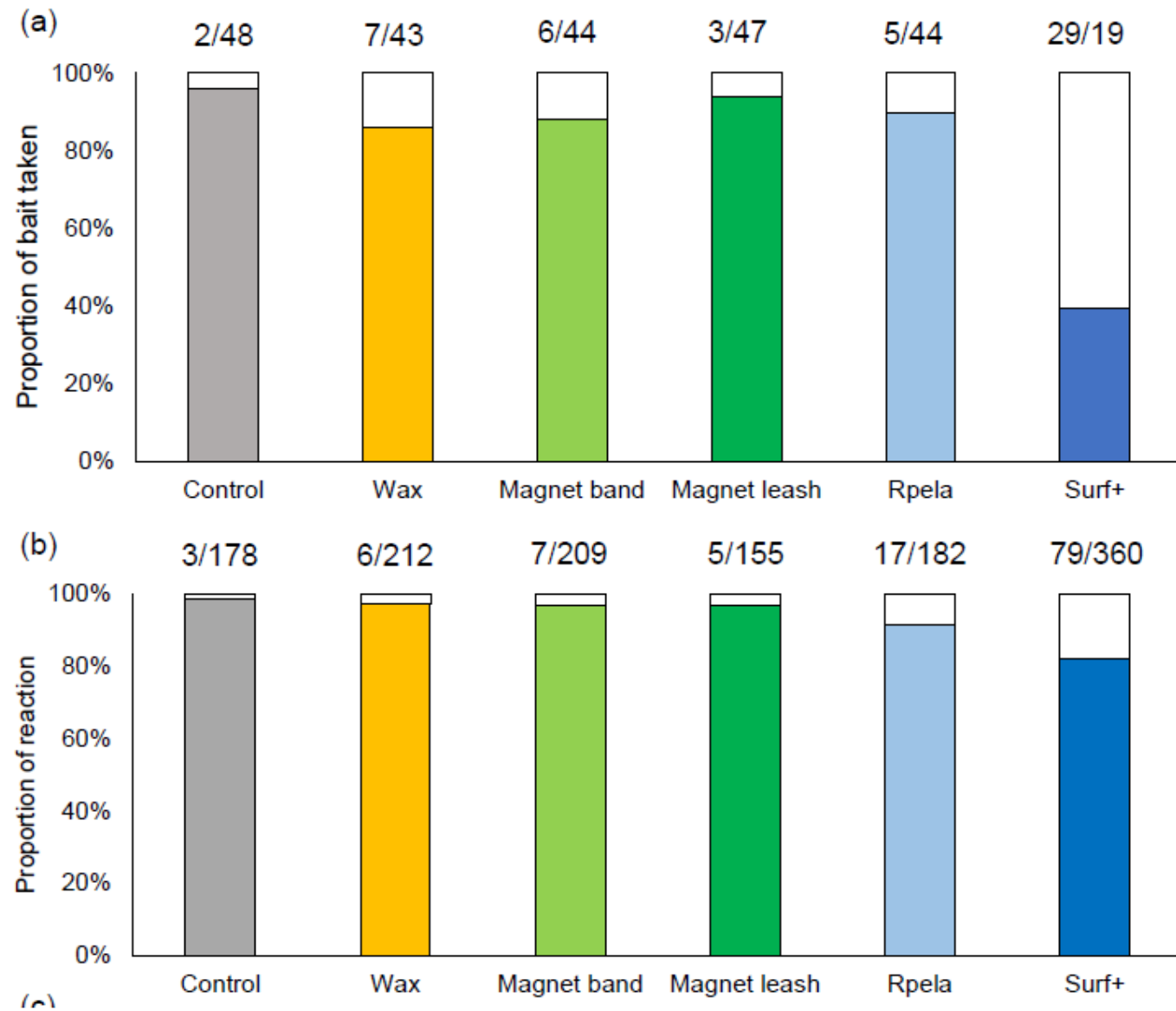
6'2" x 21" x 2 3/4" - 98 L  
By Neilson for KRISTI





# SHARKBANZ

THE GLOBAL  
LEADER IN  
SHARK DETERRENT  
TECHNOLOGY



From: Huveneers, C., Whitmarsh, S., Thiele, M., Meyer, L., Fox, A., & Bradshaw, C. J. (2018). Effectiveness of five personal shark-bite deterrents for surfers. *PeerJ*, 6, e5554.

# Take Home Messages

- Similar to address unprovoked shark bite:
  - There is no magic bullet for addressing the problem of shark depredation.
  - Addressing the problem of shark depredation can involve technical and behavioural solutions.
  - Solutions need to be tailored to local conditions and stakeholders.
  - Independent testing of technical solutions is critical.
- There is and will continue to be substantial entrepreneurial activity directed at technical solutions and these will have various levels of efficacy.
  - Much of the entrepreneurial activity will take place outside traditional funding agencies and research providers.



Thank You and Questions



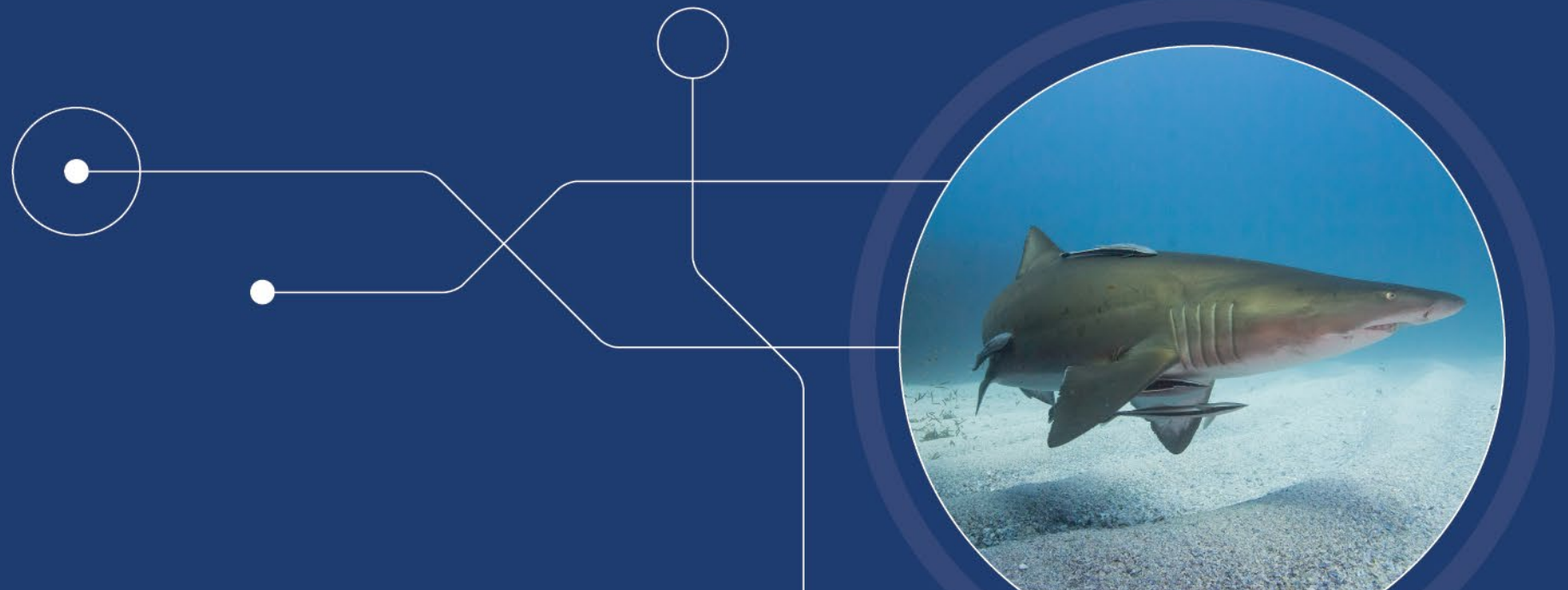
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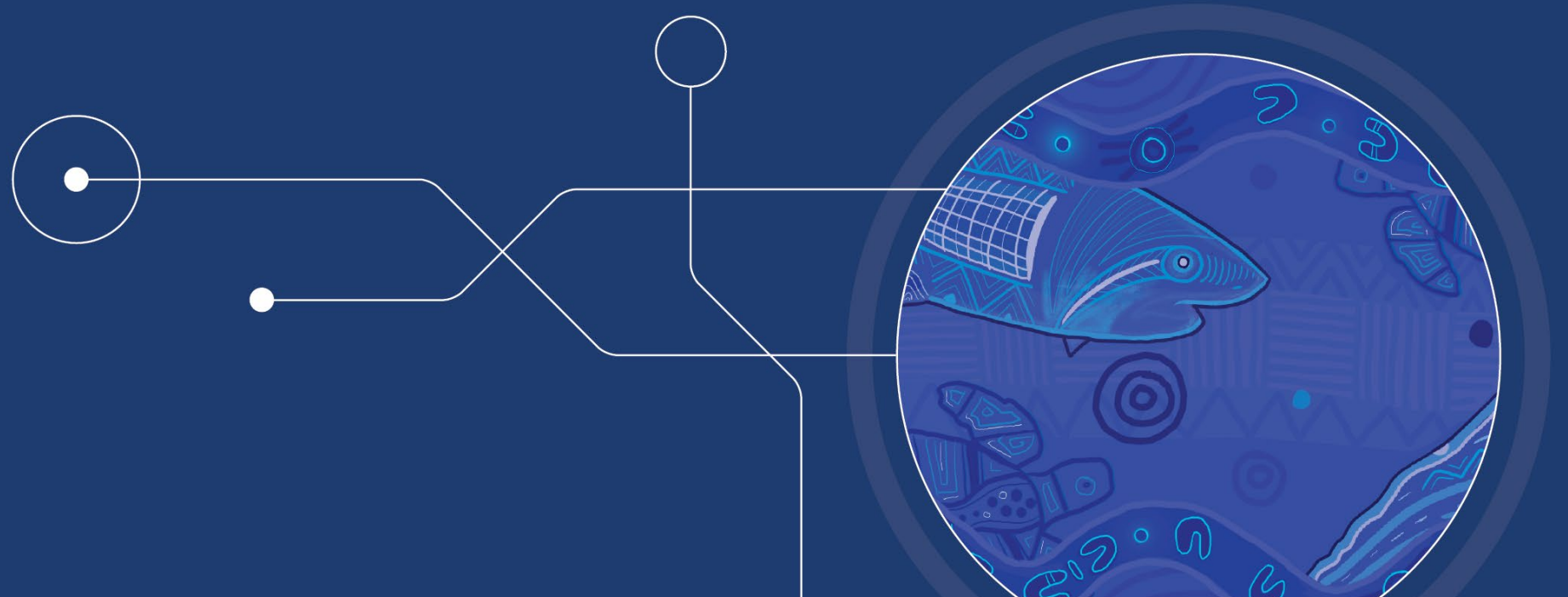
# Shark depredation workshop 2

## FRDC Update

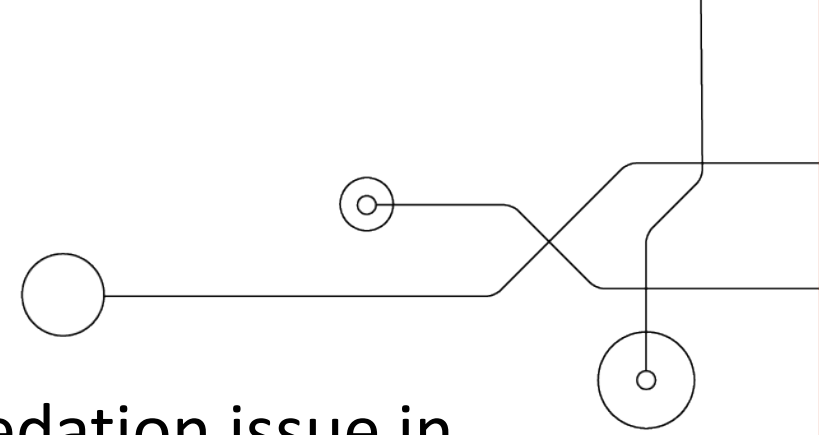
JUNE 2022



**The FRDC acknowledges** Australia's Indigenous people who are the traditional owners of country throughout Australia and recognises their continuing connection to lands, waters and culture. We pay our respect to their Elders past, present, and extend that respect to all Indigenous people.

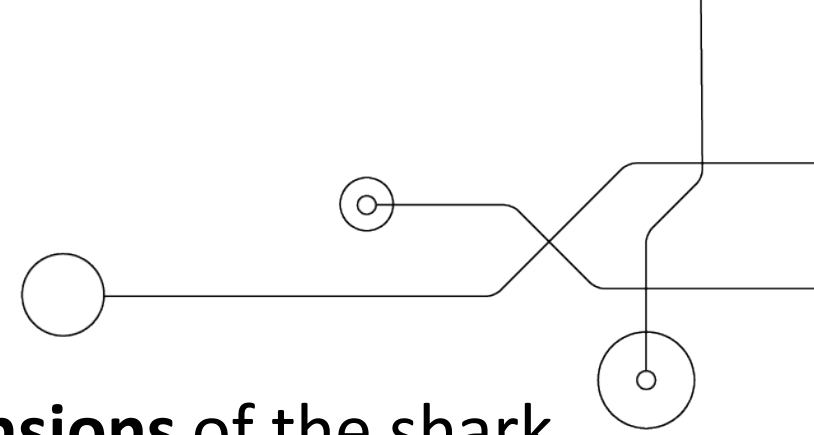


# Objectives:



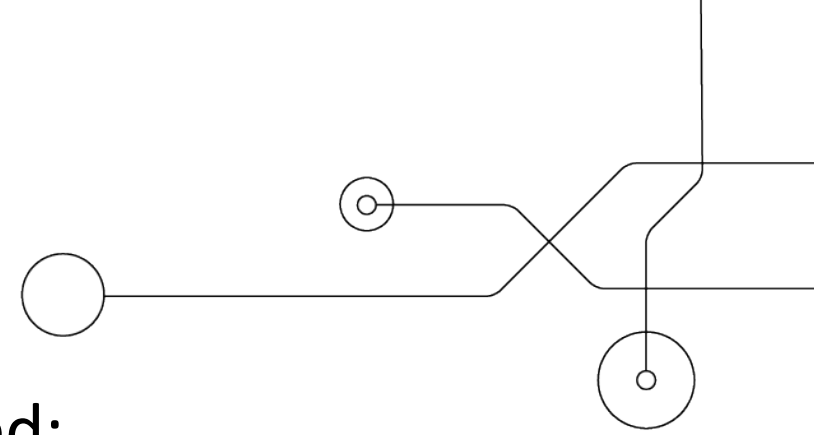
- To understand key dimensions of the shark depredation issue in Australian fisheries, and potential mitigation options:
  - Workshop 1: Developing a shared understanding of the nature and dimensions of the shark depredation issue
  - Workshop 2: Identification of possible mitigation measures and pathways towards their development or adoption
- To highlight where knowledge gaps are and RD&E needed
- This is not intended to provide policy setting advice

# Overview of Workshop 1



- Focused on understanding the **nature and dimensions** of the shark depredation issue across Australia
- Jon Mitchell (QDAF) provided an overview of shark depredation in Australia – *refer to his discussion paper*
- Representatives from fishery agencies provided overview of the scale and scope of the shark depredation issue in their jurisdiction
- Series of break out groups to discuss information gaps

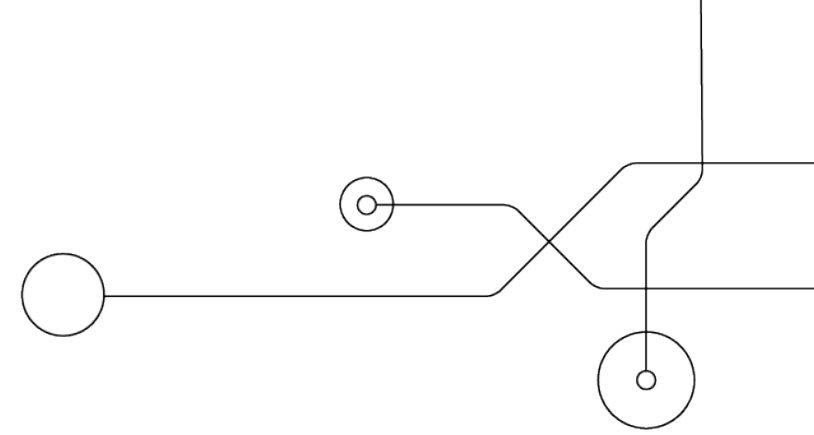
# Summary of Workshop 1



The presentations & discussion sessions highlighted:

- The variability inherent in the issue – among fisheries/sectors, gears, species, time and space
- The anecdotal nature our understanding
- Data collection is variable among jurisdictions/fisheries/sectors
- General willingness across sectors to participate in data collection
- There is an appetite for practical mitigation action
- The need for improved communication/education materials

# Outline of Workshop 2



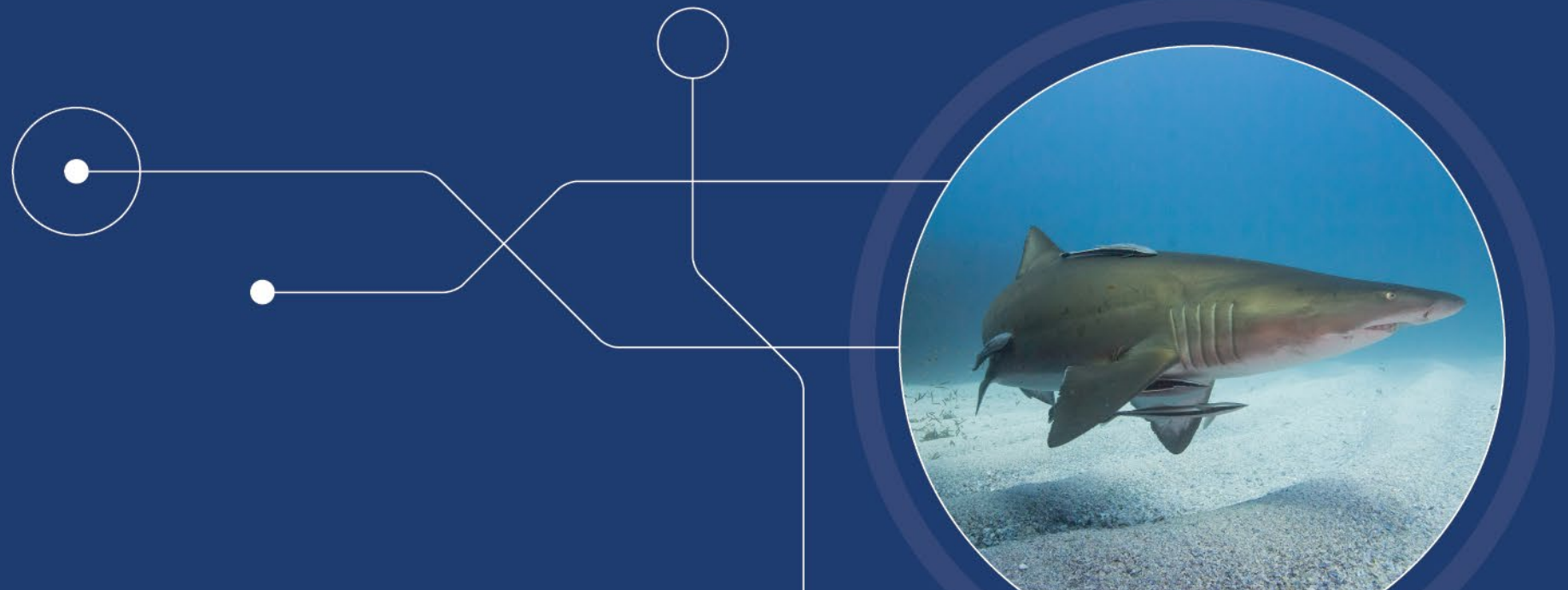
- Focus on mitigating shark depredation, by:
  - Exploring known and possible mitigation measures
  - Outlining pathways towards their development and adoption
- Discussing the information needed to demonstrate effectiveness
  
- Broadly, focusing discussions on:
  1. Adapting fish behaviours
  2. Exploring technical solutions – including modifying gears, using shark deterrents and physical protection devices



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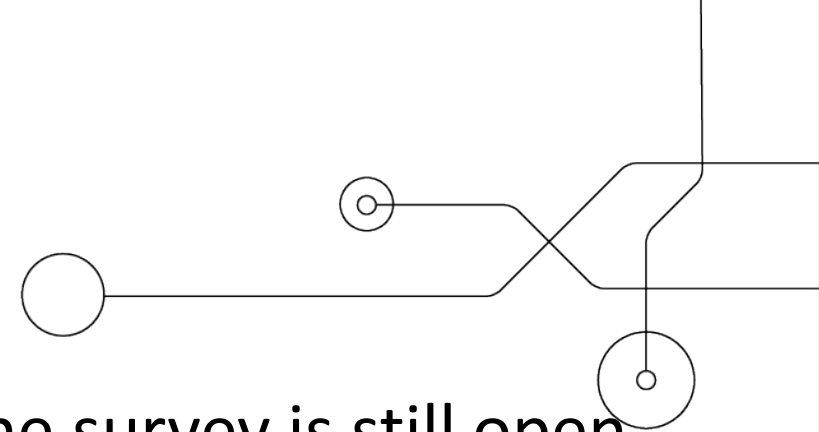
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# Summary of survey responses

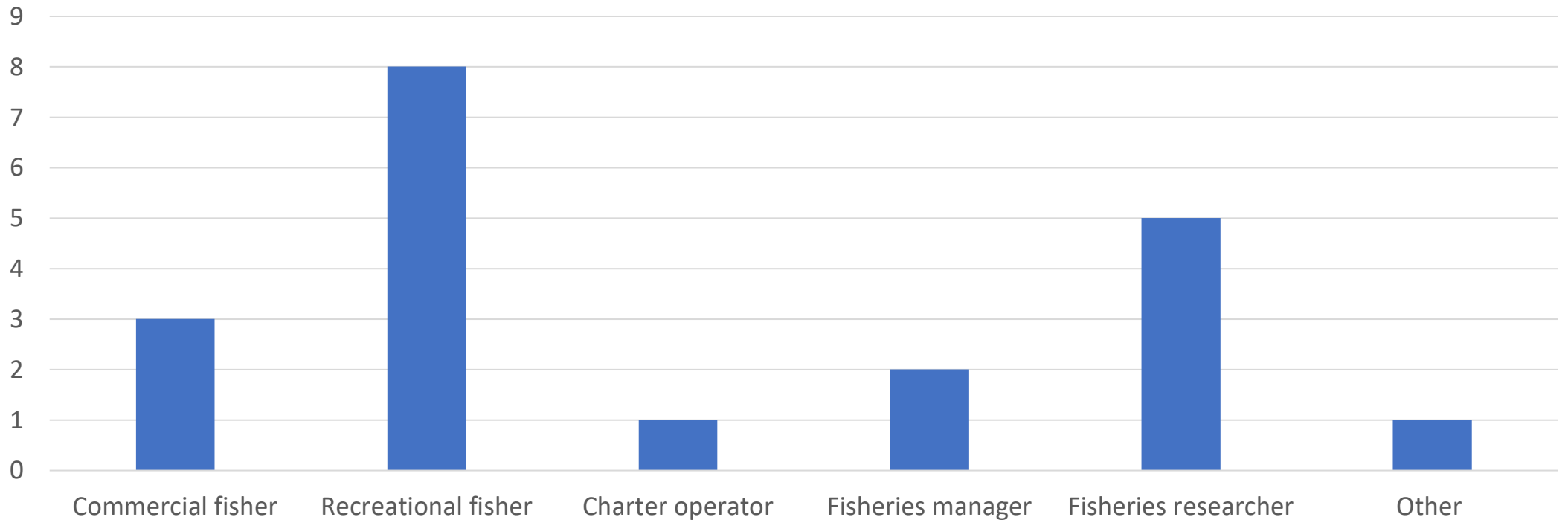




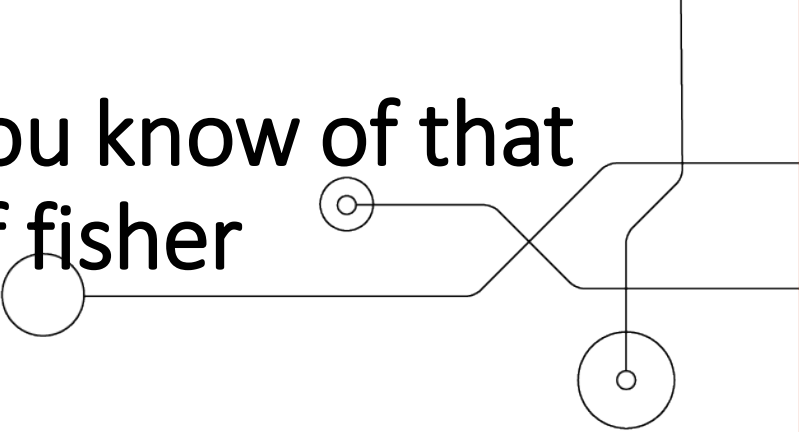
# Thank you for participating



- 20 responses at time of data compilation, BUT, the survey is still open

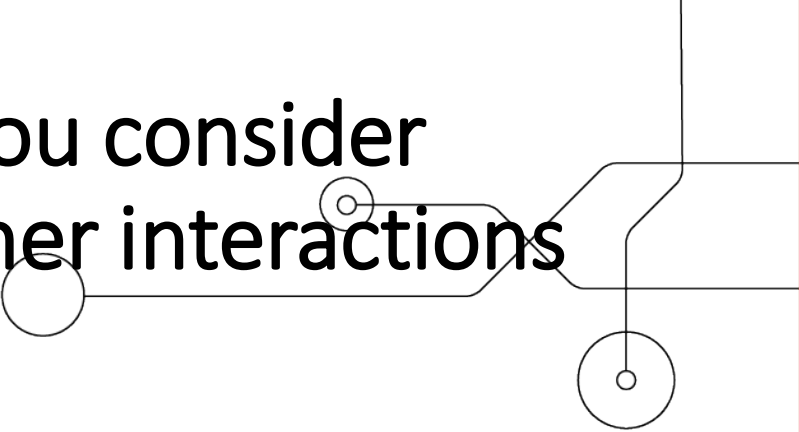


# What technical mitigation solutions do you know of that are effective at reducing the likelihood of fisher interactions with sharks?



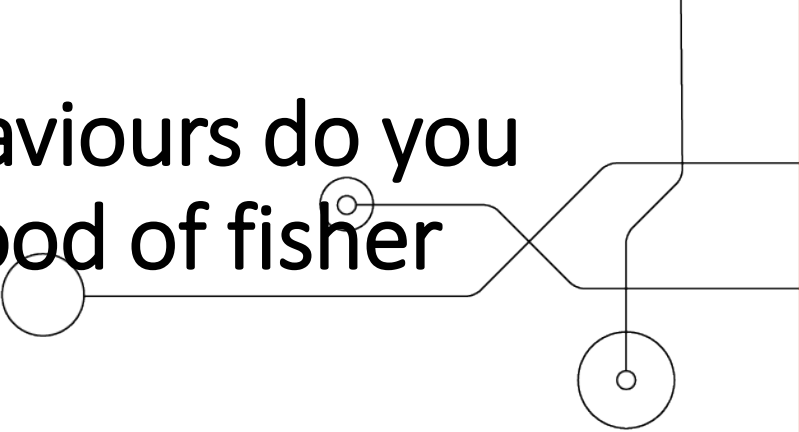
- Responses encompassed the following:
  - reducing transmitter power on sounders
  - electric reels to enable rapid retrieval of hooked fish
  - comments that most currently available deterrents have been ineffective or only mildly effective
  - changing gear types – e.g. from line to trap (commercial fisheries)
  - reduce bait use (i.e. use artificial lures where possible)
  - use of TEDs in trawl fisheries
- Some respondents noted that a suite of measures would likely be required – technical solutions only one part of a broader strategy
- Shark culls OR increased exploitation of sharks as fisheries resources

# What changes to fishing behaviours do you consider effective at reducing the likelihood of fisher interactions with sharks?



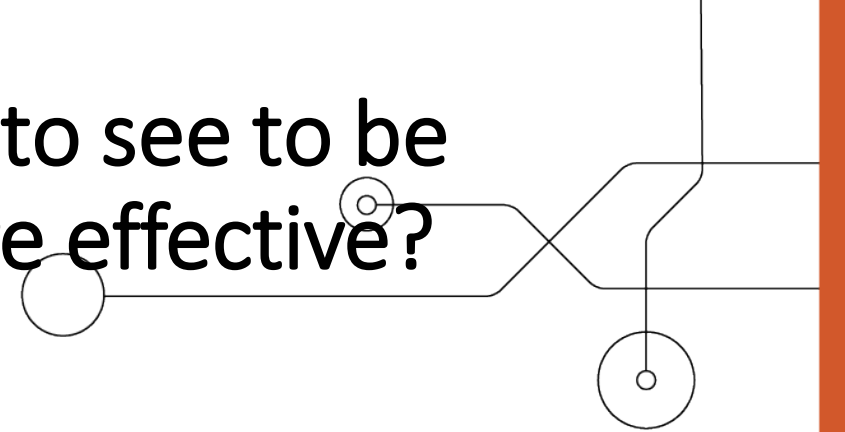
- Moving spots frequently – some respondents that this is only minimally effective in some areas (and adds to costs)
- Avoiding shark ‘hotspots’ – including certain times of day and/or year
- Different fish handling/release approaches (e.g. sailfish off Broome) – this included avoiding catch and release
- For longline gear, reduce soak times and set gear at depths less favoured by key depredating sharks
- CONTINUED OVER PAGE

# Continued: What changes to fishing behaviours do you consider effective at reducing the likelihood of fisher interactions with sharks?



- Spreading recreational fishing effort over broader spatial extents
- Avoid discarding offal or bait
- Avoid burleying if feasible to do so (noting this should be at discretion of the individual fisher)
- Discarding shark offal as a deterrent (not effective for larger sharks)
- Diversify target species to include those less favoured by sharks
- “Nothing works”

# What data/information would you need to see to be convinced that mitigation approaches are effective?



- Responses mainly fell into two broad categories:
  - a. Personally, having better fishing experiences (i.e. reduced losses to sharks) and/or hearing about similarly improved experiences from other fishers

BUT, some respondents noted the defining “better” could be difficult – for some fishers, one fish lost to sharks is too much
- Reductions in size of shark packs following vessels also suggested as a measure of success
- OR

# Continued: What data/information would you need to see to be convinced that mitigation approaches are effective?



b. Seeing the outcomes from scientifically designed trials testing the effectiveness of different mitigation measures

- Additional points associated with these responses included:
  - If mitigation measures involve some reduction in fishing effectiveness, we need to know what reduction fishers are prepared to accept
  - Realistically, depredation won't be eliminated – but reductions of even 5 or 10% could make a difference
  - Need to ensure that effects hold over time (i.e. sharks don't adapt)

Thank you



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