

Operational Review

Clever Buoy Sonar Shark Detection Trial

Department of Primary Industries and Regional
Development – Shark Response Unit
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1. EXECUTIVE SUMMARY

There have been twenty four shark related fatalities in Western Australia since 1916; of these fifteen have occurred since 2000 including six between August 2010 and July 2012, and two within one week in -2016. The most recent fatal shark bite incident in Western Australia occurred in April 2017.

Since 2008, the Western Australian Government has been working to address the issue of human-shark interactions, investing in a broad range of mitigation measures, including a trial of the Clever Buoy sonar shark detection system in early 2017.

City Beach, in the Perth metropolitan area, was selected as the trial site as the presence of two groynes provided ideal geographical conditions, and the beach is subject to daily surf lifesaving patrols. The trial commenced on 13 January 2017 and ran until 31 March 2017.

At least twenty six possible sharks were detected by the system during the trial, triggering fifteen beach closures. Eight full or partial system outages for both planned and unplanned maintenance events also occurred.

The Clever Buoy system was expected to be operational in the week beginning 12 December 2016. Following some unforeseen complications, the trial went live from 4pm on 13 January 2017, and completed at 6pm 31 March 2017, when the system was switched off.

The trial identified a number of issues including system maturity, power supply, maintenance difficulties that need to be resolved before the system could be adopted as a public safety tool.

2. BACKGROUND

There have been twenty four shark related fatalities in Western Australia since 1916; of these fifteen have occurred since 2000, including six between August 2010 and July 2012 and two within one week in 2016.

The Government has invested in a broad range of shark hazard mitigation strategies, and continues to commit to initiatives such as helicopter and beach patrols, science, education and awareness, emerging technologies, and beach enclosures.

Trials of emerging technologies in the summer of 2016-17 included drone surveillance, and the Clever Buoy sonar shark detection system.

Clever Buoy is a near shore shark detection system developed by Western Australian company Shark Mitigation Systems (SMS). The system is designed to detect objects using multi-beam sonar transducers that are mounted to the sea floor and software systems to identify those objects and relay agreed information to land managers.

SMS undertook a pre-commercialisation trial at Bondi Beach with assistance and support (non-financial) from the NSW Department of Primary Industries (DPI). The trial ran from 15 February 2016 to 10 April 2016. The NSW DPI supported further trialling at Port Stephens – November 2016.

SMS met with officers from the Western Australian Department of the Premier and Cabinet (DPC) in September 2014, and again in March 2016 to discuss the development of the Clever Buoy shark detection system. In June 2016, SMS provided the DPC with a proposal for a permanent deployment of the Clever Buoy system at Cottesloe Beach, and also presented proposals for trials and permanent deployments of the system at other Western Australian beaches to a number of stakeholders in State and Local Government through the second half of 2016.

Through August and September 2016, the Office of the Government Chief Information Officer (OGCIO) engaged in preliminary discussions with SMS regarding the application of the technology in Western Australia and its reliability. The OGCIO requested evidence of the technology's reliability, an independent assessment of the algorithms for shark swim patterns, and a formal commercial proposal.

In October 2016, OGCIO advised DPC that SMS had submitted a formal proposal for one site only, City Beach, as they considered the beach to be geographically suitable as a trial site.

The Western Australian Government announced its decision to proceed with a trial in November 2016, confirming financial support of up to \$500,000 towards operating costs.

This operational review has been prepared consistent with the requirements at Schedule 2 of the Agreement between SMS and the Department of the Premier and Cabinet.

3. DESCRIPTION OF THE TRIAL

Stakeholders

- Shark Mitigation Systems
- Department of the Premier and Cabinet
- Office of the Government Chief Information Officer
- Department of Primary Industries and Regional Development (formerly Fisheries)
- Department of Transport
- Surf Life Saving WA
- Town of Cambridge

Operational planning

Meetings with stakeholders were held to determine the most appropriate way to incorporate the Clever Buoy system into the operational responses of lifeguards and Rangers at City Beach. A key consideration was how information would be provided to the public regarding both the trial, and any objects detected during the trial.

The key objectives of the trial were to assess whether the system:

1. Is effective:
 - a. at detecting sharks;
 - b. integrating with existing operational systems and procedures; and
 - c. in having no adverse effects on, or interactions with, other marine life.
2. Is cost effective.
3. Is appropriate for roll-out at other potential sites in Western Australia.

The trial did not originally include an element to verify an object was a shark as the primary priority. Where possible, verification would be conducted, however, the priority for lifeguards would be to clear swimmers from the water and close the beach.

Adopting a conservative approach to community safety, the agreement on the operational parameters of the trial included:

- beach closures would be triggered where the SMS system assessed a greater than 60% probability that an object was a shark, and the size of the object was over 1 metre in length.
- The information on possible sharks would be communicated to the public using the same platforms used to communicate other shark risk, and would be posted to SLSWA twitter, Shark Smart and sent by text to beach responders.
- Detections would be posted using the same parameters as the detection information posted from the Shark Monitoring Network (each object triggers an alert for every five minutes it stays within range).
- Detections would be automated from the SMS feed to the Fisheries shark notification platforms, so the information would be posted in near real time.

System configuration

The system uses six multi-beam transducers located on the sea floor, and two surface buoys using solar panels for power and satellite communication connectivity.

A VEMCO Tag receiver was also installed on Clever Buoy 1 (CB1) to identify tagged sharks as a potential verification tool.

The configuration of the systems is shown below in Figure 1.

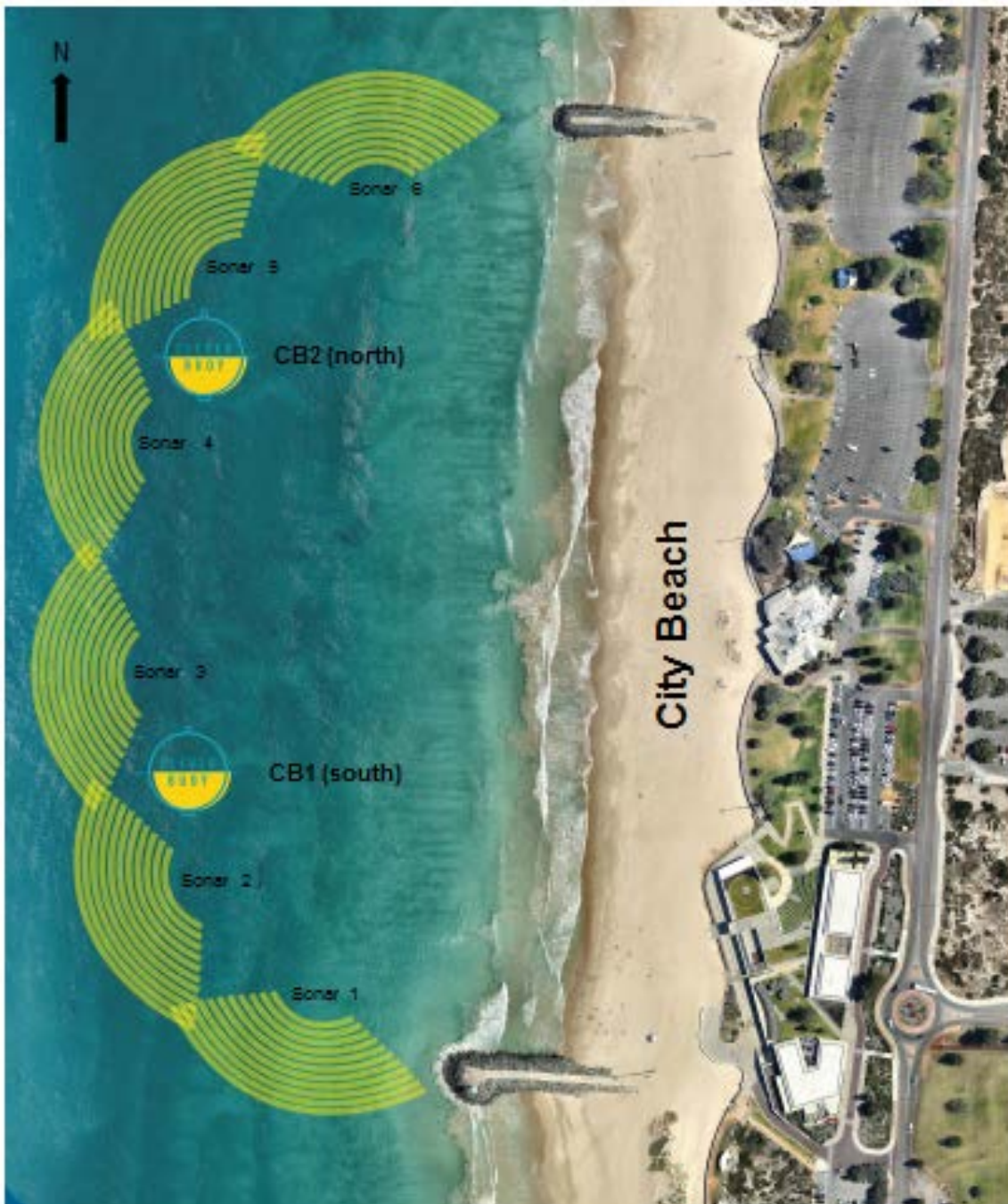


Figure 1: Clever Buoy configuration, City Beach trial

Signage was installed by the Town of Cambridge on City Beach, to inform the public of the trial, and the hours of monitoring. During outages, the signs were covered.

A copy of the sign is below at Figure 2.

TRIAL
CITY BEACH SHARK DETECTION SYSTEM

TRIAL
Commencing December 2016 until the end of March 2017, the ocean between City and Floreat beach groynes will be the site of a Government of Western Australia trial of *Clever Buoy*, a shark detection and notification system developed by local company Shark Mitigation Systems.

CLEVER BUOY SYSTEM
Clever Buoy utilises six multi-beam sonar platforms located on the ocean floor to detect sharks. Through analysis of size and movement patterns *Clever Buoy* is able to differentiate between sharks and other marine life. The six sonars will be operational between the groynes to detect sharks which enter the area. Once detected, *Clever Buoy* relays a signal to the lifeguards, so the public can be alerted.

HOURS OF OPERATION
The *Clever Buoy* will be monitored by lifeguards between the hours of 6am to 6pm, Monday to Friday and 8am to 5pm, Saturday, Sunday and public holidays.

CAUTION
Beachgoers are reminded the ocean is not without risk. *Clever Buoy* cannot provide a guarantee against attacks and we ask that swimmers take due care, be observant, and respect the ocean and other beach users.

Clever Buoy placement and sonar coverage →

Help us evaluate the success of the trial by providing your comments at www.cambridge.wa.gov.au/cleverbuoy

GOVERNMENT OF WESTERN AUSTRALIA | SMS SHARK MITIGATION SYSTEMS | WESTERN AUSTRALIA | CITY OF PERTH | Town of Cambridge

sharksmart.com.au

Figure 2: City of Cambridge signage placed at City Beach.

Date of commencement

The Clever Buoy system was expected to be operational in the week beginning 12 December 2016. Following some unforeseen complications the trial went live from 4pm on 13 January 2017 and ended at 6pm 31 March 2017 when the system was switched off.

4. OPERATIONAL ANALYSIS

Delay with commencement of trial

As discussed earlier in this report, the trial commenced some six weeks after the original planned start date. This was due to the need to get appropriate approvals, unfavourable weather conditions and technical problems with some components.

ACMA approval

On 28 November 2016 DPC became aware that the Perth Submarine Cable Protection Zone runs through City Beach. DPC requested SMS to liaise with the Australian Communications and Media Authority (ACMA) regarding the placement of anchoring infrastructure for the trial. On 12 December 2016 ACMA confirmed that SMS had completed appropriate consultations and that obligations under the *Submarine Cable (Perth Protection Zone) Declaration 2007* had been discharged for the purposes of the trial.

Installation issues

- The anchoring system for the various components of Clever Buoy and integration testing was completed on 23 December 2016.
- The system could not go live on 23 December 2016 as power and communications issues were experienced with Clever Buoy #2 (CB2).
- Unfavourable weather conditions meant that system testing and resolution was difficult and delayed. Performance testing of CB2 continued to 2 January 2017. The two damaged sonars were flown to the United Kingdom for repair.
- Repaired sonars arrived back in Perth on 6 January 2017 and following unfavourable weather conditions reinstallation of CB2 was complete on 13 January and **the system went live at 4pm 13 January 2017.**

Detections

Fisheries systems received 101 detections, issued 45 alerts automatically through its integrated notification system, and added five (5) manual notifications prior to the full automation of the system.

It is believed that at least one triggered detection was a false positive triggered by a Fisheries vessel, assisting Curtin University to conduct environmental monitoring.

It is important to note that the Clever Buoy System does not detect sharks directly in the way that a trained observer can under good conditions. The system detects sonar targets and assesses the size and movement pattern of those targets in order to determine a statistical probability that the target is a shark of a certain size.

That statistical probability utilises complex, proprietary computational algorithms. Post-trial analysis of data submitted to the Fisheries data systems from the Clever Buoy system reveals a number of minor discrepancies between what was reported at the time of the trial through the SLSWA Twitter feed, Fisheries alerts systems, and the Clever Buoy Systems data.

These discrepancies can all be accounted for by the following factors:

1. Early in the trial, full automation of the system was not functional and so Alerts were manually posted, based on Clever Buoy data displayed in a CBS App.

2. Unexpected boat traffic around the CB System resulting in false-positive target detections.
3. Aggregation of CBS targets that occurred within 2 to 3 seconds of each other and so were reported as a single target.

If contact with a probable shark-like target is lost, but then resumed shortly afterwards, the CBS array will assign a new target ID to the second target. There is no way of knowing if this is the same target, or a completely different one. In that regard, the system can report the probable presence of sharks (and their probable absence). Therefore it is not strictly correct to talk of the system recording a number of sharks, the way a receiver can do with tagged animals. That does not diminish the potential usefulness of the system to alert people to the potential presence or absence of sharks in the immediate area, but it does mean some care should be taken with reporting data from the system.

The trial revealed a relatively high amount of probable shark activity, but the site issues preventing independent verification of this activity leaves open the possibility that the system is detecting false positives, a situation which could lead to unnecessary concerns amongst beach and water users and potentially lead to unnecessary beach closures. It is recommended that the system be trialled in a location better suited to independent verification of shark activity using, for example, underwater camera footage, or aerial surveillance. Accompanied by such independent verification, the system could prove to be a valuable tool in alerting water users to shark activity.

None of the detections during the trial were independently verified:

- A VR2 receiver was integrated into one of the Clever Buoys to detect tagged sharks as a verification method during the trial. Nothing was detected.
- The City Beach VR4 satellite linked receiver detected a tagged shark during the trial, the range of the VR4 is significantly higher than the Clever Buoy system, so it is possible the shark may have been out of range from the Clever Buoy receiver.
- SLSWA deployed a drone or helicopter patrol where possible to verify the sightings. Nothing was seen in the vicinity.
- SLSWA lifeguards were not able to visibly verify any detection.

Operational outages

1) 18 January – Unplanned outage – two hours

- Interface with Fisheries paused for two hours for adjustments to two of the six sonars, not communicated internally or to the public. During the outage a detection of a “possible” 3-3.5m shark was not communicated to SurfCom, and errors in the interface were identified and rectified.

2) 3 February – Planned outage - six hours

- One of the 10-degree sonar transducers swapped for a new 5-degree transducer.

3) 5 February – Unplanned outage - seven hours

- CB1 stopped responding. CB2 remained online and fully operational.

4) 7 February 2017 – Issue with automation of messaging

- The location of a shark detection was not accurate by 80-100m and in addition no automated message was sent through the app. SurfCom called the information into Water Police for it to be posted as a sighting.

5) 10 February 2017 – Planned outage – CB1 12 days / CB2 1 day and 10 days of 12-hour coverage only

- Unprecedented weather conditions for February (>90% cloud cover for extended periods) significantly impacted battery levels in both CB1 and CB2. Both were completely shut down on 10 February.
- CB2 became operational between 6am and 6pm only from 11 – 21 February.
- Following the shutdown of CB1, issues with the on-board PC were experienced which were unable to be diagnosed remotely. CB1 was removed to run a full system check.
- CB1 reinstalled on 17 February however an issue with the buoy connecting to the sonars was identified. CB1 came back on line at 10.30am 22 February and both buoys returned to 24/7 coverage.

6) 23 March 2017 – Planned maintenance - two hours – no outage

- Sonars for CB2 inspected for growth.
- Signs at City Beach were covered over by Town of Cambridge during outages.

Meetings held during trial

- 23 January 2017 – to discuss operations so far and discuss any improvements or modifications required. Discussions included a second line of verification of detections (e.g. cameras on buoys/drones/tags etc.) and updates to business rules.
- 10 March 2017 – drone demonstration

System modifications and improvements

27 February 2017 – Planned maintenance – 30 minutes

Brief outage between the mobile app and the Fisheries interface to implement the following changes:

- Update business rules so all messages to the Shark Smart web service include detections >1m and with >60% probability to allow public notifications of detections >1m. Business rules between the mobile app and the SLSWA interface separated so that beach closures not triggered for detections <2m.
- Map view in the mobile app updated to show the direction in which the target is heading.
- A link added from the history page for each sighting to launch a map view to show details and location(s) for the shark(s) that have triggered alerts to enable a review of historical alert locations and further assist with accurate recording of alert information after the beach has been reopened.

5. CONSULTATION AND FEEDBACK

Media attention

During the trial the following media occurred:

- 6PR – radio interview with Craig Anderson 17 December 2016
- The West – 26 January 2017
- Fairfax (WA Today) – 1 February 2017
- Sunday Times – 8 February 2017
- Channel 9 – 10 February 2017
- The Australian – 15 February 2017

Stakeholder consultation

On completion of the trial, feedback was sought from key partners the Town of Cambridge and Surf Life Saving Western Australia.

Surf Life Saving Western Australia:

- System was monitored using existing resources, such as SurfCom monitoring the app.
- Daytime detections were responded to with helicopter patrols or drones where possible, and where not, visual verification was sought. Visibility and response times during the trial were generally good. None of the triggered detections were considered verified.
- The app could have provided additional detail which would have assisted in operational responses. This would include:
 - Actual position of detection in the array rather than a default position.
 - Save or send sonar images for verification purposes.
- Roll out would have been improved with more thought prior to operational implementation.
- If planned to be used as a safety tool requires further validation.
- The system was not prepared for roll out in an operational environment.

Town of Cambridge:

- Signage advising of the trial was placed at the beach, and the Town conducted consultation during the trial.
- Beaches were closed 1 kilometre either side of the detection when one occurred. This is in accordance with usual procedures. Both City and Floreat beaches were closed.
- There was an increase in beach use at City Beach; however this could be attributed to a number of factors including the completed beachfront redevelopment, Scarborough carpark closures moving beach use to the next location, or the Clever Buoy trial.
- Working group and commitment from the agencies involved in the trial worked well to identify what was required to implement the product as a safety tool.
- Outages from technical issues and planned maintenance were not reported and communicated in a timely manner at the beginning of the trial.

Overall issues identified included:

- At least one known false positive in the trial.
- Outages from technical issues and planned maintenance

- Difference between expectations for a trial environment (SMS) and an operational warning tool (Agencies).
- Range of detectors and distance offshore gives limited warning to close a beach.

Community consultation

The Town of Cambridge conducted consultation on the trial, with a survey available online. Responses to the survey were low (68 total responses), and are not statistically robust. However, the results did show a positive community response to the trial, and an increase in feelings of safety while swimming.

Of note, are the following:

- 40% of respondents swam at City Beach because they were aware of the Clever Buoy trial.
- 75% of respondents felt safer swimming in an area where the Clever Buoy is operating.
- 80% of respondents agreed the presence of a shark mitigation system (not specific to Clever Buoy) would influence beach selection.
- 85% of respondents would like to see shark mitigation systems extended to other locations on the coast.
- 56% of respondents felt the cost of the trial was justified, with 18% disagreeing, and 26% unsure. Where respondents answered no, 45% of respondents felt a cost of less than \$500,000 would be justifiable (11 respondents), with a further 37% (9 respondents) unsure.

Further detail on the survey results are attached as Attachment 1.

6. COSTS

The trial was conducted within the agreed budget with SMS being paid \$462,000.

7. FINDINGS

The Clever Buoy Operational Review considered the operational implementation of the trial for use at beaches as a notification and warning system.

The outcomes from the operational review finds that while a number of possible sharks were detected, and reported using the technology, the system was not to the stage and standard required to be implemented in an operational environment as a notification and warning tool. It should be noted however, that many system improvements were made over the duration of the trial to better meet these requirements.

8. REFERENCES

Hastie, G.D. (2012) Tracking marine mammals around marine renewable energy devices using active sonar. SMRU Ltd report URN:12D/328 to the Department of Energy and Climate Change. September 2012 (unpublished).