Mitigating the unknown: unravelling drivers of human-shark conflict

Final Report

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Introduction

Human-wildlife conflicts often suggest that wildlife species are “conscious” human antagonists. Indeed, humans often make important assumptions about wildlife behaviour when deciding how to tackle conflict, but often there is a mismatch between assumptions and reality. White sharks, in particular, are one of the most feared species by humans. This well-known conflict poses a worldwide challenge to government agencies. It seems likely that the number of attacks can be reduced, but understanding why sharks bite humans is still speculative. This leads to a crucial question: *How to mitigate the unknown?*

The highly mobile and elusive nature of White sharks means that much of their behaviour is unknown. Scientists are unsure why they even occur in such shallow coastal waters where they interact with humans. Although animal-borne cameras have been used to study some sharks, the camera size has, to date, always been problematic.

This project was designed to develop a specialised “shark-cam” to better understand the behaviour of potentially dangerous sharks when they are in nearshore regions in close proximity to humans. The project proposed to link with the NSW DPI shark tagging program to better understand why white sharks (*Carcharodon carcharias*) were in such shallow waters and whether their nearshore behaviours could elucidate why sharks occasionally bite humans.

The present seed funding enabled us to develop and test an animal-borne shark-logger that includes a video camera (hereafter Shark-cam) to explore potential tagging methodologies. It was originally planned to incorporate this technology within the current NSW DPI shark tagging program; however, NSW DPI adjusted their shark tagging operations away from active catching expeditions towards relying on animals caught on SMART drumlines and on the external contractors who manage this gear. Data collected from the NSW DPI shark tagging program indicates behavioural changes in sharks after release from drumlines, with released sharks moving offshore and thereby out of the ‘zone’ of interest. This led us to reassess our field methods for deploying shark loggers in wild sharks. Below, we present evidence on how we fulfilled the different proposed research phases that enabled us to develop an animal borne shark-cam, novel tagging methodology and tagging protocols.

Development of Shark-cam and tagging methodology (Phases 1 & 2)

Both the Shark-cam and the tagging methodology are non-invasive and have been extensively used in a wide range of wild sharks following ethical approval from different institutions worldwide (Chapple et al. 2015; Norman et al. 2016).

The deployment of cameras and data loggers on the dorsal fin of sharks have not always provided a clear view of the mouth of the individual carrying the units (Figure 1a, Heithaus et al. 2001). Considering that our main research aim is to better understand foraging ecology of white sharks, it was imperative for us to visualise the mouth of the shark to accurately assess prey capture events. Therefore, we discussed the possibilities to emulate a well-known symbiotic relationship between remoras (*Remora remora*) and sharks. Remoras are marine fish that can reach up to 90 cm length and 1.1 kg of weight (Forese and Pauly 2013). This pelagic fish is characterised by a sucking disc on top of its head that enables them to non-invasively attach themselves to their hosts (e.g. sharks, sea turtles, marine mammals and others) for extended periods of time (Beckert et al. 2015, Figure 1b).

Although pectoral fins play an important role in the manoeuvrability in marine predators, data loggers were previously deployed on pectoral fins of highly mobile bottlenose dolphins (*Tursiops truncatus*) without any negative impact to the animal carrying the loggers (Williams et al. 1999). In the particular case of shark-remora relationships, remoras were observed not to influence their host behaviour while attached, except for leaving with mild skin abrasions after detachment (Hardaway 2006). To establish the feasibility of collecting data from prey capture events while deploying the Shark-cam on the pectoral fins, we trialled them using white shark carcasses from individuals that died in the NSW Shark Meshing (Bather Protection) Program shark nets (see Figure 1c).

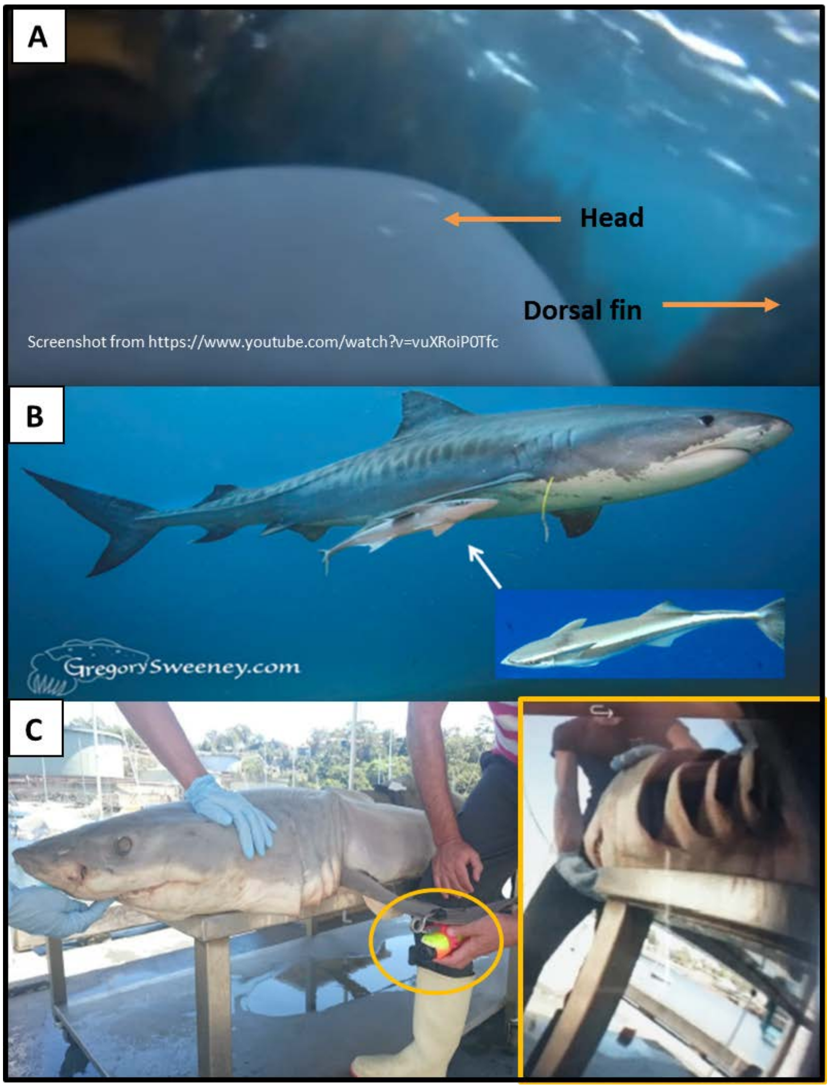

Figure 1. A) Screenshot of footage from a camera mounted on the dorsal fin of a white shark as it swims through a kelp forest. The top of the shark’s head is visible in the frame, but the mouth is not. **B**) Shark and remora in a well know symbiotic relationship in which remoras benefit from attaching themselves to pectoral fin of sharks. **C**) Testing Shark-cam attachment and viewing angle on the pectoral fin of a white shark carcass from the NSW Shark Meshing Program.

During this trial, to enhance welfare practices, we refined previous published methodology by gathering the following information:

i) We established the best location of deployment within the pectoral fins (section 2: approx. 25 cm from the body of the shark, Figure 2a)
ii) We measured the width of the fins to enable accurate design the clamps for deployment on pectoral fins (Figure 2 a)
iii) Through collaboration with the engineering team from the camera and data logger manufacturing company, Customised Animal Tracking Solutions (CATS), we adapted the design of the Shark-cam to emulate a streamline body shape of a remora (Figure 2 b, c).

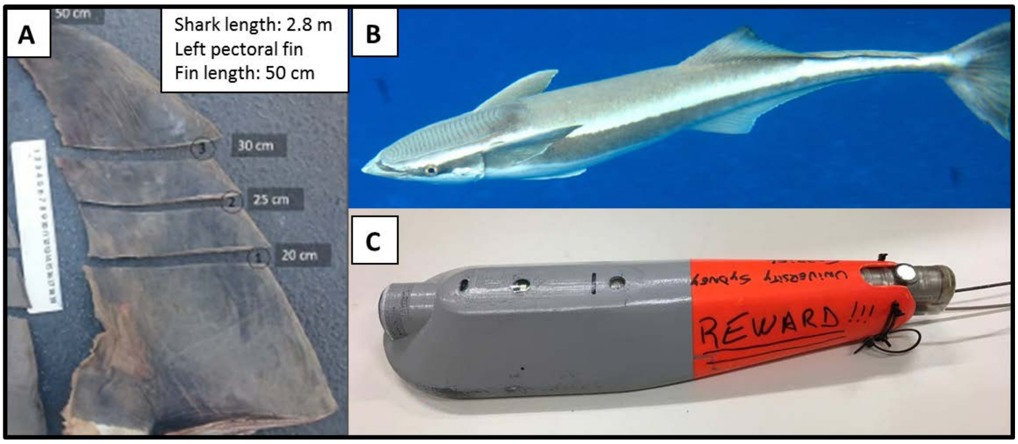

Figure 2. **A**) The pectoral fin of a white shark that died on in the NSW Shark Meshing Program. We measured the cross-sectional thickness of the pectoral fin at various distances from the body of the shark (sections 1-3) to customise and enhance the design of the clamps for deployment near the middle of the fin (section 2; 25 cm from the body on the shark that was measured). **B**) Photo showing the streamlined body of a remora and the suction pad on the top of its head that enables them to attach themselves to a wide range of marine organisms. **C**) With Customized Animal Tracking Solutions (CATS), we developed our novel design of shark-cam, emulating the remora's streamlined body shape to minimize the effects of hydrodynamic drag on the shark.

The Shark-cam and tagging equipment: are designed by Customized Animal Tracking Solutions (CATS, Australia). The logger consists of a wide range of biologging sensors including accelerometer, depth, light, speed and temperature recorders, a miniaturised video camera custom built in a micro-bubble and epoxy resin housing, and a VHF transponder for eventual gear retrieval (Figure 2c, see also Chapple et al. 2015 for more details). The Shark-cam is neutrally buoyant (albeit slightly positive), final dimensions are 25 x 8 x 4.5 (Length x Weight x Height in cm) and total weight of 600 gr, which is below the 3% threshold (the weight of gear in relation to the adult body mass) beyond which behavioural disruptions are likely to occur in sharks (Gleiss et al. 2009). The Shark-cam is attached to a specifically designed stainless steel clamp via a docking pin and a corroding Galvanic Time release (GTR). The Shark-cam is deployed using a custom built tagging pole (Figure 3).

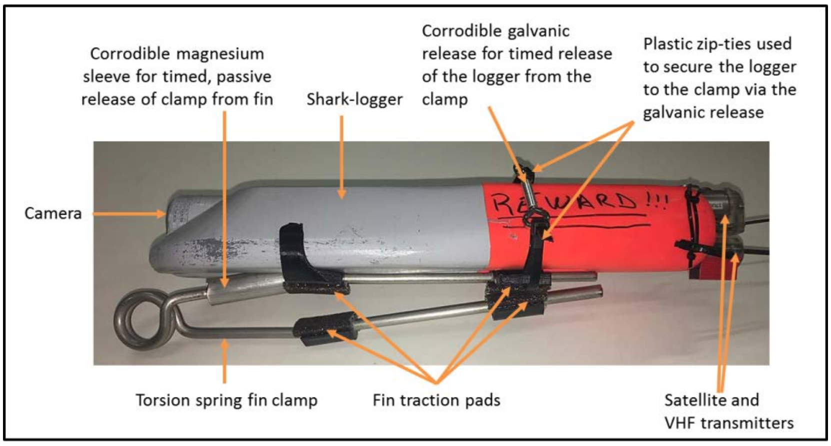

Figure 3. Side-view of the Shark-cam (video & data logger, combined) attached to the stainless steel torsion spring fin clamp. The corrodible galvanic release that secures the Shark-cam to the clamp allows for passive, timed release of the gear from the shark. After release, the Shark-cam floats freely to the surface where it can be located and recovered using the inbuilt satellite and VHF transmitters. The fin clamp has a second corrodible magnesium sleeve which allows it to break apart and fall off the shark's fin after a set period of time.

Tagging procedures established for sharks

Although the original proposal proposed to conduct trial deployments on captive whaler sharks as 'proof of concept', we were unable to establish cooperation with either of the two major aquarium companies in Australia (Gold Coast Sea World and/or Merlin Entertainments -who manage Sydney, Manly, Melbourne & Mooloolaba, Sea Life aquarium-). Therefore, considering the international success in using a similar deployment strategy with large white sharks elsewhere in the world, it was decided to attempt deployment on free-ranging white sharks off the recognised nursery grounds at Hawkes Nest, Port Stephens.

Following successful CSIRO protocols for detecting juvenile white sharks off Hawkes Nest, the following techniques were used:

1) A spotter person on the boat searched and located the sharks whilst the vessel patrolled along back-line of the surf.
2) On sighting a white shark, the boat would stop and Shark-cam prepared for deployment whilst the spotter and boat skipper determined the potential best approach to each individual shark's behaviour and their knowledge of white sharks in the region.
3) Individuals were attracted to the research vessel using fish on a hook-less natural fibre rope thrown ahead of the shark to draw its attention to the bait. Following Chapple et al. (2015) animals it was attempted to lead the shark to swim in parallel to the boat keeping the shark from eating the bait at all times. Once the shark is parallel to the boat, it was proposed that the 'tagger' (only personnel included in the present protocol) used the custom-built tagging pole to deploy the Shark-cam on the pectoral fin of the white shark. The white shark carrying the Shark-cam will swim away from the boat unharmed.

4) All activities, depending on water visibility and camera field of view, were recorded using a GoPro® camera attached to a pole extending from the roof of the vessel.

Tag release: The tag has the ability to passively release the unit from the animal via GTR within 2 days of deployment. In addition, as a back-up to the GTR, the saltwater will dissolve the magnesium sleeve locating in the clamp and a spring system will release the clamp from the pectoral fin within 2 days of deployment.

Tag recovery: Once released from the pectoral fin the tag unit will float free of the shark. A satellite tracker inside the Shark-cam will release a signal on the location of the tag and then we will use a VHF receiver to recover the tag.

Data analysis: The data will be downloaded from the tag and foraging behaviours will be and analysed with the goal to establish post-tagging and foraging behaviours.

Deployment of the "shark-logger" on wild sharks

One of the main advantages of our original proposal for the deployment of Shark-cam on the pectoral fins was the ability "*to be easily incorporated within the logistics of the NSW DPI shark tagging program*". Since then, NSW DPI adjusted their tagging operations towards relying on SMART drumlines and external contractors who manage this gear. Additionally, the tagging data collected revealed that sharks caught on SMART drumlines often head offshore after release, spending several weeks offshore before returning to nearshore habitats which are usually substantial distances from the original point of capture.

The original fully-funded proposal for this project aimed to investigate the activities of juvenile white sharks in the 'impact zone' (i.e. close to shore where surfers and swimmers are active). However, the behavioural change observed in sharks after release from drumlines led us to reassess our methods for deploying cameras to minimise the impact on the shark during tagging and thus reduce behavioural disruptions so that sharks might stay close to shore after deployment.

Bearing this in mind, we initiated a two-week fieldtrip at Hawks Nest in August 2017 with the aim of attracting juvenile white sharks to swim past the research vessel close enough to deploy a camera on their fin. As suggested on our proposal and following Chapple et al. (2015), we used a mullet to lure the sharks close to vessel with the goal of deploying the Shark-cam data logger.

Although a total of 6 juvenile white sharks were encountered, none were enticed close enough to the vessel to facilitate deployment of the Shark-cam. These juvenile white sharks, ranging from 2.0-2.5 m total length, were inherently wary of the vessel and were reticent to approach within 1.5 m from the boat. Therefore, we considered an alternative method of enticing sharks to stay close to the research vessel using a localised scent close to the boat generated from a small burley bucket of fish & fish oil, similar to that used in BRUV deployments.

Alternative tagging procedures using localised burley trail

1. White sharks were detected using human spotters and a drone launched from a small research vessel driven near the surf zone along beaches in the Hawkes Nest region.

2. Sharks were attracted to approach the vessel using a hook-less bait. The bait was thrown in the vicinity of the shark to attract its attention (Figure 4A). By retrieving the bait so that it remains positioned immediately ahead of the ‘interested’ shark, the shark was drawn towards the vessel. Our previous experience indicated that juvenile white sharks less than 2.5m total length are wary of approaching the vessel close enough for the team to deploy the Shark-cam on their pectoral fin. We therefore built a very localised burley trail emanating from a burley bucket attached to a retractable outrigger system (Figure 4B) with the aim of keeping the shark swimming past the vessel even though the bait has been removed from the water. However, due to incoming adverse weather conditions and lack of funding to continue fieldwork we did not have the opportunity to test this methodology.

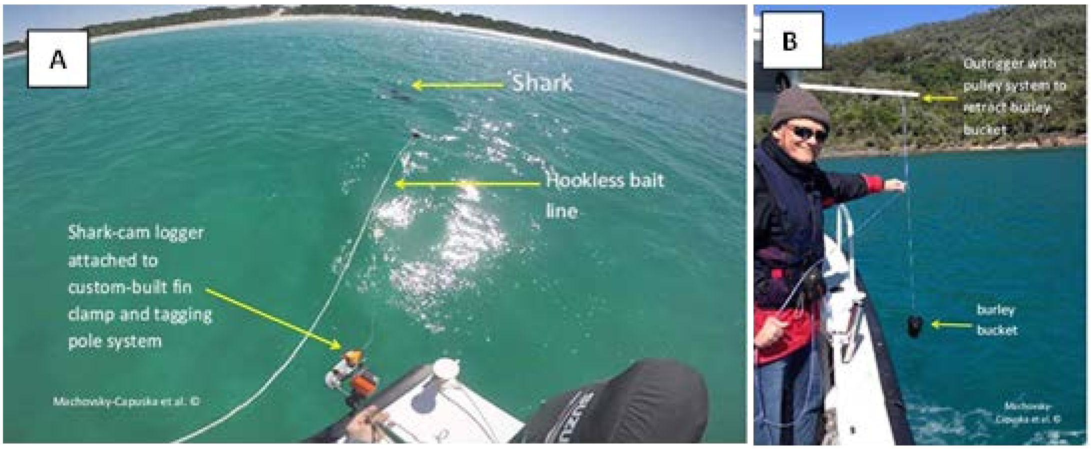

Figure 4. Methods for attracting white sharks alongside the vessel. (A) A shark being attracted to the research vessel using a hook-less bait line. (B) The outrigger burley bucket system used to generate a burley slick running parallel with the boat. The burley bucket can be removed from the water using a pulley system when the shark is next to the vessel. The Shark-cam will be attached to the pectoral fin using the tagging pole when the shark swims alongside the boat.

Conclusions of our research

1. Successful development of a Shark-cam biologging system that replicates size and shape of a remora.
2. Successful determination of the best position to place a camera for analysis of feeding events.
3. Optimal design of a clamp system suitable for pectoral fin deployment using carcasses from the Shark Meshing Program.
4. Discovery that the juvenile sharks frequenting the Hawkes Nest nursery grounds were too wary of vessels to enable non-invasive Shark-cam deployment.
5. Development of a potential new methodology to entice white sharks less than 2.5m close to a vessel, but lack of funding precluded testing of this methodology.

Future Directions

1. Pending funding procurement, test the non-invasive technique to entice juvenile white sharks to approach a vessel and enable Shark-cam deployment.
2. Use sharks caught on NSW DPI Fisheries SMART Drumlines to attach the Shark-cam to their pectoral fin: would allow the assessment of post-release behaviour of the shark, compare it to data collected after 24 and 48 hours, and also potentially compare this with data collected when the shark eventually returns to shallow nearshore waters approximately 2 weeks after release.

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