Surveys of corrosion on cannons on the wreck of the Coronation

BSAC First Class Diver Examination

25th and 26th June, 2011

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1 Introduction

1.1 Objective

This report describes the results of a survey carried out on the wreck of the Coronation to provide a baseline of the occurrence of corrosion eruptions on cannons on the site. This was conducted as part of a BSAC First Class Diver practical examination held in Plymouth on the 25th and 26th June 2011.

1.2 Dive Site[1]

Launched by Master Shipwright Issac Betts at Portsmouth in 1685 as a second-rate ship of the line, the *Coronation* carried a complement of 90 guns and 660 crew. She played a crucial role in the battle of Beachy Head in 1690 under Captain Charles Skelton and Admiral Russell. Lost in a severe gale on September 3rd 1691 off Penlee Point it is believed that the Coronation was dis-masted, capsized and driven aground with a loss of all but 17-23 persons and an estimated 94 guns on board. The wreckage trail of approximately 800 metres is divided into two main sites, the "inshore" and "offshore". Each site is protected (Offshore- Site 17 Designation Number 2 Order 1978/321 and Inshore – Site 33 Designation Number 1 order 1988.2138). The site is under the regulation of the Queen's Harbourmaster, lying within the Port of Plymouth Harbour Authority. The wreck is protected by licence and has a no-touch no-take policy which applies not only to wreck artefacts but also to marine life.

Model of the *Coronation* as it is believed she would have looked in 1685 (Kriegstein Collection)

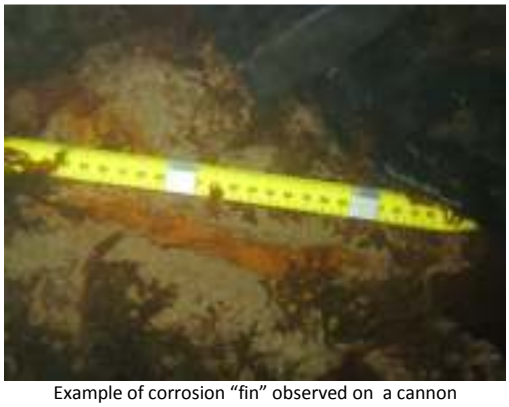
Discovered in 1977 by magnetometer, the "offshore" wreckage trail of the *Coronation* extends along the seabed with seventeen cannons and three anchors identified to date (see 1.1), in addition to further artefacts including some small and delicate items. The topography is described as rugged rock formation and sand-filled gullies and in a general depth of 18-20 metres has kelp and low level vegetable turf covering the area. The identification of the wreck was as a result of the discovery of a folded pewter plate bearing the crest of Captain Charles Skelton who was the captain at the time of sinking.

1.3 Cannons

There are a total of 17 cannons around the offshore site, numbered 1-15 and number 20 as seen in Appendix 8.5. One of the latest discoveries has not been included in this site plan as it has only recently been uncovered by the sand. The cannons range in calibre from 5.25lb (8 cannons) to 18lb (7 cannons) and are either a Culverin or Saker Cannon. Cannon 20 has yet to be identified as its body lies in the sand, but it is believed to be a 5.25lb Saker. Culverin cannons, developed in the late 16th Century by the English for navel warfare fired solid round shot projectiles (cannon balls) to bombard targets from a distance[2]. Characteristically they had a relatively long barrel and a lightweight construction. The Saker was similar to the Culverin, but is described as medium sized cannons used for mid-range bombardment.

1.4 Corrosion

Over the last few decades it has been noted that some of the cannons at the offshore wreck site have formed "fins" of corrosion. Due to the iron content used and the method of production in the late 16th century, combined with centuries of immersion in sea water, chemical reactions taking place within the cannons lead to a "bursting" effect of corrosion erupting from within the exposed areas of the cannons. This active and ongoing corrosion appears as orange streaks and fin like structures. The purpose of this study is to further investigate and document the development and existence of such corrosion sites.



Example of corrosion "fin" observed on a cannon

2 Survey Technique

2.1 Dive Brief

Diving operations were conducted on Sunday 26th June 2011. A passage plan was generated (Appendix 8.1) to reach the site and subsequently a shot was deployed onto the wreck site at the specific co-ordinates listed in the passage plan. As the wreck lies within the Port Authority surface marker buoys (SMB) are also used at all times to mark diver positions. The diving was conducted in the 18-20m depth range and conditions on the day were favourable with good visibility and a force 3-4 south-westerly wind. High water at Plymouth (Devonport) was at 14:27 (BST) meaning the initial morning dives were conducted in the slack water window approximately 2-3 hours before high water . Diving was conducted off the 10m hard boat Falcon 2 of Dartmouth[4].

2.2 Project Brief

In order to survey the entire site and each of the 16 cannons a systematic approach to investigate each of the stations placed along the diver trail created by the *Coronation* wreck project was devised. Beginning at station 9 teams worked in a clockwise direction systematically searching each cannon for evidence of active corrosion. Once active corrosion was found a note was made of the site number and relative position of the cannon within the site (at some stations there was more than one cannon). The key elements to note for each cannon were decided as: the location of the corrosion on the cannon – using brief sketches; measurements of the dimensions of the eruption; photographs for additional clarity.

2.3 Materials Used

Each team carried the following instruments:

- Yellow metre rule
- 3 metre reference line (taped at 50cm intervals)
- Digital compact camera in waterproof housing
- Recording slate

3 Survey Results

3.1 Overview of Results

Over the course of three survey dives all cannons except site 6 were surveyed for signs of corrosion eruptions. Each diver used a pre-prepared slate to record the details of any cannons where corrosion was sited. The approximate location of the corrosion was sketched and measurements taken of the length and height of the eruption. Photographs were then taken to provide additional data. Scans of the completed dive slates are shown in Appendix 8.7.

The data from these slates were processed to provide an overview of the distribution of corrosion around the site and any patterns identified.

Corrosion eruptions were identified on cannons at all sites surveyed. Only cannons 1, 6, 8 and 12 were not logged as having any sites of significant corrosion. Eruptions were generally orientated horizontally, but unusually one eruption on cannon 10 had vertical orientation.

In addition to the large areas of corrosion that were logged some smaller examples were also observed on some of the cannons which had not yet erupted.

Tidal flow in the area runs approximately south west/north east. The majority of cannons are orientated in this direction, with only cannons 2, 6 and 8 of the cannons surveyed lying in a different orientation. Neither cannon 6 or 8 were recorded as having corrosion eruptions in the baseline survey while cannon 12 is the only cannon in the more common orientation which was not recorded as having a corrosion site. Overall there is no strong evidence that the orientation of the cannons has any impact on the likelihood of corrosion appearing.

Corrosion eruptions were identified on nine cannons on the offshore site, in general eruptions were roughly rectangular extending along the length of the cannon with expansion restricted in the vertical plane. The exception to this is the site on cannon 7 which is squarer in shape (90x80mm).

Figure 1 shows the distribution of length of eruption, it can be seen that the eruptions range from less than 100mm to over 1500mm in length. The smaller eruptions are most frequent but there is a broad range of sizes across the survey site.

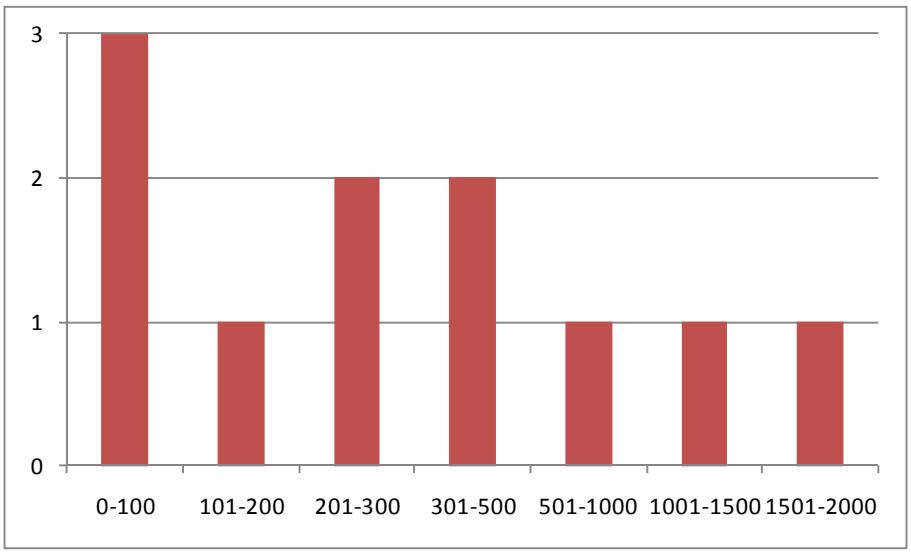
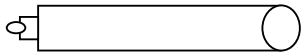
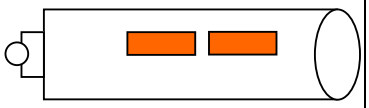


Figure 1: Frequency of eruption length

Buoy	Cannon	Dive Team	Cannon Type	Sketch
10	1	AN & CY	5.25lb 8’6” Saker	
10	2	AN & CY	18lb 9’ Culverin	
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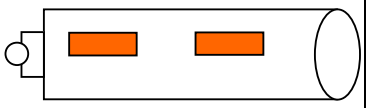
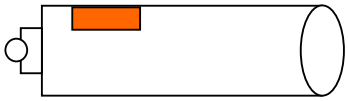
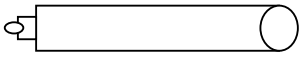
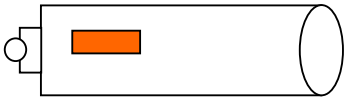
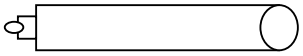
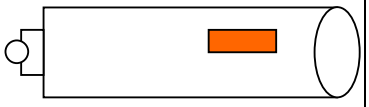
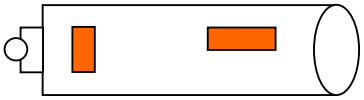
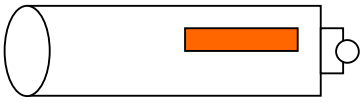
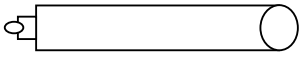
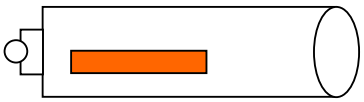
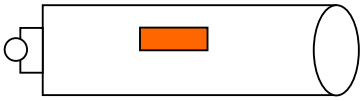
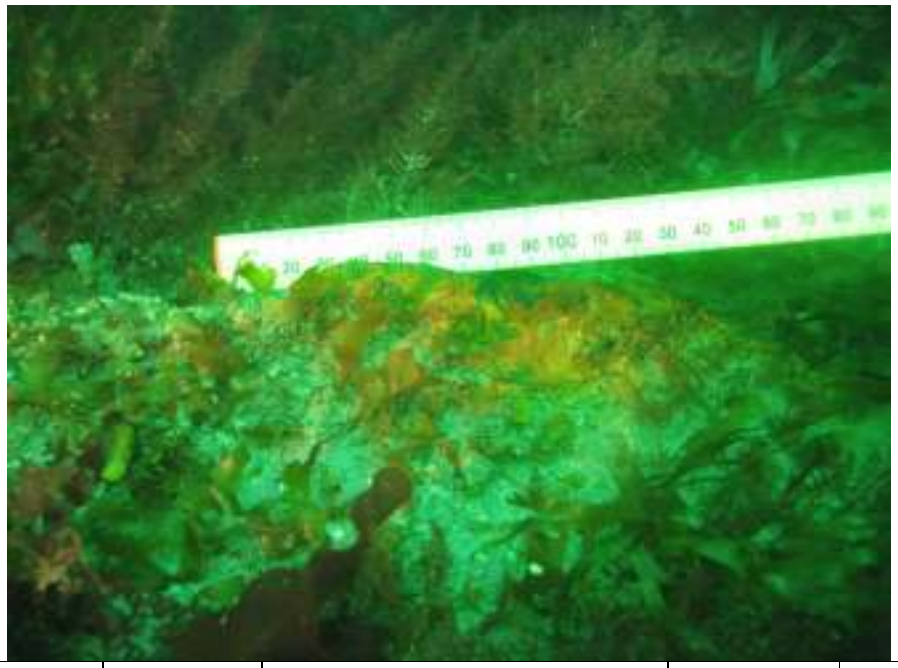
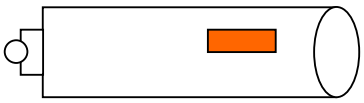
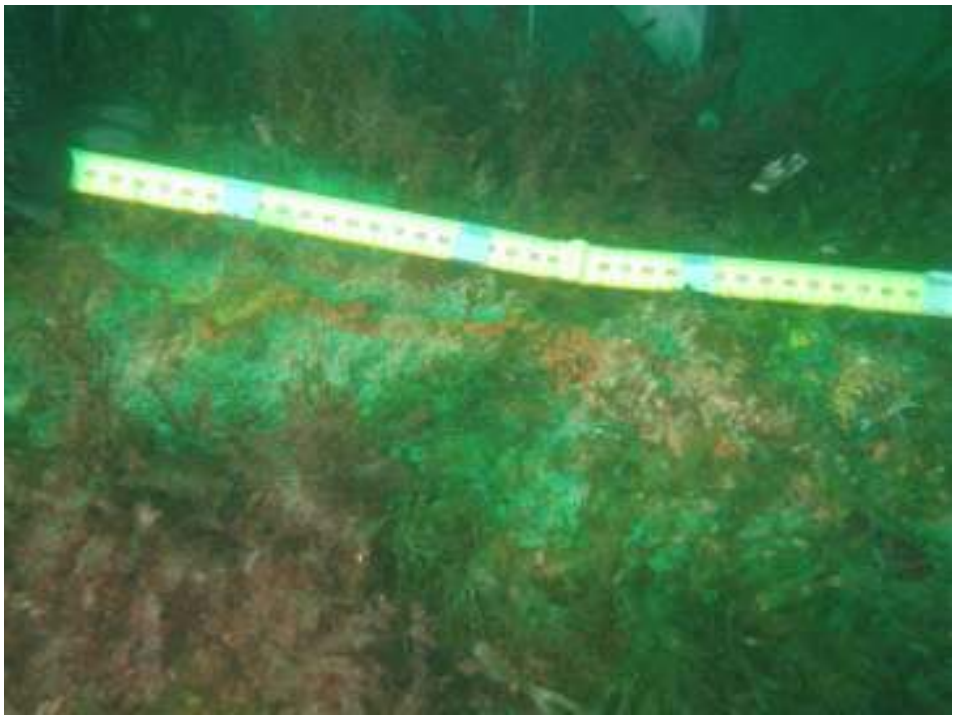
3	4	AN & CY	5.25lb 7’ Saker	
4	5	AN & CY	5.25lb 8’6” Saker	
4	6	AN & CY	5.25lb 8’6” Saker	
2	7	AN & CY	18lb 9’ Culverin	
9	8	LW & GC	5.25lb 8’6” Saker	
9	9	LW & GC	18lb 9’ Culverin	
8	10	LW & GC	5.25lb 10’” Saker	
8	11	LW & GC	18lb 9’ Culverin	
8	12	LW & GC	18lb 9’ Culverin	
7	14	LW & GC	18lb 11’ Culverin	

3.2 Detailed Results

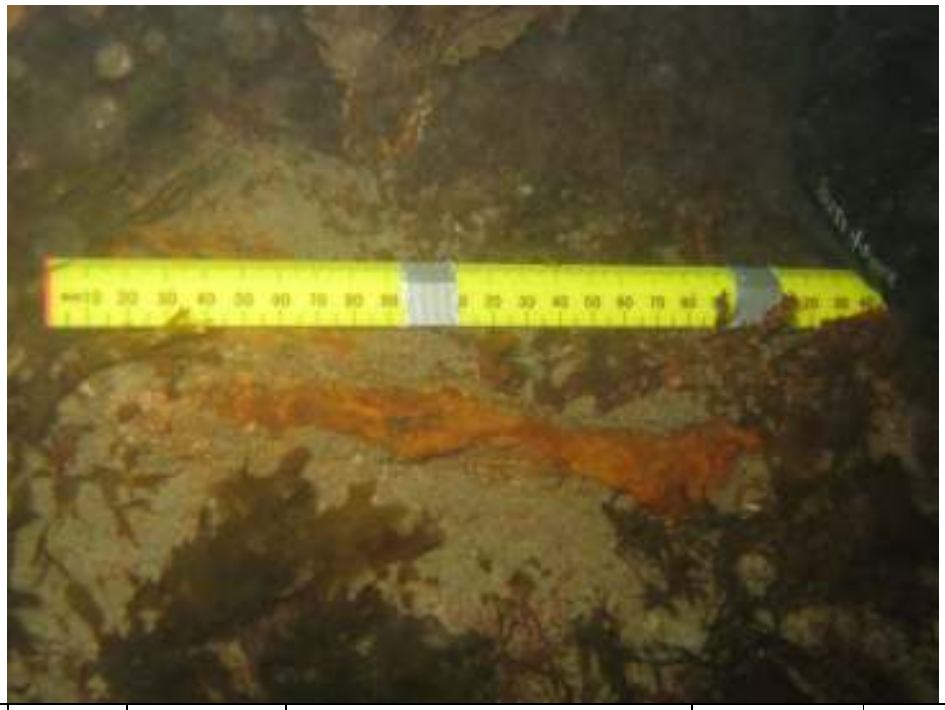
Buoy	Cannon	Team	Sketch	Length (mm)	Height (mm)
10	2	AN & CY		100x30	30

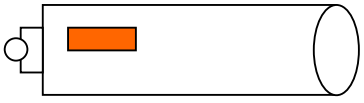


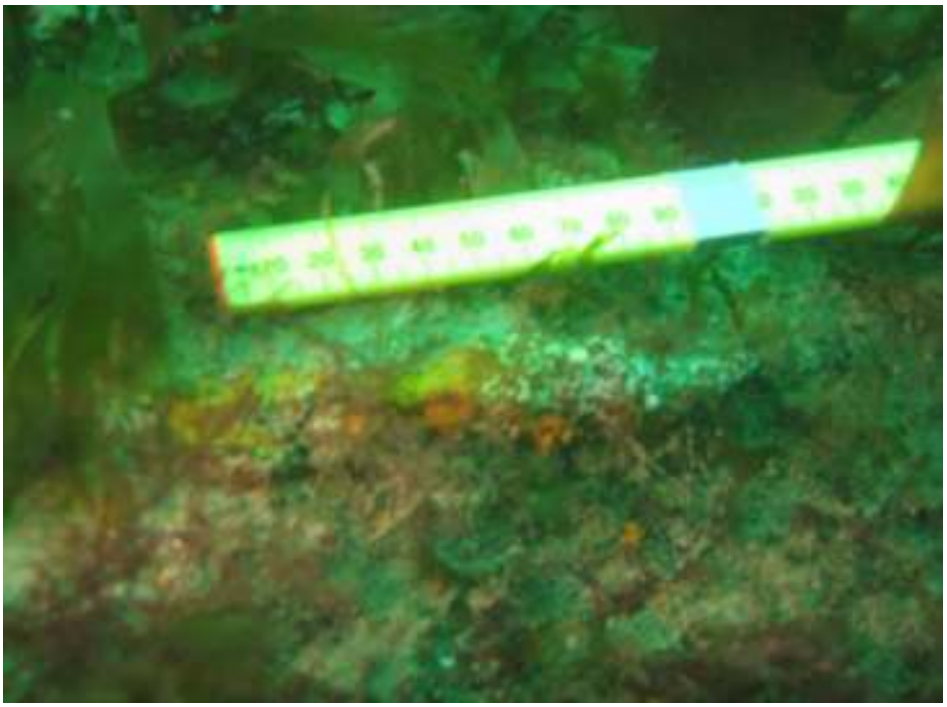
Buoy	Cannon	Team	Sketch	Length (mm)	Height (mm)
10	2	AN & CY		100x40	10



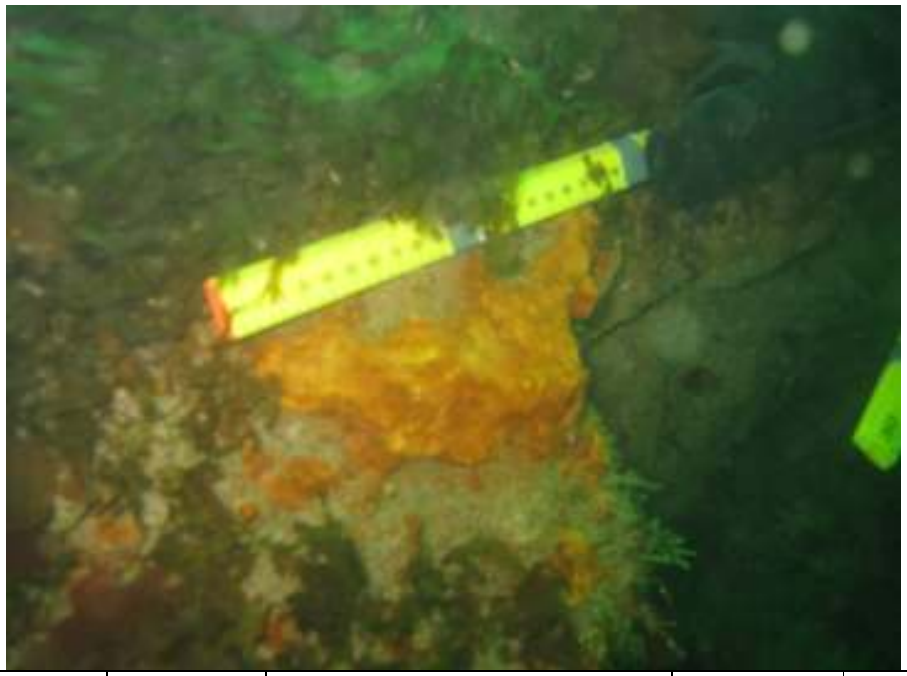
Buoy	Cannon	Team	Sketch	Length (mm)	Height (mm)
3	3	AN & CY		1700x10	10

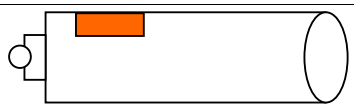


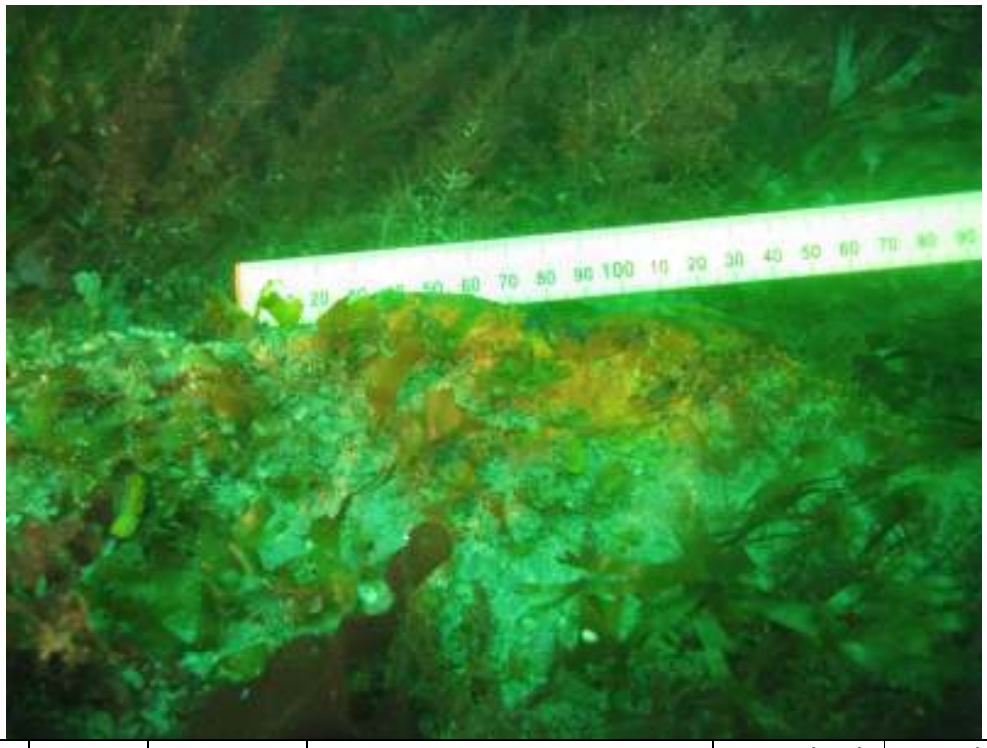
Buoy	Cannon	Team	Sketch	Length (mm)	Height (mm)
3	4	AN & CY		200x20	10

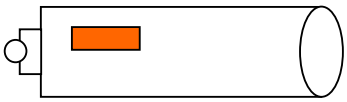


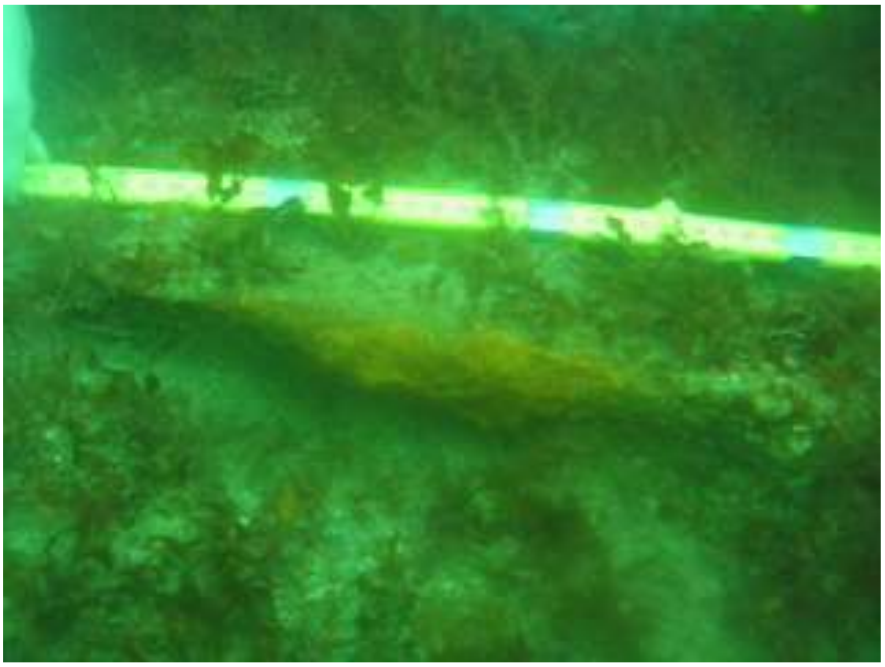
Buoy	Cannon	Team	Sketch	Length (mm)	Height (mm)
3	4	AN & CY		1500x15	25

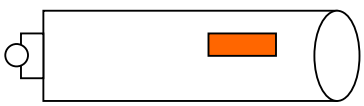


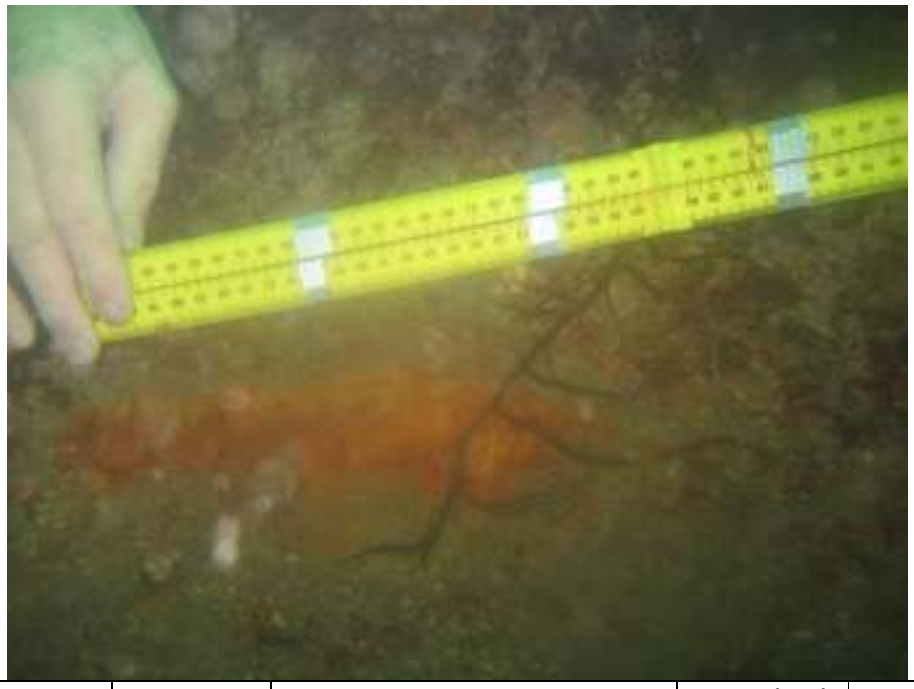
Buoy	Cannon	Team	Sketch	Length (mm)	Height (mm)
4	5	AN & CY		800	20



Buoy	Cannon	Team	Sketch	Length (mm)	Height (mm)
2	7	AN & CY		90x80	10



Buoy	Cannon	Team	Sketch	Length (mm)	Height (mm)
9	9	LW & GC		470	110



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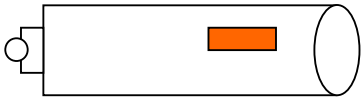
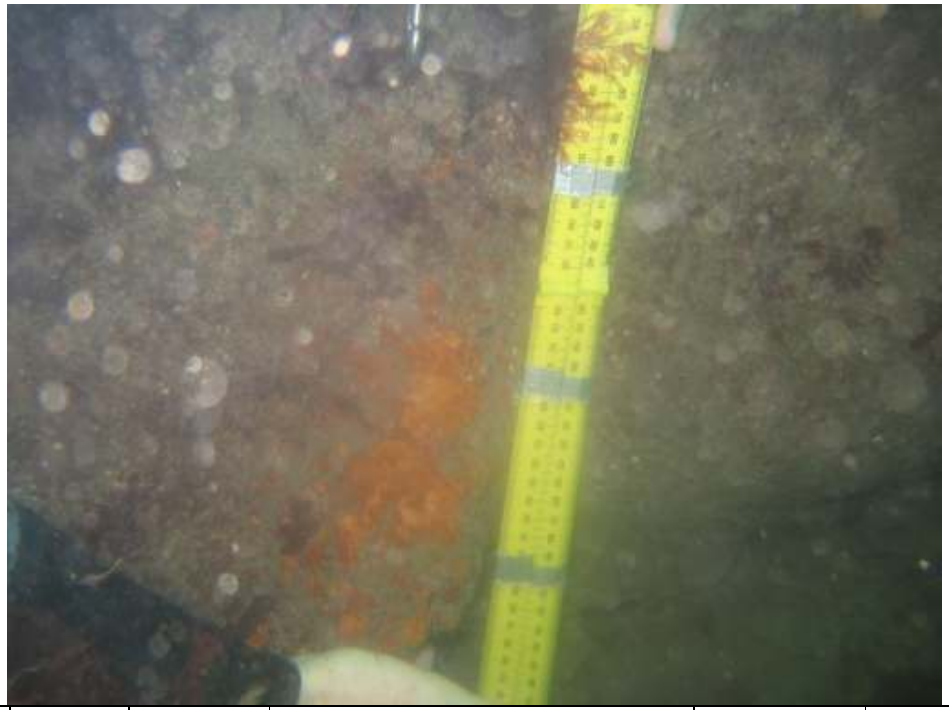
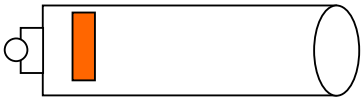
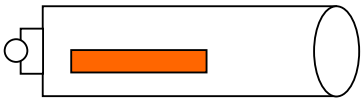
8	10	LW & GC		220	140



Buoy	Cannon	Team	Sketch	Length (mm)	Height (mm)
8	10	LW & GC		230	130

Buoy	Cannon	Team	Sketch	Length (mm)	Height (mm)
7	14	LW &GC		460	190

4 Review of Survey Techniques

4.1 Review of Corrosion

The aim of the survey was to provide a baseline of the distribution of corrosion eruptions across the cannons on the offshore site of the Coronation. The survey teams worked methodically round the cannon sites, examining each cannon for any signs of corrosion. When corrosion was observed sites were measured and logged. The data collected will allow future survey teams to target the sites for a more detailed monitoring programme.

4.2 What Worked Well

Survey strategy

The overall strategy used for the survey worked well for a small team. As only one team was in the water surveying at any one time we could coordinate the teams' activities easily with a handover brief after each dive. This ensured that there was no duplication of effort and that full coverage of the site was achieved. If multiple groups had been in the water at one time it would have been necessary to allocate survey sites more specifically.

Equipment management

Although it was necessary for each team to handle multiple items of equipment (slate, measuring stick, camera and marker buoy) the divers coordinated themselves well, passing the equipment between them to allow hands to be free to record or take pictures as necessary.

Data recording

The slates prepared for recording of data were simple and provided useful prompts to the divers for recording purposes. These were prepared prior to the task to streamline proceedings during the survey.

4.3 Suggestions for Improvement

Equipment management

Through practical experience it worked well to clip the survey board off to the marker buoy. This would then have been easier to manage if the board had been slightly weighted and there had been a stowage option for the pencil.

Orientation

It would have been helpful to have a copy of the simple site diagram attached to the back of each recording slate to allow easier orientation on the site.

Standardisation of results

The mean height of corrosion recorded by one team was 16mm while that recorded by the other was 140mm. This suggests that there may have been a difference in the way the teams interpreted the measurement offset. When more detailed surveys are conducted on the site survey teams should be carefully briefed to ensure that they are taking consistent measurements.

5 Conclusions

The survey performed successfully led to the recording of data regarding the existence of corrosion eruptions on eight of the nine cannon sites on the offshore site of the Coronation. This baseline data can then be used to select sites for follow up survey work to monitor the development of these eruptions.

In addition the survey also identified several smaller sites of potential corrosion which could indicate possible locations of further sites in the future.

6 Acknowledgements

The data in this report were gathered by the team of divers detailed below. Particular thanks go to Tony Hoile for his support, guidance and helpful suggestions throughout the examination and to Colin Yule for organising and coordinating the event.

Mark Wilson	NI, FCD Event Chief Examiner
Colin Yule	NI, FCD Examiner
Ginge Crook	NI, FCD Examiner to be, Coronation guru
Mark Mumford	NI, survey member
Alun Newsome	FCD Candidate
Louise Whitehouse	FCD Candidate

7 References

1. www.coronationwreck.co.uk (Information remains copyright of the Coronation Wreck Project, Reproduced with permission)
2. http://en.wikipedia.org/wiki/Culverin
3. http://en.wikipedia.org/wiki/Saker_(cannon)
4. http://www.dartboat.com/home.htm

8 Appendices

8.1 Tidal Set and Drift at the Coronation Offshore Site 26/6/2011

Time Ref to HW Plymouth	Time	Height Above CD	Direction (Set)	Drift Neaps (Knts)
-6	08:27	2.1m	236°	0.4
-5	09:27	2.4m	264°	0.3
-4	10:27	3.0m	316°	0.3
-3	11:27	3.5m	031°	0.2
-2	12:27	3.8m	047°	0.4
-1	13:27	4.3m	053°	0.5
HW (14.27)	14:27	4.4m	081°	0.5
+1	15:27	4.3m	111°	0.4

8.2 Passage Plan from Mountbatten to Coronation

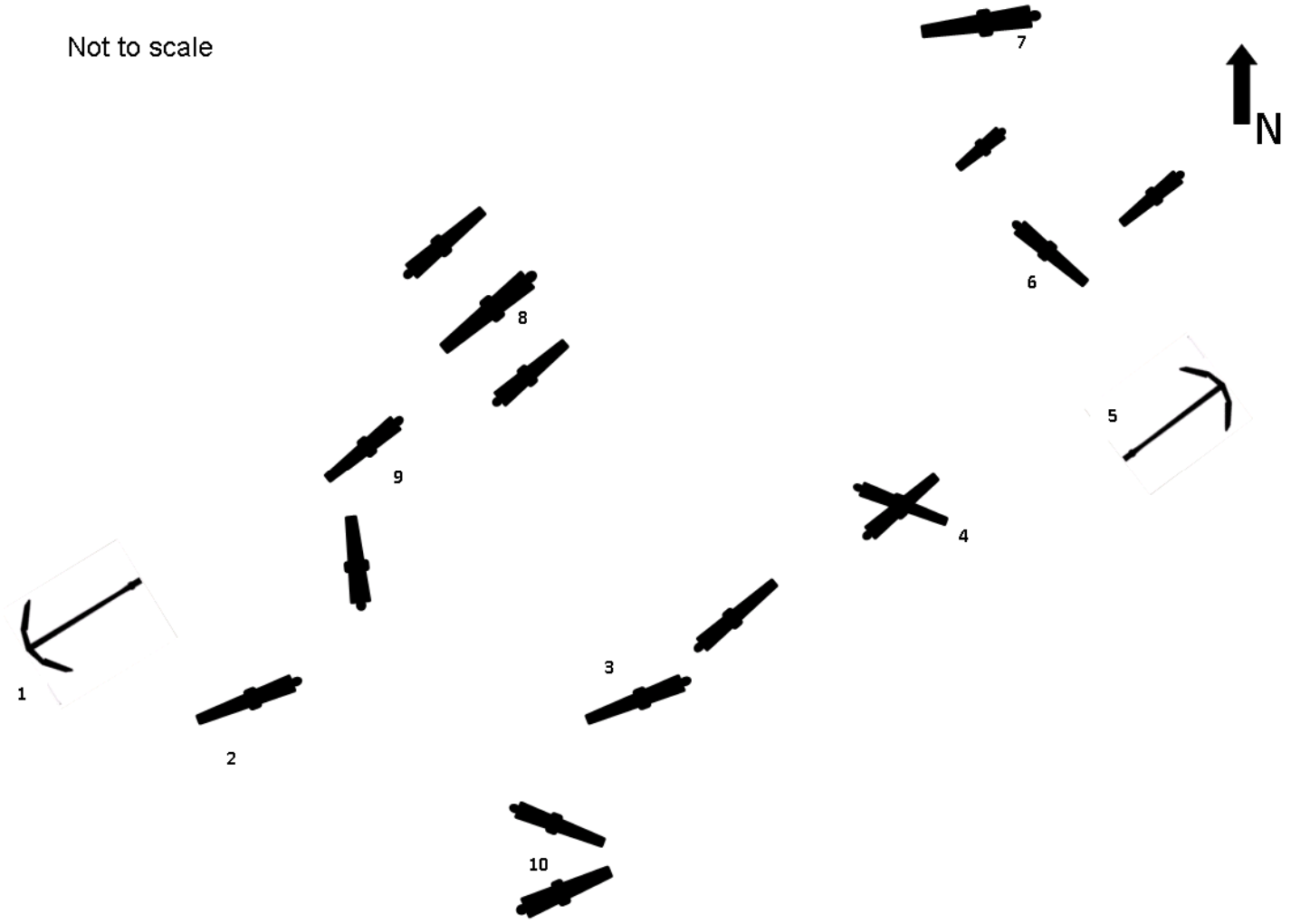
WP #	From waypoint name	Position	Transit to (name)	Brg (T)	Brg (M)	Distance (Nm)	Leg time (mins)*	Arrival time	Comments
	Pontoon		Mountbatten Breakwater	-	-	-	10	09:10	Pilotage to breakwater
1	Mountbatten Breakwater	50 21.56N; 004 08.18W	Western end of Plymouth Breakwater	215	218	1.8	14	09:24	
2	Western end of Plymouth Breakwater	50 20.10N; 004 09.69W	Red lateral buoy off Penley point	219	222	1.6	14	09:38	
3	Red lateral buoy off Penley point	50 18.85N; 004 11.10W	Coronation	251	254	0.7	5	09:43	
4	Coronation	50 18.70N; 004 12.10W	Red lateral buoy off Penley point	035	038	0.7	5		
3	Red lateral buoy off Penley point	50 18.85N; 004 11.10W	Western end of Plymouth Breakwater	039	042	1.6	14		
2	Western end of Plymouth Breakwater	50 20.10N; 004 09.69W	Mountbatten Breakwater	071	074	1.8	14		
1	Mountbatten Breakwater	50 21.56N; 004 08.18W	Pontoon	-	-	-	10		Pilotage to pontoon

*8 knot travel speed assumed at all times

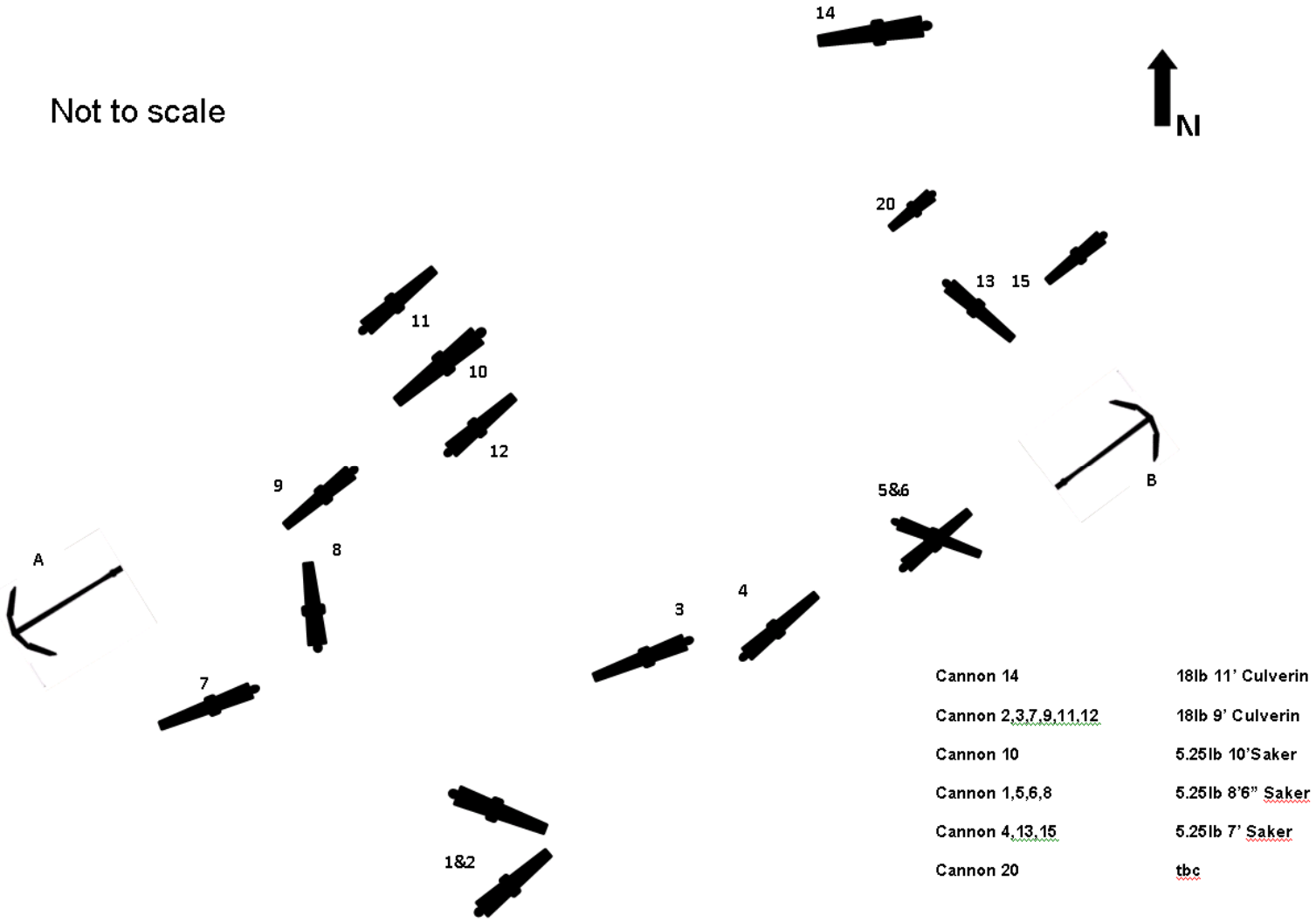
8.3 Dive Log Details 26th June 2011

Wave	Dive	Name	Cylinder Capacity	Mix	Gas in	Gas out	Time Down	Time Up	Max Depth	Dive Time	Stops
1	1	Louise Whitehouse	2x12	21	220	150	09:57:00	10:41:00	17.1	44	3@6
1	1	Ginge Crook	2x10	21	240	140	09:57:00	10:42:00	17	45	3@6
1	1	Mark Wilson	2x12	21	220+170	150+110	09:57:00	10:42:00	18	45	3@6
1	1	Mark Mumford	15	21	250	130	09:57:00	10:41:00	18.6	44	3@6
2	1	Colin Yule	2x12	25	230	130	11:04:00	11:51:00	17.4	47	3@6
2	1	Alun Newsome	15	21	230	70	11:04:00	11:51:00	17.4	47	3@6
1	2	Mark Wilson	2x12	21	150+110	70+70	13:26:00	14:01:00	20	35	3@6
1	2	Ginge Crook	2x10	21	130	50	13:26:00	14:01:00	20	35	3@6
2	2	Alun Newsome	15	21	220	100	13:30:00	14:05:00	18.7	35	3@6
2	2	Colin Yule	2x12	25	130	70	13:30:00	14:05:00	18.8	35	3@6

8.4 Site and "Diver Trail" Station Map With Buoy Numbers

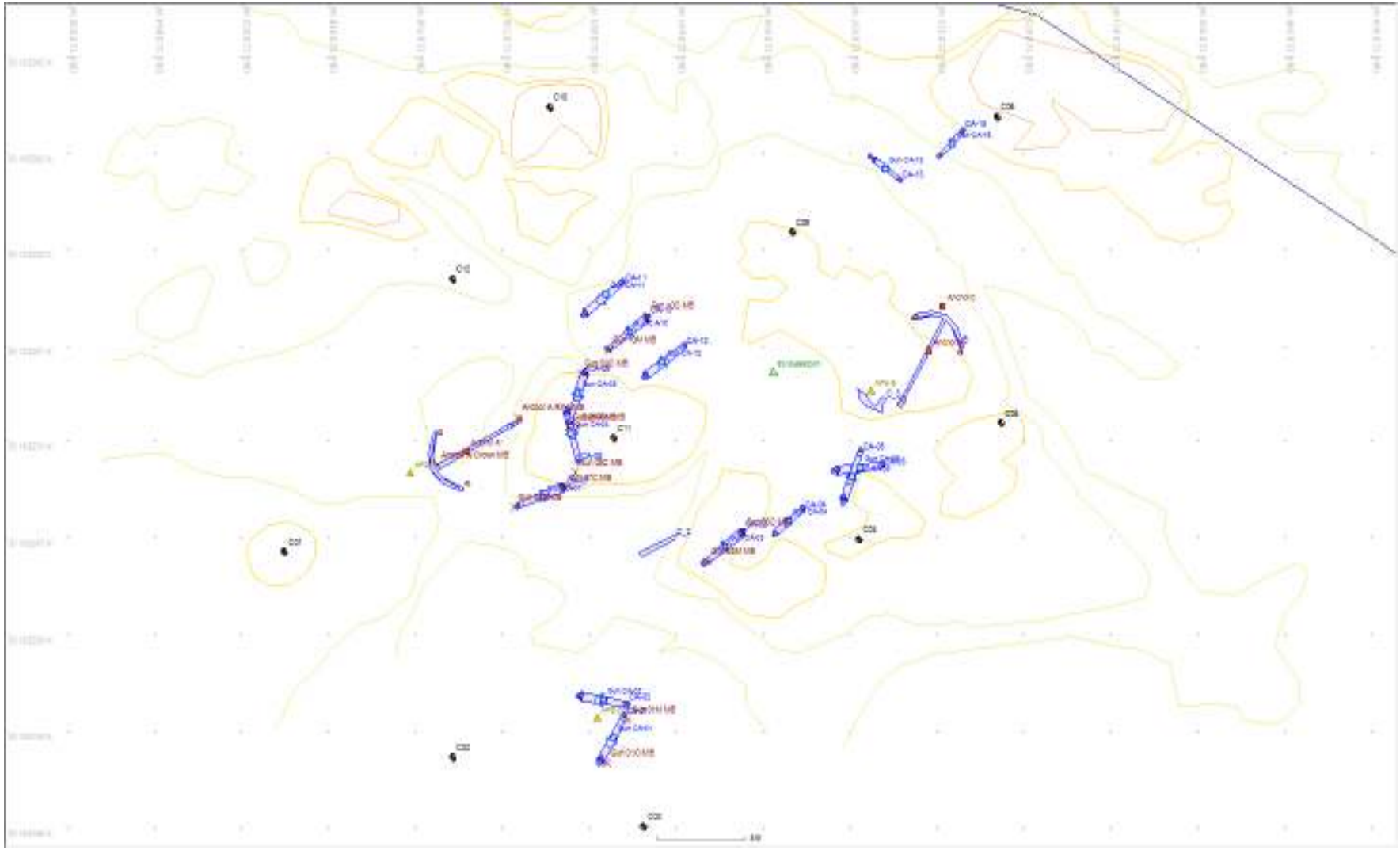


8.5 Cannon Map

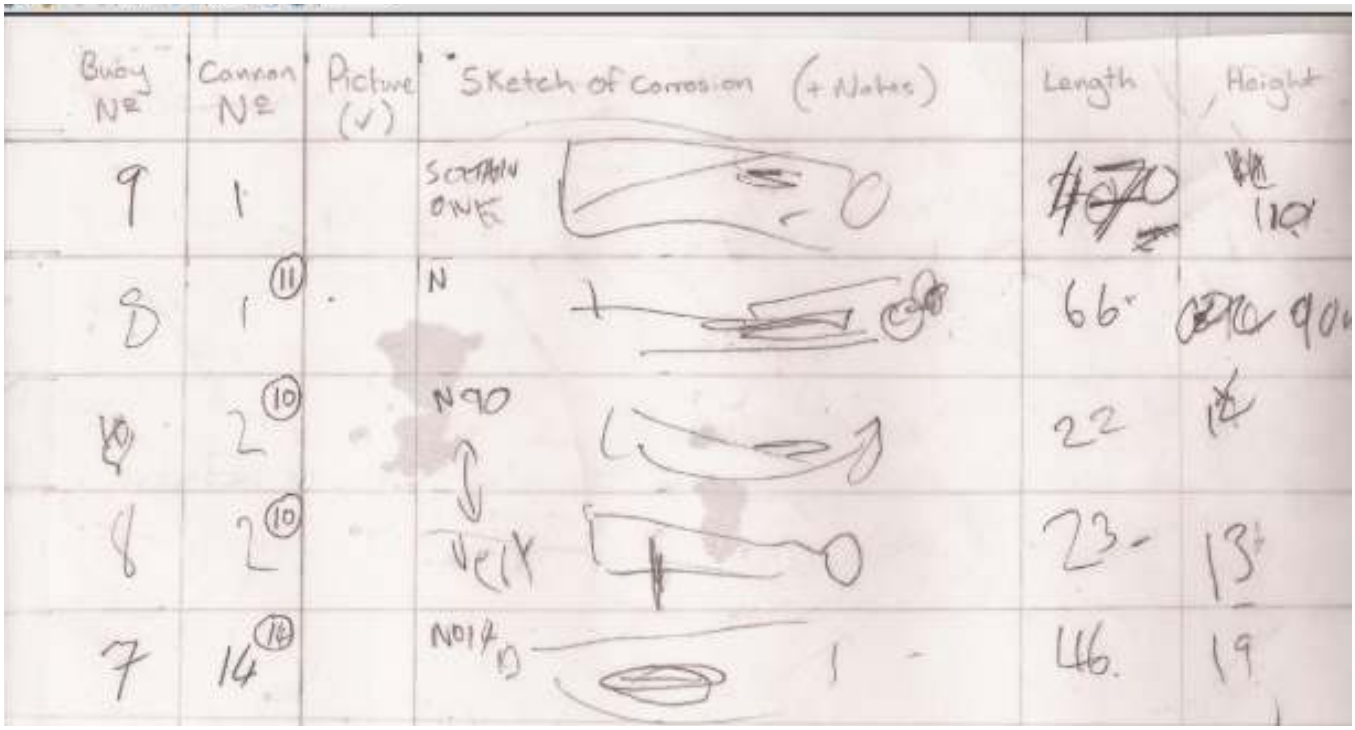


Cannon 14	18lb 11' Culverin
Cannon 2,3,7,9,11,12	18lb 9' Culverin
Cannon 10	5.25lb 10'Saker
Cannon 1,5,6,8	5.25lb 8'6" Saker
Cannon 4,13,15	5.25lb 7' Saker
Cannon 20	tbc

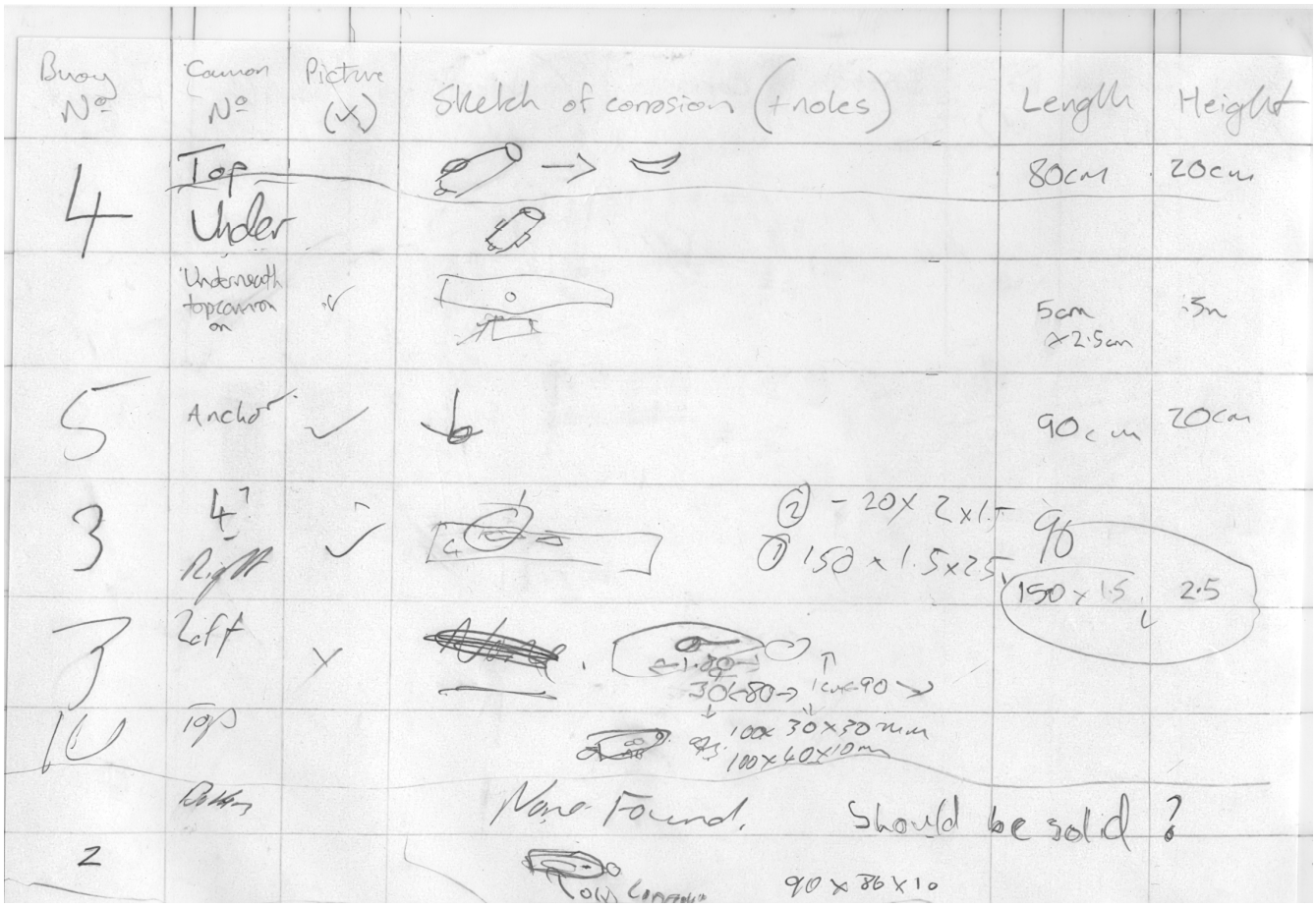
8.6 Datum Map



8.7 Raw Data (Slates)



Buoy Nº	Cannon Nº	Picture (✓)	Sketch of Corrosion (+ Notes)	Length	Height
9	1		SCATTERED ONES	470	110
8	1 (11)		N	66	90
10	2 (10)		N90	22	
6	2 (10)		VERY	23	13
7	14 (14)		NOISY	46	19



Buoy Nº	Cannon Nº	Picture (✓)	Sketch of corrosion (+notes)	Length	Height
4	Top Under			80cm	20cm
	Underneath top cannon on	✓		5cm x 2.5cm	5cm
5	Anchor	✓		90cm	20cm
3	4 Right	✓	② - 20 x 2 x 1.5 ① 150 x 1.5 x 2.5	150 x 1.5	2.5
7	Left	X	30 x 80 → 1 cm = 90		
10	Top		100 x 30 x 30 mm 100 x 40 x 10 mm		
	Bottom		None Found. Should be sold?		
2			90 x 86 x 10		