2 Existing Environment and Harbour

2.1 Geography

Mullion Cove is situated on the west coast of the Lizard Peninsula, the most southerly region of England (refer to Figure 1.1). Located within the Parish of Mullion at Grid Reference SW 667 177, Mullion Cove is bordered by cliffs to the north and south, a number of residential and commercial buildings to the east and the Atlantic Ocean to the west.

The climate within Cornwall demonstrates significant variation across the county. In West Cornwall, plant growth ceases for only a few days each winter and on average there are more than 250 frost free days. In terms of rainfall, the West experiences figures in the region of 110cm per year (at Falmouth).

The administrative authorities which cover Mullion Cove are Kerrier District Council and Cornwall County Council.

The area is geographically defined as 'Remote Rural' because of difficult access and dispersed low density population.

2.2 Land use

The main land uses of Mullion Cove are tourism and harbour related activities (fishing, boat trips). There are also a number of residential properties, the majority of which are seasonal holiday lets. Surrounding land is mainly in agricultural and nature conservation use.

Mullion Village is the nearest service centre to Mullion Cove, located approximately 2km away.

Helston is the nearest town to Mullion Cove; it occupies a strategic location on the Lizard Peninsula. Its role as an employment and service centre for local residents has been undermined in recent years by changes in farming practices, retailing, consumer habits, transport and competition from other centres (Cornwall County Council and Kerrier District Council, 2000). Helston has a close knit community together with a well developed social network and service provision. In 1996, the population of Helston was recorded as 8,720 and it is one of the fastest growing towns in Cornwall.

2.3 Transport infrastructure

The transport infrastructure serving Mullion Cove and Mullion Village is limited. The B3296, a secondary road, connects Mullion Cove with Mullion Village. A number of smaller roads run off this route providing access to the south towards Predannack. However the majority of transport routes in the area surrounding Mullion Cove are trackways and lanes. Mullion Cove is linked via the B3296 to the A3083, the principal road from Helston to the Lizard peninsula. There are no railway lines close to Mullion; the nearest station mainline station is at Redruth, 17.5km from Helston. However, a special bus service between Helston and Redruth ensures connection with the train.

2.4 Public Rights of Way

A long-distance Public Right of Way, the South West Coast Path, traverses Mullion Cove. Emerging just north of the harbour breakwaters, the path crosses to the rear of the harbour and continues south of the harbour along Mullion cliffs towards Predannack and around the Lizard Peninsula. The South West Coast Path National Trail consists of 630 miles of coastal

walking (from Minehead on the edge of the Exmoor National Park to the shores of Poole Harbour in Dorset). There is also wider public access along the road network.

The land adjacent to Mullion Cove is classified as 'Non Agricultural' and inland towards Mullion Village this classification changes to Grade 3.

2.5 Fisheries, diving and Harbour Association

Fishing is a long established tradition at Mullion Cove and was undertaken in the days prior to the construction of the Harbour when the Cove supported a thriving pilchard fishery. The harbour enables fishermen to launch their boats in a wider range of weather conditions. It also enables fishermen to leave their boats in the harbour at times of the year, which would otherwise require the boats to be brought up the slipway.

In 2004, there were three fishermen working two boats from Mullion Harbour though numbers have since fallen to one. The fishermen work on a part time basis, supplementing their incomes through labouring and operating boat trips for tourists. In 2004, one indicated that tourism was of equal importance to fishing as a source of income and another stated that fishing represented "a way of life" as much as a job.

In 2004, two fishermen supplied their entire catch to the Mullion Cove Hotel. The other sold to Kellyknack Fish Merchants. Table 2.1 illustrates the fishing catches from Mullion Harbour for 2002, 2003 and 2004. It is clear from this table that catches vary significantly between the three years (it has been indicated that results for 2004 may appear low due to poor response rates from fishermen). The market value of these catches in not known but in terms of employment, fishing from the harbour supports no more than one full-time equivalent job.

Some 100-150 divers per year typically use the area, launching from the slipway, when their preferred location on the east side of the Lizard Peninsula is not usable and mild conditions prevail at Mullion (generally with easterly winds and swell). The divers paid fees to the harbour amounting to some £500 in 2004.

Day to day harbour management was delegated in the early 1970s to the Mullion Harbour Management Board as part of the Mullion Harbour Association, formed of various user groups of the Cove (principally boat users). A Harbour Master is employed, responsible to the Chairman of the Board, with some wage contribution (re litter collection only) from the Trust. The Board is elected from members of the Mullion Harbour Association, a Small Boat Owners Association and the Winch Society which was brought into being by approval in May 1972. The Small Boat Owners Association is for users of pleasure crafts, and the Winch Society, which predates Trust ownership of the harbour, is for full time working fishermen.

The Association raises income through fees for membership subscriptions and fees from external users, principally dive boats.

Revenue associated with harbour users (e.g. fishermen, divers, boat users) has been assessed as part of the socio economic study, based on information provided by the National Trust (pers comm. 2005) and local fishermen (pers comm. 2004, 2005). The harbour user revenue is estimated at approximately £27,000 per year (see Appendix A, section 3.3.4).

Table 2.1 Fish Catches (kg) for 2002 – 2004

	Cock Crab	Hen Crab	Spider Crabs	Lobster	Crawfish	Velvet Crab
2002	48	77	221	182	-	49
2003	49	151	245	258	-	72
2004	19	25	26	36	-	20

Source: Cornwall Sea Fisheries April 2005

2.6 Economy

The economy of Mullion was founded on activities such as agriculture, mining and fishing. Up until the 18th century the majority of people were employed in agriculture, with seasonal fishing employing inhabitants in the spring and autumn (Cornwall County Council and Kerrier District Council, 2000). It was not until the late 19th century with the arrival of the steam trains at Helston station (closed in the 1960s) that tourists began to visit the Lizard peninsula. Today Mullion is a busy village with all the services needed for it to be an independent, self contained community.

Mullion Village is the largest settlement on the Lizard Peninsula. It has a large number of shops and facilities which in part are dependant on tourism for their viability; this has been exacerbated by the recent opening of an edge of town supermarket at Helston. Table 2.2 below outlines the number and type of businesses in Mullion Village and Mullion Cove. A café and a souvenir shop are the only commercial premises at Mullion Cove. Revenue is also generated at the cove by harbour users (fishermen, harbour Master, boat trips) and accommodation providers (Bed & Breakfast, holiday lets and a chalet camp).

Table 2.2 Types and number of businesses identified in Mullion Village and Mullion Cove

Type of Business	Known No. of Businesses
1. Accommodation	
1.1 Hotel	2
1.2 Guest House/B&B	6
1.3 Self Catering	6
1.4 Touring Caravan	1
2. Restaurants, Cafes & Pubs	10
3. Retail	
3.1 Food	4
3.2 Gifts/Souvenirs	6
3.3 Art	4
3.4 Other (Kite Shop, Post Office, Chemist, Estate Agents, Electrical Retailer)	5
4. Harbour Users	
4.1 Fishing	2
4.2 Boating	2
4.3 Harbour Master	1
5. Recreation	
5.1 Horse Riding	1
5.2 Golf Club	1

Type of Business	Known No. of Businesses
6. Other Services	
6.1 Builders	2
6.2 Hairdressers	2
6.3 Garage/Mechanics	3
6.4 Other (Tourism Consultant, Funeral Home, Driving School, Tax and Accounting Specialists, Window Cleaners, Doctors, Solicitors)	8

2.7 Tourism

Mullion is one of the main centres for tourists visiting the Lizard Peninsula. As the largest village on the peninsula, tourists can use Mullion as a base from which to visit the surrounding area. There is a high number of accommodation providers, restaurants, bars and arts and craft shops within the village and the surrounding area. The National Trust estimates that 80,000 people visit Mullion Cove each year (National Trust, 1998; National Trust, 2005).

A recent study by Halcrow (2005) on the socio economic importance of Mullion Harbour revealed that the majority of the tourist related businesses at Mullion Village and the areas just outside of the village place considerable importance on Mullion Harbour as a tourist attraction. The results of this study are found in Appendix A.

A rough order, indicative assessment of revenue potentially generated by the Mullion Cove/Mullion Harbour site, based on visitor numbers and average spend per visitor, has been undertaken as part of the socio-economic study (refer to Appendix A). The assessment, which necessarily makes a number of assumptions and is therefore a rough guide to the order of magnitude of revenue and not a precise estimation, indicates that visitor revenue potentially attributable to Mullion Cove/Mullion Harbour is of the order of £200,000 to £1.4 million per year. Should the revenue figures be used as the basis for any decisions on the harbour's future, then a detailed visitor survey would need to be undertaken to confirm the assumptions made regarding visitor numbers, spend per visitor and proportions of spend attributable to the presence of the harbour structures at Mullion Harbour, in addition to the expected transferability of spend to Mullion Cove without harbour structures.

2.8 Infrastructure

The drainage infrastructure of Mullion Cove lacks a sewage treatment plant, and at present it is believed that sewage from some properties around the harbour is discharged into Mullion Cove.

2.9 Community services

Mullion is a well serviced community; there is a primary school, a secondary school (the only one on the peninsula), a post office and a health centre.

The village has had substantial modern housing development but it has reached a point where there is now only scope for limited development and further infilling. Substantial expansion into the countryside would threaten the visual amenity of the rural and coastal setting of the village.

RNAS Culdrose is identified as the largest employer in the area. It supplements the local economy through domestic expenditure of service and civilian personnel on housing, food, entertainment etc. However due to MOD central purchasing policies there are limited opportunities for local supply chains for the base to be established.

2.10 Landscape

Mullion Cove is located within the Cornwall Area of Outstanding Natural Beauty (AONB) and Heritage Coast (refer to Figure 2.1). The Cornwall Landscape Assessment identifies three distinct character areas within the Peninsula. The south, covering Mullion is described as 'A special landscape containing many remnants of the past perceptible in a coherent way to give a feeling of time and continuity'.

The Lizard peninsula as a whole is an exposed upland landscape with dramatic coastal scenery. Its particular character derives from the unique geology, with highly metamorphosed rocks such as serpentine, schists, gneisses and gabbros exposed in many locations around the coast. Immediately inland from the Cove is a relatively soft, undulating landscape over Devonian rocks, sparsely populated with farmsteads and small hamlets and characterised by small farm woodlands.

Mullion Harbour occupies a small valley on the west coast of the Lizard, where it is sheltered from the rest of the peninsula but exposed to westerly storms from the Atlantic. The adjacent cliffs rise high above the cove and provide a dramatic backdrop to the small fishing harbour. The colour of serpentine rock in the cliffs and the abundant spring and early summer flowers growing on the cliffs make an important contribution to the visual appeal of the Cove. The harbour arms themselves, built of both local and imported stone, enclose and shelter the cove, giving it much of its character. Many of the adjacent buildings clearly relate to its history and use as a fishing harbour and a few, such as the fishermen's store and the winch house, are built of local stone. The presence of fishing boats, pots, buoys and other equipment contributes strongly to the character. The ensemble of the harbour, buildings and related structures has strong coherence and is most visually pleasing.

Twentieth century development has occurred on a small-scale around the cove. A number of buildings of disparate designs are located along the north side of the harbour and some of this is of significantly lower visual quality than the older properties. However, most relatively modern development is further inland along the bottom and lower slopes of the valley, so it does not detract from the harbour itself. Mullion Cove Hotel occupies a commanding position overlooking the Harbour from the north.

Views of the Harbour are limited to the immediate environs of the cove and the adjacent cliffs. For the walker or the driver, there are few visual clues as to the presence of the cove before arriving there. This hidden quality makes a strong contribution to its sense of place.

Views from the Harbour are contained by the dramatic cliffs to north and south. Out to sea, the mass of Mullion Island forms a strong visual focal point, as well as providing a degree of shelter from wild westerly storms.

2.11 Nature conservation

The Lizard peninsula is of outstanding nature conservation interest, as a result of its unusual geology and mild, maritime climate. Indeed, for its size it has one of the greatest floral diversities in Britain, with many rare and unusual species. Lizard Heath, dominated by Cornish Heath *Erica vagans* (refer to Figure 2.2a), is a vegetation community almost confined to the Lizard. Most semi-natural habitat on the peninsula is designated as Sites of Special Scientific Interest (SSSIs) and is incorporated within The Lizard Special Area of Conservation (SAC).

Mullion Cove is bordered by (but excluded from) two, predominantly coastal, Sites of Scientific Interest, both of which are included in The Lizard SAC (refer to Figure 2.2b):

- Baulk Head to Mullion encompasses the cliffs to the north of the Cove and was notified for both its biological and geological interest in 1995. The exposed cliff top is occupied by maritime grassland, which includes a number of rare plants (western

clover *Trifolium occidentale*, autumn squill *Scilla autumnalis* and fringed rupturewort *Herneria ciliolata*). Some cliff faces support a maritime rock crevice community. Sheltered areas support scrub such as blackthorn *Prunus spinosa*, gorse *Ulex europaeaus* and bracken *Pteridium aquilinum*. The site's geological interest relates to the Gunwalloe coastal section.

- Mullion Cliff to Predannack Cliff, originally notified in 1951, encompasses the cliffs to the south of the harbour, as well as Mullion Island. Most of the site is underlain by serpentinite and hornblende schist, while Mullion Island is composed of pillow lavas and cherts. Cliff vegetation comprises complex maritime communities including maritime rock-crevice communities at low levels, maritime grassland, maritime bluebell communities in sheltered areas and maritime heath on the cliff top. Unusual plant communities with several rare species are associated with the thin, basic, nutrient-poor soils overlying serpentinite, contrasting with the base-poor soils overlying hornblende schist. Rare species include golden samphire *Inula crithmoides*, fringed rupturewort *Herniaria ciliolata*, long-headed clover *Trifolium incarnatum* and wild asparagus *Asparagus officinalis*. Cliff flush communities are dominated by common reed and other wetland species. A rich insect fauna is associated with the diverse topography and vegetation of the site.

The features of The Lizard SAC which are considered to be of European importance are:

- Vegetated sea cliffs of the Atlantic and Baltic coasts.
- Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.
- Mediterranean temporary ponds.
- Northern Atlantic wet heaths with *Erica tetralix*.
- European dry heaths.
- Dry Atlantic coastal heaths with *Erica vegans*.

Offshore nature conservation interest is also significant. The waters around the Lizard are host to species rarely found elsewhere in UK waters. The JNCC 'Seabirds at Sea Study' has recorded the presence of a number of cetacean species in waters close to Mullion Harbour including Common Bottle Nose Dolphin, Short beaked Common Dolphin, Long finned Pilot Whale and Harbour Porpoise.

Basking Sharks (refer to Figure 2.2a) have been seen in the waters off Mullion Cove in summer months. Atlantic seals are also common in the area. Mullion Island is a haven for birdlife, and is home to the Lizard's only breeding colonies of Kittiwakes (refer to Figure 2.2a), Razorbills and Guillemots. Fulmars are also found on the island.

A report prepared by Spalding Associates on behalf of the National Trust provides information on the ecology of the intertidal zone at Mullion Harbour. The report found that the biological communities within the rocky shore are typical of more exposed shores in the south. Lichens are common on the splash zone. The upper and mid eulittoral zones are dominated by barnacle crusts with locally abundant Common Mussel and the bladderless variant of Bladder Wrack which is typical of bare sand scoured rock. The sedimentary shore supports polychaetes within harbour sediments, and polychaetes and amhipods within the sandy shore of Mullion Cove.

No rare or protected species or habitats were found at Mullion. However the provisionally Nationally Scarce fish Montagu's Blenny and the southern species Snakelocks Anemone and amphipod were present.

Mullion Cove also supports four scarce intertidal biotopes:

- Barnacles, *Patella spp.* and *Fucus vesiculosus* on exposed eulittoral rock.

- *Corallina officinalis* on very exposed lower eulittoral rock.
- Mixed red seaweeds on moderately exposed lower eulittoral rock.
- *Porphyr purpurea* or *Entermorpha spp.* on sand scoured mid or lower eulittoral rock.

2.12 Cultural heritage

Mullion Village has medieval origins but settlement of the Cove occurred later, apparently between 1748 (when it was not mapped) and 1811 (when it was shown as "Porth Mellin" on an OS Surveyor's drawing). The main surviving historic structures date from the 19th Century, predating the construction of the Harbour. The Cove supported a successful fishing industry and was also active in the smuggling trade. The Harbour walls were built in 1895 to compensate local fishermen for several poor pilchard fishing seasons. A lifeboat station operated at the Cove from 1867 to 1908, during which time only 14 service calls were made.

There are six listed buildings, all Grade II, in Mullion Cove (Table 2.3). The Cove is also a proposed Conservation Area (Kerrier District Council, pers comm.).

Table 2.3 Listed Buildings

PRN	Name	Description
40006	Harbour wall, south pier	Harbour
40006	Harbour wall, northwest pier	Harbour
4006	Shelter/harbour light	
	Winch House and Fish Cellar	
10681	Capstan	Used for hauling up seine boats and the Life Boat from the cove.
	Fishermen's net store	

Source: Cornwall County Council Historic Environment Service (HER)

Because of the importance of the Cove's cultural heritage, an archaeological and historic assessment has been commissioned as part of the study, undertaken by the Historic Environment Service of Cornwall County Council (refer to Appendix B for the assessment report in full).

A total of 32 sites were identified and graded during this assessment. These were graded according to the criteria used in the Cornwall Historic Environment Record, as follows:

- 6 sites are Listed Buildings, all Grade II, including both the harbour breakwaters, the shelter on the north pier, the winch house, the capstan, and the fishermen's net store.
- 6 sites are of regional importance. These include the Harbour Master's House (site of former coastguard station and fish cellar), Porthmellin Café, Harbour House (former lifeboat station and some extant remains of a former fish cellar), and a wooden fishermen's store.
- 20 sites are of local importance. These include the site of a former mill, Porth Mellin, the stream outlet, The Retreat, Cellar House, former watch house, Cove Cottage, the Boathouse, the structure northeast of the boathouse, a former homestead and meadow boundary, small footbridge, Nansmellyon Road, site of

former tank trap, private residences, the mill leat, boat house and garages, store houses and the caverns.

Figure 2.3 shows a selection of the sites. A complete gazetteer of sites as recorded and classified by the Historic Environment Service is given in Appendix B, and descriptions of each site are included in the report.

Although relatively recent in terms of its construction, for many people Mullion epitomises a small Cornish fishing harbour. The older buildings and the use of locally quarried serpentine stone within them and the harbour walls give the historic core of the settlement its character.

2.13 Planning/legislative framework

2.13.1 Consents and approvals

Development at Mullion Harbour falls under two categories. Kerrier District Council is the planning authority responsible for consenting development above Mean Low Water Spring. For any works below Mean High Water Spring, consent for works involving placing materials on the seabed must be sought from Defra's Marine Consents and Environment Unit under the Food and Environmental Protection Act 1985 (FEPA) and Coast Protection Act 1949 (CPA), which deals with navigational safety. Details of the consents required for the different options considered in this study are given in Section 7.3.

2.13.2 Environmental impact assessment

Within the context of the Town and Country Planning Regulations (EIA 1999), a screening opinion by the competent authority (Kerrier District Council) will be required to establish if an environmental impact assessment (EIA) is required to support an application to:

- 10 (m) 'Coastal work to combat erosion and maritime works capable of altering the coast through the construction, for example, of dykes, moles, jetties and other sea defence works, excluding the maintenance and reconstruction of such works.' Under criteria given in Schedule 3, EIA may be required for all development in this category;
- 13 (a) Any changes to or extension of development in a description listed in Schedule 1 or paragraph 1 to 12 of column 1 of this table, where that development is already authorised, executed or in the process of being executed, and the change or extension may have significant adverse effects on the environment'. In this case whether EIA is required depends on the criteria specified in Schedule 3. This category would include changes or improvements to existing sea defences schemes, which the harbour arms may be considered.

Outside the remit of the Planning Authority and in connection with applications for consent under FEPA and CPA there may be a requirement for a formal environmental impact assessment.

An EIA is also required to satisfy the Harbour Works (Environmental Impact Assessment) Regulations 1999 (SI 1999/3445) where a scheme is proposed which is to be sited in or partly within a port or harbour. However, The Regulations only apply to harbour works that exceed 1 hectare, are in a defined "sensitive area", or are determined by the Secretary of State to require EIA under the EC Directive.

If an EIA is required, an Environmental Statement (ES) would be produced as the output from the EIA process. Statutory consultees (English Nature, English Heritage and the Countryside Agency) would need to be consulted on the ES and their formal responses would be required. In addition, the ES would need to be advertised publicly and made available for public viewing for a period of one month. Following this period, efforts would need to be made by the Trust to resolve any objections received to the ES. If objections

were unable to be resolved, they would be referred to the competent authority for decision on whether to uphold the objections (either requiring a change to the proposed works to avoid the reason for the objection or preventing the works from proceeding) or dismiss them (in which case the works would proceed as planned).

2.13.3 Conservation Regulations 1994

Any application in respect of proposed works within or adjacent to a European Site (a Special Areas of Conservation, SAC or Special Protection Area, SPA) is liable to be subject to the provisions of the Conservation (Natural Habitats &c.) Regulations 1994. The first test to be applied is whether the planned project is likely to have a significant impact on the designated (or candidate) site. If the project is likely to have a significant effect on the European Site an appropriate assessment will be required to assess these effects and determine if an 'adverse effect' may occur.

2.13.4 Consent of landowners

The National Trust owns Mullion Harbour and three adjacent buildings and the foreshore of Mullion Cove.

For works below Lowest Astronomical Tide, consent may be required from the landowners, the Crown Estate (refer to Section 7.3 for details of consents required for the options considered in this study).

2.13.5 Statutory and Non-Statutory Plans

Cornwall County Council Structure Plan, Kerrier District Local Plan and Lizard Point to Land's End Shoreline Management Plan all set out policies for the sustainable development and management of this section of coastline. The policies of these plans which are relevant to this study are outlined in Appendix C.

2.13.6 National Trust Legal Obligations

The Harbour has been reviewed by the Trust solicitor. In terms of legal obligations, the Trust must consider any obvious physical impact on neighbouring land arising from how it deals with the harbour walls, but it is under no obligation (either under the general law or the legislation under which Mullion Harbour was built) to keep the harbour walls in place, or to repair them for as long as they are there, nor is the Trust responsible for any economic loss (such as loss of business or any reduction in a property's value) which might result from the condition of the harbour walls, or from their removal. '

2.14 Coastal processes

The wave climate at Mullion Harbour was analysed using numerical modelling comprising three main analyses: extreme event/storms analysis, assessment of offshore wave conditions and wave modelling in and around Mullion Harbour. The extreme event analysis provided the predictions of wave heights and periods for different storm conditions. These storm conditions were predicted for the once-yearly storm event and once in 5, 10, 20, 50, 100 and 200 year events. This analysis used 20 years of historical wave data supplied by the Meteorological Office, Admiralty Chart bathymetric data and further bathymetric data from a survey undertaken for the study (Herrington Geoscience, 2004). Advanced numerical models were then used with this data to track offshore wave conditions propagating into Mullion Cove from a range of directions. Principally, these directions were between a North-Westerly and South-Westerly bearing. Results from the offshore wave analysis were then applied to the more detailed wave model of Mullion Harbour, which was used to predict the upper limit wave heights both inside and outside the structure. Wave climates for present sea level and for sea level in 100 years were modelled, allowing for sea level rise at 5mm/yr based on government guidance (Defra, 2002).

Numerical simulations of Mullion Cove and Mullion Harbour were undertaken and from these results it was found that damage to the harbour is primarily caused by storm waves from the West on a bearing of 270°. As they pass Mullion Island, they change direction slightly and attack the harbour from directions between 250° and 280°.

Figure 2.4 shows a result from a numerical simulation of the wave activity around Mullion Harbour. It can be seen from this plot that the largest wave activity occurs at the head of the Western Breakwater and along the length of the Southern Breakwater. The wave activity inside the harbour is at its largest in the North-west corner. These results coincide with the recorded historical damage to the harbour (refer to Figure 2.5) and observations made by local residents during storm events.

As Mullion Cove is exposed to the sea conditions arriving from the Atlantic Ocean, the wave climate around Mullion Harbour is severe and typically involves large scale wave breaking.

The numerical modelling of Mullion Harbour highlighted the "*depth-limited*" nature of the wave climate around the structure. A depth-limited wave exists where the wave height is restricted due to the sea-bed levels and hence depth of water that it is passing through. This is normally due to a wave breaking offshore and reducing in height, as is the case at Mullion Harbour.

The results of the numerical simulations suggest that, for a typical large storm event that could occur once a year, wave heights of between 4 and 4.5m would occur at the head of the Western Breakwater, with a wave of period 11s. Within the harbour basin the wave heights will typically be reduced to between 1-2m in the majority of areas, but with areas of waves as high as 2.5m at the North-western corner. Technical details about the wave climate numerical modelling are given in Appendix D.

There is very little large-scale sediment transport interaction on any of the Cornish coastline due to its hard, rocky, headland-dominated form. The coastline is essentially composed of a number of self-contained bays, separated by long lengths of rocky coast along which there is very little coastal process linkage. The coastline at and adjacent to Mullion Harbour consists of sandy pocket beaches trapped between and backed by rocky cliffs. There are no major contemporary sources of sediment feeding into the coastal system and the beaches comprise relict sediment. A closed sediment cell transports material in a near-circular pattern within Mullion Harbour and Mullion Cove with little sediment movement around the adjacent headlands delineating the Cove. There is little cross-shore sediment transport.

2.15 Sea flooding/storm damage

From the information shown in the Environment Agency flood risk maps (http://maps.environment-agency.gov.uk/wiyby/mapController) and discussions with the local community, the land around the edge of Mullion Harbour is understood to experience occasional sea flooding. The flooding consists of surface water on the land around the harbour's edge due to waves running up the slipway and adjacent revetments, and due to wind-induced spray. The natural phenomena that cause the sea flooding and storm damage are high sea levels (e.g. due to storm surge combined with high tides), large swell waves and onshore winds.

As the land around the harbour is relatively steep, rising to high ground, the area presently affected by sea flooding and potentially by storm damage (in an extreme event) is expected to be limited to a strip of land some 5m wide bordering the coast. This area drains naturally into the harbour via overland flow and drainage would appear to be adequate to deal with the sea flooding.

2.16 River flooding

The Environment Agency flood risk maps indicate that the valley leading into Mullion Harbour is subject to flooding. Floods discharge into Mullion Harbour from the valley stream via the culvert beneath the Northern Quay and, potentially, in a large event, via overland flow from the culvert inlet and across the slipway.

Catchment management planning and analysis is not part of this study but it is noted that the catchment draining into Mullion Harbour may experience flash floods, similar to the 2004 Boscastle floods. Whilst this type of flood is possible, the geographical layout of the harbour is very different from that at Boscastle. Debris could be swept down the valley, but this is not likely to contain cars as happened at Boscastle. The top of the slipway is relatively open and most debris would be likely to pass through without causing major damage.

2.17 Climate change and sea level rise

2.17.1 Present guidance

The Intergovernmental Panel on Climate Change (IPCC) predicts, in its Third Assessment Report (2001) that "Human activities - primarily burning of fossil fuels and changes in land cover - are modifying the concentration of atmospheric constituents or properties of the Earth's surface that absorb or scatter radiant energy. In particular, increases in the concentrations of greenhouse gases (GHGs) and aerosols are strongly implicated as contributors to climatic changes observed during the 20th century and are expected to contribute to further changes in climate in the 21st century and beyond. These changes in atmospheric composition are likely to alter temperatures, precipitation patterns, sea level, extreme events, and other aspects of climate on which the natural environment and human systems depend."

The UK Climate Impacts Programme (UKCIP), which addresses future climate change in England and Wales, released new climate scenarios in April 2002, following the issue of the 2001 IPCC reports. Based on these UKCIP scenarios, the Department for Food, Environment and Rural Affairs (Defra) have developed detailed guidance on the application of the scenarios, intended for day-to-day use in flood and coastal engineering studies (Defra, 2002, Climate Change Scenarios: Implementation for Flood and Coastal Defence: Guidance for Users: R&D Technical Report W5B-029/TR). This guidance has been widely adopted within many UK flood and coastal engineering studies, notably many studies performed on behalf of the Environment Agency.

The Defra guidelines set out appropriate precautionary allowances for climate change over the next 100 years (including the effect of post-glacial rebound, which is the change in land level due to removal of large ice sheets that formed during the last Ice Age). Table 2.4 summarises the relevant marine parameters. Some aspects of climate change are better understood than others due to the amount of research that has been undertaken to date and the complexity of the systems involved. The degree of confidence (i.e. the reliability given the current state of knowledge) for different climate change predictions therefore varies from parameter to parameter. This is also indicated in Table 2.4.

Table 2.4 Appropriate precautionary allowances for climate change (Defra, 2002)

Parameter	Precautionary allowances for climate change	Confidence
Mean sea level	5 mm/yr for the Cornwall region	Medium
Extreme sea level	Usually assumed to be as for mean sea level	Medium
Wave climate and extreme wave conditions	Add 10% sensitivity allowance to offshore wave heights by 2080s (and 5% to wave periods)	Low

While the guidance provided by Defra is widely accepted as the current best practice for the long term prediction of sea level rise (SLR), research in this topic is ongoing. Taking advantage of the increasing availability of accurate global climate data, scientists are gaining an improved understanding of the probability intervals for a range of climate change events (Defra, Met. Office, 2005). However, at present this work is in the early stages of development and a universally agreed update to the existing Defra guidance on SLR has yet to be provided.

For this option assessment study, the precautionary allowance for SLR of 5mm/year (Cornwall region) from the Defra guidelines has been applied. There is a reasonable degree of confidence in these allowances and they are therefore included, in accordance with standard practice, at this preliminary stage. Precautionary allowances for wave climate are much less reliable at this time and the Defra guidelines recommend that the allowances be used for sensitivity testing only. Variation of actual future SLR from existing predictions and the effect of possible changes in wave climate are taken into account in this study through the risk assessment, while detailed sensitivity testing would be undertaken as part of the detailed design and costing phases of the project. In addition, it is sensible to reassess the management strategy for the harbour at regular intervals to include for updated climate change guidance.

2.17.2 Sea level rise at Mullion

As noted above, due to the effects of global warming and post-glacial rebound, a sea level rise of 5mm per year is presently projected for Cornwall. Over the 100 year timeframe considered in this study, this will equate to a total of 0.5m. As described in Section 2.14, the waves at Mullion Harbour are depth-limited, and therefore if the water depth increases, 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 sea level. This will effectively increase the wave height of the largest waves experienced at Mullion Harbour and the frequency with which waves of a given height are experienced at Mullion Harbour.

For example, the once-yearly storm event predicted for today's sea level has a wave height of 2.0m. With the 0.5m rise in sea level by 2105, the wave height for this once-yearly event would be expected to increase to 2.3m. This 2.3m wave height is greater than the wave height corresponding to the present day 1 in 100 year event. Table 2.5 illustrates this point, showing the recurrence intervals and wave heights with present day sea level and in 50 and 100 years for wave heights modelled at the toe of the slipway.

Table 2.5 Variation in wave height for different recurrence intervals and sea levels

Sea level	**Present day sea level**		**In 2055 with 0.25m SLR**		**In 2105 with 0.5m SLR**	
Recurrence interval	**11 in 1 year**	**11 in 100 year**	**11 in 1 year**	**11 in 100 year**	**11 in 1 year**	**11 in 100 year**
Wave Height (m)	22.0	22.2	22.1	22.3	22.3	22.3

2.18 Geology and hydrogeology

A geological survey of Mullion Cove and Harbour was undertaken by Herrington Geoscience in July 2004 in order to identify the underlying geology of the area to assist with the identification of appropriate engineering solutions for the Harbour. The types of rock

occurring at the site, the superficial geology (cliffs and beach material) and mapping of the discontinuities (faults, fractures and schistosity) are shown in Figure 2.6.

The geological survey indicated two faults within the harbour, one through the centre of the harbour and the other under the Western Breakwater running North-west - South-east. Further details are contained in the geological report in Appendix E.

A hydrogeological survey was undertaken between September and December 2004 in order to identify any routes for fresh water, with particular consideration to:

- The line of the fault through the centre of the harbour.
- Water from the cliffs above the Northern Quay

Two piezometers and an automatic data logger were installed to measure water levels within the structures of the Northern Quay and Western Breakwater and a conductivity survey was carried out along the harbour side of the Western Breakwater.

It was anticipated that the faults could provide a route for fresh water under the Western Breakwater and this water could cause deterioration of the rock under the breakwater. It was only possible to carry out the survey for a distance of 12m from the north west corner and no fresh water was found.

No fresh water was found along the front of the Northern Quay. The survey was carried out in November when the weather was unusually dry.

The salinity tests on water in the Northern Quay showed that fresh water is permeating into the Quay from the cliffs. It is likely that this water is ground water with possibly some surface water mixed with the sea water. Further details of the hydrogeological survey can be found in Appendix E.

Thirty five boreholes were drilled, of which 26 were taken down into the bedrock. The boreholes showed that the breakwaters and quay are founded on rock and that the rock formation levels vary. The levels under the Northern Quay are particularly variable, with the rock only 2m below the surface close to the culvert, increasing to 6.3m at the north west corner.

From the petrographic analysis of core and rock chipping samples (refer to Appendix F for full report), the rock formation was confirmed as Traboe Hornblende Schists (hornblende) and Lizard Peridotite (serpentine) of the Lizard Ophiolite complex. All three harbour structures are built on the complex contact zone between the Traboe schists and Peridotite.

The rock quality was generally good and from the petrographic analysis of the samples there was no evidence of brittle faulting or zones of weak or porous rock. However the drilling records showed that fissured rock was found in a borehole close to the fault and from this borehole only 20% of the rock core was recovered. In other areas the recovery was 75-85%. Another borehole close to the fault found "loose" rock.

Whilst the geological fault was apparent from the boreholes, the degree of deterioration of the formation under the Western Breakwater did not appear to be very significant.

Weathered rock, rather than fissured rock, was found in one of the Southern Breakwater boreholes and in three of the Northern Quay boreholes.

2.19 Harbour condition

The Western Breakwater is constructed of coursed (ashlar) masonry outer walls and a central core (hearting) of un-reinforced concrete. The walls on the seaward side are mainly of granite blocks, weighing in the order of four tonnes; the blocks are well formed with very thin joints. Past the knuckle, on the outer face, the granite gives way to local Elvan stone (Hornblende and Serpentine), in similar large blocks and with similar thin joints. The masonry on the harbour side is also of local Elvan stone and, whilst the stones are still massive, the workmanship and quality

of the work is not as good as on the seaward side. The top of the Breakwater is paved with granite setts with a level surface suitable for vehicles. The end of the breakwater has had a considerable amount of remedial work carried out over the years, principally to maintain the existing construction, but also including the installation of vertical, inclined and horizontal steel ties. The construction is shown in Figure 2.7.

The Western Breakwater has a parapet which extends from the cliffs at the northern end to the lamp house and for approximately 2m beyond. The parapet has an average height of 2.1m and a width of 1.7m. The top of the wall slopes downwards towards the seaward side. The walls are constructed of dressed local stone brought to coursing with relatively wide joints. The core of the parapet is of concrete, placed in fairly small lifts (approximately 350mm). The parapet has a raised walkway alongside on the harbour side. A length of parapet was rebuilt in 1999 using a similar construction to the original, but incorporating steel dowels. At the time of the reconstruction the original concrete core was chemically tested and found to have degraded as a result of sulphate attack from the ingress of sea water.

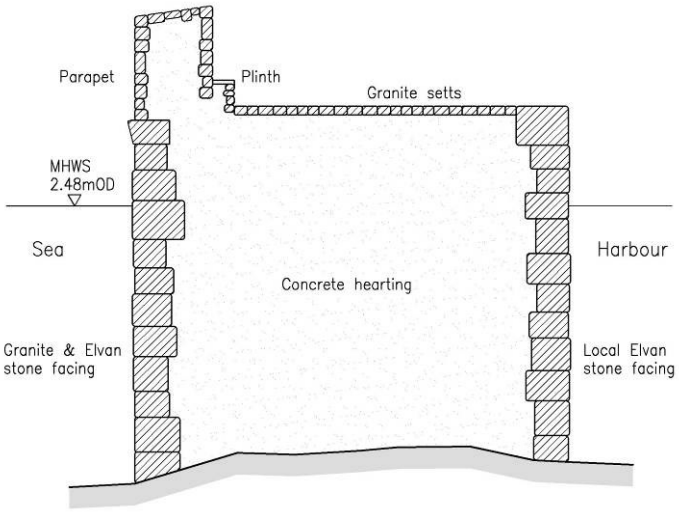

Figure 2.7 Cross section of the Western Breakwater

The Southern Breakwater is constructed of coursed local stone with an un-reinforced concrete core. The workmanship of the Southern Breakwater is not of the same standard as the Western Breakwater. Granite quoins and copings have been used but the most of the wall consists of local Elvan stone. The surface is paved with local stone "puddled" into a concrete bed, set in a random pattern and with a slightly domed surface.

Visual and dive inspections and boreholes were carried out in mid-2004 and full details are included in the reports in Appendix F. The details below cover the main findings.

All faces of the harbour structures were visually inspected, including the seaward side of the Western Breakwater by boat. Generally the walls were in good condition, but water was seen emanating from the Western Breakwater at the end and on the seaward side in a few locations and from the Northern Quay in the north west corner. This indicated holes or cracks in the facing with a void in the structure.

The surfaces of the Western Breakwater and Northern Quay were in reasonably good condition to line and level, but there is a need for some repointing (approximately 25%). The Southern Breakwater surface is not in such good condition, due to the original construction. The surface requires approximately 25% repointing, but the work involved is greater than with the setts. The slipway is in relatively good condition (stones are all in position) but approximately 40% requires some repointing.

Part of the wall above the steps to the Western Breakwater was slightly bulged. The parapet wall had some cracking on the seaward elevation.

Metalwork to handrails was in reasonably good order, but does require regular maintenance.

A dive survey was carried out along the seaward sides of the Southern and Western Breakwaters, returning around the end of the Western Breakwater and for a short distance into the harbour. The dive survey found the structures were generally in good condition, but there were some voids on the seaward side of the Western Breakwater, generally at sea bed level. The most significant defect was at the end of the Western Breakwater where scour has exposed two steel piles and these have started to corrode. No voids were recorded for the Southern Breakwater.

The thirty five boreholes confirmed that the hearting is of concrete in all the structures. The boreholes generally showed a sequence of concrete/sand and rock of varying degrees of firmness until bedrock was encountered.

In the Western Breakwater, little sand was recorded in the boreholes for the first 30m from the harbour mouth, then the quantity of sand recorded increased with significant quantities in the final 25m. However, the boreholes were drilled by "open hole" i.e. the "sand" was firm enough to keep the hole open for drilling. It is likely that the material recorded as sand was decomposed concrete. There was also significant sand recorded in the Northern Quay, particularly at the north west corner where loose sand and voids were found in one borehole. This was the only one of all the boreholes where open hole drilling was difficult.

The seaward end of the Southern Breakwater was generally solid concrete, but sandy fill was found from the knuckle to the landward end. Again this is likely to be concrete that has deteriorated.

Analysis of samples (Table 2.6) from the hearting showed that much of the concrete was in good condition despite being more that 100 years old. It appeared that the hearting concrete had been placed in hessian bags, probably weighing about one and a half hundred weight (75kg) each. This concrete has deteriorated from the outside inwards forming "shells" of different quality concrete. The innermost concrete was in good condition, whilst the outermost shell of the bag had deteriorated to the extent of losing all its strength and being sand-like. Between these two extremes there were two levels of deterioration, forming shells around the sound concrete core of each bag.

Table 2.6 Boreholes and testing

Location	No. of boreholes	No of boreholes to bedrock	Fissured or weathered rock	Sandy hearting	Samples		
					Cores	Bedrock	Hearting
Western	22	14	3	5	4	2	5
Southern	6	5	1	4	0	2	2
Northern	7	7	3	4	0	3	0
Total	35	26	7	13	4	7	7

The internal structures of the ends of the Western and Southern Breakwaters are in good condition with firm concrete fill. Both structures deteriorate in condition towards the landward ends. This is because the maintenance that has been carried out has been largely concentrated on the seaward ends of each breakwater where the most damage has occurred as a result of the highest loads.

From the 2004 investigations, the harbour structures were found to be generally in good condition with the following areas needing attention:

Western Breakwater

- Voids to the seaward side and end.
- Scour to the end.
- Wall bulged above the steps.

Northern Quay

- Voids in the north west corner.

All structures

- Repointing to walls, setts and slipway.

2.20 Summary of principal findings

In summary, the principal findings regarding the existing environment that have been made through the first part of the Mullion Harbour Study (i.e. the desk studies, field investigations and analysis) are as follows:

- A total of 32 sites were identified and graded during an archaeological and historic assessment by the Historic Environment Service of Cornwall County Council. Six sites are Grade II Listed Buildings, six sites are of regional importance and twenty sites are of local importance.
- No rare or protected species or habitats were found at Mullion. However the provisionally Nationally Scarce fish Montagu's Blenny and the southern species Snakelocks Anemone and amphipod were present. Mullion Cove also supports four scarce intertidal biotopes. Mullion Cove is bordered by (but excluded from) two, predominantly coastal, Sites of Scientific Interest, both of which are included in The Lizard SAC.
- The majority of the tourist related businesses at Mullion Village and the areas just outside of the Village place considerable importance on Mullion Harbour as a tourist attraction. Visitor revenue attributable to the cove/harbour site could potentially be of the order of £200,000 to £1.4 million per year. Fishing from the harbour supports a full-time equivalent job. Harbour user revenues are estimated at approximately £27,000 per year, most of which is private income from fishing.
- The geological survey indicated two faults within the harbour, one through the centre of the harbour and the other under the Western Breakwater running north west – south east. The fault under the Western Breakwater does not appear to be structurally significant and the boreholes confirmed that the breakwaters and quay are founded on solid rock (hornblende schists of the Traboe series).
- The numerical modelling of Mullion Harbour highlighted the "depth-limited" nature of the wave climate around the structure, where the wave height is restricted due to the sea-bed levels and hence depth of water that it is passing through.
- Due to the effects of global warming and post-glacial rebound, sea level rise of 5mm per year is presently projected for the South-West region. As described above, the waves are depth-limited and therefore if the water depth increases, so will the wave heights. This will effectively increase the wave height of the largest waves experienced at Mullion Harbour and the frequency with which waves of a given height are experienced at Mullion Harbour.

- Of the 35 holes drilled in the Western and Southern Breakwaters and the Northern Quay (26 to bedrock) only one showed voids. Analysis of the concrete showed that much of the concrete was in good condition despite being over 100 years old.
- In general, the inspection and condition survey of harbour arms found the harbour to be in reasonably good condition, considering the age of the structure and particularly as no major works have been carried out since 1998.
- The following areas of the harbour structures need attention:
    - Western Breakwater: voids to the seaward side and end, scour to the end, wall bulged above the steps.
    - Northern Quay: voids in the north west corner.
    - All structures: repointing to walls, setts and slipway.