Marine Biodiversity Hub

National Environmental Science Programme

Project A4: The status of human-shark interactions and initiatives to mitigate risk in Australia

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Important Disclaimer

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EXECUTIVE SUMMARY

Considerable political, public and media attention in Australia has recently been focussed on the interactions between sharks and humans in the marine environment and specifically surrounding shark attack and ways to mitigate this risk. This has initiated considerable investment at the State Government level in new technologies, techniques and their operational testing, as well as publicly accessible information that supplement existing strategies in an attempt to reduce the risks of shark-human interactions.

In general, these new strategies have focussed on ways to mitigate risk that are not lethal to sharks. Investment has been in key areas of:

- research on shark movement patterns,
- research into shark senses,
- development, testing and application of systems to detect or deter sharks, or separate them from in-water users,
- automated systems of reporting the presence of tagged sharks to local authorities vested with coastal safety, and
- development of interactive websites providing the latest information on sharks and automatically updating web-mapping showing locations of sightings, incidents and tagged shark detections which are available directly, via apps and with notifications via Twitter feeds.

Three species of shark are responsible for 60% of shark attacks in Australian waters - bull shark, tiger shark and the white shark, with white sharks alone accounting for 26%. All fatalities since 1938 have been attributed to one of these three species. Although any bite by a shark can have potentially serious consequences the remaining 40% of attacks are associated with species that rarely cause serious injury including wobbegong and reef sharks. The distribution of attacks by bull, tiger and white sharks reflect their known distribution in Australian waters and the distribution of Australia's urban regions and high use in-water areas. The incidence of shark attack has gradually increased in Australian waters over the last four decades, a trend in common with world-wide statistics. The most common activities during which attacks are sustained are swimming, diving and surfing. Whereas attacks on swimmers and divers have generally remained at stable levels, attacks on surfers have increased which may reflect an increase in participation in this activity, although data on participation trends are inadequate to define.

Finding the most appropriate policy balance between maximising public safety, the conservation of sharks in the marine environment as well as understanding the broader social and economic ramifications of shark attack are continuing challenges for Government.

There is significant data, resource and knowledge-sharing across Government jurisdictions in Australia and direct links between Government and the University sector in the area of development and testing of shark attack mitigation strategies.

Given the significant investment from State Governments addressing shark attack mitigation strategies, further direct investment under NESP in this area is not warranted at this time. However, tracking distribution and abundance data of sharks tagged under the NESP program will continue to provide a context and sometimes specific data that will help determine whether new technologies are likely to be successful in reducing the incidence of white shark attacks in Australia.

This report provides brief summaries of shark attacks in Australian waters, focussing on the three main species implicated and the current initiatives being developed and implemented to supplement the already established shark control programs in New South Wales and Queensland to reduce risk.

1. SUMMARY OF SHARK ATTACKS IN AUSTRALIAN WATERS

There are approximately 830 recorded shark attacks (defined here as when a person sustains an injury as a result of being bitten) recorded in the Australian Shark Attack File (ASAF) for the period 1791 to 2015 – all species combined. The ASAF is administered by Taronga Zoo, Sydney and is affiliated with the International Shark Attack File administered by the Florida Museum of Natural History. These numbers of recorded attacks in Australia specifically do not include listings under the ASAF where no injury was sustained (e.g. where a shark has approached/investigated a person in the water, or made contact with a surfboard, kayak or other in-water craft). Although these latter can be highly dangerous situations, the ability to report such incidents has dramatically increased in recent years with the advent of smartphones, miniaturised waterproof cameras and the rise of social media. This has seen a concomitant rise in reporting of non-injurious interactions and thus the frequency of these incidents is not easily compared over time. It should also be noted that although incidents of shark attack have been recorded since 1791, organised recording, via the ASAF was not formally established until 1984. Thus data during the 1800s and early decades of the 1900s are unlikely to have captured all records of attack. For this reason, the summary below focuses on data from the last four decades.

There have been 330 recorded attacks over the last four decades and the incidence of shark attack has gradually increased in Australian waters over this period, a trend in common with world-wide statistics (Figure 1).

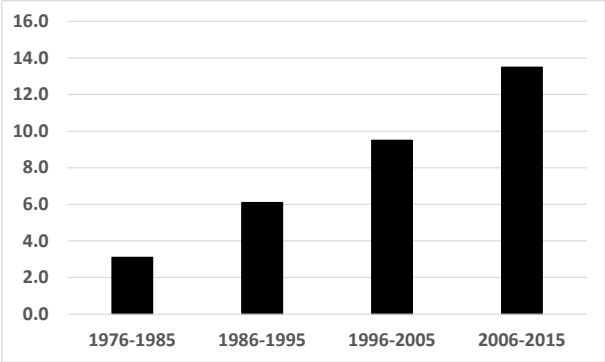

Figure 1: Mean number of annual shark attacks (all species) over the last four decades.

The distribution of shark attacks is generally consistent with the distribution of Australia's human population with the majority of recorded attacks being in eastern Australia between Cairns (Qld) and Eden (NSW), including the greater metropolitan areas of Brisbane and Sydney (Figure 2).

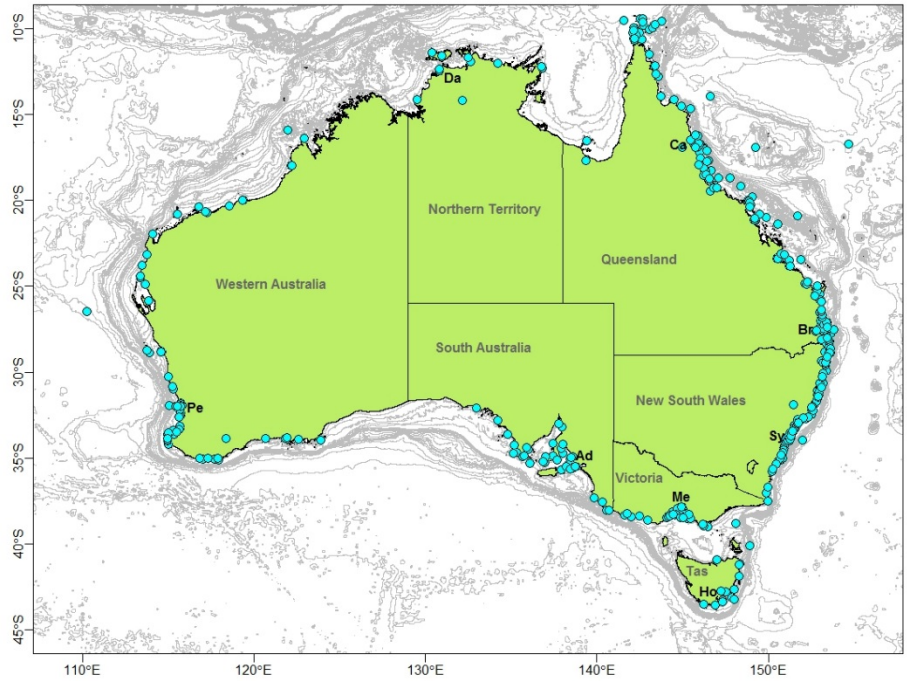

Figure 2: Location of recorded shark attacks in Australia (all species) 1791-2015 (Source: Australian Shark Attack File, Taronga Zoo Sydney). Da = Darwin, Ca = Cairns, Br = Brisbane, Sy = Sydney, Me = Melbourne, Ho = Hobart, Ad = Adelaide, Pe = Perth.

The most common activities during which attacks are sustained are swimming, diving (including all types of diving activities e.g. snorkelling, scuba diving and hookah diving) and surfing. It is clear from these data that although attacks on swimmers and divers have continued at a reasonably stable level, over the last four decades, attacks on surfers have shown an increasing trend in recent years (Figure 3).

Three species are responsible for approximately 60% of shark attacks in Australian waters - bull shark (*Carcharhinus leucas*), tiger shark (*Galeocerdo cuvier*) and the white shark (*Carcharodon carcharias*). Attacks attributed to the white shark account for the most for a single species - 26% of all recorded incidents. The distribution of attacks by these species reflect their known distribution in Australian waters and, as with the distribution of all attacks, the distribution of Australia's urban regions and high use in-water areas.

Records of attacks by bull sharks range from Perth in Western Australia around the north coast to the southern coast of NSW which corresponds to their known range (including seasonal movements). Most attacks have been recorded in eastern Australia between Rockhampton and Sydney (Figure 4).

Records of attacks by tiger sharks show a similar distribution to bull sharks reflecting their tropical habitat. However, the main areas where attacks have been recorded range from Brisbane, north, to Torres Strait (Figure 5).

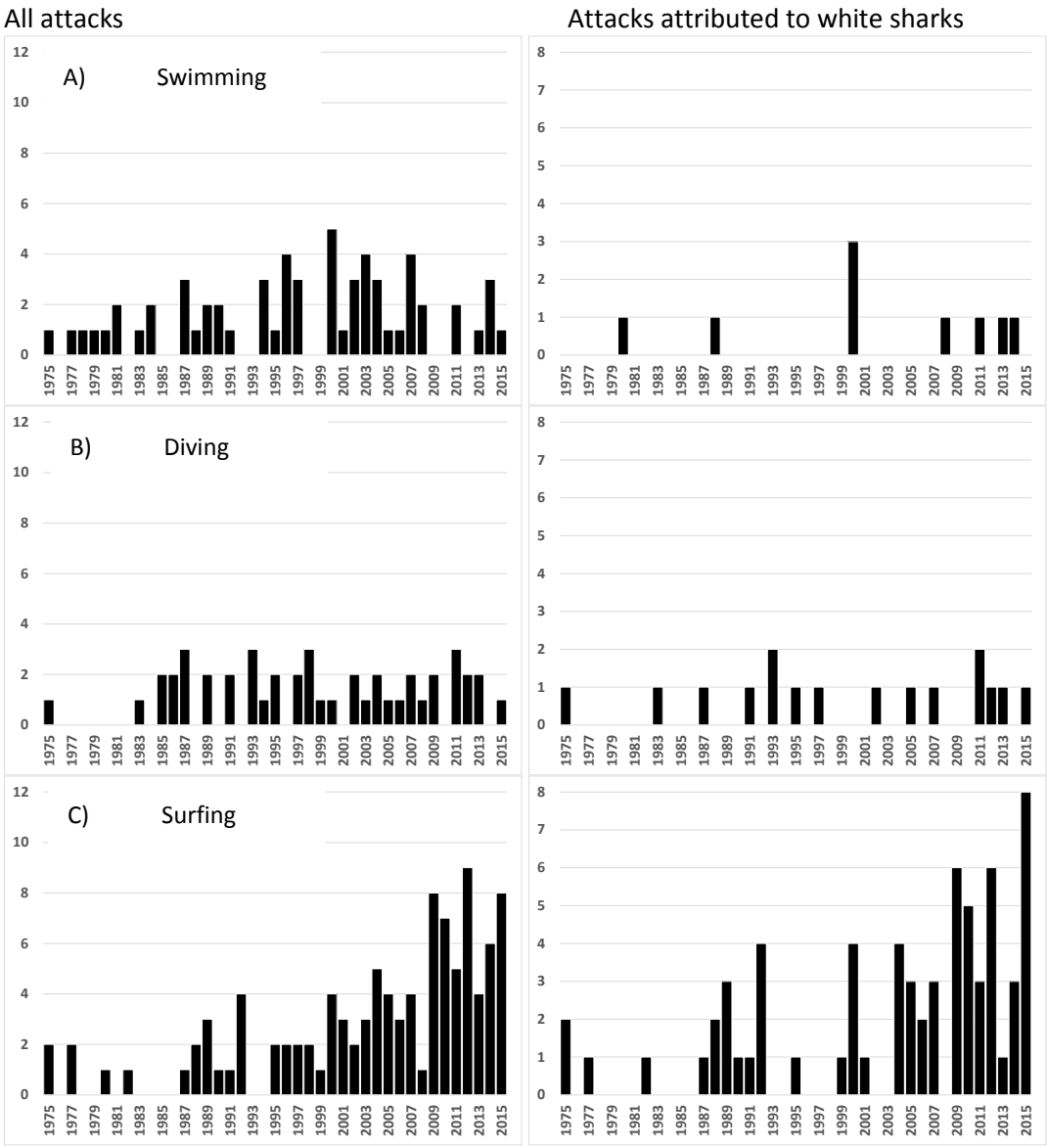

Figure 3: Shark attacks by activity since 1975.

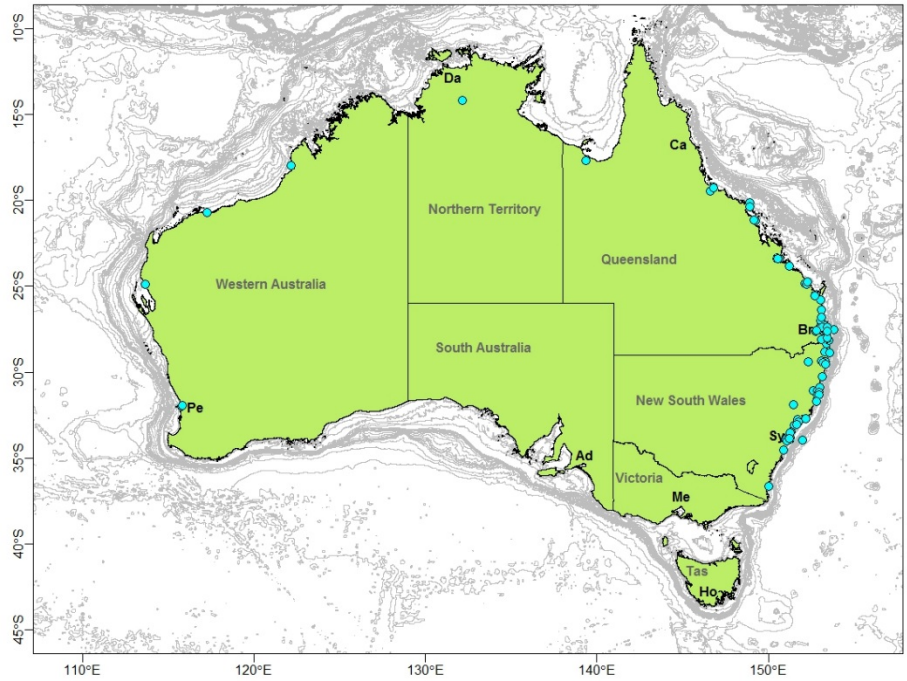

Figure 4: Location of recorded bull shark attacks in Australian waters (1791-2015). (Source: Australian Shark Attack File, Taronga Zoo Sydney). Da = Darwin, Ca = Cairns, Br = Brisbane, Sy = Sydney, Me = Melbourne, Ho = Hobart, Ad = Adelaide, Pe = Perth.

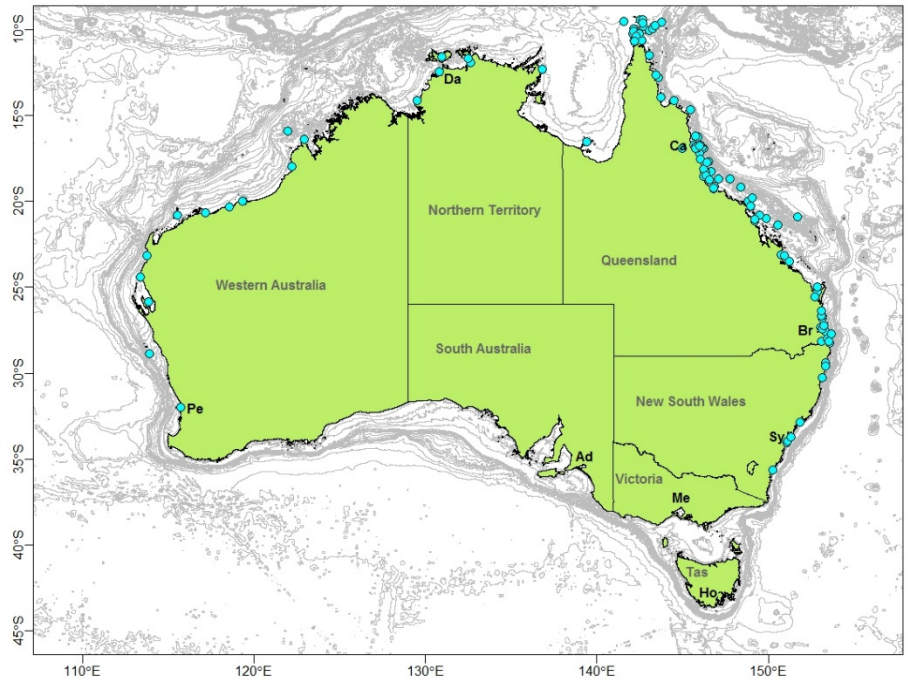

Figure 5: Location of recorded tiger shark attacks in Australian waters (1791-2015). (Source: Australian Shark Attack File, Taronga Zoo Sydney). Da = Darwin, Ca = Cairns, Br = Brisbane, Sy = Sydney, Me = Melbourne, Ho = Hobart, Ad = Adelaide, Pe = Perth.

White sharks naturally occur from northwest Western Australia around the south coast to central Queensland. Records of attacks by white sharks exist across their Australian range and reflect this more southern distribution. Cases range from the Abrolhos Islands in Western Australia, around the south coast to the Brisbane region in southeast Queensland (Figure 6).

NSW has the highest number of attacks attributed to white sharks of any Australian State. Seven white shark attacks, including one fatality have occurred on beaches within the operational area of the NSW Shark Control Program since the program was introduced. Recent attacks in northern and central NSW have been attributed to white juvenile sharks (<3.5 m in length).

As is the case in most jurisdictions around the world, Australia has seen a gradual increase in the total number of attacks attributed to white sharks over recent decades (Figure 3).

White sharks were protected in all Australian jurisdictions over the 1996-1998 period following similar conservation measures world-wide for the species. The distribution of attacks by white sharks after their protection in 1996-1998 is similar to the distribution of attacks prior to their protection (Figures 7 and 8) and continue to reflect the location of human population centres and areas of high recreational in-water use.

There is a growing body of information on the distribution and movements of bull, tiger and in particular, white sharks – the latter generated by NERP/NESP initiatives and research by State Government (Fisheries) and various University-based researchers (e.g. see Figure 9).

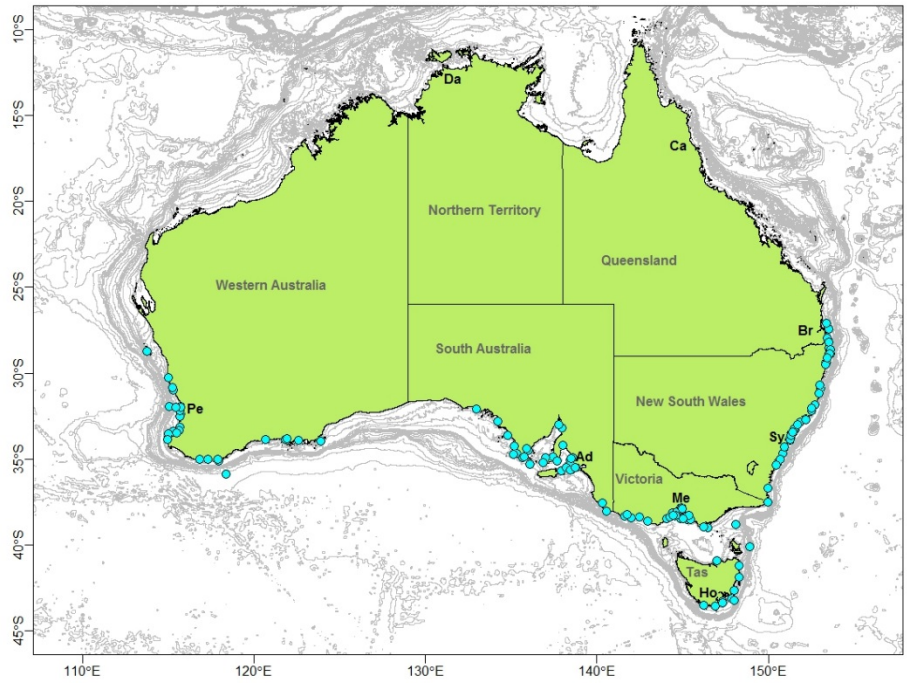

Figure 6: Location of recorded white shark attacks in Australian waters (1791 – 2015). (Source: Australian Shark Attack File, Taronga Zoo Sydney). Da = Darwin, Ca = Cairns, Br = Brisbane, Sy = Sydney, Me = Melbourne, Ho = Hobart, Ad = Adelaide, Pe = Perth.

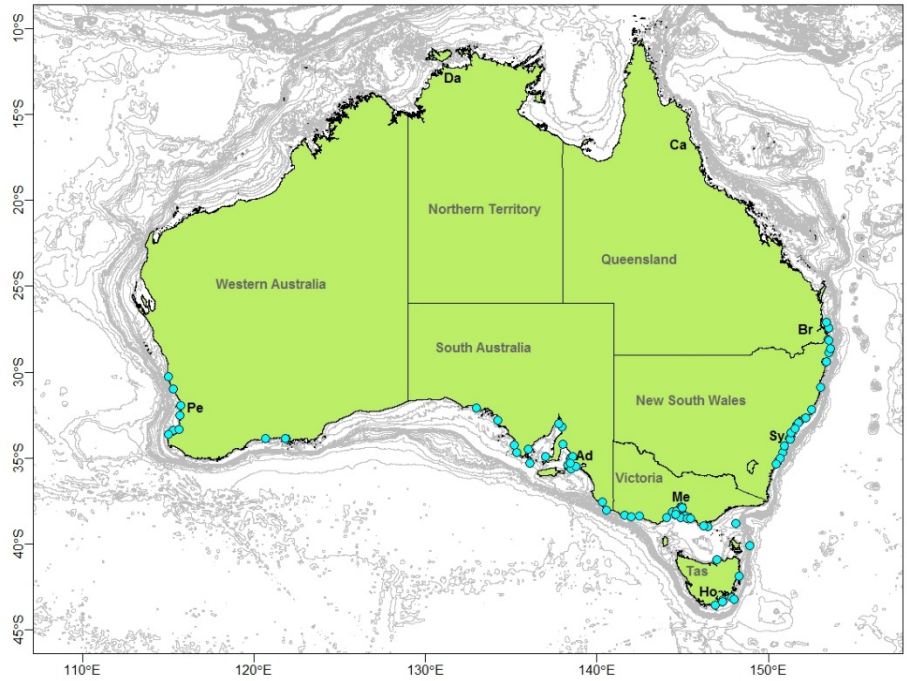

Figure 7: Location of recorded white shark attacks in Australia prior to the species protection. (Source: Australian Shark Attack File, Taronga Zoo Sydney). Da = Darwin, Ca = Cairns, Br = Brisbane, Sy = Sydney, Me = Melbourne, Ho = Hobart, Ad = Adelaide, Pe = Perth.

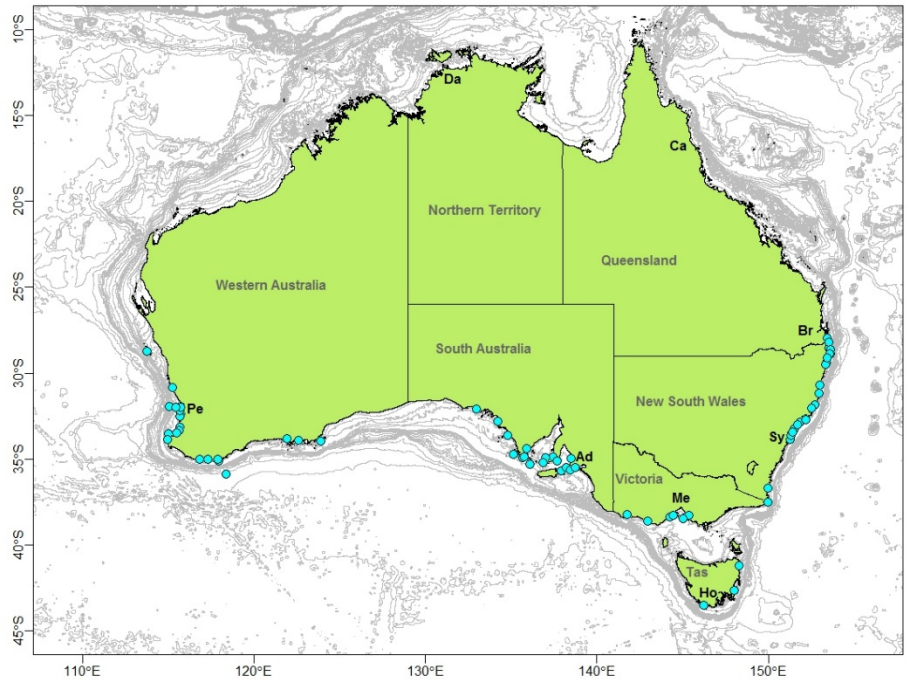

Figure 8: Location of recorded white shark attacks in Australia after the species protection. (Source: Australian Shark Attack File, Taronga Zoo Sydney). Da = Darwin, Ca = Cairns, Br = Brisbane, Sy = Sydney, Me = Melbourne, Ho = Hobart, Ad = Adelaide, Pe = Perth.

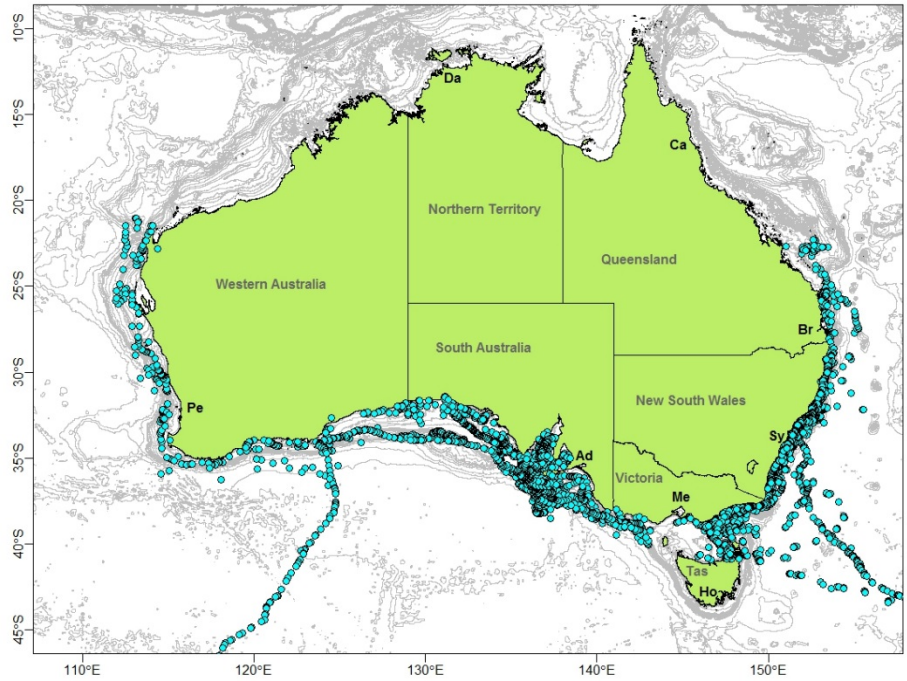

Figure 9: All recorded positions for satellite tracked white sharks (n = 55 sharks; 1.7 to 5.2 m Total Length) tagged in Australian waters. Each dot represents a satellite derived location. Data from CSIRO Oceans & Atmosphere.

These data, and in particular the developing long-term data series on movement patterns via acoustic tagging, offer some promise for describing movement patterns and distribution that may assist in understanding the risk of encountering sharks in Australia's coastal waters. However, the link between *encounters* (sharks and people being in the same immediate vicinity) and *attacks* is poorly understood and likely to differ between regions, vary temporally and vary dependent on the motivational status and size of individual sharks. This limits the practicality of attempting to estimate the risk of shark attack from the distribution of sharks alone. For example, areas of high abundance of white sharks do not necessarily have a higher number of recorded attacks compared to surrounding regions despite a high level of in-water use. One such area is in NSW centred around Port Stephens. The area is a known nursery area where white sharks of approximately two to three metres in length commonly occur, particularly during the spring and early summer, which are times of high recreational in-water use in the area. Although attacks attributed to white sharks on coastal beaches are recorded immediately north and south of this area, there have been no recorded attacks on ocean beaches within the footprint of the nursery area - specifically at Birubi Point and Hawks Nest, despite being popular surfing and swimming locations and having records of frequent shark encounters. Two attacks have, however, been recorded inside the Port Stephens estuary – both attributed to white sharks (Figure 10).

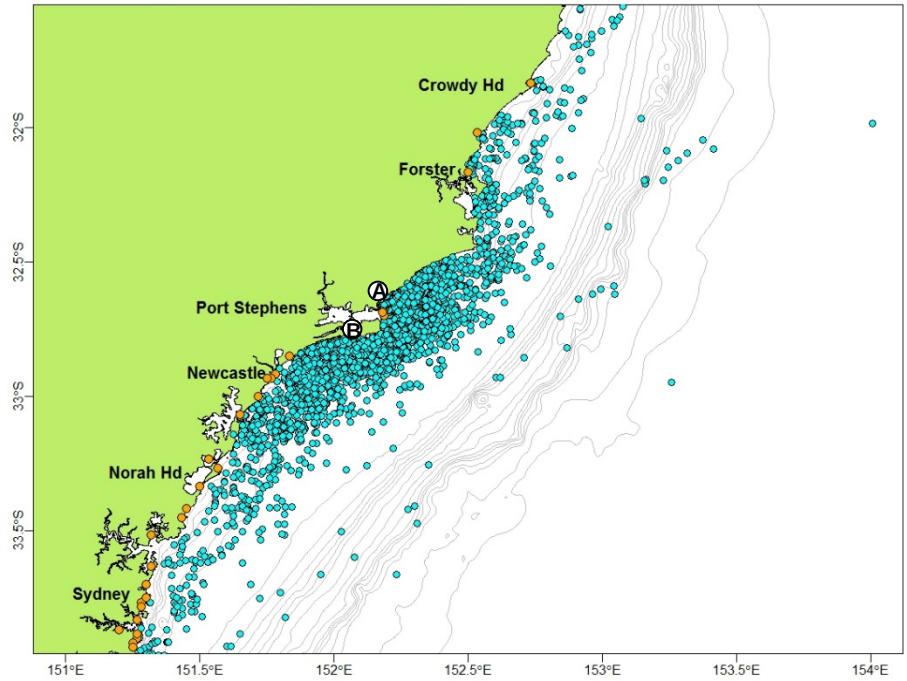

Figure 10: Distribution of satellite tracked white sharks in the vicinity of Port Stephens and the distribution of white shark attacks in the region. A = Hawks Nest, B = Birubi Point.

2. RECENT INITIATIVES TO REDUCE SHARK ATTACK RISK IN AUSTRALIAN WATERS

Although a range of procedures have been in place in Australian waters to reduce the risk of attack for many decades, including the shark control programs in NSW and Queensland, attacks over the last 5 years, particularly in Western Australia and New South Wales have prompted significant recent investment by State Governments in new tools, techniques and publicly accessible information that supplement these existing strategies. In general, these new strategies have focussed on ways to mitigate risk that are not lethal to sharks. Investment has been in key areas of:

- research on shark movement patterns,
- research into shark senses,
- development, testing and application of systems to detect or deter sharks, or separate them from in-water users,
- automated systems of reporting the presence of tagged sharks to local authorities vested with coastal safety, and
- development of interactive websites providing the latest information on sharks and automatically updating web-mapping showing locations of sightings, incidents and tagged shark detections which are available directly, via apps and with notifications via Twitter feeds.

Key recent Australian reviews have been recently published on shark deterrent technologies, shark attack statistics and public perceptions regarding attack mitigation strategies (see the section ‘Recent publications relating to shark attacks, development of mitigation strategies, risk and public perception in Australian waters’ below) and this topic continues to be an active area of focus.

However testing the overall efficacy of deterrent technologies under true conditions is inherently difficult because: shark attacks are relatively rare (requiring considerable data sets to distinguish patterns from coincidence), it is difficult to know what percentage of sharks might attack under particular conditions, what those conditions are and, in the case of personal deterrent technologies, how sharks respond to humans wearing such devices as opposed to bait canisters or test decoys.

2.1 WA Government initiatives

2.1.1 Research and development into risk mitigation technologies

The WA Government recently funded a series of projects to develop tools for shark attack mitigation see below (Table 1). While progress has been made in some areas, no single technology has proven unequivocally successful with both development and testing an active area of effort.

Table 1: Recent Western Australian Government funded projects

Project	Institution
Test and improve existing shark deterrents	University of WA
Develop and test novel deterrents (e.g. bubble curtains sounds and strobe lights)	University of WA
Sonar imaging and detection of sharks	Curtin University
Computer algorithms for real-time automatic shark detection	University of WA
Electronic shark deterrents and surfboards	Shark Shield Pty Ltd
Systems to mask noise by swimmers and surfers that attract sharks	Curtin University
Acoustic systems to detect sharks approaching beaches	University of WA
Sensory cues that trigger shark attack	University of WA
Trial (Eco-Barrier) beach enclosure	Dunsborough Council
Beach surveillance (aerial patrols)	Surf Life Saving WA Westpac Helicopter
Shark observation towers	Cottesloe Council

2.1.2 Operational shark monitoring system

The WA Government also developed the Shark Monitoring Network which is based on acoustic tagging and receivers. The main component of the network features a series of Iridium-satellite-linked acoustic receivers (VR4G receivers, Vemco Nova Scotia) which, on detection of a tagged shark sends details of the tag code detected through a database link which matches the tag code to the details of tag deployment and automatically sends an email/sms to local authorities to alert the presence of a tagged shark including details of the species and its size. The system continues to report the shark until it is no longer detected. The time between detection and receiving the alert message is 1-2 mins.

This information has been successfully used to pre-emptively close beaches when a shark is detected. Shark detections are immediately available on the WA SharkSmart website http://www.sharksmart.com.au/, see below.

In addition to the above initiatives the WA Government has also invested considerable resources in research on shark movement patterns with tagging programs focussing on white sharks, tiger sharks and various whaler shark species.

2.2 NSW Government Initiatives

The NSW Government initiated a Shark Summit in September 2015 that provided a review of current and emerging strategies and technologies designed to mitigate the risk of shark attack at the scale of 'whole of beach'. A key objective of new initiatives under the NSW strategy is to increase bather protection while minimising harm to sharks and other marine animals. The salient outcomes of the shark summit that drive the NSW shark strategy were that:

- No single technological solution was likely to suit all applications and integrating technologies was likely to provide the best results.
- All technologies currently being developed require further operational testing and development before they could be considered viable.
- There is potential scope to test some emerging technologies in NSW.

In response, the NSW Government has primarily focussed their direct initiatives on the operational testing of mitigation technologies, as opposed to their specific development, as well as research into shark movement patterns. A number of shark attack mitigation strategies and emerging technologies are being directly trialled by NSW DPI and aspects of this program are scheduled to run for up to five years (Table 1). In addition, the NSW Government has instigated a Competitive Grants Program aimed at supporting advances in and testing of personal shark deterrents, area-based shark deterrents (e.g. aimed at beach protection), shark detection technologies, shark biology relevant to interactions with humans (http://www.dpi.nsw.gov.au/fishing/sharks/shark-management/annual-competitive-grants-program). Specific priority areas are currently:

- Personal shark deterrents
- Area-based shark deterrents (e.g. electrical or other types of barriers)
- Shark detection methods (e.g. sonar technologies, shark recognition software)
- Shark biology relevant to interactions with humans (e.g. sensory systems)
- Socio-economics of shark-human interactions (e.g. changes in human behaviour and perceptions following implementation of particular approaches)

Table 2: Locations of shark hazard mitigation operational trials and research in NSW.

Location	Aerial surveillance	Shark barrier trial	Real-time monitoring of acoustic tagged sharks	Shark tagging	Drone Trial	SMART Drumline trial	Sonar 'Clever Buoy' trial
Tweed Heads			✓				
Byron Bay	✓		✓	✓	✓		
Lennox Head	✓	✓	✓	✓	✓		
Ballina	✓	✓	✓	✓	✓	✓	
Evans Head	✓		✓	✓	✓		
Yamba	✓		✓				
Coffs Harbour	✓		✓	✓	✓	✓	
South West Rocks	✓		✓				
Port Macquarie	✓		✓				
Harrington				✓		✓	
Hawks Nest				✓		✓	
Sydney				✓			✓
Wollongong to Moruya	✓						

Brief details of the technologies being trialled in NSW are provided below.

2.2.1 Real-time automated monitoring and reporting: acoustic-tagged sharks

NSW DPI, similar to the WA Government, have deployed Vemco VR4G Iridium satellite-linked acoustic receivers at strategic sites along the coast in NSW (Table 1). These units are linked to the WA Shark Monitoring Network System and have similar operation characteristics to units deployed in WA, detecting the acoustic code of tagged sharks. VR4G units are deployed at Tweed Heads, Byron Bay, Lennox Head, Ballina, Evans Head, Yamba, Coffs Harbour, South West Rocks, Port Macquarie and Forster. Further deployments are scheduled for the southern half of the NSW coastline by early 2017. Detections of tagged sharks are automatically provided to authorities who may take preventative action to close beaches and detections are publically available via NSW Surf Life Saving Twitter feed and the NSW-developed SharkSmart App. Data collected complement information on the overall movement patterns of acoustic-tagged sharks monitored by extensive deployments of conventional acoustic receivers in east Australian coastal waters by NSW DPI, the Integrated Marine Observing System (IMOS) and various affiliated research institutions.

2.2.2 SMART drumline

SMART (Shark Management Alert in Real Time) drumline was developed for use at Reunion Island after a cluster of attacks occurred there. These units comprise a baited drumline with a communication modem, GPS and hook sensor. When a bait is taken, the unit alerts a response team that an animal has been caught. A response team can then be despatched to the drumline and attend to the hooked animal. NSW DPI are currently trialling Smart Buoys off northern NSW. They have been successful in catching juvenile white sharks with these units and responding to captures in a short period of time (provided that the capture team is on immediate standby in a vessel a relatively short distance away and ready to attend). At present, SMART drumlines are used as a research tool for the capture and tagging and release of sharks. However, the concept that these units can provide a means to selectively release animals without harm under normal operational conditions has not yet been tested (e.g. experiments on how long an animal hooked on the drumline will survive without being attended to).

2.2.3 Clever Buoy

Clever Buoy™ is an Optus-platform sonar buoy. The system uses a sonar capability to detect and identify targets as sharks. The unit is designed to alert authorities to the presence of targets, provided they can be identified as sharks, over two metres whereby an appropriate response can be taken. The problems to overcome are the challenge of using sonar in a surf zone environment, the ability to identify shark signatures from other targets and a relatively limited effective range of the units. NSW DPI is planning current trials of the capability of Clever Buoy to establish its capabilities.

2.2.4 Shark barriers

Installations of two styles barrier nets, developed in WA, are being trialled off Lennox Head and Ballina in northern NSW starting in mid-2016 for a three year evaluation of their practical

application. These barriers (produced by Global Marine Enclosures and Eco Shark Barrier respectively) are modular plastic mesh systems that extend out from shore, are anchored to the seafloor and provide a swimming/surfing enclosure that separates sharks and in-water users. These trials will determine the efficacy and maintenance requirements of such enclosures in the highly dynamic NSW coastal environment.

2.2.5 Personal shark repellents

Although a number of personal shark repellent devices are commercially available, many lack independent scientific studies that test and report their efficacy. Such testing is, however, encouraged under the NSW Government Competitive Grants Program. Personal repellents that have received the most testing to date are the commercially available Shark Shield Freedom7™ units. Two recent Australian-based studies have investigated these unit's efficacy in reducing the consumption of static baits and surface interactions with towed seal decoys in white sharks (see Huveneers et al 2013 and Kempster et al. 2016 below). Although the experimental set up differed between the studies, both concluded that these units significantly influenced the approach behaviour of sharks to baited canisters and towed decoys although the response varied between sharks.

2.2.6 Observation tower program

NSW DPI have also established a program to install up to ten new observation towers on beaches or beach headlands per year commencing in 2015 to aid in beach surveillance including visual detection of sharks.

2.2.7 Drones trials – aerial surveillance

NSW DPI have been using helicopter surveillance of beaches to alert authorities and beach-users to the presence of sharks. In addition, they have recently completed a trial using drones to spot and monitor shark activity close to shore near Coffs Harbour and a comparison between sightings from a helicopter and a drone in the Byron region reporting positive results.

2.2.8 Shark movement patterns

NSW DPI maintain a current program tagging white sharks, bull sharks and tiger sharks in coastal waters with acoustic and satellite tracking tags.

3. EDUCATION AND COMMUNITY AWARENESS

3.1.1 Western Australia

The Western Australian Government maintains a detailed and informative online system for reporting the distribution of shark sightings and detections.
http://www.sharksmart.com.au/

3.1.2 South Australia

PIRSA maintain a tabulated online log of reported shark sightings. The general public and fishing industry are encouraged to report sightings to the log via SA Police, Surf Life Saving SA, a 24-hour FishWatch hotline, the SA Recreational Fishing Guide smartphone app or via an online reporting form.

This is a tabulated list only and does not provide a visual representation of the distribution of shark sightings. http://www.pir.sa.gov.au/fishing/fishwatch/sharks/shark_sightings_log

3.1.3 New South Wales

The NSW Government has developed a SharkSmart App which is based on the WA SharkSmart website. It includes a map of current shark sightings, incidents and detections of tagged sharks via the acoustic receiver network. As with WA, this information is also available via the Surf Life Saving Australia Twitter feed.

4. INTERNATIONAL INITIATIVES

Current actions in Australia are similar to initiatives world-wide to reduce the risk of shark attack and specifically to move away from methods involving the capture and killing of sharks, although such programs still exist in South Africa (beach meshing and drum lines) and Reunion Island (drum and longlines). Information and resource sharing between Australian research groups and international researchers and organisations currently occurs with respect to testing and analyses of personal shark deterrents and advances in electronic and physical barrier technologies.

5. COMMUNICATION UNDER THIS NESP PROJECT

This project provided information on shark attack, strategies applied in Australia and world-wide to reduce risk and summaries of research on shark movements, distribution and research on estimating shark abundance via direct briefings with Federal Senators, Minister for Science and senior advisors within the Minister for the Environment's office. Briefings and presentations were also provided to Surf Life Saving Australia and to the New South Wales Legislative Assembly Committee on the Management of Sharks in NSW Waters (NSW 2016).

This project also supported NSW government researchers through sharing information on shark movements, sharing research equipment and resources, providing training in shark capture, handling and tagging procedures and presenting biological data in public fora and through the media.

REFERENCES

The following provides a list of recent relevant publications that refer in part or full to Australian information or studies.

Bradford, R. W., Bruce, B. D., McAuley, R. B. and Robinson, G. (2011). An evaluation of passive acoustic monitoring using satellite communication technology for near real-time detection of tagged animals in a marine setting. The Open Fish Science Journal. 4: 10-20.

Cardno (2015). Shark deterrents and detectors: Review of bather protection technologies. Report prepared for NSW Department of Primary Industries. Cardno Pty Ltd. 42 pp.

Crossley, R., Collins, C. M., Sutton, S. G. and Huveneers, C. (2014). Public perception and understanding of shark attack mitigation measures in Australia. Human Dimensions of Wildlife: An International Journal. 19: 154-165.

Curtis, T., Bruce, B., Cliff, G., Dudley, S. J., Klimley, A. P., Kock, A., Lea, R. N., Lowe, C. G., McCosker, J., Skomal, G. B., Werry, J. M. and West, J. G. (2012). Responding to the risk of white shark attack: updated statistics, prevention, control methods and recommendations. In Domeier, M (*ed*) Global Perspectives on the Biology and Life History of the Great White Shark. CRC Press, Boca Raton, FL. pp 477-509.

Gibbs, L. and Warren, A. (2015) Transforming shark hazard policy: Learning from ocean users and shark encounter in Western Australia. Marine Policy. 58: 116-214.

Hart, N. S and Collin, S. P. (2015). Shark senses and shark repellents. Integrative Zoology. 10: 38–64.

Huveneers, C., Rogers, P. J., Semmens, J. M., Beckmann, C., Kock, A. A., Paige, B. and Goldsworthy, S. D. (2013). Effects of an electric field on white sharks: In situ testing of an electric deterrent. PLoS ONE 8(5): e62730. doi:10.1371/journal.pone.0062730

Kempster, R. M., Egeberg, C. A., Hart, N. S., Ryan, L., Chapuis, L., Kerr, C. C., Schmidt, C., Huveneers, C., Gennari, E., Yopak K. E., Meeuwig, J. and Collin, S. P. (2016). How close is too close? The effect of a non-lethal electric shark deterrent on white shark behaviour. PLoS ONE 11(7): e0157717. doi:10.1371/journal.pone.0157717

McPhee, D. (2014). Unprovoked Shark Bites: Are they becoming more prevalent? Coastal Management. 42: 478-492.

Muter, B., Gore, M., Gledhill, K., Lamont, C., & Huveneers, C. (2013). Australian and U.S. news media portrayal of sharks and their conservation. Conservation Biology. 27: 187–196.

Neff, C. (2012) Australian beach safety and the politics of shark attacks. Coastal Management. 40: 88–106.

NSW (2016). Management of sharks in New South Wales waters. Legislative Assembly, Committee on Investment, Industry and Regional Development. Sydney, NSW. Report No. 1/56 Committee on Investment, Industry and Regional Development. 91 pp.

West, J. G. (2011). Changing patterns of shark attacks in Australian waters. Marine and Freshwater Research. 62: 744–754.

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