Guidance on environmental impact assessment of offshore renewable energy development on surfing resources and recreation

by Surfers Against Sewage

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Part 1: Introduction

1.1 Who are SAS?

Surfers Against Sewage (SAS) is a UK-based non profit-making organisation campaigning for clean, safe recreational waters, free from sewage effluents, toxic chemicals, marine litter and nuclear waste. Using a solution based argument of viable and sustainable alternatives, SAS highlight the inherent flaws in current practises, attitudes and legislation, challenging industry, legislators and politicians to end their ‘pump and dump’ policies. Through its Climate Chaos campaign, SAS supports the UK’s investment in more offshore renewable energy where its development is acceptable to the environment.

1.2 Why are SAS producing this guidance?

The UK government is committed to delivering 15 per cent of all energy consumed by transport, heat and power generation from renewable sources by 2020. As of mid-2009, the UK generates less than 2 per cent of its energy from renewable sources and its total energy consumption is rising. Large-scale renewable energy development is required to achieve the 2020 target, and offshore renewable energy is expected to be a major contributor.

Surfing is a growing recreational activity in the UK and is an important socio-economic contributor to the local and regional communities where waves are consistently surfable. The surfing community is concerned that offshore renewable energy development threatens surfing resources and recreation. To date, studies on surfing resources and recreation suggest that the impacts of offshore windfarm developments and tidal stream demonstrator projects are negligible and the impacts of wave demonstrator projects are small but of concern to surfers until proven otherwise by monitoring. However, the future developments proposed to deliver the 2020 target are substantially larger than those studied to date, which suggests the impacts on surfing are going to be larger too.

The surfing community is also concerned that it and its views are being ignored or overlooked. For example, the recently completed Offshore Energy Strategic Environmental Assessment (SEA) process is supposed to consider the environmental implications of the Round 3 seabed leasing plan for offshore wind energy development. However, the resulting SEA Report (DECC, 2009) contains no reference to surfing resources or recreation, and its annex covering the environmental baseline for tourism and recreation at best contains a few anecdotal references to surfing in some areas (e.g. “Casual surfing, canoeing and wind-surfing take place from many of the Region’s beaches…”) and contains no references at all to surfing in other areas, including the areas covering south-west of England where surfing contributes £21M per annum to the local economy of Cornwall alone (Arup, 2001).

SAS believe that climate change poses a major threat to recreational water users, the marine environment and the global environment as a whole, and agrees that action needs to be taken to combat it. SAS also believe that offshore renewable energy has the potential to help tackle climate change, but is concerned that future development has the potential to cause negative impacts on surfing resources and recreation (SAS, 2007).

Impacts on surfing resources and recreation will happen if and when offshore renewable energy developments affect the coastal wave dynamics and coastal morphology. The presence and operation of energy generation infrastructure could cause waves to be weakened, cause them to approach the beach from a different direction, cause them to interfere with each other, or cause them to break differently at the beach, all of which could potentially damage surfing recreation.

SAS recognise that offshore renewable energy development is regulated through legally implemented consenting procedures, and that these procedures include Environmental Impact Assessment (EIA) of individual developments and thereby provide the most appropriate opportunities for ensuring that the surfing community is engaged and impacts of surfing resources and recreation are robustly assessed. For this reason, SAS will consider each development proposal on a case-by-case basis before deciding whether to support or object to consents.

Against this background, SAS decided to produce a guidance document to promote the surfing community's interests, to protect surfing resources and recreation, and to support the EIA process concerning offshore renewable energy development.

The guidance provided is divided into the following sections:

- part 2: surfing resources and recreation
- part 3: impacts on surfing resources and recreation
- part 4: guidance on environmental impact assessment.

This guidance builds upon existing generic guidance already applied to EIAs for offshore renewable energy development and so its application should make future EIAs better informed and more robust, but should not make them substantially more onerous. Since the time taken for a development to gain consent is in part related to the quality of the EIA process, then the adoption of this guidance should facilitate the interests of those who want to protect surfing recreation and resources and those who want to develop offshore renewable energy.

Part 2: Surfing resources and recreation

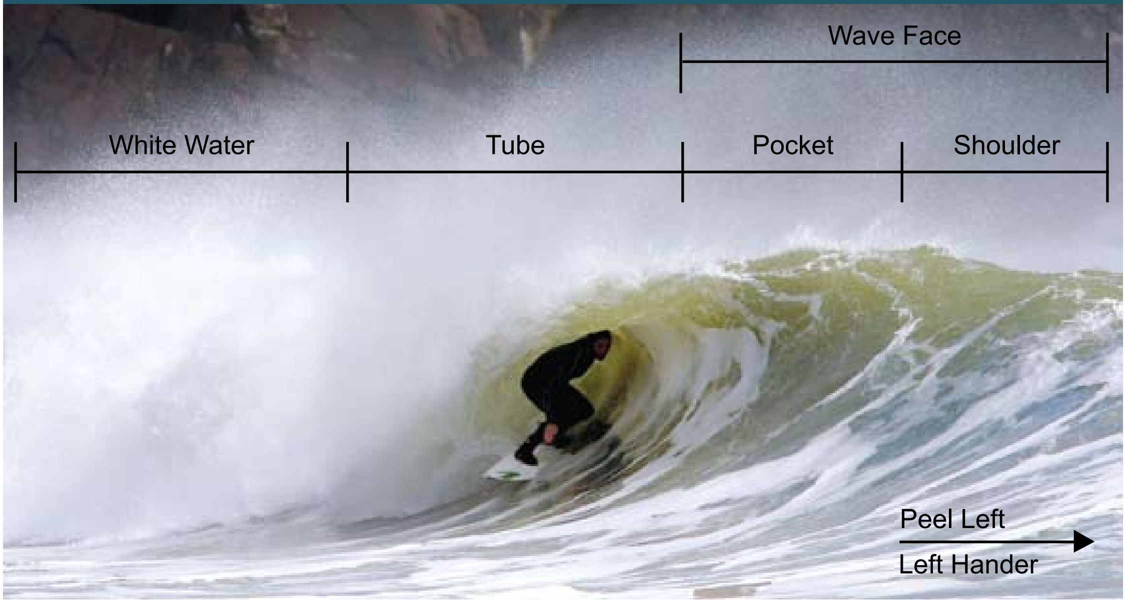
This part of the guidance provides background information to enable developers, EIA practitioners, regulators, statutory advisors, non-governmental organisations, local communities and members of the public with an overview of surfing resources (i.e. waves) and recreation (including its economic impact), and the factors that affect them.

Information is provided on:
surfing resources (i.e. the waves and breaks that create surfable waves; see Section 2.1)
surfing locations (i.e. the main surfing breaks around the UK coast; see Section 2.2)
surfing recreation (i.e. surfing activities; see Section 2.3)
surfing socio-economics (i.e. expenditure in local, regional and national economies; see Section 2.4).

2.1 Surfing resources

Waves break when they reach water depths that are roughly equal to their height. However, not all waves can be surfed. For a wave to be surfable, the right combination of wave climate and seabed bathymetry is needed to create a wave of suitable height that breaks progressively along its crest (i.e. a peeling wave). Surfers want to ride along the unbroken face of peeling waves (see Figure 1) which, if they are skilful enough, allow them to perform manoeuvres or catch tubes: "They surf just ahead of the advancing wave crest within the 'wave pocket' where most of the wave's power is located. Unless they are beginners, surfers are not satisfied with riding waves that do not peel" (Scarfe et al, 2003).

Figure 1 Common terminology applied to the characteristics of surfing waves (source: Pierro, 2008) Photo taken on Cornwall's south coast.



Surfing wave resources

The sources of wave formation influence the surfing wave resource. Swell waves are preferred by surfers. Swell consists of waves arriving at a location having propagated from a distant storm, as opposed to windsea which is locally generated. Swell waves are more regular and organized whereas windsea is more chaotic. (see Figure 2).

Figure 2 Swell waves in the Atlantic (left) and wind waves in Cornwall (right)

Surfing break resources

A number of bathymetric features form the seabed contours required to create surfable waves. There are various classifications (e.g. Walker, 1997; Mead and Black, 2001) with four breaker types consistently recognised: beach breaks (including sand bars), reef breaks, point (or headland) breaks, and river mouth / estuarine delta breaks. Beach breaks and reef breaks are the main breaks in the UK, while point breaks (e.g. Lynmouth in north Devon) and river mouth breaks (e.g. Hayle in west Cornwall) are less numerous.

Beach breaks comprise of soft, unconsolidated materials such as sands, gravels and cobbles that can be re-distributed by wave action on a regular basis. Reef breaks generally comprise of hard rock or large boulder fields that cannot be re-distributed by wave action. In other words, beach breaks can adapt to wave conditions while reef breaks cannot and, therefore, they present very different breaking characteristics for surfers since they are not stable or predictable.

There are many beaches around the UK's coastline but a relatively small number provide suitable surfing breaks and, those that do, differ considerably. Nevertheless, beach breaks outnumber other breaker types around the UK coast. Pierro (2008) describes how the surfability of a beach break relates to its dominant beach and sand bar morphologies (and their response to fluctuations in wave conditions and sediment supply throughout the year) because these morphologies influence two of the principle characteristics of surfing waves: peel angles and wave breaker type. A wave needs to propagate shoreward at an angle to the underlying seabed contour to create a peeling wave. Peel angles range from 0° to 90° and relate to wave direction and seabed contour, and can be measured as the angle between the unbroken wave's crest and the broken wave's white-water. If the peel angle is very small (<30°), the peel rate is large and causes unsurfable (close-out) conditions where long sections of the wave crest break at the same time.

Butt (2004a) differentiates beach characteristics by slope and relates this characteristic to wave breaker type. Gently sloping (dissipative) beach breaks are characterised by waves that break on sand bars a long way from the shore and then roll in, dissipating energy until they reach the shore. Well-known examples include the beach breaks at Saunton in north Devon and Godrevy in Cornwall. These breaks are more likely to create spilling waves (see Figure 3). Steeply sloping (reflective) beach breaks are characterised by waves that break very close to the shore, dissipating their energy over a short distance and on occasions reflecting some of that energy seawards. These breaks are more likely to create plunging waves (see Figure 3a) or, in extreme cases, surging waves. Well-known examples include Porthtowan in Cornwall and Croyde in north Devon. Unlike dissipative breaks, waves at reflective breaks do not break much further offshore with greater wave energy. Of course, most beach breaks have slopes that are neither exceptionally gentle nor exceptionally steep, and can provide both spilling and plunging waves depending on secondary factors such as the initial incoming wave steepness and the wind strength and direction.

Figure 3 Beach breaks: spilling waves in North Yorkshire

Figure 3a Beach breaks: plunging waves in Cornwall (below)

Like many beach breaks, many reef breaks are also not suitable for surfing. However, where they are suitable they offer some of the UK's best quality surfing waves (e.g. the breaks along the coast of Caithness at Brimms Ness and around Thurso, and Porthleven in west Cornwall) (see Figure 4). From a surfer's perspective reef breaks offer advantages in that they can break and hold large waves and have a consistent wave breaking point, and offer disadvantages in that they are hard and sometimes sharp, which can make for uncomfortable water access and harmful wipe-outs. Reef breaks have been categorised by Butt (2004b) and those found around the UK's coast include flat sedimentary rock platforms, folded sedimentary rock platforms and granite reefs.

Figure 4 Reef breaks: Cornwall's south coast waves (Top) and Caithness (Bottom)

Surfing wave quality

Assuming a wave is surfable, a number of factors contribute to its quality including wave height, wave breaker type and wave peel angle. Wave height, the distance between a wave's crest and trough, is a key factor on the surfer's perspective of a wave's quality. Surfable wave heights range from approximately 0.5 metres to 10 metres. Larger waves can be surfed, sometimes with the assistance of jet-skis to tow surfers into them, but they are rare in the UK.

According to Pattiaratchi (1997), it is the wave breaker type that really defines the surfability of a wave since this determines its shape. There are three types of wave breaks: spilling waves (i.e. full waves with shallow take-offs), plunging waves (i.e. tubing, hollow waves with steep take-offs), and surging waves (i.e. very steep collapsing waves). Plunging waves and, to a certain extent, spilling waves are generally surfable. Very flat spilling waves or very steep surging waves are generally unsurfable.

Good quality surfing waves break by peeling laterally along the wave's crest. As identified in Figure 5, the unbroken wave face closest to the breaking crest is referred to as the pocket. Surfers prefer to surf in the pocket because it is at this point that the wave is steepest and therefore allows a surfer to gain the most speed from it. Mead (2003) summarises the influence of peel angles on surfing waves as follows: "Peel angles range between 0° and 90°, with small peel angles resulting in fast surfing waves and large angles in slow surfing waves. There is a limit to how small the peel angle can get before it becomes impossible for a surfer to stay on the unbroken wave face, ahead of the breaking section; when this is no longer possible the wave is termed a 'close-out' (see Figure 5). On the other hand, as the peel angle increases towards the maximum of 90°, peel speed is reduced until it becomes too slow to be considered good for surfing".

Figure 5 Peeling waves in Caithness (Top) and closing out waves in Cornwall (Bottom)

Surfing wave quality is also dependent on the experiences and skills and, therefore, the relative preferences of individual surfers. Skill levels have been classified by Hutt et al (2001) based on wave peel angles and heights, including beginner surfers (peel angle of 90o, wave height of 0.7-1m), learner surfers (70°, 0.65-1.5m), surfers able to execute standard manoeuvres consecutively on a single wave (50°, 0.5->4m), top amateur surfers (29°, 0.4-.4m), professional surfers (27°, 0.35->4m). An Australian survey of the behaviour of 430 surfing tourists found that most surfers preferred waves of between four and six feet in height, although they also preferred different wave breaking types including “fun beach breaks”, “easy points and reefs”, “challenging hollow waves” and “thick grinding barrels” (Donicar and Fluker, 2003a). In summary, while inexperienced surfers may be satisfied to surf spilling waves with smaller wave heights, experienced surfers may not and prefer to surf plunging waves with larger wave heights.

2.2 Surfing locations

Surfing takes place around most of the UK’s coastline where surfable waves break. Some regions receive a better wave climate and have better seabed morphology than others and consequently they have more consistent good quality surfing waves and more surfing locations and breaks. Depending on the density of the local surfing community’s population and the proximity and density of the travelling surfing community’s population, surf spots can contain varying numbers of surfers. These factors and the quality of the waves themselves both contribute to the number of surfers sharing the waves. However in some cases relatively poor-quality waves in densely-populated areas can be very popular (e.g. Southern England), or excellent-quality waves in remote areas (e.g. Northern Scotland) can be quite uncrowded. It should be borne in mind that, in both cases, the waves are of value to the community.

South-West England (see Maps 1-5, Annex 1)

North-westerly, westerly and south-westerly swell waves generated in the Atlantic Ocean arrive at the coasts of Cornwall and Devon to create the most consistent good quality surfing conditions in England, particularly along the north coast of the peninsula from Sennen Cove in west Cornwall to Lynmouth in north Devon. There are more than 50 surfing locations along this stretch of coast including the very popular and often very crowded surfing hot spots around Newquay, Bude and Croyde, extensive beach breaks at Sennen Cove, Gwithian, Porthtowan, Perranporth, Newquay, Widemouth, Saunton and Woolacombe, and the big wave spot known as the Cribbar which only breaks on the biggest swells but is becoming a major media attraction.

All the surfing break types exist in this area - beach, reef, point and even river-mouth breaks. Some are exposed to the prevailing winds, which can reduce the number of surfable days, but others face north and provide clean surfing waves when the main westerly exposed beaches have onshore winds or are too big. The breaks in north Devon also receive a push effect of the incoming tide entering the Bristol Channel, which can make weak swells surfable. The south-west coastal path makes all these breaks easily accessible.

The south coast of the peninsula from Lands End in west Cornwall to Start Point in south Devon receives south-westerly swells from the Atlantic Ocean and southerly wind waves from the English Channel but also receive the accompanying winds which reduce the number of surfable days with clean waves. There are a number of popular surfing locations along this coast though including the beach breaks of Praa Sands in west Cornwall, Whitsand Bay in south Cornwall and Bantham in south Devon. But the highest-quality and most popular break is at Porthleven in west Cornwall, which is probably England's best reef break.

South Wales (see Maps 6-7, Annex 1)

The south Wales coast from the Gower Peninsula eastwards receives swell waves from the Atlantic Ocean. The Gower Peninsula contains some of Wales's best surfing breaks, including the Llangennith beach break in Rhossili Bay and a variety of breaks in Langland Bay, which can be very popular. Further east, good quality surf is less consistent although at the extreme easterly end of this area is the unique wave created by the Severn tidal bore which occurs on high spring tides.

Pembrokeshire (see Map 8, Annex 1)

The Pembrokeshire coast also receives swell waves from the Atlantic Ocean. The main surfing waves are beach breaks such as those at Manorbier, Freshwater West, St Brides Bay and Whitesand Bay.

West and North Wales (see Map 9, Annex 1)

The wave climate along this stretch of the coast is much less consistent than further south but good quality surf occurs at various beach and reef breaks in Cardigan Bay (e.g. Aberystwyth and Borth), around the Lleyn Peninsula and Anglesey. The waves are generally uncrowded but of high quality.

Northern Ireland (see Map 10, Annex 1)

The coast of Northern Ireland receives swell waves from the Atlantic Ocean and its breaks are aligned such that the prevailing south-westerly wind blows offshore. The main surfing breaks are beach breaks situated along the stretch of coast between Magilligan in the west to Ballycastle in the east. The most popular surfing location is around Portrush where there are a number of very popular breaks particularly in summer and at weekends.

The West Coast and Isles of Hebrides (see Maps 11-12, Annex 1)

The western isles are exposed to swell waves generated in the Atlantic Ocean and offer a range of west to north facing beach and reef breaks located along the coasts of the Mull of Kintyre, and the Isles of Islay, Tiree, Harris and Lewis. Some of these spots are of very high quality, although the remoteness of the location means they remain uncrowded most of the time.

Sutherland and Caithness (see Maps 13-15, Annex 1)

Some of the UK's best surfing breaks are situated along the north coast of Scotland. The coast receives swells from the west around to the north-east and winds that blow offshore a large proportion of the time. It provides a range of high-quality, reefs some of which are world-class; notably around Brimms Ness and Thurso. The Sutherland coast includes sandy beach and boulder breaks and includes locations such as Sandwood Bay, which alone is reported to offer 9 different breaks. The Caithness coast is famous for its flat slab reef breaks that can break large, powerful surfing waves. Thurso East is a wave of world renown and the focus of the O'Neill Highland Surf competition.

Orkney Islands (see Map 16, Annex 1)

The islands receive large swell waves and have many surfing breaks on sandy beaches and rocky reefs. The main breaks include the Bay of Skail and Outshore Point. Exposure to strong winds affects the consistency of surfable waves but there are sheltered breaks that can work when other breaks are blown out. The Orkneys are still largely unexplored as far as surfing is concerned, but the coastal geology suggests that it has the potential to contain the same world-class breaks as Northern Scotland.

East Scotland (see Maps 17-18, Annex 1)

Scotland's eastern coast receives swells from the north and north-east and consistent offshore winds, but can also receive swells from the east and south-east. The coast between the Moray Firth and Fraserburgh has more than 15 surfing locations that receive their best swell waves from the north. As the coast extends further south the population increases and the more accessible surfing breaks such as those at Pease Bay become more popular.

North-east England (see Maps 19-20, Annex 1)

The north-east coast of England from Blythe in Northumbria down to Flamborough Head in Humberside includes more than 30 breaks that mainly receive waves from the north and, to a lesser extent, from the south-east. Although the swell waves are less consistent than in south-west England, the prevailing south-west winds are offshore along this coast, which helps to produce clean surfing waves on good quality beach and reef breaks. Popular surfing locations include the areas around Tynemouth, South Shields, Hartlepool, Saltburn, Whitby and Scarborough. This area also contains a range of very high-quality reefbreaks, which, although inconsistent, attract surfers from all over the country.

East Anglia (see Map 21, Annex 1)

There are a few surfable wave breaks along the short stretch of coast between Sheringham in north Norfolk and Lowestoft in north Suffolk, which receive inconsistent waves from the north and the south-east, although the prevailing south-west winds are offshore along this coast, which helps to produce clean surfing waves. The most consistent surfing wave breaks at East Runton near Sheringham. Elsewhere, surfing is more marginal, particularly where beach breaks are affected by coastal defence structures, such as at Walcott and Happisburgh.

South England (see Maps 22-23, Annex 1)

The south coast from Start Point in south Devon to Kent receives infrequent, short duration swell waves and wind waves but also receives the accompanying winds which reduce the number of surfable days with clean waves. Nevertheless, there are clusters of extremely popular surfing locations around Bournemouth, the Isle of Wight, the Witterings and Brighton, and some very high quality surfing breaks along the Jurassic Coast of Dorset, such as the reef breaks in Kimmeridge Bay. Recently, surfing at these breaks has been threatened by the Ministry of Defence's proposal to close public access to this part of the coast as of June 2009 (latest information available at: www.broadbench.co.uk).

Channel Islands (see Map 24-25, Annex 1)

Both Jersey and Guernsey receive swell waves and have a number of good quality beach and reef breaks along their west and north coasts. St Ouens Bay faces west and hosts many of Jersey's breaks along its length. Vazon Bay and Perelle Bay are the main surfing locations on Guernsey. Surfing in this area very popular, particularly in Jersey.

2.3 Surfing recreation

Surfing involves a wide range of wave-riding activities using various equipment including surf boards (short boards, long boards (also known as Malibu boards or mals) and intermediate length boards (also known as mini-mals)), body boards (also known as boogie boards), paddle boards, surf skis, and surf kayaks and canoes, while some surfers simply body surf (see Figure 6).

Surfers use the waves to perform various manoeuvres such as turns, cut backs and floaters, and when the conditions are right, to surf inside the tube formed by a plunging wave (see Figure 7). Wind surfers and kite surfers also use waves for surfing and performing manoeuvres.

Figure 6 Surfing types: long-boarding in Cornwall (left) and surf kayaking in Cornwall (right)

Figure 7 Surfing manoeuvres: an aerial in Cornwall (left) and top turn in Cornwall (right)

Profile of surfers

The following profile of surfing participants can be inferred from a survey of surfers in Cornwall (Arup, 2001):

- in terms of age, 16 per cent of surfers are aged less than 18, 43 per cent are aged 19 to 25, 32 per cent are aged 26 to 35, 3 per cent are aged 36 to 45, and 6 per cent are aged over 46
- in terms of length of time surfing, 22 per cent of surfers have surfed for less than 2 years, 32 per cent for 2 to 5 years, 23 per cent for 5 to 10 years, and 23 per cent for more than 10 years
- in terms of frequency of surfing, 37 per cent surf more than twice a week, 13 per cent once or twice a week, 15 per cent once or twice a month, 26 per cent a few times a year, and 9 per cent once a year or less
- in terms of participating in surfing competitions, 59 per cent never participate, 15 per cent intermittently participate, 23 per cent participate 1 to 4 times a year, and 3 per cent participate more than 4 times a year
- in terms of surf club membership, 81 per cent of surfers belong to a surf club and 19 per cent do not, suggesting that using club membership numbers would significantly underestimate the number of surfers
- in terms of annual income, 30 per cent of surfers are unemployed or in full-time education, 17 per cent earn less than £10,000 thereby indicating part-time employment and/or education, 10 per cent earn between £10,001 and £15,000, 17 per cent earn between £15,001 and £25,000, 10 per cent earn between £25,001 and £30,000, 9 per cent earn more than £30,000, and 7 per cent did not provide an answer.

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Factors affecting participation in surfing

On the basis of identifying what would encourage surfers to surf more in Cornwall, the factors affecting participation in surfing and their importance can be inferred from a survey of surfers in Cornwall (Arup, 2001). Consistent surfing conditions was identified as the most important factor by between 55 and 60 per of respondents. Other factors were identified including focal points for surfing such as the National Surfing Centre at Newquay and improved beachside facilities at key surfing locations (43 per cent of respondents), better weather conditions (39 per cent of respondents) and improved access by road, rail and air (c.28 per cent of respondents).

Numbers of surfers

The total number of UK adults participating in surfing in 2008 was estimated by the Royal Yachting Association (RYA) to be 501,615

The British Surfing Association has 13,000 members

According to a survey carried out in 2004 (see BBC, 2004) in Cornwall alone, turnover from the surfing industry is estimated at £64m per year, compared with a sailing industry turnover of £52m and golf with a turnover of £32m. The surf industry provides over 1,600 jobs in Cornwall.

Surfing competitions

As a sport, surfing competitions take place throughout the year around the UK. At a professional level, the best surfers take part in the World Championship Tour (WCT) which is run by the Association of Professional Surfers (ASP). The WCT comprises the world's top 44 surfers and comprises a series of competitions held at surfing locations around the world. The world champion is the surfer who has scored the most points during each tour. The UK has not been represented in the WCT since Russell Winter appeared in 2002. The ASP's World Qualifying Series (WQS) follows a similar format to the WCT. The surfers performing best in the WQS are promoted to the WCT to replace the surfers performing worst in the WCT. Several of the UK's top professional surfers compete in the WQS. A number of UK surf competitions form part of the WQS including the O'Neill Coldwater Classic event held in and around Thurso. This is a 6-star prime rated event and therefore one of the highest ranked events in the WQS. It attracts surfers from around the world and rewards the best with significant amount of prize money (US$145,000 in 2009). The 5-star rated Boardmasters event held at Newquay is another high ranking event in the ASP. The 2009 Relentless Boardmasters competition offers prize money of US$120,000.

At a UK level, there are one-off annual UK and national championship competitions. The UK's premier tour for male and female surfers is known as the UK Pro Surf Tour (UK PST) and is organised by the British Professional Surfing Association (BPSA). This tour visits surfing locations around the UK. The 2008 tour ran from April to November and staged events at Croyde (north Devon), Lusty Glaze (Newquay), Watergate Bay (north Cornwall), Porthmeor (west Cornwall), Porthcawl (Wales), Longsands (Tynemouth), Thurso (Caithness), Portrush (Northern Ireland) and Fistral (Newquay). All events are sponsored by multi-national retailing companies with interests in surfing and outdoor recreation. The BPSA also holds events for junior professional surfers, long-boarders and 'grommets' (i.e. young surfers under 16 and under 12 years of age). In addition to the UK PST, there are numerous open events held throughout the UK throughout the year.

Surfing organisations

Surfing in the UK is promoted, supported and protected by various non-governmental organisations (NGOS) and commercial organisations. Table 1 identifies the UK's principal organisations and their roles.

Table 1 UK's principal surfing organisatons

Organisation	Role	Contact information
Surfers Against Sewage (SAS) (formed in 1990)	Non profit-making organisation campaigning for clean, safe recreational waters, free from sewage effluents, toxic chemicals, marine litter and nuclear waste, and for the UK to invest in more offshore renewable energy technologies that produce clean and safe energy at no cost to the environment	Unit 2, Wheal Kitty Workshops, St Agnes, Cornwall, TR5 0RD 01872 553001 www.sas.org.uk
British Surfing Association (BSA) (formed in 1966)	Governing body for the sport and recreation of surfing in Great Britain, the Isle of Man and the Channel Islands, a role that, according to their Memorandum of Association, requires the BSA "to work for the conservation and improvement of coastal environments and the protection of surfing resources"	National Surfing Centre, Fistral Beach, Newquay, Cornwall, TR7 1HY 01637 876474 www.britsurf.co.uk
British Professional Surfers Association (BPSA) (formed in 1998 by UK Surf Promotions Ltd)	Commercial organisation seeking to raise the profile of British surfing across the UK by providing a uniform event format and a platform for surfers and sponsors to raise their profile in the surfing industry, and by highlighting the quality of surf conditions and locations across the country	Bay Hotel, Esplanade Road, Newquay, Cornwall, TR7 1PT 01637 854854 www.bpsauktour.com

2.4 Surfing economics

Surfing is a growing sport and has an associated surfing industry that particularly influences the retail industry (e.g. surfing equipment and accessories) and the tourism industry (e.g. surfing tourism) at many economic scales.

At a national scale, the BSA's 1999 business survey estimated that the total business turnover for the UK's surfing businesses to be £160 million per annum and Rip Curl estimated that the worth of surfing to the UK economy in 2000 to be around £200 million and employment of around 3,000 people (Arup, 2001).

At a regional scale, surfing is particularly important to the Cornish economy. Arup (2001) predicted the annual expenditure on surfing in Cornwall to be £21 million per annum as a direct spend of surfers in the local economy. Surfing forms part of a wider tourism industry associated with water-based recreation in south west England where, according to the Environment Agency (2007), "Water-based sport and recreation is particularly significant in Cornwall and the Isles of Scilly, where they generate in the region of £300 million each year."

Surfing equipment and accessory values

Surfing equipment essential to participation includes surfboards, bodyboards, wetsuits and smaller items such as leashes, deck grips, board wax, booties and gloves. Surfing accessories include sundry items associated with surfing but not essential to participation, including t-shirts, sweat shirts, shorts, shoes, watches, sunglasses, bathing costumes and sun block. Arup (2001) noted "the significance of this category is that just as these items are not necessary to participation they are very much a part of the image that so many non-surfers wish to be associated with. Essentially the surfing apparel market is bigger than the sport itself and has more to do with street culture than the actual sport…It is estimated that only 1% of surfing apparel sales are directly due to those who surf, such is the wide appeal of these products".

Globally, sales of surfing equipment and fashion-related accessories were reported by the Surf Industry Manufacturers Association (SIMA) to be US$7.48 billion in 2006 (SIMA, 2007). Fluker (2003) reported that surfing related retail outlets in Torquay, Australia (location of the famous surf break at Bells Beach and headquarters of the multi-national surf equipment and accessory company Rip Curl) turned over Aus$400 million per year.

In the UK, Arup (2001) predicted the annual expenditure on surfing equipment to include £450 per person by local and visiting surfers in Cornwall and reported that a survey by the BSA in 1998 found that on average their members spent £683 per person per annum on surfing equipment (notably surfboards, bodyboards and wetsuits) and accessories (notably clothing).

Surfing tourism values

Fluker (2002) defined surf tourism "as the act of people travelling to either domestic locations for a period of time not exceeding 6 months, or international locations for a period of time not exceeding 12 months, staying at least one night, and where the active participation in the sport of surfing, where the surfer relies on the power of the wave for forward momentum, is the primary motivation for destination selection." Dolnicar and Fluker (2003b) identified five market segment profiles of surfing tourists based on various psychographic and demographic variables including expenditure, which they termed “price-conscious safety seekers”, “luxury surfers”, “price-conscious adventurers”, “ambivalents” and “radical adventurers”.

There is generally a lack of information about the socio-economic value of surfing tourism, but the information that is available suggests that it is an important contributor to the tourism industry and economies at international, national, regional and local scales where good quality consistent surfing waves are accessible. For example, at a national scale, Lazarow and Blackwell (2007) noted that “a study in Costa Rica revealed that over 100,000 surfers visited the country in the first half of 2006 and spent over $200 million. Based on these figures, surf related tourism makes up 25% of Costa Rica’s economy, worth more than coffee and second only to bananas.”

In the UK, there is evidence that surf-related tourism is also worth a great deal to the economy, especially at locations such as Cornwall and, in particular, high-profile surfing towns such as Newquay. If the waves were seriously degraded at Newquay, for example, evidence suggests that a large proportion of the money received by local businesses would disappear.

Surfing wave values

Surfing waves at famous surfing breaks help to illustrate the potential importance of surfing to the economy at a local scale. Nelsen et al (2007) estimated that surfers visiting Trestles contribute an annual economic impact to the city of San Clemente in California that is between US$8 million and US$13 million, while Murphy and Bernal (2008) estimated that surfing at Mundaka in northern Spain contributes an annual economic impact of up to US$4.5 million and supports up to 95 jobs in a town where the population is approximately 2,000 people.

California Business Minute (date unknown) reported that more than three million surf visits per annum are made to the eight-mile long popular surfing beach at Huntington Beach in California. In terms of economic impact “the city believes that surfing directly contributes between ten to fifteen percent of the entire economic gross product of Huntington Beach. The city’s beaches generated $135 million in federal tax revenues and $25 million in sales-tax revenues. So surfing in Huntington Beach - assuming that it’s ten to fifteen percent of all economic activity - generates close to $20 million tax dollars a year for the federal government on top of its $17.3 million city contribution.”

In Australia, Lazarow (2006) estimated that surfers spend Aus$20 million and Aus$0.23 million at South Stradbroke Island and Bastion Point per annum respectively. The difference in expenditure reflects the different numbers of surfers in the local community (11,500 at South Stradbroke Island and 75 at Bastion Point).

There is a limited amount of data concerning the expenditure of surfing related tourism in the UK but, according to a survey carried out in 2004 (see BBC, 2004) it is estimated that surfers spend 8.5% more per head than other visitors to Cornwall. Also, Arup (2001) predicted the annual expenditure on surfing in Cornwall to include £830 per person per annum on visiting costs by visiting surfers. This level of expenditure is very similar (and could have been based on) a survey by the BSA in 1998 that found that on average their members spent £831 on surfing holidays (based on the 72% of BSA members who took a surfing holiday in 1997, of which 40% of holidayed in Britain).

Surfing competition values

In California, Huntington Beach hosts fifteen pro-surfing events and up to 70 amateur contests each year. According to California Business Minute (date unknown), the annual US Open is believed to account for nearly 60 percent of the revenue generated from these events. On average, up to 250,000 people attend the contest and its associated exposition. During the week of this competition local hotel rates are highest and retailers do more business than at Christmas.

In Australia, Ernst and Young (1995; in Fluker 2003) estimated that the 1995 Rip Curl Pro surfing contest at Bells Beach, Torquay attracted 20,050 individual visitors who spent approximately Aus$860,000 on surfing merchandise and increased direct expenditure in the region by approximately Aus$2.11 million.

In the UK, Rip Curl estimated that the worth of 2001 Newquay Board Masters Tournament to be £17 million to the local economy (Arup, 2001). Sports Vision estimated that the same event in 2008 to have attracted 175,000 people over the four days it was held (see Figure 8) and be worth £10.5 million to the local economy on the basis that each person was estimated to have spent on average £15 on food, accommodation, travel and shopping. In addition, staging the competition itself required a direct spend of £0.75 million on local staffing and business (Sports Vision, pers comm., 2009).

Figure 8 Rip Curl Board Masters at Fistral Beach, Newquay in 2008

Part 3: Impacts on surfing resources and recreation

This part of the report concerns the potential impacts of offshore renewable energy development on surfing resources in the form of surfing wave resources (see Section 3.1) and surfing break resources (see Section 3.2), and surfing recreation (see Section 3.3). The information herein draws upon publicly available information including academic research, EIA reports (i.e. environmental statements (ESs)) and SEA reports.

3.1 Impacts on surfing wave resources

A suitable wave climate (i.e. wave height, period and direction) is one of the principal requirements to create surfable waves and, particularly, good quality surfing waves. When they are unaffected by offshore renewable energy development, waves – and particularly swell waves - propagate from offshore to nearshore and to the surf zone where they break. Impacts on surfing wave resources occur when offshore renewable energy development interrupts waves' shoreward transmission and changes their characteristics to such an extent that these changes are manifest at the surf zone when the waves break there. In simple terms, the potential for offshore renewable energy development to impact on surfing wave resources is a function of the magnitude of the change in wave climate and the distance between the offshore location of a development relative to the local surfing breaks.

Offshore wave climate impacts

The principle impacts on surfing wave resources concern changes to the wave climate (as wave height period and direction) as waves pass through an offshore development site. In essence, wave energy transmission is reduced by the presence of the offshore renewable energy structures. These structures cause wave energy to be blocked, re-directed and, particularly in the case of wave energy converter devices, extracted as it passes through a development site. For example, in the case of the Round 2 offshore wind farm development known as the London Array situated off the Essex coast, RPS (2005) noted that near-field impacts on the wave climate occur as a result of the turbine structures scattering the incoming waves to generate a reflected wave field that interacts with the unaffected surrounding wave field (and hence "this wave-wave interaction exerts an influence upon the distribution of wave heights behind the structure") and absorbs the wave energy. Accordingly, the principle factors that can modify wave resources as they pass through a development site are wave energy absorption, diffraction and refraction, and they all need to be considered for their potential to influence the nearshore wave climate.

EIA studies for the Round 1 Burbo offshore windfarm development in Liverpool Bay were subject to computational modelling and based on a 1 in 1 year offshore storm event generating waves passing through 30 turbine structures of 4 metres diameter. Concerning near-field impacts on wave climate, Seascape Energy Ltd (2002) predicted: "The general effect is a dampening of the incoming wave as a function of the structures with local reductions around each unit. These reductions are typically <0.1m, and represent a 3% reduction in wave heights. Reflections off structures and scattering are also evident in confined areas with local increases in waves up to 0.1m, which also develop off the front and lee of each unit, with some interaction evident between units. Down-drift of the windfarm the influence on the near-field wave regime dissipates quickly and the differences become minimal".

During the initial assessment of its effects, the Round 1 Scroby Sands offshore windfarm development "was regarded at the time as the worst-case scenario in terms of potential impacts on coastal processes, involving the emplacement of 30 turbines situated upon monopole foundations 4.2 m in diameter in an environment with fast tidal currents and mobile bed sediments" (Cefas, 2006). Research on this offshore windfarm identified that its diffraction effects on wave climate remain in its near-field. Cefas (2005) found: "the implications are that wave diffraction effects from a monopile-based windfarm reduce the wave climate in the direct vicinity of the windfarm by 2-5%. The effects decrease rapidly away from the windfarm to reach background values a distance of 2-3 turbine spacings away".

However, the offshore windfarms proposed under ongoing Round 2 and future Round 3 are many times larger than Burbo and Scroby Sands offshore windfarms (e.g. numbers of turbines, diameters of monopile foundations, areas of development). Since diffraction "varies with the wavelength of the waves compared to the size of the obstacle – the longer the wave relative to the size of the obstacle, the more diffuse is the shadowing" (Faber Maunsell & Metoc, 2007), then it is very likely the diffraction effects of future offshore windfarm developments will be larger than those identified by Cefas (2005) and, therefore, it is important that wave climate changes are appropriately considered during the EIA process.

The changes to offshore wave climate are typically identified as loss of the wave energy transmitted shoreward after waves have passed through a development site. The loss of wave energy transmitted primarily causes a reduction to wave height, and to a lesser extent causes a change to wave period. For offshore windfarms, wave energy transmission is reduced by the energy absorbed and re-directed by turbine towers and their foundations. The designs and sizes of foundations appear to be the principle factors influencing an offshore windfarm's potential to change wave climate. For example, on the basis of numerical modelling, RPS (2005) reported different magnitudes of wave energy absorption and transmission for three alternative foundation designs for the London Array offshore windfarm. Monopile and tripod foundations were found to have a low obstruction effect and a low capacity to absorb energy from passing waves. Monopile foundations were found to have a wave transmission rate "close to unity" (i.e. close to 100% of the wave energy is not absorbed and passes through the development site). Compared to monopile foundations, tripod foundations were found to have a slightly lower wave energy transmission rate. Despite the structural differences between monopile and tripod foundations, their absorption of wave energy was found to be of a similar magnitude because "although the tripod structure contains more structural elements than the monopile, many of them are of small diameter and the majority are well below the free surface. It is the central tower that provides the major resistance to the passage of the wave". Gravity base structure (GBS) foundations were found to have the greatest obstruction effect and the greatest capacity to absorb energy from passing waves, particularly at water depths of less than ten metres. Wave energy transmission rates were found to decrease with decreasing water depth because relatively more of the water column is occupied by the GBS in shallower water.

Academic research and the findings of various environmental statements suggest that the magnitude of wave height reduction at the shore increases as the wave energy transmitted through offshore renewable energy development sites decreases. The research of Millar et al (2006) illustrates this relationship using the Wave Hub project. In this research, the Wave Hub project was considered to comprise a 30MW wave farm with a range of wave energy converter devices deployed 20 kilometres north-west of St Ives on the north coast of Cornwall, and the wave climate for the reference sea state comprised a significant wave height of 3.3 metres and a mean wave period of 11 seconds for all wave directions.

In the absence of wave energy absorption data for the devices to be deployed at the Wave Hub, Millar et al (2006) used the following range of wave energy transmission rates to represent different impact scenarios:

- 0% wave energy transmission to represent complete absorption of all incoming wave energy at the obstacle - an unachievable scenario that was considered likely to produce the largest possible shoreline impact
- 70% wave energy transmission to represent an array of densely spaced, high efficiency devices – a scenario that was considered to be an optimistic target for a wave farm developer to achieve
- 90% wave energy transmission to represent an array of widely spaced, lower efficiency devices - a more likely scenario that was considered more realistic at the Wave Hub site
- 40% wave energy transmission to allow the study to establish trends - although this scenario was considered to be extremely improbable that it could be attained in reality.

Based on the results of Millar et al (2006), the averaged impacts on wave transmission in the offshore area to the immediate lee of the Wave Hub site caused low magnitude wave height changes (average wave heights are reduced by between c.0.3 and 3 percent) and negligible magnitude wave period changes (average wave periods are increased by c.001 and 0.1 percent).

For comparison, to assess the impacts of the Wave Hub project, Halcrow (2006) estimated the wave transmission coefficients for different wave energy converter devices based on PIANC's (1994) design guidance for floating structures including Wave Dragon (0.68), Pelamis = (1.0), Power Buoy (1.0) and Fred Olsen FO3 (1.0). Halcrow (2006) noted that the transmission coefficients were applied in their computational model "only over the width of the WEC devices which face the oncoming wave (the offshore face); no wave absorption was assumed in the gaps between the devices".

Nearshore wave climate impacts: offshore windfarms

Previous EIAs for offshore renewable energy developments suggest that the magnitude of impacts decreases with distance from the development sites where the wave climate is initially affected by the structures. The EIAs for a number of Round 1 and Round 2 offshore windfarms predicted larger impacts on wave resources in the near-field compared to the far-field.

For the Round 1 Burbo offshore windfarm, Seascape Energy Ltd (2002) predicted that "the general pattern of change is for a small reduction in wave heights in a 'down-wind' direction which do not extend far beyond the development site and do not reach the adjacent coastlines".

For the Round 2 London Array offshore windfarm, RPS (2005) found that far-field wave climate impacts under north-easterly (i.e. onshore) winds were related to the foundation type and the state of the tide. The following far-field wave height reductions were predicted against a baseline wave height of between 1.75 and 2.5 metres:

- up to 10 centimetres well beyond the development site and of up to 5 centimetres at the coast of north Kent for a scenario based on GBS foundations at times of high water and peak ebb tides
- up to 10 centimetres just beyond the development site and no changes at the coast of north Kent for a scenario based on GBS foundations at times of low water and peak flood tides
- up to 5 centimetres just beyond the development site and no changes at the coast of north Kent were predicted for a scenario based on monopile foundations and times of peak ebb tides.

Nearshore wave climate impacts: offshore wave farms

Millar et al's (2006) research on the impacts of Wave Hub predicted the following impacts in relation to different wave climate parameters under the realistic scenario of 90 percent wave energy transmission:

- concerning wave height, Millar et al (2006) predicted average wave height reductions would be 1 centimetre and maximum wave height reductions would be up to 3 centimetres at popular surfing locations along the north coast of Cornwall including Gwithian, Porthtowan, Perranporth, Fistral, Newquay Bay, Watergate Bay, Constantine and Harlyn Bay, which is an important finding because consultation during the Wave Hub's EIA process identified that surfers were concerned that an impact on wave height would occur (see Table 2)

- concerning wave period, Millar et al (2006) predicted negligible changes to wave period at the surfing locations, which is an important finding because consultation during the Wave Hub's EIA process identified that surfers were concerned that an impact on wave period would lead to losses of the 'clean' longer-period swells that surfers enjoy for their best surfing days
- concerning wave direction, Millar et al (2006) found that waves approaching from directions between 330° and 30° produce the largest changes at the shore, while waves approaching from directions between 90° and 240° produce negligible changes at the shore, which is an important finding because it suggests that surfing waves from the best directions would be impacted the most.

Table 2 Average and maximum reductions to wave heights and wave periods at popular surfing locations in the lee of Wave Hub under the realistic scenario of 90 percent wave energy transmission (source: Millar et al, 2006)

Surfing location	**Average change to wave height**		**Maximum change to wave height**	
	metres	**percent**	**metres**	**percent**
Gwithian	0.01	0.36	0.02	1.08
Porthtowan	0.01	0.47	0.02	0.97
Perranporth	0.01	0.65	0.03	1.65
Fistral	0.00	0.38	0.02	1.06
Newquay Bay	0.00	0.12	0.01	0.88
Watergate Bay	0.00	0.19	0.01	0.79
Constantine	0.00	0.18	0.01	1.15
Harlyn Bay	0.00	0.17	0.01	1.67

Potential impacts of wave height reductions in relation to surfing waves have been predicted and considered specifically by the EIAs for the Wave Hub project and the Wave Dragon demonstrator device.

For the purposes of assessing impacts of the Wave Hub project, Halcrow (2006) consulted with SAS and the BSA and identified a number of wave height and period combinations to represent wave resource conditions important to nearshore water recreation including:

- small surfing waves (i.e. those waves experienced during summer when nearshore water recreation is important for surfboard rentals, wetsuit rentals, surf schools, etc over the peak tourist season with a wave height of 1 metre and a wave period of 7 seconds)
- large “classic” surfing waves (i.e. those waves occasionally experienced during autumn when swells originate from storm conditions over the mid Atlantic Ocean with a wave height of 4 metres and a wave period of 16 seconds).

The results of computational modelling for the Wave Hub project (Halcrow, 2006; see Figure 9) predicted the following wave height reductions at surfing locations along north Cornwall:

- up to 3 per cent reductions to wave heights at the coast between Gwithian and Newquay during a 1 in 1 year storm event for the likely case scenario for the layout of wave energy converters
- up to 5 per cent reductions to wave heights at the coast between Gwithian and Newquay for the worst case scenario for the layout of wave energy converters
- up to 5 per cent reductions to small and large surfing wave heights between Portreath and Chapel Porth for the likely case scenario for the layout of wave energy converters
- up to 11 per cent reductions to small and large surfing wave heights between Portreath and Chapel Porth for the worst case scenario for the layout of wave energy converters

For the purposes of assessing impacts of the Wave Dragon demonstrator, PMSS (2007) identified a number of wave height and period combinations to represent different wave climate conditions including:

- moderate wind waves (i.e. those waves with a wave height of 2 metres and a short wave period of 7 seconds)
- very large wind waves (i.e. those waves with a wave height of 4 metres and a wave period of 9 seconds)
- moderate swell waves (i.e. those waves with a wave height of 2 metres and a wave period of 9 seconds)
- large swell waves (i.e. those waves with a wave height of 4 metres and a wave period of 9 seconds).

The results of computational modelling for the Wave Dragon demonstrator (PMSS, 2007) predicted the following wave height reductions at surfing locations along Pembrokeshire:

- up to 1 per cent reductions to wave heights at the coast of Pembrokeshire including Westdale Bay during small wind waves
- up to 10 per cent reductions to wave heights at the coast of Pembrokeshire including Marloes Sands during large wind waves and moderate swell waves
- up to 2 per cent reductions to wave heights at the coast of Pembrokeshire during large swell waves.

Figure 9 Reductions to wave heights along north Cornwall due to Wave Hub (source: Halcrow, 2006)

Figure 9.1 Worst case scenario layout, 1 in 1 year storm event conditions (Hs = 10m, T = 12s) (left) and typical case scenario layout, 1 in 1 year storm event conditions (Hs = 10m, T = 12s) (right)

Figure 9.2 Worst case scenario layout, small wave conditions (Hs = 1m, T = 7s) (left) and worst case scenario layout, large wave conditions (Hs = 4m, T = 16s) (right)

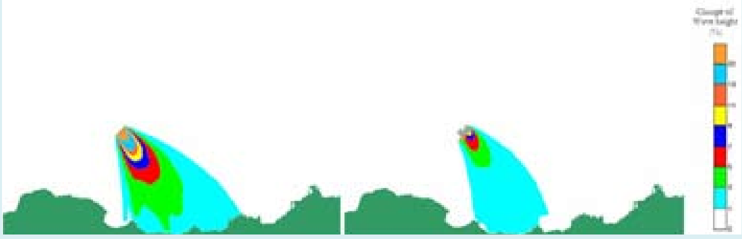
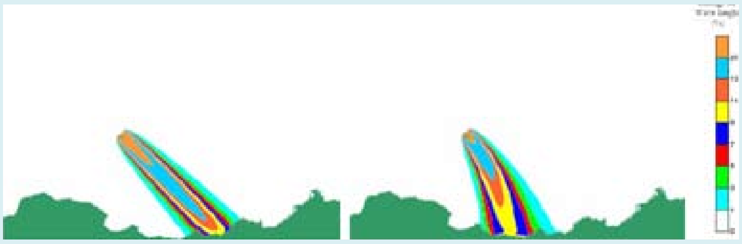


Figure 9.3 Worst case scenario layout, small wave conditions (Hs = 1m, T = 7s) (left) and typical case scenario layout, large wave conditions (Hs = 4m, T = 16s) (right)



Different impact magnitudes occur under different wave sources of wave generation: that is, swell waves and wind waves. Swell waves with longer wave periods are generated by wind blowing across ocean surfaces. The coasts of south-west England and Wales receive swell waves typically generated over the mid Atlantic Ocean, while the coasts of north and east Scotland and north-east England receive swell waves typically generated over the Arctic Ocean. Wind waves with shorter wave periods are generated by wind blowing across more local waters, such as along the English Channel. For example, the results of numerical modelling for the Wave Dragon pre-commercial demonstrator wave device can be used to illustrate this point. Using a wave climate with a wave height of 4 metres and wave period of 9 seconds, PMSS (2007) reported wave transmission reductions of 50 per cent for wind waves and 10% for swell waves in the immediate lee of the Wave Dragon device, and wave reductions of 10 per cent for wind waves and 2 per cent for swell waves at nearshore locations in West Wales. The magnitude of wave energy reductions experienced in the lee of the Wave Dragon and at the shore (including the surfing breaks at Marloes Sands and Westdale Bay) was higher for wind waves than for swell waves because the Wave Dragon device absorbed more energy from short period wind waves than from long period swell waves. In other words, wave transmission rates for the Wave Dragon device were lower for wind waves, which lead to higher reductions to the wave energy reaching the shore.

Nearshore wave climate impacts: offshore tidal stream farms

There is little information available to review the potential for offshore tidal stream farms to impact on surfing wave resources. During its EIA, MCT's SeaGen demonstrator project in Strangford Lough, Northern Ireland was found not to have the potential to significantly affect wave resources at its scoping stage (Royal Haskoning, 2004) and, therefore, a more detailed assessment was not reported in the subsequent EIA process.

3.2 Impacts on surfing break resources

The nearshore bathymetry (i.e. the seabed contours in the surf zone that give waves their breaking and peeling characteristics) is one of the principal requirements to create surfable waves and, particularly, good quality surfing waves. When it is unaffected by offshore renewable energy development, the seabed's contours at many of the UK's beaches rarely provide good quality surfing waves and/or are subject to dynamic morphological change due to local sediment transport patterns to the extent that the quality of surfing waves can be inconsistent. Reefs and their breaks are more stable morphologically and so they can provide consistent waves and, in some cases, some of the UK's best surfing breaks. Despite the UK's extensive coastline and potential for wave breaks, only a small percentage of wave breaks deliver surfable waves and fewer breaks deliver consistently good quality surfing waves.

Impacts on surfing break resources occur when offshore renewable energy development alters the hydrodynamic conditions (i.e. tidal flows, wave climate) and sedimentary environment conditions (i.e. sediment erosion, transport patterns and deposition) to such an extent that nearshore sedimentary bedforms (e.g. sand bars, beaches) change in the surf zone in such a way that they change the characteristics of the surfing waves that break there. For example:

- a sand bar's orientation may change in relation to the dominant wave direction to cause a peeling wave to be replaced by a closing out wave
- a sand bar's height underwater may change to cause a wave to break over less time throughout the tidal cycle
- a beach's slope angle may reduce to cause a plunging wave break to be replaced by a spilling wave break.

Note that this is an important ‘second-order’ process whereby the waves themselves have already been altered (which may have already led to a degradation in the surf), but the change in incoming wave characteristics also goes on to further alter the morphological or hydrodynamic characteristics, which affects the waves even more. With strong feedback like this the system sometimes becomes chaotic. In most cases the effects are highly unpredictable.

Offshore sediment impacts

Sediment transport patterns can be affected by changes of offshore renewable energy development on the offshore wave climate and other hydrodynamic conditions including tidal flows. Because changes to the offshore sedimentary environment are of concern to offshore windfarm developments, and particularly those that are situated on sand banks separated by channels, detailed research and consideration during the EIA process has been given to these issues.

Changes to the wave climate are associated with wave energy modification due to the interruption of wave propagation and the resulting hydrodynamic effects such as refraction and diffraction. If they are of sufficient magnitude, wave climate changes can affect the sedimentary environment of the seabed. RPS (2005) provided a useful illustration of how offshore windfarm structures can change the near-field wave climate and cause scouring of seabed sediment: “The presence of an installed turbine tower and foundation provides a local obstruction to flows which otherwise would not occur in the baseline scenario. The effect of the obstruction is to increase local turbulence in the flow regime. Theoretically, the head-on flow first slows down in front of the obstacle before bifurcating to find an alternative passage around it. At this point the diverted flows join with the adjacent flow to lead to locally increased speeds, before meeting-up behind the obstacle to form a wake in a region where the flow speeds have again been slowed. This effect continues through the tidal cycle and becomes most prominent at the peak of the tide (i.e. flood and ebb periods on a spring tide). This process is the fundamental mechanism which, in the absence of scour protection, could lead to local scouring around each structure under conditions when the threshold for sediment mobility is locally exceeded by increased flow speeds”.

In the case of the Round 1 offshore windfarm development at Scroby Sands, which itself is situated in a dynamic sediment environment, Cefas (2005) found that changes to wave climate associated with diffraction caused by monopile structures “will marginally reduce the tendency for sediment transport by waves. The results signify that wave diffraction effects on sediment from a Round 1 scale, monopile based offshore windfarm are negligible in the immediate vicinity of the development and, by inference, negligible at the coast and the local surfing breaks. Further research by Cefas (2006) identified a number of sedimentary changes as a result of the various infrastructure deployed at the Scroby Sands offshore windfarm, and concluded that “bathymetric impacts of monopile-based offshore wind farms (OWFs) are probably limited to the order of 100 m around each monopile. Given monopile spacings of over 300 m, such bathymetric impacts are thus unlikely to be cumulative between monopiles and across the turbine array. Monopiles may act to initiate trains of sedimentary bedforms, so that in these terms the impacted area may be much larger and cross the gap between adjacent monopiles. This is likely to be the case particularly along the flanks of sandbanks where net transport rates of bed sediment are high. Such bedform generation is unlikely to alter either the net sediment transport rates along sandbank flanks or the overall sediment budgets of such sandbanks". Cefas (2006) also concluded that the "the sedimentary features associated with turbine foundations at Scroby Bank are likely to be typical of those likely to be identified in other (but not all) OWFs, but observations elsewhere (e.g. London Array) indicate that the magnitude of the features may be significantly larger".

The conclusions of Cefas (2005 and 2006) appear well founded for Round 1 offshore windfarms since they are backed up by monitoring of scour at a number of sites. For example, scour features measured at Scroby Sands include scour pits (with a depth of approximately 5m and a typical horizontal diameter of 60m), secondary scour pits (due to scour protection on each corner of the monopile), scour tails (up to 400m in length and capable of spanning the distance between monopiles thus resulting in a potential for cumulative impacts), and scour pans with u-shaped cross sections rather than v-shaped scour pits (Anon 1, date unknown; see Table 3). Monitoring of other Round 1 offshore windfarms has reported no long term scour at the North Hoyle site around turbines or within the development site, scours of between 1 and 6 metres at the Barrow site, and the possibility of very localised scour at the Kentish Flats site to depths between 0.8 and 1.4 metres (Anon. 2-4, dates unknown).

Table 3 Summary of offshore sediment impacts of the Scroby Sands offshore windfarm (source: Anon 1)

Scale	Type of impact	Significant impact?
0 to 100 metres	Scour pits	Yes but predicted by the EIA
100 to 1000 metres	Scour tails	Tails not significant with respect to the total bank volume change
1000+ metres	Global and swash channels	No evidence

Despite no evidence for impacts Cefas (2005) recommended that caution be taken when considering alternative foundation structures for offshore windfarms (i.e. GBS foundations) because larger cross-sectional areas have a greater potential to change the wave climate - which agrees with the findings of RPS (2005) concerning the alternative foundations considered for the London Array offshore windfarm – and, therefore, a larger potential to change the sedimentary environment in the near-field and, potentially, the far-field. However, the scale of these impacts should not be assumed for all offshore windfarms. The scales of Round 2 and Round 3 developments are much larger than Round 1 developments, and the scales of the infrastructure being deployed are also much larger.

Nearshore sediment impacts: offshore windfarms

Monitoring of Round 1 offshore windfarms has found little evidence of nearshore sediment impacts at a number of sites including Scroby Sands (see Table 3), North Hoyle, Barrow and Kentish Flats (Anon. 1-4, dates unknown). Nevertheless, Cefas (2005) recommended that caution be taken when considering alternative foundation structures for offshore windfarms (i.e. GBS foundations) because larger cross-sectional areas have a greater potential to change the wave climate - which agrees with the findings of RPS (2005) concerning the alternative foundations considered for the London Array offshore windfarm – and, therefore, a larger potential to change the sedimentary environment in the near-field and, potentially, the far-field.

However, the scale of the impacts measured for Round 1 offshore windfarms should not be assumed for all offshore windfarms. The scales of Round 2 and Round 3 developments are much larger than Round 1 developments, and the scales of the infrastructure being deployed are also much larger. The potential for nearshore sediment impacts has been addressed by some EIAs for Round 2 offshore windfarms with the focus being on the potential for changes to sediment transport patterns associated with factors such as bed load (i.e. sediment on the seabed), suspended load (i.e. sediment in the water) and scour (i.e. erosion of sediment around offshore renewable energy structures on the seabed due to changes in the flow regime).

In relation to the potential for the London Array offshore windfarm to impact the sediment regime at the coast, RPS (2005) predicted that the project:

- would not significantly alter bed shear stress values (i.e. the threshold at which sufficient energy occurs at the seabed to mobilise sediment) to the extent that a significant increase or decrease in the amount of transport would be expected as a result of changes to bed load
- would not significantly alter hydrodynamic and wave regimes to the extent that they would cause a change to sediment transport rates or pathways along the Essex and north Kent coasts.

RPS (2005) also predicted the volumes of sediment that could be scoured from different foundations.

- scouring around monopile foundations would create truncated cone-shaped scour holes with maximum depths between 5 and 7.2 metres and would erode 1,222m^3 of sediment
- scouring around tripod foundations would create scour holes with maximum depths of between 7 and 10.5 metres and would erode between 5,993m^3 and 11,366m^3 of sediment
- scouring around GBS foundations would create scour holes with maximum depths of between 5.4 and 13.5 metres and would erode between 5,089m^3 and 12,724m^3 of sediment.

Under the scenario for GBS foundations, RPS (2005) predicted short-term increases in the concentrations of suspended sediments of between 50 and 500 milligrammes per litre. This change to water quality was predicted to occur mainly in the near-field and against baseline concentrations of 150 milligrammes per litre at the water surface and 100 to 1,000 milligrammes per litre above the sea bed. Impacts were not predicted in the far-field well beyond the development site and/or near the coast.

Nearshore sediment impacts: offshore wave farms

The results of computational modelling for the Wave Hub project (Halcrow, 2006) predicted changes in seabed bathymetry of between up to -0.2 metres and up to +0.2 metres at surfing locations along north Cornwall for the likely case and worst case scenarios for layouts of wave energy converters case and worst following surfing break changes, and concluded that changes of this magnitude would be “largely indiscernible against background sediment transport conditions and beach levels along the northern Cornish coast”.

Nearshore sediment impacts: offshore tidal stream farms

As for nearshore surfing wave impacts, there is little information available to review the potential for offshore tidal stream farms to impact on surfing break resources. During its EIA, MCT’s SeaGen demonstrator project in Strangford Lough, Northern Ireland was found not to have the potential to significantly affect sediment transport at its scoping stage largely due to the seabed comprising solid bedrock (Royal Haskoning, 2004) and, therefore, a more detailed assessment was not reported in the subsequent EIA process.

3.3 Impacts on surfing recreation

The quality and consistency of surfing waves are two of the most important factors influencing the experience and participation of surfing recreation. For example, some of the key concerns expressed by the surfing community during consultation about the Wave Hub project included the “direct impact on surfing by reduced inshore wave heights” and “effects of the devices on the wave period, which could lead to losses of the “clean” longer-period swells that surfers enjoy for their best surfing days” (ASR Ltd, 2007). Other studies have reported similar findings; for example

- “the number of surfing days (consistency) and wave quality are the two aspects most valued by surfers” (ASR Ltd, 2007)
- “the two most important factors affecting destination choice [of surfing tourists] were swell and wave consistency, and to surf uncrowded waves” (Hugues-Dit-Ciles et al, 2003)

The importance of surfing wave quality is also fundamental to the economic value of surfing. In their study on the potential contribution of marinas & watersports to increasing prosperity in

Cornwall, Arup (2001) highlight that improved surfing conditions are the largest single factor that would attract more surfing to Cornwall. Conversely, it is implicit that worsened surfing conditions would be the largest single factor that would reduce surfing recreation and its economic benefits.

The causes of impacts on surfing wave quality and consistency are the changes to the surfing wave and break resources described in Sections 3.1 and 3.2. Changes to the surfing wave resources include changes to the wave height wave period, wave power, and wave direction relative to the seabed contours. Changes to the surfing break resources include changes to the wave peel angle, wave breaking intensity, wave section length, and seabed contours relative to the wave direction. One or more of these changes could impact on surfing recreation by reducing the number of surfable days at a surfing break and/or location or a number of surfing breaks and/or locations in the affected area.

Since EIAs of offshore wind farms and tidal stream farms have generally not needed to consider impacts on surfing recreation, there is limited information to draw upon apart from studies for wave energy projects that, in the UK, are the Wave Hub project (i.e. Halcrow, 2006; Millar et al, 2006; ASR Ltd, 2007) and the Wave Dragon demonstrator project (i.e. PMSS, 2007). The impacts of these projects on surfing recreation have been summarised as follows:

- “There is little cause for concern that effects introduced by the Wave Hub will be felt by shoreline users of the sea.” (Millar et al, 2006)
- “With the WECs operating, the main potential impact is the effect on surf conditions due to the devices utilising wave energy and thereby reducing wave heights at the coast. The computer modelling undertaken to examine effects on wave climate predicted up to 5% and 11% magnitude reductions in typical small and big surfing wave heights for the example case and worst case scenarios for WEC layouts respectively. Surfing sites between Portreath and Penhale could be affected but under most conditions it is unlikely that the impact will be noticed by surfers given its magnitude and the other factors that influence the quality of a surfable wave.” (Halcrow, 2006)
- “The Millar et al. study is substantially under-estimating the wave height shadow at the shoreline during best surfing times of narrow-band swell. The Halcrow modelling is closer to the likely outcome, particularly the monochromatic modelling. This occurs because Halcrow have considered the monochromatic conditions that are highly valued by surfers.” (ASR Ltd, 2007)
- “The predicted changes are potentially significant with respect to surfing, although surfers are generally more interested in the longer period swell that is less affected. As the loss of energy will be greater from the short period wind waves, then the waves arriving at the beach will be skewed towards longer period waves, giving slightly better surfing conditions albeit with slightly less energy. The impact of Wave Dragon on overall surfing conditions enjoyed at Marloes Sands will be minor, depending on location and

> increasing from west to east. The impact on specific conditions that may be of interest to the small number of local surfers who use Westdale Bay may also be minor (say an energy reduction of 5 to 10 percent for large swell waves that occur with an annual probability of about 2 percent of the time, but with an offsetting benefit of reduction in short period waves in favour of longer period swell).” (PMSS, 2007).

Overall, the findings of Millar et al (2006), Halcrow (2006) and PMSS (2007) provide some consideration of how changes to surfing wave and break resources affects surfing recreation, but more detail needs to be presented in future EIA work where impacts occur. For example, Halcrow (2006), Millar et al (2006) and ASR Ltd (2007) all report that surfing resource and recreation impacts would occur over a long stretch of Cornwall’s north coast including many good quality surfing locations, which suggests that larger wave farm developments could cause larger scale impacts to occur over a longer stretch of coast covering more surfing locations in one region. SAS believe that the potential impact on surfing recreation must be assessed in detail for each surfing location because many surfing locations offer more than one surfable break and a range of surfable waves that, for example, are different under different swell conditions, are suitable for surfers with different abilities, break over seabed features, provide different surfing conditions relative to wind direction and tidal state, etc. So, if surfing wave and/or break resources are changed or lost at one surfing location, several breaks and their different qualities could be affected. SAS also believe that a significant reduction and/or loss of surfing resources could impact the social side of surfing recreation. For example, in the water, the principal recreational issues relate to over-crowding (i.e. too many surfers competing for a limited surfing resources) and/or “localism” (i.e. a local surfing community’s protection of surfing resources from incoming surfers).

3.4 Summary

To date (i.e. 2009), research and EIA studies have concerned the impacts of offshore renewable energy developments that are considerably smaller in scale than future developments proposed under current seabed leasing rounds (i.e. Round 3 offshore windfarms and Round 1 wave and tidal stream farms) and have predicted negligible or minor changes to surfing wave resources.

However, with the benefit of detailed studies concerning different structures such as monopiles of wind turbines (RPS, 2005), the Wave Hub project (Halcrow, 2006; Millar et al, 2006; ASR Ltd, 2007) and the Wave Dragon demonstrator (PMSS, 2007), it is clear that the increased scale associated with future offshore renewable energy development has the potential to impact on surfing resources and recreation. Accordingly, the key concerns for SAS include uncertainties about the following scenarios:

- If the Wave Hub project (rated up to 20MW) is predicted to cause wave height reductions of up to 13 per cent at some of the UK’s surfing locations along the north Cornish coast, what will be the (cumulative) impact on wave heights at the surfing breaks along the Caithness coast as a result of the ongoing seabed leasing for wave and tidal stream projects (rated up to 700MW) in the Pentland Firth and surrounding waters?

- if wind farm foundations change in size and design (e.g. tripods, GBSs, floating systems), what will be the impact on wave energy transmission offshore and will this impact propagate as far as nearshore locations as reductions to wave heights at surfing breaks?
- if the Wave Hub project (rated up to 20MW) is predicted to affect surfing wave resources and recreation along a long stretch of north Cornwall's coast, what will be the geographical extent of impacts on a region's surfing recreation with the development of larger wave farms?
- if significant impacts occur with one development, how much more significant will be the cumulative impacts of two or more developments?
- if one or more of the above impacts occur, what will be the socio-economic impacts in terms of over-crowding and reduced expenditure in local and regional economies?

Part 4: Guidance on environmental impact assessment

This part of the report concerns the specific assessment of potential impacts on surfing resources and recreation and supports the overall EIA process applied to consenting arrangements for offshore renewable energy development. The guidance herein draws upon existing guidance widely used in EIA generally (e.g. DCLG, 2000; IEMA, 2004) and EIA for offshore renewable energy development specifically (e.g. Metoc, 2000; DTI, 2000; Cefas, 2004; DTI, 2005) to provide guidance focused on assessing impacts on surfing resources and recreation. Accordingly, this guidance reinforces best practice and promotes practical impact assessment methods without making the EIA process significantly more onerous.

4.1 Legal context

Consents for development

As of summer 2009, proposed deployments of most offshore renewable energy developments that will generate more than 1MW of electricity, including pre-commercial wave and tidal stream energy demonstrator devices, are likely to be subject to consents under the following pieces of legislation:

- Electricity Act 1989 (e.g. for energy generation)
- Town & Country Planning Act 1990 (e.g. for relevant onshore works)
- Coast Protection Act 1949 (e.g. for potential interference with navigation)
- Food & Environment Protection Act 1985 (e.g. for deposit of substances and articles in the sea).

Consenting under the Electricity Act can incorporate consent under the Coast Protection Act, and can include 'deemed planning permission' under the Town & Country Planning Act, and is determined by the Department of Energy and Climate Change (DECC). Consenting under the Food & Environment Protection Act and Coast Protection Act (outside of the Electricity Act) is determined by the Department for Environment, Food and Rural Affairs (Defra).

Environmental impact assessment

Applications for the principle consents may be the subject to EIA in accordance with the requirements of European Directive 85/337/EEC as amended by Directive 97/11/EC (the EIA Directive). As noted by the DTI (2000), "The purpose of the EIA Directive is to ensure that the competent authority [i.e. DECC or Defra], in relation to development that is likely to have significant effects on the environment, has appropriate information to enable it to come to a decision on whether or not to grant consent". The EIA Directive is transposed into UK legislation through various statutory instruments including the Electricity Works (Environmental Impact Assessment) (England and Wales) Regulations 2000 and the Marine Works (Environmental Impact Assessment) Regulations 2007. Where developments are the subject of EIA their consents applications need to be accompanied by a report known as an environmental statement (ES).

EIA process

The EIA process comprises a number of stages following the initial determination that a proposed development requires it (i.e. screening). The key EIA stages considered in this report are:

- scoping (see Section 4.2)
- baseline environment (see Section 4.3)
- impact assessment (see Section 4.4)
- mitigation (see Section 4.5)
- monitoring (see Section 4.6).

While the stages of the EIA process are largely undertaken chronologically, the EIA process is an iterative one and some aspects of it may require re-evaluation as new information becomes available (e.g. after consultation or survey) and is fed back into the process. The process requires and is facilitated by consultation. Consultation with surfing organisations and the local surfing community is recommended at all stages of the EIA process, and should be considered fundamental to a robust and transparent EIA process for developments that are likely to have significant impacts on surfing resources and recreation.

Recommendations

Recommendation 1: Cefas's (2004) EIA guidance with respect to EIAs for offshore windfarm developments should also be applied to EIAs for wave and tidal stream developments; particularly where this guidance concerns the assessment of impacts on coastal and sedimentary processes parameters.

4.2 Scoping

IEMA (2004) defined scoping as follows: "Scoping is the process of identifying the issues to be addressed by an EIA. It is a method of ensuring that an EIA focuses on the important issues and avoids those that are considered to be less significant".

To conduct the EIA process in accordance with the requirements of the EIA Directive and the guidance of IEMA (2004) and Cefas (2004), both the direct and indirect impacts of offshore renewable energy development need to be identified. In the context of surfing resources and recreation, the following direct and indirect impacts need to be identified during scoping:

- direct impacts are most likely to be identified as the impacts on the surfing resource both in terms of the surfing wave resource (i.e. changes to wave height, period and direction; see Section 3.1) and the surfing break resource (i.e. changes to to bathymetry, seabed slope, sand bars, etc; see Section 3.2)
- indirect impacts are most likely to be identified as the impacts on surfing recreation (i.e. changes to surfing activities and associated socio-economic activities such as surf-related retail businesses, surfing competitions, surf tourism, etc; see Section 3.3) as a result of direct impacts on surfing resources.

Construction phase impacts

Although there is limited potential for the construction phase of offshore renewable energy developments to significantly affect surfing resources and recreation, the potential for impacts needs to be assessed during scoping. In particular, scoping needs to consider whether construction at nearshore and onshore locations (e.g. the cable route and shore connection point, stockpiles of construction materials) will coincide with the location of surfing recreation and, if so, needs to consider whether there be a potential impact on surfing recreation (e.g. loss of access to the beach and/or water, health and safety risk, reduced water quality). For example, in relation to the Wave Hub project, Halcrow (2006) identified that cable-laying across the beach and in the near-shore water area would require an area of Hayle beach to be cordoned such that, if necessary, alternative access points to the beach would need to be provided in order that access is not restricted and that part of the beach would be unavailable for a short period of time when the cable is to be installed.

Scoping also needs to consider whether construction at offshore locations will affect surfing resources and recreation. Typically, there is likely to be some construction equipment working in the sea to install devices and their foundations, mooring systems, cables, scour protection systems, etc. For example, wind turbines are typically installed one at a time using piling equipment operated from jack-up platforms, wave and tidal stream devices are towed into place by vessels, and cables are laid from specialist vessels. The small physical magnitude of construction equipment has little potential to affect the wave resource and beach resource, which has led impact assessors (e.g. RPS, 2005) to predict that changes to baseline environmental conditions are likely to occur temporarily and only in the immediate near-field of the construction works and, therefore, it is unlikely that construction will significantly affect wave resources, beach resources and surfing recreation.

Post-construction / operation phase impacts

The main potential for impacts on surfing resources and recreation is likely to arise during the post-construction / operation phase of an offshore renewable energy development. It is during this timeframe that the structures have the most potential to directly affect the surfing wave and break resources and, as a consequence, indirectly affect surfing recreation.

While more information is provided in Sections 3.1 to 3.4, the potential for offshore renewable energy development to have a significant impact on surfing wave resources depends principally on two factors:

- a development's potential to change the baseline wave climate offshore to the extent that wave breaking characteristics are changed where surfing takes place
- a development's potential to change the baseline hydrodynamic and sedimentary regimes offshore and in the coastal zone to the extent that the seabed's bathymetry and morphological features are changed where surfing takes place.

Decommissioning phase impacts

As identified for the construction phase, although there is limited potential for the decommissioning phase of offshore renewable energy developments to significantly affect surfing resources and recreation, the potential for impacts needs to be assessed during scoping. Again, scoping needs to consider whether decommissioning at offshore, nearshore and onshore locations will coincide with the location of surfing recreation and, if so, needs to consider whether there be a potential impact on surfing recreation. Decommissioning is, in essence, construction in reverse and typically, there is likely to be some construction equipment working in the sea to remove devices and their foundations, mooring systems, cables, scour protection systems. Accordingly, the potential for significant impacts to surfing resources and recreation is similar to the construction phase.

Post-decommissioning phase impacts

For the most part, it can be assumed that most devices and their foundations will either be fully recovered or remain buried below the seabed and, therefore, it is unlikely that any features present post-decommissioning will affect surfing wave resources, break resources and surfing recreation. Nevertheless, the impacted surfing wave and break resources will adapt to the environment where the structures are no longer in place to affect the wave climate and sediment regimes. To a certain extent this scenario may see a reversal of the impacts that would occur in the post-construction / operation phases.

Impact identification

Scoping should initially identify whether a proposal for offshore renewable energy development has the potential to interact with and impact on surfing resources and recreation. This requires some initial analysis of available information and professional judgement that, at its most basic level, should start with a consideration of a development's proposed offshore location in relation to surfing locations in the relevant coastal areas. [Note: maps of the major surfing locations around the UK's coast are provided in Annex 1, courtesy of ***The Stormrider Guides*** and copyright of Low Pressure].

Consultation should be undertaken with SAS, the BSA and the local surfing community as early as possible in the scoping process. Although consultation during scoping tends to focus on the views of statutory authorities and agencies, "the concerns of those that are likely to experience the environmental effects are important". Consultation would quickly identify whether surfing organisations and the surfing community have concerns about the potential for an offshore renewable energy development to affect their interests.

Impacts on surfing resources and recreation are most likely to occur where offshore renewable energy development interrupts wave climates, particularly where the dominant wave direction is onshore and surfing locations are in the lee of the interrupted waves. Known examples include:

- ongoing development of the Wave Hub project and any additional wave farm development in this area would interrupt the transmission of waves propagating to surfing locations along the coast of north Cornwall (i.e. Gwithian, Porthtowan, Perranporth, Fistral, Newquay Bay, Watergate Bay, Constantine and Harlyn Bay; see Maps 2-4, Annex 1)
- ongoing development of the Wave Dragon demonstrator would interrupt the transmission of waves propagating to surfing locations along the coast of Pembrokeshire (i.e. Marloes Sands and Westdale Bay; see Map 8, Annex 1)
- future offshore wind farm developments in the Round 3 seabed leasing zones situated in the Bristol Channel, off the Dorset coast to the west of the Isle of Wight (see Figure 11) would interrupt the transmission of waves propagating to surfing locations along the coasts of south Wales (e.g. Llantwit Major; see Map 6, Annex 1) and the Isle of Wight (e.g. Freshwater and Compton; see Map 22, Annex 1) respectively
- future wave and tidal stream energy developments in the Pentland Firth seabed leasing area (see Figure 10) would interrupt the transmission of waves propagating to surfing locations along the coasts of Sutherland, Caithness (i.e. Brimms Ness, Thurso East) and the Orkney Islands (see Maps 13-16, Annex 1)
- future offshore wind farm developments in the Scottish exclusivity seabed leasing zones situated off the coast of Tiree would interrupt the transmission of waves propagating to surfing locations along the coast of Tiree (e.g. see Map 11, Annex 1).

Figure 10 Pentland Firth seabed leasing area (source and copyright: Crown Estate)

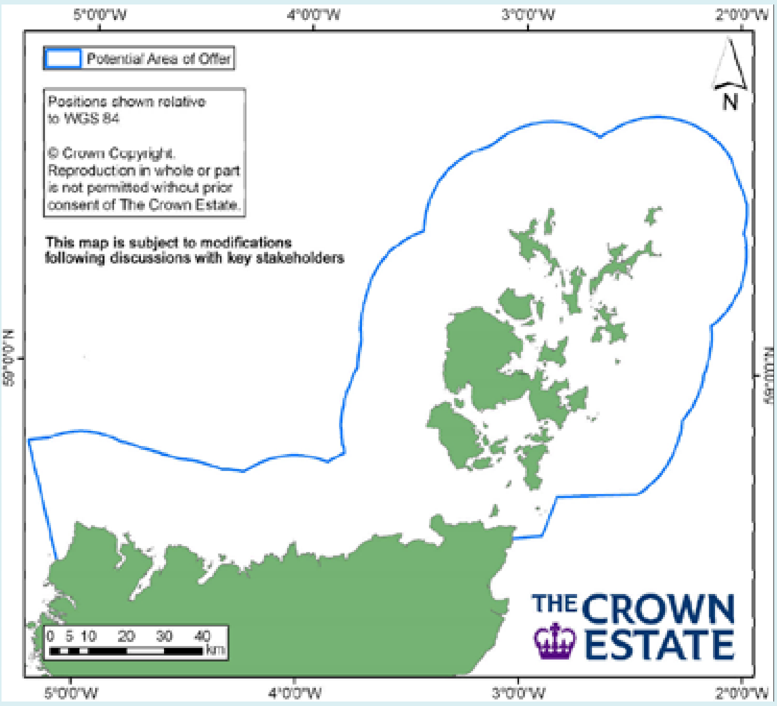
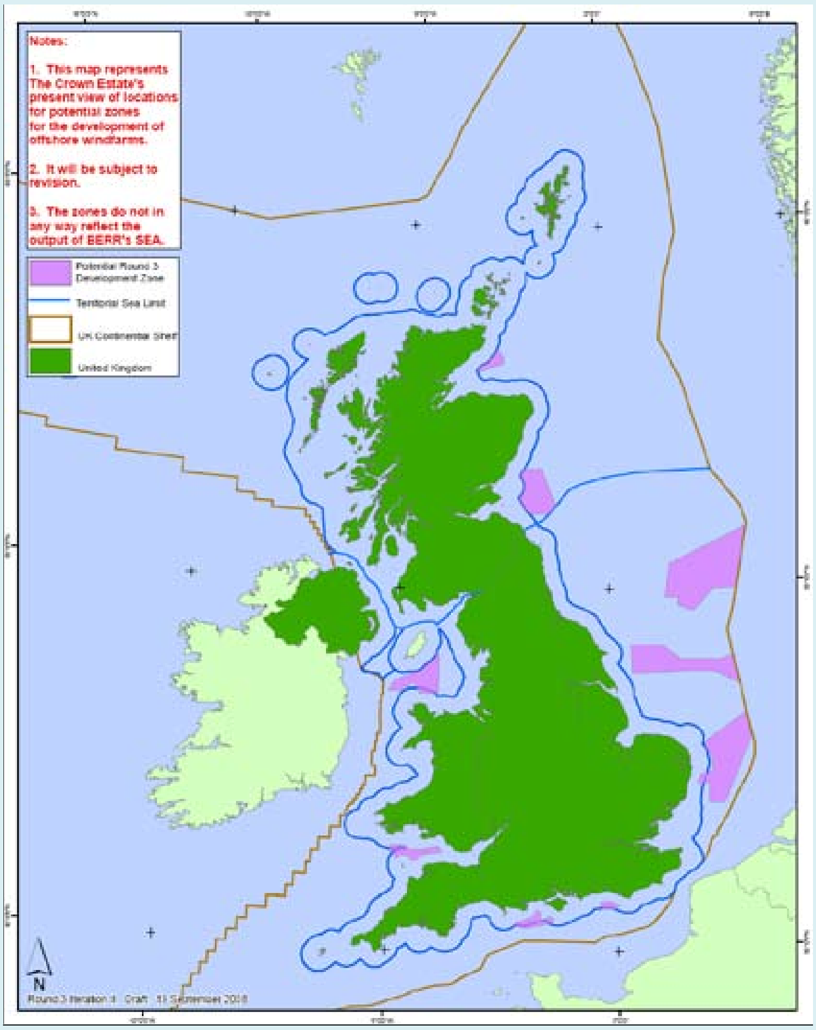


Figure 11 Round 3 indicative economic potential for offshore wind (source and copyright: Crown Estate)



Impacts on surfing resources and recreation are also likely to occur where tidal and wave power is potentially exploitable for offshore renewable energy development. Reference to the *Atlas of UK marine energy resources* (ABPmer, 2008) suggests that future examples may include:

- wave farm developments around the coasts of south-west England (west and north Cornwall), south Wales, Pembrokeshire, the Inner and Outer Hebrides, and north Scotland including Sutherland, Caithness and the Orkney Islands.
- tidal stream farm developments around the coasts of south-west England (north Devon), south England (Dorset and the Isle of Wight), south Wales, Pembrokeshire, north Wales (Anglesey), Northern Ireland (Londonderry and Antrim), the Inner Hebrides, the Orkney islands and the Channel Islands.

If initial analysis and consultation identifies the potential for an impact, scoping should involve more detailed consultation and analysis to identify how development could interact with and impact on surfing resources and recreation by assessing whether the wave climate and hydrodynamic and sedimentary regimes would be affected. In terms of consultation, SAS recommends that a small focus group be created at this stage of scoping and be maintained throughout the rest of the EIA process. The focus group must be representative of the surfing community including surfing organisations such as SAS and the BSA, local surfers and other stakeholders including local businesses.

Cefas (2004) identify a number of 'coastal and sedimentary processes' parameters that should be considered in the EIA process. These are identified in the left hand column of Table 4. Examples of the relevance of these parameters to impacts on surfing resources and, indirectly, on surfing recreation are identified in the right hand column of Table 4.

Table 4 Relevance of EIA coastal and sedimentary processes parameters (Cefas, 2004) to surfing resources and recreation

Coastal and sedimentary processes parameter	Relevance to surfing resources and recreation
Sediments (e.g. composition, geochemical properties, contaminants, particle size)	Impacts on surfing break resource (e.g. changes to particle size = impact on beach slope and plunging wave quality) Impacts on surfing recreation (e.g. changes to particle size = impact on beach slope and plunging wave quality = indirect impact on surfing wave quality)
Hydrodynamics (e.g. waves, tidal flows)	Impacts on surfing wave resources (e.g. change to wave climate = impact on wave height) Impacts on surfing recreation (e.g. changes to wave climate = impact on wave height = indirect impact on number of surfable days, surfing wave quality, etc)
Sedimentary environment (e.g. sediment re-suspension, sediment transport pathways, patterns and rates, and sediment deposition)	Impacts on surfing break resources (e.g. change of bathymetry = impact on tidal range of surfable waves) Impacts on surfing recreation (e.g. change of bathymetry = impact on tidal range of surfable waves = indirect impact on number of surfable days, surfing wave quality, etc)
Sedimentary structures (e.g. channels, banks, large-scale bedforms, bioturbation, depth of mixed layers)	Impacts on surfing break resources (e.g. change of sand bar position = impact on surfable waves) Impacts on surfing recreation (e.g. change of sand bar position = impact on surfable waves = indirect impact on number of surfable days, surfing wave quality, etc)
Suspended sediment concentrations (SSCs)	Impacts on surfing recreation (e.g. change to SSC = impact on water quality at surfing locations)

In terms of analysis of potential impacts on surfing recreation, SAS suggests that at least the following criteria should be considered during scoping:

- surfing locations and breaks including their characteristics to identify the scale and nature of the surfing recreation available (e.g. spilling waves at shallow sloping beach breaks that are good for learners and surfing schools, plunging waves over reef breaks that are good for experienced surfers and competitions)
- surfing communities including local and visiting surfers and any social issues associated with surfing (e.g. over-crowding, education)
- surfing economics including local businesses related to and reliant on surfing (e.g. surf schools, surf hire outlets, surfing retail outlets, surf board manufacturers, accommodation, etc) and competitions (particularly those contributing to regional, national and/or international events and/or tours).

Recommendations

Recommendation 2: Scoping should identify potentially significant impacts on surfing resources and recreation at all stages of an offshore renewable energy development, recognising that these may be both direct and indirect impacts.

Recommendation 3: A small surfing focus group representative of the surfing community should be created at the scoping stage and be maintained throughout the rest of the EIA process, and should include surfing organisations such as SAS and the BSA, local surfers and other stakeholders including local businesses.

4.3 Baseline environment

The environmental baseline establishes the conditions against which changes due to development can be assessed. IEMA (2004) noted that “environmental studies will ultimately underpin the quality and validity of an EIA. If the environmental baseline is poorly or inadequately considered, the EIA findings may lack robustness and be open to challenge, however well the potential impacts and mitigation measures have been researched. In some cases, poor understanding or appraisal of the baseline position could make an ES invalid”.

EIA guidance on offshore windfarm development by Cefas (2004) sets out the information requirements for establishing the baseline environmental conditions for coastal and sedimentary processes prior to assessing the magnitude and significance of environmental impacts (see Box 1). Although this guidance provides an initial inventory of the baseline conditions for wave climate and the hydrodynamic and sedimentary regimes influencing surfing resources, additional environmental baseline data is required to establish specific baseline conditions for surfing.

Box 1 Baseline environmental information requirements for coastal and sedimentary issues relating to EIAs of offshore windfarms (source: Cefas, 2004)

"In order to assess potential impacts the developer must first fully understand the natural physical environment of their site and the surrounding area, including:

- identification of processes maintaining the system, reasons for any past changes, and sensitivity of the system to changes in the controlling processes
- identification and quantification of the relative importance of high-energy, low frequency ('episodic' events), versus low-energy, high frequency processes
- identification of the processes controlling temporal and spatial morphological change (e.g. longevity and stability of bedforms), which may require review of hydrographic records and admiralty charts
- identification of sediment sources, pathways and sinks, and quantification of transport fluxes. [*Note: Any numerical models should be validated and calibrated, and should present field-data in support of site conditions, boundary conditions, complex bathymetry, flows and sediments, to include measurements of hydrodynamics, and suspended sediment, in order to demonstrate accuracy of model performance, and should include sensitivity analysis or estimate of errors in order to enable confidence levels to be applied to model results*.]
- identification of the inherited geological, geophysical, geotechnical and geochemical properties of the sediments at the site, and the depth of any sediment strata. [*Note: A sediment sampling campaign (including surface samples and cores) should have far-field spatial coverage and include the range of sedimentary environments, with consideration of the controlling hydrodynamic flows, sediment pathways and sites of particular interest*.]".

Surfing wave resources

In terms of surfing wave resources, baseline environmental conditions need to be established specifically for the wave height and period that is most relevant for surfing. SAS appreciate that the information necessary to do this may not be readily available so consultation with a surfing focus group (see Recommendation 3) is recommended. For example, in the case of the EIA of the Wave Hub project, a number of wave climate scenarios were identified through a combination of data assessment and consultation with SAS and the BSA (see Table 5).

Table 5 Offshore wave climate scenarios considered for the Wave Hub EIA (Halcrow, 2006)

Wave height (m)	Wave period (s)	Probability of occurrence
1	7	Average probability of occurrence of 38% in a particular summer (1 May until 31 August) (i.e. 45 days/122 days) Average probability of occurrence of 28% in any particular year (i.e. 100 days/365 days)
1.6	5.4	Mean wave conditions over the whole year
2	10	Average probability of occurrence of 8% in a particular summer (i.e. 10 days/ 122 days) Average probability of occurrence of 13% in any particular year (i.e. 48 days per year)
3	12	Average probability of occurrence of 3% in any particular year (i.e. 13 days per year)
4	14	Average probability of occurrence of approx 1% in any particular year (i.e. c.3 days per year)
4	16	Average probability of occurrence of 0.3% in any particular year (i.e. c.1 day per year)
10	12	1 in 1 year return period wave conditions

Further consultation then identified two wave height and period combinations to represent the wave climate that best reflected the baseline conditions important to surfers and surfing related economies. These were:

- small surfing waves experienced during summer when nearshore water recreation is important for surfboard rentals, wetsuit rentals, surf schools, etc over the peak tourist season (height = 1 metre and period = 7 seconds)
- large “classic” surfing waves occasionally experienced during autumn when swells originate from storm conditions over the mid Atlantic (height = 4 metres and period = 16 seconds).

Surfing break resources

Baseline environmental conditions for surfing break resources have been described briefly by the EIAs where surfing has been addressed. Descriptions have identified surfing locations and have provided little additional information other than that available in surfing guides. For example, in relation to the Wave Dragon demonstrator project, PMSS (2007) quoted the descriptions for Westdale Beach and Marloes Sands directly from www.surf-forecast.com.

In terms of surfing break resources, more detailed baseline environmental conditions need to be established specifically for the individual breaks and their wave characteristics that make the waves surfable and attractive for surfers (see Section 2.1). Again, SAS appreciate that the information necessary to do this may not be readily available so consultation with a surfing focus group (see Recommendation 3) is recommended. Where significant impacts are likely to occur due to changes to sedimentation, wave break characteristics and quality should be determined in line with baseline sediment transport patterns and measures of surfing wave quality including wave height, wave breaker type and wave peel angle. This may require original data collection and/or survey.

Surfing recreation

Baseline environmental conditions for surfing recreation have been virtually overlooked in SEAs and described very briefly by the EIAs where surfing has been addressed. While it is acknowledged that some of the regional sea areas covered by the Offshore Energy SEA are indeed offshore, Table 6 identifies the extent to which surfing is considered in the tourism and recreation annex to the draft Offshore Energy SEA Report (DECC, 2009) and thereby highlights the lack of attention surfing receives at a strategic level. Furthermore, in relation to the Wave Dragon demonstrator project, PMSS (2007) only noted “The British Surfing Association estimate that a total of up to 12,000 surfer days per year or average of about 32 per day throughout year (includes long and body boarding) participate in Pembrokeshire”.

Table 6 References to surfing recreation in the tourism and recreation appendix to the draft Offshore Energy SEA Report (DECC, 2009)

Regional sea	Reference to surfing
1	No reference
2	No reference
3	No reference
4	No reference
5	No reference
6	In relation to the whole region: “In general, there has been a decline in the number of visitors to traditional seaside resorts and growth in the number of people partaking in a wide range of land and water-based leisure activities including walking, golf, bird watching, yachting, sailboarding, angling, surfing and diving throughout the Region“ In relation to Wales: “Casual surfing, canoeing and wind-surfing take place from many of the Region’s beaches” In relation to the Isle of Man: “Other watersports practised around the Isle of Man include canoeing (common in Port Erin Bay), surfing (mostly at Bay ny Carrickey), windsurfing (Bay ny Carrickey, Castletown and Derbyhaven) and snorkelling”
7	In relation to Northern Ireland: “Other popular coastal recreational activities include golf, sea angling, swimming, surfing, canoeing, windsurfing and scuba diving”
8	No reference

In terms of surfing recreation, more detailed baseline environmental conditions need to be established specifically for the use of the breaks, numbers of surfers, crowding issues (see Section 2.3) and associated surfing related economic values associated with businesses, competitions, etc (see Section 2.4). Once again, SAS appreciate that the information necessary to do this may not be readily available so consultation with a surfing focus group (see Recommendation 3) is recommended.

Recommendations

Recommendation 4: Consultation should be maintained with a surfing focus group (see Recommendation 3) to facilitate baseline information collection about surfing resources and recreation.

Recommendation 5: At least two offshore wave climate conditions (in terms of wave height and wave period) should be identified (via consultation) to establish baseline surfing wave resources, and these conditions should be used in subsequent stages of the EIA process (see Recommendations 8 and 9).

4.4 Impact assessment

The assessment of main and/or likely significant impacts is the principal focus of the EIA process. The emphasis placed on this part of the EIA process is clearly recognised by regulators of offshore renewable energy development. For example, in relation to tidal stream and wave farm developments, the DTI (2005) noted “EIAs will need to be sufficiently robust and comprehensive to provide clarity on the likely impacts and the risks associated with them. In view of the current stage of industry development and the importance of marine renewable energy to future renewable energy generation and therefore the environment, it is essential that devices and their impacts are understood in a timely and efficient manner”.

In relation to impact assessment methodology, IEMA (2004) noted “the assessment stage if the EIA should follow a clear progression; from the characterisation of ‘impact’ to the assessment of significance of the effects taking into account the evaluation of the sensitivity and value of the receptors”, and Cefas (2004) advised “with knowledge of the site and its surroundings, informed by the above baseline assessment, the magnitude and significance of the impact of the development may be quantitatively and qualitatively assessed using hypothesis-driven investigation”.

Impact characterisation for surfing resources

The characterisation of impacts on surfing resources should take into account guidance in Cefas (2004). For example, in relation to offshore windfarm development, Cefas (2004) advised “assessment should specifically include an assessment of the…spatial design of the turbine grid array and the subsequent effect on the spatial distribution of wave patterns, tidal flows, and sedimentation (within the near-field), and additionally on wave direction and wave energy (at far-field and coastal sites)”. Although this guidance requires that impacts on the near-field and far-field wave climate and sedimentation be assessed, assessments need to be tailored towards surfing interests to adequately characterise impacts on surfing resources and recreation. Surfing communities will want to know, for example, the wave height and/or seabed morphology changes that a development will cause at their surfing breaks in order to inform their opinions as to whether such impacts are significant and acceptable.

In real life conditions, a whole spectrum of wave directions and periods are distributed about dominant values in each swell. In surfing terms, clean swell with clear lines of waves occurs when there is a narrow spectrum of wave directions and periods, while irregular swell occurs when there is a narrow spectrum of directions and periods clustered around the dominant values. The importance of the frequency (i.e. period) distribution is summarised by ASR Ltd (2007): “surfers greatly value monochromatic to narrow-banded spectral swell. The ‘messy’ (wide spectrum) sea is not as important to surfers, although they still ride waves in these conditions”.

Since computational modelling is typically used to measure changes and quantify impact magnitudes, it can be used to assess the wave climate that is of most interest to experienced surfers by modelling the impact on monochromatic waves and of general interest to all surfers by modelling the impact on spectral waves. As noted by ASR Ltd (2007) in relation to the EIA process for the Wave Hub project “by limiting the modelling to the part of the spectrum that is most important to surfers, the impact on surfing can be more effectively defined. That is, the monochromatic modelling shows the impact of the Wave Hub on the dominant part of the wave spectrum that is valued by the surfers, even if these waves are embedded within a sea of other waves. As such, the monochromatic modelling shows the effect on the main surfing waves in all conditions. While monochromatic conditions are not common along this coastline, the monochromatic modelling remains relevant to common conditions along the coast.”

As identified in Section 2.1, there are a number of surfing break characteristics that define the quality of a surfing location. Most surfers know the breaker type characteristics of their local or favourite surfing locations and tend to determine whether to surf on the basis of wave height on a particular day. Accordingly, SAS recommends that impacts on surfing wave resources be assessed primarily on the basis of changes to wave height at each surfing location.

Surfers would prefer impact assessments to assess changes to the maximum wave height on any given day at the surfing location(s) subject to an impact. This is not realistic and a statistical annual average for a surfing location is insufficient to assess an impact on surfing resources. Accordingly, SAS recommends that surfing wave height impacts be assessed for at least two offshore wave climate conditions (in terms of wave height and wave period) for each surfing location, thereby maintaining the scenarios established in Recommendation 5.

Characterising an impact on wave climate will be influenced by the wave energy transmission coefficient (or factor) used in computational modelling. This coefficient represents the residual amount of energy in a wave after it has passed through an offshore renewable energy development site. Choosing a representative coefficient to apply in computational modelling can be based on capture width (i.e. the length of wave crest absorbed by a structure) and appears to be problematical, especially for wave energy converter devices, due to a lack of knowledge and commercial sensitivity. ASR Ltd (2007) considered the energy absorption of the

Pelamis device - in terms of capture width relative to wave height and period - and noted that wave energy converter devices “are tuned to achieve maximum capture efficiency for the most common periods, which are around 7 s on this coastline. There is a sharp drop in absorption with both increased and decreased periods. For example, the absorption is typically reduced by a factor of around 4 between 7 and 11 s”. Accordingly, SAS recommends that absorption rates and wave transmission coefficients are chosen on the basis of at least two offshore wave climate conditions (in terms of wave height and wave period), thereby maintaining the scenarios established in Recommendation 5.

In terms of changes to sedimentation patterns at the breaks, impacts initially need to be assessed to predict whether they would be discernable against baseline conditions and particularly the variability that can be experienced at beach breaks due to sediment movements onshore, offshore and alongshore. If impacts are likely to be discernable, then further computational modelling should be undertaken to predict the changes to seabed morphology so an assessment can be made for impacts on the resulting wave breaking characteristics and associated wave quality.

Second-order impacts

SAS suggests that the characterisation of second-order impacts on surfing recreation has been inadequately assessed to date. For example, in relation to the Wave Dragon demonstrator project, PMSS (2007) assessed the impact on surfing in the following three sentences which insufficiently detail the magnitude of change (e.g. no quantification of change to wave height) and the sensitivity of the receptor (e.g. number of surfers and surf schools regularly using the breaks): “The direct impact on surfing has not yet been assessed. However, based on feedback from Surfers Against Sewage on the Wave Hub EIA, it is likely that any possible reduction in surf would not be noticeable at the beach. The device is positioned between Marloes Sands and Westdale Bay and it is envisaged that the vast majority of swells would pass through to Westdale unaffected and therefore little to no impact would be felt there. A greater impact may be noticeable at Marloes Sands but this is a wider beach which should reduce any issues”.

Impacts need to be characterised on the basis of changes to, for example, the use of surfing breaks, numbers of surfers, crowding issues, etc. One method for assessing this impact would be to use questionnaires and undertake a statistic analysis of the results. An approach using questionnaires has been reported by Corne (2009) in a study of effects of coastal protection and development on surfing. Questionnaires were made and undertaken by the Surfrider Foundation to gain information about “wave quality, crowd levels, stakeholder participation, and the economic importance of surfing to the local area before and after the construction of coastal protection”. An example of the questionnaire is appended to Corne (2009).

Impacts on surfing recreation also need to be assessed in terms of changes to economic values associated with surfing businesses, competitions, etc. This assessment should be made by applying standard economic assessment methods to provide measurements of change to parameters such as revenues and jobs.

Impact significance

RPS (2005) identified various insignificance criteria to initially assess whether the London Array offshore wind farm would have a significant impact upon the wave climate and hydrodynamic and sedimentary regimes in the near-field (see Table 7) and the far-field (see Table 8). These criteria provide a useful reference for assessing whether near-field and far-field impacts of offshore windfarms are significant or not.

Where impacts are significant, their significance is often assessed by cross-referencing the magnitude of environmental change (against baseline conditions) with the sensitivity of the receptor. For surfing wave resources, this could mean, for example, cross-referencing the magnitude change to wave height with the sensitivity of the surfing location. The sensitivity of a surfing location could be established with reference to its baseline surfing resource (e.g. wave quality, number of days with a surfable wave height) and recreation conditions (e.g. numbers of surfers, number and standard of competitions) and economic value (e.g. number of surfing related businesses and their turnover and number of employees).

The sensitivity of surfing resources could be measured by using particular surfing wave parameters such as those identified by Scarfe et al (2003) (i.e. wave height, wave peel angle, wave breaking intensity and/or wave section length). However, these measures only consider the physical aspects of surfing resources and do not take into account social and economic aspects of surfing recreation. Accordingly, SAS believes that further investigation is required to establish an acceptable methodology by which the sensitivity of UK surfing resources can be measured.

Table 7 Criteria for the initial assessment of ‘insignificance’ applied to various potential coastal processes changes in the near-field (source: RPS, 2005)

Regime	**Issue**	**Specific issue to be addressed**	**Criteria for ‘insignificance’**
Tidal	Changes to flows	Bifurcation of flows	Structures will inevitably lead to flow bifurcation. However, these changes would be expected to be localised and should be confined to within the wind farm site and a narrow strip outside the site boundaries. To consider the significance in more detail requires placing the changes to flows into the context of their implications for sediment transport. Therefore, changes to near-field flows are considered insignificant if (1) they do not alter the gross tidal residual circulation around banks that are important bank maintaining processes and (2) they do not lead to scour effects that are considered significant (see scour around structures below)
Wave	Changes to wave heights	Changes to wave transmission	As above, structures in the marine environment will inevitably lead to a change in wave transmission past the structure. However, these changes to waves would be expected to be localised. Therefore, if the changes to wave transmission do not translate to a significant change to the regional wave climate, then these changes are considered insignificant (see far-field changes to wave climate in Table 6)
Sediment	Scour around structures	Creation of scour holes	The turbine structure will also inevitably lead to a degree of scour (in the absence of scour protection). However, provided the scour holes created by each individual structure do not interact with adjacent scour holes then this can be considered to be insignificant, in the context of physical processes and the physical environment

Table 8 Criteria for the initial assessment of ‘insignificance’ applied to various potential coastal processes changes in the far-field (source: RPS, 2005)

Regime	**Issue**	**Specific issue to be addressed**	**Criteria for ‘insignificance’**
Tidal	Changes to flows	Direction / magnitude	No anticipated large scale alteration to tidal flow speeds and/or direction on a regional scale. Assessment to take into account the magnitude of baseline flows and the magnitude of the change with respect to these baseline flows
Tidal	Changes to flows	Tidal residuals	No anticipated changes to the direction and magnitude of residuals, relative to the baseline, that represent a switch in tidal dominance (i.e. the flood to ebb or vice versa) or alterations to gross residual circulations around banks, sufficient to affect bank maintaining processes
Wave	Changes to wave climate	Alteration to regime wave climate characteristics	No anticipated changes to the regional wave climate that would be expected to impinge upon other seabed uses / features or along adjacent coastline
Sediment	Increase in suspended sediment from foundation spill	Creation of plume	No anticipated increases in background suspended sediment levels with a duration and extent considered to impact upon seabed / coastal interests
Sediment	Increase in suspended sediment from foundation spill	Fate of sediment	No anticipated deposition of sediment on the seabed arising from foundation spill impacting upon seabed features / users, for example smothering of benthos, reduction in navigation depths
Sediment	Increase in suspended sediment	Impacts from cable laying (sediment disturbance)	No anticipated increases in background suspended sediment levels arising along the cable route due to the cable burial process with a duration and extent considered to impact upon other adjacent seabed / coastal interests
Sediment	Changes to existing transport pathways	Changes to bed load pathways	No anticipated alteration to a known bedload transport pathway that is likely to impinge on downdrift features or features affected by any newly created pathway. The direction and magnitude of the pathway to be considered where possible along with the sensitivity of the environment
Sediment	Scour	Creation of plume	No anticipated increases in background suspended sediment levels with a duration and extent considered to impact upon seabed / coastal interests
Sediment	Scour	Fate of scour material	No anticipated deposition of sediment on the seabed arising from scour around foundations impacting upon seabed features / users, for example smothering of benthos, reduction in navigation depths
Sediment	Interaction with other projects	Interaction of sediment plumes / hydrodynamics	Assessment of the potential for interaction of any sediment plume or predicted change to hydrodynamics arising from [other] activities. Considered insignificant if no anticipated interaction leads to a greater effect than would be reasonably expected from the individual activities not acting in combination

Recommendations

Recommendation 6: Consultation with a surfing focus group should be maintained so the surfing community's opinions on impact assessment methods and the assessed impacts can be fed back into the EIA process.

Recommendation 7: Impacts on surfing wave resources should be assessed using computational modelling of monochromatic waves and spectral waves to represent impacts on the wave resource under the most important surfing wave and real life surfing wave conditions respectively.

Recommendation 8: Impacts on surfing wave resources should be assessed primarily on the basis of changes to wave height at each surfing location for at least two offshore wave climate conditions (in terms of wave height and wave period), which should be consistent with the conditions established under Recommendation 5.

Recommendation 9: Impacts on surfing wave resources should be assessed on the basis of absorption rates and wave transmission coefficients at the development site for at least two offshore wave climate conditions (in terms of wave height and wave period), which should be consistent with the conditions established under Recommendation 5.

Recommendation 10: Impacts on surfing break resources should be assessed on the basis of discernible sedimentation changes and the effect this has on resulting wave breaking characteristics and associated wave quality.

Recommendation 11: Impacts on surfing recreation should be assessed on the basis of questionnaires and statistical analysis of the resulting information on criteria including wave quality, crowding levels and the economic importance of surfing to the local community.

Recommendation 12: Impacts on surfing related local economies should be assessed using standard economic assessment methods.

Recommendation 13: the sensitivity of surfing as an impact receptor should be made on the basis of its resources and recreation.

4.5 Mitigation

IEMA (2004) notes that mitigation facilitates the inclusion of the environment into a development's design process and can improve the chances of a development receiving consent in relation to its environmental acceptability. Early consideration of mitigation during the EIA process facilitates the integration of mitigation measures into a development's design.

A mitigation hierarchy should be applied when addressing options to offset significant environmental impacts on the basis that it is preferable to avoid impacts in the first case. If impacts cannot be avoided, then it is preferable to reduce impacts. If impacts cannot be avoided or reduced, then they have to be compensated for.

The preferred mitigation option is to avoid an impact. As identified by IEMA (2004), avoidance "implies the need for some level of redesign of the project". In the case of offshore renewable energy development, project redesign could require an alternative location, alternative array layout, alternative types of devices, alternatives types of foundations, etc. For example, Halcrow (2006) showed how different wave energy converter devices had different impacts on wave height reductions at surfing beaches along the coast of north Cornwall, and RPS (2005) showed how different turbine foundations had different effects on wave energy transmission.

Mitigation by reduction may also require the consideration of alternatives (e.g. alternative foundations) or the addition of mitigation measures (e.g. scour protection systems to reduce sediment erosion).

Compensation is a last resort mitigation measure to make a development environmentally acceptable. There is very little opportunity to compensate for the loss of a surfing resource and recreation at a surfing location, and so compensation should only be considered when avoidance and reduction measures have been ruled out on environmental, technical and economic grounds.

Artificial surfing reefs are the only compensation option of any substance, but the development of these structures is still in its infancy and the efficacy of those structures that have been built remains uncertain. LaTourette (2005) reported that many surfing NGOs believed that artificial surfing reefs should not be used as mitigation to offset an impact on an existing surfing break, and were concerned that development could be justified on the basis that "developers are able to offer an artificial surfing reef in exchange for the destruction of an existing [surfing] spot". SAS's opinion is that artificial surfing reefs are unlikely to offer an acceptable compensation for a significant impact on surfing resources and recreation.

Recommendations

Recommendation 14: Mitigation should be considered as early as possible in the EIA process and be revisited as necessary to ensure an iterative approach to determining the best practicable environmental option.

Recommendation 15: Consultation with a surfing focus group should be maintained so the surfing community is included with a consensus approach to determining acceptable mitigation measures.

Recommendation 16: Mitigation should be based on a hierarchical priority of avoiding and then reducing impacts. Compensating for impacts is unlikely to be acceptable and should be seen as a last resort for mitigation.

Recommendation 17: Developers should commit to mitigation to the extent that mitigation measures form part of the development proposed for consent and are, therefore, secured through consent conditions (or alternative legal agreements) to the extent that the developer is legally obliged to implement them.

4.6 Impact monitoring

For offshore renewable energy developments, monitoring is typically enforced as conditions attached to development consents to test the conclusions of the EIA process and to establish the actual impacts.

Reference to the licences issued under the Food & Environment Protection Act (see www.mfa.gov.uk), monitoring conditions have been attached to the licences for many of the Round 1 and Round 2 offshore windfarms and for the Wave Hub project. These licences contain monitoring conditions for various environmental parameters and include conditions relating to hydrodynamic and sedimentary regimes typically under the sub-heading ‘seabed morphology and scour’. For example, the licence for the Round 2 Greater Gabbard offshore windfarm requires “The Licence Holder must undertake two (one winter and one summer) high resolution swath-bathymetric surveys (including a pre-construction baseline) of the wind farm array and cable route to assess the extent of any changes to bedform morphology” (MFA, 2007).

To date, there has been no (perceived) need to monitor specifically for the actual impacts on surfing wave resources and recreation. However, given the uncertainties associated with impact assessments derived from computational modelling (e.g. ASR Ltd, 2007), monitoring should be undertaken and included within development consent conditions where significant adverse impacts on surfing resources and recreation are predicted.

Monitoring surfing resource impacts

An example monitoring programme for wave climate impacts was presented by ASR Ltd (2007) in relation to the Wave Hub project. In the absence of any other monitoring programme concerning the impacts of offshore renewable energy development on surfing wave resources, the programme proposed by ASR Ltd (2007) should be used as a starting point for joint consideration, evolution, agreement and adoption by developers, regulators and the surfing community.

ASR Ltd (2007) proposed the following 3 stage monitoring programme:

- Stage 1: wave measurements on the offshore and inshore sides of the Wave Hub
- Stage 2: wave measurements along a shoreward transect
- Stage 3: monitoring of the relative wave heights at critical surf breaks along the impacted shoreline as a function of offshore wave statistics (height, period, direction).

For stage 1, “wave recording instrument locations should be a transect (e.g. east/west), and about 2 km either side of the Wave Hub zone. The inshore instrument would be placed “downstream” relative to dominant wave direction of the first installed device or downstream of the region where most generators are deployed. Some preliminary monitoring of the upstream and downstream locations would be needed prior to device installation (e.g. 2-3 months) to gain baseline information and to cross-calibrate the instruments”.

For stage 2, “in addition to the instrument offshore of the Wave Hub, wave recording devices should be placed 2 km, 5 km and 10 km downstream of the Wave Hub along a transect agreed by stakeholders and consultants to be most appropriate and likely to show impact, e.g. predominantly east/west with some southerly rotation”.

For stage 3, “wave height recording instruments to be placed nearshore in depths of around 10-15 m at say 3 beaches, with at least one in the line of the direct shadow for the most common wave direction. An impact could be discerned in one of two ways by considering the ratio of inshore heights divided by the heights measured offshore of the Wave Hub as follows:

- knowing the relative heights at these beaches by early monitoring without the Wave Hub (e.g. 3-6 months prior), an impact could be discerned if this ratio changes after Wave Hub commissioning
- the ratio of heights at the nearshore instruments in and out of the shadow could be determined”.

The proposed monitoring by ASR Ltd (2007) is staged to avoid unnecessary expenditure: that is, stage 2 monitoring would be triggered if an insignificant impact cannot be confirmed after stage 1 monitoring, and stage 3 monitoring would be triggered if an insignificant impact cannot be confirmed after stage 2.

Monitoring surfing recreation impacts

As identified in Section 4.4, one method for assessing and, therefore, monitoring impacts on surfing recreation (by repeating the exercise) would be to use questionnaires as reported by Corne (2009).

As identified in Section 4.4, one method for assessing and, therefore, monitoring impacts on surfing related economics (by repeating the exercise) would be to use standard economic assessment methods.

Recommendations

Recommendation 18: In the absence of specifically designed and well-established methods, the monitoring of impacts of offshore renewable energy development on surfing resources, recreation and economics should be based on the findings of ASR Ltd (2007), questionnaires and economic assessment methods respectively.

Recommendation 19: Consultation with a surfing focus group should be maintained so the surfing community is fed back monitoring data and allowed to make comments about the outcomes.

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