

EMEC/UKERC WORKSHOP: ENVIRONMENTAL IMPACTS AND MONITORING OF MARINE ENERGY CONVERSION DEVICES

Meeting Report, 14th September
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THE UK ENERGY RESEARCH CENTRE

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Future Sources of Energy (FSE)

Future Sources of Energy is a research and networking theme within UKERC. Activity focuses on a number of supply technologies which have yet to achieve commercialisation. Within these a range of issues are addressed, including technical development, appropriate policies and institutions for supporting innovation, and wider issues of social and community engagement. To avoid duplicating research and development funded by other public and private sector programmes, much of FSE's efforts are on co-ordination and networking rather than original research.

This Document comprises notes from the Workshop and summarises the issues raised. It is divided into 6 sections and 1 Appendix:

Section A.	Summary
Section B.	Setting the scene
Section C.	General Discussion
Section D.	Review of Ecological and Socio Economic Issues
Section E.	Environmental Monitoring Requirements at EMEC
Section F.	Common Environmental Monitoring Program
Appendix A	English Nature, Countryside Council for Wales and JNCC joint research priorities list for marine renewable projects¹

A. Summary

The following points emerged as the most important:

- There needs to be a link between physical modelling of devices and biological models or data sets
- The impact on sea-mammals, birds and fish should be **urgently addressed**
- Any Environmental Monitoring should be in 3 stages: **before, during and after** device installation, and each stage should ideally take place over at least 12 months to take into account seasonal effects. Time is not on the device developer's side
- There is very little data available on the movement of birds and sea mammals, and nothing can be ascertained about their interactions with devices until *in situ* data/observations are made (e.g. at EMEC)
- Continuous monitoring is very expensive, time consuming and difficult. At present there is little funding available and what funding there is, is very difficult to release
- The boundaries of acceptability have to be defined to assist developers.
- There should be an agreed environmental monitoring programme that all developers are encouraged to follow at all sites (bearing in mind particular sensitivities of site)
- It is not clear what parameters should be measured and what is the best technology available for an environmental monitoring programme.
- A monitoring programme should concentrate on possible showstoppers for marine developers

B. Setting the scene

- Marcus Mueller gave a summary of the UKERC, including its structure and research areas
- Jennifer Norris introduced the main section of the workshop by setting the scene in the context of environmental monitoring requirements at EMEC, but also of the developers
- Within the EMEC EIA guidance document a Summary Impact Matrix has been produced to provide an indication of the impacts that various activities may have on receptors in the environment. Some of the information required for this matrix is unknown at present. Environmental monitoring programmes of prototype devices or arrays are expected to inform this process
- From the meeting EMEC/UKERC are looking for:
 - some consensus on what activities/potential impacts should be specifically monitored, both generally and at EMEC
 - information pinpointing existing technology / methods that could be used to monitor for specific impacts: also, what aspects need

- technology / methodology development before adequate monitoring will be possible?
- should we be leaning towards monitoring outputs of devices or effects on receptors – or both?

C. General Discussion

Scale of wave and tidal installations

- Consider the scale of devices from prototypes to large arrays of devices. Single prototype devices will have a very different impact to an array, and hence should break down the research accordingly
- In the short term prototype devices will be installed, and these should be used to investigate the impact on birds, mammals and on the sea bed. In terms of wildlife, the impact should be monitored over a long period of time to investigate any seasonal effects
- Some of this will of course be site-specific

What are the borders of acceptability?

The following views were expressed:

- Developers should be given some guidance on what is acceptable in terms of impact on wildlife, e.g. how many fatalities are acceptable; importance placed on behavioural / dispersal effects
- Some activities in the installation of devices will have more of an impact than others. For example, seabed blasting for installation of a mooring system may lead to limited fatalities and temporary behavioural changes, but what is considered acceptable?
- Is there any information available from the offshore wind developments that may be of use (e.g. COWRIE research on electromagnetic effects of cables)?
- In order to really learn about the impacts of devices on the environment, there should be fewer restrictions on the first prototypes, provided these are monitored (note different view below)
- The EU has published guidelines for designated conservation sites, which clearly state what can and cannot be done. The guidelines are very stringent, and include the potential impact of activities outside the site. All developers should consult these guidelines
- Outside the EU designated areas there is ongoing discussion on the potential impacts
- Environmental issues should not be relaxed for prototypes (note different view above)
- It is important to measure the impacts, but also to determine at what level and at which locations there are no impacts
- It is very important to identify **positive impacts** as well as negative impacts. We should avoid the trap of assuming that all impacts of the industry will be negative

General Issues of Monitoring

- Location is crucial. Sea mammals exhibit different behaviour depending upon the site, and the behaviour changes from year to year. They are unpredictable, which makes monitoring very difficult. Timing of monitoring should be sufficient to show behavioural changes, where this is possible
- The scale of the device and the timing of the installation are also important
- A monitoring programme should consist of three stages: **before, during and after** device deployment. Each stage should aim to cover 12 months in order to determine the seasonal impact. There is conflict as developers need to deploy devices in the water soon in order to demonstrate performance and build investor confidence. In the case of tidal devices at EMEC, some prototypes are due to be installed in summer / autumn 2006. Failure to deploy during the summer months will mean a long delay due to weather restrictions on installation
- Continuous monitoring is very expensive and at present there is little funding from the DTI – **how do we go about getting this money?**
- **Agreement all round that a monitoring programme should be implemented soon, but who will fund it?**
- The **DTI Marine Deployment Fund** has £8M allocated for infrastructure building – some of this could be allocated to environmental monitoring.
- Some of the environmental issues are generic to all developers, but of course some are device specific. DTI published a scoping exercise on tidal stream 5 years ago, including an environmental testing programme: reference <http://www.dti.gov.uk/renewables/publications/pdfs/t0400213.pdf>
- In order to maximise benefit from any environmental monitoring on a device (or an array of devices) there should be a common testing programme regardless of the site
- It is not clear what parameters should be measured in an environmental monitoring programme

General Points Raised

- The potential showstoppers should be investigated first as these will have the greatest impact on device developers
- The biggest gaps in knowledge are:
 - Impact on birds
 - Impact on sea mammals – collision risk, what is the barrier effect of tidal arrays?
 - Impact of the energy variation within a tidal channel on the habitat
- EMEC has a role in determining the impact on the above from installation and operation of a single turbine and later from small arrays

- English Nature, Countryside Council for Wales and JNCC have compiled a joint research priorities research list for marine renewable projects (appended to this document)
- The DTI Tidal scoping document needs to be reviewed – could Ian Bryden please email web address to the group, and then send back comments to Jenny at EMEC or Markus at Edinburgh/UKERC
- Some participants felt that we should not rely solely on DTI funding
- There was some concern that devices being installed in waters off other European states, Portugal in particular, would not be exposed to the same rigorous environmental assessment and monitoring as in UK waters – if anyone has information on the difference/s please pass this on to Jenny or Marcus

D. Review of Ecological and Socio Economic Issues

General discussion led by Jennifer Norris

(This section refers to Table 2.2 in EMEC EIA Guidelines)

Ecological impact & Disturbance to Water Masses (points 1 & 3 of Table 2.2)

- The Supergen consortium is modelling the impact of arrays on the actual physical resource in Work Package 1, but not looking at the ecological impact
- Supergen is concentrating on the downstream effects and can model at the device scale
- CCW and Crown Estates plan to work on this aspect next year:
 - Biological side – impact on species on the seabed
 - Predictions – merging the physical and biological side
- Aberdeen University (**Beth Scott**) has done work linking biology with the physical aspects – done this in the Forth. Investigating feeding ‘Hotspots’ and relation to physical characteristics of sites. Team has observed differences in foraging due to mixing of the water column – birds, fish and seals. The knock-on effects of changes in foraging are unknown. Degree of mixing is bell shaped. There is clear scope for investigating this at EMEC – relates to point 3 of Table 2.2
- Primary modelling is required in which scenarios from Supergen are combined with the models developed at Aberdeen for specific sites.
- Aberdeen’s modelling work is based on experimental data
- **Ben Wilson from SAMS** asked what change in energy balance actually takes place in a tidal channel – this needs to be known so that the impact on species can be determined
- **Ian Bryden responded:** an individual device can take out 40%, but from a simple channel, if take out 20% of kinetic energy there will be a 5% reduction in flow speed. In terms of the energy balance there is very little

change – there is a redistribution of energy within the channel. An estimate of 0.25% change was made. This is site dependant

- Even with such a small change (0.25%) the impact on species is still unknown. Perhaps this is something EMEC can assist with during the installation of devices at the new tidal site. **Funding** will be needed for such a study. Is the technology available to measure this impact?
- In order to obtain any depth of understanding of impacts, monitoring needs to take place **before, during and after** deployment
- Everyone agreed that research is required to link physical modelling of devices and energy extraction to ecological and biological models to determine the ecological impact

Disturbance to sea bed habitats (Point 2 in Table 2.2)

- Effects need not necessarily be negative
- Marine current device will result in a redistribution leading to hot spots and cold spots, but it is not yet clear what impact this will have. Scope for further research
- 2nd round of COWRIE is looking at consequences of sediment transport around sand banks
- Guidance available from offshore wind farms re. disturbance on the seabed. There is an offshore wind farm guidance document re scour etc – from CEFAS website (www.cefass.co.uk/publications/files/windfarm-guidance.pdf)
- Also contains information on human impact activity

Disturbance to shoreline & landward areas (Points 4 & 5 in Table 2.2)

- Work has been done on this already. Needs longer term monitoring of potential coastal effects, particularly in relation to shallow wave devices

Behavioural changes in Wildlife & Wildlife Entanglement (Points 6 & 9)

- Location, scale and timing are crucial –impacts on behaviour may differ according to the site characteristics, and may change from year to year. In order to really understand the impact on behaviour monitoring has to take place over at least a year, and should be done before, during and after. Hence a robust programme would require 3 years overall before there is any real understanding of the impact. Time is not on the developers' side
- CEFAS – have project investigating how offshore wind structures impact on fish – just starting, internal project with DEFRA. It will be mainly desk based, but may be some monitoring – site as above
- Little is known about the behaviour of cetaceans and sea mammals, particularly in relation to underwater structures. Have some knowledge of seal locations at certain times of year, but little about porpoises. SMRU are using satellite to follow these animals, but this is on too large a scale.

Starting to use GPS. No bank of data available on movement of animals. Basically monitoring is difficult and expensive. Funding is required to do this, and we need to identify specifically what should be monitored

- As a first step we could investigate the impact of a device on mammals in the localised area – EMEC could do this at the new tidal test site, but would need funding
- Questions that need addressing include: should the developers install deterrents to protect the wildlife from marine devices? If so, what other consequences might there be from the deterrent? Will the animal be actually injured by the device? and so on. The fluid mechanics of tidal devices mean that animals are only likely to receive a glancing blow, but of course this could lead to a fatality later, which is difficult to measure. Some form of tank testing could be done to investigate and demonstrate the impact on floating bodies in a tidal channel with energy converter installed. Tip speed is 10m/s – lies in the speed range at which whales throw herring out of sea with tails
- Mammal strikes by high speed ferries is a bigger problem than is realised and there is a lot of info available. A type of black box recorder is being developed to identify strikes, but a way must be developed to attribute later fatalities to such strikes. Could apply such technology to marine devices
- Sonar technology could be used to determine strikes and impact of turbine. Such monitoring could be funded by DTI
- Ian Bryden is developing an EPSRC project to look at the interactions of devices and impact on marine life. He has a physical research project, but requires input from the biologists. This project would look at some generic protection systems
- The temporal effect of a tidal turbine on a local population should also be considered (especially in regard to breeding seasons)

Impacts on conservation areas and protected species (Point 7 in Table 2.2).

- It was felt that identification and consideration of these species and areas should be part of the developer responsibility, since they are site-specific issues. Developers deploying at EMEC will have this information provided (by the site EIA), and the Scottish Executive Strategic Environmental Assessment (SEA) will also give some information for key deployment areas
- A standard risk assessment is required for these areas
- EU Guidance notes on Article 6.3 and 6.4, Impact on Birds Directive and Habitats Directive – all technology developers should have access to these documents. These EU articles define the regulations for designated areas.
- Site selection very important: Scottish Exec. SEA will assist in this
- Impact issue was covered by the DTI study. In this study Ian Bryden proposed a (thought) experiment in which thousands of objects

instrumented with strain gauges and accelerometers should be released into a tidal stream, and then examined downstream. Data captured from the sensors would indicate the damage and the degree of force of a blow experienced by an object

Underwater noise, light and vibration.

- Look to COWRIE studies on windfarm-related underwater noise: 2 reports are available on the COWRIE web site
- http://www.thecrownestate.co.uk/newscontent/92_cowrie_noise_reports.htm
- There is also an EU project at Aberdeen - **could Beth Scott please provide more details**
- *Subacoustech* have looked at underwater acoustics for wave and tidal devices
- Noise is classed as priority A on the research priority list maintained by JNCC and English Nature (appended to this document)
- These issues could contribute to Behavioural Changes and Wildlife Entanglement (Points 7 & 9)

Airborne noise

- No particular issues

Electromagnetic and electrical effects

- COWRIE 1 study of Beatrice project– measured electromagnetic output of cable (completed), and how species react to magnetic fields (underway)
- Should include thermal effect of cable – clams are attracted by heat from cables

Marine archaeology

- COWRIE 2 is to look at guidance in relation to impacts of offshore wind and piling on marine archaeology
- Marine Developers must be aware of this

Navigation sea user interference

- EMEC are monitoring vessel movement at the test facility. There is a live video camera at the wave site, but no similar plans for tidal site
- Safety issues include adequacy of moorings
- There should be guidance on exclusion zones around marine devices

It was pointed out that consideration of cumulative impacts of multiple devices should be included wherever multiple devices are deployed.

E. Environmental Monitoring Requirements at EMEC

Led by Jennifer Norris

- EMEC is in the process of obtaining base data that will inform monitoring in the future
- EMEC would like an indication from the regulators and the research community regarding scope of potential impacts to monitor at its sites, and what methods to use, given the current status of the technology
- EMEC offers the potential to further research as well as simply complying with monitoring requirements of regulators

JN emphasised the need for robust baseline data, collected by repeatable and 'best available' methods, in order to assess the impact of any devices – this point reiterated by Crown Estates.

The meeting agreed that EMEC should concentrate on monitoring for impacts on main sensitivities at sites.

There was agreement that the following issues should be monitored at EMEC, with priority to sea mammals and diving birds:

- Collision with, and behavioural change of sea mammals and diving birds. Baseline counts (land-based observations) of sea mammals and diving birds are already underway at EMEC. Observations began in July
- Monitor bird activity at EMEC site, use the site for developing radar or other modelling techniques. EMEC to have separate discussions with RSPB about monitoring methods. EMEC are applying for joint research project with ICIT (Heriot Watt) on characterising underwater signatures of diving birds
- Noise. Baseline acoustic data is already being addressed at EMEC – SAMS tasked with looking at methods for acoustic characterisation (tidal site). A full year for *before study* is difficult because due to time pressure (although wouldn't expect enormous seasonal variation throughout the year). First tidal devices planning to deploy in summer 2006, depending upon consents
 - Could monitor noise with turbines turned off if not enough time available in advance.
 - Impact on sea bed during installation.
 - JNCC has a project looking at the impact of noise from piling in offshore wind farms 25 miles away from developments in the Thames Estuary.
- Impact on habitat - this will be difficult because of limited testing time.

Points made re. monitoring:

- Monitoring programmes can require 3-4 months to get up and running – must be taken into account
- Developers should consider what monitoring should be done in advance – part of the consents process and included in the project costs
- Who makes the decision to stop a project if an environmental problem arises observed during monitoring?? Does a hierarchy of control of the development need to be established?
- EU demand robust scientific evaluation of the environmental impact using existing knowledge available. EU look favourably on Renewable Energy projects, but must show robust monitoring plans
- Identify the acoustic signatures of diving birds – Heriot Watt and EMEC to build on a project done by Jenny Norris which centred on the gannet
- Remote monitoring technologies are coming on stream, developed for onshore and offshore wind – scope for transfer of the technology

F. Common Environmental Monitoring Program

Led by Ian Bryden

- Wave devices have been instrumented since the 1970s – Japanese OWC was the first such device. Included in the instrumentation were methods for determining the environmental impact. Data collected was governed by what could be measured and the period of time for measurement, which on the whole was too short. Hence the data collected was actually useless
- The Archimedes Wave Swing installed off Portugal in 2004 was also heavily instrumented, but the instrumentation so specific that the output was not useful for the developer – let alone the community as a whole
- For tidal – MCT have done some limited environmental monitoring on Lynmouth device. However since the DTI funding was based on device performance, limited environmental monitoring is taking place
- There should be a set of guidelines or a list of what developers should be monitoring, with advice on how to do it, so that it is useful for the community. EMEC plan to start this for developers deploying at their sites, provided funding can be obtained
- Crown Estates are in a position to impose monitoring requirements in regard to potential environmental impacts, but should not be too prescriptive (or onerous)
- What is necessary from a regulatory point of view, is not necessarily good for the industry. Environmental impacts will vary with devices and sites
- **Funding issue is of crucial importance**
- In the longer term the regulations should be governed by the best available scientific knowledge. There are some clear knowledge gaps, which need to be filled to allow good methodologies to be developed, and to inform regulators

What do we need to measure, but does not cripple a project?

- Must measure chlorophyll – good indicator, and easily measured. (Beth Scott)
- Noise
- Impact on sea mammals, in particular the degree to which they are frightened away. It may be possible to develop experiments to investigate this without the device installed – US Navy does this with whales (but based on sound)
- Disturbance to habitat
- Identify changes in water column that may impact animals down the line.
- Record of birds at the site
- Monitoring of sediment movement for wave power devices

The following points were raised from the discussion re. the list above:

- This is a first pass at a definitive list. There was some concern that the list may mislead developers, and may not satisfy regulators. Need to decide how the data measured informs the regulator
- **Agreement across the board that DTI needs to think about generic issues and should fund these**
- There is no financial incentive to developers to provide/make available this data. How are they to be incentivised to collect such data?
- Should we be lobbying DTI and the Scottish Exec to include such a generic monitoring programme for marine renewables in R&D programmes?
- BWEA Path to Power is a 6 month programme to engage with stakeholders and politicians – can we take advantage of this?
- Need to look at monitoring prospective sites outside designated areas – need this information to assess the impact once devices are in the water

Jenny Norris, EMEC, Orkney

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6th October 2005

Appendix A

English Nature, Countryside Council for Wales and JNCC joint research priorities list for marine renewable projectsⁱⁱ

Version 1 25 August 2005

Subject	Device types ⁱⁱⁱ	Issue	Scope of work required	Recent / pending research	Priority ^{iv}
Removal of energy from the marine environment	Cw&t, Dw&t	The biological implications of the removal of energy from the marine environment	<p>Monitoring to confirm the validity of predictions for different technologies.</p> <p>Review of the reliance of habitats and species on energy (wave and tidal stream) in the marine environment.</p> <p>Predictions of the biological impact of energy extraction (wave and tidal)</p> <p>Assessment of the scaling up of projects from demonstrator to commercial farms will require consideration in the future – for example what will be the impact of arrays on wave regimes?</p>	Some initial work planned by CCW and Crown Estate to be undertaken 2005/6.	A

Subject	Device types ⁱⁱⁱ	Issue	Scope of work required	Recent / pending research	Priority ^{iv}
Lessons from Round 1	All	All issues subject to monitoring by R1 projects	<p>A structure for periodic collation, analysis and dissemination of information arising from the R1 projects is required</p> <p>A framework should be provided for regulators and advisors to use R1 data to appraise FEPA conditions and inform future conditions for R2 and beyond</p>	Defra may be taking some of this on but will need additional resourcing	A

Subject	Device types ⁱⁱⁱ	Issue	Scope of work required	Recent / pending research	Priority ^{iv}
Assessment of cumulative impacts	All	Assessment of cumulative effects	<p>The assessment of cumulative impacts is required under the SEA and EIA directives however currently the carrying out of such assessments is problematic. The SEA requirements also include the monitoring of predicted cumulative impacts.</p> <p>Establishment of a workable method of assessing cumulative effects and creation of guidance to industry</p> <p>Areas of particular concern include:</p> <p>Cumulative impact of windfarm development on birds – migratory routes, foraging etc</p> <p>Cumulative impact of windfarm construction and operation on underwater noise levels</p>		A

Subject	Device types ⁱⁱⁱ	Issue	Scope of work required	Recent / pending research	Priority ^{iv}
Underwater noise	All	Assessment of levels of underwater noise during construction and/or decommissioning	Guidance for developers is required dealing with assessment of noise levels from piling and the prediction of impacts (models, differing site conditions and bathymetry) and the establishment of monitoring schemes to inform future projects		A
Underwater noise	All	Impacts of underwater noise on marine mammals and fish during construction and/or decommissioning	<p>There is currently insufficient information on the likely response of marine mammals and fish to loud subsea noise. Information is particularly required on impacts on behaviours.</p> <p>Indirect impacts may occur, e.g. noise may affect fish spawning areas with a knock on effect on bird feeding</p> <p>Likely cumulative impacts, particularly in respect of noise from construction activities occurring simultaneously at different sites, are also not well known</p>		A

Subject	Device types ⁱⁱⁱ	Issue	Scope of work required	Recent / pending research	Priority ^{iv}
Underwater noise	All	Mitigation of noise impacts during construction and/or decommissioning	<p>A review of the efficacy of proposed mitigation and possible alternatives (e.g. bubble curtains etc) is required studying the technical solutions available and the efficacy, reliability and practicality of those solutions.</p> <p>The development of guidance on industry best practice for effective mitigation for piling</p> <p>A review of the efficacy of deterrents such as pingers and scarers is required particularly in the context of long periods of construction during which receptors may become conditioned to such measures</p>		A

Subject	Device types ⁱⁱⁱ	Issue	Scope of work required	Recent / pending research	Priority ^{iv}
Underwater noise	All	Assessment of level of underwater noise from operation of generation units	<p>Monitoring of wind and demonstration phase projects for their acoustic impact is required as there is currently insufficient information on what levels of sound the projects produce.</p> <p>The impact of the operation of generation units on cumulative background noise requires further study</p>	Current COWRIE Subacoustic project is carrying out some of this for wind only. Needs expanding to wave and tide and additional work for wind depending on conclusions of COWRIE project	A

Subject	Device types ⁱⁱⁱ	Issue	Scope of work required	Recent / pending research	Priority ^{iv}
Underwater noise	Wi, Cw&t	Impacts of underwater noise on marine mammals and fish during operational period	<p>There is currently insufficient information on the likely response of marine mammals and fish to underwater noise created during the operation of arrays or farms</p> <p>Consideration of the impact large scale developments may have on feeding and other behaviours is required. Is a barrier effect likely to occur ? Can this be mitigated by layout ?</p> <p>What indirect impacts are likely to occur – e.g. how will operational noise impact on spawning areas which may have a knock on effect on bird feeding</p> <p>Impacts of maintenance trips and their timing should also be considered</p>	Current COWRIE Subacoustic project is carrying out some of this for wind only. Needs expanding to wave and tide and additional work for wind depending on conclusions of COWRIE project. There are 2 other relevant projects currently funded by DTI (Oil and Gas) looking at noise source characterisation and impacts on species	A

Subject	Device types ⁱⁱⁱ	Issue	Scope of work required	Recent / pending research	Priority ^{iv}
Marine mammals	All	Standardisation of marine mammal survey and assessment techniques	Standardisation of marine mammal survey techniques (similar project to that run for birds under COWRIE) An assessment is also required as to the extent to which surveys can usefully inform the EIA process.		A
Marine mammals	All	Standard methods are required for marine mammal post-construction monitoring similar to those adopted for birds.	Develop standard survey methods for marine mammal survey including acoustic and sightings surveys.		A
Benthos	All	Recovery of seabed habitats	To pull the results from the R1 sites together and learn from this document. Focuses on wind but could be used for W&T.	Round 1 licence conditions require benthic monitoring	C

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Subject	Device types ⁱⁱⁱ	Issue	Scope of work required	Recent / pending research	Priority ^{iv}
Birds	Wi	Effects on flight patterns, migration patterns, barrier effects (and, to a lesser degree, collision risk)	<p>Practical development and testing of methods such as</p> <ul style="list-style-type: none"> • Radar • Infra-red systems • Collision detection systems <p>Assessment of the probability of bird collision or avoidance and therefore barrier effect (taking into account different bird species / lighting / turbine layout and heights and weather conditions).</p> <p>Assessment of the level of monitoring data that would be required for use in population viability analysis models</p>		A
Birds	Wi	Mitigation of bird impacts	Development of deterrents / mitigation measures to reduce blade strike e.g. turbine spacing		B
Birds	Wi	Offsetting bird impacts	Consideration of mitigation for displacement e.g. managing other areas of sea as seabird feeding/roosting areas		A

Subject	Device types ⁱⁱⁱ	Issue	Scope of work required	Recent / pending research	Priority ^{iv}
Birds, large marine species	Cw&t, Dw&t	Collision with sub-surface structures	Investigation of the potential impact of collisions between marine species (diving birds, marine mammals, basking shark etc.) and wave and tidal generation devices		A
Seascape	All	Public acceptance of offshore renewables	<p>Collation of public perception studies, understanding tolerance limits and what matters to people and why.</p> <p>Wider scope than merely visual intrusion or aesthetic factors but should also consider tourism, quality of life etc issues</p>		A
Seascape	All	Lack of baseline for strategic planning for siting of renewable energy developments	<p>Establishment of regional seascape units and assessment of -</p> <ul style="list-style-type: none"> • visibility of the sea • character of coastline • quality • value • capacity to accommodate change for these units. 		A

Subject	Device types ⁱⁱⁱ	Issue	Scope of work required	Recent / pending research	Priority ^{iv}
Seascape	Wi	<p>Appraisal of the efficacy of visual limits used in R2.</p> <p>CCW, and SEA, for Round 2 used modified 'Sinclair' threshold distances for high, moderate and low visual impact.</p>	<p>Testing and refining for future licensing rounds the visual limits used in R2</p> <p>Suggest project using public questionnaires to gauge the acceptability of levels of visual impact at different distances, which will help to establish thresholds. Could use North Hoyle as case study. Public tolerance is a key issue.</p>		A

Subject	Device types ⁱⁱⁱ	Issue	Scope of work required	Recent / pending research	Priority ^{iv}
Benefits	All	Investigation of refuge effect/value	<p>Assessment of the role which offshore renewable projects could play in enhancing biomass and biodiversity and/or fisheries</p> <p>Monitoring of round 1 projects is unlikely to provide sufficient information to reveal whether a refuge effect is occurring</p> <p>Study would need to consider effect of reef communities, exclusion of shipping, exclusion of fishing between structures, array design, impact of safety zones etc</p> <p>[practical trial of excluding other activities]</p>	There are a large number of studies on artificial reefs, recolonisation and exclusion of marine activities from protected areas. Need more focussed, practical trial	B

Subject	Device types ⁱⁱⁱ	Issue	Scope of work required	Recent / pending research	Priority ^{iv}
Fish and shellfish	Wi	Potential impacts of electromagnetic fields (EMF)	Identification of key species and their sensitivities to EMF to be established (including consideration of different life cycle stages) Development of practical guidance on practical and workable mitigation	COWRIE – recommendations of Phase 1.5 and implementation of COWRIE phase 2	A
Fish and shellfish	Cw&t, Dw&t	Potential impacts of electromagnetic fields	As above	As above	C
Fish and shellfish	All	Spawning / nursery areas – risk assessment for [Habitats Directive and] UKBAP species	There is currently insufficient information on the distribution of spawning / nursery areas for priority marine species		C
All species and habitats	All	Guidance to developers on areas of high sensitivity	Indicative sensitivity mapping for birds, marine mammals, Habitats Directive features etc	Query extent to which SEA process should deliver such information	A (but too late for R2)

Subject	Device types ⁱⁱⁱ	Issue	Scope of work required	Recent / pending research	Priority ^{iv}
Coastal processes	Wi, Cw&t	Impacts on seabed and coastal processes e.g. scour and sediment transport	<p>The development and application of a methodology for the studying of long-term impacts (including those arising from cabling)</p> <p>Monitoring to confirm the validity of predictions.</p> <p>The production of guidance for developers on coastal processes.</p>	<p>ABPmer – Scroby Sands study</p> <p>ABPmer – Assessment of Potential Impact of Round 2 Offshore Wind Farm Developments on Sediment Transport</p> <p>Need to cross ref with above studies to check what already covered</p>	B
Coastal processes	Wi, Cw&t	Stability of seabed features e.g. sandbanks	<p>The development and application of a methodology for the studying of long-term impacts (including those arising from cabling).</p> <p>The production of guidance for developers on coastal processes.</p>	<p>ABPmer - Sand banks, Sand transport and offshore windfarms</p> <p>Need to cross ref with above studies to check what already covered</p>	B
Coastal processes	All	Monitoring of actual impacts in the context of natural change of dynamic systems.	A methodology for the studying of long-term impacts and a programme of monitoring is required to confirm the validity of predictions		B

Subject	Device types ⁱⁱⁱ	Issue	Scope of work required	Recent / pending research	Priority ^{iv}
Coastal processes	All	Indirect impacts of sedimentation/scour on nature conservation	Indirect impacts of changes in sedimentation etc are not well known. One area of concern that has been voiced is the impact on the prey of diving birds		C
Recreational users	All	Impacts on recreational users of the sea	Understanding the spatial and temporal use of coastal seas for recreation and potential conflicts of renewable energy projects with various recreational user groups (yachting, surfing, kiting etc) Consideration of relative economic values of loss of recreational space and increasing of generation capacity		C

ⁱ Because of the very different nature of marine barrage/tidal containment technologies (in terms their of construction and operation and the level and nature of their environmental impacts) such projects do not fall within the scope of this paper

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ⁱⁱⁱ Wi = offshore wind, Cw&t = commercial wave and tide, Dw&t = demonstration wave and tide, Cw = commercial wave. Note that currently this table does not seek to distinguish between different wave and tide technologies. As it becomes clear which technologies will be commercially viable (and monitoring and research increases our understanding of possible impacts) the distinction between offshore/nearshore/shoreline wave and tidal stream projects will need to be made.

^{iv}

A =High priority issues relevant to a large number of projects or of a generic nature where consideration of these issues is urgent either as part of the EIA/consenting process or because of the magnitude of potential impacts

B = Issues of a more specific nature or where the level of potential impacts may be less severe than those issues designated as "A" priority

C = Issues relevant to individual sites / devices and/or where consideration of such issues will be required in the future (for example in respect of commercial wave and tide roll-out