A History of Plymouth's Breakwater Fort



Peter Holt

The SHIPS Project 2024



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The SHIPS Project

www.shipsproject.org

Front cover: The Breakwater Fort in Plymouth, from the air [Cyberheritage]
Back cover: Drawing of the interior of the Fort showing the method of construction [Mackie]

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1. Introduction

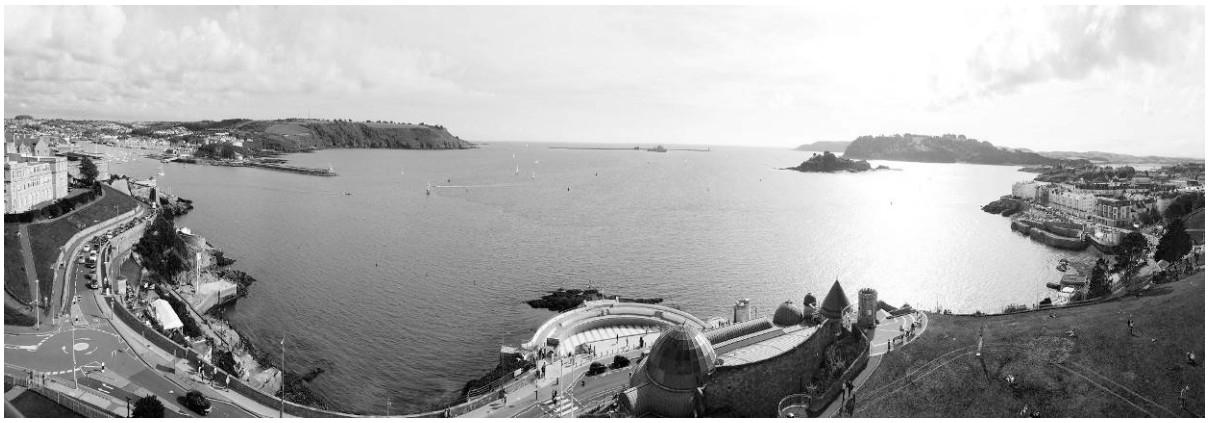

Figure 1: Plymouth Sound from the Hoe looking south with the Breakwater in the distance [SHIPS Project].

This book is one of a series of publications that highlight the maritime and aviation heritage contained within Plymouth Sound National Marine Park. The SHIPS Project has been finding and recording this heritage both underwater and on the foreshore in the numerous rivers of the Tamar waterway, on the seabed in Plymouth Sound and further offshore. One of the aims of The SHIPS Project is to promote and publicise our hidden underwater cultural heritage and so save it for future generations.

From the high vantage point of Plymouth Hoe, the iron fort by the Breakwater can easily be seen in its commanding position in the middle of Plymouth Sound. This is just one of several Victorian-era forts that surround Plymouth and one of the many historical features around Plymouth Sound. The Breakwater itself was one of the greatest feats of the age and was known as the 'Great National Undertaking', built to protect shipping in the harbour from storms. But in 1859 a different kind of protection was at the forefront of public discussion, the defences of Plymouth against invasion by the French. A study of Plymouth's defences at that time identified a gap where enemy ships could break through between the shore forts at Picklecombe to the west and Bovisand to the east. The proposed solution was to build a seafort in the middle of the Sound and close the gap in the defences, and the politicians and the public pinned their hopes on this 'Plymouth Iron Fort'.

Many designs for the iron fort were suggested. The first was for a huge structure housing 90 guns, but later designs were reduced in size and cost to something more manageable. The main difficulty was in creating a structure that could withstand sustained battering by the latest in large-calibre French artillery. This required a design for the fort that was equally new and revolutionary.

The Breakwater Fort was the first of its kind to be built from iron rather than stone. More accurately, the upper part where the guns were housed was a fortress made of iron while the larger part of the fort that sat in the sea and acted as a platform for the guns was built from stone and concrete. Building the fort in the sea was a masterpiece of engineering requiring the latest in civil engineering technology. This was a time when major leaps forward were being made in both artillery and the defence against artillery. To gauge its effectiveness against the latest weapons, the design of the iron fort was first tested at an artillery range in Shoeburyness where a mock-up fort was battered with large calibre shells at close range. Once proven in trials, the real iron fort was constructed in Millwall in London and then shipped in pieces to Plymouth where it could be installed on its stone base built in the sea. There is some doubt that the fort was constructed according to the original plan but fortunately it was never tested in battle, so its actual strength remains unproven.

The fort was eventually disarmed, it became a signal station, then an anti-aircraft training site before being decommissioned. A commercial diver training company took over the fort for some years and placed structures on the seabed around it. The fort, the structures on the seabed around it and its sheltered location made the site the ideal base for scientific experiments which still happen today. The fort itself is a heritage monument and the seabed around it is a home for marine life where rare and protected species flourish.

About The SHIPS Project CIC

This book is one of a series written by The SHIPS Project to highlight the wealth of cultural heritage that lies underwater or on the foreshore of the Plymouth Sound National Marine Park. The park contains over 1000 shipwrecks, more than 35 crashed aircraft, many scheduled ancient monuments and over 100 vessels abandoned on the foreshore. Other books in this series cover sport diving shipwrecks, foreshore hulks, Royal Navy shipwrecks and submarines, historic wrecks, and shipwrecks in deep water.

The SHIPS Project is a volunteer non-profit organisation that undertakes research and exploration of maritime historical sites and events, both on land and underwater. The SHIPS Project is based in Plymouth, England, and the focus of our work is centred on that city. Plymouth has a wonderful maritime heritage that stretches in time from the Bronze age to the present day and includes maritime and shipping, military and aircraft, fishing, industrial and transport, piers, docks, and harbours as well as Roman and prehistoric sites. The work of The SHIPS Project is undertaken by unpaid volunteers. In 2021 The SHIPS Project became a Community Interest Company (CIC), a special type of limited company which exists to benefit the community rather than private shareholders. The SHIPS Project has been kindly assisted by several commercial organisations, institutions, and universities many departments at Plymouth University and the Oxford University dive club OUUEG. The SHIPS Project partners with many sports diving groups providing training and assistance with fieldwork, especially the Plymouth Sound and Totnes branches of the British Sub-Aqua Club (BSAC).

The SHIPS Project can be contacted by:

- Sending an email to pete@shipsproject.org or through the website: shipsproject.org.
- Contacting us through social media.

Contributors

As with everything we do at The SHIPS Project, this book was a collaborative effort involving many people. Our thanks go to all the people who provided information for this publication, the historians, the enthusiasts, and archivists, but particularly to the divers who provide a unique insight into what remains on the seabed. Special thanks go to Dr Keith Hiscock who wrote the section on marine biology, to Alan Bax for insights into Fort Bovisand and to Peter Bernardes and Mick Whelan who described the commercial diver training operations.

David Boon, Nigel Boston, Paul Dart, the late Martin Dean, Alan Down, Steve Fletcher, Jon Greenough, Neil Griffin, Fran Hockley, Colin Irwin, Ray Ives, Stephen Johnson, Kit McAllister, Richard Larn, the late Peter Mitchell, David Page, Jon Parlour, David Peake, Steve Roue, the late John Spencer, Prof. Bob Stone, Kostas Thoctarides, James Williams, Cyberheritage, Sonardyne International Ltd., Swathe Services Ltd., Wavefront Systems Ltd.

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Other books by The SHIPS Project

Other books in this series by The SHIPS Project include:

- Aircraft Crash Sites in and Around Plymouth Sound National Marine Park, ISBN 978 1 7397053 0 5
- Sport Diving Shipwrecks in and Around Plymouth Sound National Marine Park, ISBN 978 1 7397053 2 9
- Historic Ships on the Foreshore in and Around Plymouth Sound National Marine Park, ISBN 978 1 7397053 1 2

For more information see The SHIPS Project website: shipsproject.org.

Acronyms and Glossary

AA	Anti-Aircraft.
Asphalt	Bitumen, a semi-solid form of petroleum, when refined asphalt is called pitch.
Ballast	Weight used to sink an object.
Calibre	The internal diameter of a gun barrel bore.
Casemate	A bombproof vault of brick, stone, or iron, usually covered with earth, which provided an emplacement for a gun or living quarters for soldiers.
CSWIP	Certification Scheme for Weldment Inspection Personnel.
Decompression	For a diver, reducing the ambient pressure slowly to avoid decompression sickness or 'the bends'.
Embrasure	Opening for a gun in the iron shield.
HMS	His/Her Majesty's Ship.
Ironclad	A ship built of wood armoured with iron.
lb, lbs	pound, pounds.
Magazine	A storage room for artillery shells and gunpowder.
Mantlet	Hanging net made of interwoven heavy rope for catching splinters.
Palliser shot	An early British armour piercing shot that was invented by Sir William Palliser.
Pdr	Pounder.
PMARIG	Plymouth Maritime Archaeological Interest Group
QF	Quick Fire Gun. A gun that has a quick action breech mechanism and fires a type of projectile that has the charge fixed to the shell or contained in a separate brass cartridge case.
RML	Rifled Muzzle Loading. A gun that is loaded through its muzzle and has a rifled bore.

2. Timeline

1788 Plans are made for a breakwater pier from Staddon Point to Panther Rock.
1806 Rennie and Whidbey submit a report on a breakwater in Plymouth Sound.
1812 The first block was laid for the Plymouth Breakwater.
1820 The Duke of Wellington suggested building a fort in the centre of Plymouth Sound.
1841 Breakwater completed.
1859 French ironclad warship *Gloire* was launched, Breakwater Fort idea was conceived.
1861 Breakwater Fort construction started.
1862 Timber scaffolding constructed on Shovel Rock.
1863 First foundation stone was laid.
1865 The foundations were completed.
1868 Artillery experiments at Shoeburyness.
1872 The iron casemates were installed.
1879 Breakwater Fort completed.
1880 Breakwater Fort fully armed.
1889 The fort was commissioned as an Admiralty signal station.
1903 A searchlight was installed on the roof of the fort.
1911 A second searchlight was installed on the roof.
1913 *Hopper Barge No. 42* sunk off the Breakwater.
1914 Fort already disarmed, now used as the Port War Signal Station.
1916 H.M.T. *Abelard* sunk by a mine off the Breakwater.
1920 The barque *Yvonne* is wrecked on the Breakwater.
1936 The Fort becomes an anti-aircraft training school with AA guns installed on the roof.
1942 Sunderland flying boat W6054 is wrecked behind the Breakwater.
1945 Fort was used as a naval signal station.
1970 Plymouth Ocean Projects Ltd. took over Fort Bovisand.
1976 Military released the fort for use as a diver training school.
1995 Trinity House tender *Tavy* sunk at the Breakwater Fort.
2009 The SHIPS Project started.

3. The Plymouth Breakwater

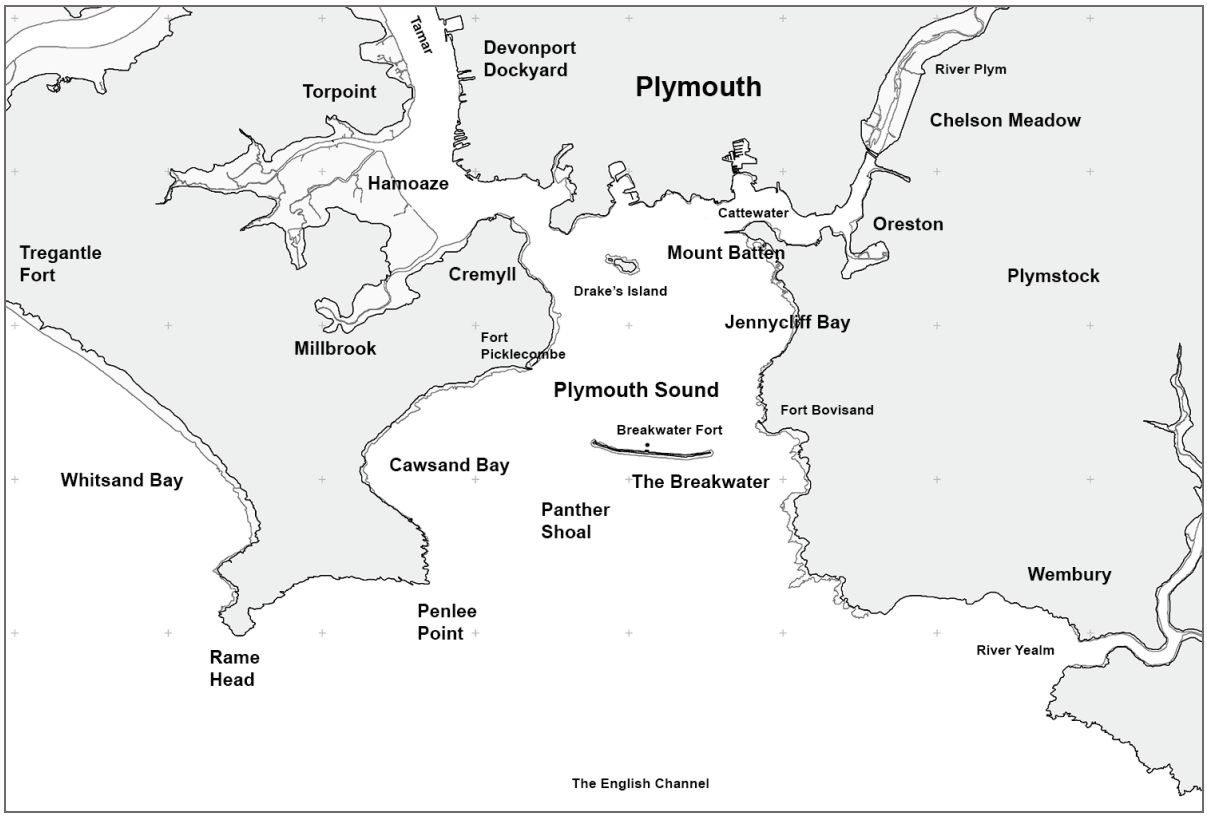


Figure 2: Map of Plymouth Sound [SHIPS Project]

Plymouth Sound is a large natural harbour with a wide southern entrance which is sheltered from winds from the west, north and east. The prevailing winds are from the southwest, so sailing ships anchored in the Sound were at risk of dragging their anchors and ending up wrecked on the rocky eastern shore. What was needed was a breakwater to be built across the entrance to Plymouth Sound to protect ships riding at anchor. In 1788, a Mr Smith, the Master-Attendant at the nearby Royal Dockyard, proposed a plan to build a long stone pier from Staddon on the east side of the Sound westwards out to Panther Shoal. Funding was not available at that time for such a huge venture nor was the technology to build it, but the idea still gained some momentum. Finally, in 1806, the civil engineer John Rennie and Joseph Whidby, the Master-Attendant at Woolwich Dockyard in London, were ordered by Lord St. Vincent to draw up a report and plan for a breakwater at Plymouth. The two gentlemen were joined by the current Master-Attendant of the Plymouth Dockyard, a Mr Hemans, in a meeting on 18th March 1806 and their report was completed on 21st April, recommending that a free-standing breakwater be built along the line of the shallow Panther, Shovel and St Carlos Rocks that lie in the middle of Plymouth Sound.

After much deliberation, the plan was finally accepted and an Order in Council was issued by the Prince Regent in June 1811, which was soon followed by Admiralty instructions given to Rennie to draw up detailed plans. The breakwater was to be a mile long, would use 2,000,000 tons of limestone and would cost over a million pounds at that time. The foundation stone was laid on 8th August 1812 and just two years later it was tall enough to protect ships in its lee. The work continued for many years, particularly after severe storm damage changed the profile of the breakwater in both 1817 and 1824, and the remedial work continues to this day with huge concrete blocks still being added to the seaward side.

4. A Gap in the Defences

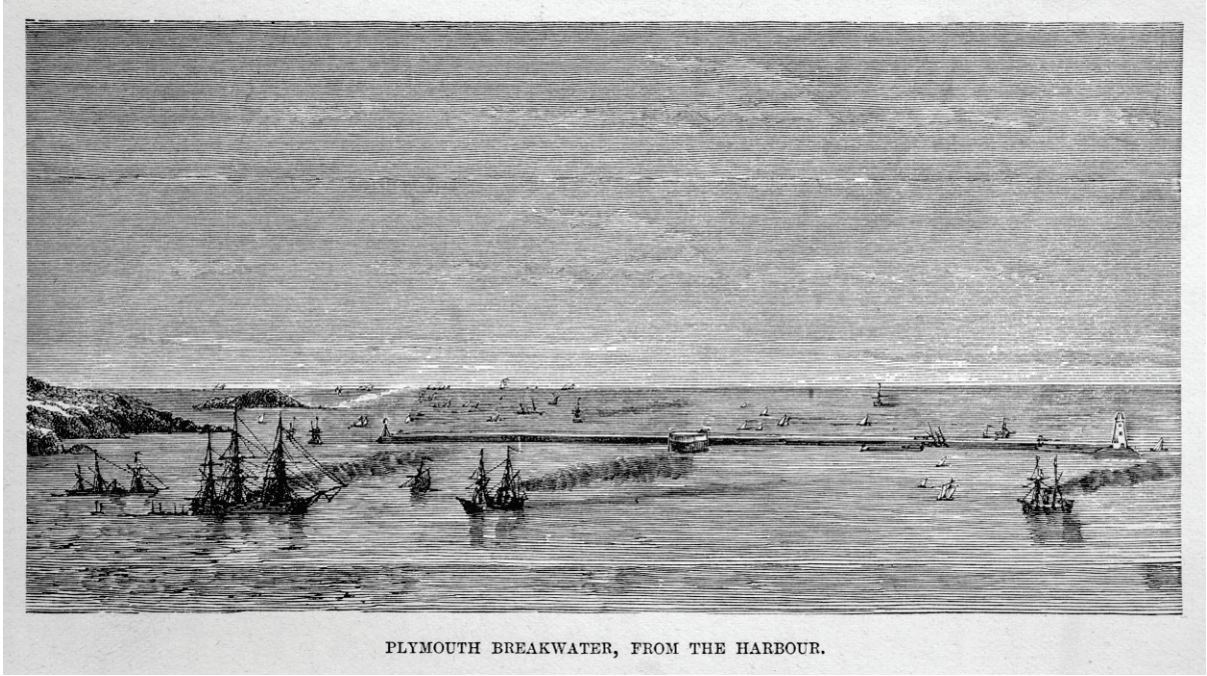


Figure 3: The commanding position of the Breakwater Fort in Plymouth Sound [SHIPS Project]

Plymouth has been one of Britain's most important naval ports for centuries because it has a commanding position in the Western Approaches and warships based there were well placed to control shipping in the English Channel. The defence of Plymouth port and its huge naval dockyard was through a combination of fixed shore gun batteries placed at strategic points inside Plymouth Sound along with warships anchored in the Sound acting as guardships. This means of defence stood the test of time while Britain ruled the waves, and since the battle of Trafalgar in 1805 the British had thought their ships were invulnerable.

This idea was shattered in 1859 when Britain's historical natural enemy over the water, the French, launched the world's first ironclad warship, known as the *Gloire*. This revolutionary ship was protected by 120mm thick iron armour plate backed with 430mm of solid timber. This combination was tested by the French against the largest guns available at that time, but just to be sure they tested the material at a range of just 20m! The *Gloire* made the Royal Navy's finest battleships obsolete overnight as shells from British guns would simply bounce off the new French battleship's armoured sides. In the peace after the Napoleonic wars, Britain's military forces were neglected and downsized, with no investment in innovations, so Britain had nothing in development to compete with this new French ship. In light of this, the First Lord of the Admiralty claimed that the Royal Navy was now unable to defend Britain's coast. This statement produced two results, the first was widespread panic amongst a public now terrified of a French invasion. The second result was for the Admiralty to immediately set up its own ironclad development programme, which eventually resulted in the launching of HMS *Warrior* in 1860, Britain's first ironclad warship.

The British government's response to the widespread panic was to set up a Royal Commission to determine the current state of the country's defences, the 1859 Royal Commission Report on the Defence of the United Kingdom, under the direction of Lord Palmerston. The programme looked at the defences of key infrastructure around the UK coast, mainly focussed on naval ports like Portsmouth and Plymouth. The wide-ranging recommendations represented the largest maritime defence programme since the initiative of Henry VIII in 1539-40. The Commission looked at the capability of existing defensive works, recommending improvements and extensions but also commissioned the building of a whole new series of fortifications. There were eventually some 70 forts and batteries in England which were due wholly or in part to the Royal Commission.

Because Plymouth was an important Naval port it was investigated in great detail, looking at how the port could be attacked both by sea and by land. Plans were made of the possible covering fire inside Plymouth Sound based on the range of big guns available at that time. The man in charge was Major (later General) W.F.D. Jervois R.E., the Assistant Inspector-General of Fortifications. The longer range of modern artillery allowed Jervois to design the fortifications to be constructed further apart from each other than had been done previously, so now a ring of detached works could be built to protect the city. In the analysis, they identified a gap in the ring of defences between the forts at Picklecombe in the West and Bovisand in the East, and their solution was to build a huge seafort somewhere in the middle of Plymouth Sound.

The Defence Commissioners were tasked by the Secretary of State for War to investigate the problem. The results of their work were published in 1862 in a lengthy report where they considered putting a fort at each end of the Breakwater, a single fort built on top of the Breakwater, or a single fort built on the seabed behind it. One of the early proposals was that the fort would be fitted with huge coal bunkers and would be used to coal the Navy's steamships, removing one of the wooden coal hulks anchored in the Sound that were currently employed in that task. At that time, space to anchor warships was in short supply in Plymouth Sound so gaining one more anchorage would have been a great advantage. They considered building a fort in front of the Breakwater on the south side, but it would be exposed to the full force of any southerly gales and would make access to the fort and the ability to coal ships impossible. Building such a huge structure on top of the breakwater was also dismissed as the breakwater's limestone rubble foundations would not support the weight. Just one option was left, so the fort was to be built behind the breakwater. Fortunately, Shovel Rock on which the breakwater was built extended over this area and would provide a sufficiently firm foundation for this heavy structure. The seabed was inspected using a diving bell and it was found that the rock was fairly level with a thin covering of fine silt, which was then deemed suitable for the foundations.

The design of the fort changed considerably between conception and completion. Being stuck midway between the Western and Eastern entrances to Plymouth Sound meant that enemy ships would attack the fort from very close range, less than 1000 yards (914m), so the fort had to be both extremely strong to resist artillery fire and well-armed enough to fight back. The initial enthusiasm to build something vast and expensive was partly fuelled by the invasion scare so many wild ideas were proposed before more sensible heads and budget limitations made the design more manageable. The Royal Commission initially specified a huge fort with 100 guns and accommodation for 600 men, while one newspaper described the planned fort as 'a fortress mounting 90 guns supported by 1000 men', the embrasures would be 'as high as the lantern on the Breakwater lighthouse' and made of blocks of stone fastened together.

The Breakwater fort will be the strongest and most important structure of the kind in existence. Nothing nearly so formidable exists anywhere else; and it will be the key to the defences of the Sound. Tavistock Gazette 1870

5. Constructing the Fort

There was neither the money, the guns nor the manpower to support a huge iron fort so the grand plans were immediately downsized. A new design by Capt. Siborne was approved in November 1860, this was for an oval-shaped fort 144ft long by 114ft wide (44m x 34m) with four floors rising 16ft 6in (5m) above high-water spring tides, with two tiers of granite gun casemates behind thick iron shields. Two huge gun turrets were to be installed on the roof, fitted above the two staircases, armed with a pair of 600pdr guns which were at the time the largest in existence. Work started in 1861 on the foundations for the fort which was built on a flat area of Shovel Rock that extends north of the Breakwater. By June 1862, a huge piling engine mounted on a ship had driven 42 huge timber piles 62ft (19m) long into holes bored in the seabed and fixed into the rock with massive iron clamps. The separate vertical piles were then to be connected at the top to create a platform that was strong enough to support a steam crane (Fig. 5).

The plans for the defences around Plymouth were drawn up and overseen by the Plymouth District Office of the Royal Engineers under Colonel Owen. At each site within the District, Colonel Owen would assign a Royal Engineer Officer or sometimes two to oversee the work and a Royal Engineer SNCO Clerk of Works who would work directly with the site foreman. The work on the Breakwater Fort was carried out by civil engineering contractors Henry Lee and Son, of Finsbury in London, who had previously built railways, bridges, graving docks, and other large construction projects. The project was under the supervision of 35-year-old Scottish engineer Mr Thomas Ormiston C.E., who had previously drawn up the designs for the foundation for the fort but had then been taken on by Henry Lee and Son to supervise the work itself. Ormiston directed operations on site until October 1864 when he took up the job of chief engineer to the Elphinstone Land and Press Co. of Bombay, a company intent on reclaiming a large extent of land from the foreshore of Bombay harbour, building tidal basins for ships and all the other infrastructure required by a busy port.

Four of the newly designed type of diving bells were used for securing the piles to the seabed and excavating the seabed around the piles (Fig. 4). The diving bells were lowered to the seabed from vessels moored above and breathing air was pumped down to men working inside using steam-powered air pumps. In the next four months, the underwater labourers removed two feet of mud from the seabed to expose the bedrock below in what would have been cold, wet, and back-breaking work.

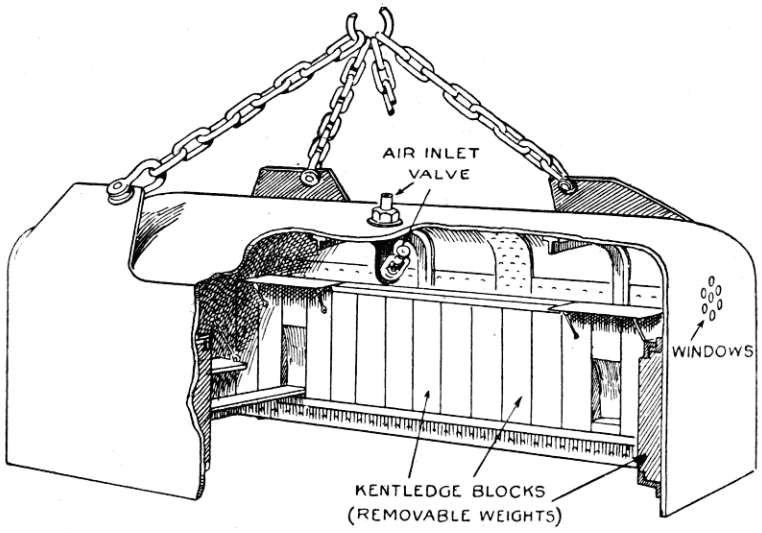


Figure 4: Cross section of a diving bell [SHIPS Project]

The bedrock was not flat, so the high spots were removed using underwater explosives placed by divers in the bells. Accounts suggest that the fuses were ignited from the surface once the diving bells had been recovered and the support ships moved away.

Divers using standard dress equipment with copper helmets and lead boots were also employed to help clear the seabed. Newspaper accounts from the time reported that the air exhaust valves on the divers' suits would get choked with mud and stop working, so the suits would inflate, and the diver would shoot to the surface. The heavy divers in their stiff, inflated suits would then be hard to recover into the rescue boat when the sea was rough. It is reported that the divers working on the foundations used to go down for four to five hours at a time; one diver called George Harris would usually dive at 7 am and not come back up till noon, presumably for his lunch. The combination of long dive times and rapid, uncontrolled ascents to the surface would be very dangerous for the divers but there are no accounts of anyone having lost their life during the construction.

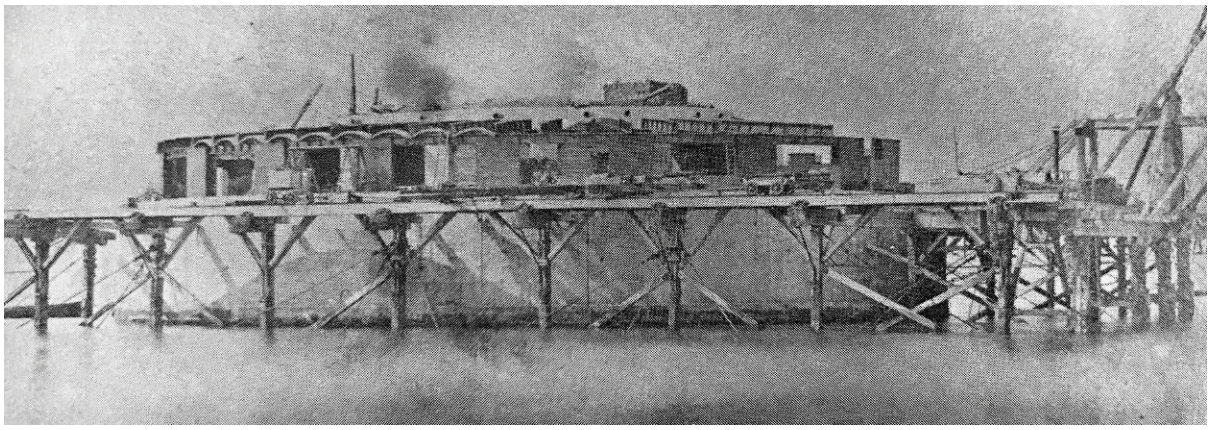


Figure 5: Constructing the fort using the timber staging around the outside [Cyberheritage]

The preparatory work was made more difficult because of the exposed location in the middle of Plymouth Sound and diving was limited to good weather days only. The weather not only stopped work in August but violent westerly gales on the 30th destroyed some of their hard-won efforts. On that day the construction crew were working on the tops of the piles about 20ft (6m) above the sea, busy connecting the piles together so the travellers used to move heavy stones could run on top. The engineers had prepared for bad weather by securing the piles to large iron anchors dug into the seabed, but they only did this on the western side from where the prevailing winds would blow. While the crew worked on the piles above, a diving bell was underwater carrying on the work of securing the tops of the piles to the anchors using strong chains. While the teams were working a strong easterly gale came through and brought the massive staging crashing down with no warning, leaving many huge timbers floating in the water. The crew working up top all fell into the sea, but the support boats pulled everyone to safety, and no one was killed. The diving bell was still underwater when the storm arrived and when the bell was hauled up both divers were found to be unconscious. One of the falling timbers had hit the bell and knocked it over releasing all the air inside and rapidly filling it with water, briefly drowning the divers. Luckily, both drowned divers regained consciousness sometime later. The timber piles were set up again and secured against future storms from both directions by chains attached to more anchors and to the Breakwater itself. By September the staging had been replaced and the final pile was driven into the seabed a month later. Next, a steam crane was built on the staging around the foundations to lift stones from barges alongside, and travellers were rigged on the stage to move the stones to where they were needed. The first foundation stone was laid on the seabed on the Prince of Wales's 21st birthday on 9th November 1862. Concrete blocks were laid up to a height of 32 ft (9.8m) and faced with granite blocks, with up to 2400 tons placed in position each week, and then 14,000 tons of rubble masonry were thrown in.

Once the blockwork was high enough, the underground rooms inside the fort were constructed along with the spiral staircases that were used to access them. Below the main gun deck were magazines for artillery shells and 1500 barrels of gunpowder as well as coal storage, a freshwater reservoir, and several storerooms. Lifts were installed for bringing powder and shot from the magazines below to the guns above. On the roof on the north side was a huge travelling crane that was used to lift the heavy guns from lighters below up to the level of the gundeck. The huge stone base for the iron fort was completed in 1865.

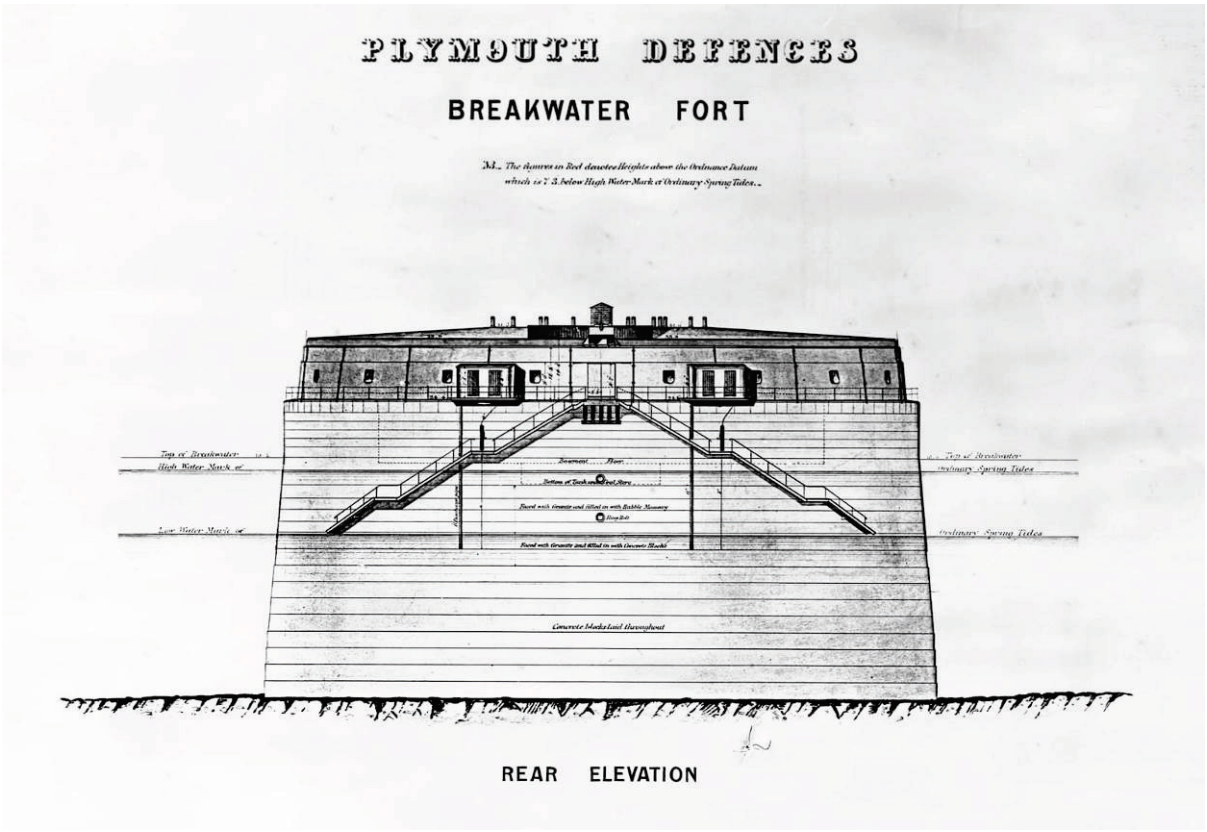


Figure 6: Elevation of the Breakwater Fort looking south [Bax Archive]

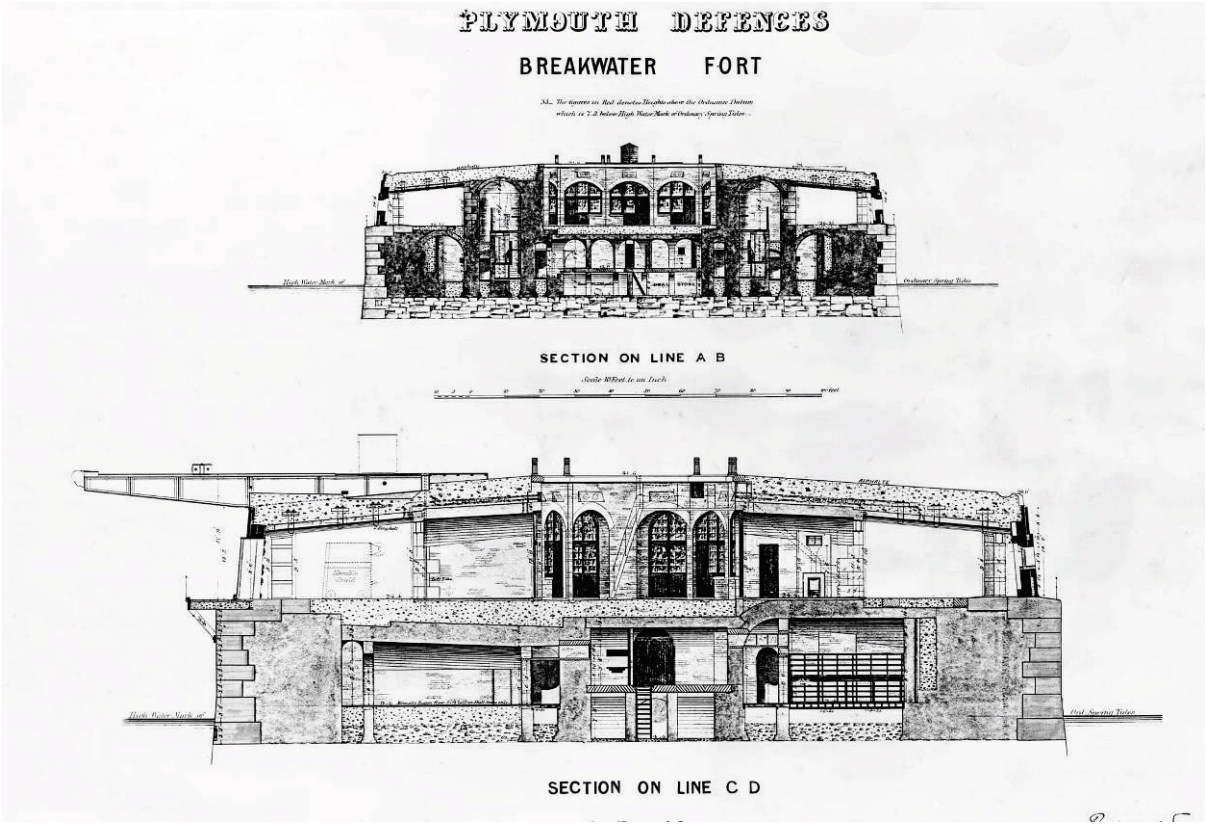
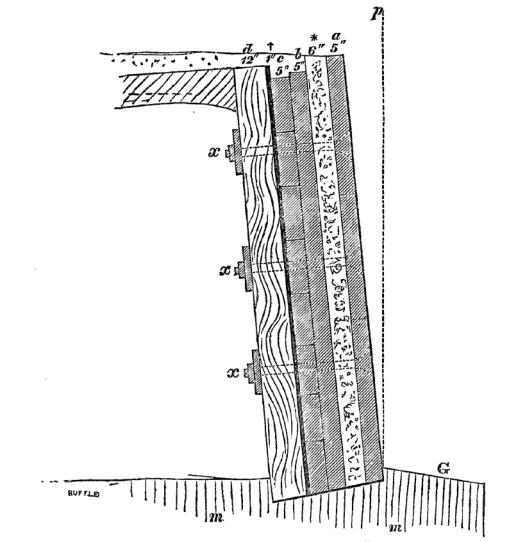


Figure 7: Cross section of the upper Breakwater Fort from the west [Bax Archive]

By 1866 the plan for the fort had again been downsized so now there were to be only two storeys, the lower for stores and magazines and the upper for 18 heavy guns in casemates, entirely protected from direct fire by iron rather than stone. The plan still included the two turrets on the roof mounting four heavy guns. To be able to defend itself against the latest enemy technology the fort was to be fitted with what was at the time the largest calibre British guns available, 10in 400 pdr guns.

At this time, weapons technology was advancing far faster than a fort could be constructed so by the time a set of plans had been agreed the design had become obsolete. Anything designed to withstand shelling by the largest enemy guns was found to be inadequate a few years later because gun technology was advancing so quickly. Artillery experiments proved that only an iron structure would be proof against the new heavy Rifled Muzzle Loading (RML) shells, so the plans were adapted as the fort was being built. This design was novel, it was the first attempt at constructing a land fortification where the main defence was made entirely of iron. The upper part of the fort that housed the guns was to be made of 15-inch (380mm) thick iron plate, formed from three tiers of 5in (127mm) thick plates, 21ft 9in (6.6m) long. The iron plate was to be backed with 6in (152mm) of 'iron concrete' made from iron turnings embedded in asphalt. Behind this were 5in (127mm) bars 16.25in (413mm) wide laid vertically then similar size bars laid horizontally. Behind this was a 1in (25mm) thickness of 'iron concrete'. This was supported internally by vertical iron bars 5in (127mm) thick and 12in (304mm) deep placed upright and edgewise let into the floor, packed with wood planks set edgewise. The whole lot was fastened together with through bolts, having rounded or cup heads on the concrete part, and conical heads on the upper plate above the concrete, fastened using special nuts designed by Lt. English R.E.



SECTION OF IRON WALL, SHOWING SYSTEM OF STRUCTURE.
a. Face armour ; * Concrete ; *b*. Vertical bars ; *c*. Horizontal bars ; † Iron concrete ; *d*. Wood plank, with iron struts at intervals ; *x x x*. Bolts, backing ; *p*. Perpendicular ; G. Glacis ; *m m*. Masonry foundation.

Figure 8: Cross section showing the construction of the iron shield [Mackie]

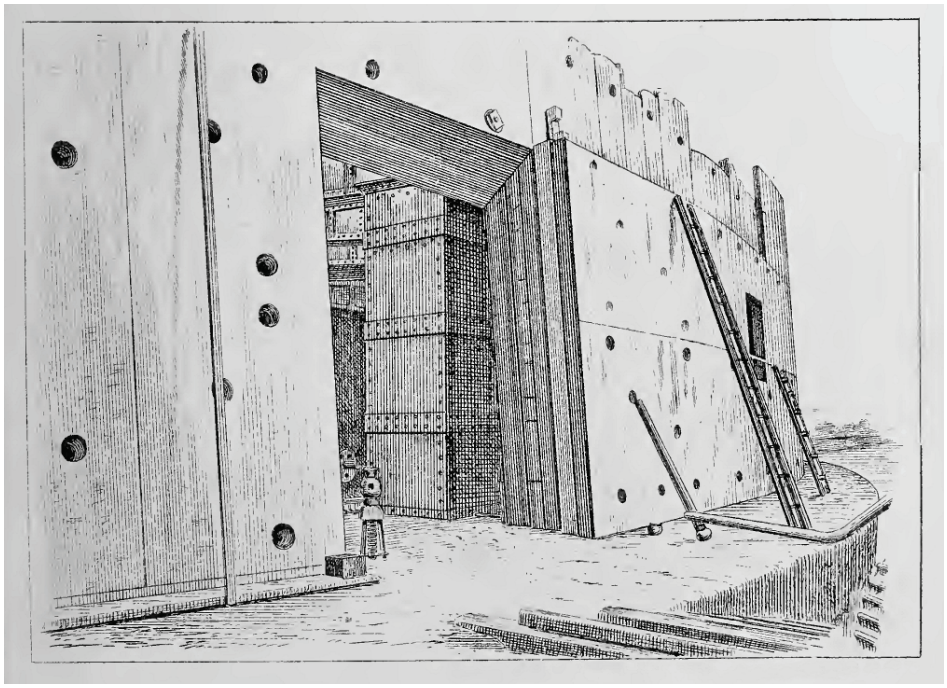


Figure 9: Constructing the main doorway into the 'Iron Fort' [Mackie]

Gun ports were set into the structure 2ft 10 3/4in (880mm) tall by 2ft 5in (731mm) wide and sited 4ft (1.2m) from the ground, designed to suit muzzle pivoting gun carriages. The ports were strengthened with an inner port plate of 5in (127mm) iron instead of the vertical bars, plus an additional 5in (127mm) iron plates above and below the port, making a total thickness of 20 inches (508mm) of iron plus 6in (152mm) of 'iron concrete'.

The casemate piers on which the wrought iron girders supporting the bombproof roof rested were 14ft (4.3m) apart and detached from the iron wall. The concrete roof was supported by brick arches springing from longitudinal iron girders, supported in front by transverse box girders. A mantlet made of interwoven rope was to be slung from the roof, perpendicular to the wall and attached to each pier, used to block flying splinters.

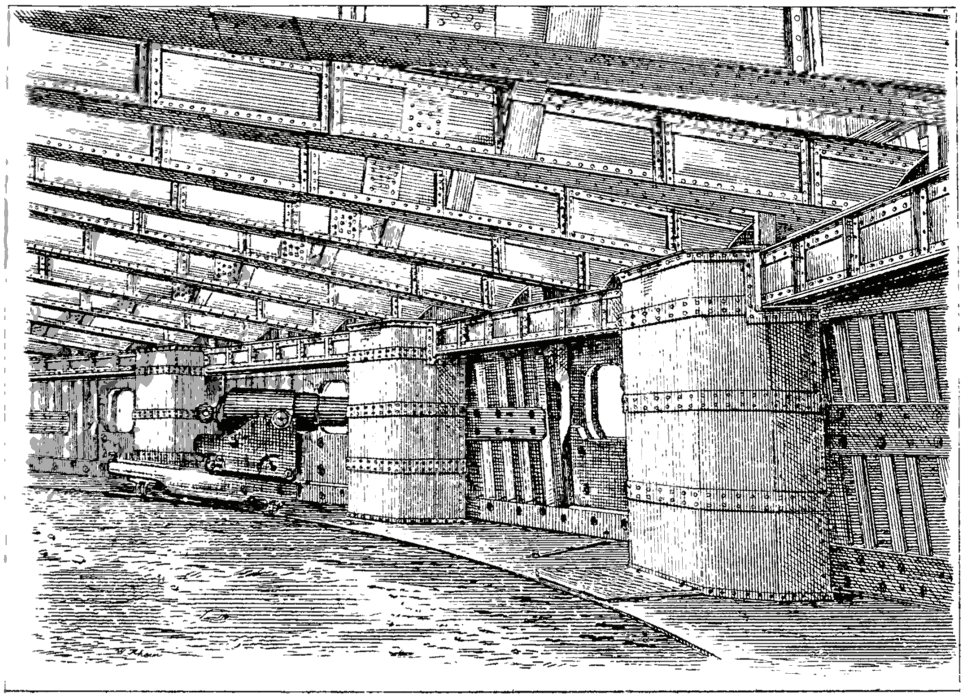


Figure 10: Inside the 'Iron Fort' [Mackie]

The iron structure was to be made at the Millwall Ironworks with some of the more complex-shaped pieces made by Brown in Sheffield.

The effect on defensive structures of large calibre rifled shells was not known so Sir John Pakington ordered experiments to be made which were undertaken at Shoeburyness in 1868. A test section of wall 21ft (6.4m) long and 13ft (4m) high was constructed in the same design as the fort but made flat rather than curved like the fort wall to save money. This design of armoured casemate was intended to be used on the Breakwater Fort and at Fort Cunningham in Bermuda. Fort Cunningham is on a small island which defends the approach to the Royal Dockyard and the harbour of St George, and here they were to build a fort with three straight faces mounting nine heavy guns, one built from masonry with iron shields and the other two would be iron casemates using the Plymouth fort design. They tested a whole range of structures which reflected the thinking of the time about defence against shellfire; an experimental casemate of a different design, a section with two single unbacked iron plates 15in thick one made by rolling and the other made by hammering, two masonry walls faced with iron of different kinds and a gun shield made by Millwall Iron Company.

This experimental section was shelled from just 200 yards (182m) range with battering charges, Palliser projectiles at 12in, 10in, 9in diameter and a few Rodman 15in calibre smoothbore projectiles. Tests on the section of the fort showed that the weakest part of the structure, a joint, could be penetrated by a 600lb (272kg) shell fired from a 12in 25ton RML using 76lbs (34kg) of powder at 200 yards (182m). The tests proved that the 3 x 5in laminated armour was equal to the 15in solid plate when most thought that the solid would be superior. The bolts held the armour plates and the uprights together, with very few bolts being broken in the tests. The structure supporting the roof could not be damaged by horizontal fire unless the wall had been breached first. They also found that the rope mantlet worked as it should, catching and stopping fragments of armour, bolts, and nuts, and on one occasion catching a flying fragment of armour weighing 800lbs (362kg). In the meantime, a more powerful gun had been developed than that used in the Shoeburyness tests, so the arms race still moved on apace.

A newspaper account from September 1869 suggests that the iron topside of the Fort was assembled into a single structure at Millwall foundry, a huge structure 143.5ft (43.5m) long by 112.5ft (34.3m) wide, ready for erection on the Breakwater Fort base in four months' time. By this time the fort was to be fitted with eighteen 18-ton 10in RML guns, firing Palliser projectiles of 400lbs (181kg) weight with 60lb (27kg) charges, capable of penetrating the armour of any existing ironclad at that time at 1000 yards (914m) range. The assembly of the iron structure began in Plymouth and the walls of the fort were largely complete by 1870. At the same time, the forts at Bovisand and Picklecombe had iron shields fitted to their embrasures as a defence against flying splinters of granite from the facings used in their construction. By April 1871 the last armour plate had been put into position on the Breakwater fort leaving the shell-proof concrete roof four feet thick and the two huge gun turrets still to be done.

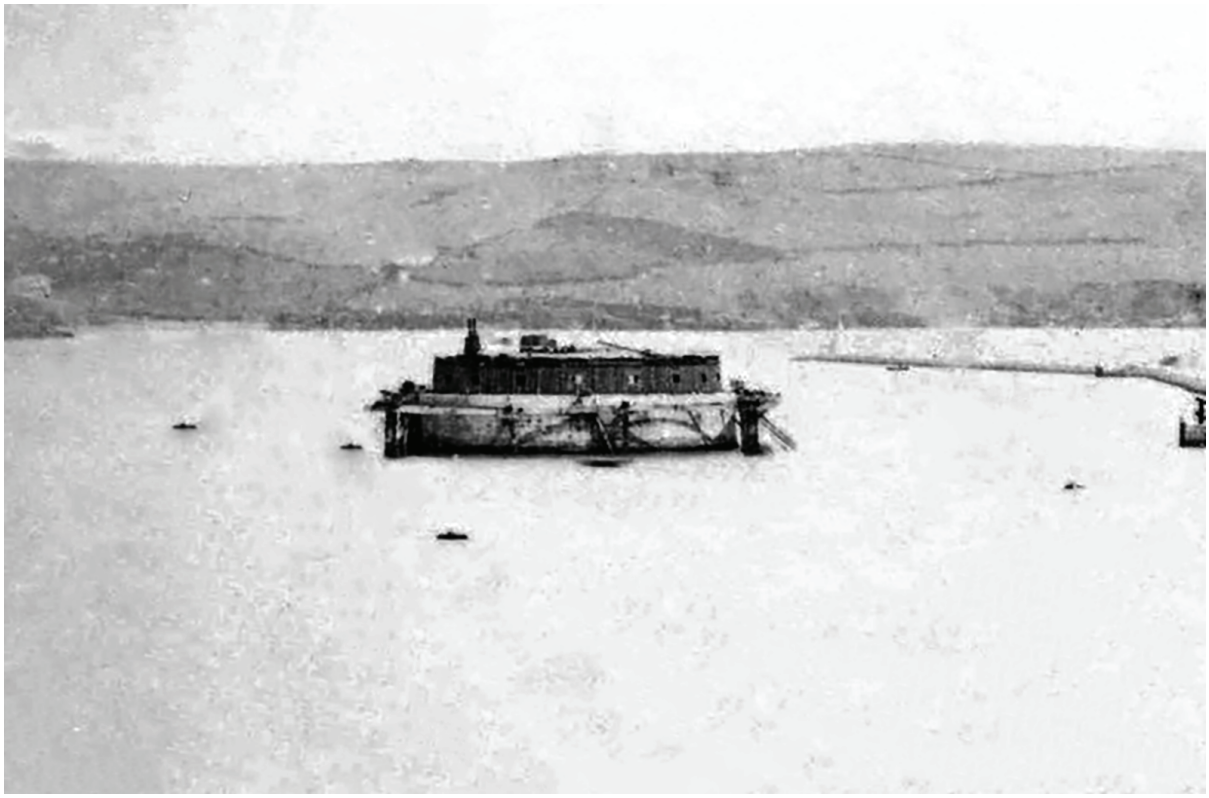


Figure 11: The Fort under construction with the iron casemates in place [Cyberheritage]

A newspaper account from April 1871 reported that the rubbery 'iron concrete' was in the end not used in the construction of the casemates. The 'iron concrete' was actually made from iron turnings embedded in asphalt, and although technically a kind of 'concrete', this word left room for misinterpretation. To reduce the costs of construction, real concrete made from ordinary Portland cement and shingle was used instead of the 'iron concrete', a material much harder and more brittle than the material it replaced. A scathing paper written in the same year by Mackie pointed out these deficiencies in the construction, as the ordinary concrete would break up under the battering from shellfire, the securing bolts would come loose and '*the armour will clatter about in certainly a very noisy manner*'. The Breakwater Fort was described in the press as '*the strongest and most important structure of its kind in existence*' and '*the key to the defences in the Sound*', yet penny-pinching during final construction by replacing the 'iron concrete' with building concrete could have been the fort's undoing. Fortunately, the Breakwater fort was never used in anger and the effect of using the cheap building concrete was never tested.

Complications caused by constructing a fort during a very rapid and significant arms race caused huge delays which meant that the 'Plymouth Iron Fort' was the last of the coast forts to be finished.

More information about Plymouth's Palmerston Forts can be found in the book *Forts or Follies; A History of Plymouth's Palmerston Forts* by Freddy Woodward published in 1997, and a catalogue of Plymouth's defences has been published in the book *The Historic Defences of Plymouth* by Pye & Woodward, published in 1996.

6. Operations

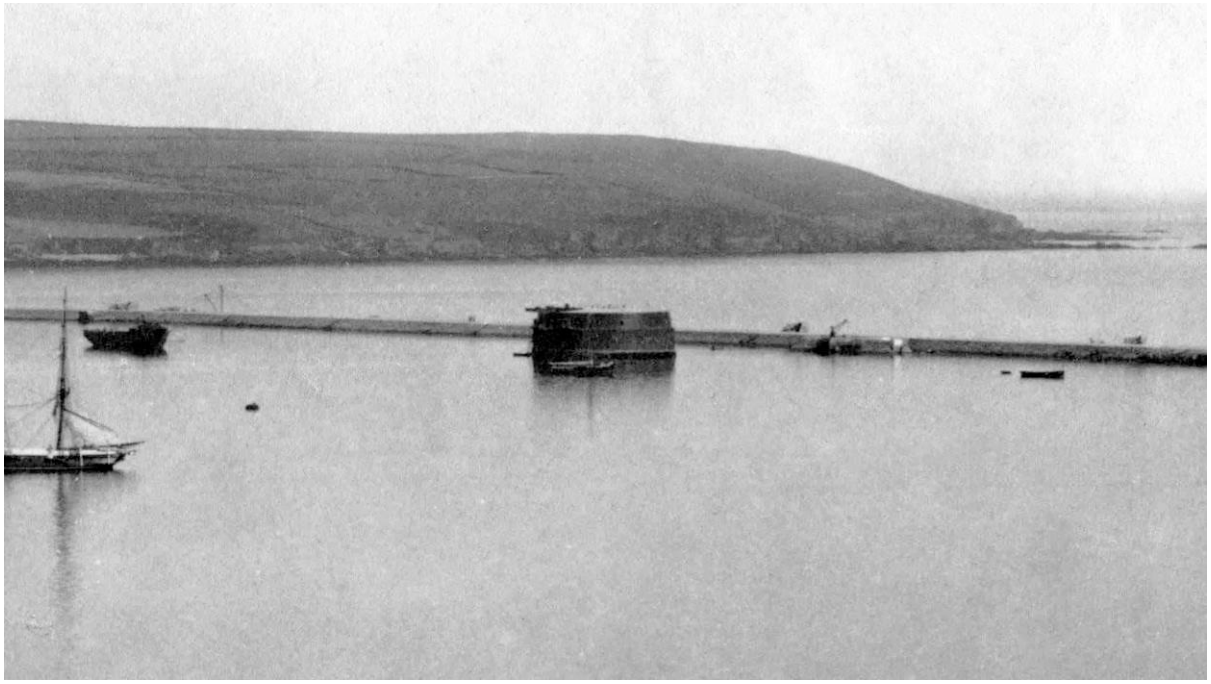


Figure 12: The fort recently completed on a very calm day [Cyberheritage]

In 1874 the armament on the fort had changed again. The idea of installing two massive turrets on the roof each fitted with two of the largest guns available was shelved, as it was noticed that no funds had been allocated for this work. The 1875 armament included fourteen 12.5in 35-ton RML guns to cover the approach to the harbour with four 10in 18-ton RMLs pointing north to cover the anchorage behind. Special 'small port' muzzle pivoting carriages were developed for the fort to use the smaller gun embrasures that had been built. Unsurprisingly, water ingress was a perennial problem and in 1876 they found that the magazines were too damp to store powder and repairs had to be completed. The first of the larger type of guns were fitted in 1879 and the fort was fully armed in 1880, nineteen years after construction had started.

At some point, the exterior of the fort was painted in a black and yellow chequered pattern to disguise the location of the gun ports, and some of this original paintwork can still be seen today. The fort originally would range its own guns but later the rangefinder firing information for the guns was sent via a submarine cable from positions at Fort Bovisand and Picklecombe as they had a more commanding view of the Sound. In 1888 it was announced that the fort would be fitted with 3 arm semaphore signalling equipment and in June 1889 new signal station on the fort became operational with its semaphore lights visible a mile beyond the Breakwater, plus a telephone to keep in touch with the signal station at Mount Wise and with Admiralty House. Two men were to be always on duty in the lookout station on the roof which included cooking and sleeping accommodation. The Fort was also associated with the construction of a torpedo range at the Breakwater used by HMS *Defiance*. In 1893 it was thought that the fort gun deck was too crowded, so seven of the 12.5in guns were removed and redeployed in new batteries on Staddon and Maker Heights. At the same time, four smaller 6pdr quick-firing guns on saddle mounts were fitted and the underground level was strengthened by filling in the seaward-facing casemates as further protection against shellfire.

The Fort made the local papers again in 1893 for accidentally bombarding Penlee Point on the Cornish side of Plymouth Sound. Due to an error of alignment during a test firing, two shots fell in the water close to staging where workmen were building a new pier at Penlee. A third shot landed in the garden near the coastguard station close to a group of men felling timber, the shell buried itself four feet into the ground, the men hastily took cover but fortunately, the shell failed to explode. The press reported that the third shell '*resulted in the destruction of a bed of very promising cabbages*'.

By 1898 the fort armament was reduced to six 12.5in guns plus six 6pdr Quick Firing (QF) guns. In 1903 another 12.5in RML was removed, and a searchlight was added to the roof followed by another searchlight fitted in 1911. By this time the guns in the fort were made obsolete by advances in technology so the fort was disarmed before the start of WW1, leaving just the searchlights on the roof still operational. During the First World War, the fort was used as the Port War Signal Station.

In 1936 the Breakwater Fort became an anti-aircraft training school with AA guns mounted on the roof. However, in 1929 a Fairey IIID biplane crashed in front of the Breakwater during an exercise with the R.N. gunnery school at Devonport, who were operating guns on the Breakwater Fort, so there may have been anti-aircraft training at the fort earlier than is recorded. In 1939 an official naval anti-aircraft range was set up south of the fort covering '*a distance of 7000 yards [6.4km] on a bearing between 150° and 200°*.



Figure 13: Picking up spent cartridge cases after a training exercise with the AA guns [Cyberheritage]

After World War II the fort was disarmed and reverted to being a signal station until the 1950s. In 1976 the Fort was taken over by the diver training company Plymouth Ocean Projects and used for training commercial divers for work offshore until the company ceased trading in 2000.



Figure 14: Commercial divers under training at the Breakwater Fort [Kostas Thoctarides]

7. Location and Environment

The Breakwater Fort lies to the north of the Plymouth Breakwater in the middle of Plymouth Sound at:

NGR SX 4716508
50° 20.063 N 004° 08.940 W (WGS84)

The Fort is 3.3km from Plymouth Hoe to the north, 1.5km from Fort Bovisand to the east and 1.9km from Fort Picklecombe on the west side of Plymouth Sound. The Fort is not quite centrally placed on the Breakwater being 680m from the west end of the Breakwater and 830m from the eastern end while the south wall of the fort is 68m from the inshore side of the Breakwater.

The average seabed depth around the Fort at mean low water spring tides is 7m to 9m to the south and east of the Fort and 10m to 12m to the north and west. The fort lies in a sheltered position and is protected from most tidal currents, but a strong westerly current occurs on an ebb spring tide. The seabed close to the fort wall is a mix of blocks and rubble probably lost over the side during construction. The rubble slopes down to a soft, flat mud seabed that extends to the north. To the south, several rock ridge outcrops are visible on the seabed running from the fort to the Breakwater. Lots of more modern debris is scattered all around the Fort, mostly originating from the Fort itself. Several large electrical cables connect the Fort to the shore at Fort Picklecombe to the west, to Fort Bovisand to the east, and the Breakwater to the south, but the cables are no longer in use.

The Fort is owned by the UK Ministry of Defence and lies in the Plymouth Sound and estuaries Designated Special Area of Conservation (SAC). Since 1971 the Fort has been a Scheduled Ancient Monument number 1002623 under the Ancient Monuments and Archaeological Areas Act (1979).



Figure 15: Buildings on the roof of the fort in 1976 [Bax Archive]

8. Nearby Shipwrecks and Aircraft Crash Sites

As soon as the Breakwater was built it became both protection for ships and a hazard to navigation. Many ships were wrecked on it before a petition to have a lighthouse built on the Breakwater was successful.

On 22nd November 1824, the 110-ton former East India Company hoy *Coromandel* was knocked down in a storm and the battered hulk was washed up on the western end of the Breakwater, her cargo of cork on its way to London was scattered all over Plymouth Sound. The brig *Erin* was wrecked there on 20th March 1833 followed a year later by the *Two Brothers* on 7th March 1834. One account of her loss states '*On Tuesday night a smuggling vessel named the Two Brothers of Cawsand was chased by the Revenue cutter Arrow and driven onto the Plymouth Breakwater during a gale from the south-west. The crew consisting of five persons got on board the Breakwater and commenced crying for help, when they were rescued by the boat belonging to the light-vessel near the entrance to the Sound. The vessel was afterwards taken possession of, but the greater part of the kegs on board were staved and the smuggler is a wreck*'. In 1838 the crew of 6 from the *Thetis* was saved by the Coastguard galley from Bovisand, under Lt. Thomas Holman RN, who rowed out and took the men off the breakwater. In 1843 the brig *Mayflower* was lost followed by the *Ocean* in 1853, and the *Mary Ann* in 1854 foundered off the west end of the breakwater, following a collision with the S.S. *Nile*.

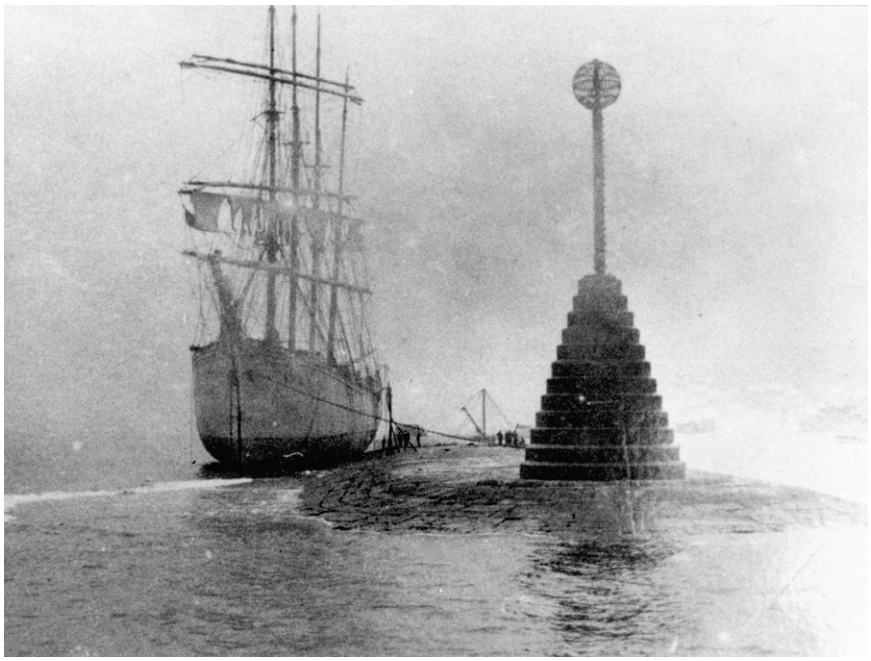


Figure 16: The* Yvonne *aground on the Breakwater [Richard Larn]

On 16th October 1877, the 726-ton barque *R. H. Jones* from Bremerhaven to Newport in ballast wrecked about 100m east of the Breakwater lighthouse in a gale. The ship broke up, scattering wreckage all over the Sound and there was only one survivor, a German seaman called Albert Blom. Some ships were thrown right over the Breakwater during particularly bad storms. In February 1884 the French ketch *Bon Pasteur* was on a voyage from Le Havre in France to Bristol carrying a cargo of phosphate when she was caught in a storm, the sea rose to terrific heights, her rudder got damaged, and the vessel became unmanageable. The ship made a run for Plymouth Sound, but when attempting to sail in through the western channel she was driven beam on to the breakwater, 100 yards from the lighthouse. A huge sea then picked her up bodily, washing the ship over the breakwater, where she became caught in a large iron derrick structure. The ship's crew were thrown into the sea on a broken section of the ship's hull and managed to get back onto the breakwater where they climbed up the derrick, remaining there for over four hours. The crew eventually made it to the safety of the lighthouse, but the broken and smashed *Bon Pasteur* washed away and sank.

In 1886, the *Marie Blanche* sank off the breakwater in a force 7 gale and became a hazard to navigation so was blown up and dispersed. The western end of the Breakwater saw yet another wreck when in 1887 the brigantine *Orion* failed to tack correctly and went ashore on the western end ripping big holes in her bottom. April 1874, the steamer *Somersetshire* carrying 300 passengers and a general cargo drove straight into the middle of the breakwater in thick fog, while under the command of a Plymouth Pilot. Fortunately, a steam tug was in the Sound and the stricken steamship was quickly refloated and taken safely into port. Two years later the *Irex* struck the breakwater in a force 7 gale and sank.

Some ships were wrecked in calm conditions; on 13th September 1913 the 150-ton self-propelled barge *Hopper Barge No 42* wrecked on the western end of the Breakwater on a dark but clear night, the skipper having been confused by the many bright lights in the Sound. The barge was refloated the next day but promptly sank off the western end of the breakwater and her remains are occasionally visited by divers today. One mystery wreck is the *Abelard,* she was a side trawler built in North Shields and taken into Admiralty service in WW1. On 24th December 1916, the ship sank on the outside of the eastern end of the Breakwater for reasons unknown, although it is thought she may have hit a mine. The remains of the *Abelard* are a well-known dive site in 10m depth often used for training sports divers.

In 1919 the ship *Fair City* left Fowey in ballast when the wind started to increase and by the time the ship was seven miles south of the Eddystone rock the conditions at sea were dreadful. Making their way to the safety of Plymouth the ship drove on to the Breakwater close to the Breakwater Fort. The mainmast fell overboard, and the noise caused the troops from the fort to turn on their searchlight, illuminating the wreck. The troops threw ropes to the ship from the Breakwater and the crew scrambled ashore, the vessel going to pieces along with all her gear and stores. One of the biggest ships to be wrecked on the Breakwater was the *Yvonne*, a 68m long French-owned barquentine built in California, USA as the *John Palmer*. On 3rd October 1920, the Yvonne wrecked on the outside of the eastern end of the Breakwater in a southerly gale and mountainous seas. The ship sat on the Breakwater for several months and she was eventually set on fire to get rid of her.



Figure 17: **Hopper Barge No. 42** ***aground on the Breakwater [Alan Down]***



Figure 18: **LST493** ***after being wrecked on the west end of the Breakwater [SHIPS Project]***

It is not just ships that were lost on the Breakwater as a few aircraft crashed there too. On 15th July 1929, a Fairey IIID two-seat general-purpose biplane belonging to Lee-on-the-Solent seaplane base crashed on the south side of Plymouth breakwater. The crash happened during an exercise with the R.N. gunnery school at Devonport, who were operating guns on the Breakwater Fort. The biplane appeared to have trouble flying in the strong breeze and at one point flew low outside the breakwater, executing what one observer described as 'a series of hops' before crashing in the sea. Short Sunderland Mk II flying boat W6054 crashed on landing in Plymouth Sound at night and in thick fog on 12th November 1942. The aeroplane was bringing back five passengers from Gibraltar to Plymouth, piloted by Flight Lieutenant Wynton Thorpe and with a crew of 11 airmen. On 13th February 1943, a Lancaster heavy bomber crashed at the west end of Plymouth breakwater after hitting a barrage balloon cable on the way back from a raid on Lorient in France. On 11th December 1944, a Sunderland Mk III aircraft ML782 from Pembroke Dock suffered engine failure and then came down in Plymouth Sound. The sea was choppy, there was a 3-4ft (1m) swell, and the aircraft bounced three times damaging her bow before she stopped near the submarine boom by the west end of the Breakwater, slowly sinking. On 9th February 1945, Sunderland Mk III ML829 captained by Flt. Lt. Stan Reeve attempted to take off from Plymouth Sound on an operational sortie. She hit a wave, raised into the air but stalled near the eastern end of Plymouth breakwater, she struck the boom defence on the end of the breakwater, broke up and sank almost immediately.

Another large vessel was the U.S. Landing Ship Tank LST493. On 12th April 1945, she drove straight onto the western end of the Breakwater at night and in rough weather due to a navigation error, unable to free the trapped ship she was broken up where she lay in December 1946. On 2nd December 1947, the 400-ton Admiralty lifting craft *Freija* wrecked on the eastern end of the Breakwater in heavy seas. The motor launch *Grey Owl* had wrecked there three months earlier and *Freija* was removing the remains of the launch when her anchors dragged. The crew of fourteen escaped in the ship's boat and the ship was later refloated and taken into Devonport.

9. The Glaucus Experiments

The 1960s were a time when man was keen to explore both outer space and what became known as 'inner space', the world under the sea. Many scientific and military programs were started to find out how men could live and work underwater, and by the end of 1964, both the French and the Americans had completed experiments in long-term living under the sea. The French were represented by Jacques Cousteau with his Conshelf I in 1962 and Conshelf II in 1963 and the US were represented by Edwin Link and his 'Man in the Sea' Project in 1962. The Royal Navy had been experimenting with deep diving but had not yet been interested to see if their divers could live underwater. In 1965, in typical British fashion, it was left to two amateur enthusiasts from the Bournemouth and Poole Branch of the British Sub-Aqua Club to pick up that gauntlet. These enterprising aquanauts were Colin Irwin, the 19-year-old Scientific Officer for the diving club and John Heath, a marine biologist. At that time the Bournemouth club was the only diving club in the area and included over 100 members, so it was big enough to support a project of this size.

The two divers put a plan together to design and build a habitat that would allow them to live underwater at 35ft (10.7m) depth for seven days. The problems they had to overcome included maintaining a breathable atmosphere inside the habitat, providing food and drink, dealing with the cold, and keeping them both safe. They also had to manage their gas decompression because living under pressure for a week would saturate their bodies with gas which had to be released slowly before they could return to the surface. Finding sufficient funding was difficult so the amateur divers attempted to recreate for pennies what had cost the other projects millions of pounds. Despite their tiny budget, they designed the habitat, a semi-closed circuit air purification system, a way for food and supplies to be brought down to them by support divers, a communications link to the surface and a scheme for decompression. The two divers were helped by RN Surgeon Lieutenant Commander Elliott who gave them access to the Royal Naval Physiological Laboratory library. The project, now named '*Glaucus*' after the legendary Greek fisherman, was estimated to cost £1000 (about £21,000 in 2022) to be raised by donations or regained from the sale of film, advertising, and news. From the start, the venture was run as a credible science project. The project had well-defined aims including maintaining an artificial atmosphere independent from the surface, trying two different decompression schedules, studying the ecology and diurnal migrations of crabs, testing the viability of the habitat, and observing the reactions of the two guinea pig divers, all while doing this at a minimal cost. The project report document goes into detail about the design process for the habitat, and how it should be big enough to accommodate the two divers without boredom, cramp, or constipation, yet be small enough to deploy onto the seabed.

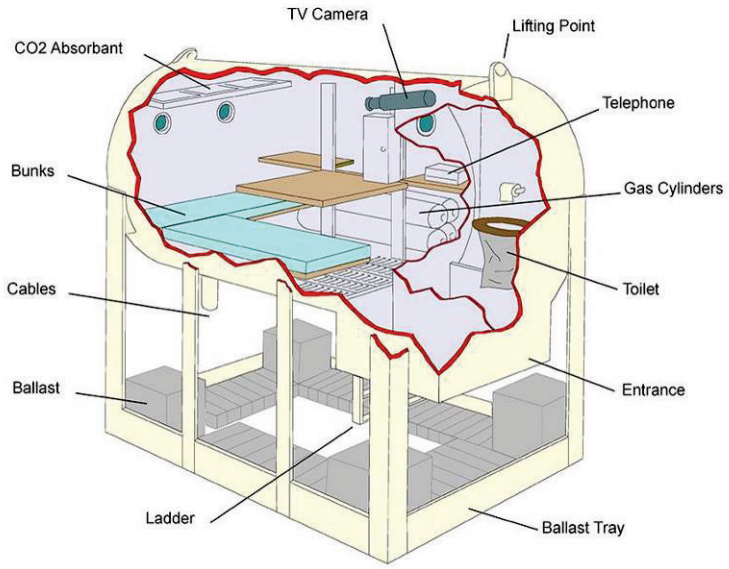


Figure 19: Cross section showing the inside of* Glaucus *[SHIPS Project]

The habitat buoyancy must not be more than 20 tons, it was to be weighted with moveable ballast and able to be lifted with the cranes that were available to the team. The interior should be fitted with two folding bunks, a folding table, portholes for entertaining the divers, storage for scrubber and gas cylinders, lighting, telephone, toilet, and flooring over the bilge.

Their working design was for a steel cylinder on legs made from 1/4in (6.3mm) plate, 12ft (3.7m) long and 7ft (2.1m) in diameter, with a buoyancy of 13 tons, sat on a steel tray to hold the ballast, so overall it was 12ft (3.7m) tall. There was a 1ft (304mm) long skirt around the entrance to the living space and a 3ft (914mm) gap underneath the skirt for access by the divers. The entrance hatch was 4ft x 3ft (1.2m x 0.9m) and divided into two, one half went into the living area while the other provided access to the toilet which could also double up as a ballast tank during deployment and recovery. Cables fed through a duct at one end of the house for power and communications, low voltage DC electrical power was fed from the surface to be used for internal lights and there were backup batteries on board if that failed. Communications to the surface were via a self-contained battery-powered telephone and a closed-circuit television system would be used to monitor the two aquanauts day and night.



Figure 20:* Glaucus *being launched at Millbay [Pathe]

The steel *Glaucus* habitat was built in a shipyard in Poole. The team sensibly did a dry run of the experiment on land in the boatyard with the two divers sealed up inside the habitat, they wanted to complete 24 hours 'underwater' but on the second day they experienced breathing problems, then Colin vomited twice so the test was abandoned. Modifications were made to some of the fittings inside the habitat and they progressed to the next stage. All the other experiments living underwater

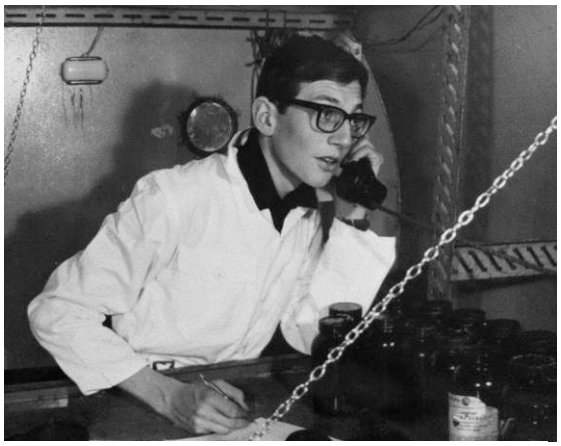


Figure 21: Colin Irwin on the telephone inside* Glaucus *[Colin Irwin]

so far had been done in warm water locations but to keep costs down the team decided to do their experiment on the south coast of the UK. The Queens Harbour Master at Plymouth had given permission for the tests to be run there so *Glaucus* was shipped off to Devon by road. The test site was next to the Breakwater Fort in the middle of Plymouth Sound, sheltered from the south by the Breakwater and from the east by the Fort. The Fort could also be used as a dry and stable base for the surface team rather than having a vessel moored on standby next to the habitat.

Glaucus was taken to Millbay Docks in Plymouth on Monday 13th September 1965, she was lowered into the water by crane then towed out to the site and sunk, and then the divers entered the habitat on Thursday 16th. The air inside the compartment had to be kept within tolerable breathing conditions so it was analysed every eight hours and any required adjustments made to the carbon dioxide scrubbers or the oxygen system. The cold was always a problem as there was no heating system in the habitat and the steel hull soon cooled down to the outside water temperature. Everything was damp inside, there was no room to exercise to get warm, and going to the toilet meant the divers had to duck out of the main compartment and into the sea and so get even colder. The only relief was the three hot meals per day and hot drinks when diving. The two crew spent their time listening to the radio, reading, or watching any passing wildlife at the habitat entrance when the water was clear enough. Unfortunately for the first half of the week, the site was battered by southwest gales creating very rough seas above the habitat, but it remained firmly on the seabed held down by tons of ballast. Unfortunately for the divers, the waves overhead produced a six-inch swell in the entrance, and this swell repeatedly pressurised then depressurised the cabin which made the divers' eardrums pop. Despite the poor conditions the surface crew still managed to take down meals, newspapers and dry towels and they kept a constant watch on CCTV. The divers also had jobs to do outside on the seabed, so they put on their SCUBA gear and dropped out of the entrance and into the sea. Care was taken to ensure that when the two aquanauts were diving they stayed attached to the habitat and did not venture more than 3m above it, as for them the habitat was the safe refuge and surfacing would have brought on decompression sickness.



Figure 22:* Glaucus *arriving back at Fort Bovisand in 1969 [Bax Archive]

The weather eventually cleared and the remaining days passed by. Having completed their chilly but successful week underwater it was time to bring the divers up. The original plan was to bring the habitat and the divers up to 10ft (3m) and leave it hung off the steps on the north side of the Fort for 12 hours for the divers to decompress. When attempting to do this they found that it was impossible to control the buoyancy, so *Glaucus* shot to the surface, lost some of the air keeping her afloat then sank back to the seabed. A second attempt at the same procedure produced the same result, both times done with Colin and John still inside! It was decided that raising the habitat that way was not possible and that the divers should make their own way out. The oxygen level was raised inside the habitat allowing the

aquanauts to decompress, this allowed them to safely ascend to the surface, and they reappeared safe and well on Thursday 23rd. As a safety precaution, the two aquanauts were taken to HMS *Drake* to be given a thorough examination and kept under observation for two days. Bad weather over the next few days held up the recovery of *Glaucus* but the team returned two weeks later and towed the steel cylinder back to the dock. *Glaucus* was returned to Poole, and it sat in a pub car park for a while before being sent to Watford as it was intended to go to the diving centre at Stoney Cove. This plan failed, and she was eventually sold to POP Fort Bovisand in 1969 and she returned to Plymouth in December of that year. The team at Fort Bovisand refurbished the habitat giving her a smart coat of paint and a new logo so she could be used for more experiments by Dr Brian Ray from Imperial College in London with divers from Aston University Sub-Aqua Club, who spent another week underwater in *Glaucus* in 1970. After the Imperial College experiment, the habitat appears to have been left on the seabed for some time. Photographs from 1974 show *Glaucus* being raised and put on the end of the pier at Fort Bovisand, much worse for wear with big dents in her hull and most of her paint missing. Sometime later she was again placed on the seabed on the north side of the Fort where her remains can still be seen today.

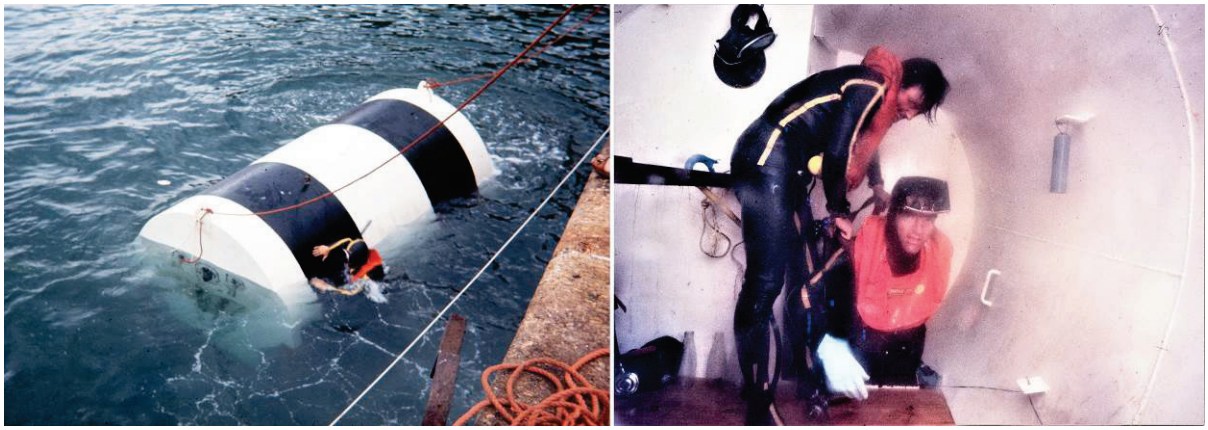


Figure 23: A newly refurbished* Glaucus *at Fort Bovisand, Alan Bax and diver inside [Bax Archive]



Figure 24: Battered and with most of her white paint gone,* Glaucus *is recovered at Fort Bovisand in 1974 [Bax Archive]

Glaucus was visited by aquanaut Colin Irwin in July 2015 on the 50th anniversary of the first experiment. A team from The SHIPS Project helped divers from Bournemouth BSAC put Colin back underwater so he could see *Glaucus* again, watched by BBC presenter Jenny Walrond and a local TV camera team. The team attached a plaque on one of the habitat's legs that explains to visiting sports divers what it was and why *Glaucus* was so important.

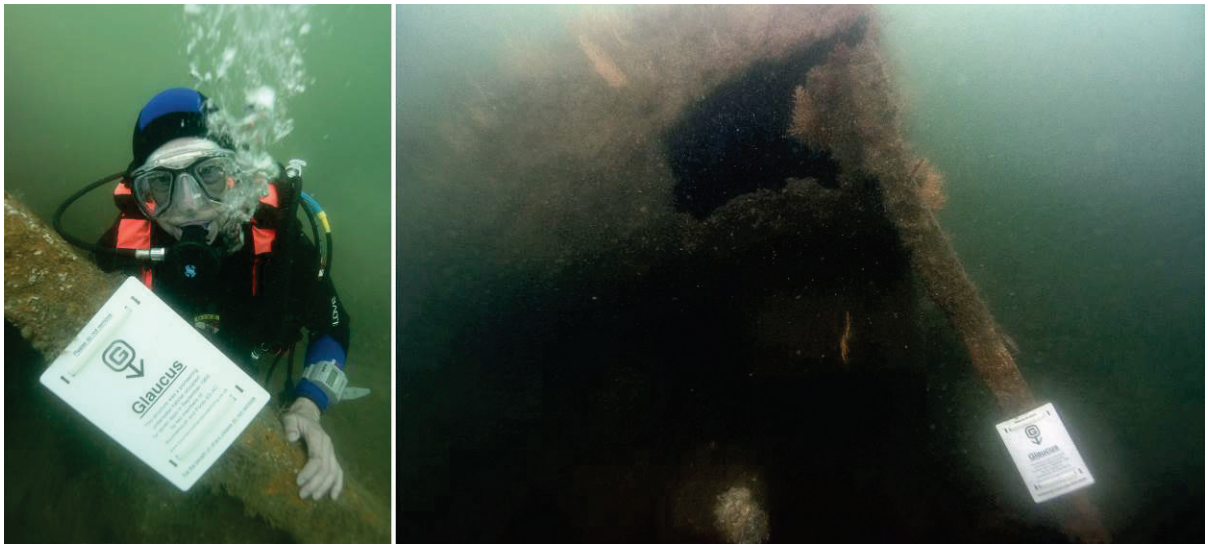


Figure 25: Original aquanaut Colin Irwin revisits* Glaucus *in 2015 [SHIPS Project]

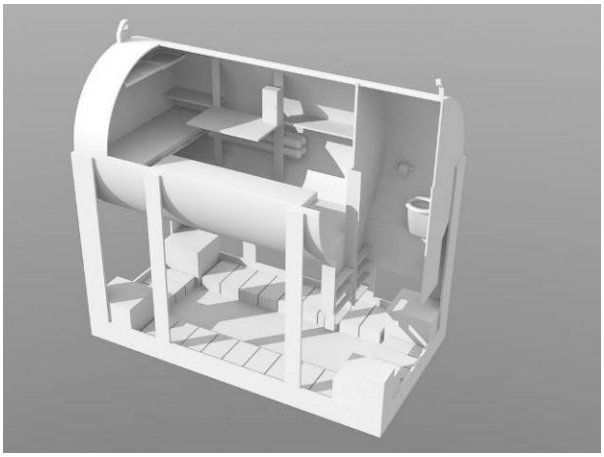


Figure 26: 3D Virtual reality model of Glaucus [HIT Team]

Prof. Bob Stone and the Human Interface Technologies Team at the University of Birmingham created a 3D virtual reality model of *Glaucus* that you can go inside in a computer simulation.

10. POP Fort Bovisand and The Breakwater Fort Structures

In 1976 the Breakwater Fort was taken over by the diver training company Plymouth Ocean Projects and used for training commercial divers for work in the challenging environment of the North Sea.

The first diver training course run at the Breakwater Fort was the CSWIP training and examination, used to train divers in the underwater examination of steel and concrete structures. Established in 1969 as the Certification Scheme for Weldment Inspection Personnel, CSWIP provided a standardised approval of proficiency. Today CSWIP provides internationally recognised qualifications for people engaged in welding, joining, and inspection in manufacturing, construction, operation or repair of high-integrity structures, plant, or machinery. There were various sections to the exam, visual inspection, Magnetic Particle Inspection (MPI), concrete inspection, grinding a weld fillet underwater plus a written exam. The initial training was often done in a large tank at Fort Bovisand before the divers were allowed to progress to training in the sea. The CSWIP examinations usually included three or four students, starting their day early and staying out at the Fort until the exam had been completed.

The trainee divers used a diving system where air was supplied to them through a hose into Kirby Morgan SuperLite 17 diving helmets fitted with cameras. There was a large low-pressure air compressor and storage cylinders on the Fort to provide the air that the divers breathed and a large electrical generator for the Magnetic Particle Inspection system that required 400 Amps. There was a system for providing hot water that could be pumped through the diver's suit, a system that was used offshore to keep divers warm underwater in the chilly North Sea. Dives were often 3 to 4 hours long, usually with the diver wearing a drysuit rather than the hot water suit. A neoprene drysuit is supposed to keep a diver warm and dry but water often leaks in making for an uncomfortable dive.

The divers were lowered into the water from the working area outside of the fort on the level of the main gun deck. The cage was operated by a winch which allowed two divers to be raised and lowered at a time. Inside the main entrance on the south side of the fort was the control room which had breathing air control panels and communications systems for three divers at a time, two trainee divers plus one emergency diver on standby ready to rescue a trainee if there was a problem.



Figure 27: Early diver training at Plymouth Ocean Projects [Bax Archive]

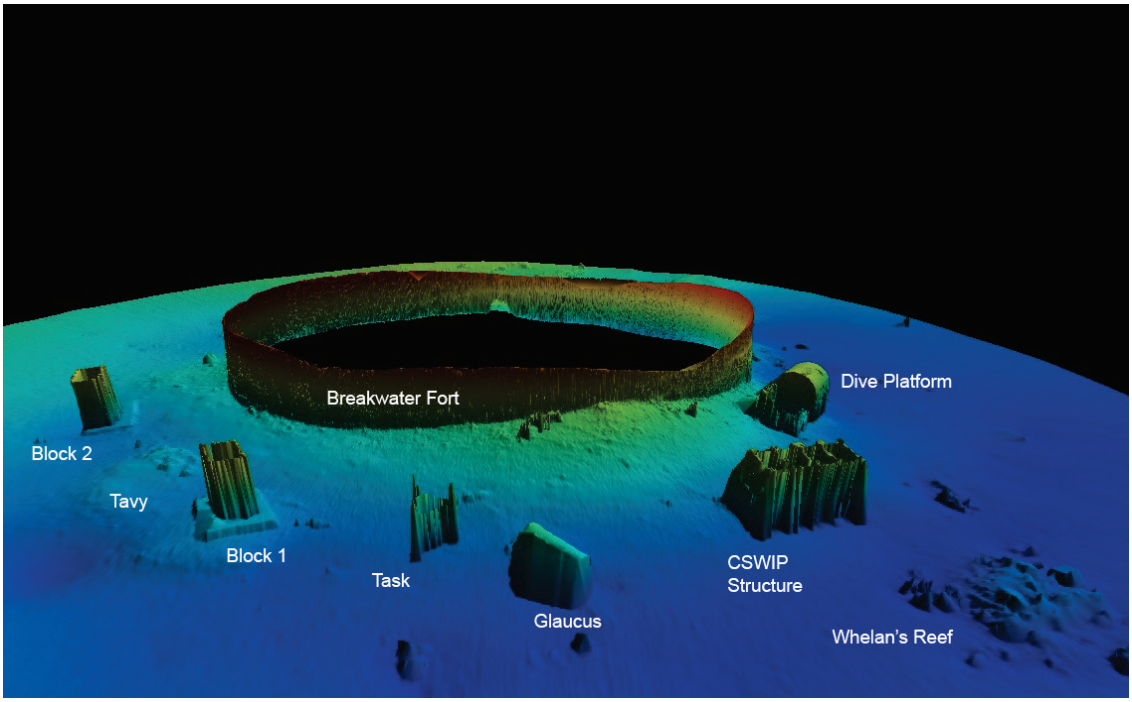


Figure 28: 3D Sonar model of the Fort structures, looking south [SHIPS Project / Swathe Services Ltd.]

The CSWIP inspection courses stopped being run, then the Fort was then used for training divers in the three HSE professional air diving courses, known as Part 4, Part 3 and Part 1. The divers completed practical exercises including the use of lifting bags, seabed searches, underwater knot tying, diver rescue and mechanical assembly tasks. The Fort was also used for sport diver training and courses in underwater photography.

The seabed just to the north of the Breakwater Fort is home to several curious structures that are shown in the 3D sonar image above. From east to west, the structures include a hollow concrete block, the remains of a Trinity House pilot tender, another concrete block, a construction task, the *Glaucus* underwater habitat, a steel structure that was once part of an oil rig, a pile of junk and tyres, and a modified Admiralty salvage pontoon. Further north is an intact salvage pontoon still in one piece and lots of unidentified objects that have been dumped on the seabed. Blocks 1 and 2 are large, hollow structures made of concrete that are open at the top and sit on wide concrete bases. The blocks were placed there in 1984 and were used for testing inspection divers' skills at detecting flaws in the concrete, as each was specially made with a range of flaws and imperfections.



Figure 29: One of the concrete blocks showing the hollow structure [SHIPS Project]

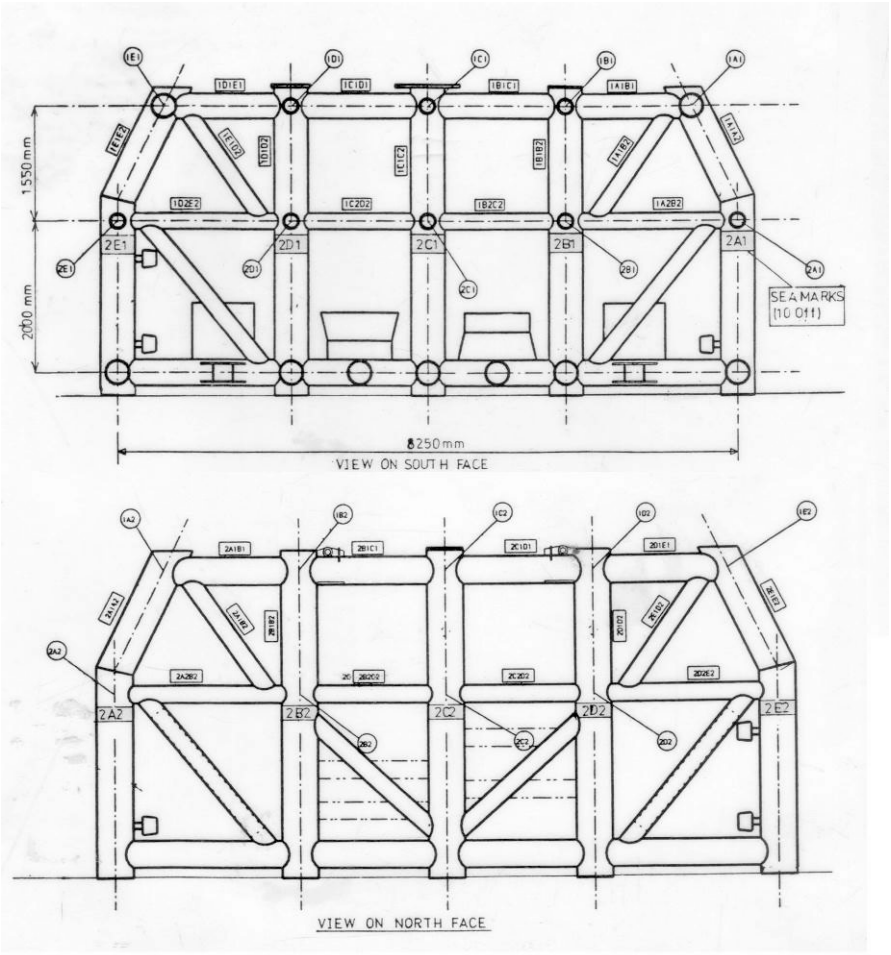


Figure 30: Engineering drawing of the CSWIP Structure [Paul Dart]

In 1983, a section of tubular steel oil rig structure was sunk on the seabed north of the Fort. Like the concrete blocks, the 8m long steel CSWIP Structure also included a range of flaws so it could be used for training divers in the art of underwater inspection and as a place to test their skill in examinations.

The 'Task' was another large steel structure used for training divers that will be remembered by many who went through the Fort Bovisand training scheme. The three-legged task was hung on chains at a depth of 20m under a barge moored in deep water in Barn Pool at the north end of Plymouth Sound. Teams of trainee divers would have to dismantle the cross members holding the Task together by unbolting the flanges and then bring the pieces up. Once done the divers would have to reassemble it underwater. Good teamwork was essential to take it apart and put it back together while diving from a wet diving bell with the tide running and often in poor visibility. The barge in Barn Pool eventually sank, so the Task was placed on the seabed north of the Breakwater Fort.

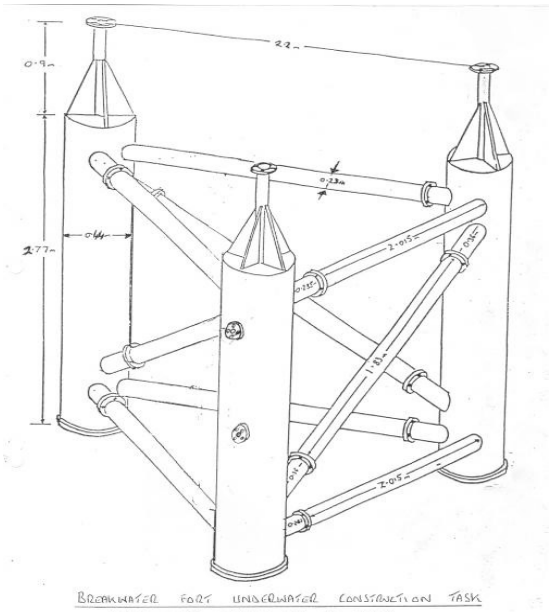


Figure 31: Sketch of the Task [Paul Dart]

On 15th January 1979, the large trawler *Nordzee* limped into Plymouth Sound in a sinking condition. The ship made it as far as Jennycliff Bay, but the crew abandoned ship just as it rolled over and

sank. Plymouth Ocean Projects won the contract to salvage the ship and they acquired two Admiralty salvage pontoons for the job. The salvage was not a success, and it was later completed by another company. One of the salvage pontoons was dumped on the seabed 60m to the north of the Fort while the other was cut down by Peter Bernardes and Alan Lane with the intention of turning it into a dive platform to be used by the company. The idea was abandoned because the unusually shaped vessel was not a good dive platform, and the cut-down pontoon was later sunk on the seabed up against the Fort wall.



Figure 32: The Salvage Pontoon being modified at Turnchapel [Peter Bernardes]

The story of the Trinity House pilot tender *Tavy* will be told in the next chapter, sunk in 1995 between the two concrete blocks she survived for a few years before breaking up. The story of the *Glaucus* habitat was told earlier, it was used for experiments in living underwater and was eventually placed on the seabed near the CSWIP Structure.

To the northwest of the fort lies a pile of steel scrap and tyres about 10m long by 5m wide. When Michael Whelan started teaching divers at the Fort the seabed was covered with junk, so with the help of the student divers, they started to tidy it all up into one big pile. The junk was moved to one area which became known as 'Whelan's Reef'. North of this is an unknown structure and 10m further on can be found the other Admiralty salvage pontoon.

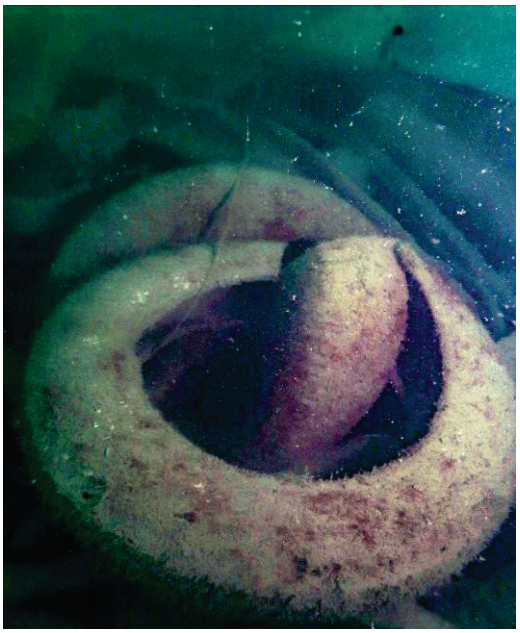


Figure 33: The junk and tyres that make up Whelan's Reef [Fran Hockley]

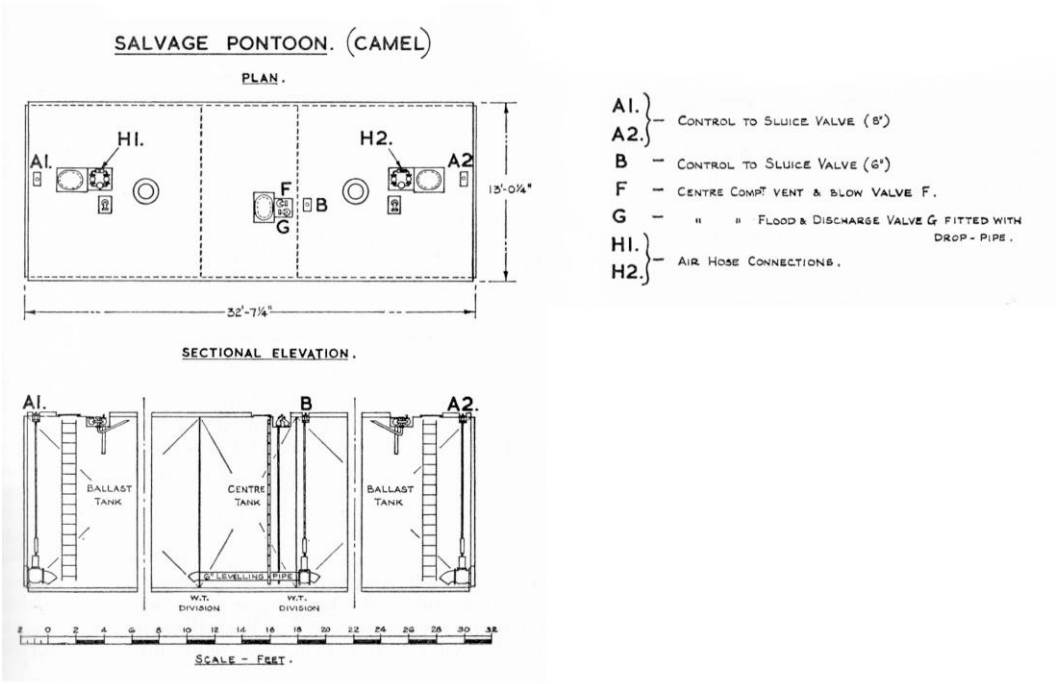


Figure 34: A drawing of an Admiralty Salvage Pontoon [SHIPS Project]

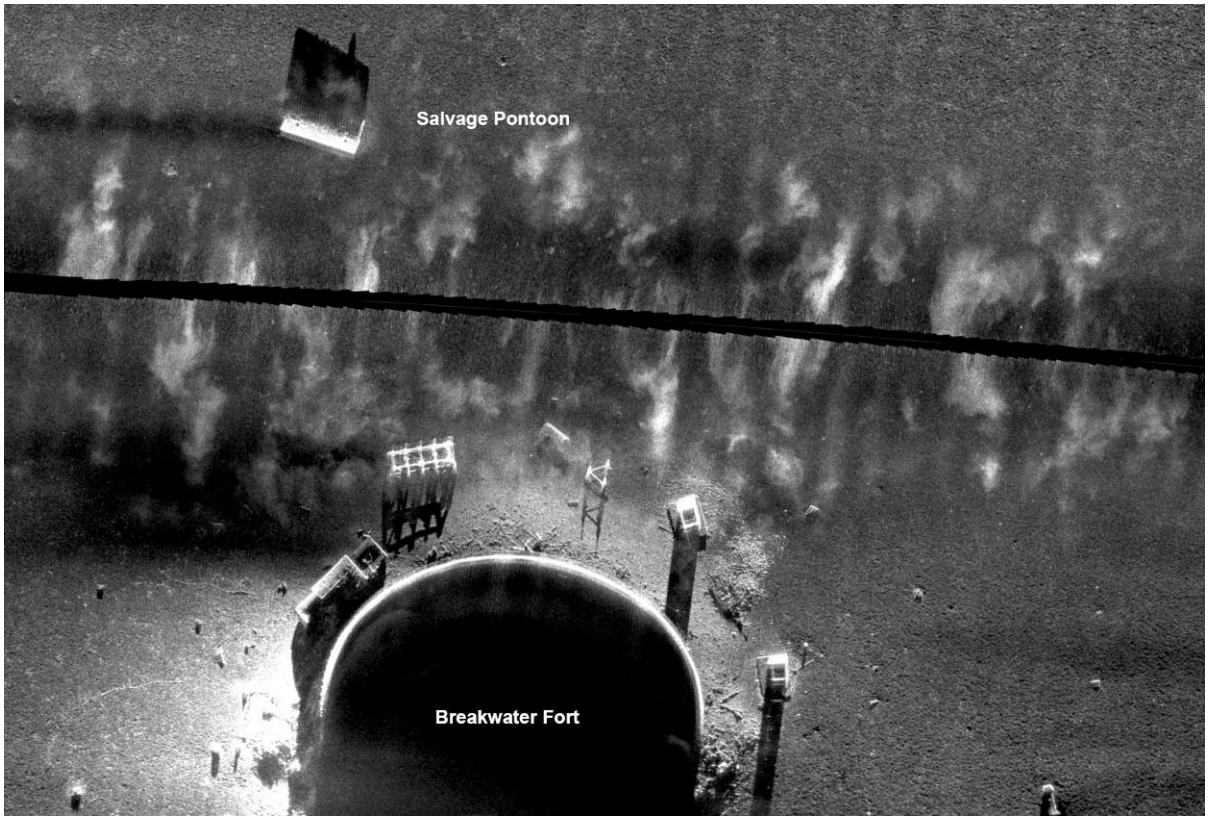


Figure 35: A plan sonar image of the seabed from above showing the fort, the structures and the salvage pontoon to the north. This was created using a Solstice sonar [Wavefront Systems Ltd.]

11. Sinking *Tavy*



Figure 36: Trinity House tender* Tavy *(foreground) at the Mayflower Steps [SHIPS Project]

At a meeting in May 1995, three members of a Plymouth underwater archaeology group called PMARIG, Jon Greenough, Paul Dart, and the author, started planning to create a site that could be used for doing experiments in surveying and recording techniques used in underwater archaeology. Gordon Watts had made the 'Sinkentine', a 1:1 scale 10ft x 10ft (3m x 3m) replica section of a hull of a ship from fibreglass to be used for hands-on training in a swimming pool. The team wanted to do something similar by sinking a timber ship in the sea so the training would be done on a real ship's hull under realistic conditions. This site would be an asset for training divers in underwater archaeology techniques, it would be an ideal site to carry out research by universities and it would be used to promote Plymouth as a centre of excellence in this field. The seabed to the north of the Breakwater Fort was already in use by Plymouth Ocean Projects for commercial diver training and already had a collection of structures on the seabed, so it was an ideal location to add one more. The Fort site was sheltered from waves by the Plymouth breakwater, it was easily accessible by divers, it was shallow, and the Fort could be used as a dry and stable base for setting up any electronic equipment needed for the survey work.

The original idea was to use the bow section of a decommissioned trawler called *Atlantis*, but this was very tall and needed a lot of work to make it safe for divers to record. Instead, the team were offered the ex-Trinity House tender *Tavy*, a clinker-built wooden vessel launched in 1959, at 7.6m long and with a beam of 1.54m she was a much more suitable size. Skipper Dave Boon had bought *Tavy* from Trinity House, and she was later sold to the oil company Conoco as a tender to a fuel barge, but she ended up in the boatyard at J. Boston & Son, so *Tavy* was donated to the project by Nigel Boston. *Tavy* was prepared for sinking between August and October 1995 by volunteers Kit McAllister, John Spencer, and Jon Parlour, who removed the wheelhouse, any loose objects and anything that was likely to snag on a diver's equipment. Fortunately, most of the hard work had already been done as the engine and steering gear had already been removed. Permission to sink the vessel was obtained by Nigel Boston and Alan Bax at Plymouth Ocean Projects so the team were ready to go. *Tavy* was loaded on the deck of Nigel Boston's large dive support vessel *Terschelling* and she sailed out into the Sound on a lovely calm day on Friday 23rd December 1995, accompanied by a team of volunteers from PMARIG and a local TV crew. The big dive boat was secured to the fort in the right location, the small timber boat on her deck was prepared for scuttling and *Tavy* was lifted over the side. The little wooden ship was loaded up with scrap chain and sinker weights and she sank to the bottom, sheltered between the two large concrete blocks used for diver inspection tests.



Figure 37: **Tavy** ***being made ready for sinking in 1995 [SHIPS Project]***



Figure 38: **Tavy** ***on the seabed by the Breakwater Fort in 1995 [SHIPS Project]***

12. Scientific Research at the Fort



Figure 39: Paul Dart on the bow of the Sonardyne trials vessel* Rangemaster *at the Fort [SHIPS Project]

The Breakwater Fort has been used as a platform for undertaking several scientific experiments. This seems appropriate as the 'iron fort' itself was an experimental design, despite it becoming obsolete before it was finished.

In 1965 the Fort was used as a base for the *Glaucus* Project where two aquanauts lived underwater in a steel habitat for a week. Similar tests were run using the same habitat but as a joint venture between Imperial College and Plymouth Ocean Projects in 1970. By 1976 the Fort had been taken over by Plymouth Ocean Projects and was used for training commercial divers until the company ceased trading in 2000.

In 1981 the area behind the Breakwater next to the fort was used for trials of a new underwater positioning system developed by Sonardyne International Ltd. that was used during the installation of the Conoco Hutton oil platform in the North Sea. One of the tripods used for that trial can still be found on the seabed to the west of the Fort.

In the late 1990s, the Fort was used as a base for practical Nautical Archaeology Society (NAS) training courses with the first NAS Introduction to Practical Archaeology Underwater run on the Fort in early December 1995. Later that month the PMARIG team sank the Trinity House tender *Tavy* in amongst the other structures on the seabed on the north side of the fort.



Figure 40: Paul Dart and NAS trainees in the diver cage at the Fort [SHIPS Project]

The structures around the fort and the wall of the fort itself became a test site for research into mapping and recording shipwrecks.



Figure 41: Jon Greenough testing the new Sonardyne DiveTrak underwater navigation system [SHIPS Project]

At that time the usual way of recording shipwreck sites was to use fibreglass tape measures about 30m long. Accuracy in this type of survey was important to archaeology but the accuracy was not known, so the PMARIG team decided to find out. The survey site was set up with fixed measurement points on the concrete blocks, *Tavy,* and the Fort itself. Lots of tape measurements were made on the test site by many people between 1996 and 1997, with each person having differing levels of skill and experience from first-timers to experts. All the measurements were processed together in a computer program to work out how they best fit together and the team worked out how accurately you could survey a shipwreck from this data. The results of this research were published in the International Journal of Nautical Archaeology in 2003.

Once the Trinity House tender *Tavy* had been sunk on the seabed it was monitored to see how the hull and its environment changed. The ship stayed in one piece for a few years, but later the stern deck was damaged, it has been suggested that a boat had tied a rope to the vessel and tore away the deck, so accelerating the collapse of the hull. By 2003 the remains of *Tavy* were just a collection of flattened timbers held down by the chains originally used to sink her.

With the site accurately surveyed and mapped it could be used as a baseline with which to compare similar surveys using alternative techniques. Shipwreck surveys using tape measures were time-consuming and prone to errors so the team wanted to find a quicker way to map shipwrecks that would give similar accuracy. Two methods were tried, the first used a Homer Pro made by Sonardyne International Ltd. and the second was an underwater navigation system called DiveTrak made by the same company. The Homer Pro is an acoustic tape measure that can measure distances underwater using sound waves while DiveTrak is like an underwater version of the system in your phone or satnav that tells you where you are.

In October 1995 a survey of the Fort site was completed using a Sonardyne Homer Pro and four transponders placed around the site. Two concrete blocks, the *Glaucus* habitat and the CSWIP structure were positioned relative to four transponder beacons attached to the Fort and one attached to the east end of *Glaucus*. A survey using Sonardyne's prototype DiveTrak system was attempted in 1994 but was unsuccessful due to bad weather and technical problems but was repeated later in 1996. Other recording methods tried on the site were an early form of 3D photogrammetry, a method that has now largely replaced underwater surveying using tape measures. Nick Strange recorded the hull of *Tavy* with 3D photogrammetry using a software program called PhotoModeler for his University of Plymouth undergraduate project in 1998.

In 2006, the 'Innovative approaches to Rapid Archaeological Site Surveying and Evaluation (RASSE)' project team from the University of St Andrews came to Plymouth to do fieldwork for English Heritage. The team used multibeam sonar and side scan sonar to identify objects placed on the seabed near the Fort and included the test site set up around the Fort in their analysis.

In August 2012 James Williams used the Fort site to collect data from several different multibeam sonars to see how well each of them would work mapping the structures around the fort for his University of Plymouth Masters in Hydrography. Student Charlotte Alexander in the same year used the site to investigate how marine animals degrade timber underwater for her degree in Environmental Science. Commercial companies have also used the structures around the site to test their equipment, notably Wavefront Systems which tested their Solstice sonar there in 2012.

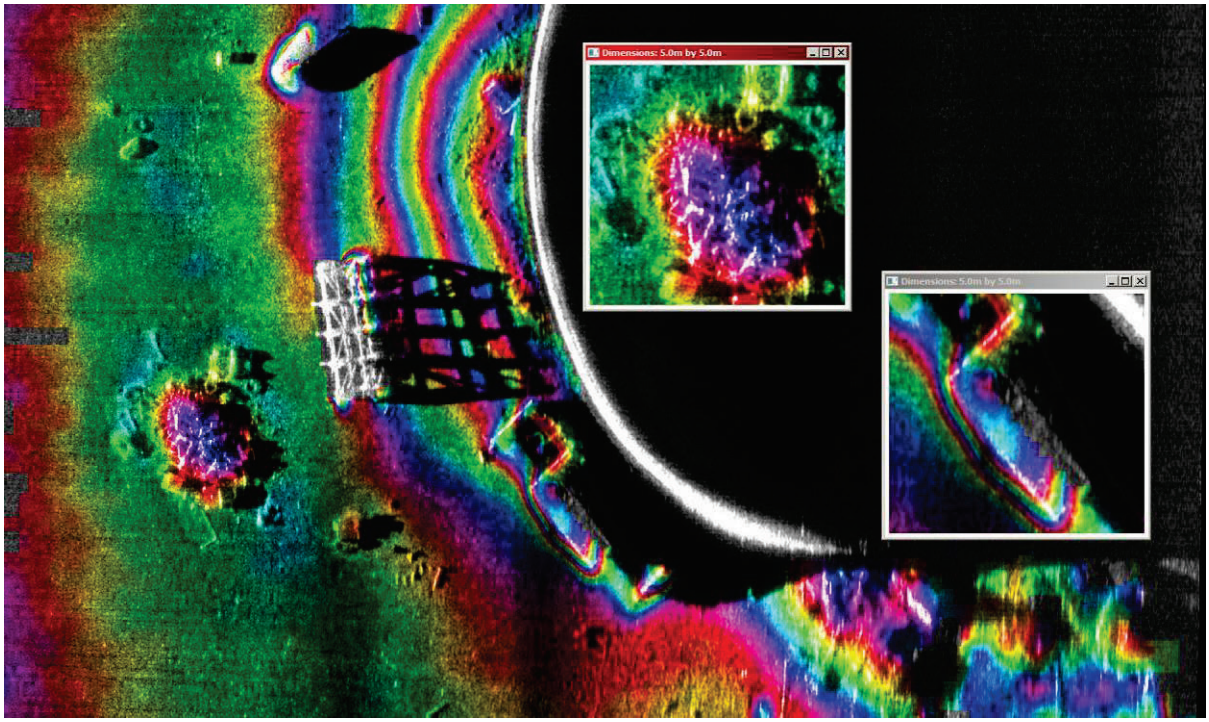


Figure 42: 3D Sonar image of the seabed north of the Fort showing the CSWIP Structure, the Salvage Pontoon and Whelan's Reef. The different colours represent seabed depth [Wavefront Systems Ltd.]

13. Marine Biology

By Dr Keith Hiscock, MBE

The Breakwater Fort and surrounding area provide a multitude of habitats for marine life including some rare, scarce, and charismatic species. The Fort hosts the shallowest known population of pink sea fans – a protected species that looks like it belongs in tropical waters (Fig. 43).

There are large numbers of sea fans, and the shallowest depth they are found is about 3m below extreme low water level, although one record is from only 2m depth which is within snorkelling depth. The image of pink sea fans is from shallow water on the wall of the Fort.

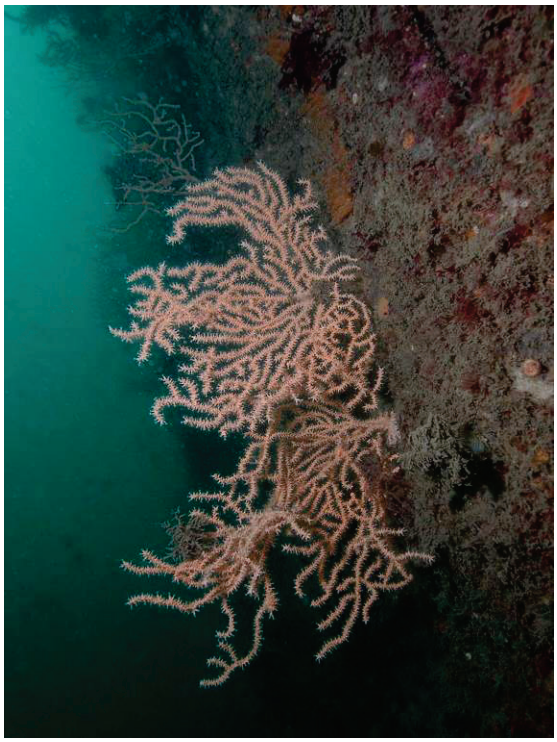


Figure 43: Pink sea fans

In addition to pink sea fans being a protected species, it is the animals that rely on this coral for food – the seaslug *Duvaucelia odhneri* shown here laying eggs (Fig. 44), and the nationally rare sea fan cowrie *Simnia hiscocki,* only seen once at the Breakwater Fort. This image from offshore south of Plymouth at Hand Deeps (Fig. 45).



Figure 44: Seaslug



Figure 45: Sea fan cowrie

Another species worthy of note is the nationally scarce southern cup coral *Caryophyllia inornata*. As recently as 1981, the species had not been recorded in Britain but is now known at several locations with a strong population on the CSWIP structure by the Fort (Fig. 46).

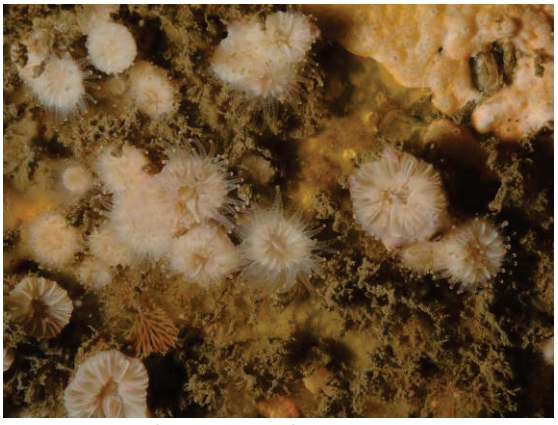


Figure 46: Southern cup coral

One of the most attractive species colonizing the structures around the Fort is the jewel anemone *Corynactis viridis*. The species is very widespread and often dominates large areas of reef all around Britain and is a highlight for divers,



Figure 47: Jewel anemone

the image Fig. 47 is of a pink variety photographed at the Breakwater Fort in 2012.

Divers like to see fish and there are plenty around the Fort. Everyone's favourite is the friendly tompot blenny *Parablennius gattorugine,* found especially in the crevices between the stone blocks that make up the Fort base (Fig. 48).



Figure 48: Tompot blenny

Another *Parablennius* species, the ringneck blenny *Parablennius pilicornis* was first recorded in Britain in 2008 in Plymouth Sound and is now a feature of the Breakwater Fort including being seen with eggs. The species is also known as the 'variable blenny' and does indeed have several colour



Figure 49: Ringneck blenny

morphs. The image here is from Firestone Bay in Plymouth Sound (Fig. 49).

There are frequent sightings on the Breakwater Fort of another species that photographers find themselves being accused of slipping an image from a tropical coral reef into a slide show – the corkwing wrasse *Centrolabrus exolotus*. The male wrasse builds a nest of soft seaweeds (on the inside) with more robust calcareous algae on the outside, females are attracted to the nest to lay their eggs and it is the male that maintains and defends the nests and keeps the eggs clean. Nests are sometimes seen at the Breakwater Fort, but this image is from nearby Bovisand Harbour (Fig. 50).



Figure 50: Corkwing wrasse

There are unusual species on the structures around the Fort that perhaps only a marine biologist would get excited about. One such species is the rarely-seen sponge *Ulosa digitata*, here photographed at the Fort in December 2005 (Fig. 51).

Other species can be seen around the Fort that are not seen elsewhere in the Sound anywhere north of the Breakwater – some are attractive to divers, such as red sea fingers, a type of soft coral.

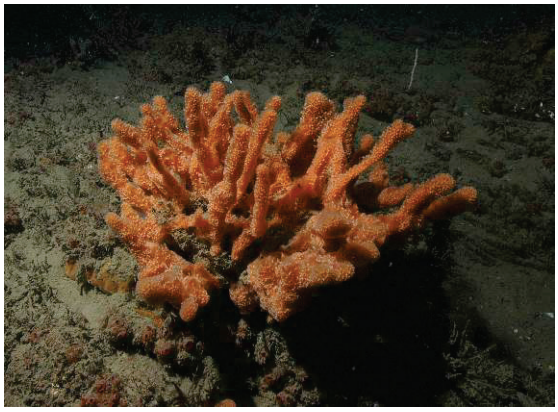


***Figure 51: The sponge* Ulosa digitata**

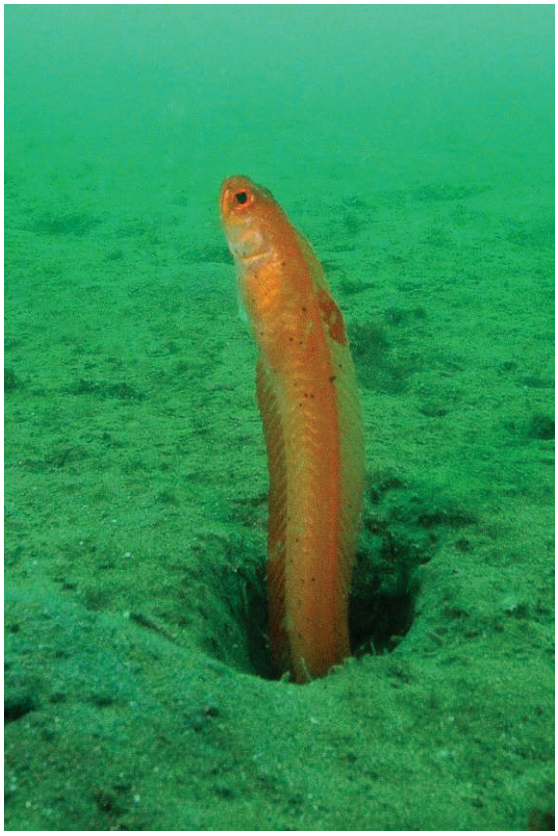


Figure 52: Red band fish

Around the Fort, much of the seabed is thick mud, an unusual habitat in shallow water and the result of the shelter that the Breakwater provides. That mud is greatly burrowed by species that do not often show themselves, but a diver could be lucky. Perhaps the most spectacular is the red band fish *Cepola rubescens* which can be up to about 50cm long and lives in vertical burrows, emerging to feed on passing plankton (Fig. 52). This image is from Firestone Bay in Plymouth Sound.

Another is the bizarre angular crab, *Goneplax rhomboides*, the occupant of the burrows that are dug at a shallow angle (Fig. 53).



Figure 53: Angular crab

A species that is always there but can extend itself from the sediment when conditions are favourable is the sea pen *Virgularia mirabilis*. The ones in Plymouth Sound are small compared to some other locations such as Portland Harbour, Holyhead Harbour, and the Scottish sea lochs. The sea pen shown in Fig. 54 is from May 2009.



Figure 54: Sea pen

What the diver can see around the Fort varies from year-to-year. Black-faced bennies, *Tripterygion delaisi*, were once frequently seen at the Fort and elsewhere in Plymouth Sound but have not been seen after about 2018. Triggerfish, *Balistes capriscus,* another 'tropical-looking' species, come into British waters each summer drifting on currents probably from the Azores and the east coast of the USA, but in variable numbers and the Fort is a favoured location, perhaps because there are plenty of structures for the fish to rest in. They die when the water gets too cold so a poor destination for a holiday. Plumose anemones, *Metridium senile*, seem to be in lower abundance than 10-30 years ago at the Fort, but also on some wrecks in the area.

14. The Breakwater Fort Today

By 2000, the Breakwater Fort was no longer being used as a base for training commercial divers, so it was abandoned and left unoccupied. The mast on the roof still carries communications antennas and cameras for monitoring port traffic, but visitors to the fort are now rare.

A review of its structural condition showed that repairs were needed to the roof to protect the fort from water ingress and repairs were needed to the pointing of the granite blockwork. These repairs were done, and at the same time, some of the structures on the roof were removed including the WWII lecture room, the hut, the port war signal station, and the electrical workshop. But much of the original structure and fittings remain in place, although partly hidden by temporary walls and equipment added much later. The iron crane that was once used to lift the huge RML guns out of transport barges and into the fort is still present with its main girders projecting out beyond the roof along with its wheeled trolley that runs on top.

Under the roof are the casemates and the positions for the 18 huge guns. The casemates are much as they were left when the diving school worked there, they seem to have left everything behind including the air compressors that fed air to the divers underwater. The dive control station still has pictures on the wall with old diving suits and diving gear abandoned on the floor. The wooden partitions between casemates added after the guns had been removed are rotting and full of holes, most of the embrasures are blocked up but one or two are open. The casemates still have pivots and racer rails for traversing their huge guns, the casemates now looking empty as the guns would have taken up the available space inside. Below this is the basement level which is now accessible by only one staircase. Remains of WWII-era diesel generators can be found in the basement which also has the ammunition lifts for the 12.5in guns still in place in the shell and cartridge magazines laid out around the central building core. One of the spaces was a WWII operations room that still can be seen today, though it is much vandalised now.

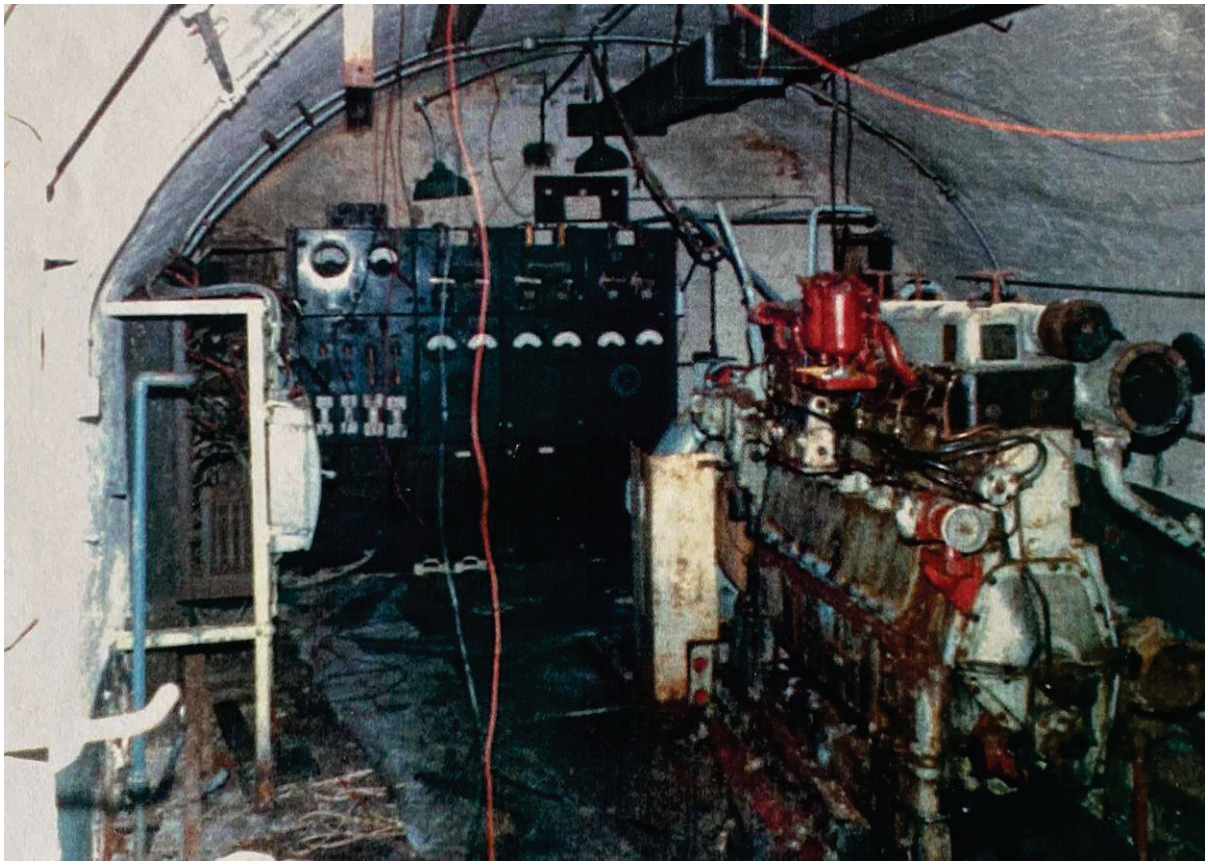


Figure 55: One of the WWII-era diesel generators in the basement, most of the fittings in this picture have now been removed [Cyberheritage]

15. Diving Around the Breakwater Fort

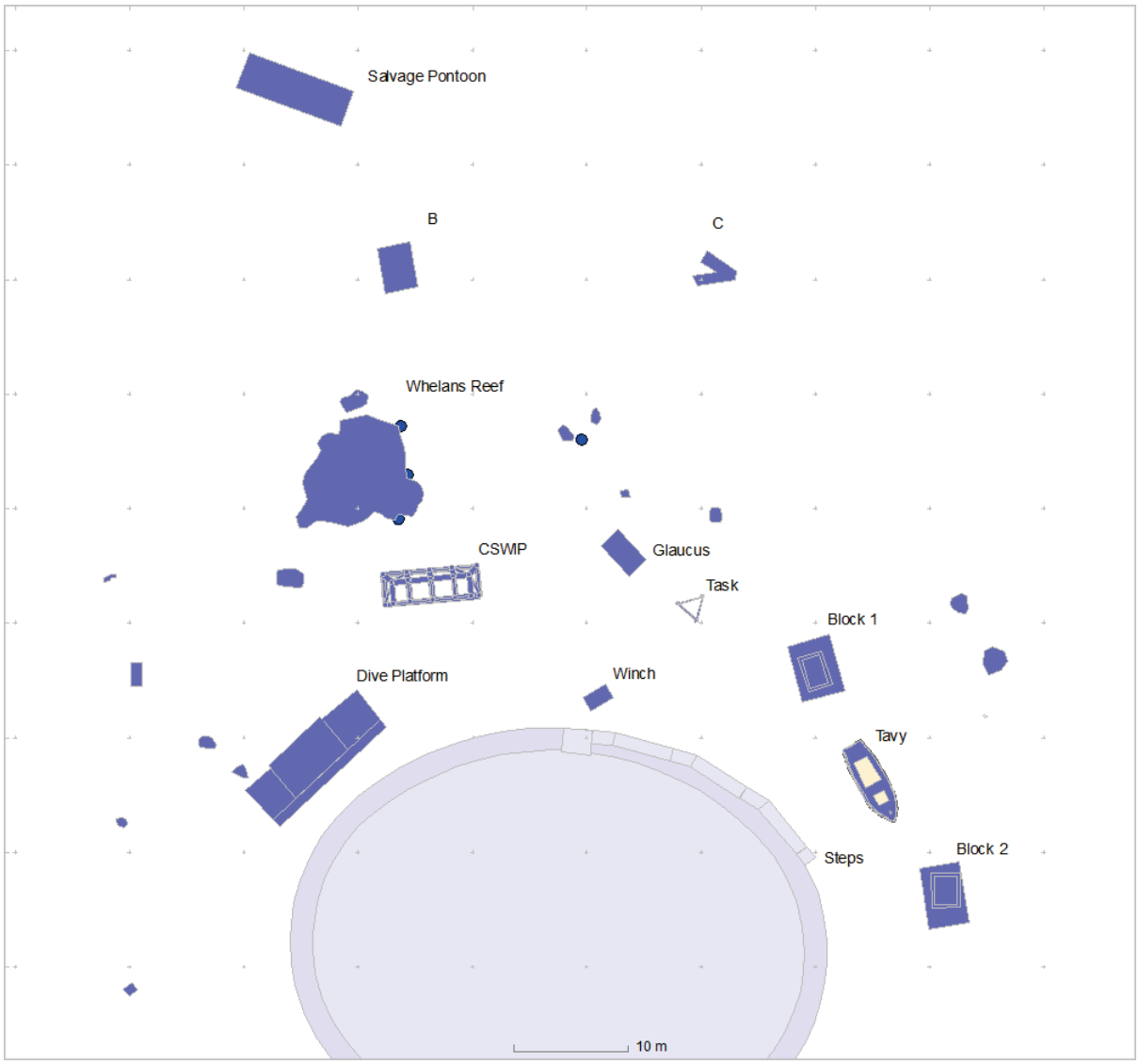


Figure 56: A Plan of the structures on the seabed north of the Breakwater Fort [SHIPS Project]

The Breakwater Fort is a well-known location for sports divers to visit, being both shallow and sheltered by the breakwater the site often gets used as a safe place for training divers or as somewhere to dive when it is too rough to explore elsewhere. There is much to see on the seabed and this dive guide will help visiting divers find their way around.

The seabed depth ranges between 12m and 15m on the north side and there is 7m to 12m of water between the Fort and the Breakwater to the south. Visibility is variable and on good days can be 5m or more, but after storms or a lot of rain it can be 1m or less. Being sheltered the seabed is covered in a layer of silt which is easily stirred up so care must be taken to keep fins off the bottom. Diving just off the time of slack water is an advantage as the current soon clears any silt that has been kicked up. Tidal currents can be strong on an ebb spring tide but most other times the site can be dived.

Since commercial diver training stopped in 2000 the site has been taken over by marine life, so please be careful not to disturb what is growing on the structures, particularly the pink sea fans as they are protected under law.

A Dive Tour of the Breakwater Fort Site

1. Start at the bottom of the steps leading down from the fort, head straight out from the wall on a bearing of 50° to the flattened remains of the *Tavy* about 9m from the Breakwater Fort wall.



Figure 57: The flattened remains of* Tavy *[SHIPS Project]

2. Turn left and 5m from the stern of *Tavy* you will find the big concrete block called Block 1.

3. Swim to the western side of Block 1 and the three-legged tubular structure called the Task is 8m away on a bearing of 290°, swim to the other side of the Task and the collapsed *Glaucus* habitat is 5m further on. Note that compass bearings will be affected if you are close to steel structures so move away from the structure before taking a compass bearing.



Figure 58: The three-legged Task [SHIPS Project]



Figure 59: The top of a concrete Block [Paul Dart]



Figure 60: The collapsed remains of* Glaucus *are now a home for marine life [SHIPS Project]

4. To get to the CSWIP Structure from *Glaucus* swim 12m west.
5. From the north side of the CSWIP Structure, the low artificial reef known as Whelan's Reef is 5m to the north. At this point, you can either carry on for a longer swim out to the salvage pontoon or head south to the Dive Platform.
6. To get to the Salvage Pontoon, swim north from Whelan's Reef to the 4m x 3m unknown structure 10m away shown as B on the site plan. From B the Salvage Pontoon is 11m away on a bearing of 330°.
7. When you have finished exploring the Salvage Pontoon the return trip to B is a distance of 11m on a bearing of 160°, and then Whelan's Reef is 10m further south.



Figure 61: The CSWIP Structure before it was placed on the seabed [Bax Archive]

8. Swim over Whelan's Reef and head south to pass the CSWIP structure on your left and the Dive Platform is 10m further on.

9. To get back to the fort steps head east along the wall of the fort keeping the wall on your right-hand side, head past the winch and the steps are 20m further along.
10. Alternatively, you can swim right around the base of the fort and explore the mix of construction materials, junk and marine life that can be found there. There are a lot of unknown objects on the seabed off the west side of the fort wall which can be explored, perhaps some are parts of the many ships that were wrecked on the Breakwater.



Figure 63: A diver exploring the marine life on the Fort wall [SHIPS Project]



Figure 62: Diver and a pink sea fan on the Dive Platform [SHIPS Project]

16. End Note

The Breakwater Fort has been many things to many people and is fondly remembered by people who worked there. It was the untested defender of Victorian Plymouth against attack by the new French ironclad warships and the military aspirations of Napoleon III. It was the defender of the city against the German raiders who came to drop bombs on Plymouth during the Blitz in WWII. It has been a training facility, a base for scientific experiments, a popular site for sports divers to explore, a historical object and now a haven for underwater wildlife. All these things make it an important landmark that should be preserved and maintained for future generations.

17. References

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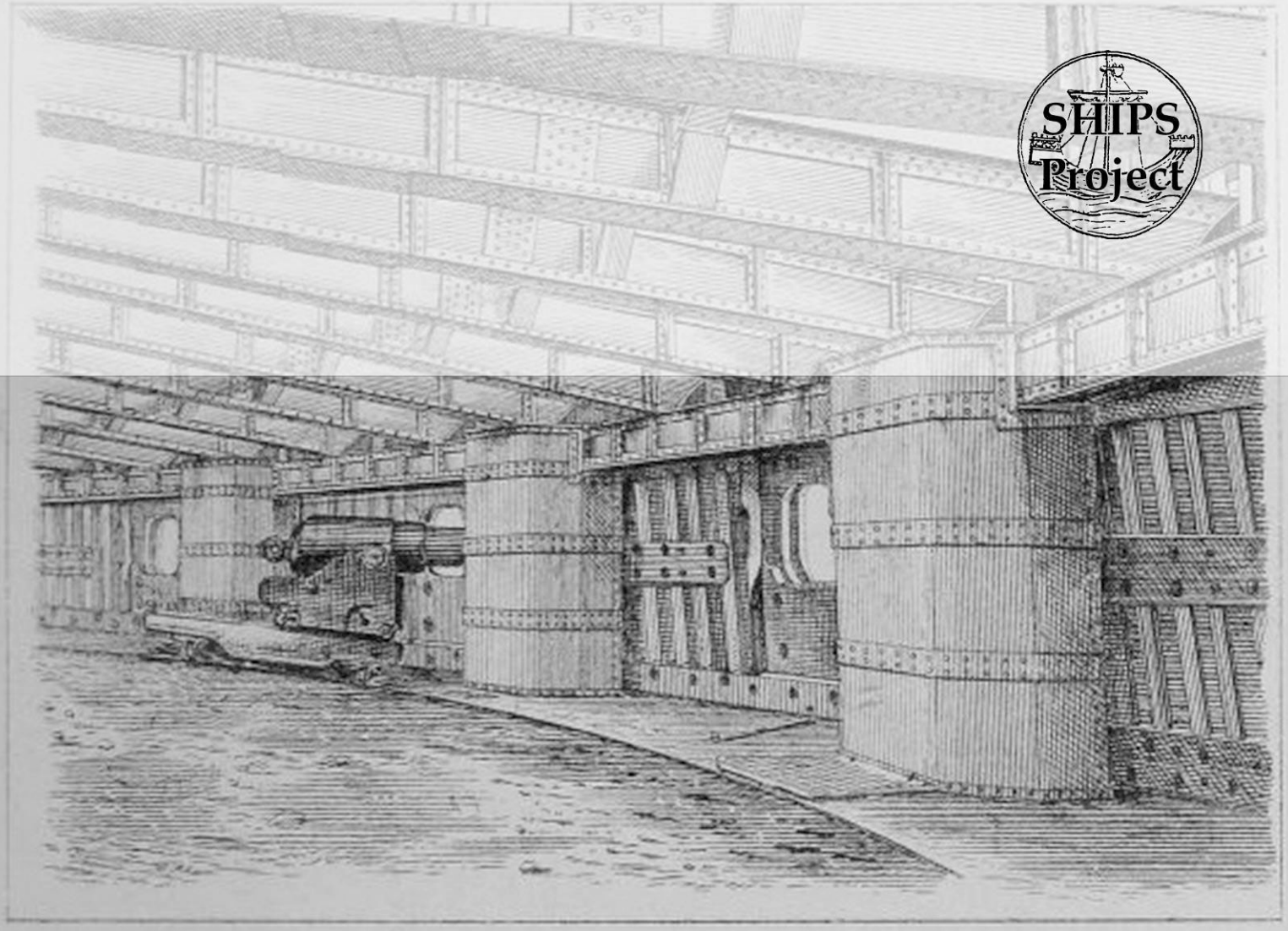

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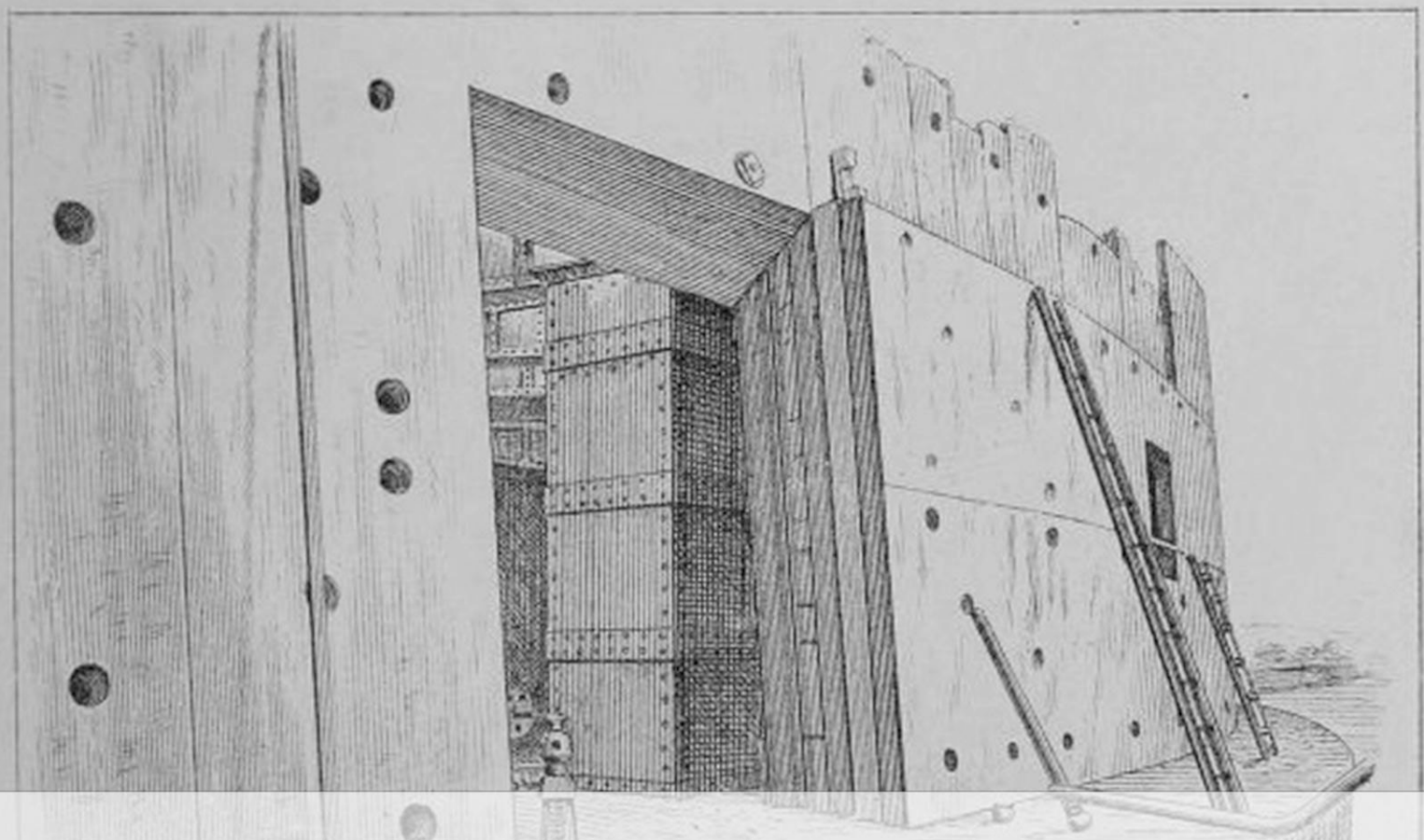

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