

1 Introduction and Background

1.1 Introduction

The Mullion Harbour Study was commissioned in 2004 by the National Trust, owners of Mullion Harbour, to investigate management strategies for Mullion Cove for the next 100 years. The Study was prompted by significant damage suffered by the harbour structures in the 1990s and concerns about the increasing frequency of such damage with climate change. The Study will assist the Trust in selecting an appropriate strategy for managing the harbour over the next 100 years.

1.2 Issue

Mullion Harbour (refer to Figure 1.1 for location and Figure 1.2 for harbour layout) comprises two stone block breakwaters (the Western Breakwater and the Southern Breakwater) and a quay (the Northern Quay), which are approximately 115 years old. The breakwaters have suffered repeated damage from storms since their construction, the most recent episode being during the last decade. The repairs cost the National Trust some £1 million and have addressed the damage.

However, the structures will continue to deteriorate as they age. In addition, the sea level has risen since the structures were built and projected, accelerated sea level rise over the next century due to climate change will result in larger waves attacking the structures more frequently. Due to the effects of global warming and post-glacial rebound, sea level rise of 5mm per year is currently projected for the South-West region. If the water depth increases (due to sea level rise), so will the wave heights. It is expected that the wave heights approaching the harbour will increase by approximately 60% of the predicted increase in water level. By 2100, it is presently projected that the sea will have risen by 0.5m, and therefore the wave heights would be expected to increase by approximately 0.3m. The result of the structural deterioration, sea level rise and increased wave energy is that repair and maintenance costs for the harbour will increase over the next 100 years.

The National Trust has significant but limited resources with which to manage, repair and maintain the 705 miles of coast that it owns as well as its inland properties. It wishes to use these resources in the best way possible, in an effective and sustainable manner.

The potential conflict between increasing repair and maintenance costs and the Trust's ability to fund these costs is the key issue for Mullion Cove in the 21st century. The Trust is very mindful of the local community and environment, however. Associated concerns are therefore the impact of the Trust's management of the harbour on the local economy, community and the environment.

1.3 Study objectives

The aim of the Mullion Harbour Study is, as noted above, to assist the National Trust in selecting an appropriate strategy for managing Mullion Cove over the next 100 years. The study objectives towards this aim are:

- To identify practicable strategy options using information on the present harbour condition and predicted wave conditions for the next 100 years.
- To provide a technical, environmental and cost assessment of the strategy options and to select with the Trust the most appropriate strategy.
- To incorporate stakeholder views in the study and to provide a strategy that is acceptable to the majority of the local community and stakeholders.

1.4 *Study process*

The study has included the following elements:

- Data collation, incorporating a review of archive information on the harbour, desk-based review of environmental information and obtaining wave and water level data.
- Field investigations including:
 - Bathymetric and topographic surveys.
 - Geological investigation.
 - Environmental inspection.
 - Hydrogeological investigation.
 - Condition assessment using boreholes through the harbour structures and underwater inspection.
 - A survey of the local community.
- Analysis of the issue facing the harbour by assessing the wave forces acting on the harbour at present and over the next 100 years (with sea level rise) and considering the harbour's present condition.
- Development of strategy options, which divide into three generic types:
 - Major embellishment.
 - Repair and maintenance.
 - Retreat.
- Assessment of the strategy options over the next 100 years, considering sea level rise.
- Option selection using a matrix approach to rank the relative merits of the strategy options.
- Consultation via a stakeholder group with the local community, regulatory authorities, statutory consultees and regional groups. The consultation has continued throughout the study.

1.5 *Report structure and authorship*

This report discusses the results of the Mullion Harbour Study. The report format is as follows:

- Section 1: Introduction to the study and this report, including the reasons why the study was undertaken, the issue that the study has investigated and background information about the harbour.
- Section 2: A description of the existing environment at Mullion Harbour, including the natural and human environments, and the present condition of the harbour. This description has been prepared from the results of the desk-based reviews and field investigations that are listed in Section 1.4. That is, it comprises a summary of the findings of the first half of the study.
- Section 3: A description of the practicable strategy options including a summary of the technical assessment of these options. This section also discusses briefly the options that have not been taken forward for further assessment because of technical concerns.

- Section 4: Environmental assessment of the strategy options with identification of potential environmental impacts and of possible mitigation measures for these.
- Section 5: A summary of lifetime costs for the strategy options and a discussion of available avenues for funding the options.
- Section 6: A qualitative assessment of the risks of the strategy options and identification of mitigation measures and responsibility for managing the risks.
- Section 7: A summary of the consultation undertaken as part of the study and the feedback obtained. This section also sets out the approvals and consents that would be required for the different strategy options.
- Section 8: Comparison of the strategy options using a matrix approach to rank their relative merits and guide selection of a preferred strategy.
- Section 9: Summary of study conclusions and recommendations.

There are a number of technical appendices following this main report, which have been prepared for specific elements of the study. These have been written for a technical rather than a general readership but are included as appendices for completeness.

This report has been prepared by the Mullion Harbour Study team, which comprises:

- BSW, consulting structural engineers.
- Halcrow, consulting engineers and environmental scientists.
- National Trust Devon and Cornwall Region.

1.6 *History*

In the 1890s, there was a pilchard fishing fleet at Porth Mellin (Mullion Cove) and the boats were kept on the beach as can be seen in Figure 1.3. Following a few seasons of poor fishing Lord Robartes decided that a harbour should be built at Mullion Cove to provide protection for the fishing fleet. The original harbour scheme was to construct a harbour wall from Scovarn (known as Ear Rock) northwards to the land, blocking the present gap. The Northern Quay would then have continued northwards (rather than south as at present), thus forming a harbour in a northerly direction between Scovarn and the land. Mr Matthews, a Civil Engineer of Westminster, prepared a report in 1890 for Lord Robartes stating that the originally proposed scheme would not function as a harbour and he recommended that the harbour should be built to the present layout. Figure 1.4 shows the layout he proposed, superimposed on the original cove. The drawing shows that a significant quantity of rock had to be removed within the harbour and some from under the Western Breakwater. The original route of the stream is shown exiting between the Southern and Western Breakwaters. In his report he proposed that the external faces of the breakwaters should be of stone, with heartings of concrete and large rocks.

The Western Breakwater was built in 1890 and was linked to the Northern Quay, which appears to have been constructed just before the Western Breakwater. The construction of the Southern Breakwater followed in 1895. The estimated cost of the harbour was £9,300. Figure 1.5 shows the harbour in 1929.

From records held by the National Trust it appears that up to 1914 the harbour was maintained, using lime mortar, by a Mr J Harry, a local mason. In 1928 Lord Robartes sold the harbour to Mr Meyer. Between 1914 and 1928 there is no mention in the records of any maintenance work having been carried out.

Just prior to 1930 the Southern Breakwater suffered damage as shown in Figure 1.6. No maintenance work was carried out between 1928 and 1945 and the Southern Breakwater continued to deteriorate. Figures 1.7 to 1.11 show the deterioration in 1934, 1935, 1936, 1937 and 1946 and Table 1.1 shows how much of the deck was lost between 1929 and 1946.

Surprisingly, the rate of deterioration was faster for the first 6 years than for the succeeding 13 years.

Table 1.1 Deterioration of Southern Breakwater 1929 to 1946

Date	Length of Southern Breakwater deck lost
1930	6 feet (1.8m)
1932	8 feet (2.4m)
1936	16 feet (4.8m)
1938	28 feet (8.5m)
1946	40 feet (12.2m)
1949	40 feet (12.2m) some hollowing

On 8 October 1945 the National Trust acquired the harbour from Mr and Mrs Montague Levison Meyer. The National Trust has extensive records from this time and these were searched to obtain details of the history of the harbour from 1945 to the present day. It was not always clear, from the records, whether the recommended work was actually carried out. Where possible the extent of works carried out was checked, but this was not always possible.

Once the Harbour was owned by the National Trust a great effort was made to raise funds to repair the harbour. Mr Alan Wilfrid Ladner AMICE (Member of the Institution of Civil Engineers) was involved with a one hour radio presentation on the Third Programme on 10 August 1947 on the harbour; unfortunately the BBC could not locate a transcript. The Development Commissioners provided a grant of £1,000 and an application was made to the Ministry of Agriculture Fisheries and Food (MAFF) for funding, but it is not clear whether this was successful. A fund raising leaflet was prepared and donations were received from far and wide.

Mr Ladner prepared a report in 1950 for submission to the Institution of Civil Engineers. A draft version of the report was obtained and this gave a wealth of information on the state of the harbour in 1950, and before, and recorded the works which were carried out.

It was decided that the end of the Southern Breakwater should be rebuilt with a sloping face and that the end of the breakwater should be set back 12 feet (3.6m) so that it could be constructed on rock. Figure 1.12 shows a plan and section of the deterioration and the remedial works. In 1950 the tender for the works to the Southern Breakwater was £4,233 from Costain who carried out the works; Figure 1.13 shows the works nearing completion.

The Western Breakwater had also suffered damage. The harbour had been undermined at the end on the harbour side as shown in Figure 1.14; Figure 1.15 shows the repairs being carried out.

In 1950 the National Trust recommended the setting of a maintenance budget of £20 to £25 annually and a sinking fund of £100 per year.

In the National Trust records there are reference to various areas of damage and to storm events or a series of storms. Table 1.2 shows the dates, weather and damage as recorded in the files. Most of the damage appears to have been caused by a series of storms or a period of gales and heavy seas, rather than one storm.

Table 1.2 Damage at Mullion Harbour related to weather conditions

Date	Weather	Damage
1951-1952 (prior to Mar 5)	Winter storms were “some of the most severe experienced within living memory”. Reference is made to the Flying Enterprise disaster.	Southern Breakwater (SB)– damage at junction of rebuilt splayed end and original structure and at foundation level on the outer face.
End Sept 1953	Exceptional storm	Grout loss to top of parapet on Northern Quay (NQ), some resurfacing required and minor repairs.
14.1.55	Season of rough but not unduly rough seas with absence of ground seas	Harbour not materially damaged
16.4.55	Heavy ground seas and gales (presumably immediately prior to this date)	2 quoins missing below steps on Western Breakwater (WB).
Oct 1959 to Jan 1960	Weather broke in early Oct 1959 and was the worst period of weather for very many years with rain, gales and heavy seas with only one short lull. Relentless storms	See below
Nov 1959		Part of winch house roof lost. 3 garage building lost
24.12.59	Storm	2 steps lost
25.12.59	Storm at its maximum	
26.12.59		Coping to WB removed for 24’x3’ wide to a depth of 17-18”. 200ft ² of granite setts lost. Diagonal crack to WB in from of end bollard. Concrete core behind steps disintegrated. One main end coping stone not found. Other large coping stones located west of end.
24.1.89		Movement of end of WB. Coping lost near lamp house. Coping missing on SB
Days preceding 14.12.94	Storm over a number of days. Severe weather over last two months.	9m long section of seaward face of SB at knuckle lost to a maximum depth of 2.2m. Copings and paving lost on SB.
4.1.98 on	Storm. Max wind speed 82 knots at Culdrose.	Corner of WB lost. Stones to 4T found 60-90m from end of WB. Section of parapet approx 10m long lost on WB from hut northwards. SB movement of coping, cracking for 6m on top of the breakwater at the westerly end on the inner corner. Surface stones on the seaward side at the knuckle
6.9.98	Storm	WB parapet badly cracked along main length for 22m (requiring rebuilding). Many setts lost 25m ² . Stones generally in the harbour.
26 to 27.10.04	Intense depression and spring tides. Gusts to 55 knots on morning of 27.10.04 from E then wind from SE	Damage to end of SB (crack width increased and mortar missing) and to the seaward side (longitudinal crack at top in paving)

Between 1951 and 1960 general maintenance was carried out and repairs were done (refere Figure 1.16) including grouting of the parapet, systematic re-pointing of the whole harbour, replacement of 2 quoins and repairs to undermining of the toe of the Southern Breakwater (which took two years to complete)

Repairs were carried out in 1960 following the October to December 1959 storms and Figure 1.17 shows the repairs being carried out.

In 1970 a report was prepared by Mr Andrew Bury, Chartered Civil Engineer, and Figure 1.18 shows his record of defects. In 1972 E Thomas carried out work and it is assumed that the works carried out were in accordance with Mr Bury's recommendations.

In July 1976 the area of wall under the steps on the Western Breakwater was tied back to the main structure with six inclined rock bolts. The steps were also fixed down with six steel rods.

In 1978 the sloped end of the Southern Breakwater was rebuilt back to its original square end (as seen today). It appeared that the sloping end was breaking away from the main body of the breakwater. The end of the breakwater was constructed approximately 5.6m back from the line of the original 1895 construction. Four through ties were also added to the Southern Breakwater. The cost of the works was £35,000.

Major repair works were carried out in 1992, 1995 and 1998 to repair storm damage and to generally enhance the harbour structures. The cost of these works was of the order of £1,000,000.

In 1992 the end of the Western Breakwater and harbour wall (to the steps) were tied to a concrete block within the harbour, as shown in Figure 1.19. Bag work to fill voids on the seaward side of the Western Breakwater was carried out as shown in Figure 1.20 and a reinforced concrete slab was installed below the setts on the end of the Western Breakwater and ties were fixed down to the seabed. On the Southern Breakwater vertical grouting was carried out on the seaward face.

In January 1995 storm damage resulted in the loss of a length of 9m of wall stone and a considerable length of coping as shown in Figure 1.21. The old bridges to the Southern Breakwater were replaced in 1995 and large rock armour was added to the south east corner of the harbour in 1996. The lamp house on the Western Breakwater was filled with concrete.

Figure 1.22 gives an indication of the waves that cause damage at Mullion. This particular wave was at the end of a storm that started three days previously and caused the damage seen in Figure 1.23 and in the isometric view in Figure 1.24. The works carried out in 1998 included:

- Western Breakwater: rebuilding the end, 32 through ties and 8 longitudinal ties, repairs to the piled inner corner, rebuilding approximately half the length of the parapet, bagwork, grouting, pressure pointing and repair to the setts, all as shown in Figures 1.25 and 1.26.
- Southern Breakwater: substantial repairs to copings, rebuilding part of inner corner, repair at the outer knuckle, bagwork and pressure pointing.
- Northern Quay: repairs to the coping and setts

Figure 1.27 summarises the works and repairs carried out since 1950 to the present day. In addition to the work carried out the records show that on many occasions repair work that has been carried out has been washed away in storms or bad weather during the works, when concrete and mortar has not gained sufficient strength.

To summarise, the main repairs to Mullion Harbour have been to:

- The ends of the Western and Southern Breakwater.
- Bagwork to the seaward side of the Western and Southern Breakwater.
- Pointing and pressure pointing throughout the Western and Southern Breakwaters.
- Parapet.
- Setts.