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CSIRO Submission 16/576

Inquiry into the efficacy and regulation of shark mitigation and deterrent measures

Senate Environment and Communications References Committee

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Executive Summary

CSIRO conducts research into shark movements, behaviour, biology, genetics, population assessments and related research in collaboration with government agencies and national and international research institutions. CSIRO does not undertake research related directly to shark attack (including shark control measures and detection or deterrent devices) as these are areas of active research by State Government agencies. CSIRO does not have any policy responsibilities for protecting, culling or control of sharks.

ToR (a) Research into shark numbers, behaviour and habitat

There are no current reliable estimates of population size in Australian waters for white, bull or tiger sharks due to a lack of usable historical and contemporary data from conventional catch records. Thus, it is not currently possible to say if populations of any of these species are increasing, decreasing or stable as there are no reliable data from which such assessments can be made.

CSIRO and its research partners, under the National Environmental Science Program (NESP) are, however, currently engaged in the development, application and refinement of novel techniques for estimating total population size for white sharks in Australian waters.

Tiger, bull and white sharks are similar in that they roam over considerable distances (1000s of km) as part of their normal movement patterns and utilise both nearshore and offshore waters as part of their normal habitat.

White sharks are not permanent residents at any one site. Their movements indicate temporary residency at various sites, mixed with periods of long-distance travel that may include common corridors.

Research indicates broad-scale movements of white sharks in eastern Australia between Tasmania and central Queensland and between eastern Australia and New Zealand. Movements include multi-year return and occupancy of two known east coast nursery areas (Port Stephens, New South Wales and 90 Mile Beach-Corner Inlet area, Victoria).

Nearshore areas, including surf zones and some estuaries, are common habitat for juvenile white sharks with sporadic areas of temporary residency along the coast likely in response to the distribution of prey.

ToR (c) The range of mitigation and deterrent measures currently in use;
and
ToR (d) Emerging mitigation and deterrent measures

There is a broad range of mitigation and deterrent measures currently in use (or being developed or tested) ranging from devices aimed at personal protection, detecting sharks entering an area, deterring sharks from entering an area, preventing sharks entering an area, or removing sharks that are present in an area. Many new technologies and devices lack the robust, independent testing of their efficacy that is required to inform policy options and public debate.

CSIRO does not currently have the capacity to conduct independent testing of shark deterrent devices, nor does this align with CSIRO's current strategic research priorities. State based agencies are, however, actively involved in some testing and CSIRO supports some of these projects by providing biological advice and information on shark movements and behaviour.

Lethal risk mitigation methods include the semi-permanent deployment of baited drum-lines and/or shark nets off various beaches in New South Wales and Queensland, and sporadically in Western Australia. Both

are designed to capture target sharks with the objective to reduce the abundance of these species at a select beach or to remove a particular shark. Neither provide a barrier to stop sharks approaching beaches. Although there is little doubt that these devices reduce risk of shark encounter by removing sharks, the actual amount by which risk is reduced has not been assessed. It is clear from research on movement patterns and occupancy of beach areas by sharks that the number and frequency of attacks is often a poor indicator of the local abundance of sharks.

Notwithstanding the policy question of whether the removal of sharks improves public safety, such programs are faced with a trade-off between what level of shark removal will reduce the risk of shark attack and what level of removal will not place populations of sharks at risk. In the absence of more robust information on shark population sizes, it is advisable that such programs include effective catch monitoring, clear trigger points and decision rules regarding the level of catch for both target and bycatch species and agreed actions in response to these trigger points – all linked to defined management objectives.

ToR (f) Alternatives to Currently Employed Mitigation and Deterrent Measures, including Education:

Comment on this ToR is specifically restricted to public education. Information on sharks is easily found and disseminated, however, the veracity of some of this information is questionable. There is an important role in continuing to provide accurate information to the public regarding sharks in the marine environment.

ToR (h) Other Relevant Matters:

CSIRO notes the following gaps in current scientific knowledge of relevance to shark mitigation and deterrent measures and required to inform public debate and government policy:

- Robust estimation of shark population size and trends for species implicated in shark attack.
- A strategic framework for assessing the potential efficacy of all shark risk mitigation strategies and tools. This should include independent testing of personal shark deterrent devices, shark detection technologies and a robust assessment of the efficacy of nets and drumlines in reducing shark numbers at beaches where such infrastructure is deployed.

Introduction

CSIRO welcomes the opportunity to provide input to the Senate Environment and Communications References Committee inquiry into the efficacy and regulation of shark mitigation and deterrent measures.

CSIRO conducts research into shark movements, behaviour, biology, genetics, population assessments and related research in collaboration with Commonwealth and State government agencies (especially in New South Wales, South Australia and Western Australia), as well as various other national and international research institutions. The output of this research underpins actions in National Recovery Plans for listed species, biodiversity and conservation management actions, the management of commercial shark resources, and supports local-scale policies and management relating to sharks.

CSIRO does not undertake research related directly to shark attack or its mitigation (including shark control measures and detection or deterrent devices), nor does CSIRO have any policy responsibility for protecting, culling or control of sharks. Minimising human-shark interactions is a key area of public concern, but to avoid duplication of effort, it has specifically not been part of CSIRO's research brief. This work is primarily done by State government agencies, particularly in New South Wales, Queensland and Western Australia. However, CSIRO's advice and research output provides support to these areas of State government research as well as policy regarding public safety, management of shark-based tourism, and conservation management actions.

Some specific examples where CSIRO's research output/advice has been used include:

- Information on biology, movement patterns, habitat use and population assessments for National Recovery Plans and related conservation management actions including for whale shark, grey nurse shark, white shark, mako shark, euryhaline sharks and rays as well as deep-water dogfish.
- Assessing the Western Australian government shark control drum-line program for the Western Australia-EPA. CSIRO is also currently collaborating with the Western Australian government through the NESP Marine Biodiversity Hub, including releasing joint scientific reports and publications on various species including white sharks.
- CSIRO is supporting the New South Wales government's response to recent shark attacks through technical assistance and biological advice. CSIRO also collaborates with the New South Wales government through the NESP Marine Biodiversity Hub, including releasing joint scientific reports and publications, and has participated in New South Wales Parliamentary and public briefings on shark management strategies including the 2015 New South Wales Shark Summit.
- CSIRO has previously reviewed shark cage-diving operations off South Australia for the Department of Environment and Natural Resources. This resulted in several operational modifications to the industry including a reduction in effort and various changes to licence conditions managed by the State for this activity. CSIRO is also working with South Australian-based researchers to study movement patterns and behaviour of white sharks in South Australian waters and releases joint publications with Flinders University and the South Australian Research and Development Institute (SARDI).
- CSIRO currently works with a variety of State government and university-based research teams to achieve a broad coverage of tagging and genetic sampling of white sharks. This supports research into a national-scale understanding of their movements, behaviour and population status. Such information also helps with the interpretation of human-shark interactions and can inform assessments of the efficacy of both shark control programs as well as shark detection and deterrent devices.

Of the seven specific Terms of Reference (ToR) for the inquiry, CSIRO's submission addresses ToR (a), (c), (d), (f) and (h). Comments on ToR (c) and (d) are covered in a single section. Comments on ToR (f) are

restricted to public education. Comments are specifically restricted to three species of shark (white, bull and tiger) that, combined, are implicated in 60% of shark attacks in Australian waters (Australian Shark Attack File data – Taronga Zoo Sydney). These are the primary target species in shark control and detection programs as well as being the species that shark deterrent devices are primarily aimed at. Most comments will relate to white sharks (= great white sharks) as CSIRO has conducted research on this species for over a decade and currently leads a nationally coordinated project aimed at estimating their population size and status. This project is jointly funding through the NESP Marine Biodiversity Hub (https://www.nespmarine.edu.au/project/project-a3-national-assessment-status-white-sharks). CSIRO does not currently conduct species-specific research on either bull or tiger sharks, but these species are included in research projects on the movements and habitats of sharks in general in areas such as south-east Queensland and northwest Western Australia.

CSIRO response to the Terms of Reference (ToR)

ToR (a) Research into shark numbers, behaviour and habitat

Shark numbers

CSIRO has had a long history in assessing the population size and status of, in particular, commercial fish species including sharks. This has taken the form of analyses and modelling of catch rates and management strategies as well as developing novel methods to estimate population size when conventional catch data is either lacking or inadequate for the task. Many (but not all) sharks have life history traits such as high longevity, large size and age at first reproduction, low reproductive output and high natural survival rate. These characteristics render such species vulnerable to human-based mortality (e.g. fishing) which can result in population declines and, once depleted, stocks can take considerable periods to recover even if pressures on the population are reduced or eliminated.

There are no current reliable estimates of population size in Australian waters for white, bull or tiger sharks. This is because the conventional data required to do so, such as detailed catch records over suitable time periods, is limited, unreliable or non-existent. None of these species are, or have been, the primary focus of commercial fisheries, although tiger and bull sharks are retained by some fisheries. White sharks have been protected in Australian waters since the late 1990s, but data on their historical and contemporary catch has been poorly recorded and is inadequate for estimating population size or trend. Bull and tiger sharks have not been the focus of targeted research to estimate population size in Australian waters, although analyses of tiger sharks captured in the Queensland Shark Control Program (QSCP) indicate significant declines in catch rates and average size between 1993 and 2010 (Holmes *et al.* 2012).

With respect to white sharks:

- Genetic and tagging data suggest there are two populations of white sharks in Australian waters, separated east and west by Bass Strait (Blower et al. 2012; Bruce and Bradford 2012). Bass Strait is not a barrier to movement and some sharks cross from east to west and vice-versa, but the general pattern is for sharks to remain either east or west of Bass Strait.
- It is not currently possible to say if white shark populations are increasing, decreasing or stable as there are no reliable data from which to estimate historical population size and from which such assessments can be made.
- However, in 2014, CSIRO and partners through the NESP reported the first ever empirical estimate of adult white shark abundance – provisionally 750 to 1,200 adult white sharks for the eastern Australia population. Additional data and more recent refinements to these analyses suggest that the figure is more likely to be at the lower end of this scale.

- These data have been further developed to give an estimate of total population size including an estimate of all other life history stages juveniles in the population. This research is the subject of current external peer-review as part of the normal process for publication in an international scientific journal.
- A population estimate for the southern/western population is also being progressed by CSIRO and research partners under the NESP Marine Biodiversity Hub.
- This research is also providing a basis for estimating measures of key population attributes (reproductive frequency, survival rates) needed to estimate population trends.

Behaviour and habitat

Tiger, bull and white sharks are similar in that they roam over considerable distances (1000s of km) as part of their normal movement patterns and utilise both nearshore and offshore waters as part of their normal habitat. Extensive tagging of tiger sharks has been undertaken in Western Australia (Department of Fisheries Western Australia) and eastern Australia (University of Queensland). Extensive tagging of bull sharks has been undertaken in eastern Australia by the New South Wales Department of Primary Industries (NSW DPI), AIMS, James Cook University and Griffith University. Results in eastern Australia indicate regular annual movements of bull sharks from tropical to temperate waters including travel between Sydney Harbour and Townsville (Heupel *et al.* 2015) and movements ranging from central Queensland to southern New South Wales for tiger sharks (Holmes *et al.* 2014). Bull sharks are particularly notable in their use of nearshore habitats including surf zones and estuaries (Heupel *et al.* 2010, Werry *et al.* 2011).

With respect to white sharks:

- White sharks are not permanent residents at any one site. Their movements indicate temporary residency at various sites, mixed with periods of long-distance travel that may include common corridors. Areas close to favoured sites and common corridors of travel are likely to experience more encounters with white sharks (Bruce et al. 2006, Bruce and Bradford, 2013 + 2015).
- Results provide evidence of broad-scale shark movements in eastern Australia between Tasmania and central Queensland and between eastern Australia and New Zealand (Bruce and Bradford 2012, Bradford et al. 2012). Movements include multi-year return and occupancy of two known east coast nursery areas (Port Stephens, New South Wales and the 90 Mile Beach-Corner Inlet area, Victoria). Nearshore areas and surf zones are common habitat for juvenile white sharks with sporadic areas of temporary residency along the coast likely in response to the distribution of prey. Some estuarine areas are also confirmed as part of white sharks' normal habitat (Harasti et al. 2017).
- CSIRO has also been assisting the NSW DPI with tracking juvenile white sharks tagged off northern New South Wales. This research shows that white sharks are not permanent residents to this area. They are part of the general east coast population and move extensively throughout the species known east coast range (http://wildlifetracking.org/index.shtml?project_id=1141).

ToR (c) The range of mitigation and deterrent measures currently in use; and

ToR (d) Emerging mitigation and deterrent measures

In 2015 the NESP Marine Biodiversity Hub Director asked CSIRO to develop a project on human-shark interactions, with other partners, in response to prioritisation of this issue by the then Commonwealth Department of the Environment for the 2015 NESP Research Plan.

CSIRO reviewed the information generated by the 2015 New South Wales shark summit and existing or potential research and development on human-shark interactions in Australia and overseas including summaries of the distribution of shark attack incidents in Australian waters and an overview of non-lethal shark risk mitigation technologies currently used or in development. This report can be found at: https://www.nespmarine.edu.au/document/status-human-shark-interactions-and-initiatives-mitigate-risk-australian-waters. This document complements the review contracted by NSW DPI on emerging technologies for reducing the risk of shark attack (available at: http://www.dpi.nsw.gov.au/fishing/sharks/shark-management).

Efficacy of shark deterrent/detection devices

CSIRO does not currently have the capacity to conduct independent testing of shark deterrent devices, nor does this align with CSIRO's current strategic research priorities. However, testing of certain commercially available and developmental products has been undertaken by State-based researchers in Australia, is currently underway, or is planned with funding from the Western Australian and New South Wales governments (Huveneers *et al* 2013, Hart and Collin 2015, Kempster *et al.* 2016).

It would be very difficult to conduct testing of shark deterrent devices. Some of the complicating factors are:

- shark attacks are complex rare events, the circumstances surrounding them are not always clear and there are numerous variables that cannot be controlled
- there is a range of technologies being designed to reduce shark attack risk: some of which are personal protection devices, others aim to deter sharks from an area and some are designed to detect sharks moving into an area. Thus the required testing approaches are diverse and any testing would need to be individually designed
- testing needs to be informed by a broader understanding of shark behaviour, shark populations and the nature of human-shark interactions, areas where research data are still incomplete.

CSIRO provides biological advice to other agencies involved in the current testing of shark deterrent devices, including Flinders University, South Australia and the NSW DPI.

Both NSW DPI and the Department of Fisheries Western Australia maintain acoustic receiver networks capable of detecting and relaying, in near-real time, the presence of acoustic-tagged sharks. These receivers (VR4Gs) were initially tested in a joint project between Department of Fisheries Western Australia and CSIRO which commenced in 2008 (Bradford *et al.* 2011). The VR4G receivers use the Iridium satellite network to transmit details of tagged sharks that are detected via a purpose designed database and monitoring system. This system then relays these details to agencies vesting with public safety responsibilities and the general public via email, SMS and web-based interfaces (http://www.sharksmart.com.au/shark-activity/; http://www.dpi.nsw.gov.au/fishing/sharks/sharksmart). This system has the advantage that a detection provides accurate details of a confirmed species of shark. These details are broadly disseminated within two minutes of the detection. However, only tagged sharks are detectable. These are primarily research tools designed to provide information on the conditions under which sharks visits monitored areas and any patterns in doing so. However, they are also used to alert safety management agencies and the public to the confirmed presence of tagged sharks as part of duty-of-care. The VR4G receivers also form part of a nationally coordinated system of standard acoustic receivers (which store detections for later download rather than relay detections in real time) under the Integrated Marine Observing System (IMOS - http://imos.org.au/acoustictelemetry.html). Extensive acoustic tagging of white, bull and tiger sharks is being carried out in New South Wales, South Australia and Western Australia to support a greater understanding of shark movements and detection by this system.

Testing of alternative technologies designed to detect untagged sharks is currently being undertaken by NSW DPI.

Shark Control Programs (SCP)
Baited drum-lines and/or shark nets are deployed semi-permanently off various beaches in New South Wales and Queensland, as well as sporadically in Western Australia (the latter in response to shark attacks or when there are sightings/detections of large sharks close to populated areas). Both are fishing devices designed to capture target sharks with the objective to reduce the abundance of these species at the select beach or remove a particular shark. Neither provide a barrier to stop sharks approaching beaches. Although there is little doubt that these devices reduce risk of shark attack by way of removing sharks, the actual amount by which risk is reduced has not been assessed. For example if a single white shark was present off Bondi Beach on a particular day and it became entangled in the deployed net, then the risk of encountering a shark on that day, and hence attack risk, has been reduced to zero. If on another day there were 100 white sharks off Bondi Beach and a single shark was again entangled, the risk of encounter has not been significantly diminished despite the same catch rate. What is also unknown is whether any of these sharks were likely to be involved in a shark attack. It is clear from research on movement patterns and occupancy of beach areas that the number and frequency of attacks is a poor indicator of the local abundance of sharks and vice versa.

Notwithstanding the policy question of whether the removal of sharks improves public safety, any such programs are faced with a trade-off between what level of removal of sharks will reduce the risk of shark attack (the implicit objective) and what level of removal will not place populations of sharks at risk. In the absence of more robust information on shark population sizes, it is advisable that such programs include effective catch monitoring, clear trigger points and decision rules regarding the level of catch for both target and bycatch species and agreed actions in response to these trigger points – all linked to defined management objectives. See CSIRO (2014 a, b + c) for examples.

Observations of the relative abundance of acoustic tagged sharks to untagged sharks (e.g. in the vicinity of baited underwater video cameras) may offer a means of quantifying the number of sharks present in an area and hence the risk of encounter. Combining this information with the number of sharks removed through a SCP would provide an estimate of the proportion of sharks removed from an area by the SCP and hence the potential encounter risk reduction from that removal. A NESP research project in New South Wales where an extensive multi-species tagging program is continuing and where acoustic receiver coverage is highest, may provide some data on the numbers of sharks visiting specific beach areas and the extent to which the SCPs are successful in their capture. Although the relationship between encounter risk and risk of attack is not easily defined, such monitoring will help assess the efficacy of such programs, and provide quantitative information of how well they work. Information on the effectiveness of individual SCPs will support policy decisions that need to take into account their value and efficacy in increasing public safety, their overall impact on shark populations and any impacts on meeting the objectives of National Recovery Plans for listed shark species.

ToR (f) Alternatives to currently employed mitigation and deterrent measures, including education;

Comments under this ToR refer specifically to ‘education’.

Information on sharks is easily found and disseminated, however, the veracity of some of this information is questionable. Thus there is an important role in continuing to provide evidence-based information to the public regarding sharks in the marine environment. Some of the most important areas of education could include:

- Are shark numbers increasing? This is not known. There are no current reliable estimates of population size in Australian waters for white, bull or tiger sharks, so it is not possible to comment on population trends. Adequate data required to make such formal assessments does not exist and is difficult to

collect. Sharks are highly mobile and while there are patterns to their movements, their local abundance can change in response to a variety of factors that are unrelated to overall population size. This does not mean that shark numbers do not increase or decrease in some areas over time – the problem is interpreting how local changes in abundance relate to overall population size.

- Are shark attacks increasing? Yes. As in other areas of the world, the overall number of shark attacks has gradually increased over the last few decades in Australian waters. Various studies have attributed this overall increase to a rise in human population (e.g. West 2011). Some studies note that although the number of attacks has increased the rate of attack (being the number of attacks per time spent by people in the ocean) has decreased (Ferretti et al. 2015). Many different factors contribute to the overall increase in shark attacks that are not related to shark numbers, including human population trends, changes in human population distribution and regional demographics, as well as variations in lifestyle and behaviour of people over time. However, it is important to note that clusters of shark attacks cannot be attributed to increases in human use of the ocean or sudden increases in overall shark population size as neither of these sufficiently change over such short periods of time.
- Are there more shark attacks where the shark numbers are high? No. There are, for example, high human-use areas where white sharks are abundant but where the incidence of shark attack is low. The Western Australia drumline program revealed a significant number of tiger sharks present in coastal waters off Perth, yet no attacks have been attributed to this species in the area since 1925 (Australian Shark Attack file data). It is important to note that the incidence and frequency of shark attack may not have a direct relationship to local shark abundance and cannot be used as a proxy for shark population trend.
- Have shark sightings increased? Yes. The number of sharks sighted has significantly increased, as has the number of shark-related media reports. The impression given is that shark numbers have massively increased. What is not taken into account is the increase in surveillance effort and the increase in the rate and ease of reporting. There has been a significant increase in the number of resources, assets and tools used to detect and monitor sharks and relay this information to the public and media. This includes real-time reporting of the detection of tagged sharks, publically available satellite-based shark tracks, sightings by aerial surveillance and public reporting of sightings via social media as well as through web-based platforms. The more we have the ability to look into the marine environment for sharks, the more sightings there will be and as information flow becomes easier, the more reports there will be.
- Can humans share the waters with sharks? Yes. Sharks are part of Australia's natural environment and it is not unusual for people and sharks, even large and potentially dangerous ones, to be in the same area at the same time without incidence of shark attack. That is not to say that the sighting or detection of a potentially dangerous shark should be dismissed – such sightings should be taken seriously and represent a potential risk even if the actual risk of any one animal being involved in an attack is unknown. How to effectively respond to such sightings, taking into account their increase in frequency due to the increase in surveillance and reporting effort, will continue to be a challenge to agencies vested with public safety.

ToR (h) Any other relevant matters.

It is important that any actions taken in relation to the efficacy and regulation of shark mitigation and deterrent measures take into account scientific understanding of shark populations including their distribution and behaviour. There is significant public divide regarding shark abundance, with different groups equally vocal about the status of shark populations, their impact on public safety and how best to respond. It is important that such debate is informed by evidence-based information rather than being driven by speculation.

CSIRO notes the following gaps in current scientific knowledge that are of particular relevance to shark mitigation and deterrent measures and required to inform public debate and government policy:

- Robust estimation of shark population size and trends for species implicated in shark attack.
- A strategic framework for assessing the potential efficacy of all shark risk mitigation strategies and tools. This should include independent testing of personal shark deterrent devices, shark detection technologies and a robust assessment of the efficacy of nets and drumlines in reducing shark numbers at beaches where such infrastructure is deployed.

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