CCW recommendations for research into the environmental effects of wave and tidal stream technologies

This paper describes the Countryside Council for Wales' (CCW) view on priority areas for research to support the assessment and development of wave and tidal stream technologies.

The information and understanding gaps relating to the environmental impact of wave and tidal stream can be divided into two main areas;

1. Developing environmental baselines (to inform environmental assessment processes).
2. Impacts research (associated with device deployments)

Key research and further work required in these two priority areas are detailed below. It should be noted that although primarily aimed at the wave and tidal stream sector, much of the work described by this paper will also be applicable to offshore wind, as many of the issues discussed are generic to the marine renewable energy industry.

To discuss any aspects of the research listed in this paper, contact Dr Kate Smith or Dr Andy Hill in CCW's Marine Spatial Planning, Energy and Infrastructure Team.

1. IMPROVING BASELINE INFORMATION

A strong baseline of relevant environmental information is essential to inform Environmental Impact Assessment and strategic planning processes. Baseline information about the marine environment is often poor because of the difficulties of surveying the marine environment. Information about mobile species (marine mammals, seabirds and fish) is particularly deficient, and this is of particular relevance to understanding the effects of wave and tidal stream technologies.

Environmental baselines need to be sufficiently robust and described at an appropriate scale to characterise the resources that may be affected by these technologies. The geographical areas around Wales likely to be of interest to wave and tidal developers are reasonably well defined at a regional scale within the Atlas of UK Marine Renewable Energy Resources (ABPmer, 2008). Key environmental information is poor for some of these areas. This is a particular issue for tidal stream technologies, which are likely to be deployed in geographically restricted areas of energy resource, which are also a distinct and limited ecological resource.

The specific research priorities relating to developing environmental baselines are detailed below. A short rationale is provided for each.

a. Improved definition of size, range and connectivity of mammal populations

The six key species of most concern in Welsh waters are bottlenose dolphin, common short-beaked dolphin, Risso's dolphin, harbour porpoise, minke whale and grey seal.

The nature conservation significance of impacts on marine mammals are defined according to whether they affect the long term viability (or the conservation status) of populations. This requires an understanding of the size and range of the population on which impacts are likely to exert an influence.

Our understanding of the range of marine mammal populations and individuals within a population is limited, particularly for those species that are difficult to track as individuals. Several species have populations that are trans-boundary and wide-ranging. In the US, under such circumstances, estimations of population are based on the number found in US waters not the whole biological population. A similar approach might be taken in the UK.

Research to spatially define mammal populations, such that management units can be determined would lead to a better ability to assess the likely impacts of marine renewable devices at a realistic, biological population level. In Wales this issue is particularly pertinent for harbour porpoise, common dolphin, Risso's dolphin and minke whale. Population estimates for bottlenose dolphin and grey seal are better defined in Welsh waters.

Research to better understand the connectivity and key migrations and movements (including routes and timing) of all of the marine mammal species which occur in Welsh waters is required. Some information has been gathered for the Welsh population of bottlenose dolphin, through the use of photo ID (Pesante *et al*, 2008), though there remain questions about the degree to which these animals utilise areas outside of Welsh waters, such as the Isle of Man. In addition, some information on grey seal movements has been gathered through a limited amount of tagging work (e.g. Hammond *et al*, 2005; Gordon *et al*, 2011). Further research is required into the connectivity of all Welsh marine mammal populations, in order to help to assess the likely disturbance, displacement, barrier and collision effects of marine renewable devices.

This research is also of relevance to the offshore wind sector, since the scale at which offshore wind farms are being built under Round 3 (and any subsequent leasing rounds) around the UK's coast means that the potential for cumulative and in-combination impacts is much more likely.

b. Improved productivity rate estimates for marine mammal species and populations

Potential Biological Removal (PBR) may represent a useful tool for quantifying impacts of marine renewable devices and arrays on mammal populations and in some cases, setting thresholds for acceptable impacts. PBR was developed by fisheries scientists at the National Oceanic and Atmospheric Administration (NOAA) as means of managing the effects of human activities on marine mammal populations and allows effects to be quantified with limited data. Specifically it estimates the number of animals that can be removed from a population without preventing the population from reaching or maintaining itself at an optimum level. The formula used to calculate PBR levels includes an estimate of the net productivity rate of the marine mammal population in question.

In the case of most marine mammal species present in Welsh waters, productivity rate estimates are crude, or are even default values taken from other, better studied, populations. Research to better define productivity rates for the main marine mammal species occurring in Welsh waters would greatly improve the potential for using PBR to quantify impacts of marine renewables.

c. Improving estimates of local density site fidelity of mammals

Marine mammal sightings rates are available for Welsh waters (e.g. SCAN II and CCW marine mammal database) which provide a useful characterisation of marine mammal presence in Welsh waters at a regional scale. However, they do not provide information at a resolution sufficient to characterise the importance of areas of high tidal energy resource for marine mammals. Neither do we have a clear idea of the level of site fidelity, or reliance on particular areas of tidal resource by individuals and

populations. This information is required to inform assessments of the anticipated risk of encounters or collisions between devices and mammals and likely disturbance and displacement effects.

d. Understanding functional use of areas of high tidal energy by marine mammals

There is some evidence to suggest that areas of high tidal stream energy are important feeding and nursery areas for marine mammals (e.g. Pierpoint, 2008; Shucksmith *et al*, 2009). However, much of this evidence is anecdotal and additional research on the functional importance of these areas to marine mammals is needed.

e. Diving behaviour and depth distribution of marine mammals in high tidal energy areas

Understanding the degree to which underwater tidal turbines might pose a collision or barrier risk to marine mammals requires a better understanding of the dive profile and depth distribution of the various species. This includes the dive profiles of animals feeding within, or transiting through areas of high tidal stream. A better understanding of the dive profile of marine mammals would also help inform the development of possible mitigation to minimise effects (for example, deeper installations might be better than shallow).

Some work has been undertaken on harbour porpoise in Denmark (Teilman *et al*, 2007), but this type of data are needed for all species, with a focus on area of tidal resource, since they may behave differently in these areas. Gordon *et al* (2011) also undertook some initial trials of harbour porpoise activity in areas of high tidal energy using a vertical hydrophone array deployed from a drifting vessel off N. Anglesey, and suggested this approach might be a viable method to characterise the diving behaviour of marine mammals in such areas.

Further research on swimming orientation of mammals in relation to tidal flow is also required since this is likely to affect encounter and collision risk (encounter rates are likely to be higher if mammals are swimming perpendicular to devices, i.e. directly with or against tide). The use of accelerometer tags might be a useful means of gathering this information.

f. Estimates of sightings rates of seals at sea

There is little existing data relating to sightings rates of seals at sea, with uneven effort across Welsh waters, since historically surveys have been targeted at species other than seals. Tagging data and at sea data collected by Satellite Relay Data Loggers (SRDL) has increased knowledge of movements of seals from breeding and non-breeding haul-outs (e.g. Hammond *et al*, 2005) but a better understanding of density at sea or the location of functionally important at sea areas is required.

g. Hearing in seals

Currently, little is understood anatomically about hearing in seals. Southall *et al* (2007) reported that most pinnipeds are treated as one functional hearing group, despite the data reviewed suggesting differences in the functional hearing range among otarids, phocids and odobenids, especially underwater. There is no broad anatomical background data on pinnipeds or an understanding of how underwater sound arrives at the inner ear.

To estimate the possible effects of noise on seals, it would ideally be necessary to gather data on their hearing capacities (e.g. audiograms) and Temporary Threshold Shift (TTS) values. However, given the

practical and ethical issues surrounding the gathering of such data, an approach using computational acoustic models, based on anatomical data might be preferable.

This research would also be of use to the offshore wind sector, since noise impacts on marine mammals during construction (e.g. from pile driving and other foundation installation methods) is one of the key impacts of concern and current understanding of potential impacts on seals is low.

h. Improved definition of size, range and connectivity of seabird populations

The nature conservation significance of impacts on seabirds are defined according to their effect on the long term viability (or the conservation status) of populations. This requires an understanding of the size and range of the population upon which the impacts are likely to exert an influence. In 2004 the results of the third complete census of the entire breeding seabird population of Britain and Ireland ('Seabird 2000') were published (Mitchell *et al*, 2004). This information is now over ten years old and in urgent need of updating.

Our understanding of the range of seabird populations and individuals within a population is improving, particularly following recent work to determine foraging radii for species (RSPB and Birdlife International, 2010). However, the connectivity of birds between colonies is less well understood, particularly for those species that are difficult to track as individuals.

Research to better define seabird populations and understand the connectivity between populations (both in and out of breeding seasons), such that management units can be determined would lead to a better ability to assess the likely impacts of marine renewable devices on seabirds at a realistic, biological population level. This information would help improve our understanding of the connectivity of seabird species to protected sites and inform Likely Significant Effect judgements in relation to Special Areas of Protection (SPA) and Sites of Special Scientific Interest (SSSI).

This information would also be of use to the offshore wind sector, given the number and scale of developments, cumulative and in-combination displacement and barrier effects on SPA populations and other sensitive species are a concern.

i. Improving estimates of local sea bird density and fidelity of seabirds

Diving seabird sightings rates are available that provide a useful characterisation of diving seabird presence in Welsh waters at a regional scale. However, they do not provide information at a resolution sufficient to characterise the importance of areas of high tidal and wave energy resource for seabirds. Neither do we have a clear idea of the level of fidelity to these areas, or reliance on particular areas of energy resource by individuals and populations. This information is required (covering breeding and non-breeding seasons, to inform assessments of the anticipated risk of encounters between devices and seabirds and likely disturbance and displacement effects.

j. Functional use and behaviour of seabirds in areas of high tidal stream and wave energy

Research is required to better understand the functional importance areas of high tidal and wave energy resource in breeding and non-breeding seasons.

Understanding the degree to which underwater tidal turbines might pose a collision or barrier threat to diving seabirds requires a better understanding of the dive profile and depth distribution of the various

species. This includes the dive profiles of animals feeding within, or transiting through areas of high tidal stream.

k. Sensory ecology of mobile marine species

Sensory ecology investigates the information that underlies an animal's interactions with its environment. Research on the sensory ecology of mobile species (predominantly diving seabirds and marine mammals) is needed to better understand the likely level, and consequences of, interactions with marine renewable devices. Some work has been undertaken to assess why flying birds collide with prominent structures which intrude into the open airspace, such as power lines, communication masts and wind turbines (Martin, 2011). Whilst this research may help inform the likely interactions between birds and emergent marine renewable devices, work is needed to better understand underwater sensory perception and the potential for mitigation measures to be developed.

l. Characterisation of fish communities associated with areas of high marine energy

Very little is known about the species and communities of fish associated with areas of high energy resource (particularly tidal stream). Further work is required to characterise the fish populations and communities associated with these areas, in order to determine the likely impact of marine renewable energy device deployments on fish and their predators.

m. Determining the functional importance of areas of high marine energy for fish species

Very little is known about the functional importance of areas of high energy resource for fish species and populations, for example as essential habitats, or feeding and breeding areas. Research is required to better understand such issues to not only inform assessments of the likely impacts of developments in these areas on fish, but also on predators such as diving seabirds and marine mammals.

n. Seascape Character Assessment

Detailed spatial representation of seascapes through a character-based assessment is needed, and widespread consensus on the need for this is building across the UK and across agencies and NGOs with an interest in cultural aspects of the environment. This baseline (which would build on existing work done to date) could then be used as the context in which to consider cultural sensitivities to particular types of renewables development.

2. IMPACTS RESEARCH

Impacts of marine renewable energy devices, particularly collision prediction, can only be researched by monitoring the effects of devices that have been deployed in association with validated and intelligent modelling based on data informed by such monitoring.

The specific research priorities relating to each of these key areas are detailed below. A short rationale is provided for each.

a. Monitoring the behaviour of marine mammals and diving birds around operating marine renewable devices – quantifying avoidance and evasion

Models have been developed to assess likely levels of encounter or collision risk for tidal stream devices in relation to mobile species. Whilst useful as a planning tool, these models are not currently based on any robust information about behavioural responses of mammals to devices. Limited information is available from the SeaGen device in Strangford Lough, Northern Ireland, but the device necessarily operates with a 'shut-down clause' requiring that it is stopped when mammals are in the vicinity. Direct observations are required to gather information on the behaviour of mammals and diving birds around operating devices. This should include observations of avoidance and evasion behaviour and the attraction of inquisitive species (e.g. bottlenose dolphin and minke whale). Such observation would greatly increase understanding about the real level of risk of collisions, as well as helping to refine and validate encounter risk models.

b. Establishing suitable techniques for monitoring underwater behaviour of mobile species

Adaptive management approaches to the deployment of marine renewable devices is reliant on the ability to detect and discriminate between animals in the immediate vicinity of devices. Although development of these technologies is advancing rapidly further work to improve the resolution of observations made by these devices is likely to be needed.

c. Establishing suitable techniques to monitor mobile species collisions

Validation of collision risk assessments for mobile species is reliant on the ability of technologies to firstly detect that a collision has occurred and secondly be able to determine what collided with the device (e.g. a species of marine mammal or diving seabird or marine debris). The efficacy of existing underwater detection and collision detection methods has yet to be demonstrated but this information may be required as a condition to consent for deployments, to ensure that thresholds for collision are not breached.

d. Effects of noise from underwater devices on fish / benthos / birds

Underwater sound and the potential impacts on marine life have received increased attention in recent years, with measures to assess underwater sound having been included within the European Marine Strategy Framework Directive (MSFD). As part of the proposed requirements of this Directive Member States may have to report on the occurrence and distribution of activities within their jurisdictions that generate loud, low and mid frequency impulsive sounds that exceed levels capable of causing significant impact to marine animals. However, very little is known about specific levels of sound that are deemed capable of causing a 'significant impact' to other marine animals, particularly fish, benthos and birds. Research is therefore needed which focuses on the likely impacts of noise on these taxonomic groups, which will help in the assessment of the likely impacts of offshore energy technologies, including wet renewables and offshore wind, and in reporting under the MFSD.

e. Modelling to predict the impacts of arrays of devices

Research is needed which focuses on 'scaling up' the effects of individual devices to predict the likely effects of arrays of devices on environmental receptors. Some of this information can be determined through monitoring of multiple-device demonstration deployments. However there may also be

qualitative differences between the known impacts of relatively small-scale devices and the likely impacts of commercial-scale deployments. In particular, effects on hydrology, sediment regimes and coastal processes may be significant and, noting the recently published work demonstrating boat-generated turbulence as a potential source of zooplankton mortality (Bickel *et al*, 2011), impacts on plankton communities may also need to be addressed.

f. Modelling to predict the cumulative impacts of multiple arrays of devices

Research is needed which focuses on assessing the cumulative effects of multiple arrays of devices on environmental receptors. This could particularly be an issue for environmental receptors sensitive to changes in energy regime and mobile species.

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