Centre de ressources et d'appui sur le risque requin

Shark Safe BARRIER

SHARKSAFE BARRIER
SHARK EXCLUSION RESEARCH FACILITY

at

SAINT-PAUL (LA REUNION)

DEPLOYMENT REPORT

(15 JANUARY 2019 to 04 FEBRUARY 2019)

Submitted to: Centre de ressources et d'appui sur le risque requin (CRA)

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Issued by: SharkSafe Barriers (Pty) Ltd (SSB)

Date: February 2019

Note: Photographs by SharkSafe Barrier Team unless otherwise indicated

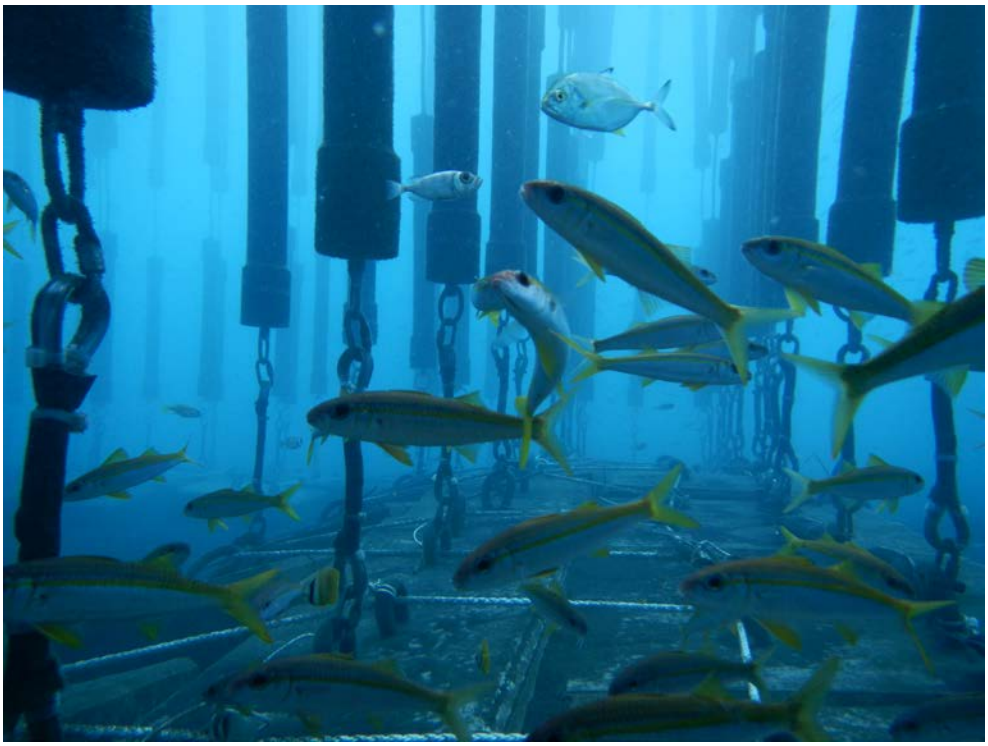

Photo: J de Bruyn (04/02/2019)

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Limitations of the study

The purpose of the deployment of the shark exclusion system at Saint Paul is aimed at enabling scientific research, for testing the effectiveness of the SharkSafe Barrier to exclude sharks from a food source.

It is stressed that the purpose is NOT to prove or test the SSB robustness to withstand large waves and/or cyclone conditions. Taking responsibility for any impact by storm waves or currents or by unauthorised persons (e.g. boat anchors) on components of the SSB system as deployed at Saint-Paul is beyond the scope of the contracted work.

Scientific context

The SSB system design draws on the scientific results of inter alia the following peer-reviewed publications:

- O'Connell, C. P., S. Andreotti, M. Rutzen, M. Meÿer, and P. He. 2014. The use of permanent magnets to reduce elasmobranch encounter with a simulated beach net. 2. The great white shark (*Carcharodon carcharias*). Ocean & Coastal Management 97:20–28.
- O'Connell, C. P., S.-Y. Hyun, S. H. Gruber, T. J. O'Connell, G. Johnson, K. Grudecki, and P. He. 2014. The use of permanent magnets to reduce elasmobranch encounter with a simulated beach net. 1. The bull shark (*Carcharhinus leucas*). Ocean & Coastal Management 97:12-19.
- O'Connell, C. P., S. Andreotti, M. Rutzen, M. Meÿer, C. A. Matthee, and P. He. 2014. Effects of the Sharksafe barrier on white shark (*Carcharodon carcharias*) behavior and its implications for future conservation technologies. Journal of Experimental Marine Biology and Ecology 460:37–46.
- O'Connell, C. P., S.-Y. Hyun, C. B. Rillahan, and P. He. 2014. Bull shark (*Carcharhinus leucas*) exclusion properties of the sharksafe barrier and behavioral validation using the ARIS technology. Global Ecology and Conservation 2:300–314.
- O'Connell C.P., S. Andreotti, M. Rutzen, M. Meÿer, C.A. Matthee 2017. Testing the exclusion capabilities and durability of the Sharksafe Barrier to determine its viability as an eco-friendly alternative to current shark culling methodologies. Aquatic Conservation: Marine and Freshwater Ecosystems 28:252-258.

The SSB system design has evolved over 6 years through full scale deployment and research at Shark Alley, Gansbaai, South Africa.

Copyright

EXECUTIVE SUMMARY

In reponse to a contract entered into between the Reunion ***Centre de resources et d'appui sur le risque requin*** (CRA) and SharkSafe Barrier (Pty) Ltd, a 10 m X 10 m (inner dimension) SharkSafe Barrier (SSB) shark exclusion facility was deployed in Saint-Paul Bay at the town of Saint-Paul on La Reunion Island in the western Indian Ocean.

The purpose of the SSB Exclusion Area is to evaluate the effectiveness of the patented SharkSafe Barrier (SSB) system as a shark exclusion method. The CRA has obtained an environmental permit to perform a series of scientific tests, aimed at evaluating the exclusion effectiveness of the SSB system, by deploying baited cameras inside the SSB exclusion area.

The SharkSafe Barrier is an innovative product proved to be an effective shark barrier composed of an array of multiple vertical tubes deployed in the ocean to bio-mimic a kelp forest when viewed from within the water. The tubes manufactured from non-toxic material, are vertically buoyant, anchored to the sea-floor and extend up to 1 m above the sea surface at high tide. Research has shown that dense kelp forests can deter certain species of sharks. It has been shown that magnets deter several shark species, including great white sharks, bull sharks, tiger sharks and hammerhead sharks. To enhance the effectiveness of the SSB, permanent ceramic magnets are arranged along the length of the artificial kelp forest.

Being shark-specific, the SSB provides a more environmentally friendly, non-destructive, and sustainable alternative to conventional anti-shark devices such as shark nets and drum lines. Details of the SSB Units deployed are provided in Section 3.

The deployment area at Saint-Paul was identified by CRA, in accordance with local government regulations and restrictions, and specifically also to avoid the simultaneous presence of shark attractants and bathers in the same area at the same time.

The contract between CRA and SSB included for SSB to carry out a survey wihin Saint-Paul Bay, in order for the appropriate anchoring system and SSB Unit design to be determined. The appropriate anchorage system for the existing sea substrate, given the amount of funding available, was the key limiting factor to be evaluated.

The survey carried out in May 2018 showed that the preferred water depth for the site was at an average depth of 8 m. The sand probes showed that the sand was mostly about 0.5 m deep above a layer of pebbles / rocks detected where the penetration of the waterjet probe was curtailed. Evidence of the pebbles / rocks can be seen on the beach at Saint-Paul after storm erosion.

Due to cost constraints with respect to the material quantities, and the transportation requirements (limited to a 6 m long shipping container) of the SSB Units, a position with average depth of 6.5 m was selected as discussed in Section 7.

This report documents the deployment, the seastate during the operation and provides information on the as-built layout. (Sections 5, 6 and 7). Operational and maintenance guidelines are provided (Section 8) with proposed procedures for preparing the SSB Exclusion research facility for imminent cyclone storms, and the subsequent post-storm reinstatement of the system integrity.

CONTENTS

FIGURES:

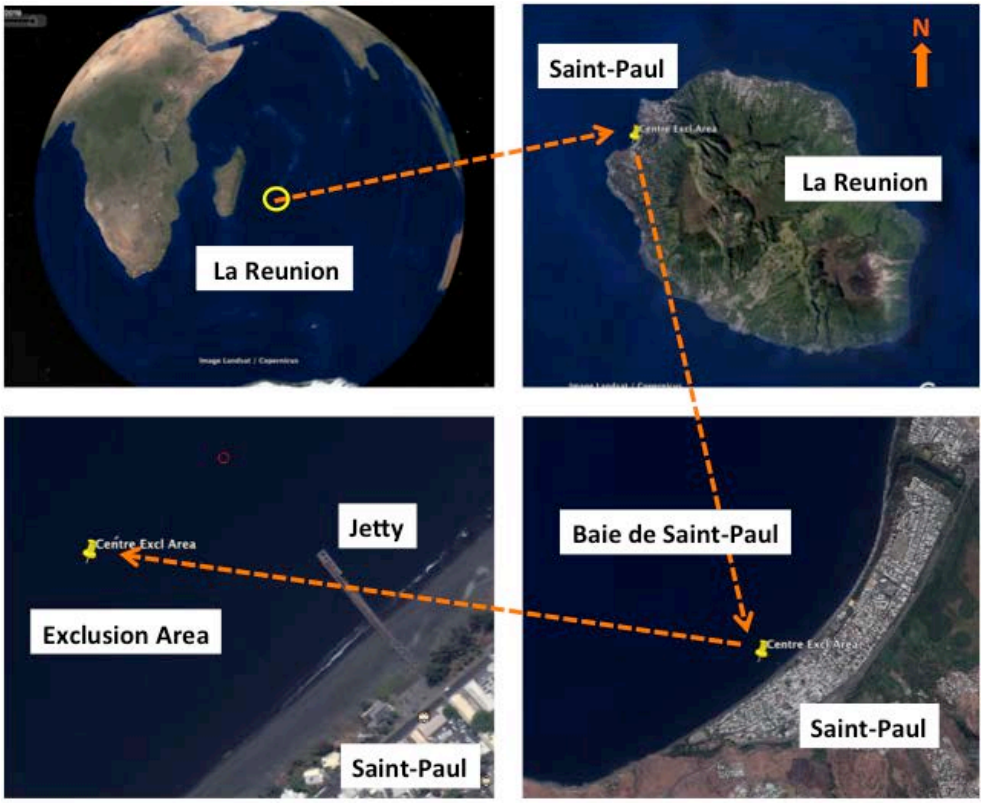


Figure 1: The shark exclusion research area is located within Saint-Paul Bay and west of the jetty at Saint Paul town, La Reunion.

1. INTRODUCTION

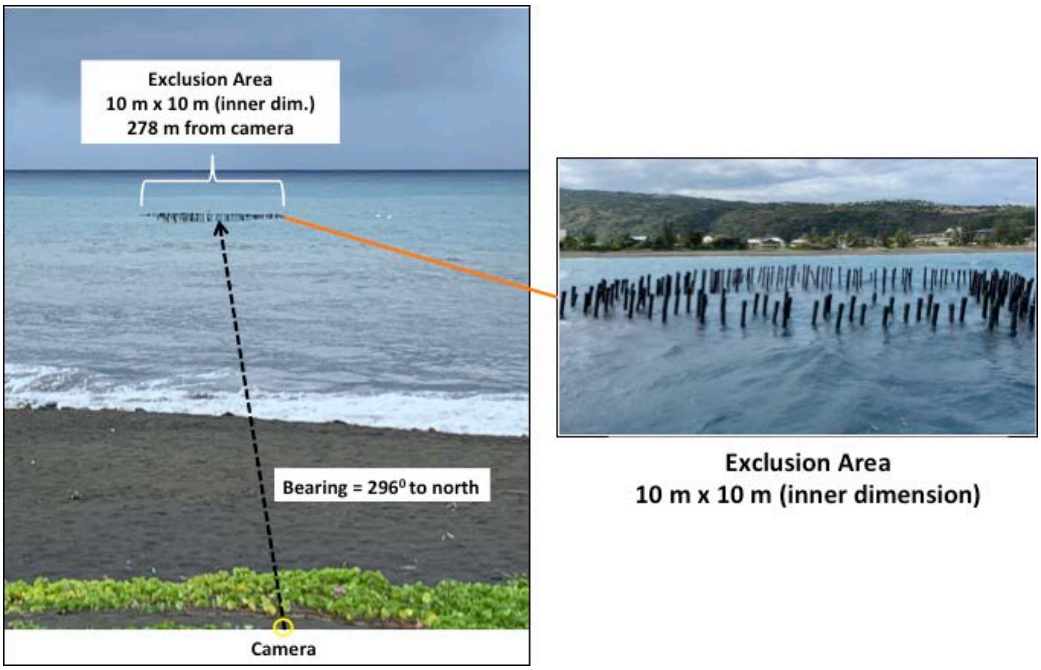
In reponse to a contract entered between CRA and SSB, a 10 m X 10 m (inner dimension) SSB shark exclusion facility was deployed at Saint-Paul.

The purpose of the SSB Exclusion Area at Saint-Paul is to evaluate the effectiveness of the SSB system as a shark exclusion method.

Note the tests are not to test or prove the robustness of the anchoring system in large waves and strong currents.

1.1 Deployment site

The SharkSafe Barrier shark exclusion research area is located in Saint-Paul Bay at the town of Saint-Paul on La Reunion Island in the western Indian Ocean (Figure 1).



Figures 2 The shark exclusion research area is located about 200 m offshore of the beach at Saint-Paul. An observation camera is attached to the northern corner of the La Capitainerie restaurant.

As shown in Figure 2 and discussed below, the SSB system was deployed about 200 m offshore of the beach at Saint-Paul, west of the end of the jetty in an average water depth of 6.5 m.

1.2 Approach and process

The 10 m X 10 m (inner dimension) SSB shark exclusion barrier was deployed at Saint-Paul over the period 15 January to 9 February 2019.

Construction equiment, facilities, vessels, diving equipment and support staff were provided by Michel Guillemard (TSMOI, La Reunion). A fourth diver, Eric Hoarau, was made available by CRA.

A total of 200 concrete anchor blocks, 180 kg in mass with dimensions of 0.5 m x 0.75 m x 0.20 m (Figure 8) were manufactured by SCPR (http://www.scpr.re/), La Reunion. The anchor blocks were delivered on pallets to the quay side at Le Port. The SSB Units were manufactured in Cape Town, South Africa and shipped via container to Le Port, La Reunion. Both the anchor blocks and the SSB Units were loaded onto a heavy duty boat fitted with a 4-tonne crane.

The SSB Units and anchor blocks were then transported to the deployment site at Saint-Paul on the same boat.

Once on site at the SSB Exclusion Area, the SSB Units were attached to the blocks and dropped into the water using the 4-tonne crane.

The divers then moved the blocks into position by making use of airlift bags. Once they were in the required position and pattern to form the 10 m x 10 m (inner dimension) exclusion area, the three types of SSB Units were moved into the required positions on the blocks. This detail is provided in later sections.

The SharkSafe Barrier deployment team consisted of:

- Michael Rutzen (dive supervisor and responsible for underwater deployment and quality control);
- Dr Sara Andreotti (diver, logistics project manager and underwater videographer);
- Jan de Bruyn (diver, electronics expert); and
- Laurie Barwell (coastal engineering, operations, onshore logistics, seastate monitoring and reporting).

2. SITE CHARACTERISTICS

2.1 Introduction

The deployment site at Saint-Paul was identified by CRA using a number of criteria; principally being the need for the chumming based research to be done away from popular swimming beaches.

The contract between CRA and SSB included for SSB to carry out a survey of the proposed are within Saint-Paul Bay in order for the appropriate anchoring system and SSB Unit design to be determined. An important limiting factor was the amount of funding available for sourcing the material and to organize the deployment logistics of the SSB Exclusion research facility.

Figures 3, 4 and 5 are from the report on the survey, which was carried out by SSB in May 2018.[1]

2.2 Site survey and key parameters

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Figure 3: The water depth along transects in the selected area of deployment was surveyed by boat to identify an area at which the SSB Unit can be deployed to form the required shark exclusion area. (Base image: Google Earth™)

Note that the preferred water depth for the site was at an average depth of 8 m. However, due to cost constraints with respect to the material quantities and the transportation requirements of the SSB Units, a position with average depth of 6.5 m was selected (See Section 7).

[1] Report on the survey of the proposed exclusion area site at Saint-Paul. SSB report submitted to CRA. May 2018.

The sand probing showed that the sand was mostly about 0.5 m deep above a layer of pebbles/ rocks detected where the penetration of the waterjet probe was curtailed. Evidence of the pebbles / rocks can be seen on the beach at Saint-Paul after storm erosion.

Although using concrete anchor blocks on sand is not the preferred design option, it is believed that concrete anchor blocks would settle into the sand in time, with wave and current action, but not sink too deep as to disrupt the dynamic action ('dancing') of the SSB units.

It was emphasized that the purpose of the SSB Exclusion area at Saint-Paul is NOT to test or prove the robustness of the anchoring system in large waves and strong currents, but to evaluate the effectiveness of the SSB system as a shark exclusion technology only.

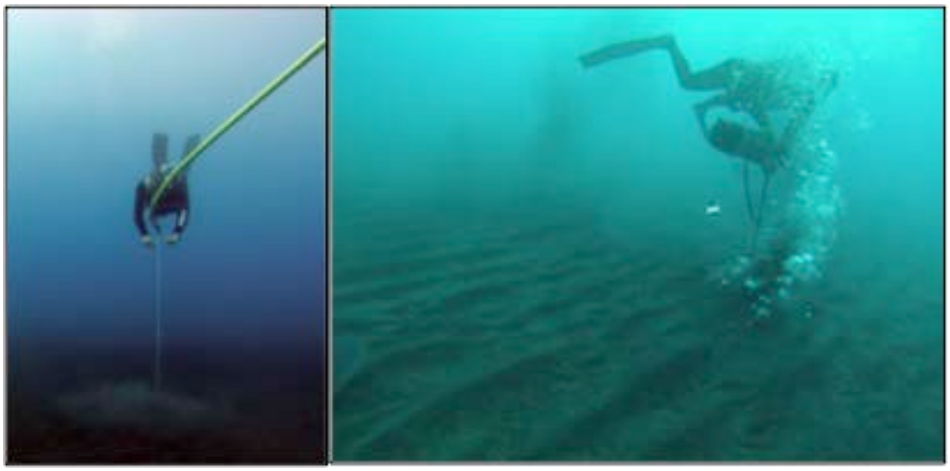


Figure 4: Underwater probing of the sea-floor, by using a waterjetprobe on the left and airjetprobe on the right, for assessing the sand depth and sea-substrate characteristics (Diver: Michael Rutzen; Photographer: Sara Andreotti)

Figure 5: The proposed location identified for the exclusion test at Saint-Paul. The preferred location is based on the depth, the characteristics of the sea-floor and the estimated wave action. (Base image: Google Earth™)

3. THE SHARKSAFE BARRIER (SSB) SYSTEM

3.1 Brief Description

This innovative product is a proved shark barrier composed of an array of multiple tubes deployed in the ocean to bio-mimic a kelp forest when viewed from within the water. The tubes manufactured from non-toxic material, are vertically buoyant, anchored to the seafloor and extend up to 1 m above the surface at high tide Research[2] has indicated that kelp forests are avoided by certain shark species. To enhance the effectiveness of the shark barrier, permanent ceramic magnets are arranged along the length of the artificial kelp forest. It has been shown that magnets deter several shark species, including great white sharks, bull sharks, tiger sharks, and hammerhead sharks. Being shark-specific, the SharkSafe Barrier provides a more environmentally friendly, non-destructive and sustainable alternative to conventional anti-shark devices such as shark nets and drum lines.

3.2 Principal beneficiaries of the technology

Municipalities, local governments, the tourism industry, as well as surfers, swimmers and other watersport enthusiasts are the principal beneficiaries of successfully separating sharks from people.

3.3 Key attributes and realised benefits

- The SSB Units (vertical tubes) are typically deployed in deep water (avg 8 m) and thus are capable of resisting oceanic wave heights up to 5 m.
- The SharkSafe Barrier can be used to protect large areas.
- Environmentally friendly: use of the barrier is not detrimental to sharks or other aquatic creatures.
- The SSB poses virtually no risk to surfers, swimmers, boats, and other water users and these can freely move across and through the system.
- The anchoring system rapidly forms an artificial reef and the artificial kelp forest becomes a refuge for marine life.
- The system is low on maintenance when compared to conventional systems such as nets.
- The protection from shark encounters will boost the local tourism.

3.4 Unique Characteristics

- The combination of a kelp-like appearance and the magnetic field provided by the SSB enhances the effectiveness of forming a shark-specific barrier.
- The tube configurations allow seaweed-like movements due to the wave and current action, improving the effectiveness of the technology by varying the point specific strength of the magnetic field.

[2] Refer to Section 3.5

- Excludes large shark species from the exclusion area and poses virtually no risk of animal entanglement.

3.5 Innovation Status

Patents

Stellenbosch University is the rightful proprietor of all rights, titles and interests in the intellectual property disclosed in the 2013 and 2017 applications by virtue of assignment agreements entered into with the inventors of the respective applications.

SharkSafe Barrier Pty Ltd was licenced by the University of Stellenbosch to commercialize the SSB technology in 2018.

Shark Barrier patent has been filed in: ARIPO – AP/P/2015/008421; Brazil – BR112015012008-3; USA – 14/647,646; South Africa – 2015/04471

Shark Barrier patent has been accepted: Australia – 213350811; Europe – 13821175.0

Shark Barrier - Harbour Entry PCT application filed – PCT / IB2017/051701

Shark Barrier – End Caps provisional patents filed in South Africa – F2016/00959; F2016/00960; F2016/00961; F2016/00962

Technology status and development progress

A full-scale exclusion prototype was built in Gansbaai and successfully tested on a rocky beach surface. The SSB barrier proved 100% effective in keeping sharks out in every scientific exclusion test conducted. Testing of prototype anchoring on deep sand and SSB Units deployed through the surfzone is progressing sufficiently.

3.6 Principal Researchers and Technology Designers

- Prof. Conrad Matthee, Head of department of Botany and Zoology at the University of Stellenbosch (US).
- Dr. Sara Andreotti, Postdoctoral researcher at the Evolutionary Genomics Group of the US.
- Dr. Craig Patrick O'Connell, Founder and Director of O'Seas Conservation Foundation.
- Michael Rutzen, White shark conservationist and shark cage diving operator.
- Laurie Barwell, Coastal Engineer.

3.7 Technical Description

The SSB comprises of multiple tubes (e.g. SSB Units) in close spacing that extend from the sea floor to above the sea surface (Figure 6). Ceramic magnets installed in the SSB Units placed on the external row of Units to over-stimulate the electro-sensory system of sharks only (no behavioral changes were observed for bony fishes or seals).

Figure 7 shows the dimensions of the SSB Units deployed at the Saint-Paul SSB Exclusion Area. Each of the 54 magnetic SSB Units (Types 1 and 2) and the 146 non-magnetic SSB Units are attached to 180 kg concrete anchor blocks (Figure 8) by means of a T-piece (Figure 9) through the reinforced loop cast into the concrete anchor block. The concrete blocks were positioned over 3 rows as for the installation logistics plan submitted to CRA[3].

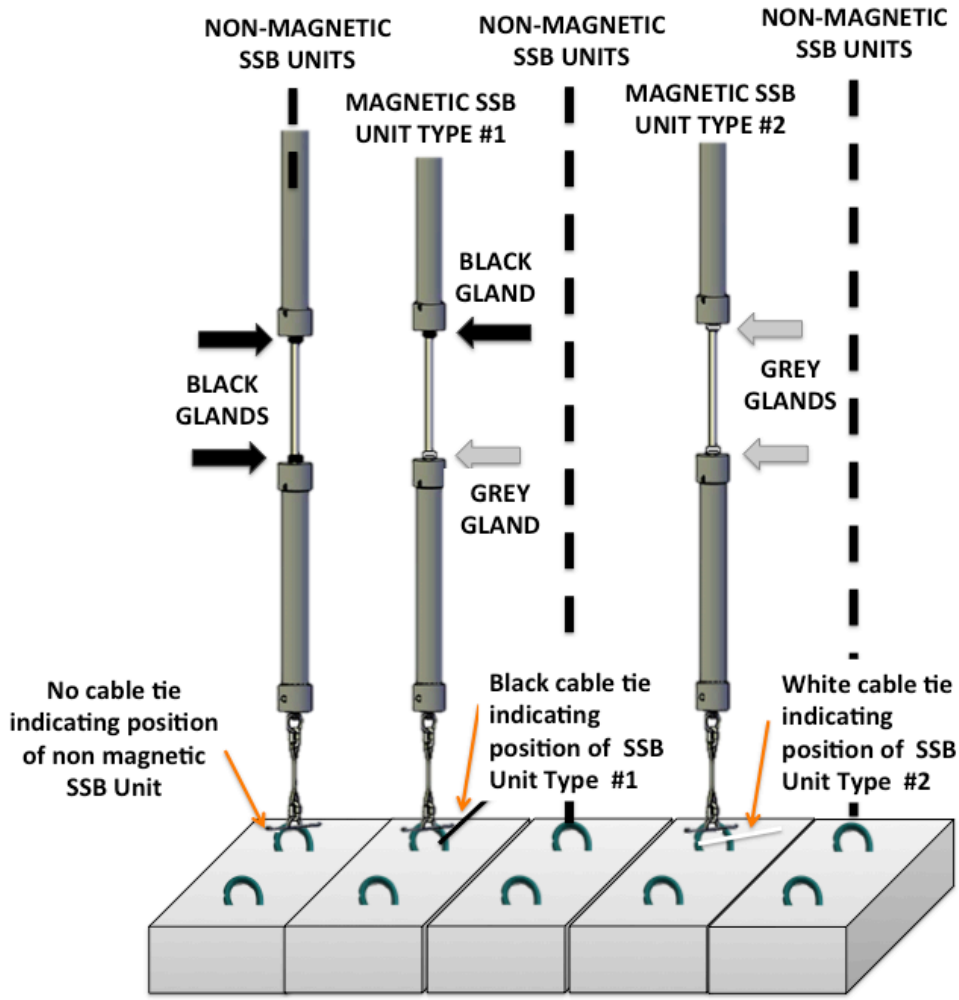


Figure 6: Along the outer row Magnetic SSB Units of Type 1 and Type 2 are deployed at 1.0 m spacing. This forms an effective magnetic curtain across the full water depth. A Non-Magnetic SSB Unit is inserted inbetween the magnetic units, (effectively at 1.0 m centres) to complete the visual barrier. Alternating magnetic and non-magnetic units are spaced 0.5 m apart.

[3] SharkSafe Barrier installation logistics, St Paul (La Reunion). Internal report submitted to CRA as part of the environmental permit application. November 2018

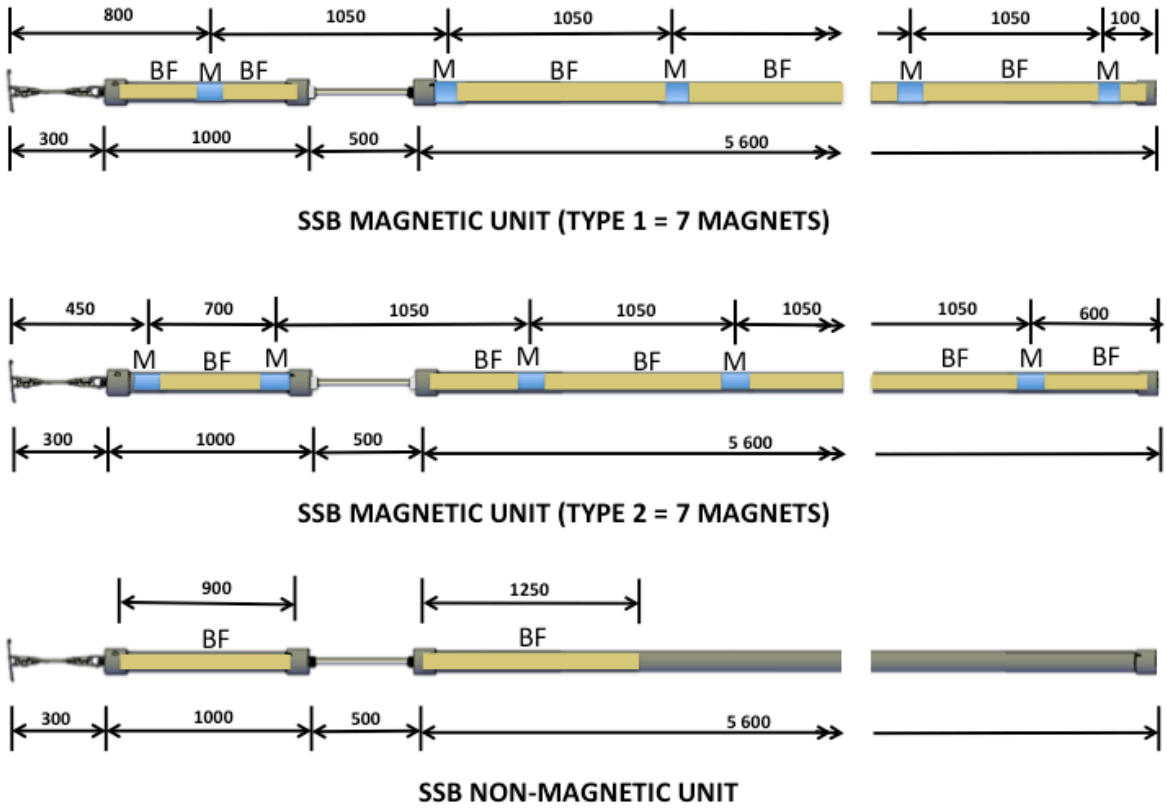


Figure 7: Dimensions of the three types of SSB Unit (M= Magnets; BF = Buoyancy foam) (Shown in a horizontal position)

A total of 200 concrete anchor blocks, 180 kg in mass with dimensions of 0.5 m x 0.75 m x 0.20 m (Figure 8) were manufactured by SCPR (http://www.scpr.re/), La Reunion.

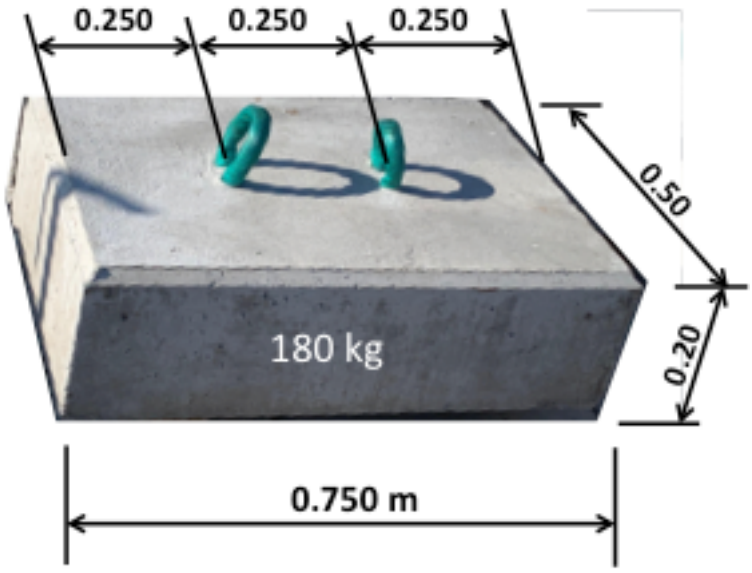


Figure 8: Dimensions of the SSB anchor blocks

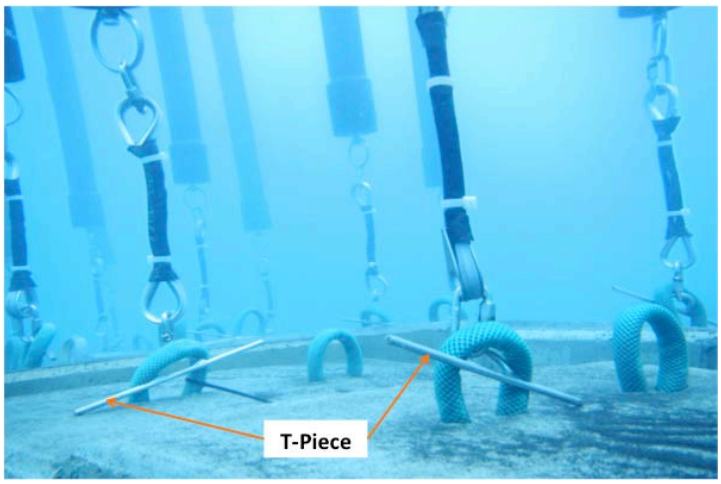


Figure 9: Each of the SSB Units are attached to the anchor block by a T-piece

In clear water the closely spaced tubes, 'dancing' as wave energy passes through them, create the illusion of a continuous underwater structure (Figure 10) with gaps that are typically narrower than the fin-width of the sharks that are known to be dangerous to humans. This bio-mimics a natural kelp forest. Research[4] has shown that these animals instinctively refrain from entering the restrictive structure.

Combined with the SSB magnetic pouches attached to the concrete anchor blocks at seabed level (Figure 11), the magnetic SSB Units create an effective magnetic curtain around the full outer row of the exclusion area and throughout the water column protruding above the water surface.

Figure 10: The closely spaced tubes create the illusion of a continuous underwater structure.

[4] Refer to Section 3.5.

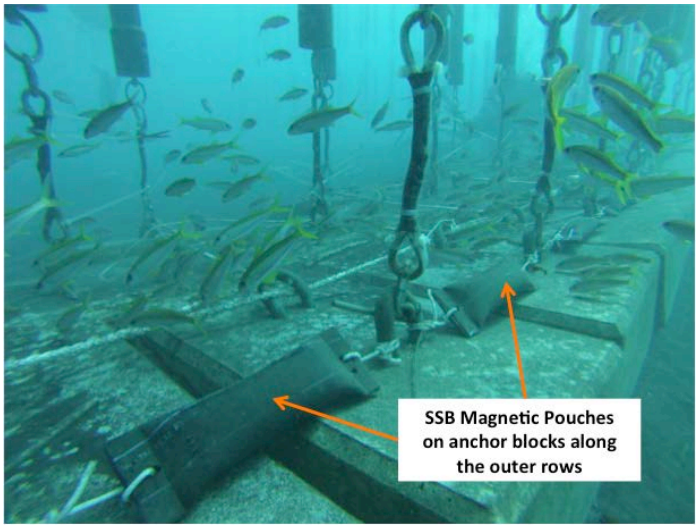


Figure 11: The SSB Magnetic Pouches are fixed to the anchor blocks to form a magnetic barrier at seabed level.

4. PLANNED INSTALLATION LOGISTICS

A detailed installation logistics plan was submitted to CRA as part of the permit application.[5]

1. Areas addressed in detail in the report include: Site inspection to confirm seabed conditions, depth, and orientation relative to the shoreline.
2. Pre-deployment environmental video record.
3. Daily block deployment schedule (total of 200 blocks).
4. Protocol for diving to position the anchor blocks as per the design configuration.
5. Protocol for diving to deploy the Magnetic and Non-magnetic SSB Units according to the planned configuration.
6. Protocol for diving to deploy the SSB magnetic pouches according to the planned configuration.
7. Post-deployment video record of the 'as-built' SSB Exclusion facility.
8. Safety and risk assessment and mitigation and response strategy.

[5] SharkSafe Barrier installation logistics, St Paul (La Reunion). Internal report submitted to CRA as part of the environmental permit application. November 2018. A copy of the report is available from CRA

5. ACTUAL DEPLOYMENT SCHEDULE

5.1 Work schedule

Table 1 below is a summary of the activities and the progress made every day. The SSB team arrived late evening on 15 January 2019 and were not on board the vessel when the first 20 anchor blocks were taken out to the site. The weather conditions on 17 January prevented any work at sea. A serious technical malfunctioning of the crane on the boat occurred on Friday, 18 January. This delayed the deployment work until 23 January. The large crane-boat was used up to 24 January when all blocks and SSB Units were on site.

The diving work was successfully completed off the smaller inflatable boat.

Table 1: Summary of day-by-day activities and progress (see Figure 12 for a pictorial record)

Date	Anchor blocks to site	SSB Units to site	Anchor blocks positioned	SSB Units placed	Magnet pouches placed	State of SSB exclusion square
15/01	20	0	0	0	0	-
16/01	26	30	27	0	0	E-side ext row blocks in place (27)
18/01	27	27	27 + 16 = 43	0	0	E- side + short second row (16)
21/01	0	0	43 + 19 + 4= 73	0	0	Above plus S-side ext row (19) plus start of N-side ext row (4)
23/01	27 + 27 +25 = 79	79 + 20	27+23+23+16+12 = 101	0	0	S and N external and 2nd rows completed
24/01	25	25 + 20	27+16 + 23+12+23 + 12 + 27 + 16 + 54 = 200	54 Magnetic	0	All blocks in position
25/01	-	0	200 (All)	146	100 (All)	All units in position. Blocks secured with zig-zag rope
29/01	-	3	All	200 (All)	All	Thimbles and pouches secured with cable ties
04/02	-	-	All	All	All	Fine-tuning and cleanup. Chum system

						installed

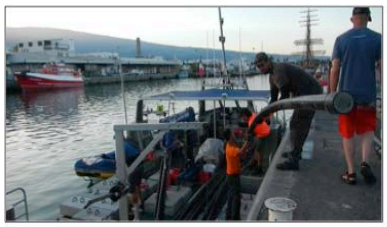
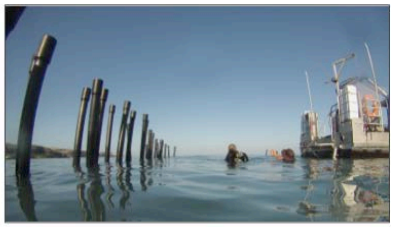
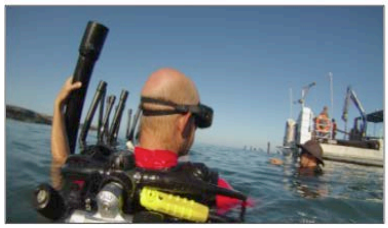
16 JANUARY 2019

- Survey of sand depth.
- Finalised the postion and configuration
- 26 Anchor blocks deployed
- 30 SSB Units deployed
- First side of external row arranged




18 JANUARY 2019

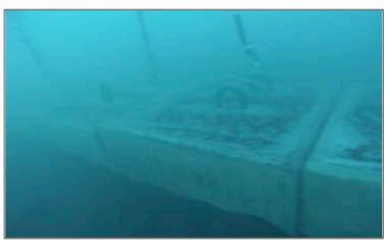
- 27 Anchor blocks deployed
- 27 SSB Units deployed
- Second side of external row arranged


21 JANUARY 2019

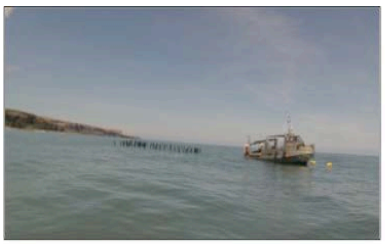
- Aligned the deployed blocks including the 20 blocks delivered on 15 January

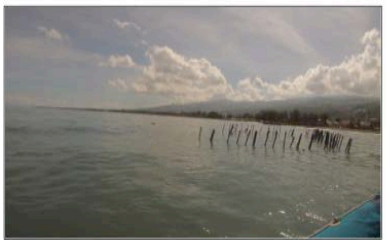


23 JANUARY 2019

- 77 anchor blocks deployed
- 77 SSB Units deployed
- Third external side completed
- Two mid-side completed





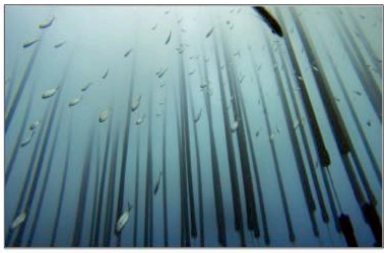
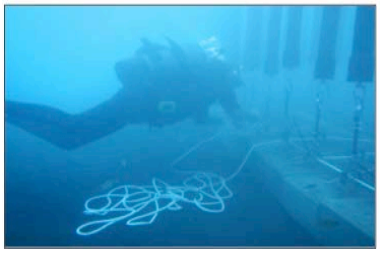

24 JANUARY 2019

- 50 anchor blocks deployed
- 50 SSB Units deployed
- Fourth external side completed
- Four mid-side completed
- Three internal sides completed




25 JANUARY 2019

- Four internal sides completed
- All SSB Units in place
- Bottom rope to secure the structure on ¾ of the blocks


29 JANUARY 2019

- Attached all SSB magnetic pouches
- Bottom rope completed
- CRA inspection

04 FEBRUARY 2019

- Finalised positions of units
- Tidied and secured whole SSB system
- Demonstrated chum drum deployment

Figure 12: Day-by-day pictorial record of the actual deployment schedule (read in conjunction with Table 1)

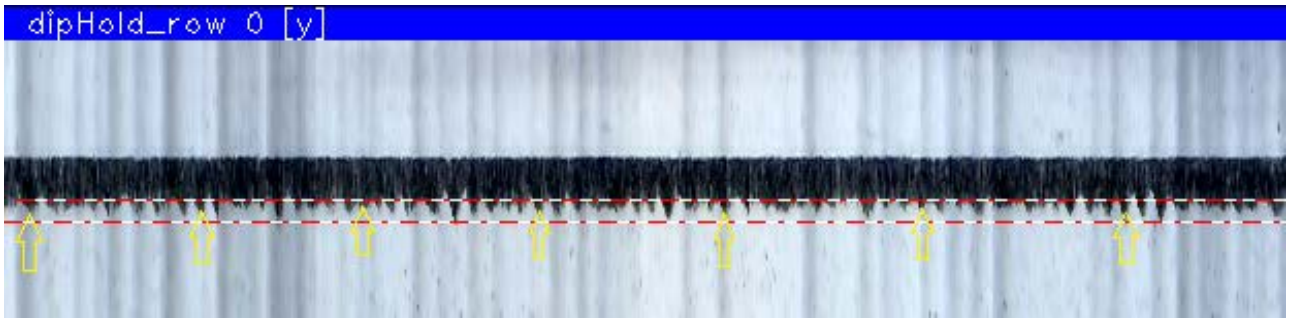
6. SEASTATE DURING THE DEPLOYMENT OPERATIONS

A number of local and international seastate forecast models are available for La Reunion. These include the (1) Surfspot model (www.surf-forecast.com) and the (2) Windy models (www.windy.com)
In addition near-real time records form CANDHIS wave measuring buoy (Campaigne 97403 – Riviere des Galets (Le Port) [020^0 56.743'S; 055^0 16.639'E in 33 m waterdepth) http://candhis.cetmef.developpementdurable.gouv.fr/campagne/?idcampagne=3295c76acbf4caaed33c36b1b5fc2cb1
are available. No directional data is available.

The forecast and actual information for the deployment days are shown in Table 2.

The video clips recorded by the HD camera were analysed using the BuoyWatch software provided by EnviroVision Solutions South Africa. EVS Systems (Pty) Ltd. www.evsolutions.biz

A Keogram (shown below) was produced, which enabled the wave height and period to be determined .



SSB exposed structure through time tracked at 1.17 fps (frames per sec). The position of every 10th wave trough is indicated using the yellow arrows. This timeline captures 927 vertical intensity profiles over 13min 5.6 sec. The position of the top of the pipes [SSB superstructure] and the wave height against the structure are recorded here.

The system was calibrated using the known height of an observed figure at the waterline (figure below), the relative height above the waterline of the camera, the relative distances from the camera to the observed figure and the distance from the camera to the SSB structure.
Whilst still in the process of being calibrated for larger waves, this technique enables valuable seastate characteristics to be observed during daylight hours.

This portion of the video clip, when the 1.8m reference height is in line with the SSB made it possible to calibrate pixel scale at the shoreline

The breaker wave height and wave period for selected times are shown in Table 2 and can be compared to those obtained from the other available sources.

The observed wave direction on site will also be derived as the analysis technique is advanced.

Table 2: Model forecast and actual information for the deployment days

Date	Time (Local)[5]	Seastate							Wind		Camera observed Seastate	
		Waverider[1]			Model forecast [2,3]						BuoyTracker[4]	
		Hs (m)	Hm (m)	T (s)	Hs (m)	T (s)	Wave Direction (from)	Wave energy[2] (kJ)	Wind[3] (km/h)	Wind Direction[3] (Onshore / offshore)	Hb (m)	T (s)
16/01	15:00				0.9	20	SW	673	5	On (NNW)		
17/01	09:00	1.3	1.8	14.5	2.4	17	SW	3134	10	On (NE)		
18/01	09:00	1.0	1.7	13.8	1.7	13	SW	1344	15	On (NNE)		
21/01	10:00	0.8	1.4	6.7	0.9	9	SSE	183	10	On (NE)	0.50	10.6
22/01	08:30	1.0	1.5	7.0	0.9	8	NNW	92	10[2]	On (N)[2]	0.77	14.2
	17:00	1.0	1.6	7.4	0.7	8	SE	92	10[2]	On (NNE) [2]	0.59	9.4
23/01	10:00	1.2	1.8	7.7	1.4	8	SW	720	10[2]	On (NNE)[2]	0.59	10.6
24/01	10:00	0.6	0.9	5.9	1.1	11.4	SW	212	15	On (NNE)	0.50	7.1
29/01	10:00	0.9	1,4	9.3	1.8	10	SSW	707	10	Off (SE)		
	16:00	0.9	1.4	7.7	1.6	11	S	575	10	Off (SSE)	0.59	10.6

Notes:

1. Campaigne 97403 – Riviere des Galets (Le Port) [http://candhis.cetmef.developpement-durable.gouv.fr/campagne/?idcampagne=3295c76acbf4caaed33c36b1b5fc2cb1
2. Surfspot model (www.surf-forecast.com)
3. Windy models (www.windy.com
4. EnviroVision Solutions South Africa. EVS Systems (Pty) Ltd. www.evsolutions.biz
5. Local time = UT + 4hrs

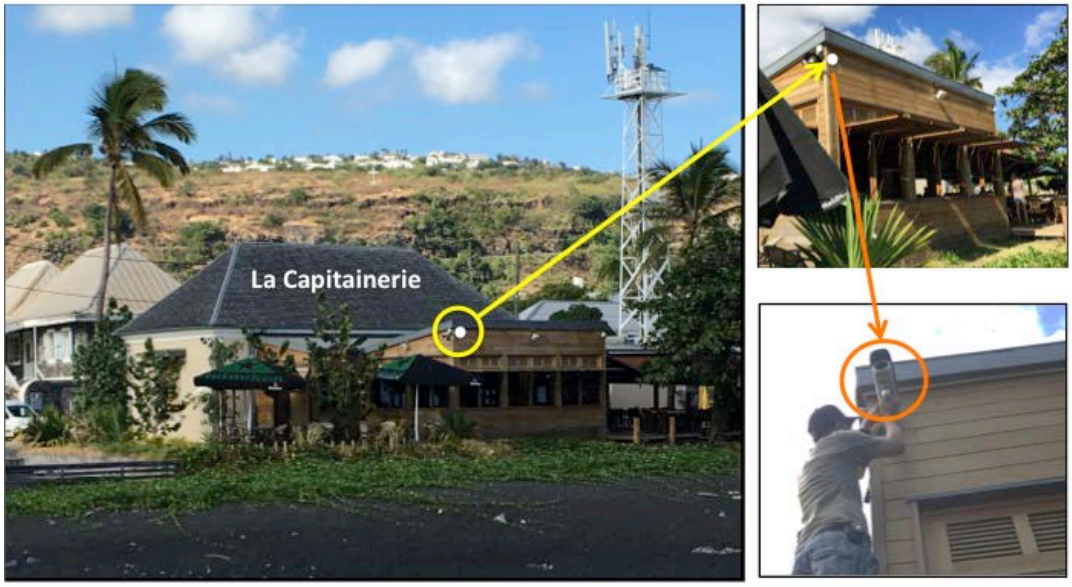


Figure 13: The HD Camera mounted on the north corner of the La Capitainerie Restaurant at Saint-Paul

Figure 14: Start of the SSB deployment on 16 January 2019 as recorded by the HD Camera

7. AS BUILT LAYOUT

Figure 15 depicts the layout and pattern as described above. Photographs of the selected areas of the SSB Exclusion Area are included.

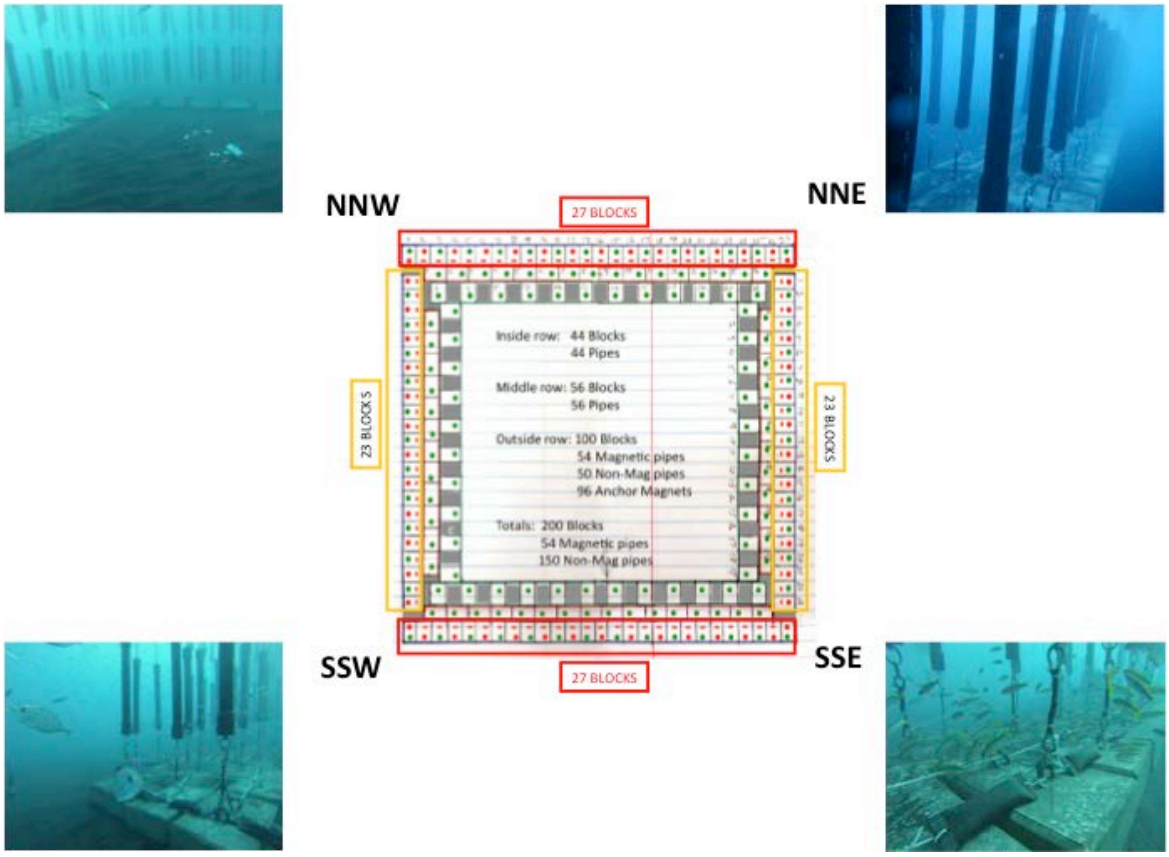


Figure 15 Final layout of the SSB Exclusion Area (inner dimensions 10 m x 10 m minimum)

The approximate coordinates of the four corners were taken using a hand-held GPS due to the risk of the SSB magnets influencing the readings. These are shown in Figure 16 below.

REF	COORDINATES		COMMENTS
	LATITUDE	LONGITUDE	
NNW	21° 0.436' S	55° 15.999' E	SEAWARD CORNER
NNE	21° 0.436' S	55° 16.008' E	SEAWARD CORNER
SSW	21° 0.446' S	55° 16.000' E	LANDWARD CORNER
SSE	21° 0.444' S	55° 16.010' E	LANDWARD CORNER
CENTRE	21° 0.440' S	55° 16.005' E	

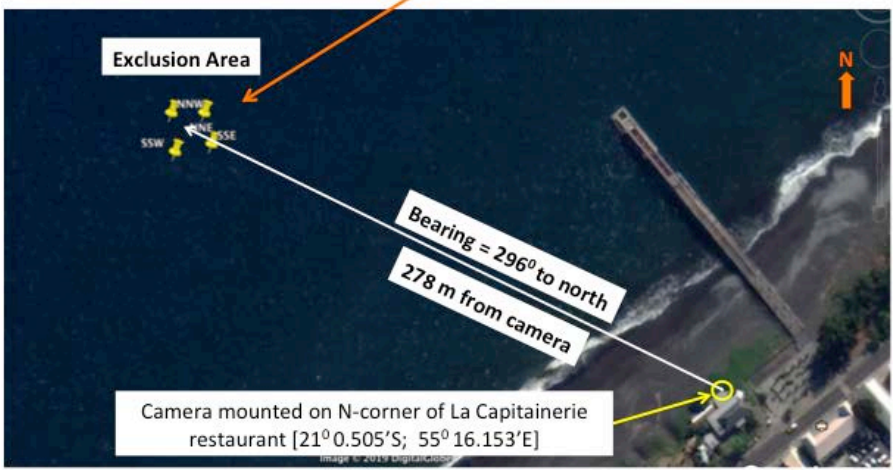


Figure 16: The position of the SSB Exclusion Area

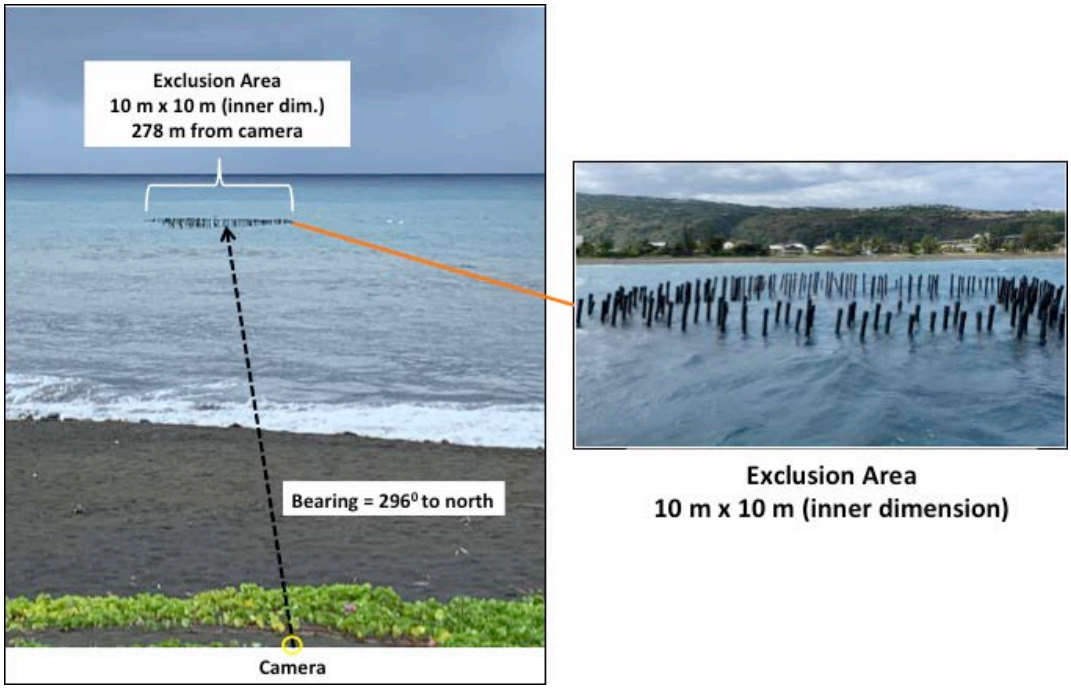


Figure 17: View of the SSB Exclusion Area recorded by the HD Camera mounted on the north corner of the La Capitainerie Restaurant at Saint-Paul

8. OPERATIONAL & MAINTENANCE GUIDELINES

I

8.1 Introduction

The SSB Exclusion area at Saint-Paul is exposed to deep-sea swell and cyclone wind-waves approaching from the SW to N sectors. The site is shielded from the E and SE sectors.

The site is directly exposed to waves approaching from the NW sector as the shoreline has a SW/ NE orientation.

Prevailing swell from the SW from the deep southern ocean is refracted around Pointe des Aigrettes to reach the site.

A CANDHIS[6] wave-monitoring buoy (Campaigne 97403) is located to the north of Saint-Paul and close to Le Port north of the Riviere des Galets.

Because the SSB Exclusion area is located in relatively shallow water (average depth of 6.5 m) it is expected that large swell and storm surges will impact on the anchoring structure at the site from time to time.

Whereas the SSB Units are robust to manage large breaking waves, the concrete anchor blocks may move due to storm surge. It is anticipated that the anchoring structure will become more robust as the blocks settle into the sand with time. A zig-zag rope has been used to tie the blocks together as far as possible so-as to allow the structure to settle as a unit.

Each of the SSB Units has been fitted with a SSB information disc as seen in Figure 18 below. This is to encourage the public to return the units to CRA should any come loose during storms and wash up along the coast.

Figure 18: SSB Unit information tag

[6] CANDHIS - Centre d'Archivage National de Données de Houle In Situ
http://candhis.cetmef.developpementdurable.gouv.fr/campagne/?idcampagne=3295c76acbf4caaed33c36b1b5fc2cb1

Any found SSB Units should be assessed for damage and the actual breakage points noted. In most cases the units are easily repaired and can be reused.

8.2 Prior to each chumming exercise

As specified in the environmental permit, the CRA and research partners are allowed to carry out a series of chumming exercises on Mondays and Tuesdays over a number of months. The purpose is to observe a statistically relevant number of individual sharks that approach the chum but defer from entering or breaching the SSB Exclusion Area.

Due to the relatively long period between diver visits to the SSB Exclusion Area, it is recommended that the research divers first inspect the whole SSB Exclusion Area to determine if stormy conditions (large waves), strong currents (or even human intervention such as snagged anchors from fishing boats during the preceding period), have damaged or moved any of the blocks and/or SSB Units.

This should be done prior to any chumming commencing.

The protocol described in Section 8.4 should be followed if damage is noticeable.

Figure 19: The chumming-drum in place

8.3 Preparing for a large storm or cyclone

Figure 20 shows a suggested Decision Tree for preparing the SSB Exclusion facility prior to the onset of a large storm or cyclone. It is reported that cyclone tracking and forecasts can provide alerts of up to 3 days in advance.

Although this is up to CRA, it is recommended that the SSB Units be removed to storage should an alert be issued.

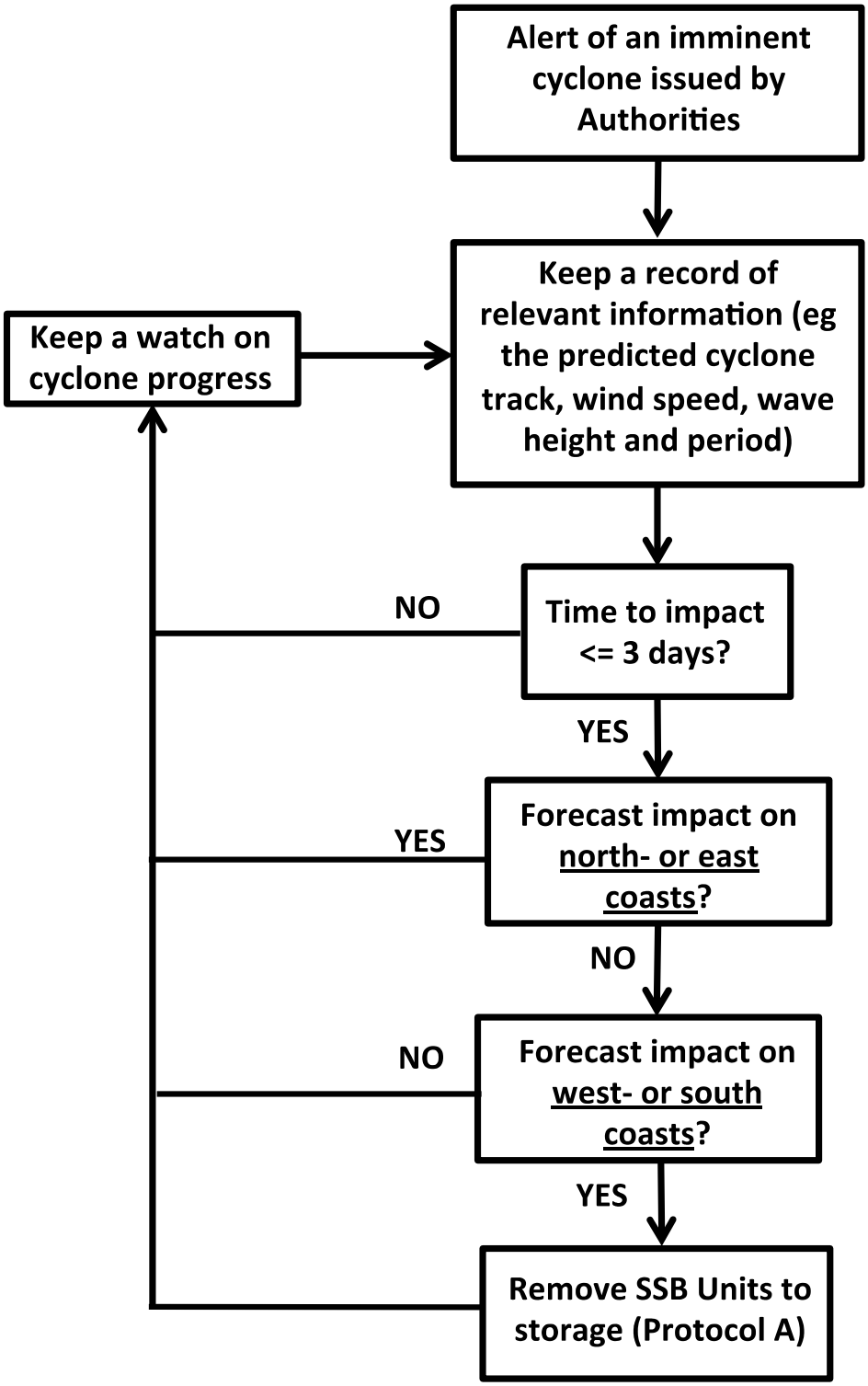


Figure 20: Pre-storm procedure

8.4 After a storm and/or cyclone

Assessing damage and reinstating the integrity of the SSB Exclusion Area after a large storm or cyclone is important. Figure 21 provides a decision support framework to assist with the process.

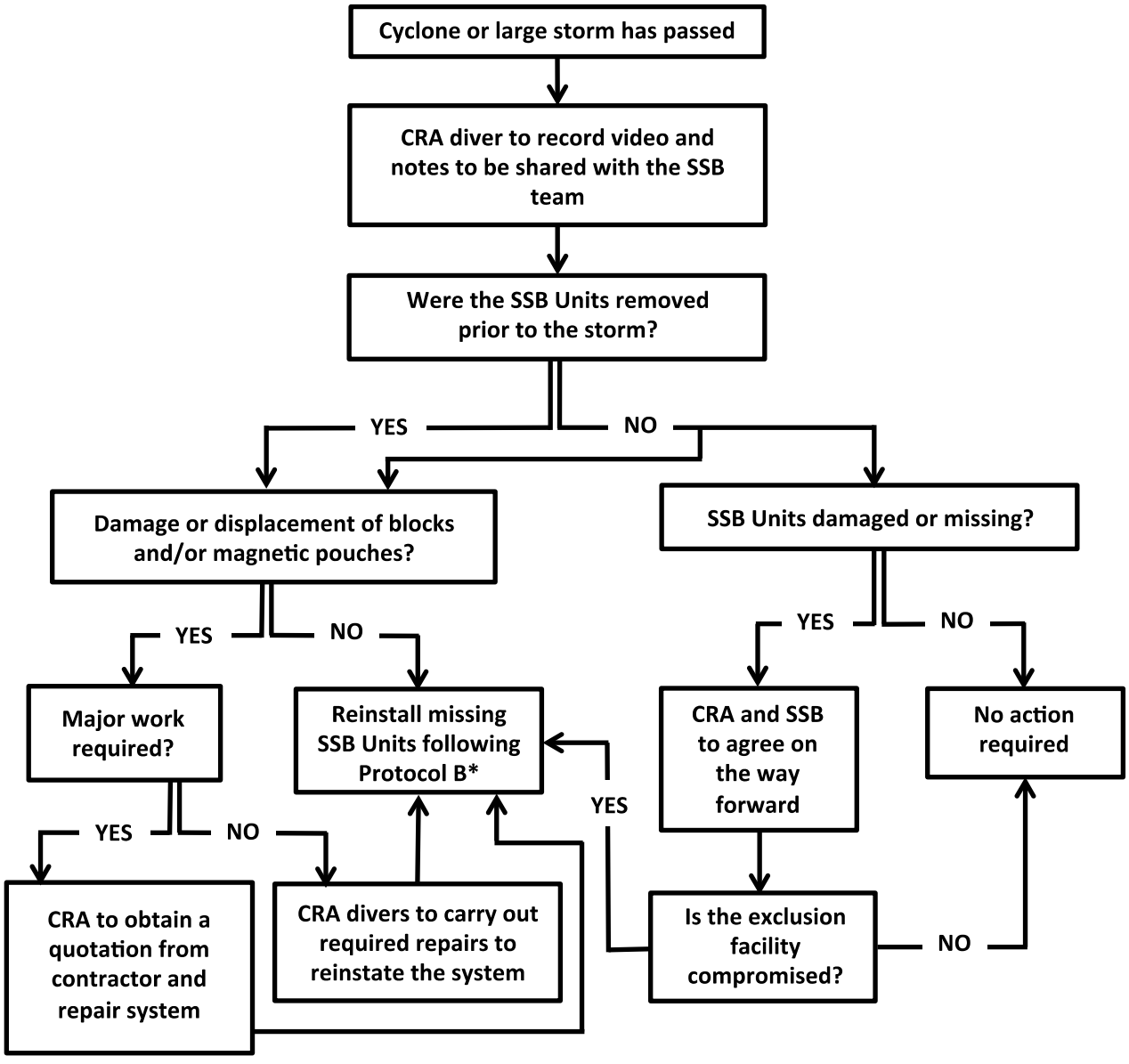


Figure 21: Post-storm procedure

8.5 Protocol A: Removal of SSB Units

The following protocol for removing the SSB Units from the exclusion installation in Saint-Paul will need to be executed in case a 3 days cyclone alert is issued for the Saint-Paul area on La Reunion Island.
Principle: The SSB Units will be released from the anchor blocks by divers. The Units will float to the surface, tied together in batches attached to a long rope and towed to the beach at Saint-Paul by a boat. The SSB Units will then be pulled onto the beach and manually carried to the storage at CRA.

- Nr of SSB Units to be removed: 200
- Nr of Divers needed for the job: 2
- Nr of boats needed for the job: 1 small boat (e.g. the Corto Maltese)
- Nr of personal needed on the boat: 2 people
- Nr of personal needed on the Saint-Paul beach: 4 people
- Time needed for the operation: 1 day (approximately 8 hours of work)

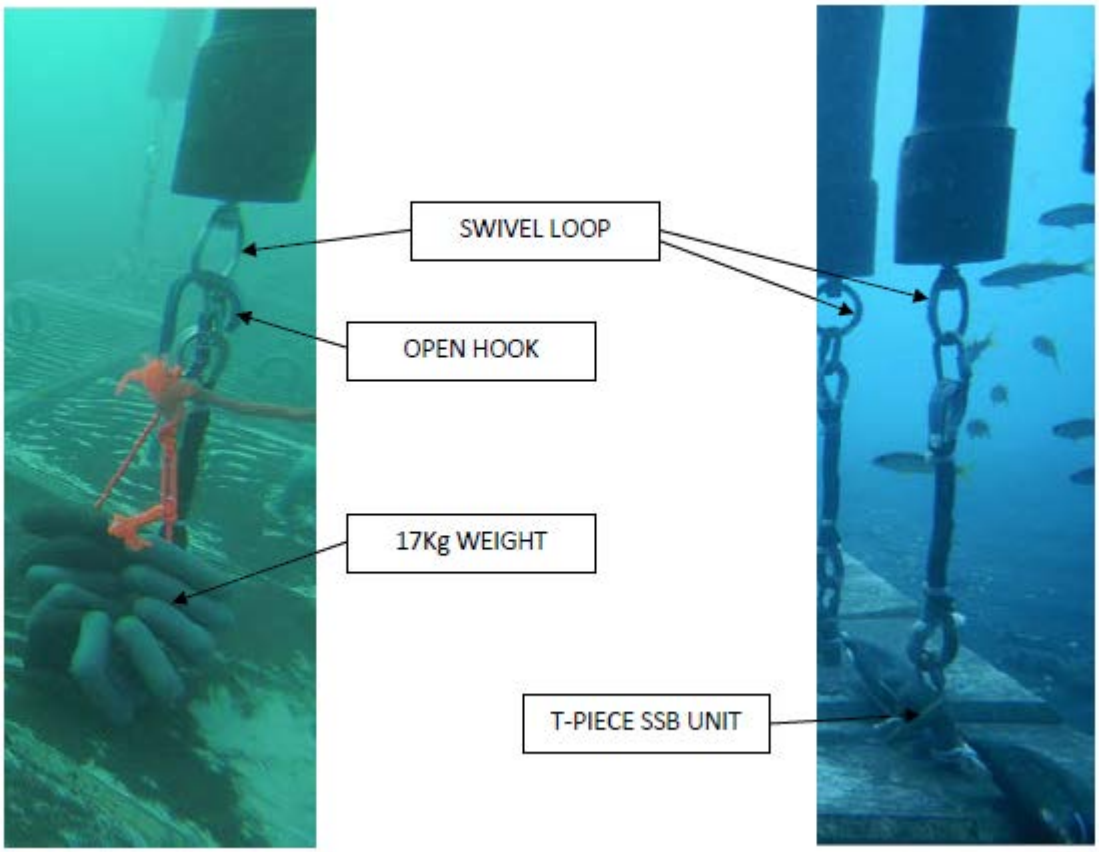
PROTOCOL NOTES:

The SSB Units are buoyant. Once taken off the anchor blocks loop they will float to the surface. Attention must be taken in having the SSB Units tied together before loosening them from the blocks. Also, due to their buoyancy, 1 weight belt (with open hook) can be used to keep the SSB Unit weighted down while removing the T-piece from the loop on the anchor block.
Please pay attention **NOT to cut the small black and white cable ties** on the loops of the external row of SSB Units, as these are marking the position of the SSB Magnetic Units (type #1 and type #2). This is important for the re-installation protocol.

Specialized equipment to prepare on-board the boat for controlled removal from the anchor blocks:

- 2 pieces of 50 m long thick rope (total thus 100 m of rope) fitted on one side by a T-piece and on the other side by a metal pin.
- 2 extra weight belts of 17 kg and large open hooks (carabina-type - one per diver)
- 1 knife and a small net-bag

SSB UNITS REMOVAL PROCEDURE:



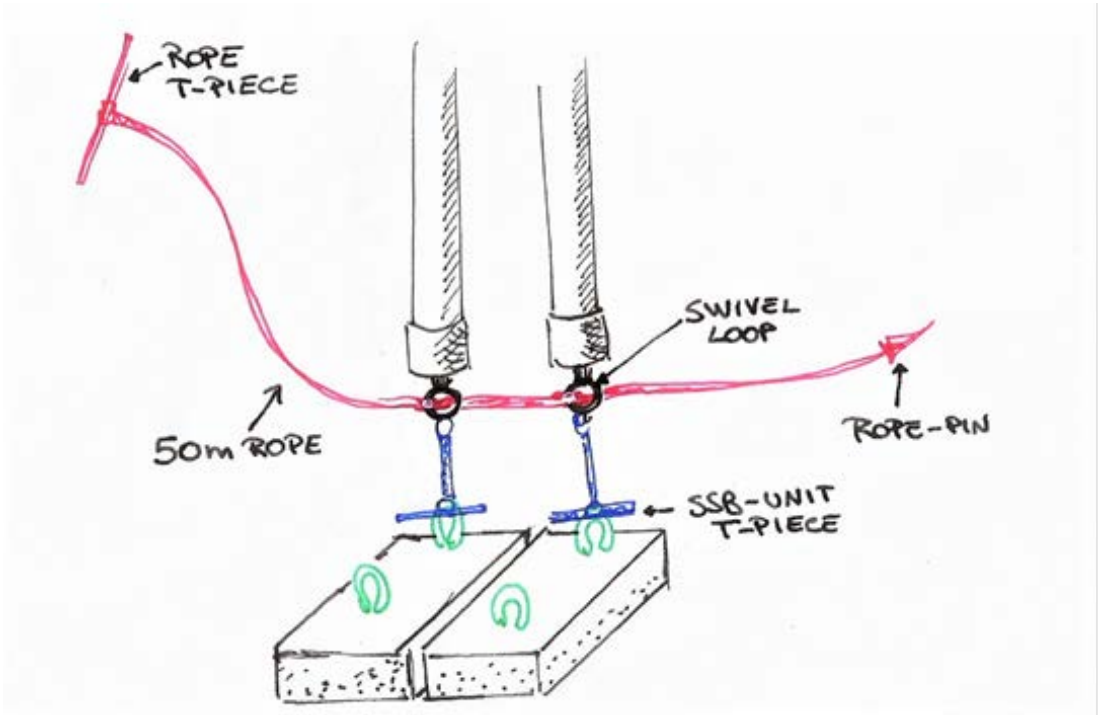


Figure 22: SSB Unit removal protocol.

- Keep the T-piece side of the 50m rope tide up to the boat.
- Insert the rope-pin of the 50 m rope through the swivel loop on the SSB Unit (Figure 22).
- Pull pipe down with 17 kg weight by hooking the open hook on the swivel loop.
- Cut the cable tie securing the T-piece and put the cable tie in the net bag (to prevent pollution).
- Undo the T-piece of the SSB Unit from the loop on the anchor block.
- Release the 17 kg weight and let the SSB Unit float up to the surface (sliding up the 50 m rope attached to the boat above)
- When about 50 pipes are on the 50 m rope, give the pin side of the 50 m rope to the crew on the boat.
- Repeat the procedure using the second 50 m rope.
- In calm conditions the boat can (slowly) pull the two ropes, each with 50 floating SSB Units to the shoreline. – the decision will have to be made by the skipper based on the sea state.
- Alternatively the boat can take each of the 50 m ropes (with 50 SSB Units) separately
- The land crew (4 people) pulls the SSB Units up the beach onto the upper beach area. The SSB Units can be slipped off from the pin side and be taken to storage..
- Once the SSB Units are secured on the beach, the line can be recovered and give back to the boat. Alternatively, 4 ropes of 50 m each can be organized to allow the divers to secure the next batch of 100 SSB Units while waiting for the boat to return from the shoreline.
- It is recommended that the SSB Units are sorted into Type 1 Magnetic, Type 2 Magnetic and Non-magnetic Units prior to storage. This will enable orderly and efficient re-installation (see Protocol B). It will also provide an opportunity for the visual inspection of all SSB Units to check for damage.

8.6 Protocol B: Re-installation of SSB Units

Specialized equipment to prepare on-board the boat for the re-installation:

- 2 pieces of 50 m long thick rope (total thus 100 m of rope) fitted on one side by a T-piece and on the other side by a metal pin.
- 4 extra weight belts of 30Kg and large open hooks (carabina) (2 per diver)

SSB UNITS RE-INSTALLATION PROCEDURE:

- The SSB Units can be towed from the beach to the exclusion area by boat, using the same rope-system as for the removal protocol above.

- It is recommended to re-install the SSB Units by bringing 50 SSB Unit at the time from the shore to the location in 4 separate trips.
- The shore crew should arrange the SSB Magnetic Units in the correct order ie Type 1, then Type 2, then Type 1 etc.
- It is recommended to run the 4 trips in the following order:
    1. All Magnetic Unit Type #1 and Type #2 (N = 54) = 1 trip
    2. All Non-Magnetic Units first (N = 146) = 3 trips (50; 48; and 48)

Once the SSB Units will be on the surface at the boat, the crew on the boat will remove one Unit at a time from the 50 m rope (from the pin side of the rope), secure a 30 kg weight to the swivel with a open hook and drop the 30 kg weight tied to a thick rope down to the bottom

- The diver at the bottom will attach the T-piece of the SSB Unit to the block – Starting along the outside row and attaching the SSB Magnetic Type 1 to the first loop (black cable tie), then skip one loop without a cable tie, then a SSB Magnetic Type 2 to the loop with the white cable tie, skip another loop without a cable tie, and so on.
- Diver undoes the 30Kg weight from the SSB Unit
- Boat crew will pull up the weight and the operation is repeated with the next SSB Unit.
- With 2 weight belts per diver, as the diver is attaching the SSB Unit, the boat crew can recover the weight of the previous SSB Unit and so on. If 2 divers: 4 weights belts can be used.

Once all the SSB Magnetic Units are secured in the correct order along the outer row, the SSB Non-magnetic Units can be installed in the gaps between the SSB Magnetic units along the outer row, and then the rest on the middle row and inner row.