

Chapter 17

Shoreline Stabilisation: Lessons from South Wales

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Abstract Shoreline stabilisation in South Wales was driven by historical industrial development. Coal from the hinterland was brought to the shore, especially during the nineteenth century for use in metal industries that were located on the coast, and for export. At that time coastline impacts were not understood and development legacies have proven to be environmentally and financially expensive. Even when early in the twentieth century seawall and groyne impacts were recognised, coastal defence strategies still followed previous patterns. With industrial decline, economic regeneration has been supported by coastal location but unfortunately, lessons from the past have not been learned. Case studies show damage to new developments resulted from inappropriate infrastructure location, while undermined seawalls are now being protected by rock armour. This is becoming increasingly serious as there is little available funding to undertake effective remedial measures. It is concluded that new strategies which consider prevailing coastal processes are needed for long-term management; otherwise paving the shoreline may become more common on the Welsh coastline.

17.1 Introduction

The coastal zone has evolved in response to many natural and anthropogenic factors and processes. Furthermore, climate change and sea level rise now pose significant threats to coastal regions. In the United Kingdom, accepted strategies to manage coastal areas under threat are: hold the line; advance the line; retreat from the line; and no active intervention. However, each of these options comes with its own problems and consequences, especially when human activities are

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threatened. Ketchum (1972) classified human activity in the coastal zone under the following groupings: residency; industrial and commercial; agriculture, aquaculture and fishing; tourism and recreation; waste disposal; conservation; and military and strategic. While all these can be currently identified on the South Wales coast, traditional industrial and commercial activities are in decline and accommodating growing development pressures is an issue. The industrial revolution, and especially industrial growth in the nineteenth and twentieth centuries, caused many present-day coastal problems (Bullen 1993). This inheritance has further complicated current protection and management of Welsh coastal assets. An evaluation of the present day status of a coastline is fundamental in deciding whether to actively manage or refrain from intervention (Simm 1996). In many vulnerable coastal areas beaches lie in front of constructed defences and it is important to differentiate between the general health of a beach and its function in coastal defence. A beach may be at a very low level and its volume may be reducing, but this does not necessarily mean that the beach needs managing to improve its defensive capability (Simm 1996). However, implicit in understanding any temporal shoreline behaviour is data acquisition. Managing the coastal zone involves policies at various geographical scales but economic drivers often lead to inappropriate local decisions. These often ignore fundamental coastal processes and lessons learned elsewhere. Consequently via case studies at Llantwit Major, Porthcawl, Port Talbot and Llanelli (Fig. 17.1), this chapter will assess consequences of historic and contemporary Welsh shoreline stabilisation. Cause and effect will be examined at each location with lessons learned and policy implications subsequently reviewed.

17.2 Case Studies

17.2.1 *Llantwit Major – Colhuw Beach (OS Ref: SS955673)*

In 1972 the Glamorgan Heritage Coast became the first coastline designated as such in the UK. Approximately 23 km long, this protected coastline has spectacular cliffs, interrupted only by the occasional bay such as Col-Huw beach, approximately 1 km south of the historic town of Llantwit Major (Fig. 17.1). The geology is Lias limestone cliffs backing a beach consisting of limited sand, Lias mudstones, shales and limestone pebbles, which range from a few millimetres to a couple of metres in diameter (Bullen 1993; SBCEG 1999). The spring tidal range is 9.6 m and the beach is subject to direct wave attack from the prevailing southwest and refracted wave attack from the southeast (SBCEG 1999). Consequently, sediment drift is strongly eastwards, driven by the oblique dominant wave approach. Due to beach shape, topography and coastal processes, good surfing waves are generated.



Fig. 17.1 Case study locations

One of the few accessible bays along this section of coastline, monitoring by the shoreline management partnership estimates cliff erosion at *circa* 0.08 m year^{-1} (SBCEG 1999).

Col-Huw is a mixture of private and local authority ownership; the local authority running the car park and the Surf Life Savers club, with the Glamorgan Wildlife Trust Reserve adjacent to the beach. It is popular for swimming and surfing with a café located on the shoreline (SBCEG 1999). Williams and Davies (1990) described it as a 'honey-pot' recreational beach, mainly a local visitor attraction with some tourist interest from other parts of Wales and elsewhere (SBCEG 1999). The area is prone to significant storms and high waves, and has been the subject of



Fig. 17.2 Storm damage to Surf Life Saver Club

many coastal defence measures. In the early 1990s, storms severely damaged the Surf Lifesaver building, cafe and car park (Fig. 17.2). Several options in response to coastal retreat were considered, including doing nothing except rebuild the Lifesaver club, but the chosen solution was partial setback and upgrade of the building with substantial hard engineering protection. This consisted of a curved, convex Carboniferous Limestone block revetment, approximately 80 m in length, 20 m in width and 6 m in height (Fig. 17.3). It was constructed with 2,900 tonnes of hardcore and 6,000 tonnes of armour stone, made up of *circa* 7 tonne blocks. It incorporated a concrete beach access ramp and is the largest engineering structure along this coast (Williams et al. 2002). However, in severe south-westerly storms, the revetment is frequently overtopped and outflanked (Fig. 17.3).

Williams et al. (1998) questioned whether the revetment should have been constructed in a coastal area where emphasis is on natural beauty, arguing that anthropogenic intervention had reduced this part of the Glamorgan Heritage Coast's aesthetic quality. Williams et al. (2002) correctly argued that any attempt to hold the line along this particular section of coastline, which is subject to beach erosion and rapid longshore drift, would always be difficult. Logically the buildings should have been relocated inland from this position of natural instability and ironically, following construction of the revetment, shoreline management adopted a policy of managed retreat for this coastline (SBCEG 1999).

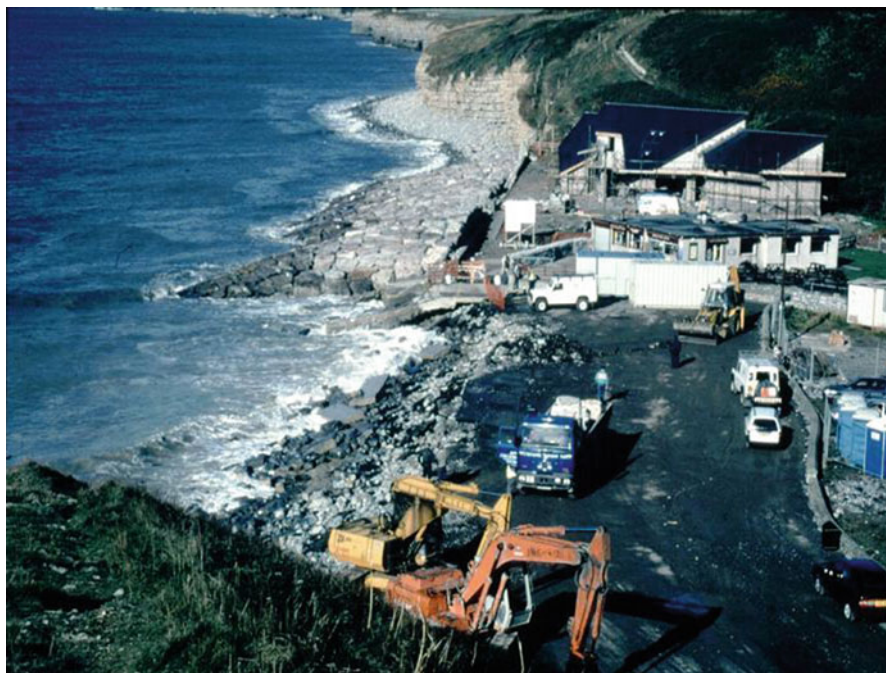


Fig. 17.3 Reconstructed Life Saver Club fronted by new revetment

17.2.2 Porthcawl (OS Ref: SS825765)

Porthcawl (Fig. 17.1) became important in the mid nineteenth century because of extensive coal exporting from its harbour. It has a spring tidal range of 8.9 m (SBCEG 1999) and under storm conditions, surges can add 2 m to tide heights (Williams 2002). Following the South Wales coal industry decline and consequent lack of trade for smaller ports, Porthcawl became residential, and the town centre focused on a developing a tourism industry. Shoreline stabilisation started in 1887 with the construction of Brogden's seawall (Fig. 17.4). A combination of spring tides and south-westerly storms caused parts of this wall to fail and in 1906 it was superseded by a vertical seawall. In 1934, exposure of its base and timber piles resulted in the seaward construction of a new 450 m long vertical wall (Williams 2002; Carter 1988, Fig. 17.4). Between the two walls, a low level promenade was created. Hard engineering structures such as seawalls, groynes, piers, etc. are traditional responses for coastal infrastructure protection, but unfortunately they are expensive and tend to promote erosion. Local beach levels continued to fall and in 1965 a concrete buttress was added, which by the late 1970s was in disrepair. Various responses were considered and in 1984/5 the Coastal Protection Authority (CPA) decided to construct a bitumen-grouted revetment (Fig. 17.5). It was made up of a 0.150 m thick asphaltic concrete layer on top of sand fill, with angled bitumen-grouted cobbled slopes, the height

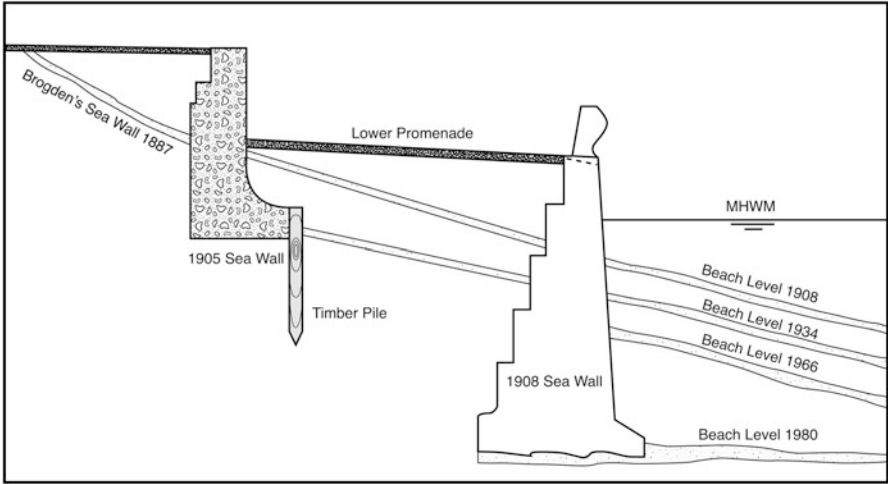


Fig. 17.4 Temporal variation in beach level (after Carter 1988)



Fig. 17.5 Bitumen revetment covering upper beach

from bedrock to seawall base being 3 m (Williams 2002). Although not aesthetically pleasing, the project was successful in preventing further erosion and damage to hinterland infrastructure. Beach tourism is supported by the nearby Coney Beach and Rest Bay to the east and west respectively. The CPA undertakes

maintenance work on the bituminous ‘town’ beach (Fig. 17.5) although the cost is minimal compared with traditional coastal defence measures. However, Porthcawl’s main breakwater receives significant wave impacts during storms and requires regular repairs, its structural integrity being of concern to the CPA (SBCEG 1999). This case study shows how shoreline stabilisation locks local authorities into a cycle of expenditure, justified by the protection of high value infrastructure.

17.2.3 Port Talbot (OS Ref: SS755875)

Port Talbot (Fig. 17.6) is located on the eastern flank of Swansea Bay and since 1100AD there has been evidence of shoreline volatility along the whole of this coastline (Bullen 1993). The town grew up around an iron and steel industry which expanded during the nineteenth and early twentieth centuries. Coal mined from the South Wales valleys was brought by rail to Port Talbot for producing steel, and this was subsequently exported via the old docks (Fig. 17.6). Workers’ homes were constructed around the steelworks, most being low-cost terraced properties and little thought was given to issues such as tourism. The coastal environment was originally sand dunes with wide beaches typical of a macro-tidal environment. Dunes were removed for the steelworks and associated development, but systems still exist to the northwest and southeast. The shoreline is highly exposed to extreme southwesterly storms and the spring tidal range is 8.4 m. Coal waste is often found on the beach, brought ashore by wave action (SBCEG 1999). The macro-tidal range is a disadvantage for all South Wales ports because ship access and egress is limited over a narrow window during the tidal cycle. Furthermore, ship size is governed by lock dimensions. With design changes at the end of the Second World War resulting in many new ships being too large to negotiate Port Talbot docks’ locks, it was the end for many previously commercially viable trading routes. Therefore, unless something could be done to address this situation, the steelworks would have inevitably gone into decline. It was decided that the large cargoes of imported iron ore and coal necessary for economic steel production required a sheltered deep water harbour and consequently, British Steel (now Tata Steel) and the British Transport Docks Board (now Associated British Ports) entered into a commercial venture to construct the Port Talbot Tidal Harbour (Fig. 17.6: OS ref: SS750880). During its construction, 11.2×10^6 tonnes of gravel, sand and silt were removed (Bullen 1993) and with an extensive industrial hinterland, mostly occupied by Tata Steel and related industries, it now dominates the area (SBCEG 1999, Fig. 17.6). However, constructing seaward of the natural shoreline has impacted on natural processes and negatively affected the north and south adjacent coastlines, including the beaches at Aberavon and Margam (Fig. 17.6). Between 1960 and 1976 maintenance dredging for the harbour equalled the capital spoil removal (Bullen 1993) and this on-going process removes sand to a spoil area in Swansea Bay where there is a weak shoreward recirculation.

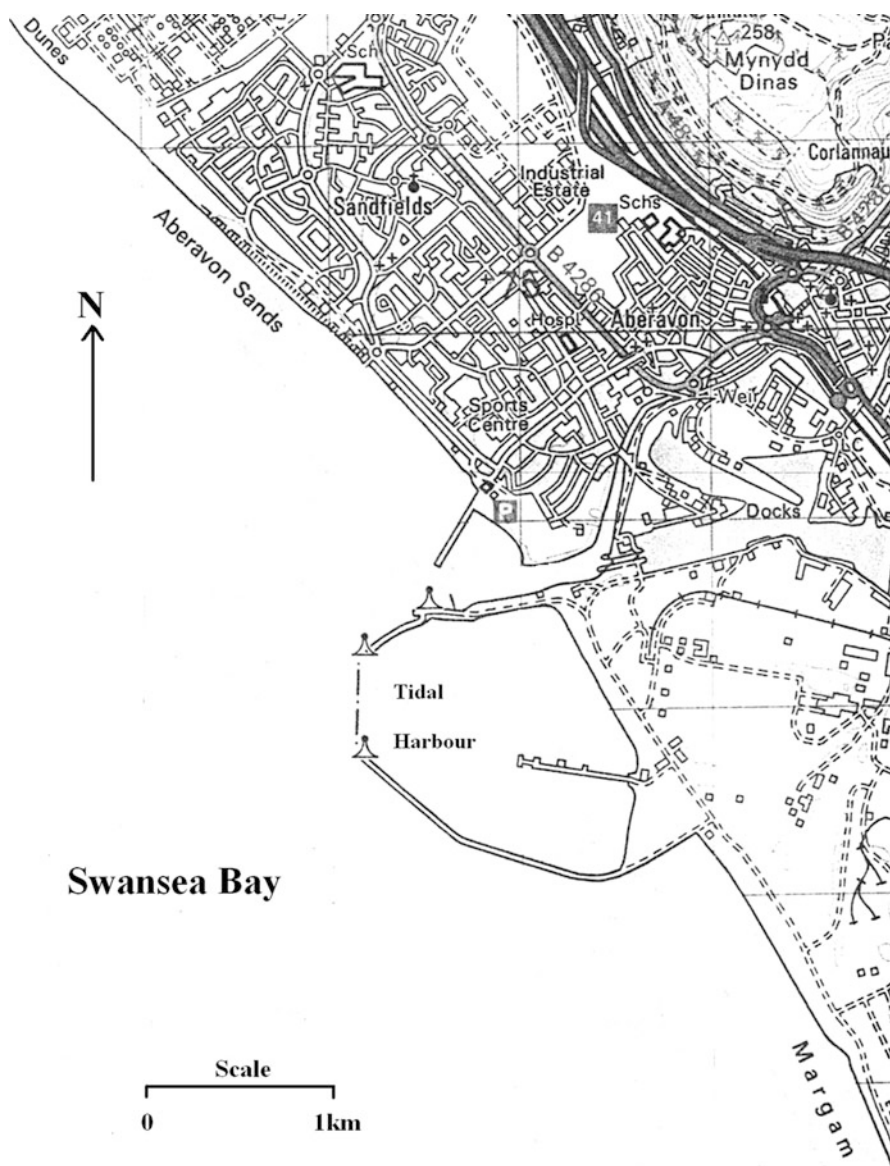


Fig. 17.6 Port Talbot coastline (Reproduced by kind permission of Ordnance Survey, Crown Copyright. All rights reserved)

Aberavon Sands (OS ref: SS735904) is a recreation beach (Fig. 17.6) with a long seawall/revetment and *circa* 2.5 km long promenade. Following completion of the tidal harbour, local authority records between 1958 and 1975 showed an average fall in beach level of 0.8 m. Analysis of a 1991 aerial survey showed that between 1975 and 1991 there had been a further average loss of 0.3 m (Bullen 1993).



Fig. 17.7 Aberavon seawall

In January 1991, as a result of many internal voids that had developed within the seawall, a section collapsed in a not-very-severe storm (Bullen 1993). The south-eastern part was built seawards of high-water and toe erosion is on-going due to wave reflection and turbulence. This is exacerbated by the adjacent tidal harbour which interferes with northerly longshore transport and starves the fronting beach of sediment. Conversely, the north-western half of the seawall was constructed landwards of high-water. Here the fronting beach is outside the tidal harbour's influence and receives sediment recharge from the south, resulting in dry sand being blown against and over the wall. Therefore, adjacent to the tidal harbour beach levels have continued to fall resulting in exposure of sheet piles at the seawall toe and this has led to rock armour protecting the seawall which in turn is protecting the promenade (Fig. 17.7).

Margam Sands (OS ref: SS768855), south-east of the tidal harbour (Fig. 17.6), was once an extensive dune line and is now a 3 km length of slag (waste from steel-making processes) and rock armour revetment (Fig. 17.8; SBCEG 1999). The Tata Steel frontage had experienced erosion over many years and between 1975 and 1991 there was a maximum beach level fall of 1.1 m (Bullen 1993). The 1991 aerial survey showed a back beach/dune line recession of between 20 and 40 m and Bullen (1993) concluded that during this 16 year period there had been significant sediment loss, equating to $950,000 \text{ m}^3$ from back beach recession and eroding foreshore. This was equivalent to an average beach level fall of 0.7 m and parallels were drawn with



Fig. 17.8 Blast furnace slag revetment

similar losses experienced between 1830 and 1870 due to disruption caused by the construction of Port Talbot docks. The slag revetments which protect the steelworks and other infrastructure such as access roads (Fig. 17.8) are themselves susceptible to erosion and sections have been reinforced with stone armour revetments. Consequently, this particular shoreline was recommended for priority monitoring (SBCEG 1999).

17.2.4 Llanelli (OS Ref: SS625530)

At the beginning of the nineteenth century, Llanelli had one small dockland while above the high tide mark, housing was built on copper slag banks (Llanelli Community Heritage 2008). Industries included agriculture, wool and pottery, ironworks, steelworks, tinsplate, copper smelting and coal and lead mining. However, it became an important centre for coal exports and in 1834 these led to the construction of New Dock. The commencement of shipbuilding in 1860 required the building of North Dock to provide larger ship facilities (Rees 2006). Transport systems were centred on these industries with additional roads, tramways, railways, canals and docks being developed in response to economic growth. By the mid twentieth century, industry had started to decline and thousands of jobs were lost.

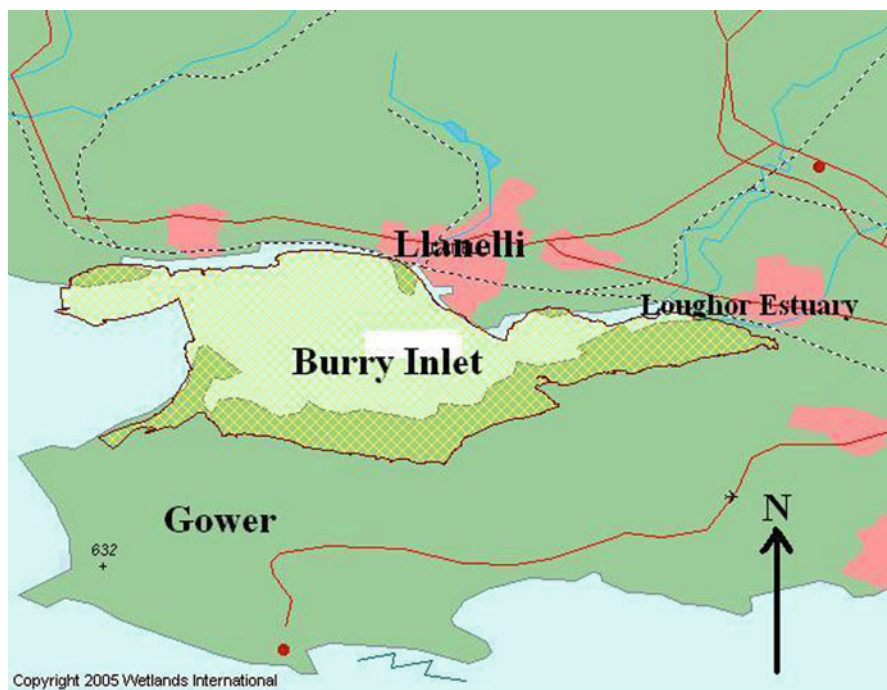


Fig. 17.9 Burry Inlet RAMSAR site (Wetlands International 2005)

The docks fell into disrepair and land was unusable due to high amounts of contaminants, by-products of various local power stations, metal industries and mining. Towards the end of the twentieth century, Llanelli's beach was surrounded by decommissioned industrial sites, docklands and part of the town. Consequently, Llanelli had high unemployment and was not an attractive prospect for developers.

Geologically, Llanelli (Fig. 17.1) and environs date from the Carboniferous with extensive Holocene coastal floodplains (Bowen 1980). The Burry Inlet is a RAMSAR site and lies between Llanelli, Burry Port and the northern edge of the Gower Peninsula (Fig. 17.9). Since medieval times there have been considerable coastal morphology changes and seawalls prompted by coastline change protect the land. It is hard to ascertain through cartography, due to human intervention, whether there have been recent local accretional or erosional patterns (James 2006). The area has a spring tidal range of 8 m and the predominantly southwest-facing coastline is characterised either by low-lying wetlands straddling tidal rivers, or fronting sand dunes (CBCEG 1999). Storm surge and high tide combinations can cause inundation beyond normal tide lines, causing problems for coastal lowlands, which have seen intensive and dramatic land-use change (James 2006). Seawalls, groynes and beach nourishment currently protect existing and new developments, including an important rail link, while Llanelli beach has a sandy foreshore that attracts tourists. Llanelli's seawall is approximately 2 km long and joins the

southeast dune system. The seawall has been locally undermined resulting in the addition of rock armour (CCCESC 2004) while Burry Port has two westward groynes to prohibit sand movement. These structures restrict sand movements which consequently affect the coastline (Llanelli Star 2006).

Therefore to facilitate regeneration, funding from the National Lottery, Carmarthenshire County Council and the Welsh Government enabled >800 Ha (2,000 acres) of contaminated industrial wasteland to be converted into the Millennium Coastal Park (MCP, Fig. 17.10). The development objective was to improve housing, commercial accommodation and recreational facilities, including construction of the 22 km Millennium Coastal Path. There are 75,000 people living in the surrounding areas (BBC 2004a) and in 2004, the area received over 500,000 tourists (BBC 2004b). The MCP gives views over the Burry Inlet and Gower Peninsula (Fig. 17.9) and a signature structure, the Earth Sculpture 'Walking with the Sea', was specifically designed to be seen from land, sea and air. It is located on the coastal path between Burry Port and Llanelli (Fig. 17.10) and previously, this coastal section had no sea defence. Constructed from Pulverised Fuel Ash (PFA), an extremely fine waste product from the old coal-fired power stations, it extends seawards into the coastal environment (Fig. 17.10). The use of PFA was seen as an environmental benefit i.e. reuse instead of disposal. Beaches were incorporated into the Earth Sculpture's western and eastern flanks while silt from Burry Port Harbour and sewage sludge facilitated rapid natural re-vegetation (UKQAA 2003). Redevelopment included new houses and seafront apartments adjacent to Llanelli Beach, such as the Millennium Quay (Fig. 17.10). High-quality housing has been constructed on floodplains to the east and further housing and office buildings have been located around the path.

Prior to redevelopment, Llanelli's coastline had not been extensively studied due to its past contaminated status and limited recreational importance. Unfortunately, in the redevelopment strategy, there is no evidence of due consideration being given to prevailing coastal processes. There had been evidence of previous problems when maintenance of river training walls in the Loughor Estuary (Fig. 17.9) ceased in the 1950s following the decline of Llanelli docks. Siltation following collapse of these walls caused nearshore channel migration and since 1970, there has been considerable damage to Llanelli beach (James 2006; CBCEG 1999). Subsequent to the MCP development, there have been a number of problems along the coastal frontage.

Burry Port is a busy recreational harbour which requires storm protection and a clear navigation channel. There are two adjacent beaches, and the eastern one is eroding while West Beach, backed by extensive sand dunes and short seawall, is relatively stable. Longshore eastward sediment transport (CBCEG 1999) is interrupted by groynes and a seawall directly west of the harbour mouth. Sand bar formations subsequently block the harbour entrance requiring sea and land dredging, and sediment is subsequently removed from the system, causing beach erosion to the east (James 2006). In 2006, a 50 m section of the path near the harbour was damaged and in March 2007, following a severe storm, a 400 m length of the coastal path was lost (BBC 2007, Fig. 17.11). Prior to its construction, the

Fig. 17.10 Millennium coastal park



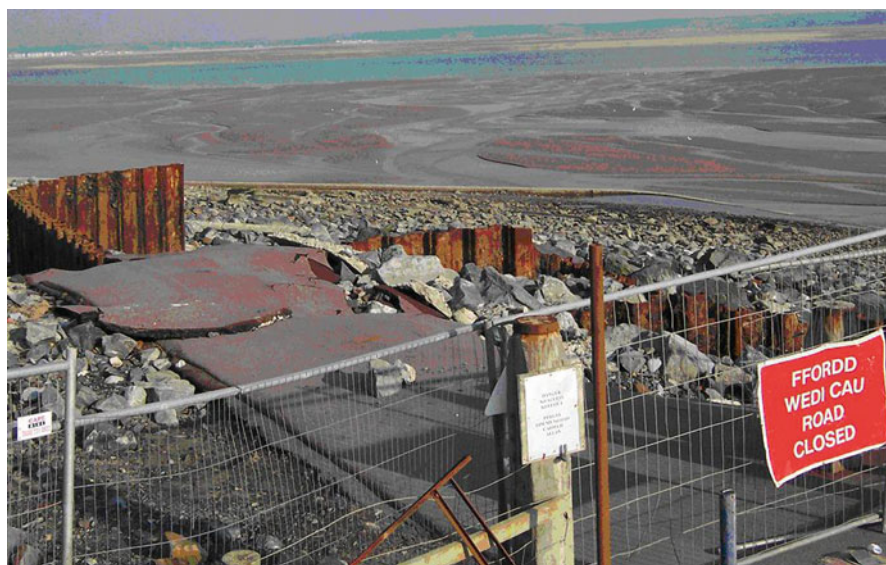


Fig. 17.11 Coastal footpath failure

beach was several metres seaward of this path, illustrating the consequences of stabilising this shoreline. The path has subsequently been repaired and protected by rock armour.

The Earth Sculpture is subject to westward river currents at low tide and eastward sea currents on incoming tides. Its construction seaward of the shoreline is compounded by its PFA composition. Consequently, it is vulnerable to wave attack and since construction, the structure has eroded together with the newly constructed beach on its eastern side, while PFA shows as black streaks on along the coastline. On completion there had been gentle gradients from the hinterland onto the beach but these are now steep. In the March 2007 storm, parts of the Earth Sculpture retreated by >10 m leaving in places >2 m vertical falls to the beach. (CCCESCTFG 2007a, b). Concrete fence posts erected to prevent people falling over an ever increasing cliff edge, now lie at intervals along the beach, some 2 m from the sculpture base. Rock revetments have been constructed to protect the coastline but without these, more of the coastal path would be lost (Fig. 17.11). Retaining walls defending the important rail link have been repaired several times and are also protected by rock armour (Fig. 17.12). Residential and commercial buildings have been constructed within 8 m of the Llanelli seawall (Fig. 17.13) and are often damaged in severe storms (SWEP 2007). These have sometimes required evacuation of residents (Llanelli Star 2005). Severe high tides and storms in March 2006 and March 2007 led to considerable seawall and promenade damage (Fig. 17.13, CCCESCTFG 2007a). The seawall has been further protected by rock armour at its base and as it joins the dune system to the east, sand levels rapidly increase. These dunes are in effect the only sustainable part of Llanelli's coastline.



Fig. 17.12 Rock armour protection of rail link



Fig. 17.13 Redevelopment adjacent to Llanelli beach

17.3 Discussion

Historically, industrial development has affected to some degree the equilibrium of South Wales's coastline, and the Institute of Oceanographic Sciences concluded that human intervention, including port developments and seawall construction, had been the main beach erosion mechanism (Bullen 1993). Similar consequences have been documented elsewhere, including Marina di Massa, Tuscany, where following port developments, beach erosion led to every kilometre of coastline being protected by 1.4 km of hard structures (Cipriani et al. 1999). Later assessments at Marina di Pisa showed 2.2 km of hard structures protecting every kilometre of coastline (Cipriani et al. 2004). Therefore, coastal erosion has been locally aggravated by some of the very strategies implemented to reverse the pattern (Gillie 1997; Weerakkody 1997). Erosion is currently affecting many EU member states with coastlines retreating on average between 0.5 and 2 m year⁻¹ and by 15 m year⁻¹ in a few extreme cases (Europa 2007a). Of the 875 km of European coastlines that started to erode within the past 20 years, 63% are located less than 30 km from coastal areas altered by recent engineering works (Europa 2007b). The Welsh Government's (WG) coastal erosion policy is to economically and sustainably reduce risks to people and the environment. However, commercial and residential development in coastal zones has led to increased infrastructure along the edge of beaches (Jędrzejczak 2004). This in turn has created a need for coastal defences to protect facilities, exemplified by these Welsh case studies. Therefore, regeneration and economic policies are conflicting with sustainable shoreline management.

During the initial industrialisation of South Wales, there was little knowledge and even less incentive to understand shoreline response to infrastructure development. However, beach consequences of seawalls and groynes were clearly recognised with publication of the 1911 Royal Commission on Coast Erosion and Afforestation (HMSO 1911). Throughout the decision-making process at Llantwit Major, there was no evidence of coastal processes being given due consideration when rebuilding the Surf Life Saver Club and revetment at a cost of approximately £750,000. In reality, hard engineering was not the correct option but the then local authority allowed its policies to be driven by replacing what was lost, without due consideration of why it was lost. Not for the first time, ignoring natural processes had economic implications for local communities. Fortunately, albeit after the event, managed retreat will be the future strategy at this location. The example of Porthcawl shows that once a shoreline is stabilised, more and more investment is required to build bigger and more substantial seawalls. Coastal processes continue irrespective of intervention and while not an aesthetic solution, Porthcawl's bitumen revetment has remained structurally sound for >25 years and consequently, can be considered a success. Industrial developments at Port Talbot have historically caused local beach and dune system loss. The tidal harbour, necessary for maintaining economic steel production, has affected both up- and down-drift adjacent coastlines. It is a substantial structure that is here to stay, and according to

SBCEG (1999) it receives >12 million tonnes per annum of iron ore and other raw material for steel production. Coastal defence measures necessitated by this structure include rock armour revetments to protect concrete and blast furnace slag seawalls at Aberavon and Margam respectively. Tata Steel needs a coastal location and it is argued that despite beach consequences, stabilising this shoreline on socio-economic grounds can be justified.

Initial development at Llanelli was undertaken in ignorance of potential coastline impacts, and following industrial decline, the need for socio-economic regeneration resulted in the MCP vision. The County Council's planning system and Unitary Development Plan (UDP) supported this development, and despite previous seawall failures and beach losses, it appears little consideration was given to prevailing coastal processes. Although the Environment Agency (EA) was consulted about flooding issues during the MCP planning stage, neither it, nor respective local authorities were further involved (CCCESCTFG 2007a). It is important for all coastal professionals to understand causes and consequences of coastal erosion and flooding. This includes sea level rise, global warming, natural and anthropogenic land changes, reduction of river sediment supply and increased coastal development (Doornkamp 1998; Coudert 2005). Beach adjustments usually involve erosive and sedimentary processes and these are mainly a response to natural and anthropogenic change (Anfuso et al. 2000). The whole MCP shoreline is experiencing post-development problems and these have caused additional pressures on sea defences. Resolving these will be difficult, not least because of cost. An MCP funding clause specified that the coastal path must be maintained and remain in place for 75 years and if lost, construction costs would have to be repaid (CCCESCTFG 2007a). Between 1994 and 2004 inclusive, £50,000 was spent on coastal protection and maintenance (BBC 2004a; CCCESC 2004), while in 2006/2007, Llanelli and Burry Port received a joint budget of £75,000 for sea defence repairs. Although this was a £17,000 increase on the previous year, it was not enough and repairs within the first month used the entire budget (CCCESCTFG 2007a). An additional combined budget of £47,550 was given to fill and repair coastal defences and the Earth Sculpture toe, but the local authority wanted this doubled for storm protection and emergency contingency funding (CCCESC 2006). In 2007 following severe storms, the WG and Carmarthenshire County Council gave £83,000 and £400,000 respectively to repair Llanelli's seawall (CCCESCTFG 2007a). Considering estimations of approximately £15–£20 M were needed to improve and repair coastal defences between Llanelli and Burry Port (Wales on Sunday 2004), the funding deficiency is clear. This is a major issue, as the coastal path could be lost if this is not addressed (CCCESC 2006).

Infrastructure at Burry Port is defended with rock armour and coastal structures. Harbour defences result in sediment loss from the system and continuation of current practices will cause further adjacent beach depletion. Therefore dredged material should be used to recharge beaches to the east. The low-lying coastal path is too close to the sea and original design problems are accentuated during storms. Its location should have been higher and further from the coastline and if it is not moved, further failure, as shown in Fig. 17.11, is inevitable. The Earth Sculpture

needs both structural and aesthetic restoration with current erosion rates exposing PFA layers. Fundamental theory regarding headland and bay formation should have alerted developers to the folly of extending seaward from the shoreline. Being built from PFA in a high-energy wave environment compounded this error. Direct and refracted wave attacks combined with strong estuary currents are eroding the sculpture from both the west and east, and management responses include gabion cages and rock armour. Currently Llanelli beach has many hard engineering structures that are incapable of total storm protection, while defences in place before the MCP development now protect additional infrastructure (Fig. 17.13). It would no longer be practical to remove Llanelli's seawall due to the height difference between promenade and foreshore. The majority of the seawall is >3 m above the beach and near the railway line, reaches a maximum height of 3.92 m. By protecting the seawall base with rock armour, which is not uncommon in the UK (Simm 1996), wave impacts are reduced. However, for effective protection greater volumes are needed. The lack of financial backing has left Llanelli's coastal defences inadequate and the local authority has to choose the least expensive instead of the most effective long-term option.

It is traditional for Anglo-Welsh coastlines to be managed through hard-engineering holding-the-line practices (Turner et al. 2007). Seawalls are constructed to protect coastal assets and these are subsequently vulnerable to wave attack and prevailing coastal processes. Therefore, seawalls themselves require protection and rock armour toe protection is a common response. Stamski (2005) suggested developing a long-term regional-scale erosion response and armouring plan to predict erosion hotspots. This would reduce the need for emergency works and increase defence capability. However, shoreline stabilisation has been cited as a costly measure that often aggravates recession (e.g. Gillie 1997), but Basco (1999) believed there are many misconceptions about seawalls. They are positioned to defend coastal infrastructure and therefore, development policies and not shoreline stabilisation are the root cause of erosion problems.

17.4 Conclusions

Shoreline stabilisation in South Wales began with the development of its metal and coal industries, especially during the nineteenth century. Development legacies have proven environmentally and financially costly at many locations; and even when early in the twentieth century seawall and groyne impacts were recognised, economic imperatives meant coastal defence strategies still followed previous practices. Following industrial decline, socio-economic regeneration has been underpinned by coastal location. However, lessons from the past have not been learned and damages to new developments have resulted from inappropriate siting of infrastructure and advancing the line without due consideration of coastal processes. Existing seawalls have been undermined and are now themselves protected by rock armour. This is becoming critical as there is a lack of funding

to undertake effective remedial measures. New strategies which consider prevailing coastal processes are needed for long-term management, including a rethink of policy. Otherwise, paving the shoreline may be the only sustainable future for the Welsh coastline.

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