Evaluation of Clever Buoy Shark Detection System

Summary of Report prepared by Prof William Gladstone (University of Technology Sydney)

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A review of shark detectors and deterrents commissioned by the New South Wales Department of Primary Industries (**DPI**) as part of its Shark Management Strategy concluded that the Clever Buoy (**CB**) system (developed by Shark Mitigation Systems (**SMS**) had potential as a shark detector provided "…durability is proven, further evaluations are made on its effectiveness at shark detection and negligible potential to have adverse impacts on wildlife including rigorous scientific evaluation".

This project tested the performance of CB in a field situation, with the specific aim of testing its capacity to detect and identify White Sharks (*Carcharodon carcharias*). The project also used the collected data to assess the ability of the CB software to provide accurate length measurements, and the experimental set-up also allowed the detection range to be evaluated under the environmental conditions that CB was deployed.

The CB was installed by SMS off Hawks Nest Beach off Port Stephens NSW in November 2016 (Fig 1). On 13 days a fleet of Baited Remote Underwater Video Stations (**BRUVS**) was deployed by DPI Fisheries within the area believed to be covered by the CB's sonar beam. The BRUVS provided an independent assessment of the presence, abundance, and length of White Sharks and other large marine organisms. BRUVS were deployed at distances from 5 to 86 m horizontally from CB (Fig 2). The trial was deployed in 9 m of water depth, and used a 10 degree sonar configuration coupled with BRUVS that recorded video at prescribed distances horizontally outwards from the sonar placement

SharkTec software incorporated with the CB imaging sonar analysed the swimming motion of objects and determined (with a % probability) the likelihood that detected objects were sharks. The data and analysis provided in this summary used V2.00.18.15 of the CB software.

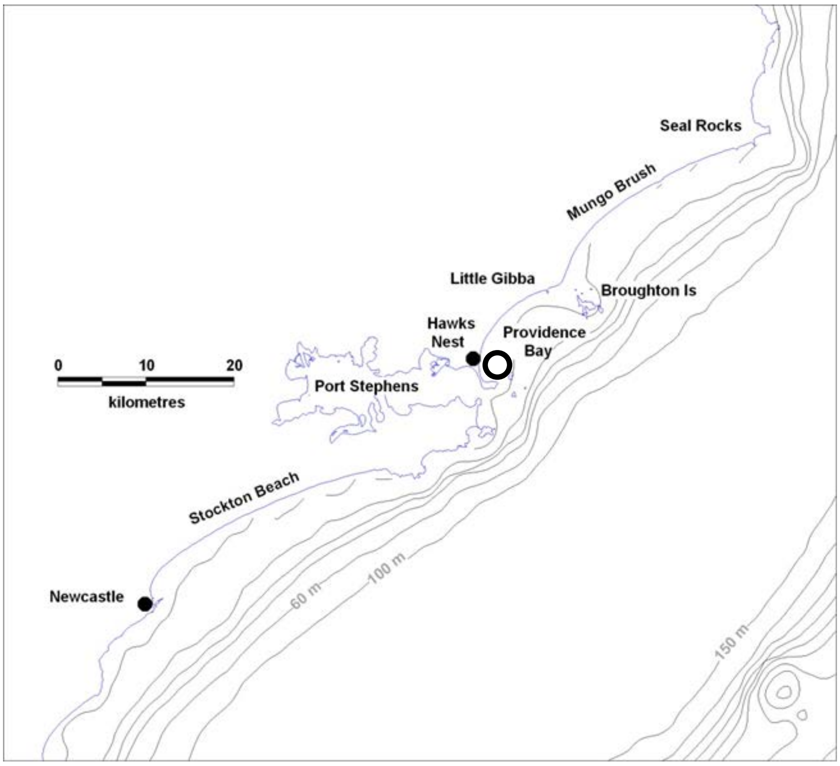

Figure 1. The study site for the Clever Buoy (CB) field experiment near Hawks Nest, NSW. The approximate position of the CB is shown by the empty circle (Map source: Bruce et al., 2013).

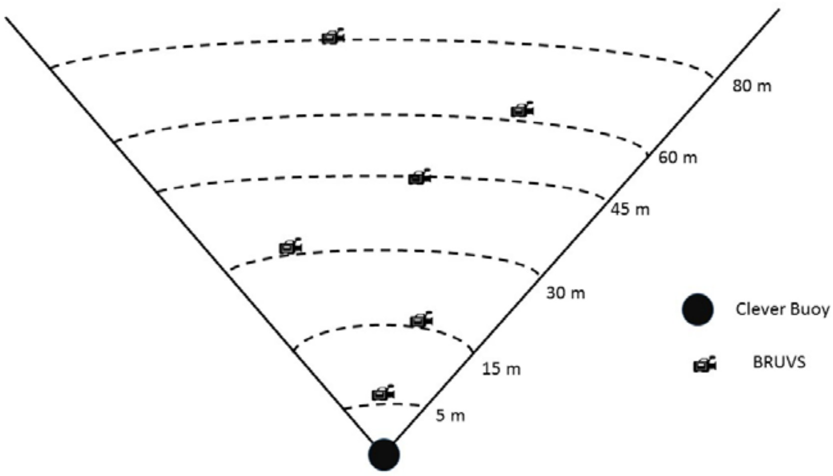

Figure 2. Deployment layout of the Clever Buoy (CB) and Baited Remote Underwater Video Stations (BRUVS) for the field experiment. The actual distances from the CB at which the BRUVS were deployed each day are shown in Appendix 1.

Major Findings

The BRUVS recorded White Sharks on 41 occasions and at all distances from the CB (Fig 3). None of the White Sharks recorded by BRUVS 42-86 m from the CB were detected by the CB. This was subsequently determined to be a result of the relatively shallow water depth and the 10 degree sonar used in the CB. The greatest distance from CB that a White Shark was detected by the CB, and confirmed by BRUVS, was 28 m. The lack of CB detections >28m from the sonar transducer occurred as a result of sonar configuration not being appropriate or calibrated for the water depth used.

A subsequent review of the experimental set-up by SMS after the field experiment was finished indicated that the theoretical range of the 10 degree sonar in the water depth at Hawks Nest, and with an optimal deployment configuration, was 46-52 m rather than the assumed 80 m. The assumed range of 80 m was based on the results of the earlier trial at Bondi where CB had been deployed in deeper water.

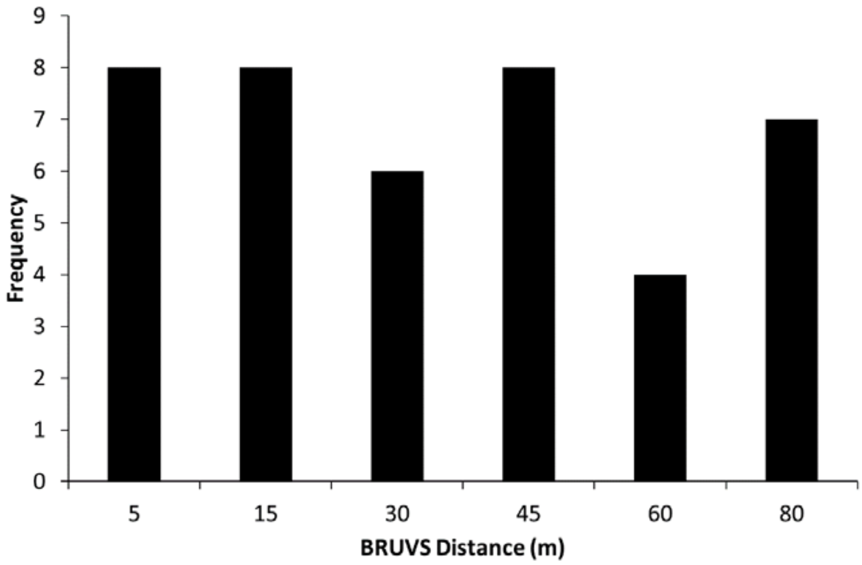

Figure 3. Occurrence of White Sharks at BRUVS at different distances from the Clever Buoy. Note: actual distances of BRUVS on each day differed slightly from the distances shown on the X-axis.

White Sharks recorded on the BRUVS varied between 1.63 m and 2.64 m total length (TL). The mean TL was 1.97±44 m (n=29) and the most common length classes were 1.75-1.999 m TL (34% sharks recorded) and 2.00-2.25 mm TL (38%) (Fig 4). The mean length of these sharks determined by SharkTec V2.00.18.15 (1.98 m) was very similar to and did not differ from the mean length estimated from the BRUVS' stereo-video images.

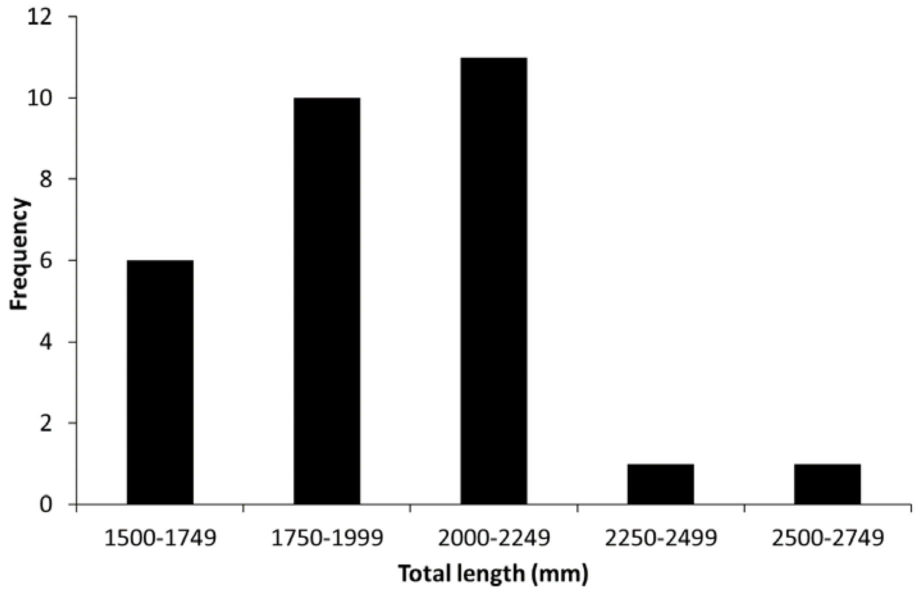

Figure 4. Total length classes of White Sharks recorded by BRUVS between 11 and 24 November 2016.

True negative (TN) rate quantifies the agreement between the BRUVS and CB for occasions when there were no White Sharks at the BRUVS. For the estimated CB detection range of 46-52 m, the TN rates were 89.7% for a range of 46 m and 90.4% for a range of 52 m.

The only other large marine animals recorded by the BRUVS were the southern eagle ray (*Myliobatis australis*) and wobbegong shark (*Orectolobus maculatus*). The CB, which was designed to detect potentially dangerous target sharks (i.e. White, Tiger, Bull, Bronze Whaler etc.), did not detect either species.

The identity of objects detected and classified as sharks by the CB software was checked (by visually assessing the CB sonar video file) for a sub-sample of the total records. Of the 705 records of CB shark detections checked, 39.1% appeared to be sharks and 60.9% did not appear to be sharks (i.e. they were false positives and were mostly the influence of the BRUVS or schools of fish). The objects that appeared to be sharks (n=17) were 8-20 m away from the CB when first detected, and occurred at various positions within the CB's beam when first detected.

Objects that were detected by the CB and that reached a high probability of being a shark (i.e. ≥90% probability) were also found to be both sharks and false positives (e.g. BRUVS).

As part of their Shark Management Strategy, DPI is interested in new technologies that reduce the risk of interaction with humans and no adverse impacts on wildlife. Observations of the behaviours of marine animals recorded on the BRUVs suggested that there was no evidence they were affected by the presence of the CB. The sonar transducers utilised by the CB operated at a frequency of 720 kHz, beyond the hearing range of any known marine organism.

Conclusions

This experiment provided additional useful understanding of the capabilities of CB.

Overall, this experiment showed that the CB was able to detect White Sharks and the length estimates were not significantly different from the lengths independently estimated by BRUVS.

It is important to note that the source data that supports the SharkTec algorithm has been developed from sharks of an average adult size of 2.5 m and greater. The sharks encountered during this trial was dominated by juvenile White Sharks with an average length of <2 m.

Given sharks >28 m from the CB were not detected it was evident that the deployment configuration and set-up of CB had a substantial impact on the performance of the sonar. From the analysis of the data collected in this experiment, it is now understood that a 5 degree sonar configuration would normally be used in this water depth, permitting a range up to 80 m. In addition, the vertical beam positioning of the sonar was sub-optimal to avoid the interference with the BRUVS. This may have resulted in the CB sonar beams missing sharks that were travelling <1.5 m from the ocean floor when recorded by the BRUVS.

The likelihood of an incorrect identification of an object as a shark (i.e. false positive) was influenced by the BRUVS equipment in the water, and a school of fish were also incorrectly identified as sharks.

The Clever Buoy system is demonstrating significant potential for mitigation strategies and future research and development of the CB and SharkTec system should be directed towards:

- (i) assessing the effect of the CB deployment and set-up on its shark detection range and ability to correctly identify sharks at distances relevant for beach safety purposes,
- (ii) changing the set-up of experimental equipment to eliminate objects such as the BRUVS that would not normally be present when CB is deployed for beach safety purposes,
- (iii) assessing the ability of the CB to detect sharks at locations where there is a population of larger sharks present,
- (iv) refining the software to reduce and eliminate false positives,
- (v) assessing the CB performance in beach environments that have wave and wind conditions representative of more ocean-exposed beaches in NSW.