Scapa Discovery: Archaeology in the Flow

A survey of the site of the remains of an unknown pinnace near Lyness.

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Photo Credits

BA, Bob Anderson
JP, Jo Porter
SW, Simon Waldman
KH, Kevin Heath
RS, Richard Shucksmith
GS, George Stoyle
RG, Rebecca Grieve
JK, Jenni Kakkonen

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1. Abstract

The wreck site of a pinnace was first formally documented in the Scapa Flow 2013 Marine Archaeology Survey.

In this Scapa Discovery survey the site was further investigated using teams of divers. Data collected included tape measurements from known reference points for later analysis in Site Recorder, photographic images for later use in video mosaicing and log sheets/notes from the dives undertaken. Environmental surveys were also undertaken with professional marine biologists using standard MNCR Phase 2 survey forms and volunteer divers using the Seasearch Survey level method. In situ recording was further supported by the use of macro photography for representative fauna and flora. Video mosaic techniques were employed to stitch images together to create a photographic site record.

Information from the historical archive was collected by Kevin Heath and this information included in the report.

Keywords: Pinnace, Scapa Flow, photomosaic, Rinnigal, scuba, NAS

2. Introduction

This Scapa Discovery project began when a small group of divers undertook NAS 1 training in Orkney in January 2012. The group had good diving experience and a wide variety of skills in other disciplines but not in archaeology itself.

Having completed the NAS 1 course, a project was sought to consolidate the skills learned and to gain experience. A fortuitous conversation with Phil Robertson at Historic Scotland highlighted the pinnace which had come into focus on the Scapa Flow 2013 Marine Archaeology Project.

The pinnace fulfilled a number of important criteria: the site was largely forgotten, little was known about the wreck, the project was small with easily definable and achievable objectives yet the depth was shallow allowing for simple dive planning and logistics. The pinnace also has a certain curiosity about it which is strangely beguiling and a good hook to engage participation.

The challenge therefore was to explore a new field and to see if previous survey skills could be successfully applied to an archaeological project whilst learning a new set of skills.

3. Background

Scapa Flow is an important historic site and was an important strategic anchorage for the British Navy during both wars. Furthermore, the German High Seas Fleet was interned here during the WW1 armistice negotiations and subsequently scuttled (Hewison, 2005). A significant recreation diving industry has grown in Scapa mainly to dive the wrecks of the German High Seas Fleet.

There are also many ancillary dive sites associated with the war effort which have been recorded in a number of reports, the most recent relevant one being that by Christie, Heath and Littlewood (2013). The pinnace wreckage site came into focus during the Scapa Flow 2013 Marine Archaeology Project and was considered to merit further investigation.

On 9th May 2014 a team of 8 divers surveyed the site and then another 2 divers returned on the 11th November 2014.

At the time of survey the pinnace lies on its port side in 14m depth water (MLWS) just off the ruined Rinnigal Pier near Lyness. The Scapa Flow 2013 Marine Archaeology Project (Christie, Heath and Littlewood, 2013) lists the site as 58 49.71N 003 10.94W. In our survey a revised position of the pinnace at 58 49.716N 003 10.927W was recorded; this position was taken from directly above the aft end of the shaft.

The pinnace sank on her port side with the bows pointing east. Over the years she has slowly disintegrated. The shaft, engine boiler and some hull remain, slightly buried in a muddy seabed with the highest point 2m above the seabed.

The anecdotal record points to the pinnace being British as Admiralty pattern marks were seen on the bell supposedly recovered by a local scallop diver. An old unattributed photograph documented the maker plate on the boiler which matched some records in the archive. Little else is known about the history of the boat, adding to the interest of the site as a subject for further investigation.

Careful consideration was given to the diving operation itself. Scapa Flow has no volunteer diving archaeology program at present despite there being a strong recreation diving industry, a long history of research diving and a good volunteer Seasearch program. The location, size and depth of the site suggest that it would make an ideal training venue for future possible NAS/underwater training courses. A view to future project possibilities was considered at the outset and built into the schedule. It is hoped that this survey highlights the potential and serves as a pilot / scoping project.

Research questions

The wreck site was explored to discovery a number of potential research questions:

- What was the story of this pinnace?

  Very little is recorded about this pinnace so it would be interesting to know some of her history, where she was made, what ship she served, what she did do during her service life and how she came to be on the seabed.

- How was the pinnace constructed?

  This small boat was a class that had a time in history and doesn't exist any longer so it would be interesting to know about her construction, the machinery that powered her and any features unique to her role.

- What influence does the wreck have on the fauna and flora of the area?

  The wreck site is a hard substrate on a sediment seabed. These are two differing habitats and it would be interesting to know what influence the wreck has on the environmental conditions influencing the animals of the area. The presence of the wreck structure provides some protection from human activities so there was interest in understanding more about the importance of this role. This is especially significant because this site acts as a small scale model to inform future studies of wider scope on the larger wrecks.

- Can volunteers lead a project to research a study site of their own choosing and produce valid results?

  Volunteer groups are a rich source of enthusiasm and knowledge albeit it in disparate fields of expertise. This project was a test to see whether a small group could harness collaboration throughout a wider community. The project needed to be safe, enjoyable, engaging and worthwhile for the participants giving divers at the grass roots a sense of involvement in the research and consequently the decisions that sprung from that research.

4. Aims

The aim of this preliminary survey was to conduct a survey of the pinnace and surrounding environment using a variety of approaches to answer the outlined research questions.

The objectives included:

1. To record, measure and image the remaining structures left on the seabed.
2. To record the flora and fauna directly supported by the pinnace remains.
3. To record the flora and fauna at a distance from the pinnace for comparison.
4. To publically disseminate the information gathered to a wide audience.
5. To develop a community driven project using amateur divers on a volunteer program.

5. Methods

Dive day 1, 9th May 2014: The group was split into 4 teams and tasks allocated as follows

Team		***Task***
Bob Anderson Jo Porter		1. Set up baseline, identify measurement datum points and then take measurements of the structure.
George Stoyle Richard Shucksmith		1. Take wide angle photographs to illustrate the structure. 2. Experiment with techniques with a view to image mosaic the structure.
Rebecca Grieve Hamish Mair		1. MNCR Phase 2 Survey and macro photography on the structure to identify and record the biology using the SACFOR scale of abundance.
Bill Sanderson Jenni Kakkonen		1. MNCR Phase 2 survey just off the wreck as a control comparison again using the SACFOR scale. 2. Two Seasearch Surveys, one on and one off the wreck.

Each team spent around 40mins in the water on a single dive recording their objectives with a slate or camera. The dives went without incident and the data successfully recorded. All dives were conducted under the Scientific and Archaeological ACoP. Log sheets for the dives can be found on the website as PDF documents available for download, along with Project Plan and Risk Assessments.

Dive day 2, 11th Nov 2014: A single team of two divers conducted 2 dives of around an hour each.

Team		***Task***
Bob Anderson Jo Porter		Trial different lens combinations Trial different tape measure techniques.

These were volunteer dives outwith 'Work' so not subject to the ACOPS.

6.1 Archaeology results

6.1.1. Site recorder results

Team 1 made a crude site map, set in place 4 datum points and took a number of measurements to prominent points on the wreckage. This data can be found in 11. Appendix.

The crude site map is displayed below:

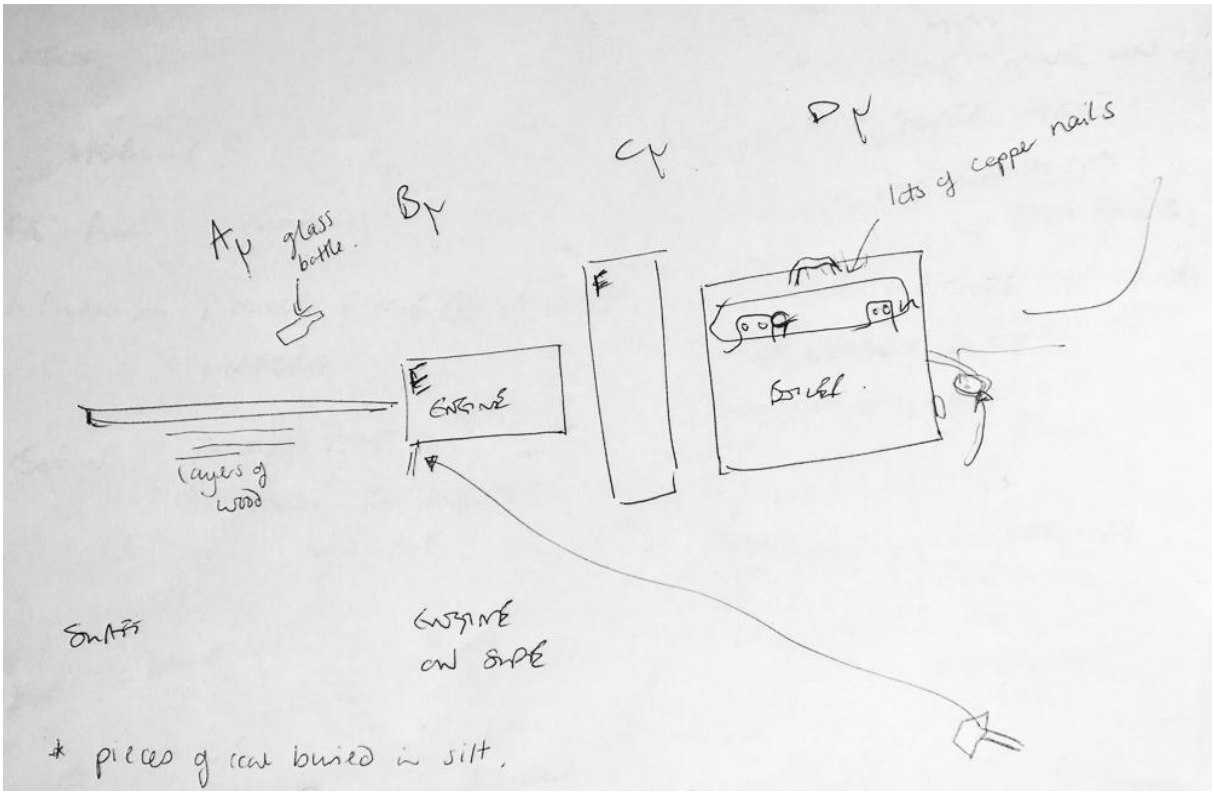

Image 1. Map showing relative position of datum and measurement points.

The points A,B,C,D were datum points marked using steel pins about 2ft long that were hammered into the seabed. The points E,F,G,H were prominent points on the wreckage.

Measurements were taken between these points and the data entered into Site Recorder.

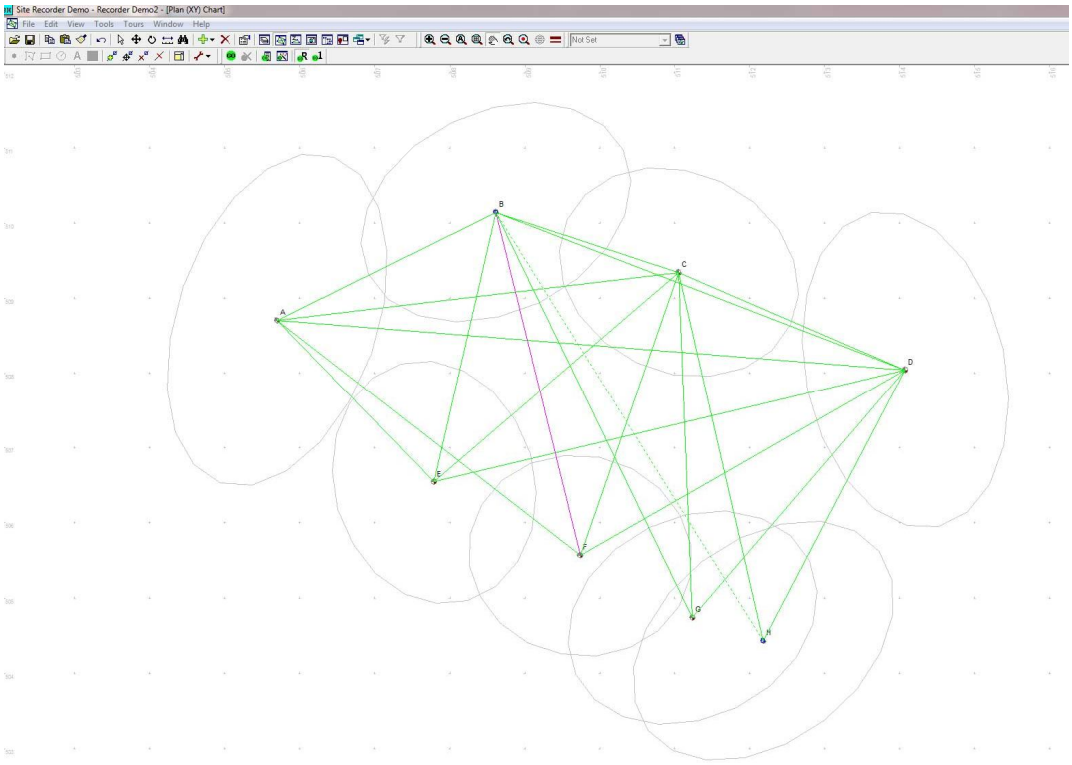

Image 2. The results from the Site Recorder software.

Output from Site Recorder

The control points and survey points were entered into the Site Recorder Demo Version. Measurements were added in between the points. The raw data is supplied at 11. Appendix 1.

The results seem satisfying given that errors are generally all green therefore within tolerance bar one measurement. As a reminder, this was the teams first attempt at the task. Most of the limitations come with the constraints of using a Demo version of Site Recorder.

The control points are all relative rather than absolute so the gps lat/long position is not calibrated with the other control points. It was felt that until a suitably accurate protocol for taking a gps position down through the water column is devised, this correlation is best left absent.

The results are felt to be a useful first step: much was learned about the methodology and a better idea gained of the issues needing consideration prior to entering the water.

Location of the wreck

The wreck was located by echo sounder and a shot line tied to the stern on the shaft by the A Frame. The shot was pulled taught and a gps position recorded whilst the gps aerial was as close to the shot line buoy as possible. The boat has two different gps units both recording positions to 3 decimal point accuracy. Positions were recorded from both and are presented here:

GPS positions

	Stern	***Bow***
GPS unit 1	58° 49 714N 003° 10 919W	58° 49 709 N 03° 10 933 W
GPS Unit 2	58° 49 716 N 003° 10 923 W	58° 49 710 N 003° 10 936 W

These were then plotted onto a GIS layer on the Admiralty chart.

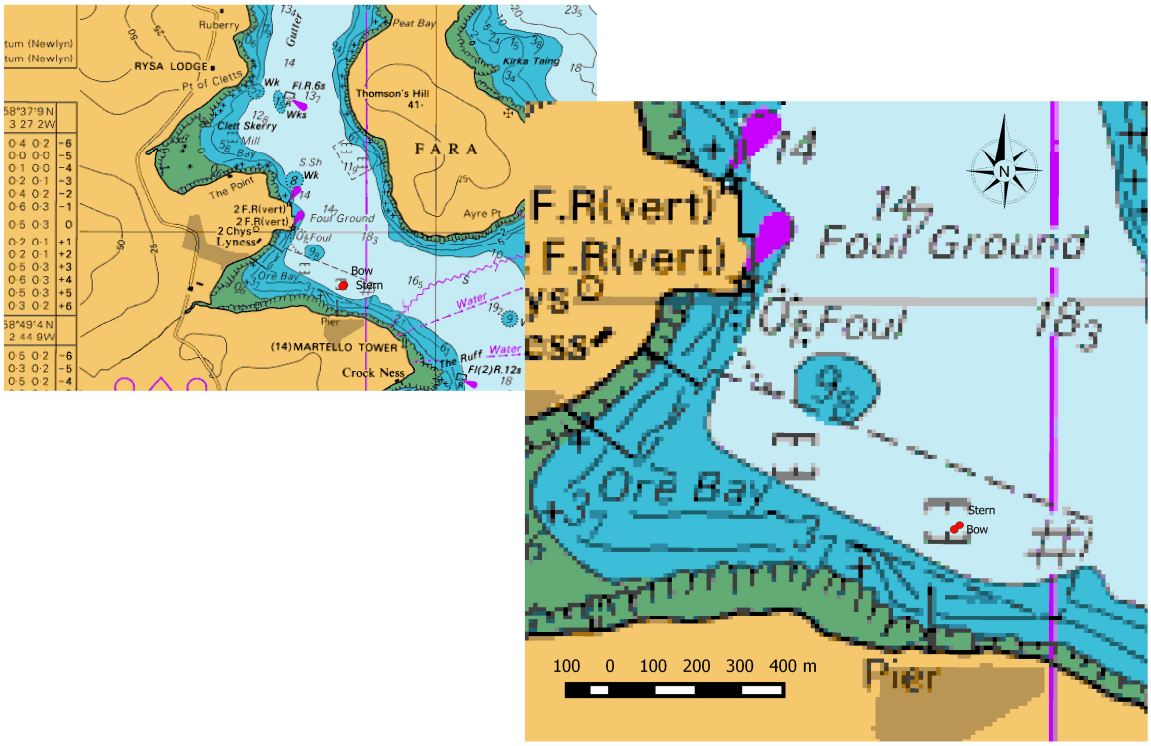

Image 3. A map showing the position of the pinnace wreck site.

Further work is needed to develop a working protocol for taking a more accurate position of an object up through the water column to a recording device on the surface and eliminate parallax error.

Side scan image

The side scan image is included for completeness.

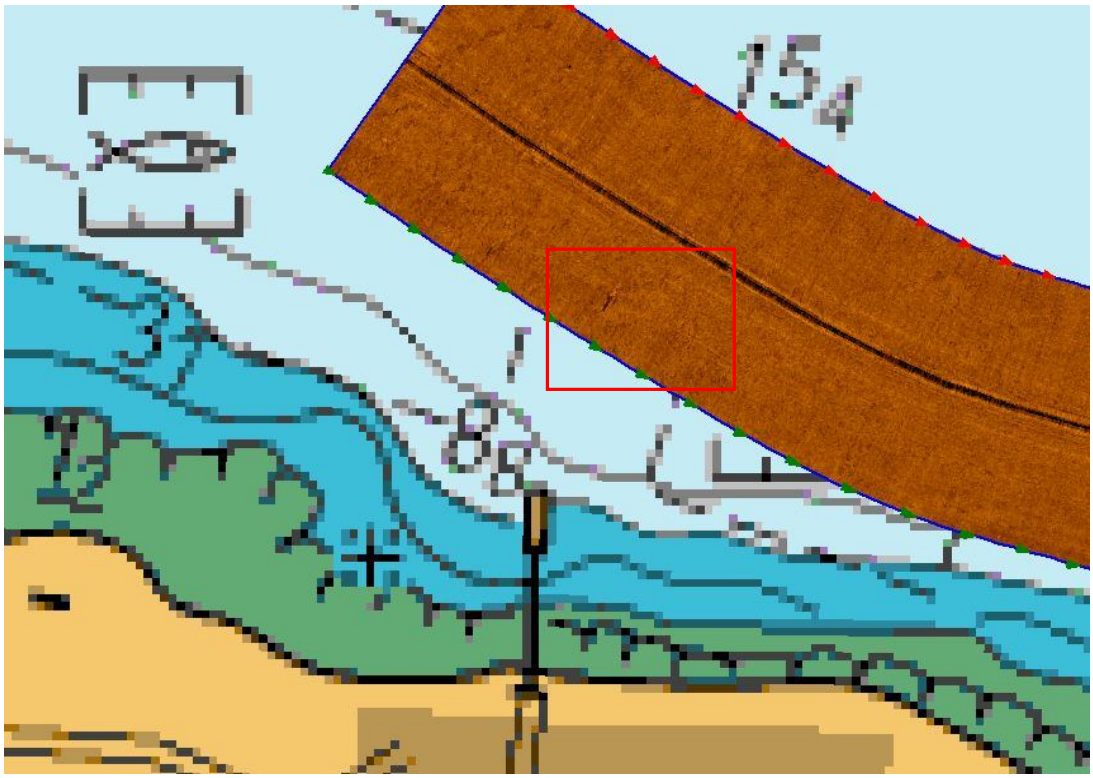

Image 4. The track of the side scan recording undertaken by Kevin Heath

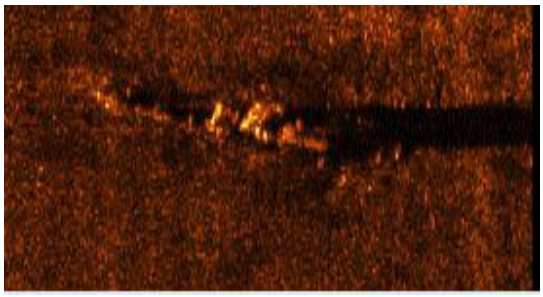

Image 5. A close up of the pinnace site side scan.

Site Recorder Discussion

As this was the first time that a full survey had been undertaken by the participants since passing the NAS 1 course, there were many things to learn. The objectives were kept simple and to a minimum. The measurements occupied all of the 50 minute dive time to record. Different techniques required to maximise accuracy were explored and recorded for future implementation.

Survey discussion

A number of positives on the survey were noted:

1. The number of measurements allocated was about right for the dive time.

2. The depth was deep enough to be free from surface disturbance but not so deep as to be limited by decompression burdens or air management.

3. The site was an ideal size, small enough to be easily manageable, visualised and navigated but substantial enough to provide interest and a sense of what the structure would have been.

4. There were significant unknowns that added interest and a sense of purpose.

A number of pitfalls were noted:

1. The measurement points were not always in sight of each other causing confusion at one point.

2. The site was silty with an overlying layer of drift seaweed; care was required to maintain a good level of visibility.

3. The relative inexperience of the team for this type of survey meant that some aspects of the survey were conducted on a trial and error basis. This provided good opportunities for adapting and improving the method as we progressed. It was useful that team members already had a good working knowledge of other types of underwater survey method, this provided useful experience to fall back upon where necessary.

4. The datum recorded by GPS was directly above the end of the shaft, measured up a taught shot line and then set by the boats GPS. Unfortunately this point was not correctly correlated to the other datum points on the seabed nor directly assessed for pinpoint accuracy with the aerial on the GPS which will lead to inaccuracies for extrapolated points later.

Site recorder output discussion

Several key problems were identified.

1. The Demo version of site recorder was used as the cost of a licensed copy was beyond the scope of this project. The limitations imposed were restrictive on the output.

2. The team's inexperience of the software further limited output which was unfortunate as the NAS1 course gave a good grounding in the Site Recorder software.

3. There was a feeling that this mechanism to gather and enter data was time consuming, prone to inaccuracy and lacking in scope. Given the modern technologies of side scan or multibeam sonar, maybe there are better techniques that would give a richer data set with greater accuracy in less time.

Recommendations

1. It would be useful to have a full copy of Site Recorder available to any project and to have the data gathered on site entered as quickly as possible. Any errors could therefore be quickly identified and addressed during the dive day. Given the cost of Site Recorder, this could be considered within any future funding application or an application made to the developer for a free copy in lieu of the voluntary nature of the project.

2. A further training day would be valuable for the team. An experienced operator present to guide the team during early practical trials would be invaluable. Pitfalls and problems could be quickly addressed and revised working protocols identified.

6.1.2 Photography results

Photomosaic 1

Team two made a photographic record and collated the images into the photomosaic (see Image 6).

The task was trialled with multiple photographers with different photographic rigs using slightly different techniques. Each process produced roughly equivalent results demonstrating the robustness of the technique.

The process was found to be relatively quick and efficient yielding good information. However, the large amount of data was subsequently time consuming to process with the quality of output directly correlated to the care taken to compile the multiple images.

This was the first time the team had attempted to mosaic a wreck so there was a steep learning curve. Initial results were pleasing. The raw images were simply imported into Photoshop and the process was left to the software to complete the final output. Generally the software worked well and it was possible to successfully create a composite image that was broadly correct and compiled in a relatively quick time.

The final composite image clearly shows the pinnace lying on its side and the major components are easily identified. One issue to highlight is that the final image is 166cm long at its widest point and so is not easily scaled to A4 size for insertion into this report. A large copy has been put online for proper investigation.

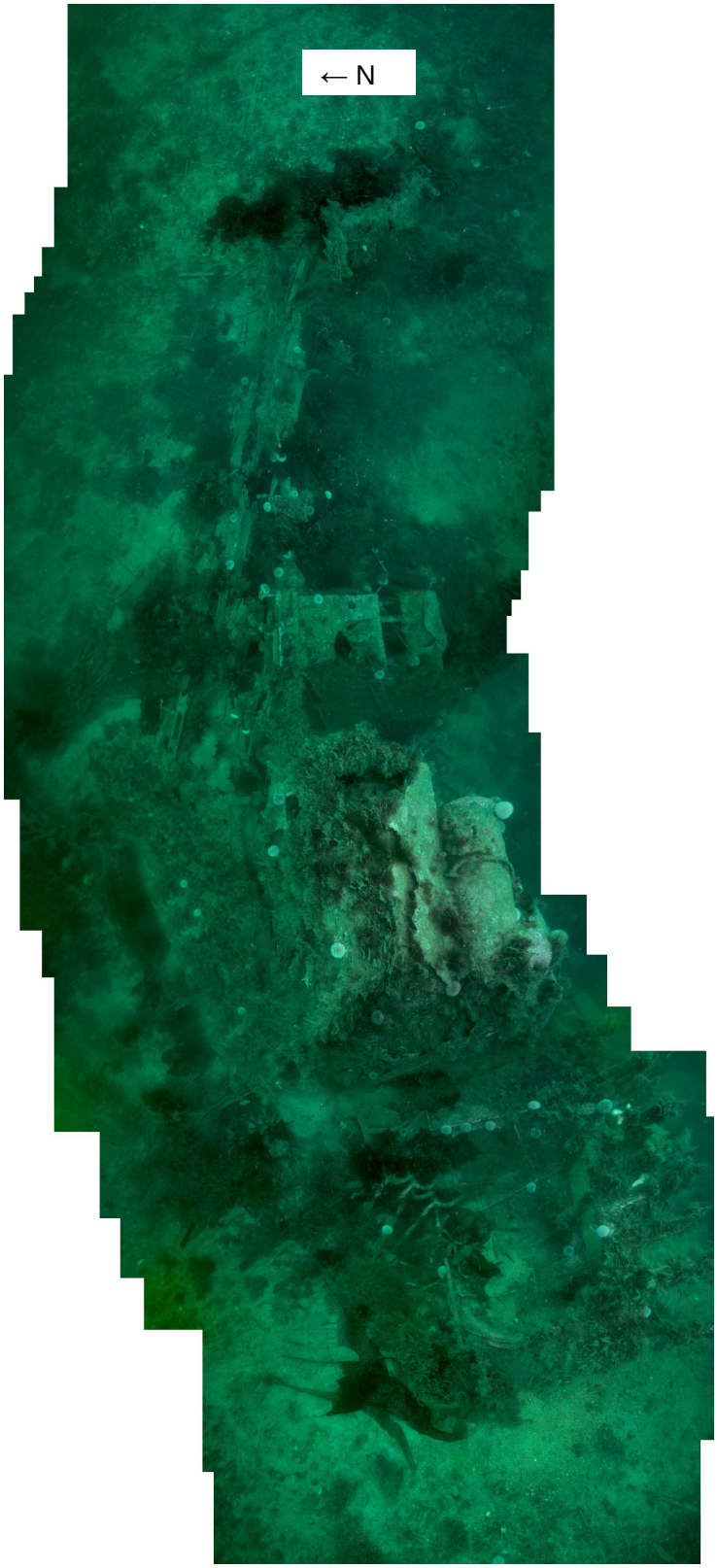

Image 6. A photomosaic to show the pinnace wreck site

Photomosaic discussion

A number of problems were encountered:

On closer examination, it can be see that the software has made a number of errors and stitched some images incorrectly. The fuel tank is absent, some features are duplicated and there is a distortion of the image. There are dedicated mosaicing software programs that could perform this task more effectively and these could be utilised in the future.

There were some issues with data overload. The composite is formed from some 50 images all around 10MB in size. The final image is 166cm long if printed. All these factors can swiftly become unwieldy. The mosaic needs to be revisited with a greater manual input to resolve some of the image overlay errors. Underwater images lack the contrast and definition that the software requires to accurately compute the stitching process. This will always be a problem and the only foreseeable solution is greater manual intervention which in turn makes the imaging take longer. However, the fact that the software can make such a good interpretation on first pass is incredible really and a real testament to the power of Photoshop.

Different lenses were trialled. Underwater photographers typically have two lenses in their bag: Tokina 10 – 17mm fisheye or a 60mm Macro. These lenses were trialled in the first instance rather than buying something especially for the job. Fisheye lenses allow a wider view when close but distort the image. This distortion needs to be corrected before the image can be mosaiced. The macro lens has a smaller angle of view therefore more images need to be taken to cover the area. Neither were entirely suitable so the next step is to trial a rectilinear wide angle lens in the region of 12mm focal length.

The composite image shows some distortion. This is a function of the software trying to reconcile multiple images and applying a free transform in order to make them match. If a baseline grid or reference was laid over the wreck, this could be corrected in post processing.

Seaweed has obscured some of the detail and some effort should be put into clearing the site of loose weed prior to photography in future sessions.

Photomosaic 2

Another day was spent on site with a view of implementing some of the above feedback, trying to refine the technique further and to gather any missing data from day 1.

Hull mosaic, close up results

An attempt was made to use a 60mm macro lens to record the mosaic photographs. This is a rectilinear lens so there is no distortion to correct. However the viewing angle is quite small at the best working distance so many more images were required.

The following image is a composite of 12 photographs taken with a 60mm lens. The final rendering of the mosaiced image was done with no manual intervention and this image demonstrates the full power of Photoshop.

The results are satisfying and relatively easy given the resources available.

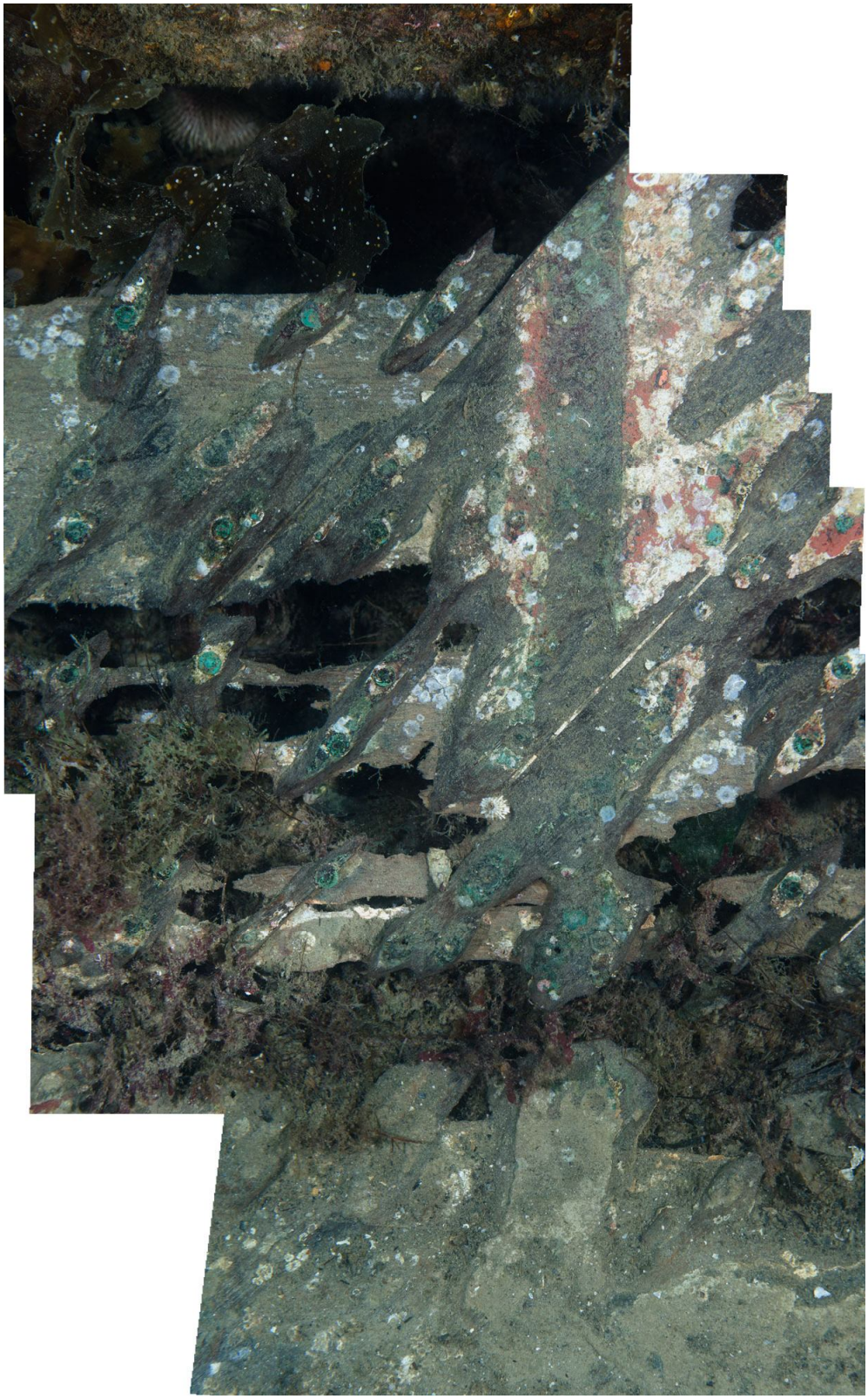

Image 7. A photomosaic of 12 stitched images to show the diagonal planking construction of the hull.

This mosaic clearly demonstrates the following characteristic features.

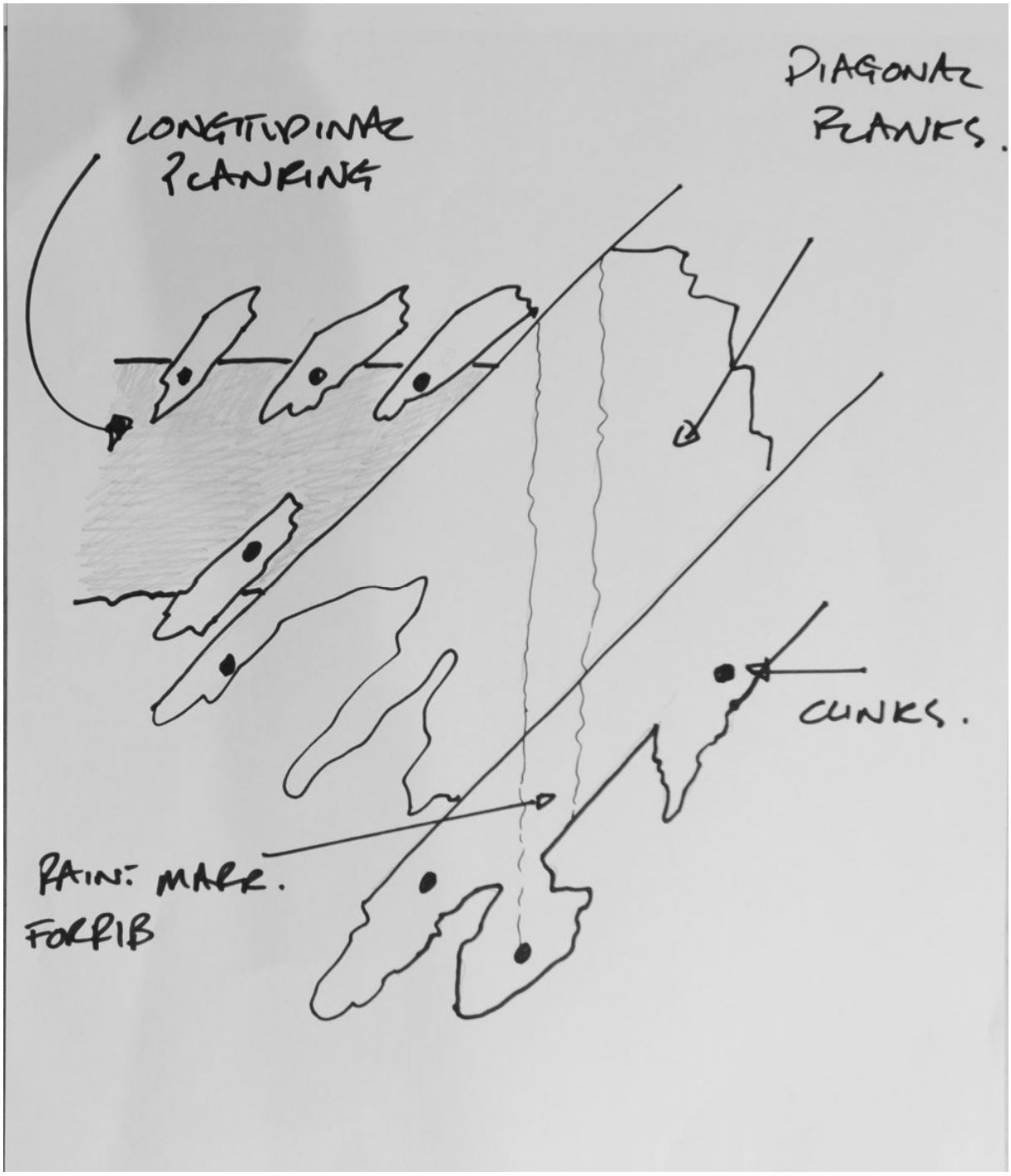

Image 8. A sketch of the photomosaic image of the hull close up to highlight relevant features.

Hull mosaic, close up discussion

The hull construction of the pinnace is unusual and distinctive. In order to understand the construction a brief explanation is required.

When the boat was built, a keel would have been laid down. From the keel, ribs would have been attached to give the shape a rounded, hydrodynamic form and internal volume. A row of planks would have been run from bow to stern on the ribs and attached running at approx 45 to the floor. This initial hull would then have been covered with two layers of calico. A further layer of planks would have been adhered to the calico using marine adhesive and running parallel to the ground. Nails called clinks would have been passed through the planks and ribs and then both ends hammered flat to form a 'rivet'.

This form of hull absorbs bumps well and gives a relatively lightweight robust construction. In addition, the hull stays watertight despite the boat remaining out of the water for considerable periods of time and in often in hot weather which would have caused the planks to shrink and thus leak in other forms of construction. However, when damage is done, it is complicated both to find and to repair.

The two diagonal layers of planking and the remains of the clinks (nails) are evident here. The old paint marks indicate that a rib would have been attached at this point but has subsequently been lost. These features are key indicators helping to target a specific identity for the wreck and correlate with the ship builder's information. There was no evidence of the calico membrane.

None of the individual photos demonstrate this characteristic as clearly as the composite. At this level photo mosaic has a clear benefit. The future requirement is to scale the technique up to a site level.

A second sequence of photos was taken of the engine block. There were 47 images that were aligned manually before an automatic stitching within Photoshop. By manually arranging the photos close to where they should be in the overall image some of the stitching computation was taken away from Photoshop which seemed to improve the output despite lengthening the workflow.

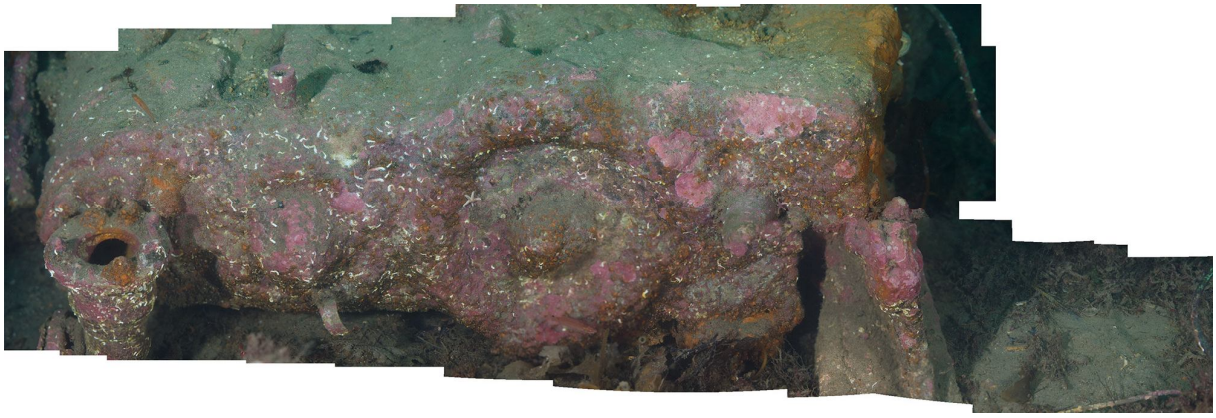

Image 9. A photomosaic of the top of the cylinder block on the engine. This is the small image size, the full size version can be found in the files section of 11. Appendix 2.

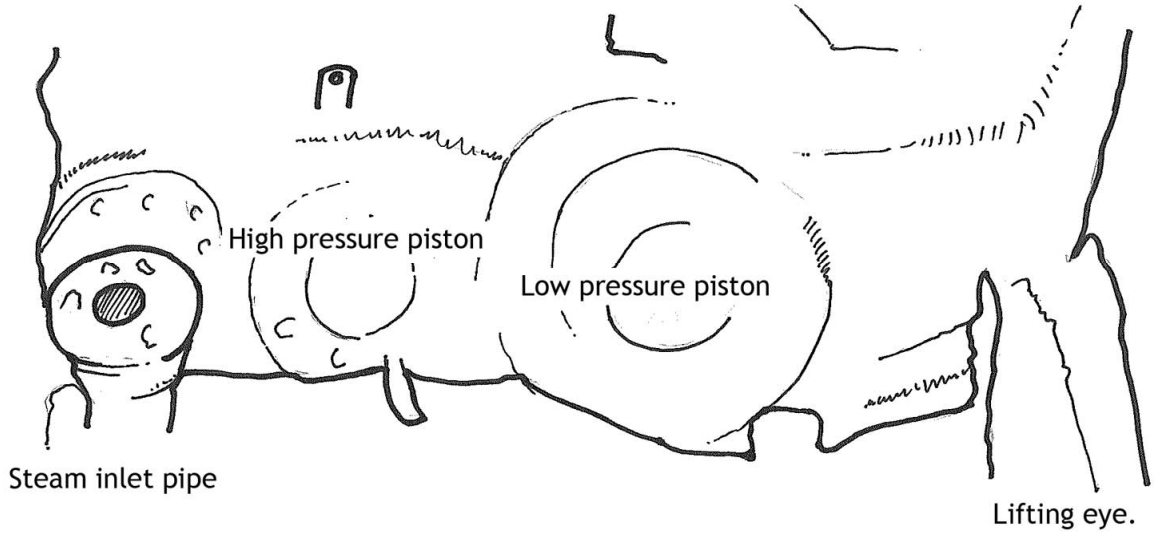

Image 9a. An explanation of Image 9, the top of the engine photomosaic..

A number of points of note are offered for future reference.

In order to gain sharpness in the images, as high a shutter speed as possible was used. In this instance it was 1/250sec which is the flash sync speed. However, this impacts the aperture which in turn limits depth of field. Many of the images have a depth of field measured in cm so areas of the image are blurred. This can be offset by careful consideration of the order in which photos are taken and then by further consideration of the y axis when the images are stacked. Stacking algorithms within mosaic stitching software have a far more accurate ability to focus stack images than can be done manually, another reason for automating the process as far as possible. However, this is a consideration that needs to be borne in mind right at the outset and integrated throughout the entire workflow from in-water to desktop.

6.1.3 Site map.

All the techniques were used to produce site maps.

Site map, site recorder results

Site recorder technique required a whole dive for two people to locate and measure 4 points on the wreck against 4 datum points.

The dive produced

- site recorder output , see 6.1.1 above.
- crude sketch map, see Site Map 1 below
- rough dimensions, see Site Map 2 below

The sketch in Site Map 1 covers the main features of the wreck and offers an illustration of the site.

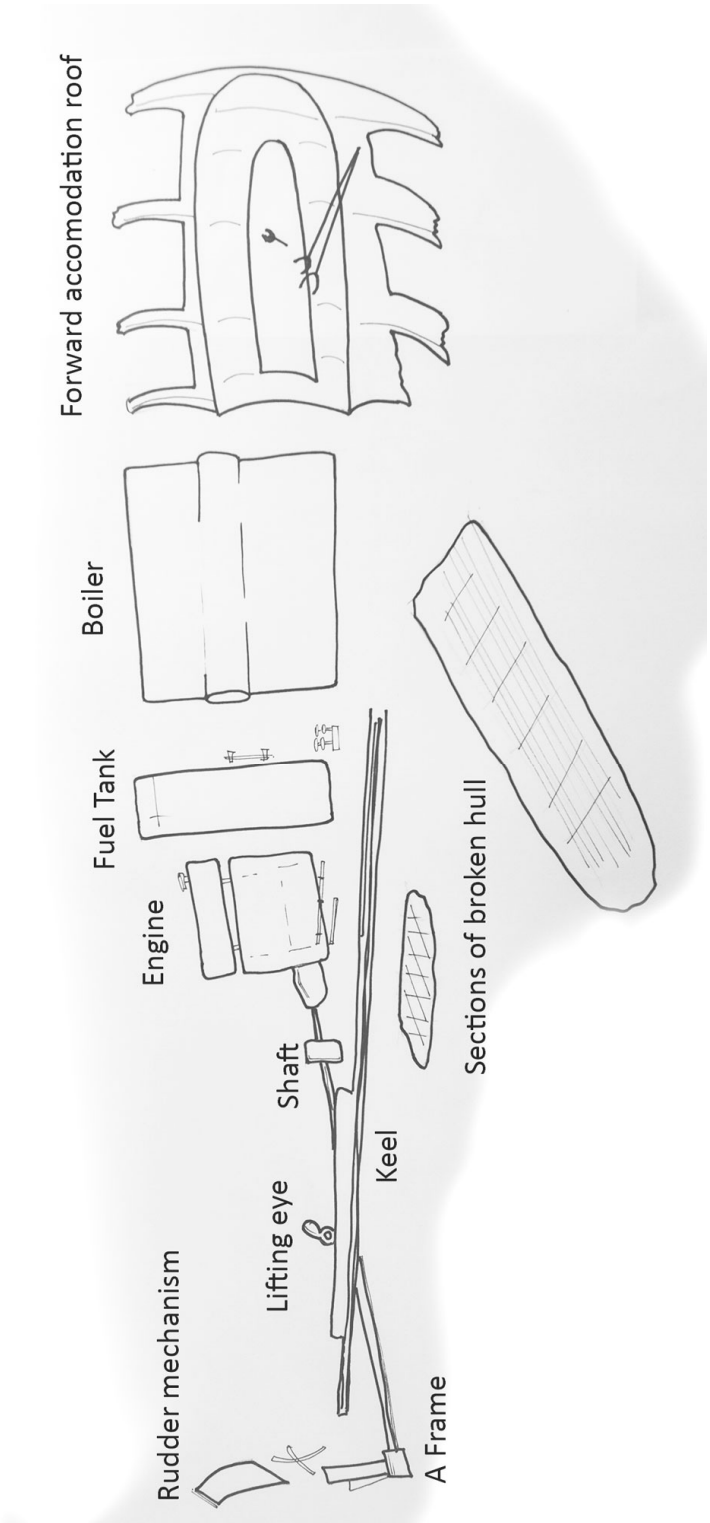

Image 10. Site Map 1: Site map made during Dive 1 by Team 1 during Site Recorder exercise labelled to show important wreck features.

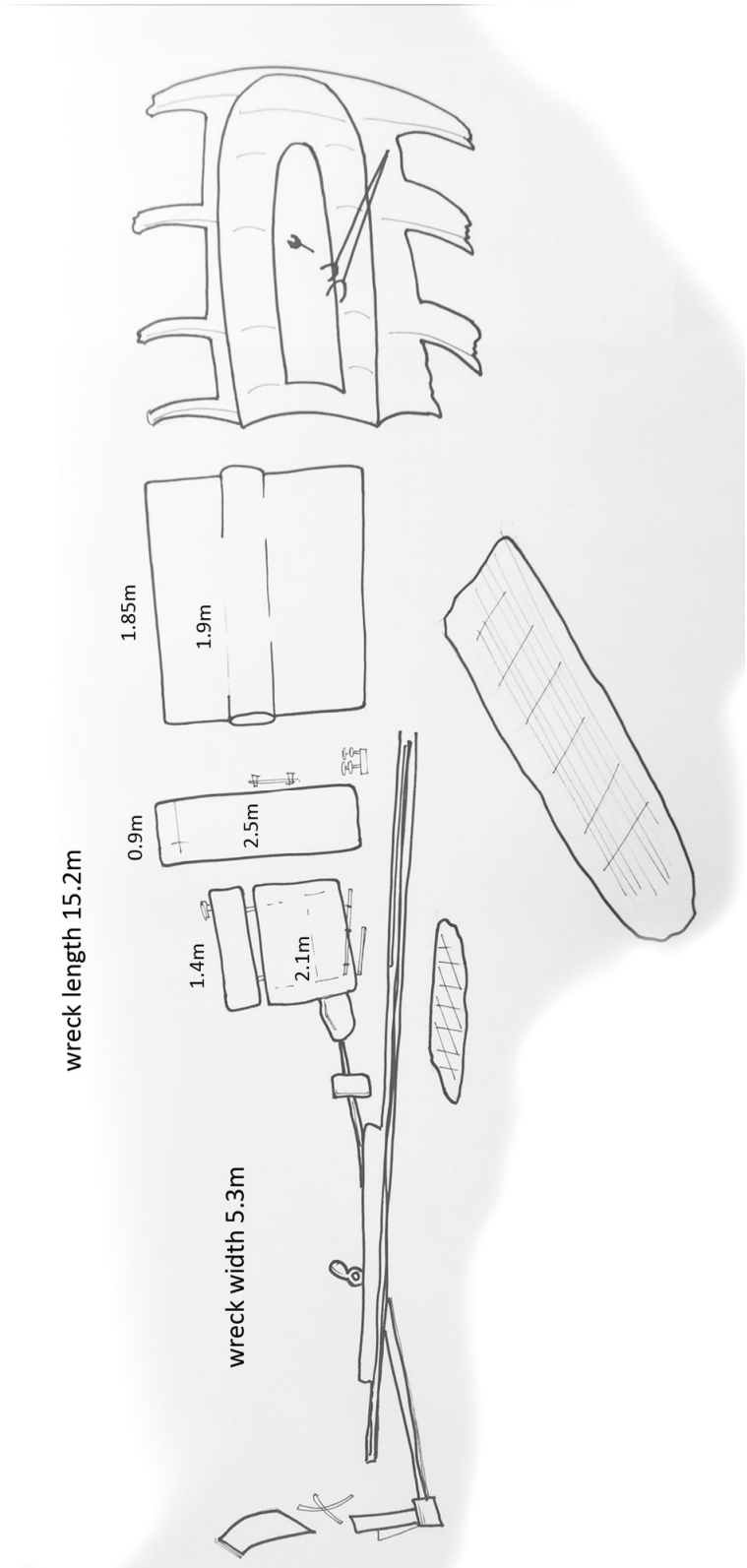

Image 11. Site map 2: Site map made during Dive 1 by Team 1 during Site Recorder exercise labelled to show dimensions of important wreck features.

Site map, Photomosaic photographs results

The photographic/photomosaic technique produced a photographic map that was traced over to pull out the detail and specific components of the wreck. This technique worked well in the efficient use of dive time revealing a large amount of data in a short time and the photographic records produced easily covered the entire site. The amount of data produced has ensured that no return visits to the site are required, however there was a large amount of post dive analysis and photo compilation generated.

This analysis has produced a number of outputs including a site map and a visual description.

Site map

The composite photomosaic was used as the base to pull out a site map by tracing round the photograph.

The map shows some key features. On the left is the rudder stock. There is a strong possibility that the rudder and stock itself were a single piece of valuable non ferrous metal such as brass. There are equivalent examples of brass rudders in Lyness museum. This would have made it attractive to any salvage effort and the presumption is that this is why the rudder can not be located on site. The 'tube' within which the stock would have been mounted remains and is marked here.

Just below the stock and not marked on the diagram are the two rubbing strips, both brass, that would have provided protection where the transom stern met the hull. These items were obscured by weed and therefore not evident in the mosaic.

The area of the bilges where the shaft passed through the hull was filled with concrete which remains. The lifting eye and stern gland for the shaft are set into this concrete. The shaft still runs from the back of the engine through the stern gland to the supporting A frame which would have been mounted on the hull. The propeller has been removed and the steel shaft cut through just aft of the A frame.

The keel runs the length of the wreck; remains of it are prominent and distinctive. Hull sections have fallen down to the seabed and now lie mainly on the north side of the wreck. The diagonal construction of the hull planking is evident; there are still a few ribs visible. However, there is no obvious sight of the membrane that would have lined the inner space between the layers of hull planks.

The engine has fallen onto its port side and broken the mounting bolts. It is formed from two enclosed sections.

Firstly, the top smaller section is the part that would have housed the pistons and there is an obvious steam intake pipe which has broken at the flange.

Secondly, the main engine housing the crank and con-rods is under the cylinder head. There are corroded holes in the block which allow sight of the internal crank and con rods. Aft of the engine on the shaft is a conical shape that could possibly be the fly wheel (it seems slightly too small for this function

but there is nothing else evident that would fulfil the role). Half way between the engine and the stern gland is a 'box' of unknown function. The thought is that it could either be a reduction gear or the reversing gear box. The limited engineering knowledge of the authors is acknowledged at this point however there is sufficient illustration to seek further advice.

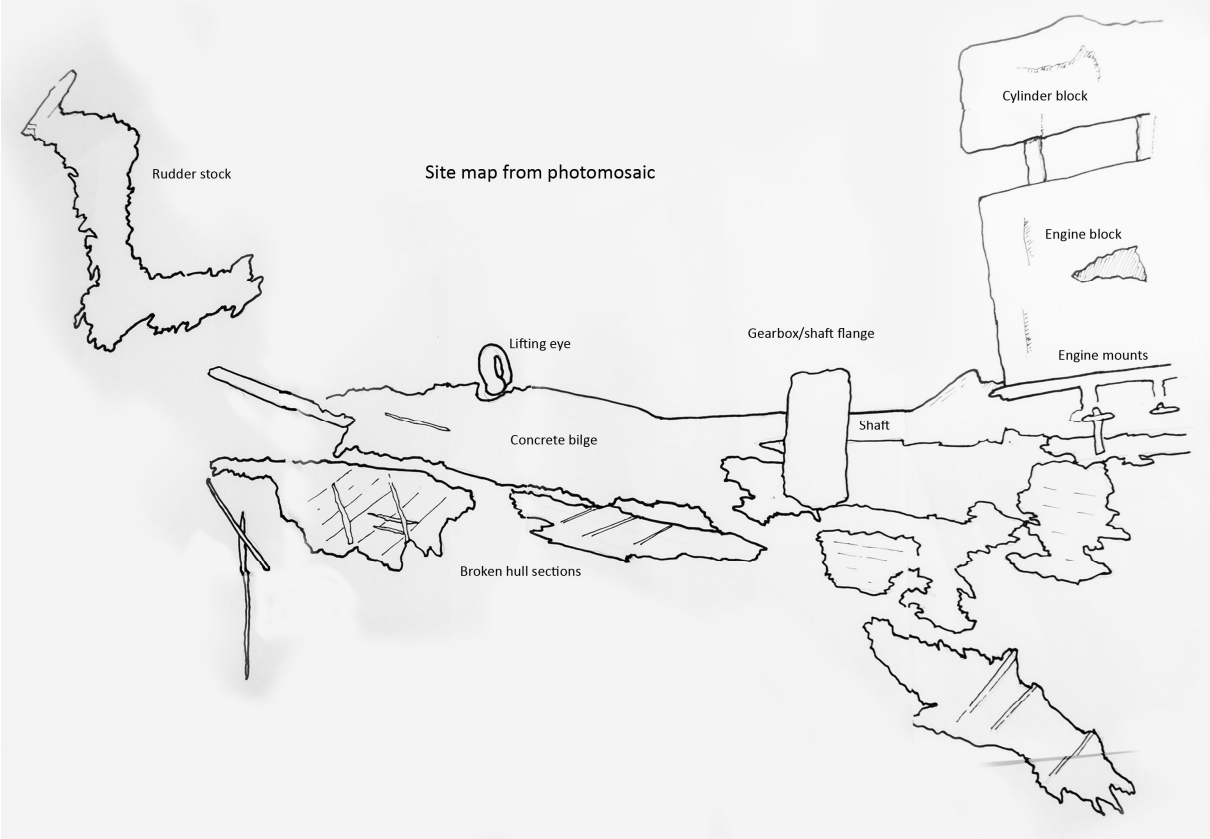

Image 12a. Site map 3: Major features of the stern end of the wreck drawn from the photomosaic.

The photomosaic starts to lose accuracy forward of the engine. The tank has been missed completely in the compilation. Also the attempt to trace round the forward deck cowl revealed results that were indistinct due to the seaweed cover. These are issues that will be addressed by re-compiling the mosaic manually.

Forward of the engine is a tank whose forward wall also forms the engine room bulkhead. The skin of the tank has corroded through allowing sight of the internal strengthening struts. There is some indication too that the tank is subdivided into 4 compartments though this is hard to say with absolute certainty. There are only very small amounts of coal visible on site, no visible coal furnace on the boiler and the presence of the tank strongly indicate that the boiler was oil fired which is correlated by the boiler plate and builders details. The presumption would be that the tank would have held fuel oil. However, there is some assumption that fresh water would also have been carried yet there is no indication of a fresh water tank. If the tank is subdivided, this may be to have separate supplies of both fuel oil and fresh water in one container. An expert opinion is needed here.

There is a gap between the bulkhead and the boiler of about 4 feet that contains a number of pipes, valves and pumps. Many of the pipes have exposed flanges that indicate a light salvage at some point. The pump is presumed to be either a fuel transfer pump or a bilge pump. However, as it looks ferrous, it is possibly more likely to be the former.

The boiler sits with a list to port of about 45°. The boiler case has a few corrosion holes allowing sight of the boiler tubes within. There are no small brass taps, sight gauges or other components also pointing to a light salvage. The boiler differs from the boiler documented on Pinnace 199 as the water pipes on either side of the Rinnigal pinnace are round not oval.

On the starboard side of the boiler is a distinctive valve chest with 4 valves.

A large section of wooden hull lies on the seabed to the starboard side of the boiler. This piece is lying internal side down with the convex side up. There are a couple of fittings evident in the hull section.

Forward of the boiler lies the accommodation casing. This is a metal section with holes that would have originally been for windows. There is some uncertainty at this point. All the images in books researched so far illustrate vessels with two raised accommodation casings on the deck (refer to images in 7. Historical Information). The larger aft one looks fixed whilst the smaller forward one has an access opening in the top through which the lifting strops would be lowered to the lifting eye in the keel. However, this pinnace wreck just has one roof section and a lifting eye below an opening slightly aft of the terminal from edge. This points to a slightly different design in the boat compared to the pictures below (see 7. Historical information). The presence of the lifting eye would suggest that there is not a missing forward accommodation casing as would be expected looking at the images.

Within the wreckage is a spanner and a number of rods with a U shaped end that are for an unknown application. As a test of the application of the photomasaic technique, a section was zoomed to 100% and traced to document the spanner.

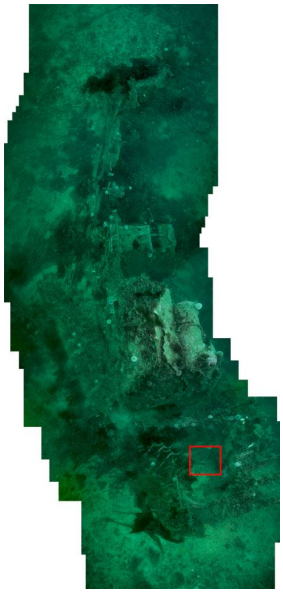

Image 12b: The red box marks the area enlarged to produce the spanner image.

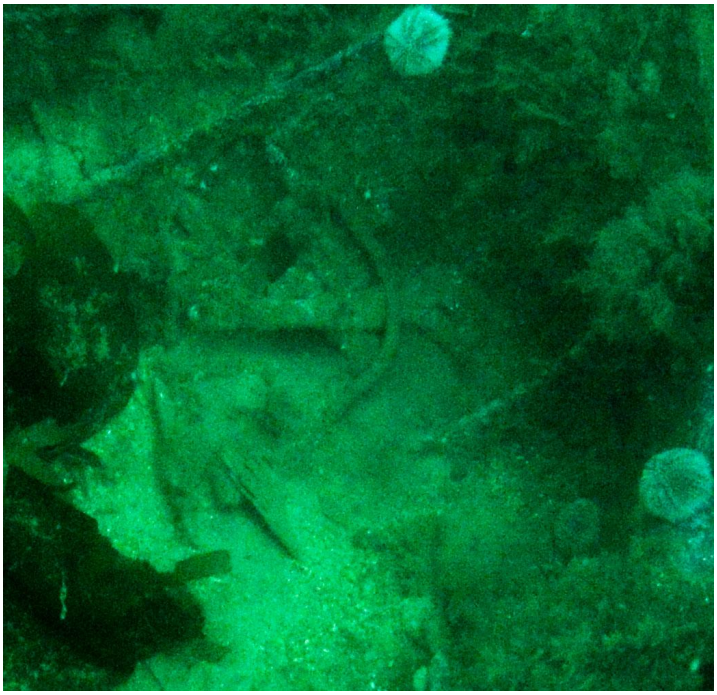

Image 12c. The image of the spanner at 100% zoom from the full size mosaic.

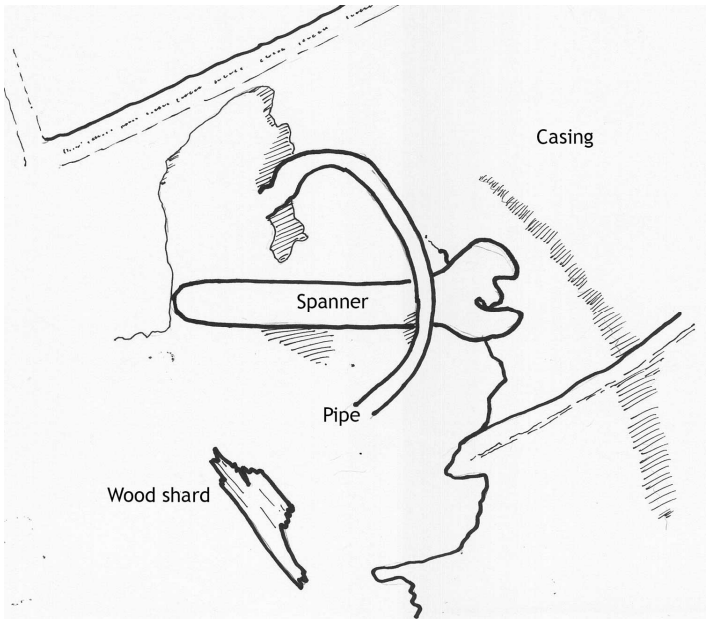

Image 12d. Detail from the spanner Image 12c. above.

Site map, Photomosaic photographs discussion

The stern of the wreck provided some very satisfying images. The area was comprised of sharp clearly defined edges with strong contrast that was converted accurately by Photoshop software. The first trace was done at a lower zoom to produce an overall site map.

There was still enough detail to conduct subsequent tracings at higher zooms and allow more detail to be pulled from the original mosaic. This provides a wealth of data that doesn't require repeat dive visits to the site, a massive advantage. The zoom image to highlight the spanner demonstrates the power of the mosaic technique especially when considering techniques to protect wreck sites.

There are issues with accuracy in this instance: the mosaic compilation process can distort the images. There was no datum measure (e.g. a metre stick) recorded in the photographic record. Both these issues could be planned for and avoided in future projects. Ultimately the data gathered from the site needs to be considered in its entirety so that the GIS data can be used to calibrate the photomosaic images.

The site itself is in a slight area of tide and so loose weed collects here. On the first day, no attempt was made to remove the weed for fear of decreasing the visibility. However the second dive day was undertaken on a day with spring tides when the water movement was enough to keep the site clean of silt even when large blades of kelp were moved. The site is also clear from any shipping movement or significant fishing effort.

6.1.4 Panorama photographs.

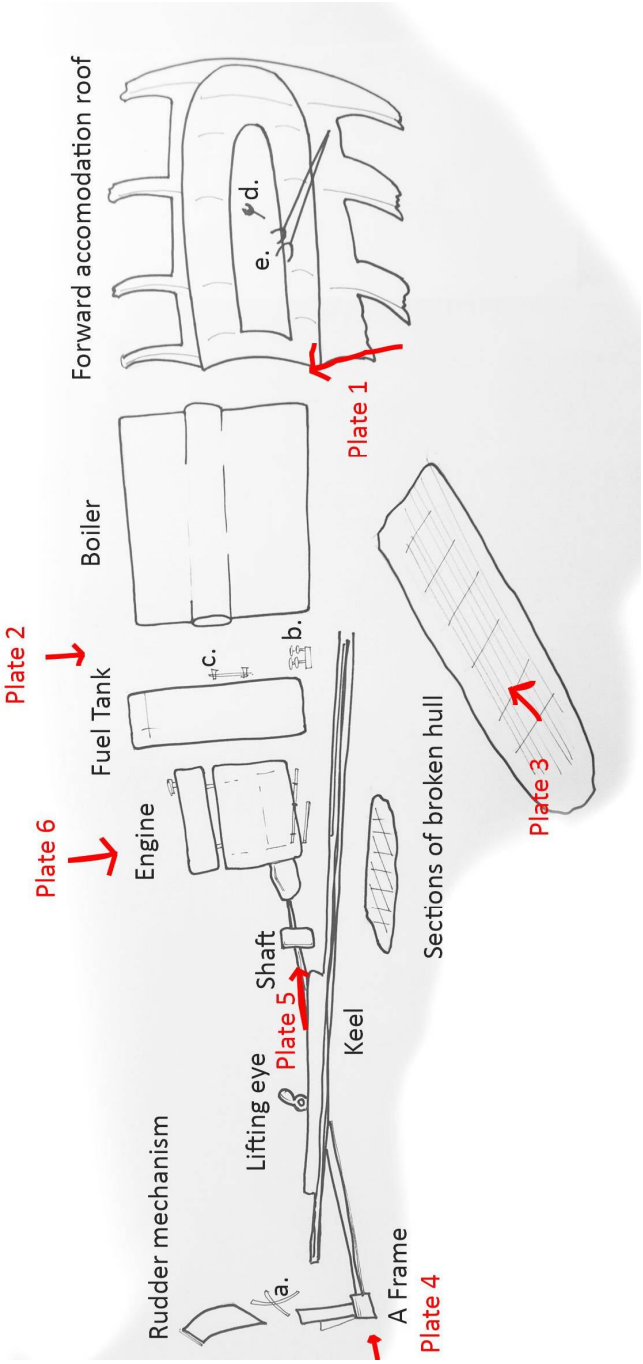

Image 13. Site map to show location of camera for wide angle panorama photographs shown below. Key: (a) Brass rubbing strips from the transom, (b) valve chest, (c) pump, (e) unknown structure that resembles a metal crutch, (d) spanner.

Plate 1

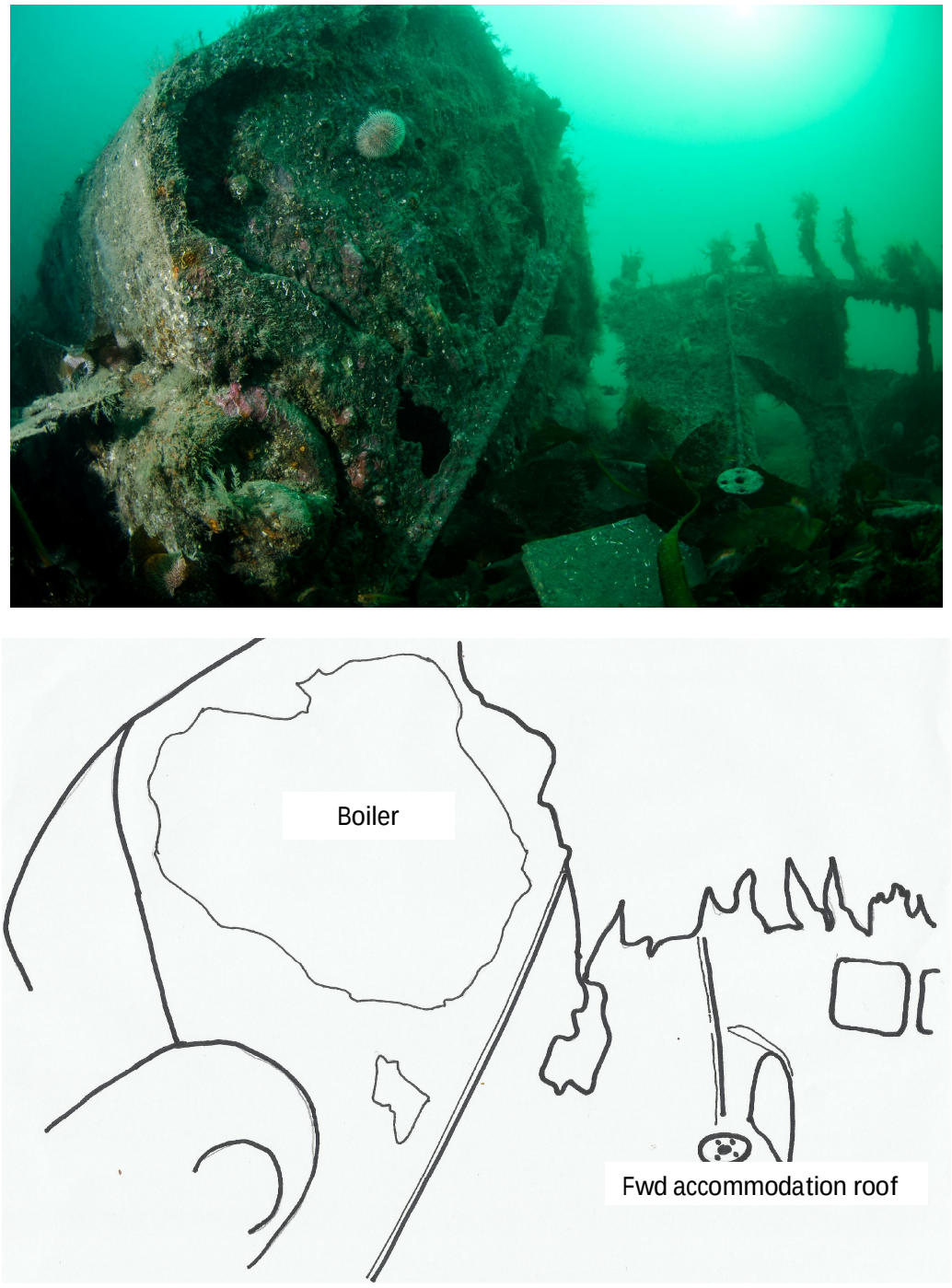

Image 14. This shows the forward end of the boiler to the left and the underside of the accommodation roof to the right. There are obvious holes in the roof that presumably would have held windows. The roof can be seen to be made from one formed shape with internal strengthening ribs. There is a broken flange from a pipe bottom right.

Plate 2

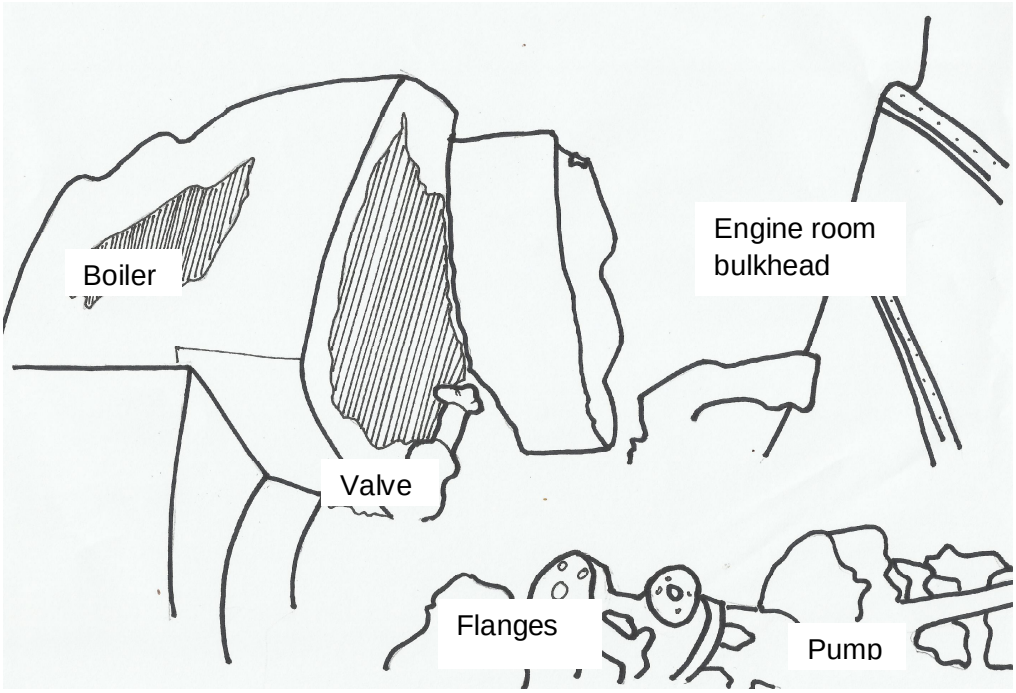

Image 15. This shows the aft end of the boiler to the left and the engine room bulkhead to the right. In the foreground are a numbers of valves and pumps (named (c) Image 13, Site map above).

Plate 3

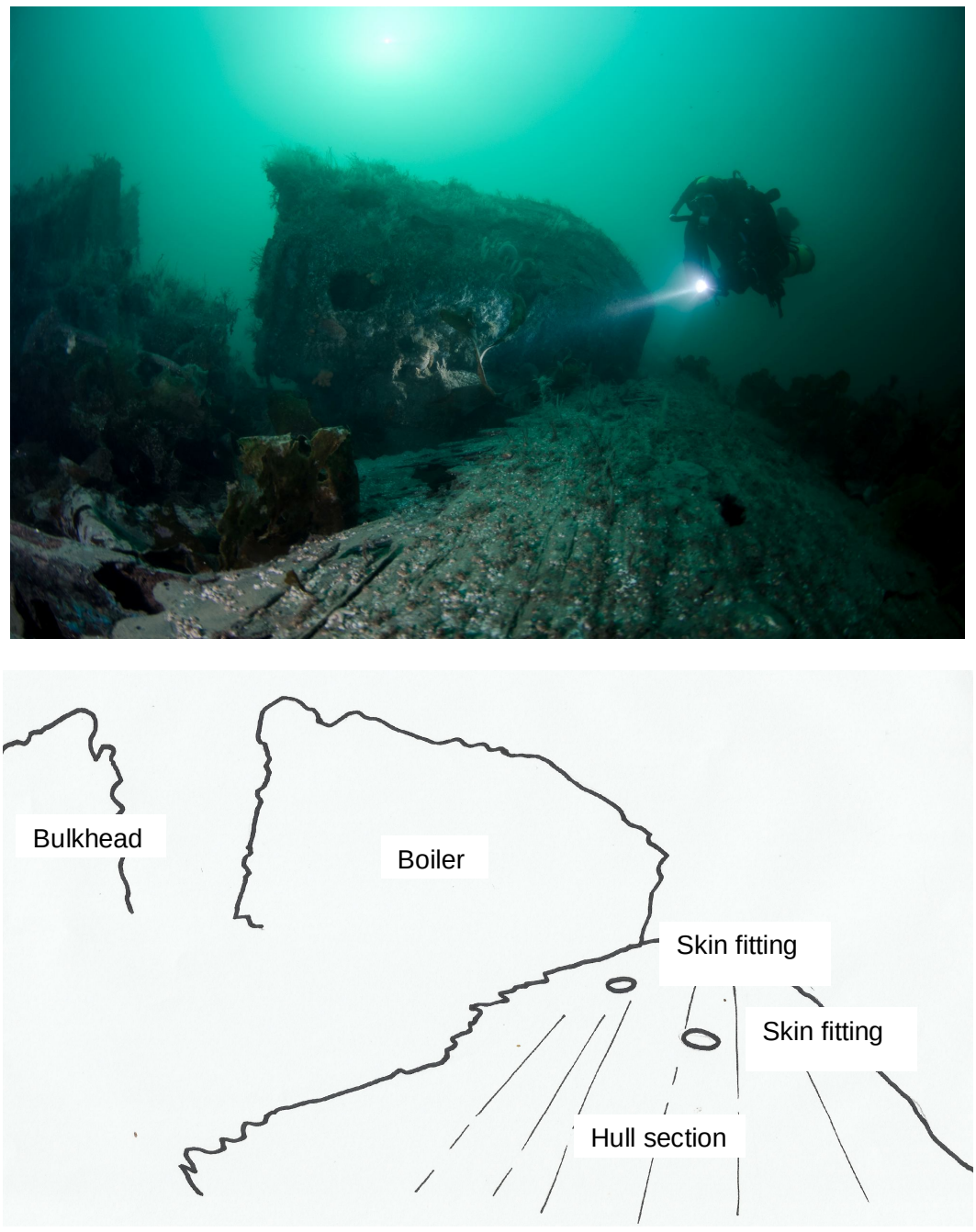

Image 16. This shows the boiler illuminated by the diver's torch with a section of hull in the foreground.

Plate 4

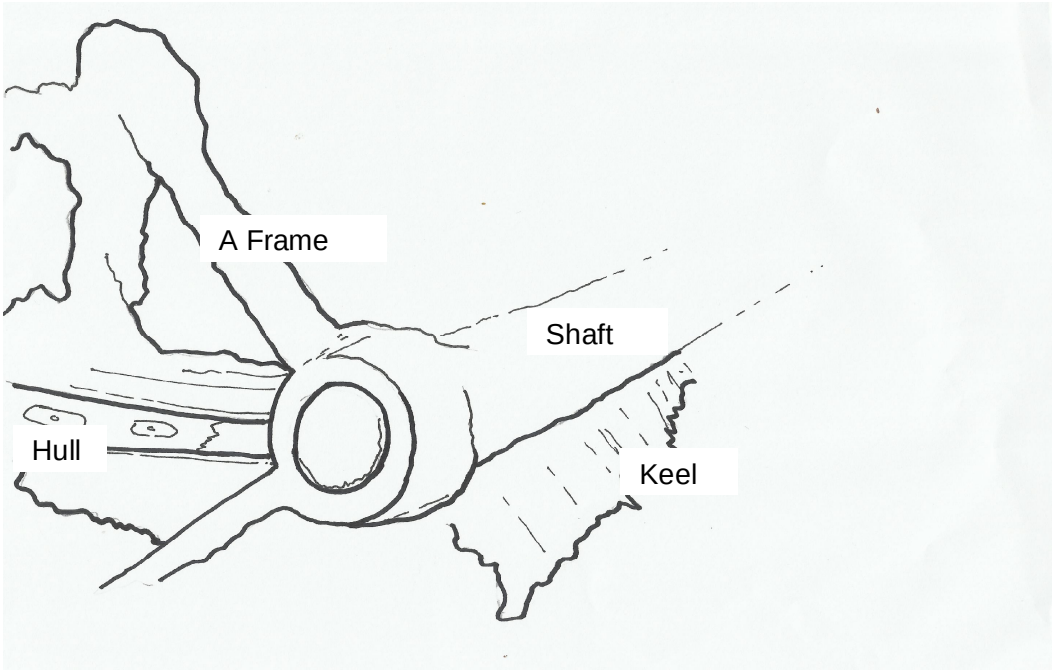

Image 17. This is the view from the aft of the boat looking toward the bow. To the left is the A frame, the cut shaft where the prop has been removed and the line of the keel to the right. Two divers give a sense of scale.

Plate 5

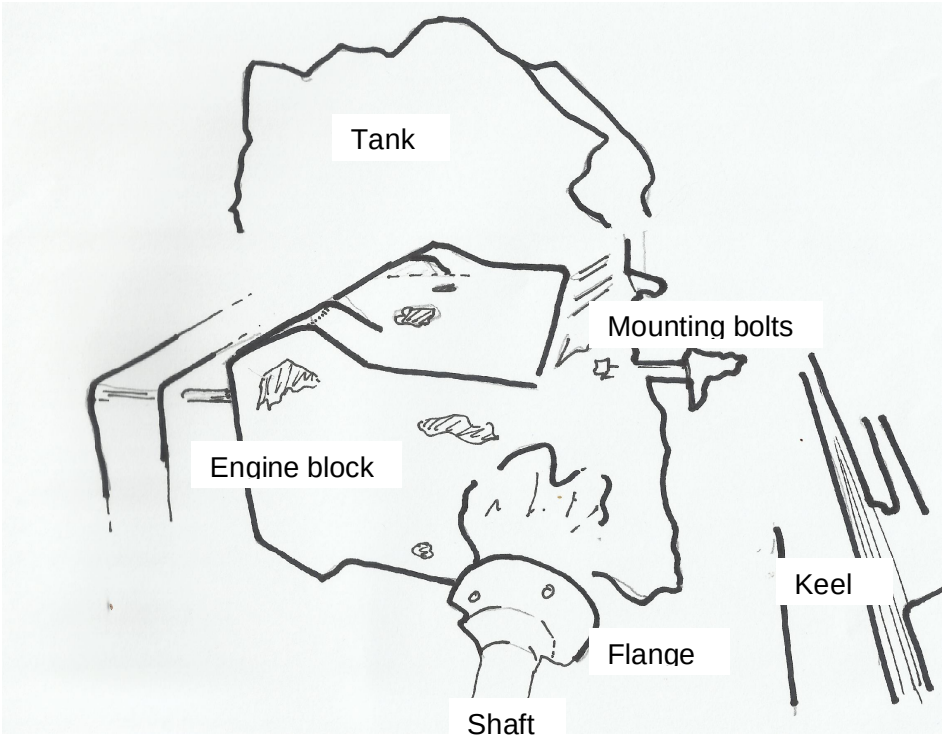

Image 18. This is the view of the engine lying on its side. The shaft flange can be seen in the foreground. To the right is the base of the engine with the mounting bolts. To the left is the head with the pistons. In the background the silhouette of the fuel tank nearly obscures the diver.

Plate 6

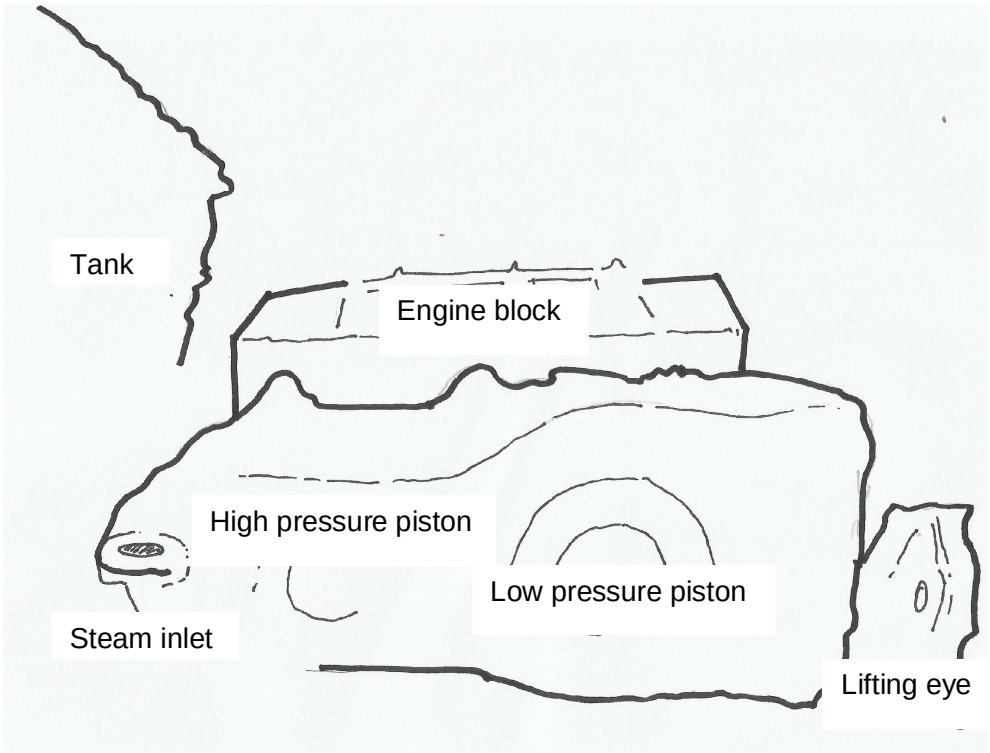

Image 19. This is the view looking down on top of the engine. To the left is the steam in pipe, next the top of the high pressure piston, then the low pressure piston then a lifting pad/eye on the end. A diver hovers over the keel of the boat at the base of the engine to give scale.

6.2 Environmental

6.2.1 MNCR Phase 2 survey on the wreck, results

Rebecca Grieve and Hamish Mair conducted a MNCR Phase 2 survey on the wreckage of the Pinnace. They followed a 25 m transect along the top of the wreck. Wreckage had siltation present on it that was heavy in some places. On the upper surfaces of the wreck branching Hydroids were common. *Echinus esculentus* (Edible Urchin) and *Asterias rubens* (Common Starfish) were common on the wreck. Some brown and red seaweed tufts occurred on the top of the wreck. Adjacent to the wreck was muddy sand with shell gravel, burrowing bivalves and common *Pomatoschistus* (Gobies) and on the surface of the sediment was abundant drift seaweed, some of which was possibly still living. There were some pieces of coal buried in the sediment.

Image 20. Clumps of the branching hydroid *Nemertesia ramosa* on the upper surfaces of the wreck (RG)

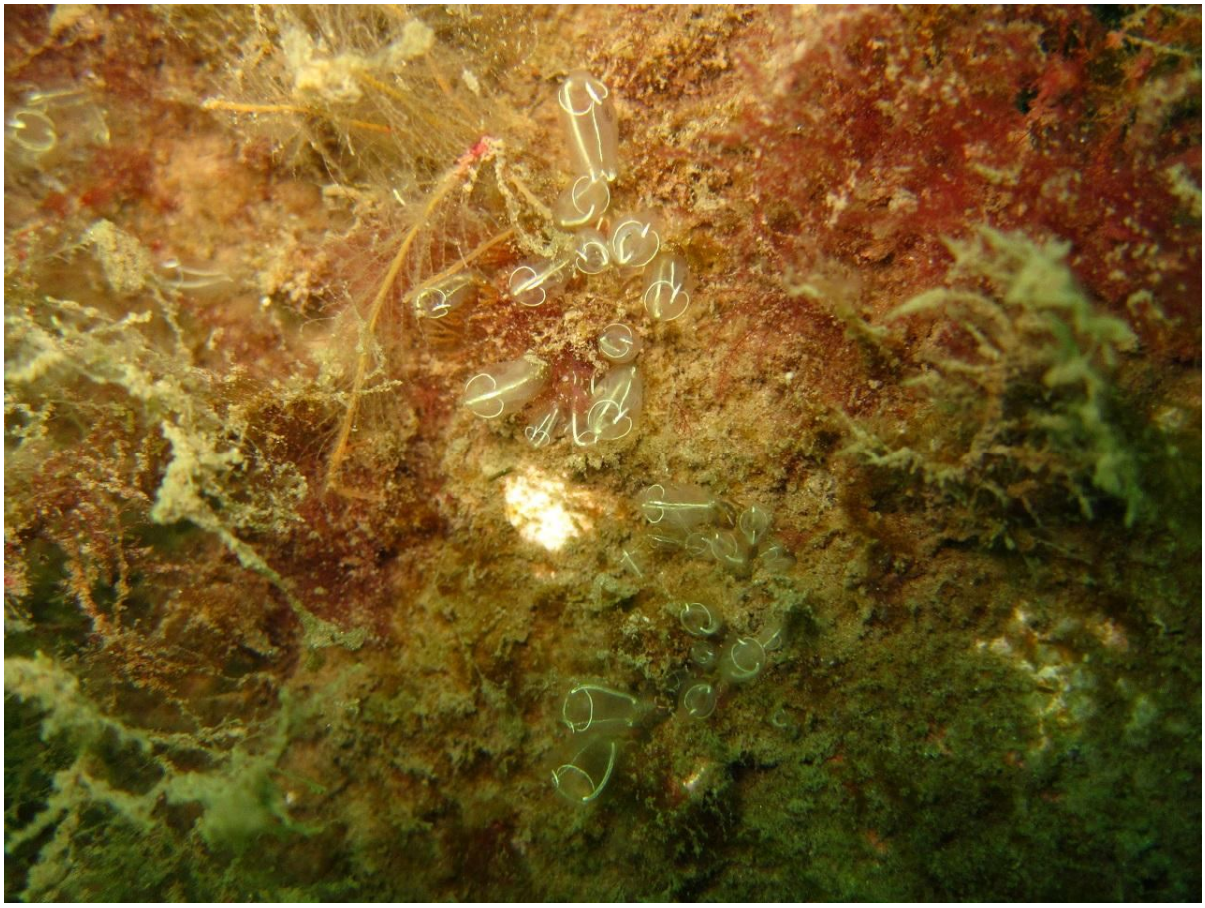

Image 21. Clumps of the light bulb sea squirt *Clavellina lepadiformis* growing on the vertical surfaces of the wreck (RG).

Image 22. Upper surface of the wreck with abundant clumps of the Herringbone hydroid *Halecium halecinum*, and grazing Edible sea urchins, *Echinus esculentus*. Occasional patches of Dead Men's Fingers, *Alcyonium digitatum* were also present and are indicative of areas where current flows more strongly over the wreck surface. There is a dense understorey of short red algal turf, indicating that light levels are sufficient for some algal growth. (RG)

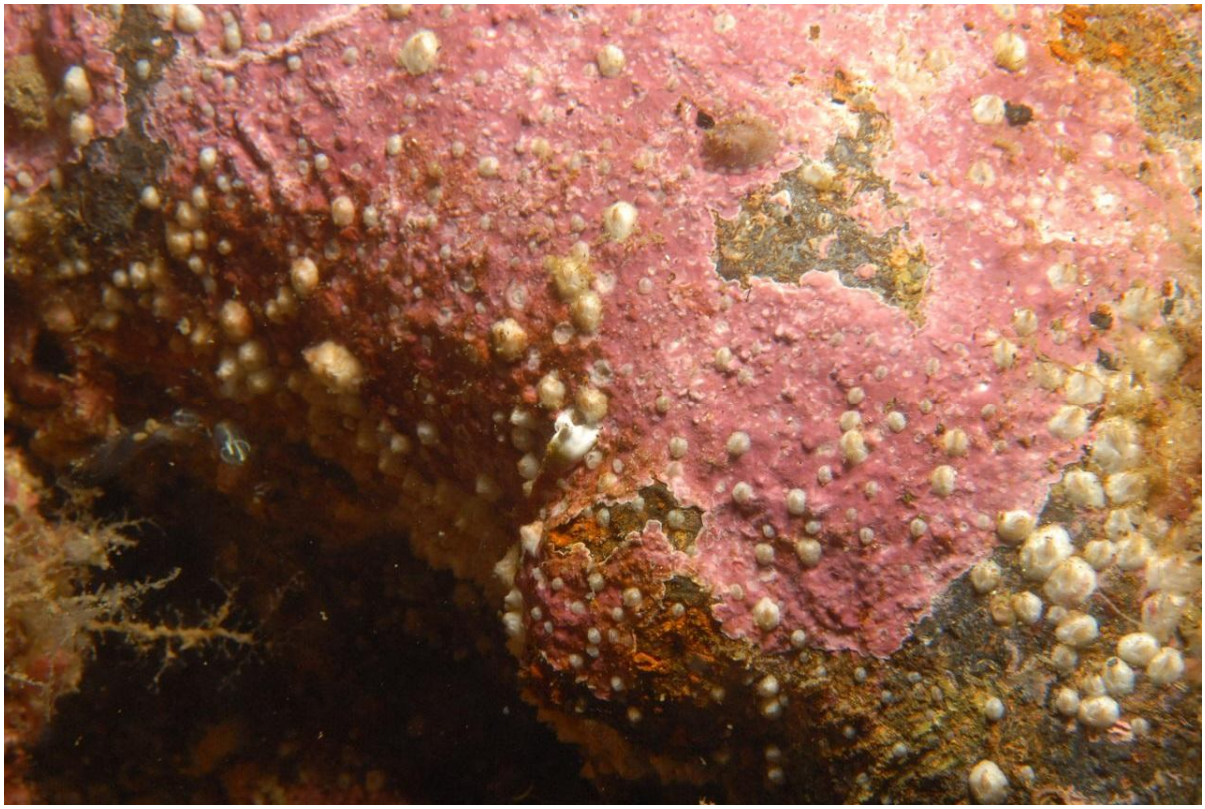

Image 23. Encrusting pink algae growing over the surface of the wreck, with abundant barnacles and rare occurrence of the china limpet *Tectura testudinalis*.(RG)

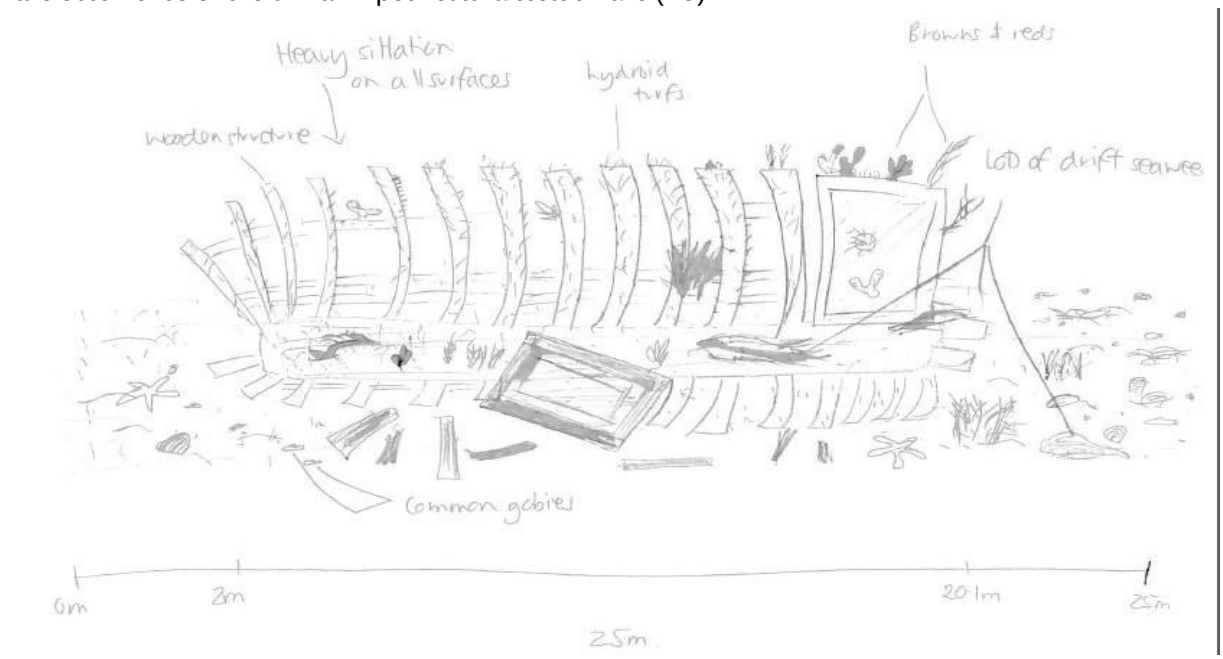

Image 24. Sketch by Rebecca Grieve (RG)

6.2.2 MNCR Phase 2 survey off the wreck, results

Bill Sanderson conducted a MNCR Phase 2 survey of the Pinnace, the position of the transect line was 15m off on the east side, 16.4m depth, on the seabed parallel to the wreck (see Appendix).

Biotope name: Infralittoral sandy mud with unattached red algae, large burrowing bivalves and burrowing crustaceans with worm casts
Biotope description: Lower infralittoral slightly sandy mud with scattered wreck debris and 40% unattached, mostly red algae that look seasonally ropey but probably living. Common large infaunal bivalves such as *Mya truncata* and notably the odd *Arctica islandica* (Rare). Common crustacean burrows (U-shaped) and scallops and occasional worm casts were observed.

Jenni Kakkonen conducted a Seasearch Survey form and the sketch for the survey is shown below (for full form see Appendix).

Abundant pink encrusting alga present on the surface of the wreck, with a dense hydroid turf. Sea urchins were common as was red seaweed cover.

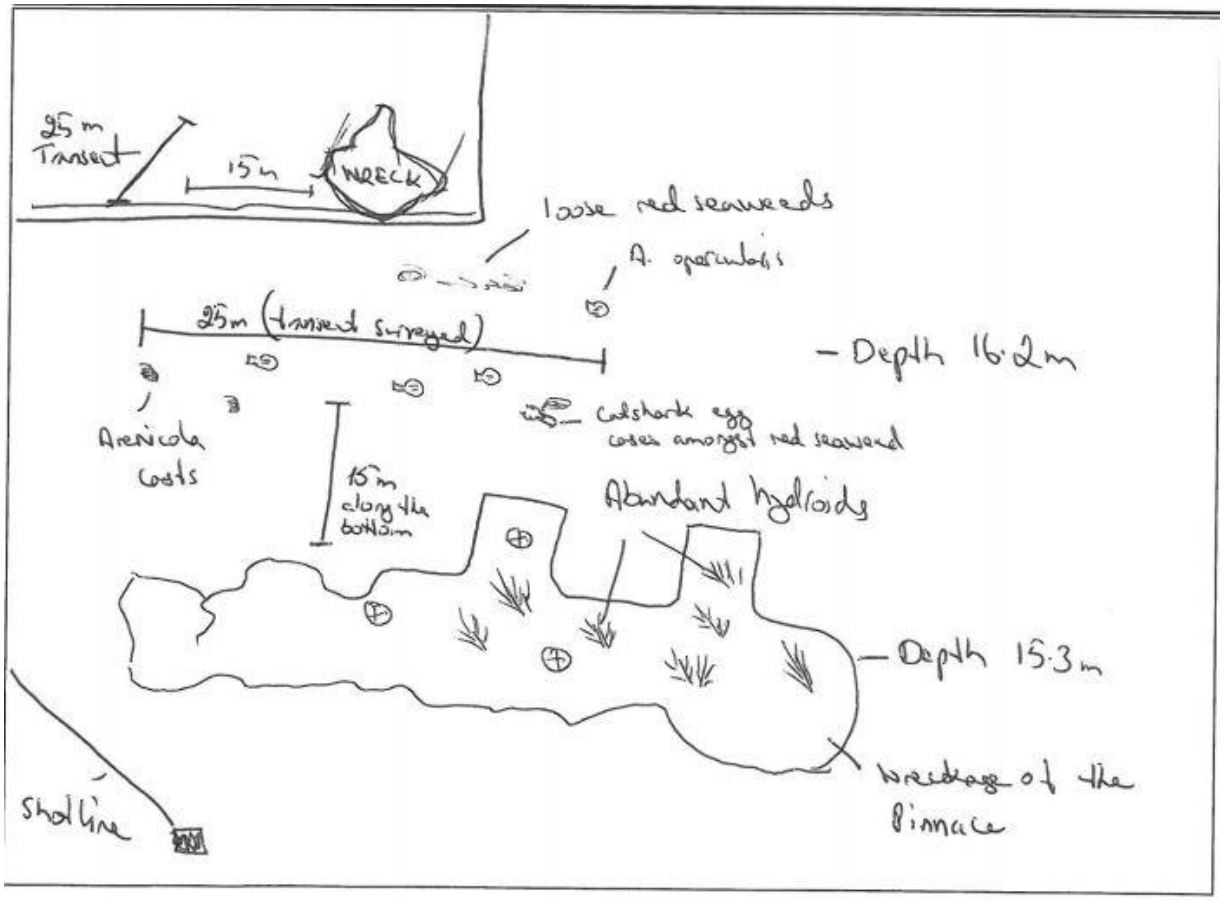

Image 25. Sketch by Jenni Kakkonen (JK)

6.2.3 MNCR Phase 2 surveys , summary of results

The surface of the pinnace was coated by a dense turf of Hydroids and red seaweed. In bare areas, the metal was covered with pink encrusting algae and barnacles, with edible sea urchins as grazers.

Adjacent to the wreck was burrowed mud habitat with bivalves such as *Mya truncata* and the long-lived Priority Marine Species *Arctica islandica,* Ocean Quahog.

6.2.4 MNCR Phase 2 survey on the wreck, discussion

Fauna and flora associated directly on the wreck surfaces

A dense turf comprising Hydroid colonies, soft corals and red seaweeds, coated the surface of the pinnace. Dominant species were the tall hydroids *Nemertesia ramosa* and *Halecium halecinum* with patches of *Alcyonium digitatum*. There were also abundant edible urchins *Echinus esculentus* acting as modifiers to the community through their grazing activity.
This type of community is indicative of conditions where hard substrates are available in combination with a slight tidal flow, sufficient to supply food particles to the hydroids and to ensure that they do not get clogged with silt particles. The growth of red algae indicates that there is sufficient light penetration through the water column and clarity of water for algae to photosynthesize at this depth (14m, MLWS).
In areas of soft sediment, hard substrates such as those provided by wreckage, can provide a different type of habitat for species to colonize, and thereby can increase species diversity of an area.

Fauna and flora adjacent to the wreck site

The full story of the Rinnigal Pinnace, is not yet known and so it is not clear for how long she has been lying on the seabed in Scapa Flow. Anecdotal information suggests that she has been there for some 50 years or more. As a result of the presence of the wreck, other activities in the immediate vicinity will have been minimal over this time period. This may explain the presence of some longer-lived species established in the sediments close in to the remaining wreck structure. Surveys of the flora and fauna adjacent to the wreck revealed the presence of the blunt gaper (*Mya truncata*) (reported to live up to 28 years of age). The Priority Marine Species Ocean quahog (*Arctica islandica*) was also recorded. Ocean quahogs grow very slowly, and can take up to 50 years to reach market size. The oldest known example was nicknamed ‘Ming’; this was an Ocean quahog dredged up off the northern coast of Iceland in 2006. Growth ring analysis and subsequent isotope analysis showed the animal to be 507 years old (Scourse et al., 2006); hence it would have been alive during the reign of the Ming dynasty. The presence of the Ocean quahog close to the Rinnigal pinnace suggests a lack of disturbance of the sediments in that area. These, like other slow-growing animals are at particular risk from bottom fishing gear, and once their numbers have been reduced the populations can take a long time to recover. This particular species is also known to be an important source of food for the commercial fish species Cod (*Gadus morhua*) (JNCC website). The presence of the wreck structure over a reasonably long period of time may therefore have enabled development of a food web that supports top level predators such as Cod).

7. Historical information

Scapa Discovery is indebted to Kevin Heath for the following wreck research.

The boiler plate lists the following manufacturer number: 1518. The Isle of Wight Heritage Service has archive records for the yard JS White with the following details recorded:

Number		Type	Client	Length	Delivery
1518 – 1521	Ad. 744 – 747	Pinnace (Oil fired)	HM Navy	50ft	D 1919/20

This data correlates nicely with observations. The steam engine is oil fired and the fuel tank is present. The documented length of the pinnace is 5 ft longer than the measured wreck length but this could be accounted for by the deterioration of the wreck structure.

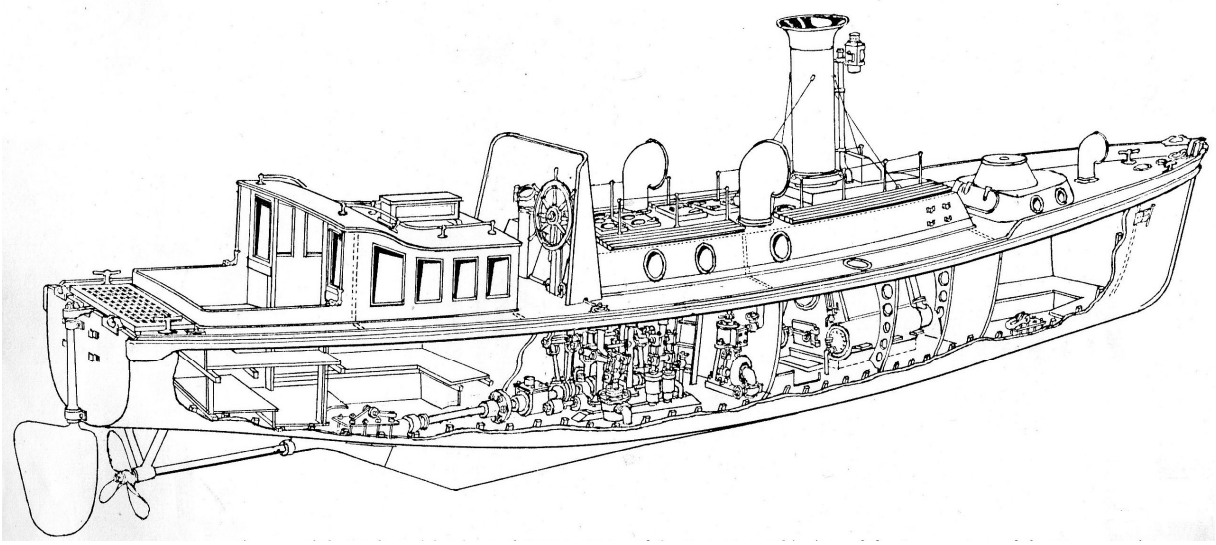

Image 26. A schematic of a pinnace similar but not exactly the same, as the one surveyed.(Stapleton, 1980)

The picture broadly reflects the features seen on the wreck but with a few noticeable differences.

The engine design is fully enclosed so that none of the workings are visible.

There is a fuel/water tank directly forward of the engine on the wreck which is not evident in the diagram (Stapleton, 1980).

The forward deck casing seems different on the wreck. The boats were designed to be lifted from the water regularly and easily. Lifting eyes were set into the keel and lifting stops passed down through the accommodation casing and directly hitched to the hooks. The stern eye is clearly visible on the wreck but the forward eye doesn't have a dedicated hatch casing obviously above it to enable this process. It is assumed that there is only a single deck casing forward and that there is not a second deck casing missing.

There are reports (Stapleton, 1980) that some pinnaces had three lifting points, one in the center around the boiler room. No evidence was found of this lifting eye.

The National Museum of the Royal Navy (Portsmouth) has restored Pinnace 199 and the majority of the contemporary images we have researched are of this pinnace. The pictures and video clips give a good account of the workings of a pinnace and give a good flavour of this class of vessel. However some care is needed as there are a number of differences between Pinnace 199 and the pinnace wreck at Rinnigal.

The best message conveyed by the contemporary media of Pinnace 199 is the beauty of the ship and the affection these boats generate in both the enthusiasts and general public who enjoy their use.

Plate 1

Image 27. Pinnace 199 restored by the Royal Naval Museum (Portsmouth)

Plate 2

Image 28. Pinnace 199 restored by the Royal Naval Museum (Portsmouth)

Plate 3

Image 29. Prime Minister Asquith leaves the Iron Duke on the Admiral's Pinnace (Miller, 2000)

There are a number of points of interest to note from the archive photos.

The pinnace wreck has several features that vary from the photographs. The pinnace in plate 1,2 looks from the transom to be carvel built not diagonal planked. There are two metal casing sections over the forward accommodation. The pinnace in plate 3 has a cruiser stern but it looks as though there is only one accommodation casing forward. The Rinnigal pinnace probably sits between these two in terms of design, having a transom stern but with a single accommodation casing forward.

The photos illustrate many ornate brass fittings including the wheel, cleats, fairleads, funnel bellmouth, handrails, portlight surrounds and other nautical furnishings. Fabricated from brass, these should not corrode even with long immersion in seawater. However, there is no evidence of these fittings on the wreck suggesting they have been removed over the years.

There is a beauty in the design of these boats that has an appeal even today.

8. General Discussion

The overall aim was to undertake a preliminary survey of the Rinnigal pinnace, focussing on recording, measuring and imaging of the wreck and the flora and fauna associated with it and its immediate environment. The aim was broadly achieved and through the project we demonstrated that a team of divers can undertake standard survey methods in a variety of disciplines to thoroughly map a site for a range of given interests. This was conducted safely and within both the Scientific and Archaeological ACoP and within the guidelines laid down by recreational diving organisations including Seasearch and the NAS. (see 11. Appendix 2.)

This is a class of boat that is under represented in the literature and of which we could only find one working example still in existence today. Six hundred and thirty four of these vessels were in service according to the Navy List of 1914. This type of vessel was frequently the first command of a midshipman before going on to command a larger vessel. As such they formed a significant part of their affection when reminiscing as well as being an important workhorse for day to day fleet operations. For these reasons this wreck site represents an important part of naval history and is worthy of further research.

The machinery on the wreck site is of an era and now superseded by modern engineering. Small steam engines/boilers in relatively good state (given the length of immersion) are a rare find so form an interesting and unusual sight. The author has no direct mechanical experience of these engines and has interpreted the remains by extrapolation of first principles and from experience of larger shipwrecks. To have a full explanation from an engineer who was fully conversant with this machinery would be very illuminating.

The wreckage has in important function by virtue of its presence providing sanctuary for animals that form the basis of a food chain that eventually culminates in important commercially fished species. This is evident on site through the presence of long lived species such as Arctica. The effect is common to many wreck sites and is well illustrated here albeit in microcosm. Thus the flora and a fauna is of interest in itself but is also indicative of the influence a wreck exerts: an influence that all the wrecks in the flow exhibit though on a larger scale. Any consideration of a wreck site should have due regard for the greater whole through larger more holistic outlook. Likewise, due consideration of a wreck site requires a cooperation between many academic disciplines each researching the components that make the whole.

This theme feeds into the wider legislative paradigm coming into play at present time and is a reminder of the wide scope needed in consulting all the relevant knowledge holders that would have expertise in the Scapa Flow wrecks. Sometimes it is easy just to thing of a wreck as an old steel machine but they do form living reefs and they do have a considerably wider influence, as demonstrated here on the pinnace site.

9. Recommendations and future scope

The next immediate stage of this project is a period of publically dissemination. All the contributors will receive a copy, as will any other significant interested parties. The information is now online on its own website (though an abridged version could find a welcome home on the Scapa Flow Wrecks website), a PDF version will be available for download, a newspaper press release is in the offing and magazine article has been submitted.

In the future we recommend that further work could be done to develop the in situ measuring aspects of the wreck site. It would be useful for the team to improve skills with the site recorder software and also the accuracy of the plots could be improved with a larger number of measurements to put forward into the three dimensional model.

In this project, surveys of the fauna and flora revealed presence of some longer lived species established in close proximity to the wreck, suggesting that the wreck structure has been affording some protection to the habitat. A separate site away from the pinnace could be recorded as a control to test this theory. There are likely to be future projects (e.g. Seasearch days) that will include this task within their remit so this should happen naturally in due course. The results will be updated here in that eventuality.

The second point to highlight is how closely related the Scapa Discovery pinnace project is to the research programmes being undertaken in Scapa Flow at present so there may be other unforeseen factors in common in the future. These can be considered through the present channels of communication such as the Orkney Marine Archaeological Forum and a close liaison with other researchers such as the Heriot Watt Scientific Divers team.

The mosaicing work in this project undertaken was the first step in a complicated and time consuming research path but one that is rewarding and yields positive results with a wide range of applications. For example, as more sites are discovered and documented, such as the Scapa Flow Wildcat crash site, so the need to ensure their protection becomes more important. Mosaicing provides a powerful baseline map to record a pristine site against which any damage can be recorded. The initial mosaic trials were conducted to work through the initial problems and to give some experience from which to ask the next level of question to any relevant experts. A period of research is now needed to consolidate some of the tools and techniques with which to progress. With this in mind, a stock of camera equipment is being built up and links made with researchers in linked fields. For example, a link has started with a study being undertaken at Newcastle University using a GoPro array to measure rugosity of the seabed with a view to studying lobster settlement.

The pinnace site has a value to the wider community on a number of levels. It has a lot of worth as training site to learn and practice underwater archaeology especially with an eye to future NAS training courses. It is likely that a great deal of interest will be generated from the effort that has been put into this project. A conversation across different organisations has been initiated through this process along with a feeling of positivity that can be carried forward into future larger scale projects. From this report an article has been submitted to Scuba, the BSAC magazine, a press release to the Orcadian is anticipated, an evening talk at the local Field Club and a copy will be sent to the national Museum of the Royal Navy (Portsmouth) The links generated will hopefully complete some of the missing pieces of the puzzle and form an important component of any future research.

Given that some data has now been generated, non-diving experts could be engaged to assist with analysis and interpretation of the results. The photomosaic record has a depth to the data that would provide a rich harvest. In addition, there are additional ways to render the images which are beyond the technical scope of the authors. With the present resource of images, albeit a relatively small folio, approaches can be made to find collaborators with the requisite skills. This will be an ongoing conversation and hopefully widen the scope of the research. Any recommendations would be welcomed.

Likewise, there can often be a technical complexity to a site that is not easily explained without a good working knowledge of ships of this era and their mechanical components. A good working relationship with someone who has this technical knowledge would reap good reward.

In summary, the work undertaken so far is the first step in a program and active steps are being made to take the project forwards so that in future, more detailed and comprehensive results will be generated. Such data may help in the long term to contribute to the increase knowledge, development of enhanced management, mitigation of deterioration and increased public understanding of the value of these sites.

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10.1 Relevant weblinks

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- http://jncc.defra.gov.uk/page-5661 Ocean Quahog *Arctica islandica*
- http://www.hse.gov.uk/pubns/books/l107.htm
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- http://www.rcahms.gov.uk/rcahms-projects/project-adair
- http://www.crashsiteorkney.com/
- http://www.nationalhistoricships.org.uk/register/40/199
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  http://www.scapamap.org

- Ministry of Defence (MoD) surveys of the HMS Royal Oak

  http://www.wrecksight.com/

- Historic Scotland-funded MBES surveys completed by Wessex Archaeology (WA) in 2011 to map the blockships in Burra Sound and other wartime wrecks (HMS Strathgarry; UB116; the F2 and YC21 barge;S54;V83; Dewey Eve).

  http://www.wessexarch.co.uk/reports/83680/scapa-flow-wreck-survey

- Christie, A., Heath, K. and Littlewood, M. 2013 Scapa Flow 2013 Marine Archaeology Survey: Final Report pp1-80.

  http://www.scapaflowwrecks.com/cms-assets/documents/158613-94536.450scapa-project-reportfinal.pdf

- This report can be found online here:

  https://sites.google.com/site/scapadiscoverypinnace/home

11. Appendix

11. 1. Appendix 1: Measurements from Team 1, Dive 1

Recording points for measurements		
Datum		*Description*
A		Datum
B		Datum
C		Datum
D		Datum
Pinnace		
E		Engine
F		Bulkhead
G		Condenser aft
H		Condenser fwd

Measurements recorded		
Datum		*Measurements (mm)*
A - B		3260
A - C		5400
A - D		8380
B - C		2540
B - D		5900

C - D		3260
Pinnace		
A - E		3000
A - F		5150
A - G		X
A - H		X
B - E		3700
B - F		2560
B - G		6000
B - H		6720
C - E		4320
C - F		3960
C - G		4620
C - H		5060
D - E		6430
D - F		5040
D - G		4350
D - H		4070

11.2. Appendix 2: Project Plan and Risk Assessment

Project Plan and Method Statements for Day 1

These documents are not included here as they are considerable documents and would make this report unwieldy. However they have been uploaded for reference and are online here:

https://sites.google.com/site/scapadiscoverypinnace/appendix-2

They form two important roles:

Firstly to illustrate to illustrate the planning to maintain a high level of safety whilst undertaking a diving operation of this nature

Secondly to form a template to aid planning for any future operations should the project continue at a later date.