doi:10.3723/ut.27.161 International Journal of the Society for Underwater Technology, Vol 27, No 4, pp 161–173, 2008

Environmental impact and appraisal – planning consent for the South West of England Wave Hub

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Abstract

Wave Hub is an innovative demonstration site for generation of wave energy located in the South West of England. In simple terms, Wave Hub consists of an offshore electrical 'socket' to connect arrays of wave energy converters to the national grid via undersea cables, allowing technology developers to demonstrate and monitor the operation of their devices in real sea conditions. A key element in the development of the proposed Wave Hub was to gain consent from the relevant UK regulatory bodies. This paper describes the process for the consent application followed and highlights the main issues encountered during the preparation of the environmental studies to support the application, and subsequent discussions with regulators and stakeholders.

Keywords: consenting process, environmental impact assessment, hub, wave energy

1. Introduction

The South West of England Regional Development Agency (SWRDA) is developing the Wave Hub project, a 20MW demonstration site which will provide the electrical infrastructure necessary to connect wave energy converter (WEC) device arrays to the national grid via a dedicated undersea cable.

Wave Hub aims to facilitate WEC development through the final demonstration and pre-commercialisation stages, by allowing developers that have proven prototypes to install, operate and monitor commercial-scale WEC arrays in realistic offshore marine conditions over a number of years. Wave Hub will, therefore, perform the function of a WEC proving zone for the efficient delivery of power derived from wave energy. In this context, Wave Hub will complement other existing initiatives, such as the New and Renewable Energy Centre (NaREC) and the European Marine Energy Centre (EMEC), for the development of wave energy in the UK.

Wave Hub will support the UK government's energy policy by contributing towards the UK's drive to meet the challenges and achieve the goals of the new energy policy, including a 60% reduction in carbon emissions by 2050. In addition, Wave Hub will support the southwest region's commitment to encouraging technologies for renewable energy generation that will contribute to the region's renewable energy target of 11–15% of electricity production by 2010 (RegenSW, 2003).

A key element in the development of Wave Hub was to gain consent from the relevant regulatory bodies to allow construction and operation of the proposed scheme. Due to the nature of the project, the diversity of WEC devices likely to be deployed at the site (currently unknown) and the early stages of development of the technology, gaining a full understanding of the likely environmental impacts of the development to support the consent application proved to be challenging. Securing consent for the proposed Wave Hub project could be critical to the development of the marine renewables industry in the UK, as it would set a precedent for future commercial marine developments. For this reason, care was taken to follow best practice.

This paper describes the methodology followed in the consent application for Wave Hub and outlines the main issues raised during the preparation of the environmental studies to support the application and the subsequent consultation process. Section 2 provides an overview of the project, followed by a summary of the legal framework and requirements for consent application for marine renewable projects in the UK in Section 3. The scope and main results of the Environmental Impact Assessment (EIA) undertaken as part of the consent application are then outlined in Section 4. This is followed by a brief description in Section 5 of the consultation process, highlighting the key issues raised by the various consultees. The paper concludes with a summary of the issues raised during the consent application process in Section 6.

2. Project description

2.1. Location

The South West of England is considered to have high potential for the generation of electricity from wave power mainly due to suitable wave climate, with less extreme conditions than in more exposed locations and sufficient calm periods for installation and maintenance; good accessibility to grid connection with adequate capacity; and existing marine facilities, strong supply chains and research capabilities.

In order to select a suitable site for Wave Hub, a careful and comprehensive screening exercise was undertaken as part of the technical feasibility study (TFS) of the project. As a result, the location of the Wave Hub deployment area was proposed approximately 10nm off St Ives Head (12nm off Hayle), on the north coast of Cornwall, in 50m of water depth (Fig 1).

The deployment area, within which the WEC arrays will be deployed and the subsea equipment will be installed, has a footprint of 4km × 2km and will be divided into four berths for deployment of four different types of WEC devices at any one time. The project will be granted by The Crown Estate a 25-year lease of the 8sq km area within which the devices will be installed, together with rights to lay the power cable within a defined corridor back to the shoreline.

The site selection was based on a number of physical, technical, environmental and economic factors, such as:

- Electrical connection availability and capacity
- Cable landing constraints
- Designated areas
- Jurisdictional constraints
- WECs operational requirements – wave climate and water depth
- Seabed conditions
- Navigational and fisheries interests
- Military exercise areas
- Technical and financial feasibility.

The proposed site location was further refined during the design and development phase to incorporate the results of a number of geotechnical and environmental surveys, as well as the outcome of extensive consultation with stakeholders. As a result of concerns raised by a number of navigational consultees regarding the risk that the initial proposed site might have posed to navigation, the proposed deployment area was moved approximately 4km northeast from the original location.

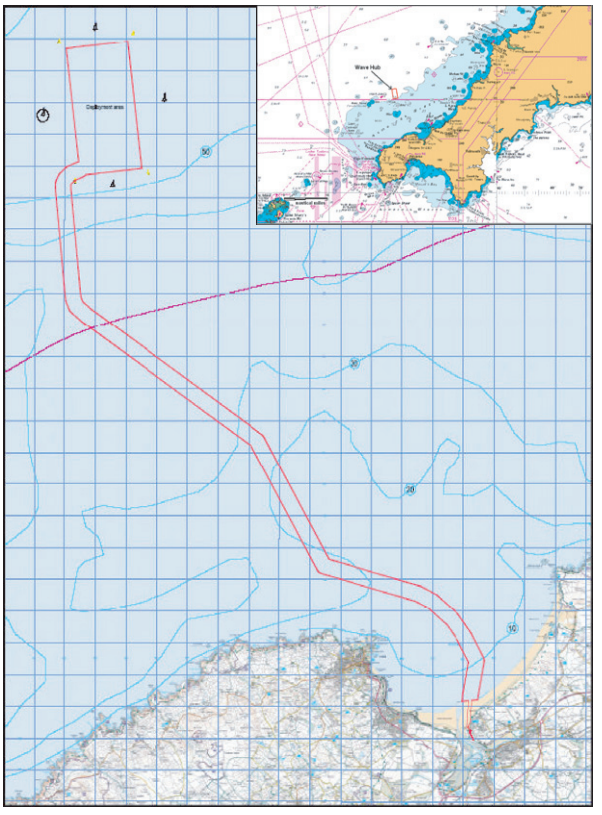

Fig 1: Proposed location of the Wave Hub deployment area

2.2. Outline design

The concept design of Wave Hub (Fig 2) as an underwater hub was developed during the TFS. The selection of this option was made after extensive assessment of a range of alternatives, such as platform and floating hub solutions, against criteria which included fit to functional specification, safety, security of assets, environmental impact, technical feasibility and cost.

The information provided by WEC developers to date on functional specification, operational requirements and power generation characteristics has been central in the design of the Wave Hub infrastructure. In line with this, the availability of proven technology was a key parameter in the selection of the subsea equipment in order to maximise system reliability.

The proposed main elements of the Wave Hub facility include offshore infrastructure fixed to the seabed comprising four underwater power converter units (PCUs) or transformer units, rated at 5MW each, connected back to a termination and distribution unit (TDU) via 24kV semi-flexible cables. Each WEC array will be directly connected to one of the PCUs, which will contain metering facilities in addition to the transformer and associated switchgear. The selection of four PCUs instead of a single 20MW transformer was made based on commercially available technology. The

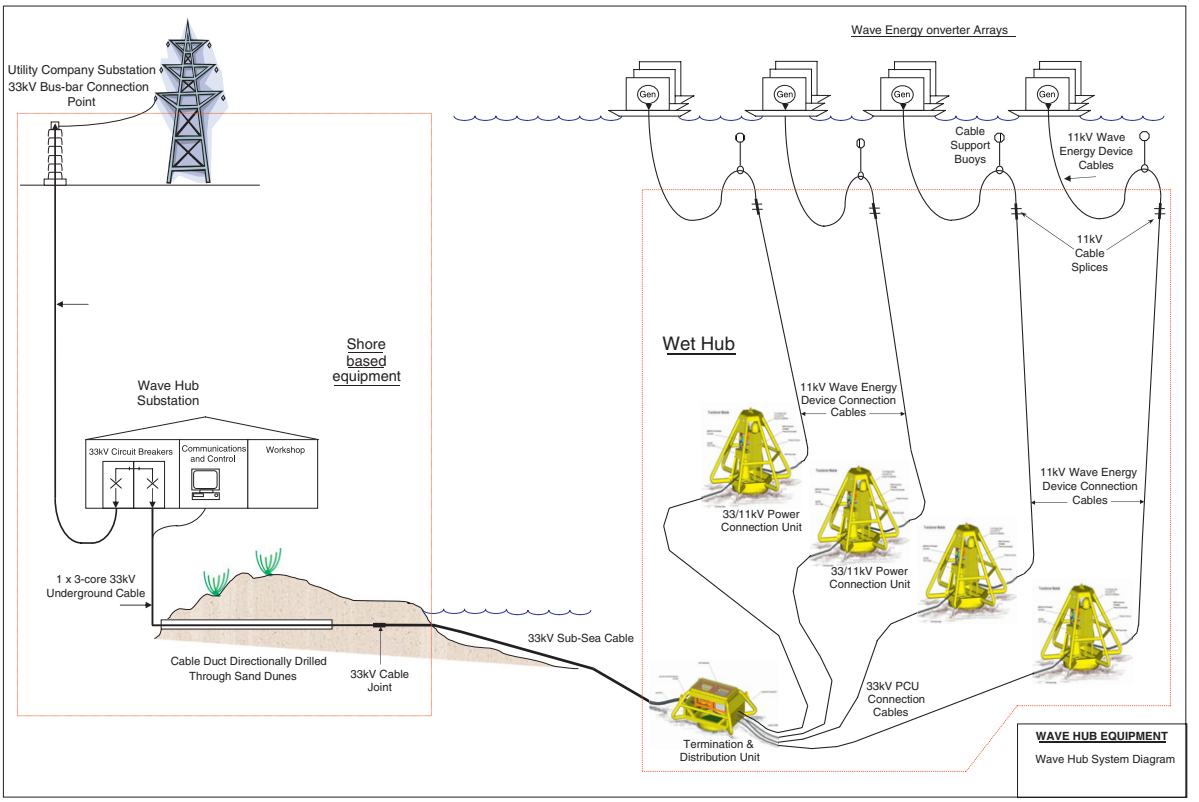

Fig 2: Wave Hub conceptual design

TDU is proposed to have four connections and a capacity of 20MW and will be an electrically passive element with no moving parts, in order to eliminate maintenance.

Another principal element to the facility is a single three-core 33kV/20MVA subsea power cable, which will connect the offshore infrastructure to the shore. The subsea cable will be approximately 25km in length, of which the seaward 17km will be laid on the rocky seabed, as the characteristics of the seabed in this section of cable corridor do not allow cable burial. Inshore, the remaining 8km of cable will be buried in silt and sand across the St Ives Bay before landing at Hayle beach. On land, the cable is proposed to be installed by directional drilling below the sand dunes system. Finally, onshore infrastructure at Hayle is necessary, comprising a new substation and associated operational facilities, which will include a transformer, power conditioning equipment, control room and metering facilities. The new substation will provide an intermediary connection point for the cable to the 33kV bulk electricity system operated by Western Power Distribution (WPD) at the existing Hayle substation complex, from where electricity generated at the Wave Hub can be passed to the local distribution system.

2.3. WEC devices selection

WECs do not form part of the Wave Hub infrastructure, although they will become an integral part of the scheme as end users of the facility. They are, therefore, material to the consent application and have been included in the description of the project and subject to impact assessment.

There is a wide diversity of WEC devices being developed at present. Broadly, WEC design can be divided into three main principles of energy capture – attenuators, terminators and point absorbers – and three locations: shoreline, near-shore and offshore. The current trend in WEC design is for offshore deployment in approximately 50m of water, mainly due to the higher annual wave energy available. Wave Hub has, therefore, been located to cater for these types of offshore devices.

Dialogue with the WEC developers active in the industry was undertaken from the early phases of the project, in order to identify their requirements and stage of development. Following this consultation, three companies were selected in December 2005 as cooperating partners for deployment in the first phase of the project on the basis that their WEC device designs were sufficiently advanced. Ocean Power Technologies Ltd will deploy up to 30 units of its 150kW PowerBuoy point absorber device. Fred. Olsen will connect up to two of its FO3 1.5MW point absorber device. Wave Wave, a consortium between E.On and Ocean Prospect Ltd, will use up to six units of the 750kW Pelamis attenuator technology of Pelamis Wave Power Delivery Ltd. A fourth developer, Australia-based Oceanlinx,

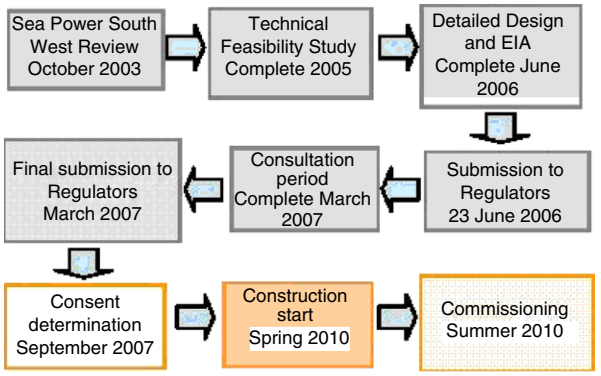

Fig 3: Wave Hub project timeline

was shortlisted in May 2007 to deploy its 1MW Oscillating Water Column device during the first phase of Wave Hub.

2.4. Project phases and timeline

The different stages of the project from the conceptual idea through to construction and commissioning are outlined in Fig 3.

3. Consent application

There are a number of consents under current UK legislation that might be required for offshore energy generation projects. However, there is not, as yet, a single, well-defined application route for consent of marine renewable developments, as some consent requirements are only applicable to certain types of projects, under specific circumstances, or to particular sites or part of a project.

3.1. Consent route

The selected consent route for the Wave Hub project was a composite consent application for the Wave Hub infrastructure and WECs, which requires, according to Bond Pearce (2005), consent from the Department of Business, Enterprise and Regulatory Reform (BERR) under the **Electricity Act (EA) 1989 – Section 36**. This is for a generating station with a capacity of more than 1MW within UK territorial waters adjacent to England and Wales out to the 12nm limit (and any Renewable Energy Zone designated by the UK government outside territorial waters under the Energy Act 2004).

Onshore, conditions would be attached to a deemed planning permission under Section 90 of the Town and Country Planning Act 1990 and enforceable by the local planning authority, Penwith District Council.

Additionally, consent is needed from the Department for the Environment, Food and Rural Affairs (DEFRA) under the **Coast Protection Act (CPA) 1949 – Section 34** for the construction, alteration or improvement of any works on, under or over any part of the seashore lying below the level of mean high water on spring tides (MHWS). The purpose of the consent requirement is to ensure that the works will not be detrimental to navigation.

A licence must be acquired from DEFRA under the **Food and Environment Protection Act (FEPA) 1985 – part II** for the placement of materials or structures in the sea/tidal waters below MWHS within UK territorial waters and the UK Continental Shelf. The purpose of this licence is to protect the marine ecosystem and human health, and to minimise interference and nuisance to other users of the sea and seabed.

The application under the Section 36 EA was made for the Wave Hub infrastructure and WEC devices to be deployed, as far as they fell in the consent envelope included in the application. On the other hand, DEFRA's FEPA licence will only apply to the Wave Hub equipment, but not to the individual WECs. WEC developers will have to make their own proportionate FEPA applications for their devices, in which they must prove that their proposals will fall within the envelope presented in the Wave Hub application in order to avoid further work to gain consent.

The application procedure for the three permits is alike and is prepared simultaneously, with the main requirement being to undertake an environmental impact assessment (EIA), which is submitted to the regulators in the form of an Environmental Statement (ES), as described in Section 3.2 below.

3.2. EIA requirement

The EIA Directive (85/33/EEC as amended by 97/11/EC) requires developers of projects that have, or are likely to have, a significant impact on the environment (listed in the Directive's Annex 1 and 2, respectively) to undertake an EIA. An EIA consists of a number of systematic and comprehensive studies aimed to provide the consenting authorities with the necessary information on the likely environmental impacts of a proposed scheme, to assist in the decision-making on the consent application. Although wave energy developments, such as Wave Hub, are not specifically listed in the Directive's annexes, regulations applying the EIA Directive in England and Wales – i.e. the Electricity Works EIA Regulations (Reg. 3) and the Harbour Works (Environmental Impact Assessment) Regulations 1999 (SI1999/3445) – require an EIA for all the energy projects that need application under Section 36 of the Electricity Act and the Coast Protection Act 1949 (Bond Pearce, 2005), respectively. Therefore, a legal requirement exists for Wave Hub to prepare an EIA.

Table 1: Application process time scales

Stage	Description	Guidance time scales	Actual time scales for Wave Hub
Pre-application	Project feasibility, EIA scoping, EIA studies	12–18 months	27 months
Application	Completion and submission of consent application	N/A	N/A
Consultation	Feedback from consultees and stakeholders, interdepartmental discussions	3 months	9 months
Determination	Grant of consent by regulators	2–3 months	6 months

Table 2: Examples of worst case scenarios for notional WEC devices

Impact/receptor	Worst case scenario	Reason
Coastal processes	4 large overtopping devices (Wave Dragon)	Predicted higher absorption factor
Seabed disturbance	120 small point absorbers (PowerBuoy)	Higher number of mooring lines
Landscape	12 FO3	Higher visibility above water surface

In addition, under the same UK regulations, an application under Section 36 of the Electricity Act, Coastal Protection Act and FEPA licence requires to be accompanied by an Environmental Statement (ES), which is a document that describes the proposed project, summarises the findings from the EIA studies and includes proposed mitigation measures. The ES is submitted to the regulators, together with licence/consent application form, and is the key element of the application for consent.

3.3. Application procedure for consent

The application for consent followed a rigorous process which included comprehensive environmental studies and continued consultation with stakeholders. This resulted in a lengthy process which reflected the complexities associated to the novelty of the project, as well as resource issues faced by the consultee organisations. Table 1 compares indicative time scales for the proposed key elements of the Electricity Act consent with the actual timelines for Wave Hub.

4. EIA methodology for Wave Hub

The EIA process for Wave Hub considered the likely impacts of the scheme through the construction, operation and decommissioning phases of the project. The main challenge in the preparation of the EIA for Wave Hub was to describe the development, particularly the notional devices to be deployed over the life of the scheme, with sufficient accuracy to enable its environmental impacts to be properly assessed.

In order to overcome this, the different environmental impacts were assessed for the worst case and the typical case scenarios, when applicable, based on the current state of WEC technology. This was done in order to establish impact thresholds for the different receptors and provide an envelope of potential environmental impacts. The worst case scenario for each receptor assumed the entire site was taken up by the type of WEC having the greatest impact on that particular receptor, while the typical cases assumed a mix of different WECs being deployed. Table 2 includes some examples of the worst case scenarios for a number of key receptors.

Various actions led to the preparation of the Wave Hub EIA, including:

- Environmental Scoping Study to determine the context and extent of the information to be covered by the EIA
- WEC assessment to collect sufficient data about the WEC devices from developers
- Surveys and specialist investigations to establish current baselines and assess likely impacts of the development on: coastal processes; water, sediment and soil quality; terrestrial ecology; ornithology; marine ecology; fish resources and commercial fisheries; navigation; landscape and views; cultural heritage and archaeology; noise and air quality and others
- Use of a stepped procedure to identify, predict and assess the environmental impacts, to devise impact mitigation measures where necessary, and to consider uncertainty about the impact assessment
- Consultation with stakeholders and interested parties to understand their opinions and share information and to gain their input into impact identification, surveys and specialist investigations.

The results of the assessment work were brought together in an ES, submitted to the regulatory

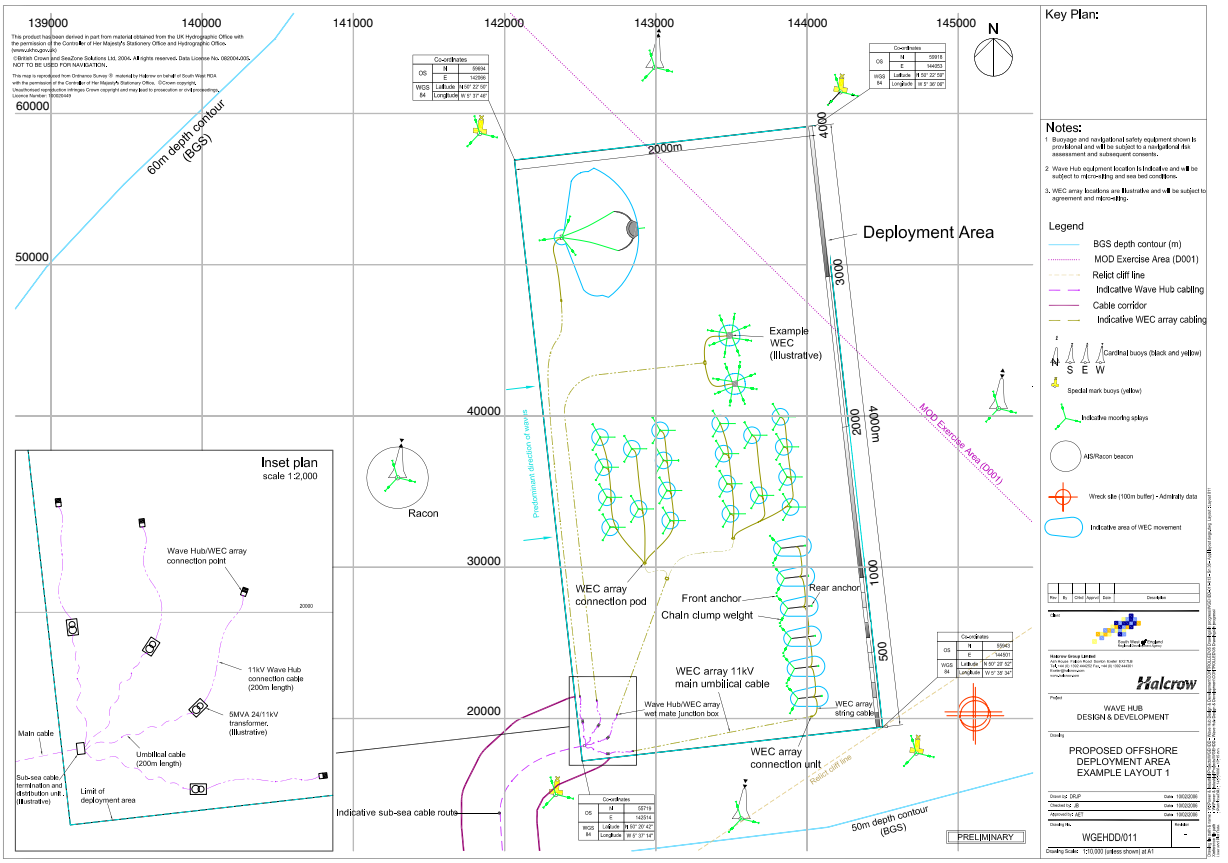

Fig 4: Typical WEC arrays layout

bodies in support of the consent application for the Wave Hub project.

4.1. EIA scoping

Scoping is a key stage in the EIA process and is defined by the European Commission (2001) as 'the process of determining the context and extent of the matters which should be covered in the environmental information to be submitted to a competent authority for projects which are subject to EIA' (Halcrow Group Ltd, 2006a).

The study undertaken to prepare the scoping report focused on the preferred options for the Wave Hub's site, landfall, cable route and design. The objectives of the study were: to provide an overview of existing conditions and constraints; to identify and assess the key potential environmental impacts; to identify the need for additional baseline data collection; to summarise the concerns of statutory consultees and other stakeholders and demonstrate how they should be addressed; and to identify the scope for further studies and EIA.

The study involved the collection of baseline data (including an ecological survey at the onshore site and a desk study on contamination issues at the onshore site), consultation with relevant organisations, an assessment of planning issues and an assessment of potential environmental impacts based on the findings of the data collection and consultation. Requirements for mitigation measures and monitoring were also identified.

4.2. Outline EIA studies and results Coastal Processes (Halcrow Group Ltd, 2006b)

Numerical modelling was undertaken to predict the potential impacts of operational WEC devices to be deployed at Wave Hub on the wave regime. MWAVE, a robust and industry-recognised modelling package, was used for the study and was calibrated using 13 months of monitored wave data (from January 2005 to April 2006) and 17 years Met Office wave model data.

Based on the understanding of the latest state of WEC technology, two layouts were modelled to represent the theoretical worst and likely impacts on the wave regime:

- Worst case scenario, consisting of a layout of four large overtopping devices – this layout scenario is a conservative approach which provides a worst case scenario in terms of impacts on wave regime
- Typical case scenario, comprising a combination of WEC devices at each berth.

Model scenarios were discussed and agreed with surfing stakeholders throughout the modelling process. An example of a typical layout is shown in Fig 4.

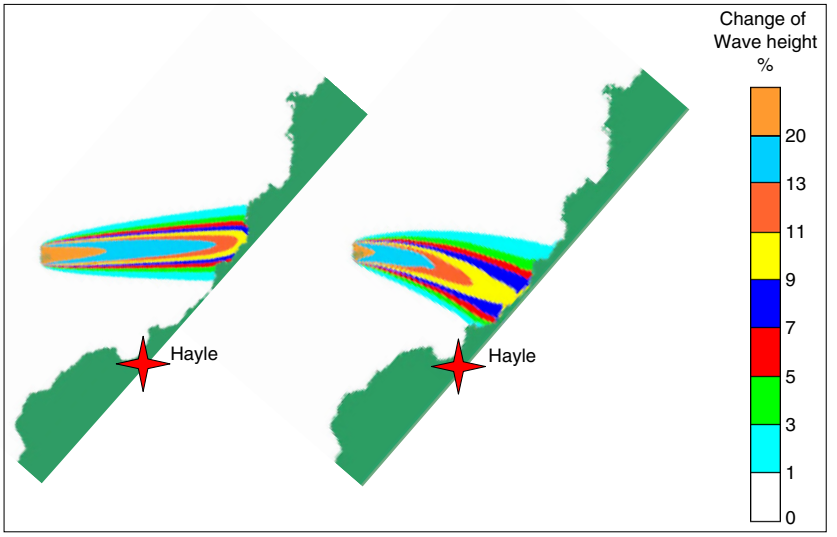

Fig 5: Changes under worst case WEC layout scenario to wave heights during small (left) and big (right) wave surfing conditions

Table 3: Predicted impacts on wave climate

		Typical case scenario	Worst case scenario
Spectral waves		0–3%	0–5%
Monochromatic waves	'Small' surfing waves (Hs = 1m, T = 7s)	0–5%	0–11%
	'Big' surfing waves (Hs = 4m, T = 16s)	0–5%	0–11%
	Other surfing waves (Hs = 2m, T = 4s)	0–7%	0–13%

The modelling focused on monochromatic waves (theoretical waves presenting constant height and period), as monochromatic to narrow-banded spectral swells are the preferred conditions for surfing. Modelling of spectral waves was also carried out in order to assess the impact of the WEC devices on typical swell conditions in the area. The model-predicted impacts on wave height are summarised in the Table 3, and changes under worst case WEC layout scenario to wave heights are shown in Fig 5.

From the sediment modelling undertaken, the impacts of the WEC devices on sediment transport are predicted to be limited (less than 0.2m in beach levels during extreme storm events) and confined to small areas near the shore. This is minimal when compared to current typical seasonal and temporal changes to beach levels (up to 1.8m variation in places following severe storms).

4.2.1. Marine ecology

Baseline surveys for intertidal and subtidal ecology were undertaken to determine the biological communities present. The intertidal survey found that the majority of the intertidal area comprises barren or amphipods dominated mobile sand shores (EMU Ltd, 2005), while the subtidal surveys found very diverse communities associated with the sand, pebble and rocky seabed (Fugro Survey Ltd, 2005; Precision Marine Survey Ltd, 2006). In addition, the potential impact of the Wave Hub's infrastructure on marine mammals (e.g. dolphins, porpoises) and elasmobranchii (e.g. species sensitive to electromagnetism such as sharks and rays) was assessed through desk-based studies and marine mammal surveys. This work revealed that the offshore area is most important for basking sharks and bottlenose dolphins.

Disturbance to seabed ecology is predicted to mainly occur due to the placement of infrastructure on the seabed. However, the works will be of low impact, short duration and with a relatively small area of seabed being affected. In the longer term, effects on subtidal ecology are predicted to be negligible. The most notable impact would be associated with the use of rock dumping as a cable protection measure. However, it is planned to keep the requirements for rock dumping to a minimum and only as the last resource to mitigate cable spanning (Halcrow Group Ltd, 2006c).

The main potential impacts on marine mammal and elasmobranch species relates to underwater noise that might be caused if pile driving is required during installation (e.g. for needed installation of the WECs mooring anchors on the seabed and navigation aids), noise caused by the operational WECs and electromagnetic fields emitted from the subsea cable (Halcrow Group Ltd, 2006c). It was found that:

Table 4: Results of generic Wave Hub navigational risk assessment (as collision/year)

		Current	With Wave Hub	Change
Vessel-to-WEC	Passing powered	N/A	5.6E–03	5.6E–03
	Passing drifting	N/A	2.7E–04	2.7E–04
Vessel-to-vessel		1.3E–02	1.1E–02	−2.4E–03
Total		1.3E–02	1.7E–02	3.5E–03

- Species should move away from underwater noise sources, but no effect on population levels was predicted given that any noise disturbance will be short-term, lasting for the duration of the piling.
- There is little empirical evidence of operational noise generation from the WECs, although it is expected that levels would be significantly below the threshold at which noticeable effects on marine mammals would arise. Nevertheless, some monitoring was recommended given the uncertainty of this prediction.
- The zone of influence of any electric field is relatively localised to the route of the subsea cable along the seabed, so pelagic species such as basking sharks should be unaffected, while benthic species such as rays may be attracted to the cable. No effect on population levels is expected, however, since damage to individuals should not occur. Studies undertaken on electromagnetic fields for offshore wind farms (OWFs) to date are inconclusive, but from results to date it is predicted that they would be unnoticeable for the Wave Hub subsea cable due to its small capacity.

4.2.2. Fish resources and commercial fishing

The existing fish resource conditions were established through four multi-gear fishing surveys to identify the seasonal importance of the area for fisheries. This information was supplemented with a commercial fisheries study, which collated information from various sources (e.g. fish landing statistics, fisheries surveillance data, academic studies, previous fisheries reports) and involved extensive consultation with local fishermen.

The studies concluded that the sea area in and around the Wave Hub deployment area is of most importance for potting (e.g. crab and lobster), with a range of species targeted by trawling in the wider area. A key component of the commercial fishery is the summer spider crab fishery (EMU Ltd, 2006).

One of the main effects of Wave Hub on fishing activity is predicted to be (Halcrow Group Ltd, 2006a,b,c) short-term interference with fishing activity (e.g. navigation of fishing vessels) due to vessels working on and servicing Wave Hub, which will be mitigated through navigation measures, Notices to Mariners, liaison with local fishermen and other measures.

Additionally, there will be potential interference of fishing gear (e.g. snagging) with to the subsea cable, which is proposed to be mitigated by minimising cable spanning applying a 'avoid-reduce-remedy' approach, and through appropriate marking of the cable position on hydrographic charts and update information concerning the cable's position on the seabed.

Finally, exclusion of fishing activity from the deployment area and safety zones around the WECs will affect the fisheries, potentially displacing established fishing grounds and adding pressure to neighbouring fishing areas, particularly for potting. This was found to have a potential moderate adverse impact on a small number of fishermen. No mitigation measures are proposed since the exclusion of vessels will be a matter of law. Prevention of fishing was expected, however, to benefit fish resources within the area in which fishing is excluded, and this has the potential to benefit fish resources outside the safety zones.

4.2.3. Navigation

Two vessel traffic surveys and a navigation risk assessment were undertaken to assess the impacts of the Wave Hub's deployment area on commercial, recreational and fishing traffic (Table 4). The navigation risk assessment was undertaken based on the guidance provided by the Maritime Coastguard Agency (MCA) Marine Guidance Note 275 (2004) and DTI methodology for assessing the marine navigational safety risks of offshore wind farms (2005). It involved a detailed computer modelling of the risk of collisions between vessels and with WEC devices as a consequence of the presence of Wave Hub. The study was supplemented by extensive consultation with navigational stakeholders.

The traffic survey concluded that the most frequent use of the area is by commercial cargo vessels. Six shipping routes between the Traffic Separation Scheme (TSS) off Lands End, the Bristol Channel, Milford Haven and The Smalls TSS were identified as passing in the vicinity of the study area. Two particular opposing routes, from the TSS off Lands End to the Bristol Channel and from the Bristol

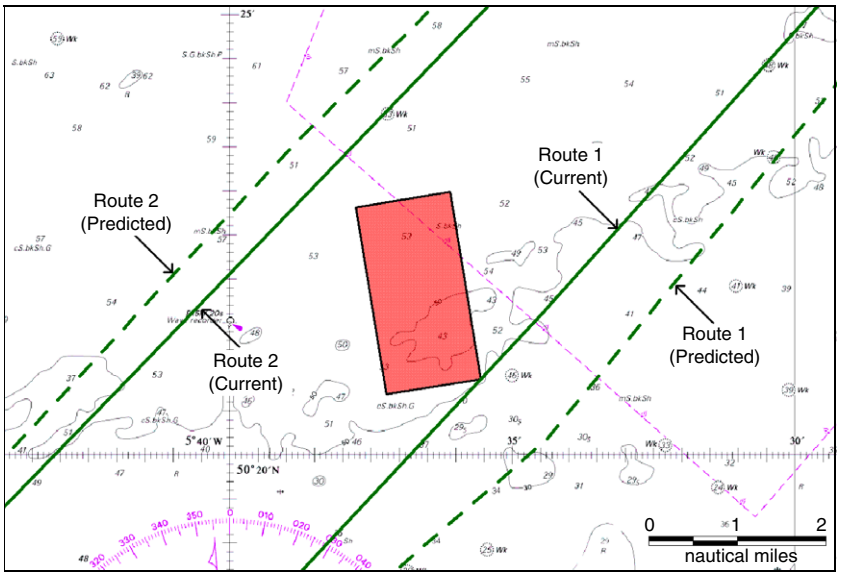

Fig 6: Anticipated impact of Wave Hub on adjacent routes

Channel to the TSS off Lands End, pass close to the south and the north boundaries of the deployment area, respectively (Anatec UK Ltd, 2006).

Given the proximity of these two shipping routes, it was found that vessels on these routes will have to divert their course slightly to avoid Wave Hub's deployment area (see Fig 6).

The separation of the opposing flows of traffic on these routes due to the presence of the Wave Hub deployment area is likely to reduce encounters between vessels and, therefore, reduce the risk of vessel-to-vessel collision to 1 major collision in 90 years, in comparison with the current situation (1 major collision in 77 years). Overall, the total collision risk is estimated to increase post–Wave Hub due to the newly introduced risk of collision with WEC devices. However, this increased risk and its associated impacts are predicted to be low. Other risks to navigation identified including potential snagging of the subsea cable with fishing gear and anchors (Anatec UK Ltd, 2006).

The proposed mitigation measures include appropriate establishment of extinguished rights of navigation and the form of an Area to be Avoided (ATBA) and/or safety zones, to be marked on nautical charts. Additionally, they include appropriate marking and lighting of the deployment area and individual WECs following the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) recommendations. Due to the unknown characteristics of the WECs to be deployed over the life of the project, each device will be subject to a device-specific risk assessment to be approved by the MCA when applying for consent to deploy at Wave Hub (Halcrow Group Ltd, 2006a).

4.2.4. Cultural heritage and archaeology

An archaeological assessment was undertaken according to the Institute of Field Archaeologists' Standards and Guidance for Archaeological Desk-based Assessments and Evaluations, Planning Policy Guidance Note 16: Archaeology and Planning and The Joint Nautical Archaeology Policy Committee's Code of Practices for Seabed Developers (2006).

The assessment was informed by desk-based research of existing sources of information, and an offshore geophysical survey of the seabed to assess the existence and nature of potential archaeological features within both the onshore and offshore areas of Wave Hub.

It was found that the site of the proposed onshore substation is adjacent to part of the Cornish Mining World Heritage Site. However, no scheduled monuments or listed buildings were identified. Offshore, there are no protected wreck sites within the area, although there are a number of known wrecks in the wider area. The geophysical survey identified a number of anomalies on the seabed that could be attributed to features of possible archaeological interest, including a wreck location which is marked elsewhere on Admiralty Charts (Historic Environment Service, 2006).

Given that it was not possible to identify the nature of the potential (or unknown) archaeological resource on the basis of surveys alone, there is a level of uncertainty involved in the impact prediction. There is, therefore, the potential for an impact of high significance to arise as a result of Wave Hub activities causing disturbance to ground and seabed materials – e.g. during onshore excavation works, cable laying or the installation of mooring anchors. In order to address this uncertainty, a number of mitigation

measures were proposed, including a programme of archaeological recording and a detailed Written Scheme of Investigation (WSI) to be prepared in consultation with the local authority and English Heritage (Historic Environment Service, 2006).

4.2.5. Landscape and views

A landscape and visual impact assessment was undertaken by drawing upon best practice guidance, as outlined in the *Guidelines for Landscape and Visual Impact Assessment, Second Edition* (Landscape Institute, 2002).

The investigations determined that the onshore site of the Wave Hub's substation is not of high landscape value. Wave Hub's subsea cable and electrical infrastructure will be on the seabed and will not be visible. However, the WECs and navigation aids will be visible from high points along the coast, including sections that the assessment determined to be of high landscape value. The assessment found that the visual impact of the WECs, even under the worst case scenario, will be relatively low, and an impact of minor adverse significance was predicted. At night time, the site will be visible due to the lighting that is needed to mark Wave Hub, and an impact of minor to moderate adverse significance is predicted (Halcrow Group Ltd, 2006a).

4.2.6. Other studies part of the EIA

Terrestrial ecology: Surveys were undertaken of the ecological interest of the area around the proposed substation. These surveys included birds, reptiles, invertebrates, plants and habitats and found that overall the ecology of the area is of some value, but impacts of the construction will be of low significance. A number of mitigation measures are proposed to limit the potential impact on ecology, such as species translocation and limiting working areas (Halcrow Group Ltd, 2006a).

Ornithology: The location of Wave Hub is outside of areas designated at international or national level of importance for seabirds. A number of intertidal and offshore species were recorded in the area by the surveys undertaken. However, due to the low duration of the construction activities, no significant impact on offshore birds is predicted. Similarly, no significant impact on offshore bird populations was predicted during operation due to the relatively small scale of the development, in the context of the surrounding open sea area (Halcrow Group Ltd, 2006a).

Water, sediment and soil quality: Surveys were undertaken to determine whether the marine sediments and soils that might be disturbed due to the construction of Wave Hub could raise levels of contaminants. The surveys found no significant contamination, and therefore the construction of Wave Hub is predicted not to have an adverse effect on water quality. Some sediment is expected to be suspended into the water during construction, but this will be highly localised and will rapidly settle to the seabed (Halcrow Group Ltd, 2006a).

Tourism and recreation: The main potential for impact on tourism and recreation is predicted to be caused by cable-laying activities across the beach and in the near-shore water area. However, these activities will be very short term and appropriate mitigation measures were proposed to minimise disruption. The potential for an adverse effect on surfing conditions during operation due to effects on the wave climate was assessed in the EIA. It is predicted that surfing sites in the area could be affected, but under most conditions it is unlikely that the impact will be noticed by surfers (Halcrow Group Ltd, 2006a).

Socioeconomics: Wave Hub is predicted to have a number of potential direct and indirect effects on the socioeconomic environment. The overall impact will be beneficial, in that the Wave Hub is expected to generate employment and investment in the region (Halcrow Group Ltd, 2006a).

5. Consultation process

The submission of the consent application to the regulatory bodies (DTI and DEFRA) on 23 June 2006, accompanied by the ES, was followed by an open consultation period. The purpose of this consultation process was to enable stakeholders and members of the public to review the publicly available ES and present their concerns to the regulators. This would allow consenting bodies to assess the potential benefits of the project in contributing to government policy objectives against any likely adverse impacts, in order to inform the consenting process and assist in the final decision thereafter.

5.1. Key consultation issues

5.1.1. Subsea cable impacts

Although the subsea power cable has been specified in general terms during the design and development phase of the project, its final detailed design, route and laying methodologies will not be confirmed until the appointed contractor undertakes further surveys and completes the detailed design of the equipment, which will happen post-consent. For the purpose of the environmental studies, a 500m-wide working corridor for the cable route was proposed for the surveys to provide sufficient buffer to avoid any potential environmental or geological constraints. As a result, several issues were

raised during the consultation process regarding the likely impacts of the proposed seabed cable, which include: likely cable spanning and associate risk of snagging with fishing gear and anchors; requirements for rock dumping and other cable protection measures; and impact of the cable laying methodologies on benthic ecology.

Regarding the risk of cable spanning, and associated risk of cable snagging, rock dumping is expected to be the most efficient mitigation measure. However, due to economic, technical and environmental implications associated with rock dumping, it is intended to reduce its requirements to a minimum. Exact quantities of rock dumping, as well as additional cable protection measures, will only be known once the appointed contractor completes the detailed design.

It was proposed that once the cable design and laying methodologies were completed by the appointed contractor, the relevant consultees and regulators will be informed in order to confirm that environmental impacts have been mitigated so far as possible.

5.1.2. Impacts on wave regime

Although the impacts of the WECs on the wave climate are predicted to be unnoticeable, as corroborated by an independent study undertaken by the University of Exeter, concerns were raised by parts of the surfing community. Discussions on the benefit of near-shore wave monitoring to validate the modelling results were held with stakeholders. However, the natural beach fluctuations and the inherent uncertainties of the monitoring equipment (which could account for an error of up to 5%), could mask the impact of the WEC devices deployed at Wave Hub, making near-shore monitoring inconclusive. Wave measurements on the offshore and inshore sides of the deployment area are considered to be a more pragmatic and viable approach, which allow the validation of the model predictions and help to gain a better understanding of the WEC devices performance and impacts on wave regime.

5.1.3. Navigational issues

Two of the navigational consultees formally objected to the proposal based on the location of the Wave Hub. They claimed that it interferes with established shipping routes in the area and that the risk posed by the proposed development site to navigation at the revised location is not reduced to 'as low as reasonably possible'

(ALARP) levels. They proposed to further relocate the site outside the 12nm UK territorial waters limit. Apart from technical, environmental and financial reasons, the main factor that makes relocation of the proposed scheme outside this 12nm limit unfeasible is the inability of the Secretary of State (SoS) to make a declaration as respects rights of navigation under Section 99 of the Energy Act 2004 outside UK territorial waters.

The MCA has also formally objected to the application on the basis that measures to assure maritime safety are inadequately addressed. This is mainly related to the uncertainty over the type of devices to be deployed at Wave Hub over its operational life. The requirement to undertake a device-specific risk assessment by the developers of each WEC device is aimed to minimise this uncertainty.

5.1.4. Impacts on fisheries

The main issues raised by the fisheries consultees were related to the accuracy of the baseline studies undertaken for the ES, which were based on DEFRA statistics that did not include catches from vessels of less than 10m in length. In order to address these concerns and any issues affecting the fisheries, a dialogue has been initiated with the local fishing community following existing guidance from the offshore wind industry. A fisheries liaison management plan (FLMP) is being prepared in collaboration with the fishing community, and a fisheries liaison officer (FLO) will be appointed. These measures are aimed at effectively managing the impacts of the project activities on local fisheries through the whole life of the scheme, as well as to establish a communication protocol between Wave Hub and the fishing community.

5.1.5. Archaeology

An initial objection to the proposed development was received from the archaeology statutory consultee, English Heritage, on the basis of insufficient archaeological coverage for the relocated site. An additional geophysical survey was carried out to inform an archaeological assessment of the final deployment area. The assessment identified a number of anomalies that could be attributed to potential archaeological features, which are of similar significance to those encountered in the original survey area. It is understood that, based on the additional information, English Heritage will remove its objection, subject to the regulators imposing a consent condition on the requirement of a detailed WSI.

5.2. Monitoring

An environmental monitoring programme was drafted as a result of the discussions with the consultees in order to gain a better understanding of the extent of the environmental impacts caused by this new technology on the marine environment. The order of priorities for developing the

monitoring programme has been receptors that are most likely to be impacted by the Wave Hub deployment activities, and receptors that may be impacted, but for which there is currently little research available (e.g. noise emissions of operational WECs, electromagnetic fields from exposed export cable).

The main elements in the proposed monitoring programme include:

- Regular remotely operated vehicle (ROV) inspections to confirm positioning of the subsea cable and assess impact on benthic habitats
- Noise and vibration monitoring of WECs to assess impact on marine mammals and inform the need for further mitigation
- Wave monitoring upstream and downstream of the deployment area to confirm impact on the wave regime
- Beach profile measurement over one winter before cable installation to gain a better understanding of sediment dynamics.

The draft monitoring plan has been included in the final application for consent, as this is a requirement of the FEPA licence. Details of the monitoring programme (e.g. parameters and management) will be discussed, clarified and agreed with the licensing authorities and their consultees.

5.3. Environmental Action Plan (EAP)

The results of the consultation process were included in an Environmental Action Plan (EAP), which sets out the project's proposed mitigation, monitoring and liaison proposals for Wave Hub during construction, operation and decommissioning, as outlined in the preceding sections. This document is intended to incorporate the consent conditions stipulated by the regulators and, if the regulators wish to use it in this way, to become a binding obligation for all the parties involved in the project.

5.4. Way forward

The formal consultation process was completed in March 2007. The conclusions of this consultation exercise were forwarded to BERR and DEFRA for their final determination regarding the consent application. The consents were granted in September 2007.

6. Conclusions

A key element in the development of Wave Hub is to gain consent from the relevant regulatory bodies to allow construction and operation of the proposed scheme. If this is achieved, it will set a precedent for future commercial wave energy projects, which will be critical for the development of the industry.

The application route to gain consent was a complex process due to:

- Difficulty to describe accurately the type and number of WEC devices to be deployed over the life of the project
- Limited available information about the technology and its associated environmental impacts
- Very limited previous experience for consent applications to apply 'lessons learnt'
- Insufficient guidance on wave energy specific consenting issues partly due to the novelty of the technology.

The main challenge faced in the preparation of the EIA supporting the application was to describe the development, particularly the diversity of devices to be deployed over the life of the scheme, with sufficient accuracy to enable its environmental impacts to be properly assessed. In order to overcome this, a typical scenario/worst case scenario approach was taken in order to provide an envelope of potential environmental impacts. Comprehensive surveys and specialist studies were undertaken to inform the EIA, supplemented by extensive consultation with stakeholders.

One of the observations drawn from this experience was the tendency of consultees and stakeholders to apply the assessment of Wave Hub to the same criteria as for commercial OWFs, mainly because most offshore renewable energy developments in the UK up to date have been related to OWFs. While there are certainly similarities between the marine renewable projects and OWFs, it is not appropriate to automatically assume that parallels may be drawn between both technologies and that control measures and conditions from OWFs may be applied directly to Wave Hub or other marine renewable projects.

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