

An incremental scenic assessment of the Glamorgan Heritage Coast, UK

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In Wales some 500 km (42%) of coastline has been designated as heritage coasts (HCs) and these areas are under increasing pressure from human activities. A 'Coastal Scenic Evaluation System', utilising a checklist of 26 physical and human use parameters, was applied at 500 m intervals along the 23 km Glamorgan Heritage Coast (GHC) to assess aesthetic changes within the HC boundaries. The technique utilised fuzzy logic analyses to quantify inherent uncertainties and subjectivities. Results at the 47 sites were differentiated into five classes by a decision evaluation parameter (D) – Class 1: ($D \geq 0.85$), none found; Class 2: ($D \geq 0.65$ and < 0.85), $n = 3$; Class 3: ($D \geq 0.4$ and < 0.65), $n = 26$; Class 4: ($D \geq 0$ and < 0.4), $n = 13$; and Class 5 ($D < 0$), $n = 5$. An overall GHC D value was determined as 0.41 (Class 3) and therefore classified as mainly natural with little outstanding landscape features. As HC boundary status lies between the 'good' and 'very good', the median value of Steer's classic work, it suggests that all HC areas should have a D value > 0.53 . Results demonstrated distinct variations in scenic quality and analysis showed that site D values varied from 0.84 (Class 2) to -0.2 (Class 5) along the coastline. D values were lowest at the eastern boundary and the location of a power station and litter on the beach were significant contributors to the low scenic value. The first 17 sites within 8.5 km of the eastern boundary represented 100% of the Class 5 sites and 77% of Class 4 sites. The mean GHC D value for the remaining 30 sites was 0.57, which complies with HC classification according to this technique. Therefore, results cast doubt on the validity of current designated boundaries.

KEY WORDS: classification, fuzzy logic, parameters, boundaries, designations, planning

Introduction

The Heritage Coast (HC) system was initiated in 1972–73 to protect coastlines of England and Wales having special scenic or environmental value from undesirable development and provide managed recreation (Britain Express 2009). The aims were simple:

- To conserve scenic quality and foster leisure activities that rely on *natural scenery* and *not* on man-made activities, and provide for the sustainable usage of the coast from public enjoyment and recreation.
- To conserve, protect and enhance the coastal environment and foster awareness and understanding of conservation.
- To maintain and improve community involvement.
- To identify the finest stretches of undeveloped coast.

The prime purpose is recreation, which is expected to be consistent with conservation of the landscape and other coastal qualities. However, where natural beauty and recreation are in irreconcilable conflict, then the former should prevail, but only where efforts to resolve the conflict by good planning and management have failed; that is, the Sandford principle. Since this is not a statutory designation, there is no withdrawal of permitted development rights but local planning authorities must take due cognisance before taking decisive action on matters affecting these coastlines. There are 44 HCs in England and Wales, approximately 34% of the coastline. The majority of these coasts (37 out of 44) are in areas of outstanding natural beauty or national parks, and are therefore accorded the protection of those designations (EUCS 2003). The seven in Wales cover 14 distinct coastal stretches and represent approximately 500 km (42%) of the Welsh coast (Williams and Ergin 2004), all being managed by the Countryside Council for Wales

(CCW). HC selection was based on scenic evaluations undertaken by Professor J. A. Steers (1944 1946). The methodology was subjective, but as Steers (1944) acknowledged, any assessment of coastal quality is likely to meet with criticism. He rated coastal scenery using three categories: 'exceptional', 'very good' and 'good', omitting developed coastlines, believing them to be of poor scenic quality, arguing that 'there is only one such belt (coastline) and it is extremely easy to spoil it' (p. 7). Coastlines rated in the top two categories ('exceptional' and 'very good') became HCs. A review concluded that HC objectives should be widened to recognise the need to preserve and enhance important habitats for flora and fauna; to protect architectural, historical and archaeological features; and to promote higher standards of environmental protection within these areas (Bishop *et al.* 1995). Interestingly, Duck *et al.* (2009) scenically assessed diverse UK regions – eastern Scotland, southwest Wales and southwest England – and argued intuitively that a statistically significant positive correlation between beach scenic quality and diversity of habitats present might be expected. However, the results of their study demonstrated unequivocally that this was not the case.

Establishing a scenic evaluation technique that is credible and accurate has often proved difficult because the precise source of aesthetic quality is lacking: is it inherent in the physical landscape, or is it a psychological product (Appleton 1975)? The former is an objective paradigm, the latter subjective and these opposing premises underpin two approaches to landscape evaluation: the 'expert' and 'perception-based' approaches respectively. The 'expert' approach relies on a standard of assumptions made by an expert surveyor regarding attractive and unattractive scenery, and each landscape is evaluated according to this standard; for example, Leopold (1969). The validity of this approach has been questioned because it assumes that scenic preferences are homogeneous between individuals. However, scenery appreciation is dependent on a complex interaction of factors, and the precise influence of each can often not be extracted from that of the others. These include psychological constructs and socio-demographic variables which combine in different ways to trigger a unique emotional response when an individual views a landscape (Morgan and Williams 1995). Perception varies from person to person and while there is nothing wrong with a subjective view of scenery, from a management viewpoint, objectivity should be a must.

The Welsh tourist industry largely depends on beaches to attract coastal tourists and excellent scenery is an important factor considered by tourists when choosing a beach holiday (Morgan and Williams 1995). The number of people seeking scenic landscapes for recreation has increased dramatically, and correspondingly, the desire to protect and con-

serve attractive landscapes has risen (Wascher 2001). He further highlighted that 12.7% of the UK land area was assigned for landscape conservation, as opposed to 5.3% for nature conservation. Similarly, Leatherman (2001, 181) commented that, 'increasing populations and development are placing significant stresses on coastal resources'. Indeed Wascher (2001) argued that many natural landscapes have become cultural landscapes and consequences of these changes have led to environmental degradation. May (2004) reported that geological and geomorphological features significantly increased visitor numbers at some coastal locations, and therefore, degradation could ultimately affect tourism income. Degradation affects aesthetics which can reduce tourism business (Houston 2002) but development is necessary to provide infrastructure in support of the industry. Unfortunately this development often reduces beach scenic value (Ergin *et al.* 2006) and results in reduced amenity (Benoit and Comeau 2005).

This paper scenically evaluates the 23 km length of the Glamorgan Heritage Coast (GHC) (Figure 1) at 500 m intervals, in order to incrementally examine aesthetic changes and compare results with Steers (1944). This was done using the methodology of Ergin *et al.* (2004), which has previously shown that HC beaches have significantly higher scenic values than non-HC beaches (Williams *et al.* 2007). It provided a unique opportunity to assess the appropriateness of one scenic designation within HC boundaries and to evaluate spatial differences. This is subsequently used to question and inform management strategies that have brought about changes from Steers's (1944) original assessment.

The Glamorgan Heritage Coast

The Lias Group of the GHC – from Aberthaw in the east to Merthyr Mawr in the west (Figure 1) – was the first coastline in Wales to be awarded HC status, in 1972, and one of three schemes piloted in England and Wales to test the low-key HC concept; that is, people are left to discover the area without, for example, large signage displays. This coastline comprises dramatic cliffs, interrupted intermittently by bays, and has a spring tidal range of c. 10 m (SBCEG 1999) with a strong eastward longshore sediment transport (Williams *et al.* 2002). The habitat variety – woodland, dunes, agriculture, rocky shore and estuarine – provides a rich biodiversity. The scoured platforms and beach deposits add an extra dimension to shore life, resulting in an ecosystem ranging from fully marine to brackish and fresh water (Gillham 1994). The flora ranges from natural plant cover to farm and agricultural land and bird life reflects this diversity of use, ranging from cliff inhabiting peregrines and fulmars, to shoreline waders and birds of valley woods and arable fields (Gillham 1994). Additional species vary from invertebrates to land and

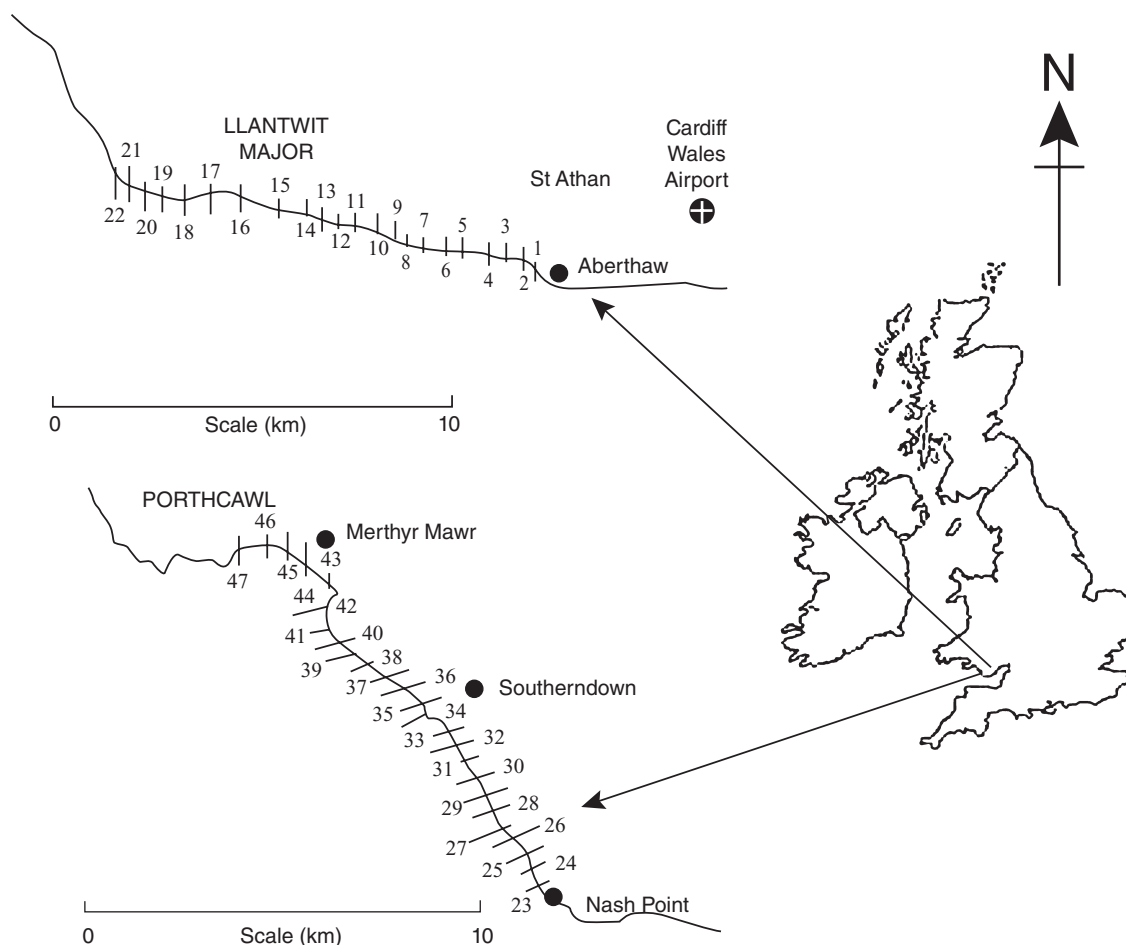


Figure 1 Beach survey locations along the GHC

marine mammals and include rare freshwater red algae, orchids and occasional sightings of seals and harbour porpoises.

The GHC includes the extensive dune system of Merthyr Mawr Warren (sites 47–43, Figure 1). Both statutory and non-statutory designations are in place comprising candidate special areas of conservation (cSACs), sites of special scientific interest (SSSIs) and national nature reserves (NNRs), and important wildlife interests include bird watching (SBCEG 1999). Between the River Ogmore and Dunraven Bay (sites 43–37, Figure 1) the rock cliff shoreline includes Carboniferous limestone and breccia with Lias facies, with shoreline movement and historic maps showing a slowly eroding natural coast. Land use is mainly recreational, with walking being the most popular (SBCEG 1999).

The Southerndown coast (sites 37–34, Figures 1 and 2) is a SSSI while Dunraven Bay is a cSAC, although this habitat is under threat from coastal erosion.



Figure 2 Section of the GHC looking east from Southerndown (site 34)

Southerndown also holds a blue flag award (ENCAMS 2007) and the main forms of land use include recreation, environmental and significant historic cultural interest around the former Dunraven House and walled garden. The area comprises the Porthkerry Formation of the Early Jurassic, including Lower Lias facies (SBCEG 1999).

The next section (sites 34–23, Figure 1) is privately owned and land use is primarily agricultural. It has designated SSSIs and the geology is mudstone, shales and limestone of Early Jurassic age. Continuing east (sites 23–15, Figure 1) along the Lias Formation there is a complex mix of ownership and interests, including agricultural, educational, residential and environmental. Monknash and Nash lighthouse meadows are both designated SSSIs with the latter under increasing threat from coastal erosion (SBCEG 1999). Llantwit Major (Figure 1) is a mixture of private and local authority ownership. The local authority runs the car park and the Surf Life Saving club and the Glamorgan Wildlife Trust Reserve is adjacent to the beach. The area is mainly a local visitor attraction (e.g. surfers, ramblers, etc.) with some tourist interest mainly from other parts of Wales (SBCEG 1999; Williams and Sothorn 1986).

Between sites 15 and 6 (Figure 1) land ownership is private agricultural, with the local authority having an interest in the coastal path. The geology is of mudstone and shale of Early Jurassic age and is classed as having high landscape value within the HC. In the final section (sites 6–1, Figure 1) land ownership is private, mostly belonging to National Power. However, much of the Aberthaw SSSI (East Aberthaw) is leased to and managed by the Glamorgan Wildlife Trust while the HC ends at the western boundary of the Aberthaw power station, which is protected by a seawall and groyne field. Consequently, land use generally revolves around power generation, with some environmental and landscape interest along the undeveloped section. The geology of the area is generally alluvium, and there is sand with outcrops of the Mercia Mudstone Group of the Triassic on the foreshore (SBCEG 1999).

Methodology

The methodology originally developed by Ergin *et al.* (2004) and Williams *et al.* (2004) comprised a checklist survey utilising fuzzy logic. The checklist contained the 26 parameters (Table 1) used in both the Ergin *et al.* (2004) original surveys in Malta, Turkey and the UK, and the Williams *et al.* (2004) survey in South Wales. These 26 parameters were derived from over 3000 questionnaire surveys and subsequent expert weighting (Ergin *et al.* 2004; Williams *et al.* 2004) and represent the fundamental features used to assess coastal scenery. This 'Coastal Scenic Evaluation System' was applied at 500 m intervals between October and December 2006, along the GHC

(Figure 1). The 500 m intervals were identified from ordnance survey (OS) maps and located on site using GPS, OS grid coordinates of the western and eastern boundaries being SS835763 and ST020663 respectively. This provided the opportunity to identify and analyse how scenic quality varied along the 23 km GHC. In essence, field work consisted of checking a box (1–5 attribute scale – presence/absence or poor quality [1], to good [5]) for all listed parameters at 500 m intervals (Table 1). Therefore, parameter values are expressed numerically and as Balkey (1968) concluded, a qualitative Delphi approach is a forward thinking procedure which can use specialist opinion and data collection for good practice and evaluation. Most checklist and rating schemes used for coastal assessment are open to criticism with regard to subjectivity and weighting, particularly in aesthetics where the viewer's preferences and priorities tend to dominate (Leatherman 1997). Furthermore, qualified/quantified grading and/or order forms obtained from qualitative, subjective observations and/or pronouncements made in linguistic terms, as in the case of many coastal scenic assessment and landscape evaluations, do not replace or overcome data vagueness.

Therefore, to quantify uncertainties and subjectivities inherent in parameter assessment, fuzzy logic assessment was used (Zadeh 1965; Ambala 2001). This technique produces robust decisive factors based on probabilities for each parameter and are introduced into the assessment procedure as weighted averages. The factor assessment set is given by:

$$F = \{\text{PHYSICAL, HUMAN}\} = \{\mathbf{P}, \mathbf{H}\}$$

where subsets are formed from the 26 assessment parameters as follows:

$\mathbf{P} = \{\text{cliff height/slope/special features, beach type/width/colour, rocky shore slope/extent/roughness, tides, dunes, valley, landforms, landscape features, vistas, water colour, natural vegetation cover, vegetation debris}\}$

$\mathbf{H} = \{\text{disturbance factor, litter, sewage, non-built environment, built environment, access type, skyline, utilities}\}$

For this specific study, the sets $\mathbf{P}$ and $\mathbf{H}$ consist of 18 and eight assessment parameters, respectively. The subgroups of the set $\mathbf{P}$ were further subdivided into the following influences:

$$\mathbf{P} = \{\mathbf{P}_1, \mathbf{P}_2, \mathbf{P}_3, \mathbf{P}_{\text{other}}\}$$

where

$\mathbf{P}_1 = \{\text{cliff height, slope, indentation}\}$

$\mathbf{P}_2 = \{\text{beach type, width, colour}\}$

$\mathbf{P}_3 = \{\text{rocky shore slope, extent, roughness}\}$

$\mathbf{P}_{\text{other}} = \{\text{dunes, valley, landform, tides, landscape features, vistas}\}$

Table 1 Coastal Scenic Evaluation System (Rev 4): scenic parameters

No.	Rating				
	1	2	3	4	5
<i>Physical parameters</i>					
1	Cliff	Absent	>5 to <30 m	30 to <60 m	>90 m
2	Slope	Absent	Around 45°	Around 60°	c. vertical
3	Special features ^a	Absent	1	2	Many >3
4	Beach face	Absent	Mud	Cobble/boulder	Sand
5	Type	Absent	<5 to >100 m	5 to <25 m	50–100 m
6	Width	Absent	Dark	Dark tan	White/gold
7	Colour	Absent	<5°	5–10°	20–45°
8	Slope	Absent	<5 m	5 to <10 m	>20 m
9	Extent	Absent	Distinctly jagged	Deeply pitted and/or irregular (uneven)	Smooth
10	Roughness	Absent			
11	Dunes	Absent	Remnants	Fore-dune	Several
12	Valley	Absent	Dry valley	(<1 m) stream	River/limestone gorge
13	Skyline landform	Not visible	Flat	Undulating	Mountainous
14	Tides	Macro (>4 m)		Meso (2–4 m)	Micro (<2 m)
15	Coastal landscape features ^b	None	1	2	>3
16	Vistas	Open on one side	Open on two sides	Green/grey blue	Open on four sides
17	Water colour and clarity	Muddy brown/grey	Milky blue/green; opaque	Wetlands/meadow	Very clear turquoise
18	Natural vegetation cover	Bare (<10% vegetation only)	Scrub/garigue (marram/gorse, bramble etc.)	Single accumulation	Variety of mature trees/mature natural cover
19	Vegetation debris	Continuous >50 cm high	Full strand line		None
<i>Human parameters</i>					
20	Noise disturbance	Intolerable	Tolerable	Single accumulation	None
21	Litter	Continuous accumulations	Full strand line	Some evidence (1–3 items)	Virtually absent
22	Sewage discharge evidence	Sewage evidence		Hedgerow/terracing/monoculture	No evidence of sewage
23	Non-built environment	None		Light tourism and/or urban and/or sensitive industry	Field mixed cultivation and/or trees/natural
24	Built environment ^c	Heavy industry	Heavy tourism and/or urban	Sensitive tourism and/or urban	Historic and/or none
25	Access type	No buffer zone/heavy traffic	No buffer zone/light traffic	Parking lot visible from coastal area	Parking lot not visible from coastal area
26	Skyline	Very unattractive	Unattractive	Sensitively designed high/low	Natural/historic features
27	Utilities ^d	>3	3	2	1

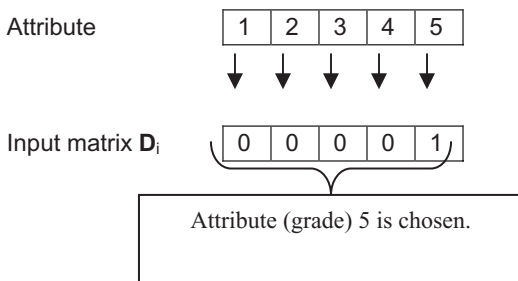
^aCliff special features: indentation, banding, folding, scree, irregular profile^bCoastal landscape features: peninsulas, rock ridges, irregular headlands, arches, windows, caves, waterfalls, deltas, lagoons, islands, stacks, estuaries, reefs, fauna, embayment, tombola etc^cBuilt environment: caravans will come under tourism: grading 2: large intensive caravan site; grading 3: Light, but still intensive caravan sites; grading 4: sensitively designed caravan sites^dUtilities: power lines, pipelines, street lamps, groins, seawalls, revetments

The rating for the assessment parameters may take any attribute between 1 and 5, establishing a possible square matrix $\mathbf{M}_g$.

Attributes:

$$\mathbf{M}_g = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

As an example, if the attribute rated as 5, the input matrix obtained from $\mathbf{M}_g$ is:



Input matrices of assessment parameters were obtained from parameter ratings.

To quantify uncertainties and subjective pronouncements inherited in the assessment parameters, the 'fuzzy logic membership grading matrix' $\mathbf{M}_i$ was introduced to replace matrix $\mathbf{M}_g$. This matrix overcomes the disadvantage of an error being introduced when an assessment grade is chosen from several other possible grades.

$$\mathbf{M}_i = \begin{bmatrix} 1 & ? & ? & ? & ? \\ ? & 1 & ? & ? & ? \\ ? & ? & 1 & ? & ? \\ ? & ? & ? & 1 & ? \\ ? & ? & ? & ? & 1 \end{bmatrix}$$

where '?' stands for uncertainty and subjectivity.

The uncertainty is estimated as the probability that a mistake may be made in assigning grades. For example, if an attribute grade, for example, water colour (parameter 16, Table 1) is selected as a '5' then the input matrix is:

$$\mathbf{D}_{16} = (0 \ 0 \ 0 \ 0 \ 1)$$

and the membership grade for this is given in the last row of $\mathbf{M}_{16}$. The estimated error is given as 0.1 in the fourth column while other probability grade errors are given in the preceding rows of the matrix. All 26 parameters were subjected to the same process.

$$\mathbf{M}_{16} = \begin{bmatrix} & 1 & 2 & 3 & 4 & 5 \\ 1 & 0.3 & 0 & 0 & 0 \\ 0.3 & 1 & 0.2 & 0 & 0 \\ 0 & 0.2 & 1 & 0.2 & 0 \\ 0 & 0 & 0.2 & 1 & 0.1 \\ 0 & 0 & 0 & 0.1 & 1 \end{bmatrix}$$

Algorithms developed for assessing membership degrees of all attributes, together with weighted averages versus attributes (Figure 3, Ergin *et al.* 2004 2006), enabled a decision evaluation parameter D to be determined for all sites (Table 2):

$$D = \frac{(-2 \times A_{12}) + (-1 \times A_{23}) + (1 \times A_{34}) + (2 \times A_{45})}{A_T}$$

where the area under the curve between attributes 1 and 2 is termed A_{12} , the area under the curve between attributes 2 and 3 is termed A_{23} , the area under the curve between attributes 3 and 4 is termed A_{34} , the area under the curve between attributes 4 and 5 is termed A_{45} and the total area under the curve is termed A_T .

D values obtained for all investigated sites are shown in Table 2, and these statistically best represent attribute values in terms of weighted areas. Ergin *et al.* (2004) gives a detailed mathematical explanation of the full process.

Weighted attribute averages of physical and human parameters enable a relative site comparison. High weighted averages of attributes such as 4 or 5 reflect a high scenic quality, and conversely, high weighted average attribute values such as 1 or 2 indicate low scenic value. The membership degree versus attribute curve produces an overall scenic assessment result and interpretation of these curves is based on the skew; a curve skewed to the right-hand side (Figure 3) reflects a high scenic assessment value, and conversely, a left skewed curve reflects low quality assessment. The results provide a means to justify protection/improvements through effective management of any coastal area. Class divisions were subsequently determined from an analysis of over 250 assessed coastal sites in Malta, Turkey and the UK, with corresponding D value ranges as follows:

- Class 1: extremely attractive natural sites with a very high landscape values ($D \geq 0.85$).
- Class 2: attractive natural sites with high landscape value ($D \geq 0.65$ and < 0.85).
- Class 3: mainly natural sites with little outstanding landscape features ($D \geq 0.4$ and < 0.65).
- Class 4: mainly unattractive urban sites, with a low landscape value ($D \geq 0$ and < 0.4).
- Class 5: very unattractive urban sites, with intensive development and low landscape value ($D < 0$).

Full details of D value range classification are given in BCR (2003), WWF (2003) and Ergin *et al.* (2004).

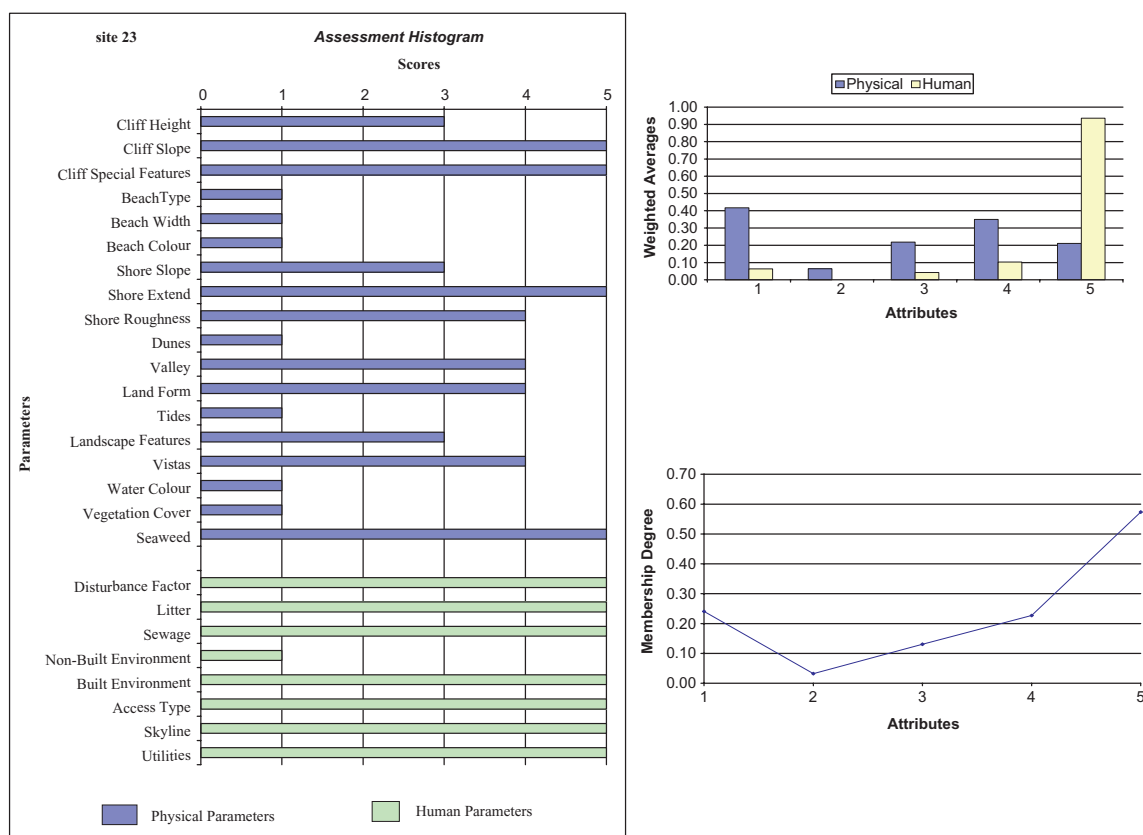


Figure 3 Assessment histogram, weighted average and membership degree (site 23)

These break points have subsequently been verified in assessments in many diverse world regions, for example Australia, New Zealand, Croatia, Japan and Spain (Ergin *et al.* 2006).

Results

Table 2 shows D values determined for each site, together with their classification from the highest, Nash Point (site 23), to the lowest, Summerhouse Bay (site 6). No GHC site achieved a Class 1 rating, probably due to locations scoring poorly on the highly weighted physical parameter of water colour. To determine an overall GHC D value and classification, D scores in Table 2 were averaged, giving a mean of 0.41 (Class 3), a median Class of 3 and a median D value of 0.5.

Class 2 locations are typically natural surroundings with limited evidence of human impacts (Ergin *et al.* 2004). Three sites (6% of the GHC) attain a Class 2 rating with D values ranging from 0.65 to 0.84 (Table 2). For example, Nash Point (site 23) scored 5 in all human parameters apart from the non-built environment and scored highly on

the physical parameters of cliffs and shoreline extent (Figure 3), achieving a D value of 0.84 (Table 2).

Class 3 sites were generally located either in urban villages or remote areas with few outstanding physical features. The main scenic problem at these sites is generally within the human parameters. Even though at many of these locations some litter could be seen, litter clearing practices were responsible for the generally clear beach face. Twenty-six sites achieve a Class 3 ranking, including the only beach with a blue flag award, Southerndown (site 36, Figure 4). This beach has a D value of 0.64 (Class 3), narrowly missing out on Class 2 status. It appears that low scores in the highly weighted human parameters of disturbance factor and non-built environment (Table 1) prevents this beach attaining a higher classification.

Typically the Class 4 sites are either undeveloped with few significant natural features or located near towns or villages and all have restricted beach faces. Thirteen sites are ranked Class 4 (Table 2). It is important to note that with the exception of three sites, for example Llantwit beach (site 15, Figure 5), all Class 4 beaches are located within 8.5 km of the GHC eastern

Table 2 Site evaluation

Site No.	D value	Class	Site No.	D value	Class
23	0.84	2	43	0.49	3
27	0.83	2	47	0.48	3
32	0.65	2	40	0.45	3
			19	0.43	3
35	0.64	3	34	0.4	3
22	0.64	3			
29	0.59	3	17	0.39	4
31	0.59	3	8	0.39	4
30	0.58	3	7	0.39	4
26	0.58	3	9	0.35	4
39	0.58	3	10	0.34	4
20	0.58	3	38	0.33	4
33	0.56	3	11	0.33	4
18	0.55	3	42	0.31	4
25	0.55	3	37	0.31	4
45	0.55	3	15	0.26	4
46	0.55	3	16	0.21	4
41	0.55	3	3	0.21	4
28	0.54	3	14	0.14	4
44	0.51	3			
21	0.51	3	6	-0.02	5
36	0.5	3	5	-0.05	5
24	0.5	3	4	-0.11	5
13	0.5	3	2	-0.13	5
12	0.5	3	1	-0.2	5

Key

Class 1 D value above 0.85, extremely attractive natural site with a very high landscape value

Class 2 D value between 0.65 and 0.85, extremely attractive natural site with high landscape value

Class 3 D value between 0.4 and 0.65, mainly natural with little outstanding landscape features

Class 4 D value between 0 and 0.4, mainly unattractive urban, with low landscape value

Class 5 D value below 0, very unattractive urban, intensive development with a low landscape value (Ergin *et al.* 2004)

boundary. Llantwit beach (Figure 5) again scores well on cliff parameters, but fails badly on the human element.

Five sites have the lowest rating of Class 5 (Table 2) and all are located within 2.5 km of the eastern HC limit. Although Class 5 sites are rated as unattractive, it should be noted that not all these sites are urban or industrial. Indeed at sites 5 and 6 (Figure 1) there is relatively little development and low classification is a consequence of high litter volumes and the absence of any outstanding physical features. Aberthaw (site 1, Figure 6), is dominated by a power station (Figure 7) and parameter scores are low in virtually all categories, apart from an absence of sewage and a sound rocky shore.

Discussion

Much of the GHC is undeveloped with limited access. Between Southerndown and Nash Point (Figure 1)

there is only one beach access point, via a steep ladder. Despite this remoteness, the overall GHC D value of 0.41 (Class 3) means it is mainly natural with little outstanding landscape features. If Steers's (1944) original assessment is still valid there must be reasons for this. HC boundary status, as defined by Steers (1944 1946), lies between the 'good' and 'very good' categories. Williams *et al.* (2007) aligned the methodology used in this research to Steers's (1944) classification, the median class being 3, with a midpoint of 0.53. Therefore all HC beaches should have a D value of >0.53 and Williams *et al.* (2007) further found that HC beach D values were significantly higher at the 99% confidence level, than non-HC beaches. Assessment of the GHC site location D values (Table 2) highlighted that 29 sites (62%) had a D value <0.53 and by this reasoning, are not worthy of HC status, while 18 sites (38%) complied with the classification. Most areas with low scenic values may be found near the eastern boundary of the GHC, between

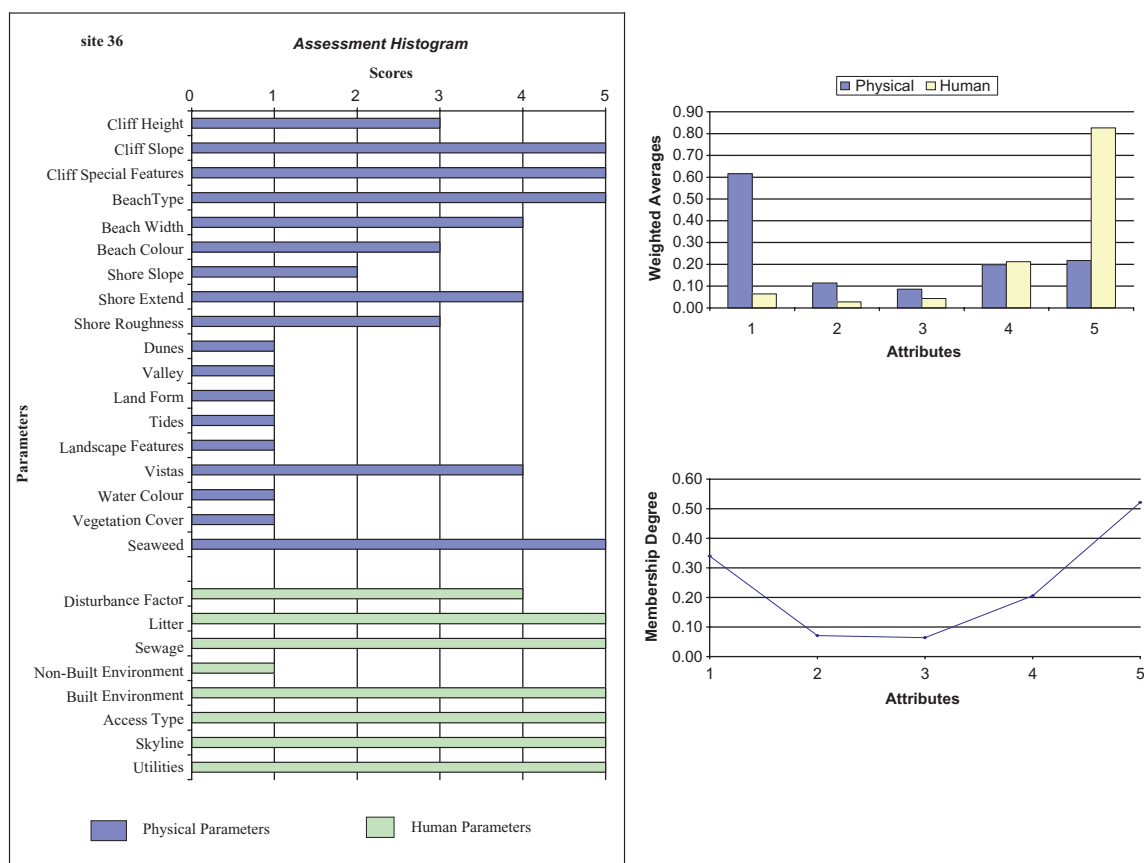


Figure 4 Assessment histogram, weighted average and membership degree (site 36)

Aberthaw/St Athan and Llantwit Major (Figure 1 and Table 2). This region has undergone significant development since Steers's (1944) original assessment, the most notable being construction of the Aberthaw power station (Figure 7). Although there are occasional sites with D values <0.53 along the rest of this coastline, it is unrealistic to expect all coastal sections will comply on an incremental basis. Furthermore, some areas such as Llantwit Major are considered 'honeypots' which attract tourists to the area and this in turn helps keep other parts of the coastline pristine.

Most areas of the GHC have undergone little change over the past 60 years due to strict planning and management policies. Essentially all development in the region since its inception in 1972 has taken place along the coastline outside the zone of protection. This is evident from the shoreline management plan (SBCEG 1999) which indicates land around Porthcawl is currently unavailable for development. From the results, there may be development potential at Llantwit Major due to its low scenic rating, which suggests that strict development restrictions at this location may not be necessary. Ogmore (sites 40–42,

Figure 1) is already seeing redevelopment of local public houses into flats. However this will not be universal as development in and around the GHC is further limited by other conservation measures, such as SSSIs, SACs and NNRs. Some parts of the coast are only accessible at low tide and this was also necessary to accurately ascertain beach width and sediment type, etc. The non-built environment of the GHC comprises primarily agricultural fields and one dune system. When physical parameter weighting is considered, dunes are valuable to the coastal landscape in terms of aesthetics, but in terms of non-built environment, a highly weighted human parameter, dunes do not score highly. Managing cliff erosion along the majority of this coastline means that there is visible evidence of cliff notch stabilisation (Figure 8) etc., measures that may be unnecessary elsewhere. Furthermore, some sites with low D values, for example Llantwit Major, obtained this because of the negative impacts of the revetment, a consequence of poor management decisions.

The high and low parameter weighting was found to be extremely important for the GHC. User perception

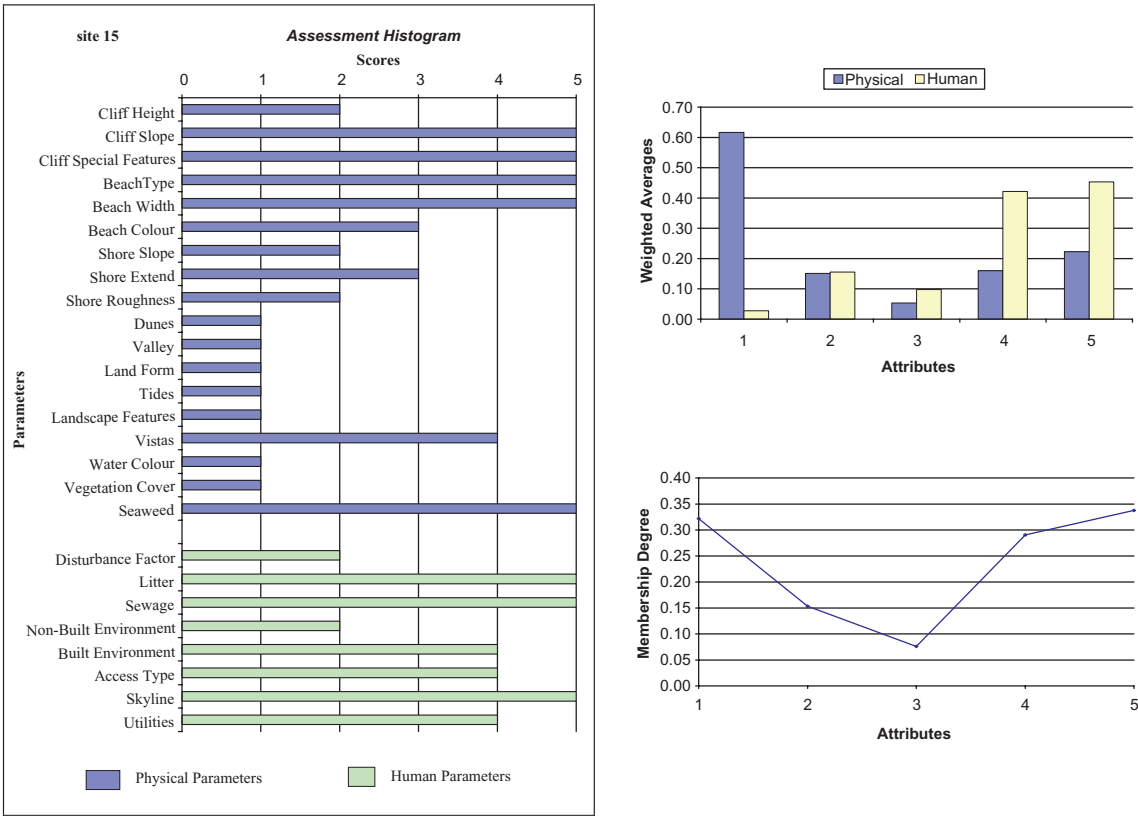


Figure 5 Assessment histogram, weighted average and membership degree (site 15)

studies showed that three of the most important beach aspects were micro tidal ranges, water colour and litter. The Bristol Channel/Severn Estuary macro tidal range (average c. 10 m along the GHC) resulted in low scoring for every site in terms of tides. Water colour is also a problem, not due to untreated effluent, but as a result of marine, sediment, geological and biological processes. There appeared to be no correlation between litter and development, with the highest litter levels present at sites with relatively little development, such as site 43 (Figure 1 and Table 2). Research by Simmons and Williams (1993) and Williams *et al.* (2003) showed that litter accumulations on undeveloped beaches in this area was due to riverine and marine sources, with GHC beaches acting as litter sinks. In the case of site 43 (Ogmore River mouth), which achieved a score of 1 for litter, improvement of this score to 5 would alter the *D* value from 0.49 (Table 2) to 0.73. However it is unlikely that complete litter removal would ever be possible due to the area acting as a litter sink. It is of more relevance for sites in lower classes, such as those to the east. Results showed that many of these sites scored 1 for litter, and consequently, site 3 (Gileston) had a *D* value of 0.21

(Table 2). Increasing the litter parameter score to 5 would dramatically increase this site *D* value to 0.49, elevating it to Class 3. The same pattern can be seen along the length of the study area. Application of this theory to a number of sites demonstrates that removal of litter has the potential to increase site value by at least one classification. This is especially relevant to beach managers due to its global significance and shows that although little can be done about physical parameters, improvement can be made to low scoring human parameters. Beach cleaning regimes, or the lack of them, made a difference, as did time of year, tide, or even time of day, especially if the beach had been cleaned earlier that morning. Therefore the commencement of a litter cleaning programme along the whole HC would raise overall scenic values.

The importance of a buffer zone was demonstrated, not just in terms of access type but because there was a clear correlation between a lack of buffer zone and noise disturbance. In areas where car parking was not visible there was no noise, other than that of the sea. For sites closer to car parks or roads, noise levels increased significantly and temporal aspects made further differences to parameter scoring. This was

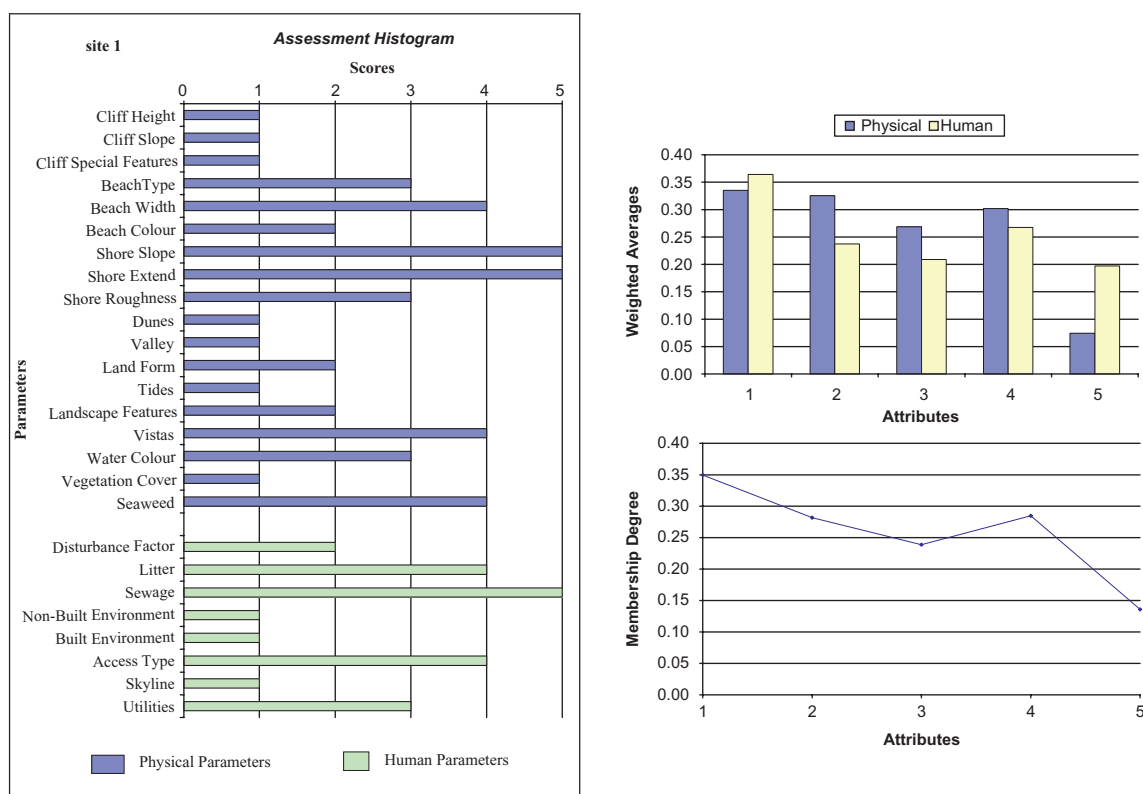


Figure 6 Assessment histogram, weighted average and membership degree (site 1)



Figure 7 Aberthaw Power Station (site 1)

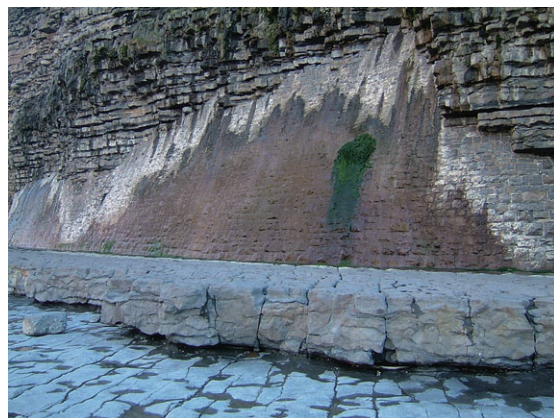


Figure 8 Cliff stabilisation near Nash Point (site 23)

especially evident at sites 1–6 (Figure 1), where proximity to RAF St Athan meant that jet engine testing was important. Noise disturbance was not constant and as the car park was not visible from the beach sites, on some days there was little noise. Therefore survey timing was relevant and consequently, multiple

visits were undertaken to accurately reflect site circumstances.

When Steers (1944) undertook his original second world war coastal surveys, he looked at the coastline in a holistic way and was impressed by the GHC cliff formations. The large tidal range, which reduced all

GHC site ratings, enabled him to see at low tide the extensive shore platforms (Figure 2). Secondly, the major negative impact on site classifications was litter accumulation on the foreshore. The ubiquitous global use of plastics from riverine, land-based and marine sources has led to many problems (Simmons and Williams 1993), and this highly weighted human parameter would not have been such an issue for Steers. Similarly, development after the second world war changed the character of many HC sites. For example, the Aberthaw Power Station, which opened in 1966 (Figure 7), cliff erosion management strategies (Figure 8) and the Llantwit Major breakwater all negatively impacted on respective site ratings. With respect to the latter three developments, the ethos of a HC designation is based on natural beauty. There is nothing natural about these examples. Similarly, GHC boundaries were not delineated by Steers and there is the possibility that he might not have agreed with the choice of eastern and western limits. For example, the first 17 sites (Figure 1) are within 8.5 km of the eastern boundary and represent 100% of the Class 5 sites and 77% of Class 4 sites (Table 2). The mean GHC *D* value for the remaining 30 sites (Table 2) is 0.57, an increase from 0.41 and consequently complies with HC classification (Williams *et al.* 2007). Therefore, this casts doubt on the validity of the GHC eastern boundary designation and warrants further review with the possibility of boundary reclassification.

Conclusions

A 'Coastal Scenic Evaluation System', utilising a checklist of 26 physical and human use parameters, was applied at 500 m intervals along the 23 km GHC to incrementally assess aesthetic changes within its boundaries. The technique utilised fuzzy logic analyses to quantify inherent uncertainties and subjectivities. Results at the 47 sites are differentiated into five classes by a decision evaluation parameter (*D*). Three sites achieve a Class 2 rating with *D* values ranging from 0.65 to 0.84 and are classified as attractive natural sites with high landscape values. Twenty-six sites achieve a Class 3 ranking (mainly natural sites with little outstanding landscape features), 13 sites are ranked Class 4 (mainly unattractive urban sites, with a low landscape value) and five sites have the lowest rating of Class 5 (very unattractive urban sites, with intensive development and/or low landscape value). Results demonstrate distinct variations in scenic quality and analysis shows that site *D* values vary from 0.84 (Class 2) to -0.2 (Class 5) along the coastline. *D* values are lowest at the eastern boundary and the location of a power station and litter on the beach are significant contributors to the low scenic value. An overall GHC *D* value is determined as 0.41 (Class 3) and therefore the coastline is classified as mainly natural with little outstanding landscape features. Tidal range and water colour are common low scoring

parameters, while breakwater construction and cliff stabilisation measures affect certain sites. Classifications were examined alongside Steers's (1944) original assessment and subsequent human impacts and boundary delineation are considered significant. Omitting the eastern 8.5 km from the overall assessment, results in the remaining coastline having a *D* value of 0.57 and therefore complying with HC scenic criteria.

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