J Coast Conserv (2015) 19:821–829
DOI 10.1007/s11852-014-0338-8

Coastal cliff conservation and management: the Dorset and East Devon Coast World Heritage Site

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Received: 30 May 2014 / Revised: 22 August 2014 / Accepted: 22 August 2014 / Published online: 4 September 2014

Abstract The 155 km long Dorset and East Devon Coast World Heritage Site is recognized for its 250 million years of earth history, including internationally renowned coastal geomorphological landforms and processes. It is a naturally active coast ranging from vertical 'hard' cliffs to very active landslides, protected by both national and international conservation designations. The primary conservation focus of the Site is geoconservation, but its cliff ecosystems also provide outstanding examples of natural resilience to rapid change as well as preserving very important communities. One of the key features of the Site is that its dynamics allow a constant renewal of the visible geology and exposures of fossils, Erosion is accepted as normal. It is a heavily used tourist location with cliff-top paths in use all year and there are concerns about safety, especially for visitors beneath cliffs and crossing mudslides. Management of the Site deals with such issues as fossil collecting and conservation, access, education, coast protection and through a management plan.

Keywords Coastal cliffs · Landslides · Coastal ecology · Geomorphology · Conservation · Tourism · Biodiversity · Dorset · East Devon · World Heritage Site · Geological Conservation Review

Introduction

The Dorset and East Devon Coast World Heritage Site, known generally as "The Jurassic Coast", is recognized for its 250 million years of earth history which includes internationally renowned coastal geomorphological landforms and processes (Dorset County Council et al. 2000). The World Heritage Site (referred to as 'the Site' throughout this paper) extends 155 km from Orcombe Point in East Devon formed in Triassic red mudstones to the junction of the Cretaceous Chalk with Tertiary strata in the southwest corner of Studland Bay (Fig. 1). Because the strata typically dip eastwards, it is possible to walk through 185 million years of earth history exposed in the cliffs. The cliffs also display the processes which have eroded, faulted and folded these strata during the past 65 million years since the end of the Cretaceous. The cliffs of this naturally active coast range from vertical 'hard' cliffs to very active landslides. They expose both the ecosystems of these modern cliffs and the past ecology of deserts, lagoons and the deep ocean in their fossils.

This paper considers the cliffs and their significance for geo- and biodiversity, the importance of World Heritage Inscription and the various approaches to site monitoring and management.

The cliffs range in height from a few metres at Ringstead to over 190 m at Golden Cap (the highest cliff on the south coast of England). The Site is protected by both national and international conservation designations. The primary conservation focus of the Site is geoconservation, but its cliff ecosystems also provide outstanding examples of natural resilience to rapid change as well as preserving very important communities. Cliff retreat ranges from less than 0.3 m/year on hard limestone cliffs to over 50 m in individual landslides. Vertical limestone cliffs in Purbeck popular for rock-climbing are relatively plant-free, with important local communities of puffins, *Fratercula artica*, and guillemots, *Uria aalge*. In contrast, well-vegetated relict landslides further west have important local plant populations as well as rare plants and insects. Back-tilted landslide blocks are typified by scrub and low wind-shaped trees, whereas the bare ground of more

Species names generally follow Stace (1991)

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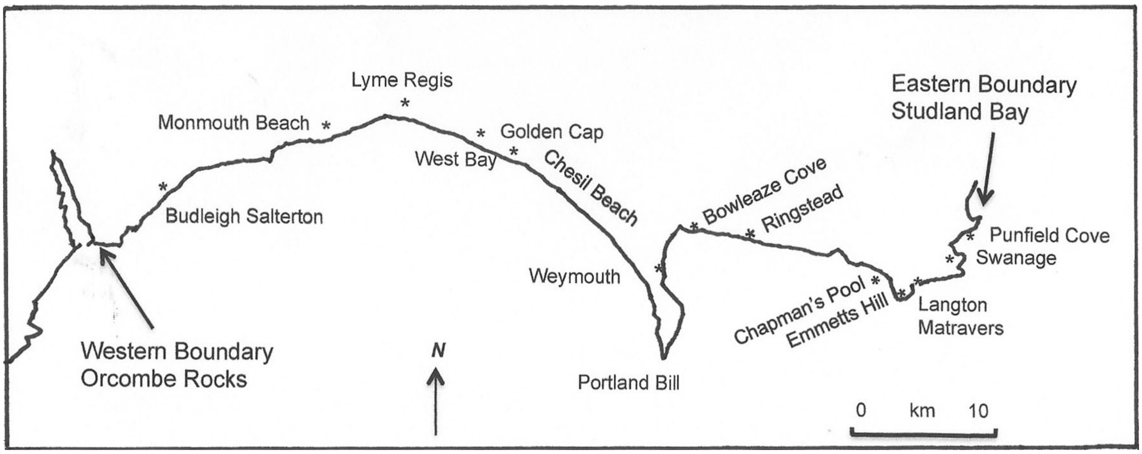

Fig. 1 Location map of places referred to in the text

active slopes reveal the process of plant succession. One of the key features of the Site is that its dynamics allow a constant renewal of the visible geology and exposures of fossils, although there are some issues about fossil collection. Erosion is accepted as normal. Coast protection works at the small towns and settlements obscure the geology and reduce erosion, as well as affecting the long shore sediment transport and so the presence or absence of beaches. It is a heavily used tourist location with cliff-top paths in use all year and there are concerns about safety, especially for visitors beneath cliffs and crossing mudslides.

Coastal cliff dynamics

The development of the application to UNESCO for inclusion of the Jurassic Coast in the World Heritage List took place against a background of variable understanding of the coastal cliff ecology. At the same time, a national review of geological and geomorphological sites, the Geological Conservation Review (GCR), provided evidence of the national and international significance of the Dorset and East Devon coast.

Cliffed coasts are the most common coastal form (about 80 % of all oceanic coasts: Emery and Kuhn 1982) and have many different forms depending upon the rocks in which they are formed, the marine and sub-aerial processes which act upon them and the response of the rocks to these processes. These can vary from very slow erosion and weathering of limestone coasts as a result of chemical weathering and solution processes to catastrophic landslides and rock falls which are typically catastrophic (Brunsden and Lee 2004) and present here (Cooper 2007; May 2003a, b,c).

Coastal cliffs vary in stability, substrate, hydrology, microclimate and vegetation (Malloch 1997; May 1977). Coastal landslides are amongst the most dynamic landscapes, and yet, as relict features, also include some of the most stable areas of coastal landscapes. They produce complex landforms and microclimates upon which there are also complex vegetation mosaics. The cliffs are often, but not always, protected from heavy human pressures and in some locations provide refuges for otherwise rare species. Because coastal cliff-top land is often well-used by agriculture and tourism development, and landslides are inherently difficult to farm and to build upon, coastal landslides often contain higher numbers of species than adjacent land. The more stable areas may be the sites for very localized symbiotic relationships between plants, birds, insects and small animals. Because of the wide range of frequencies of disturbance and the resulting patch dynamics, and because they often include near-vertical cliffs, coastal landslides are potentially very important areas for coastal conservation (May 2005).

Although coastal cliffs are recognized in Britain as having special conservation value for geomorphology, geology and biology and a small number of studies have recognized their ecological characteristics (e.g. DEFRA 2002; Hill et al. 2001; Lee and Clark 2002; Rodwell 2000), there is little appreciation of the wider importance of coastal landslides for the conservation of biodiversity through the connections between these different features and processes. Nevertheless, where land loss due to erosion is not critical for coast protection, there has been less investigation of both natural processes and vegetation. This is well exemplified by the detailed investigation of the cliff vegetation on the Undercliff landslide on the Isle of Wight where there is significant (and current) risk of damage to property and access (Cox 2010) compared to the more limited investigation of the Dorset landslides between Weymouth and Swanage. The vegetation of coastal cliff landslides has also had very little attention not least because of their natural steepness, with texts such as Walker and Shiels (2013) and a national survey of cliff erosion of the USA (Hampton and Griggs 2004) making only passing reference to cliffs.

In contrast, Larson et al. (2000) expand upon the earlier descriptions of coastal cliff ecology (Malloch 1997; May 1977, 1997a, b; Goldsmith 1977, 1997; Lovric 1997).

However, in defining cliffs as vertical or near-vertical features to the extent of treating talus slopes as 'adjacent landscapes', they exclude significant components of cliffed coasts where major slope failures mean that either large areas of cliff-top subside to replicate the cliff-top lower down the cliff, but often within a different microclimate or change angle to the extent that the original cliff-top becomes a cliff. Typically these large failure blocks form isolated cliffed features. Cliffs where hard strata form the upper and/or lower cliffs with weaker materials between or below them may also produce different landforms which are nevertheless integral parts of the landform from cliff-top to the water's edge. This can have important implications for the feeding habits of birds and animals which nest within the vertical cliffs. Larson et al. (2000) also report cliff recession rates which are significantly less than those which are recorded within the Jurassic Coast and elsewhere along the coasts of southern England and northern France.

The dynamic nature of many coasts resulting from landslides of all types has important implications for their management. The translocation of areas of cliff-top land into areas isolated from cliff-top pressures of grazing, trampling and development are very variable and often complex. However, the landslide processes give rise to land surfaces which vary in age, are frequently laid bare and provide different microclimates from those of the original surface. Comparatively stable landslides have been important sites for agriculture and small settlements, but generally they are areas which have been under much less anthropogenic pressure than other landscapes. Although there is a substantial literature concerning the geomorphology of landslides, the literature about landslide vegetation is sparse. Most concentrates on the changes which occur in forest landscapes, especially in the tropics (e.g. Walker and Shiels 2013).

Seen from the completely different, but equally important, position of tourism and recreation, cliffs are important as key elements of the tourism product, but accessible areas are at risk from the ecological impacts of outdoor recreation and ecotourism (Liddle 1997). Their natural beauty, their distinctive and photogenic features such as stacks and caves, and the dramatic contrast between land and sea all provide often essential elements of the marketing, unique selling points and recreational value of holidays. Their monetary value is high, but they also carry risks for the tourism trade if their naturally hazardous character threatens their attractiveness. Coastal management has to consider this as well as the risks to tourist assets from erosion, landslides and flooding (May 2004a, b, 2008).

World heritage and cliffed coasts

The World Heritage Site is recognized by The Convention concerning the Protection of the World Cultural and Natural Heritage, adopted by UNESCO in 1972, which requires "under the title of the World Heritage List, a list of properties forming part of the cultural and natural heritage which it considers as having outstanding universal value…", the key words being outstanding universal value (OUV). The Site was inscribed on the World Heritage List in 2001 having met Criterion (viii) that the Site should be "an outstanding example, representing major stages of Earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features."

It is perhaps surprising that, although coastal cliffs meet this requirement as well as those concerned with natural beauty and that there are many World Heritage Sites which are coastal in location, very few are designated for active coastal cliff processes. Boylan (2008) is critical of the very small representation of geological and geomorphological interests on the World Heritage List. Migon (2009) expresses a similar concern that very few sites with significant geomorphological features are included on the List. He uses three examples to demonstrate their importance, Petra (Jordan), the Iguaçu Falls (joint Argentina and Brazil) and the Dorset and East Devon Coast, which he singles out as the first site which explicitly makes geomorphological diversity central to the nomination.

A search of the World Heritage List for Sites which include coastal cliffs as part of the OUV reveals only 13, of which St. Kilda (UK) specifically recognizes the linkages between the marine and terrestrial ecosystems on some of the highest cliffs and stacks in Europe as scenically "singularly unique" (UNESCO World Heritage Centre 2013a, b, c). Of the others, it is their natural beauty or importance for specific species that is described. For example in the Gros Morne National Park in Newfoundland, Canada, its cliffs where prostrate spruce and balsam fir occur warrant specific mention. In the Islands and Protected Areas of the Gulf of California Site in Mexico, it is high cliffs and natural beauty that form part of the OUV. Similarly in the Tentative List of proposed but as yet undesignated Sites very few Sites are included for their hard-rock cliffs and their vegetation, amongst the few examples being the Coastal Cliffs and Qwara/Dwerja Sites in Malta and the Baltic Klint in Estonia (Rauka 2005). Engels et al. (2009) have also examined the significance of Serial Sites, defined as 'properties with two or more distinct, geographically separated areas that together are included on the World Heritage List. They list 36, of which the United Kingdom has two, The Gough and Inaccessible Islands and the Dorset and East Devon Coast, the latter being the smallest in area.

Conservation designations and cliff ecology within the Site

UNESCO requires that Sites are protected by national legislation and this Site is notable for being designated under 16 levels of national and international designation (Table 1). Not

Table 1 Types of conservation designation within or adjacent to the "Jurassic Coast" WHS (Sources: various)

Level of designation	Features of importance for designation	Exemplar categories	Exemplar sites
Global	Having features of ecological, biological, geological, cultural, archaeological significance at international level	World Heritage Site	Dorset and East Devon Coast
	Wetlands of international significance	Ramsar Site	The Fleet
Regional	Habitats of regional significance	European Special Areas of Conservation (SACs)	Chesil and the Fleet Sidmouth to West Bay
	Sites of importance for migrating birds	European Special Protection Areas (SPAs)	Chesil and the Fleet
National	Key habitats or species	National Nature Reserves	Axmouth to Lyme Regis Under cliff
		Marine Wildlife Reserve	Kimmeridge
		Marine Research Area	Durlston
	Protection of sensitive marine areas	Sensitive Marine Area	Lyme Bay
	Conservation of natural beauty of landscape and countryside	Area of Outstanding Natural Beauty	Dorset AONB
	Effective management of nationally important coastal landscapes	Heritage Coast	Purbeck HC
	Protection of site of scientific importance (geological or biological)	Site of Special Scientific Importance (SSSI)	West Dorset Coast Purbeck Ridge (East)
	Site with specific geological or geomorphological importance	Geological Conservation Review (GCR) site	Dungy Head - Mupe
	Protection of archaeological, anthropological or historic site	Area of Archaeological Importance (AAI)	Hengistbury Head
	Protection of wrecks	Designated under The Protection of Wrecks Act 1973 Protection of Military Remains Act 1986	Studland Bay Wreck HMS Formidable
Local	Protection of locally important habitats or species	Local Nature Reserve (LNR)	Axe Estuary Wetlands
		Voluntary Marine Nature Reserve	Kimmeridge
	Site with specific geological importance	Regionally Important Geological Site (RIGS)	Charmouth submerged forest

all are specifically concerned with geoconservation, but reflect the high value of the habitats and ecosystems which depend upon the underlying geology and landforms.

European legislation includes the Special Area of Conservation (SAC) 1992 European Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora as amended by the A,ct of Accession to the European Union of Austria, Finland and Sweden and by Council Directive 97/62/EEC (the Habitats Directive) and Special Protection Area (SPA) European Council Directive 1979 on the conservation of wild birds 79/409/EEC (the Birds Directive). The range of designations is shown in Table 1, but not all are statutory, and especially at local level depend upon voluntary agreements for their effect. In some cases, voluntary organisations such as the Royal Society for the Protection of Birds (RSPB) or the National Trust own land and so are able to provide protection to species or landscapes through their own management practices.

The Site's great diversity of structure, form and process is matched by an equally diverse range of plant species, which exploit changing environmental niches across space and time. Over 80 % of the Jurassic Coast is cliffed, with many former quarries providing additional steep faces especially in the Isles of Purbeck and Portland. The cliffs vary from steep much creviced hard limestone cliffs to very wet mobile clay landslides. The variety of plants, birds, insects, and animals is very wide. The cliffs and quarries are home to 11 of Britain's 14 species of bat. Much of the cliffed coast is designated as Site of Special Scientific Interest (SSSI) or Special Area of Conservation (SAC) and Special Protection Area (SPA) under the European Habitats and Birds Directives respectively. Much of the cliff vegetation is grassland, but where former landslides have been stable for long periods of time, there are small woods. In contrast, the frequent movement of some of the landslides means that new bare surfaces are constantly appearing, to be colonised by plants which need more open spaces. Without this renewal of the bare surfaces, the more dominant grasses would crowd out many of these species.

There has been little detailed investigation of the cliff vegetation, but an unpublished 1980 survey by Gray and Durrell analysed by May (1997a, b), identified many of the cliff plants. They identified 283 species on the Dorset cliffs:

over a quarter (27 %) only occurred once or twice. They concluded that many of the species found on the cliffs were common grassland species as well as species with wide environmental tolerances, and common ‘weed’ species. Many of the species were typical of damp and/or clay soils. A very small number of species, wild carrot, *Daucus carota*, bristly oxtongue, *Picris echioides,* and buck’s-horn plantain, *Plantago coronopus*, were found only in coastal locations. Within the cliff habitats, individual species showed a definite preference for specific sites. At Ringstead, for example common reed, *Phragmites australis*, grey willow, *Salix cinerea* and colt’s-foot, *Tussilago farfara,* occurred only on mudflows, whereas daffodil, *Narcissus pseudo-narcissus*, English stonecrop, *Sedum anglicum,* and Nottingham catchfly, *Silene nutans* were found only on the steep chalk cliffs.

In a survey of thirteen coastal landslides in Dorset, Saville (2001) identified 198 vascular plant species, the most common species being *T. farfara.* The next most common species were two grasses usually associated with damp soils, Yorkshire fog, *Holcus lanatus,* and tall fescue, *Festuca arundinacea.* This study also showed that because of the variety of cliff geology and landforms, there was not a consistent maritime cliff vegetation. At Emmetts Hill (Fig. 2), for example, where there are high steep rocky cliffs, the vegetation was characterised by thrift, *Armeria maritima*, sea aster, *Aster tripolium*, sea beet, *Beta vulgaris ssp. maritima*, wild cabbage, *Brassica oleracea* and rock samphire, *Crithmum maritimum*. In contrast, on more mobile parts of the cliffs around Chapman’s Pool viper’s-bugloss, *Echium vulgare* and sea mayweed, *Tripleurospermum maritimum,* were more common and *T. farfara* was often prominent.

Cliff-tops, as well as abandoned quarries, are often marked by red valerian, *Centranthus ruber*, especially along the edge of the cliff between paths and the edge itself. Some cliff-top species are very localized: e.g. stinking goosefoot, *Chenopodium vulvaria,* is found on eroded sandstone around rabbit burrows on cliff edges near West Bay.

Other species which depend for their survival upon the presence of other species, especially pollinators which may also be rare, also occur on the cliffs. For example bee orchid, *Ophrys apifera,* (at Bowleaze Cove) is pollinated by pseudocopulation where the flower mimics a female bee and attracts male bees. The flower then attaches sacs of pollen to the bee which carries them away hopefully to another bee orchid.

The cliffs are also very important for a wide variety of birds which feed either from the sea or from the land. The crevices and ledges of the cliffs provide breeding and roosting sites for gulls, guillemots, pigeons and many other birds. They provide nutrients for plants which grow on the ledges. The food-web of the cliff communities crosses the boundary between land and sea, especially for birds such as peregrine falcon, *Falco peregrinus,* which nest on ledges and crevices in cliffs. Although it does not feed directly from the sea, it depends upon the survival of land and sea birds for its food. If one becomes scarcer, it can increase its intake of the other.

Some birds occur along the Dorset coast in small very localized populations. For example a few pairs of puffins, *Fratercula artica,* nest on grassy cliffs near Langton Matravers in burrows, which they excavate. Headlands such as Portland Bill often act as the first landfall for migrating birds, with bird-ringing observatories which provide long

Fig. 2 Emmetts Hill (foreground) and Hounstout (background). (Source: Author 29th November 2010) Hounstout: mainly in Kimmeridgian clays and shales. Active erosion with vegetation mainly on old failure blocks. Upper cliffs in Portland sand and limestone. Emmetts Hill: Upper vertical cliffs with toppling failures provide boulders to mid-cliff resting on relic failure block. Stable shrub community. Lower cliff partially exposed Kimmeridgian clays and shales with scrub below on relic failure block. Boulder arc reduces erosion of landslide toe, hence general stability. Designations include AONB, SAC, SSSI.

records of the regular migrants as well as the occasional visitors, such as hoopoe, *Upupa epops,* and Eurasian golden oriole, *Oriolus*.

Change in the hard-rock, mostly limestone, cliffs is slow, intermittent and poorly recorded. The steep cliffs of the Isle of Purbeck in particular provide excellent examples of the processes, which occur in four groups. Group (i) cliffs are near-vertical falling directly into the sea so waves break up their face. Retreat is very slow with only occasional rock falls. Plants rarely colonize them except where water flows from springs or valleys or where there are narrow ledges. Group (ii) cliffs are also vertical with typically a narrow basal platform and/or large boulder accumulations. Large blocks and pinnacles descend with little deformation of the upper cliff and surface. Upper surface vegetation characteristics remain, with different species colonising rifts between blocks. Group (iii) cliffs form the upper parts of large, often relict, landslides, typified by pinnacles, topples and intervening rifts. Vegetation colonizes all but the very steepest surfaces and some very rare or localized species may occur. Rockfall debris lies across the under cliff and along the landslide toe (Fig. 3). Group (iv) cliffs occur either as the back-scars of large rotational landslides or as the faces of large failure blocks which moved downslope during land sliding. Original cliff-top species may persist, but may be replaced by other species depending on local microclimate. Plant and animal communities differ between Groups. Group (iii) and (iv) vegetation is important enough to be recognized by several conservation designations. Although geomorphological features are nationally significant, the related plant species usually provide the conservation protection.

Fig. 3 Purbeck coast (Source: Author 30th December 2001) Vertical limestone cliffs with incipient toppling in left foreground. Middle slope partially exposed Kimmeridgian shales with back-tilted failure block with scrub, maritime grasses and wind –modified woodland. Marine erosion retarded by boulder arcs. Middle ground: vertical cliffs in shales and clays with offshore ledges (part of marine reserve). Kimmeridge Bay beyond has high importance for Kimmeridgian fossils. Public access limited to cliff-top path

Management of the Site

Unlike many World Heritage Sites, this Site has no defined buffer zone. The wider setting of the site is largely protected by the Dorset and East Devon Areas of Outstanding Natural Beauty (AONB) designations, existing conservation designations and national and local planning policies. These provide the appropriate measures for dealing with landscape planning issues, except where applications could directly affect the OUV.

UNESCO has identified three critical management requirements for the Site: (a) the potential damage to the OUV as a result of construction of coastal defences, (b) management of ongoing fossil collection research, acquisition and conservation and (c) inappropriate management of visitors to an area that has a long history of tourism. UNESCO also recognizes the areas of European importance designated for their habitats and species as additional priorities for protection and management.

Site condition is assessed using Natural England's site information system (ENSIS). It asks a series of basic questions that apply to the full range of geological sites, not just cliffs (Table 2). For example the Target condition for World Heritage Site Attribute Exposure of Features of Interest (FoI) is that "Features of Interest are exposed or can practically be re-exposed if required". In some cases, for example where the Target is that vegetation is not obscuring or damaging FoI, there is a potential conflict with other designations which protect the habitat. Because the natural processes produce periods when cliffs may be vegetated or not, this is accepted as consistent with the long-term view of OUV. Nevertheless, the criticism is sometimes made that this inhibits access and that such sites should be cleared, despite this being in breach of statutory regulations.

Shoreline Management Plans (SMP) provide the coast protection management strategy for the next 100 years, which for the Site is generally 'No Active Intervention' (NAI). This means that there will be no action to prevent continuing retreat of the cliffs which should ensure that the notified features of the coast remain in "favourable condition". Pre-existing coast protection works can obscure the strata and limit the exposure of fossils by reducing cliff retreat and allowing the slope to stabilize and become vegetated. Similarly, natural accretion of beaches and periods of stability within landslides can mean that some cliff-faces become obscured for long periods of time, but in so doing maintain the nature and quality of the habitats and the landslide ecosystem. As a result of this natural diversity (both spatially and temporarily) parts of the Site vary between 'favourable' or 'unfavourable' reporting categories for the geological and ecological features and there is no policy to change one in favour of the other. The natural behaviour of the cliffs is paramount, even though this may mean parts of the cliff not being categorized in 'favourable condition'.

Table 2 World Heritage Site Attributes and Targets

World Heritage Site attribute	Target
Exposure of Features of Interest (FoI)	Features of Interest are exposed or can practically be re-exposed if required
Vegetation	Vegetation is not obscuring or damaging FoI
Tipping or landfill	There is no unconsented tipping or landfill obscuring or damaging FoI
Tree planting	There is no unconsented tree planting obscuring or damaging FoI
Engineering works	There are no engineering works, including inappropriate restoration works, obscuring or damaging the FoI
Planning condition	Planning conditions and restoration agreements or plans are being observed on site
Geological specimen collecting	There is no irresponsible or inappropriate specimen collecting

Fossils have been collected and used for scientific study for over 200 years, but UK law is clear that in-situ fossils belong to the landowner. Fossils, which have fallen from the cliffs or have been eroded from shore platforms, and so are ex-situ, are regarded as abandoned by the landowner unless they have stated that they wish to keep ownership of all fossils on their land (Fig. 4). Natural England (2012) has a national Code for Responsible Collecting. The West Dorset Fossil Code specifies standards for collecting and the subsequent conservation of the fossils (Dorset and East Devon Coast World Heritage Site 2012). Under the Code, collectors may not dig in-situ without permission. Landowners may use legal injunctions to prevent digging without permission. Collectors are required to record fossils identified as having key scientific importance at the Charmouth Heritage Coast Centre. Such fossils must be offered to accredited museums in the UK before a collector may sell them. In addition to regular monitoring of Site condition, there is sometimes more localized intensive monitoring where, for example unusual changes in the density and quality of specific fossils, such as a decline in the quality and number of large ex-situ ammonites on Monmouth Beach, are identified (Edmonds et al. 2005).

The condition of the GCR sites is monitored using a unique monitoring database developed by the Joint Nature Conservation Committee (JNCC) which takes account of the natural complexity of the Site where GCR sites sometimes overlap each other or extend across more than one SSSI. An example of unfavourable status of a GCR Site due to features being obscured by vegetation growth is Punfield Cove GCR Site 636 listed for its exposures of the Albian – Aptian (Lower Greensand) at the north end of Swanage Bay where natural beach accretion has reduced cliff erosion (Table 3). Another example which demonstrates periodic conflicts of interest is GCR Site 1297 in Ringstead Bay where the Kimmeridgian interest is obscured due to coast protection works that pre-date Inscription of the Site. Although the interest is partly obscured by a recharged beach held in place by terminal groyne, high magnitude low frequency storm events do re-expose all or parts of the GCR interest as occurred in the February 14th 2014 storm.

On the cliffed coastline, the landward boundary of the Site is the break in slope at the top of the most landward cliff-scarp (East Devon Coast World Heritage Site Management Plan 2009a; 2009b). Unlike SSSI boundaries which are statutory

Fig. 4 Monmouth Beach, Lyme Regis (Source: Author 4th February 2008) Key location for significant fossils – Jurassic Blue Lias and Shales-with-Beef. SSSI and GCR Site. Rapid erosion with undercutting and slides from above. Limited vegetation mainly maritime grasses and wind-shaped trees. Easy public access, so issues of safety, inappropriate collecting and implementation of Fossil Code

Table 3 Geological Conservation Review (GCR) examples of unfavourable status

GCR number and interest	Description	Reason for unfavourable status
GCR 636 Albian – Aptian (Lower Greensand)	Punfield Cove, north end of Swanage Bay.	Interest obscured by vegetation due to a decline in erosion rates.
GCR 1297 Kimmeridgian	Ringstead Bay	Interest obscured due to coastal defences that pre-date designation. The interest is partly obscured by a recharged beach held in place by terminal groyne.

mapped lines, the Site boundary is the natural feature and it is accepted that as a result it is mobile. Depending upon the features used to define the boundary of the SSSI, the retreat of the cliffs can mean that the Site moves outside the legal protection provided by SSSI designation. Although this isn't always the case, there are a number of locations where the retreat of the cliff has removed the SSSI features from their statutory protection. The Management Plan states that these will be identified and considered for re-notification. This is in process at present.

Informal monitoring is provided by a Science and Conservation Advisory Network, visiting scientists and the public, the latter being occasionally directly responsible for observing newly exposed fossils. A strategic monitoring programme, established to support the coastal authorities, provides repeat air photography and LiDAR, as well as wave conditions, accessible at http://www.channelcoast.org.

All monitoring and its implications are reported in an annual State of Conservation (SoC) report (e.g. Dorset and East Devon Coast World Heritage Site 2008, 2010). This provides evidence against which the attainment of the aims of the Management Plan can be judged. It forms the basis for meeting the requirements of both the UK Government and UNESCO for the maintenance of the Site's OUV.

The issue of inappropriate impacts from tourism is dealt with through a strong emphasis within the Management Plan upon policies which emphasise appropriate access and public awareness of the significance and values of the Site. There have been few studies specifically examining tourist behaviour, fossil collecting and its management in sensitive areas (Kim and Weiler 2013). They report that visitors to these areas typically have positive environmental attitudes and support responsible fossil collection management. However, they identify two significantly different markets in terms of gender, age and their use of on-site interpretation. The authors suggest that targeting these different segments with different on-site communication strategies could provide more efficient and effective visitor and site management. The Management Plan has encouraged significant and innovative approaches to visitor education and involvement. It is thought to be the only World Heritage Site that has a dedicated Arts policy. This has used the arts as a means of developing interest in the mechanisms of erosion and landslides, finding different ways to translate the science to both schools and the wider public.

Summary

The diversity and significance of the cliffs is very high, both biologically and geologically, as result of the combination of strata, erosion processes and conservation practices. Conservation of the geology and geomorphology of the Site is its priority, but conservation via legal protection provides the main tool for management and conservation of the coastal species, habitats and ecosystems which most visitors see as part of the coastal landscape. Nature conservation depends primarily on ensuring that designated features remain in 'favourable condition'. Site monitoring provides the evidence upon which the State of Conservation of the Site is assessed.

This World Heritage Site contains internationally recognized geodiversity which supports a remarkable range of biodiversity exploiting, through space and time, the changeable environmental niches. The key to safeguarding these interrelated interests now, and in the future, is by continuing to focus site management to support natural processes across the Site. Such a targeted and interdisciplinary approach is essential given the range of local, national and international designations along this coastline which UNESCO recognizes as having "strong legal protection, a clear management framework and the strong involvement of all stakeholders with responsibilities for the property and its setting."

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