**Poster Presentations**

Abstracts for the posters accepted for the conference, arranged alphabetically according to the name of the corresponding author (underlined).

Alexander, Karen; Heymans, Sheila and Wilding, Thomas

Scottish Association for Marine Science, Scottish Marine Institute, Oban PA37 1QA, Scotland

**Modelling the opportunities of marine renewable energy: potential mitigation?**

Marine renewable energy devices and associated infrastructure will be placed on the seabed, affecting benthic infauna and epifauna (important food sources for many commercial species). It is likely that exclusion zones will be created around offshore renewable energy installations, turning the areas into no-take zones, or creating areas which are closed to certain gear types. These effects may offer opportunities for the fishing industry and mitigate any negative impacts. Using the ecosystem model Ecopath with Ecospace, this study tested spatial scenarios on the artificial reef effect and the exclusion zone effect upon both the fishing industry, and the ecosystem upon which this industry relies.

Bald, Juan; del Campo, Andrea; Franco, Javier; Galparsoro, Ibon; González, Manuel; Hernández, Carlos; Liria, Pedro; Menchaca, Iratxe; Muxika, Iñigo; Solaun, Oihana and Uriarte, Ainhize

AZTI-Tecnalia/Marine Research Division, Herrera kaia portualdea z/g, 20110 Pasaia (Gipuzkoa), Spain

**The Biskay Marine Energy Platform (bimep), environmental impacts and monitoring plan**

On 1 June 2009, the General Council on Environmental Quality Assessment of the Ministry of Rural, Marine and Natural Environment of the Spanish Government, in the light of the Environmental Impact Assessment (EIS) of the bimep project undertaken by AZTI-Tecnalia, decided not to submit the project to the whole Environmental Impact Assessment (EIA) process. In any case, the Environmental Impact Statement (EISt) of the Ministry, taking into account the great uncertainties about some predicted environmental impacts, underlined the need to implement the proposed Environmental Monitoring Program (EMP) of the EIS. Consequently, on 29 August 2011, the Basque Entity of Energy (developer of the bimep project) entrusted to AZTI-Tecnalia the development of the pre-operational phase of the EMP. This work presents the methodology and first results of this pre-operational phase on some environmental factors such as, icthiofauna, benthic communities, marine acoustics, mammals, and hydrodynamics.

Side, Jonathan and Beharie, Robert

International Centre for Island Technology (ICIT), Heriot-Watt University, Stromness, Orkney KW16 3AW, Scotland

**Disturbance to the marine environment by underwater sound sources in developing marine renewable energy**

The Marine Strategy Framework Directive identifies underwater noise as a descriptor of good environmental status; yet marine energy developments have only recently considered the sources of underwater noise arising from many current installation methodologies. A review of underwater noise sources related to device installations and studies conducted to date are presented together with other sources of anthropogenic noise in the marine environment. Models used for transmission loss and present thresholds applied to the disturbance of marine mammals are examined, highlighting those of most concern with suggested methods of mitigation.

Beharie, Robert and Side, Jonathan

International Centre for Island Technology (ICIT), Heriot-Watt University, Stromness, Orkney KW16 3AW, Scotland

**New wave action measurement of the energetic intertidal zone to enable long-term environmental monitoring and predictions of ecological impact due to wave energy convertor arrays**

The ecological impact to shoreline species and habitats by the reduction of wave energy in total and seasonal amplitudes due to future wave energy converter (WEC) arrays is not well understood. Current ecological classification systems have no quantitative values in energy levels associated with individual shoreline biological assemblages, mainly by the historical difficulty of using equipment in this harsh environment. A new device and methodology has been developed to provide a reliable long-term measurement of wave action adjacent to WEC developments, enabling predictions of possible impacts to vulnerable species. Results presented highlight seasonal difference in biotopes currently classed as equivalent.

Bell,Michael; Rouse, Sally; Porter, Joanne; Baston, Susana and Side, Jonathan

International Centre for Island Technology (ICIT), Heriot-Watt University, Stromness, Orkney KW16 3AW, Scotland

**Hydrodynamic energy and the distribution of marine organisms: sensitivity to change**

Water movements define some of the most important factors determining the functioning of marine ecosystems and the distribution of marine organisms. Hydrodynamic energy is a property of moving water, from which it follows that the extraction of energy for power generation inevitably involves changes in water movements. The potential ecological consequences will depend on the nature, spatial scales and levels of these changes. We use survey data on the incidence of marine organisms to determine the extent to which hydrodynamic energy can be identified as an ecological factor, and consider how sensitive distributions are likely to be to near- and far-field hydrodynamic changes resulting from wave and tidal energy extraction.

Broudic, Mérin; Cheong, Sei-Him; Willis, Miles; Croft, Nick and Masters, Ian

Low Carbon Research Institute (LCRI Marine), School of Engineering, Swansea University, Singleton Park, Swansea SA2 8PP, Wales

**The impact of sediment motion on underwater ambient noise in Ramsey Sound**

In May 2011, LCRI Marine led a research Program in Ramsey Sound named the Celtic Odyssey. These underwater recordings carried out during the Neap and Spring shows that sediment transportation and notably shellfish noise have a strong impact on the underwater ambient noise in Ramsey Sound. This physical and particular noise has shown to strongly dependant on time and location. This sound also occurs at a specific frequency band: 8 kHz to above 22 kHz. The results show that sediment movement influences background noise in Ramsey Sound during high and low water and can reach up to 126 dB re 1mParms/Hz at the 22 kHz 1/3rd Octave band.

**(WITHDRAWN)**

Carter, Caroline; Wilson, Ben and Burrows, Mike

Scottish Association for Marine Science, Scottish Marine Institute, Oban PA37 1QA, Scotland

**Underwater acoustic interactions between emerging tidal-energy technologies and marine mammals**

Marine mammals have excellent underwater sensory perception and agility, their primary sense is considered to be hearing. However, existing collision parallels have highlighted that they are not always able to avoid hazards. Very little is known about the underwater acoustic environment in tidal-stream areas, how these devices may acoustically modify the area, or whether the devices will be audible in time for collision avoidance. Our underwater mapping work suggests considerable heterogeneity in underwater ambient noise and that the noise levels are linked to tidal flow and bathymetry. Measured broadband levels range between 81-128 dB re 1µPa. These results will help inform the debate regarding the perceived collision risk to marine mammals.

Christie, David

Hebridean Marine Energy Future, Lews Castle College, Stornoway HS2 0XY, Scotland

**Marine Renewable Arrays and the Wave Climate**

As the deployment of large scale arrays of marine energy devices in Scottish waters approaches, agencies, developers and stakeholders have expressed a requirement for further research on their effects on the wave climate. Cumulative scattering, absorption and radiation can alter the wave spectrum in and around a development, affecting the available wave resource and local geomorphology. However, array effects are yet to be fully incorporated into current wave modelling software, and the various ad hoc numerical treatments used are yet to be systematically compared with observation, theory, or even each other. We consider the most promising analytical approaches to the problem, and compare the results with those obtained from the numerical codes.

Cooper, Bill and Moore; Michelle

ABP Marine Environmental Research, Waterside House, Town Quay, Southampton S014 2AQ, England

**An improved resolution hydrodynamic model of the Pentland Firth and Orkney waters area**

ABPmer was commissioned by The Crown Estate to create a new hydrodynamic model of the Pentland Firth and Orkney waters strategic area, at higher resolution and with greater spatial coverage than previous models. This was to inform a review of the area by The Crown Estate, which given the existing commercial-scale projects and some interest in further schemes, was assessing two key factors: 1) Best use of energy resources, given potential for additional commercial-scale projects in future; and 2) Potential risks to existing projects posed by additional development in the near-term, with respect to resource use and other cumulative impacts. The hydrodynamic model provided an enhanced characterisation of the resources in order to inform this assessment. The model was based on the DHI Mike 21 software, and ABPmer’s work covered gathering source model inputs, calibration with observed data sets and creating technical modelling setup files. It also considered representation of wave and tidal stream farms within the model domain.

Dufaur, Juvenal

Environmental Research Institute, North Highland College UHI, Ormlie Road Thurso, Caithness KW14 7EE, Scotland

**The tidal races in the Pentland Firth as an obstacle to the tidal stream energy development** **The Stroma Skerries: could the interactions between vortices explain the formation of kolk-boils?**

The so-called Stroma Skerries is a tidal race occurring in the Inner Sound, the channel between Stroma and the mainland of Scotland. This race has various features: strong currents, a big shear layer, vortices and kolk-boils. These kolk-boils are observable over the majority of the sea surface in the Inner Sound. The kolk-boil phenomena occur in rivers and tidal flows and are due to the interaction of flow with the seabed, in specific flow and roughness conditions. They consist of a “slow” up-welling, a "quadrant 2 event", moving from the seabed all the way up to the surface, preceded and followed by inrushes of “fast” down-wellings "quadrant 4 events". They are often called horse-shoe vortices because of their shape and appearance at the surface of the water. [1]

[1] J. Best, 2005, The fluid dynamics of river dunes: A review and some future research direction, Journal of Geophysical Research, Vol 110, 1-20

Easton, Matthew, Woolf, David and Goddijn-Murphy, Lonneke

Environmental Research Institute, North Highland College UHI, Ormlie Road Thurso, Caithness KW14 7EE, Scotland

**Using acoustic underway surveys for the spatial calibration of a 2-dimensional hydrodynamic model**

High-resolution hydrodynamic models are now being used to assist in the planning and decision-making of tidal-stream energy projects. There exists the potential for significant detrimental, long-term economic and environmental impacts if the resource is not fully appraised prior to development: this includes *a priori* assumptions on the spatial structure of the flow. Models require selection of input parameters that are not completely known and which can only be measured, at best, in a subset of the model domain. Consequently, models are *calibrated* and/or *validated* with respect to measured data at few, often sparsely distributed, locations.

Acoustic underway surveys are frequently used to determine the spatial pattern of tides in oceanic and coastal waters. Here, we use underway data in an effort to improve the spatial representation of tidal currents by a 2-dimensional hydrodynamic model.

Elliott, Jim; Benjamins, Steven; Carter, Caroline and Wilson, Ben

Scottish Association for Marine Science, Scottish Marine Institute, Oban PA37 1QA, Scotland

**A review of methods for studying marine mammals in tidal stream sites**

Few inshore environments present greater difficulties for the study of marine mammal distribution, abundance and habitat use than tidal streams due to the large and variable forces associated with the rapid flow of water. These areas are, however, of increasing interest for tidal energy development, and much more detailed information is required on how marine mammals make use of them. Over the years, a range of different survey and monitoring methods have been developed that could potentially be applied in these environments; each with its own benefits and drawbacks. This presentation’s aim is to illustrate a review for their applicability in studying marine mammal distribution, abundance and habitat use in tidal streams, with particular focus on Scotland. It will include examples of specific developments used by the authors in five locations at tidal speeds greater than 4m/s acquiring over 500 hours of operational data.

Garbe, Jennifer; Beevers, Lindsay and Matthews, Peter

School of the Built Environment, Heriot-Watt University, Edinburgh EH14 4AS, Scotland

**Environmental Conflicts with Offshore Renewable Energy**

Scottish Government plans to achieve 50% of electricity from renewable energy by 2020 have caused controversy surrounding both environmental and land use/marine spatial planning conflicts it may cause. Using Orkney as a case study, a series of interviews were carried out with relevant stakeholders to determine the perceived environmental conflicts this ambitious increase in offshore development will have. The ‘Deploy and Monitor’ approach is a main catalyst for incorrect perception of environmental issues relating to marine renewables. Following from this, ways toward reducing the conflicts identified are suggested, the main focus being on longer term, more localised management and planning practices.

Gay, Marybeth; Perotto-Baldivieso, Humberto and Gill, Andrew

Department of Environmental Science & Technology, Building 56b, Cranfield University, Bedfordshire MK43 0AL, England

**Spatial analysis of fish distribution in relation to MRED cable networks**

With the extensive deployment (existing and planned) of marine renewable energy electrical cable networks, and evidence of responses by electromagnetic-sensitive species to their emissions (EMF), it is important to understand the likelihood of species encountering cables and EMFs at the appropriate scale. We are using spatial analysis techniques to assess data on the current distribution of EM-sensitive taxa (primarily benthic elasmobranchs) in relation to benthic habitat type, the location of subsea cables and predicted EMF emissions in English waters. The approach used is generic enough to provide a basis on which to analyse spatial distribution of organisms in relation to environmental changes.

Goddijn-Murphy, Lonneke; Woolf, David and Easton, Matthew

Environmental Research Institute, North Highland College UHI, Ormlie Road Thurso, Caithness KW14 7EE, Scotland

**Combining ADCP survey data and low resolution model data for tidal site selection**

In support of tidal energy developments in the UK, current profiles were measured in the Inner Sound of the Pentland Firth, Scotland, using a vessel mounted Acoustic Doppler Current Profiler (ADCP). We performed numerous four to six hour surveys to identify promising sites. The tidal changes were rapid, and because underway measurements take time, the apparent spatial patterns were affected by temporal variation. We describe a method that estimated and corrected this temporal distortion using a hydrodynamic model. A revised model prediction could be calculated from a combination of ADCP and model data.

Gormley, Kate; Porter, Joanne; Hull, Angela; Sanderson, Bill and Bell, Mike

School of the Built Environment, Heriot-Watt University, Riccarton, Edinburgh EH14 4AS, Scotland

**Mapping marine shellfish resources: knowledge of their ecosystem to underpin the Marine Planning process**

It has been acknowledged that there is a lack of research regarding the interactions of shellfish and fish with other important maritime industries, e.g. renewable energy; despite an understanding of all ecosystems and their functioning being necessary to the implementation of Marine Spatial Planning and a requirement to achieve Good Environmental Status (GES) under the MSFD. This research project aims to contribute to this understanding of the ecosystem; and to ultimately aid the understanding of how dedicated marine renewable energy zones, for example, may influence species distribution. This knowledge will be gained through examination of current shellfish species distribution (in progress); investigation of how important communities of shellfish (*Modiolus modiolus*) are genetically linked (in progress); how these communities may be influenced by changing climate conditions (future work); and how species distribution modelling can be used to underpin the marine planning system (in progress).

Greenwood, Charles

HebMarine Project, Lews Castle College, UHI, Stornoway, Isle of Lewis HS2 0XR, Scotland

**A preliminary study on the potential impacts of large scale wave energy converter arrays on wave climates**

Future developments off the West coast of Lewis will deploy larger scale wave energy converter (WEC) arrays. Developers and stakeholders are calling for research into the impacts of devices and arrays on the surrounding wave climate. A review of previous literature is applied to assess modelling techniques used when calculating wave energy coefficients and the cumulative array effects of scattering for the proposed development sites. This study uses a simple model, validated with buoy data, to quantify the alteration in the wave climate, compared to baseline values, following the arrays' installation.

Guerin, Andrew and Masden, Elizabeth

Environmental Research Institute, North Highland College UHI, Ormlie Road Thurso, Caithness KW14 7EE, Scotland

**Marine renewable energy devices and fish aggregation: beneficial habitats or ecological traps?**

Fish have a tendency to aggregate around structures in the marine environment, such as oil rigs and offshore wind farms. Such structures may therefore act as refugia from commercial fishing. Wave and tidal energy devices may also aggregate fish, meaning that marine energy farms could act as *de facto* protected areas. However, there may be negative impacts on fish populations if this aggregation leads to increased mortality, either as a result of device interactions i.e. collision or entrapment, or increased predation. Here we discuss whether marine renewable energy developments have the potential to act as ecological traps for fish.

Guerin, Andrew; Bowyer, Peter and Jackson, Angus

Environmental Research Institute, North Highland College UHI, Ormlie Road Thurso, Caithness KW14 7EE, Scotland

**Marine renewables in the North of Scotland: using hydrodynamic models to explore risks to migratory fish**

It is increasingly recognised that marine renewables may impact migratory fish, such as Atlantic salmon (*Salmo salar*), during their migrations through Scottish coastal waters. To understand this risk, it is not only necessary to evaluate the interactions between fish and devices, but also to determine the probability of fish passing through areas for development. We have focussed on the latter, concentrating on the specific case of migratory fish passing through the Pentland Firth and Orkney waters. We use a hydrodynamic model to estimate the likelihood of passively drifting objects entering areas of risk and explore factors affecting this likelihood.

Hastie, Gordon; Sparling, C and Murray, A

SMRU Ltd, New Technology Centre, North Haugh, University of St Andrews, St Andrews, Fife KY16 9SR, Scotland

**Sonar as a tool to monitor interactions between marine mammals and tidal turbines; pitfalls and possibilities**

Advances in tidal energy have led to concerns about potential impacts on marine mammals. To assess interactions, active sonar is being considered as a means of tracking animals. However, there is the potential that sonar acoustic signals could cause behavioural changes or communication disruption. Results showed that although marine mammals could be detected in tidal environments, acoustic signals could cause overt reactions depending on the sonar used. We discuss that while sonar can be used effectively to track marine mammals, such deployments should be carried out with caution, as sonar can influence behaviour with potential ecological consequences.

Hutchison, Zoë; Last, Kim; Hendrick, Vicki; Beveridge, Christine; Wilson,Ben; Burrows, Michael; Jackson, Angus and Davies, Andrew

Scottish Association for Marine Science, Scottish Marine Institute, Oban PA37 1QA, Scotland

**Responses of benthic species to burial and suspended sediments as a result of renewable energy developments**

Disturbance to the seabed will occur from installation of marine renewable energy devices and associated infrastructure. Extraction of energy will change hydrodynamics, which may also alter movement and dynamics of sediments, but information is limited. We present behavioural responses and levels of mortality observed in some commercially important and biogenic reef building benthic organisms whilst under increased levels suspended and deposited sediments. Laboratory experiments were conducted in specialist mesocosms and near/farfield sediment simulations were based on field data from the marine aggregates industry. Responses were species-specific and differed to those predicted based on literature alone. This emphasised the need for and value of an experimental approach.

McGovern, Dave; Ilic, Suzana; McClelland, Stuart; Folkard, Andrew and Murphy, Brendan

Lancaster Environment Centre, Lancaster University, Farrer Avenue, Lancaster LA1 4YQ, England

**Can collars on offshore supporting structures reduce the effect of offshore wind turbines on the sea bed?**

Deployment of offshore wind farms is progressing rapidly around the world and in particular around the UK coastal waters. Their deployment and operation has an effect on the environment. The alteration of flow in the presence of the mounting structures results in changes in the sedimentary processes and sea bed changes, all of which can have effect on the benthic habitat. We will present results from an extensive series of laboratory tests that were conducted to examine the detailed tidal flow and turbulence structures and evolution of scour around a monopile. Also we examined the effectiveness of modified piles in reducing the near bed turbulence and resulting scour. This study has informed a complementary numerical model of the scour processes around the pile.

Irvine, Ryan and Maher, Micky

Gardline Environmental Ltd., Endeavour House, Admiralty Road, Great Yarmouth NR30 3NG, England

**Review of Boat-based seabird survey methodologies in the UK**

There have been attempts to standardise methodologies for boat-based seabird surveys for offshore renewables industry in the past by Camphuysen *et al*. (2004) and Maclean *et al*. (2009), however there are still several methodologies currently in use in the UK and European waters. This paper aims to compare and evaluate the methodologies used, breaking these down into their component parts and discussing the best protocol for future surveys with an emphasis on data collection suitable for Cumulative Impact Assessments.

Jackson, Angus

Environmental Research Institute, North Highland College UHI, Ormlie Road Thurso, Caithness KW14 7EE, Scotland

**Scour around moorings for offshore wave devices**

Scour is the change in shape of the seabed through time caused by the presence of an object. Moorings for offshore wave devices are likely to be of considerable size. They are likely to be used at locations where water movements near the seabed caused by large waves, can move grains of sediment. We will sample sediment grain-sizes and rates of water flow to help predict expected scour. Scour pits will then be measured using vessel-mounted side-scan sonar and video footage from a remotely operated vehicle. If possible, development of scour will be related to wave climate and stage of the tidal cycle.

Jackson, Angus and MacLeod, Adrian

Environmental Research Institute, North Highland College UHI, Ormlie Road Thurso, Caithness KW14 7EE, Scotland

**Growth of biofilms and potential implications of developments in marine renewable energy**

The mechanisms, magnitudes and extents of ecological impacts from extraction of marine renewable energy are not yet known with any certainty. Most attention has been on species living on the seabed, in the water column or the air. Less attention has been paid to intertidal species. Photosynthetic biofilms are key components of intertidal systems and are likely to be influenced by rates of water flow. Using a combination of field studies with colour-infrared cameras and laboratory experiments with flumes, we demonstrate how amounts of biofilm respond to differences in water flow and make some general predictions about how biofilms may change as the industry develops.

Jeffcoate, Penelope; Stansby, Peter and Apsley, David

University of Manchester, Pariser Building, Sackville St., Manchester, England

**Near-field flow downstream of a barrage: experimental, 2-D and 3-D modelling of turbines**

A key problem perceived to arise from tidal barrages is the detrimental environmental impact; however, near-field, 3-D modelling has not been conducted, so accurate flow effects are largely unknown. Flume experiments, with three-component velocity measurements, and 2-D and 3-D CFD modelling were conducted to assess the velocity profiles, surface fluctuations and bed shear stresses downstream of a barrage. An experimental seven-duct barrage with both no turbine representation and turbines with stators was assessed; the turbine and resulting swirl velocity in the CFD modelling were represented by an in-channel blockage and body force respectively. The effectiveness of computational modelling for predicting flow effects of barrages was determined, including the location at which each method of modelling is most appropriate. The predicted changes to the flow velocity and the sediment transport caused by the barrage could, therefore, lead to better predictions of environmental effects.

Keir, Alison

Archaeology Department, Orkney College, University of the Highlands and Islands, Kirkwall, Orkney, KW15 1LX Scotland

**Coastal change and heritage in Northern Scotland**

Coastal change creates a series of challenges for the management of archaeological heritage. The development of industries such as those connected with renewable energy poses an additional threat to archaeological sites and landscapes. This project will research the various values which are placed on the archaeological heritage; and the potential of seamlessly utilising the land‐based, coastal and marine heritage resource for the benefit of community, education and tourism. A research aim is to provide information, methods and strategies relating to the coastal historic environment that will be of value to planners and developers on connection with renewable energy and other coastal developments.

Kershaw, Peter; Brazinskaite, Raminta; Busch, Malte; Cooper, Philip; Jackson, Emma; Jessop, Mark; Judd, Adrian; Kannen, Andreas; Kenny, Andrew; Le Quesne, Will and Paltriguera Lucille

Cefas, Pakefield Road, Lowestoft NR33 0HT, England

**Assessing the social-ecological effects of large-scale offshore windfarm development – challenges and potential solutions**

We describe the preliminary findings of an investigation into the possible **changes to ecosystem services and benefits as a result of large-scale offshore windfarm development in the southern North Sea, covering ecological, social and economic impacts. A key underlying question is to what extent such large-scale activity will affect the achievement of Good Environmental Status (under the Marine Strategy Framework Directive) for a range of GES descriptors (e.g. noise, seafloor integrity and biodiversity). This forms part of the European-funded Knowseas programme (Knowledge-based sustainable management of Europe’s seas,** www.knowseas.com**)**.

Langton, Rebecca; Davies, Ian and Scott, Beth

Institute of Biological and Environmental Sciences, Zoology Building, University of Aberdeen, Tillydrone Avenue, Aberdeen AB24 2TZ, Scotland

**Predicting the impacts of marine renewables on seabird populations**

There is potential for marine renewable developments to affect individual seabirds through collisions or modifications of habitat, prey distribution and bird behaviour. Any such changes would alter the energetic balances of adult birds and their chicks. An individual based model simulating the behaviour and energetics of family units of seabirds predicts the direction and magnitude of impacts, on adult survival and fledging mass, of different scenarios of renewable deployment and bird responses. The model will be spatially explicit and consider the affect proposed development sites in Scotland could have on the populations of seabirds nesting in the region.

Lawrence, John

European Marine Energy Centre (EMEC) Ltd, Old Academy, Back Road, Stromness, Orkney KW16 3AW, Scotland

**Numerical Modelling at EMEC’s Wave and Tidal test sites**

EMEC has commissioned wave and tidal numerical models of Pentland Firth and Orkney waters to inform decision making at EMEC’s wave and tidal test sites. The model uses the “MIKE by DHI” technology, implemented on a flexible mesh. This allows good resolution of local complex flows while not overloading available computer resources. Results from the wave model operating in a forecasting mode will be presented, with applications for device installation and operation. Results from tidal resource extraction studies at local sites will be presented. Results from a 10 year wave and tidal hindcast run will be presented, describing relevant hydrodynamic data at the EMEC test sites.

Lacey, Claire; Gillespie, Doug and Quick, Nicola

SMRU Ltd, New Technology Centre, North Haugh, St Andrews, Fife, Scotland

**Introducing PAMLA: Using novel passive acoustic techniques to study fine scale behaviour of odontocetes relative to marine structures**

This study describes the use of a novel technique to investigate porpoise movements, relative to a bridge, in order to assess the potential for barrier effects. This novel application of existing techniques is designed to investigate fine scale movement patterns of individual animals.

A four element hydrophone array was used to calculate sequential bearings to odontocete clicks thus assess fine-scale behaviour. This novel methodological approach was found to work successfully and with further studies could make an invaluable addition to the suite of monitoring and mitigation techniques which are currently available for assessing potential effects of static marine developments.

Lees, Kirsty; Grecian, James; Masden, Elizabeth and Jackson, Angus

Environmental Research Institute, North Highland College UHI, Ormlie Road Thurso, Caithness KW14 7EE, Scotland

**The impact of wave energy devices on the distributions of seabirds**

The UK has great potential for generation of electricity from wave power, with northern Scotland having a particularly large wave resource. The UK also supports internationally important populations of seabirds, but how these will respond to this emerging industry is unclear. Here, we investigate the potential for interactions between wave energy devices and seabirds. By combining several years of observational data on seabird distributions with information on the marine environment and the location of devices, we explore the potential consequences of this type of development for seabirds. Our results will provide better understanding of how seabirds use the marine environment and will be of direct value to the marine energy industry.

Lyndon, Alastair

Centre for Marine Biodiversity & Biotechnology, School of Life Sciences, Heriot-Watt University, Riccarton, Edinburgh EH14 4AS, Scotland

**Potential positive impacts of marine renewables: fisheries and aquaculture**

Environmental impact assessments for marine renewable energy structures have generally concentrated on potential negative effects, for instance in relation to birds. This paper addresses the possibility that such structures might have positive impacts in relation to fisheries ("artificial reef" and "protected area" effects) and aquaculture (enhanced potential for "offshoring" of intensive marine farming). Parallels are drawn with existing offshore structures in an effort to estimate present beneficial effects, and the extent to which these might be maintained or augmented by sympathetic placement of new structures. It is suggested that collateral benefits of marine renewable deployments should be factored into EIAs.

Macleod, Adrian; Cook, Elizabeth; Stanley, Michele and Day, John

Scottish Association for Marine Science, Scottish Marine Institute, Oban PA37 1QA, Scotland

**Colonisation of offshore marine renewable energy structures: The effects of deployment time, tidal flow and geographical region**

The large scale addition of artificial substrate associated with the marine renewable energy industry has the potential to change the recipient habitats greatly. However, little is known about how high flow environments, suitable for many types of energy generation, shape the typical fouling communities resident on devices. A network of 43 navigation buoys throughout Scotland was used to study epibenthic communities typical of artificial substrate in tidal and wave areas proposed for marine energy generation. These communities were found to be complex across a wide range of hydrodynamic conditions. Geographical region, rather than tidal flow or submersion time explained most of the variation in community composition.

Macleod, Adrian; Cook Elizabeth; Stanley, Michele and Day, John

Scottish Association for Marine Science, Scottish Marine Institute, Oban PA37 1QA, Scotland

**Life in the renewables fast lane: Do artificial hard substrate communities facilitate the propagation of non-native species in high energy environments?**

Marine renewable energy structures may facilitate the spread of non-native species. From a network on marine navigation aids two common fouling species of amphipod were identified the native amphipod, *Jassa marmorata*, and the non-native amphipod, *Caprella mutica*. A purpose built biological flume was used to study the behaviours of these species with respect to elevated flow rates typical of the environment experienced by marine renewable energy devices. Behavioural responses for *J. marmorata*, were less sensitive to elevated flow. A number of control and mix species treatments at different flow rates found displacement in the mixed species treatments were not significantly different to control treatments. Work is ongoing to investigate how ambient flow rates, habitat complexity, and species interactions influence non-native species introductions.

Masden, Elizabeth; Reeve,Richard; Desholm, Mark; Fox, Anthony; Furness, Robert and Haydon, Daniel

Boyd Orr Centre for Population and Ecosystem Health, Institute of Biodiversity, Animal Health and Comparative Medicine, College of Medical, Veterinary and Life Sciences, University of Glasgow, Glasgow G12 8QQ, Scotland

**Assessing the impact of marine wind farms on birds through movement modelling**

Advances in technology and engineering, along with EU energy targets, have stimulated rapid growth of the wind power sector. Wind farms contribute to carbon emission reductions but there is a need to ensure that these structures do not adversely impact the populations that interact with them, particularly birds. We developed movement models based on observed avoidance responses of common eider *Somateria mollissima* to wind farms to predict, and identify potential measures to reduce impacts. Using flight trajectory data collected post-construction of a Danish offshore wind farm, we demonstrate how such models can contribute to the spatial planning of wind farms.

McIlvenny, Jason; Woolf, David; Elver-Evans, Joanna; McClatchey, John and Gleizon, Philippe

Environmental Research Institute, North Highland College UHI, Ormlie Road Thurso, Caithness KW14 7EE, Scotland

**Wind and wave climatology of the North Atlantic, North Sea and Scottish waters: a review of historical data**

An understanding of the availability and reliability of wind and waves as a renewable energy resource requires good data. All offshore activity is sensitive to storm events. Long data series are important to the calculation of robust climatological statistics and an understanding of decadal variability requires data series spanning several decades. New initiatives to measure waves at important development sites need to be complemented by studies of historical sources that provide a long-term perspective. Diverse sources of data are available for the world’s oceans. Some shipboard observations date back centuries, but the quantity and quality of available data improved dramatically through the latter half of the twentieth century; firstly through the establishment of a weather ship network - strongest in the North Atlantic – and a strengthening Voluntary Observing Ship (VOS) network. The weather ship network declined from the 1970s but other data sources emerged including satellite data sets, wave buoys, coastal radar and diverse measurements associated with the North Sea oil and gas industry. Numerical weather prediction outputs and wave model outputs are also underpinned by the observational networks. Generally, data is adequate to describe broadly wind and wave statistics offshore of Scotland over the last several decades, but insufficient near shore, for example at most potential tidal or wave energy sites.

Miller, Raeanne; Burrows, Michael; Fox, Clive and Inall, Mark

Scottish Association for Marine Science, Scottish Marine Institute, Oban PA37 1QA, Scotland

**Population connectivity of offshore renewable energy structures: does larval vertical positioning hold the key?**

The deployment of marine renewable energy infrastructure in a range of oceanographic environments creates a diversity of hard habitat types in areas previously devoid of vertical relief. Many organisms colonising these structures possess a pelagic larval stage connecting coastal and renewable energy structure populations. Vertical positioning of these larvae in coastal flow fields may influence transport, dispersal, and connectivity. Using laboratory and field-based observations to parameterise a biophysical model, we explore the influence of vertical positioning on the dispersal of acorn barnacles along the Scottish west coast. Understanding the dispersal processes of fouling species such as barnacles may be important when assessing potential connectivity and biogeographic impacts of expanding renewable energy infrastructure, with further application to the spread of invasive species and the development of marine protected areas.

Morrison, James and Greenwood, Charles

HebMarine Project, Lews Castle College UHI, Stornoway, Isle of Lewis HS2 0XR, Scotland

**Tools for interpreting and disseminating wave data**

As wave energy developers are planning large scale installations off the west coast of the Isle of Lewis, the Hebmarine project deployed three Datawell wave buoys to aid the assessment of local wave resources. This paper reviews the open source software code that we developed, its features, processes and limitations in enabling the dissemination and interpretation of wave buoy data in a real-time automated process. The software developed will be released under an open license to benefit the wave energy community and to aid the development of a free common platform for disseminating and interpreting wave data.

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**Adaptive Composite Blades for Noise Reduction of Wave and Tidal Energy Converters**

The acoustic signature of a marine energy converter is a product of the combination of the different sources of noise within each device. In underwater devices the main cause is cavitation, whilst for above ocean devices it is the high operational speed of air-based equipment. Noise can travel long distances underwater, having implications for the navigation and communication methods of certain animals. This paper demonstrates the reduction of cavitation, hence noise levels, in free stream tidal turbines through application of passively adaptive, composite blades. It is considered that such blades may also be suited to certain above ocean wave energy devices. A further benefit is the increased annual energy capture achievable.

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**Using static acoustic monitoring to model cetacean occurrence at fine spatial and temporal scales at a wave energy test site**

Sustainable Energy Ireland is developing a full scale, grid-connected, wave-energy test site off Co. Mayo, Ireland. As part of the Environmental Impact Assessment of the Atlantic Marine Energy Test Site, the Irish Whale and Dolphin Group have been monitoring cetaceans acoustically using C-PODs. Static Acoustic Monitoring can provide robust datasets for exploring fine-scale occurrence at a site, especially at exposed sites where visual surveys are constrained. We modelled this acoustic dataset to determine how many sites should be monitored, and for what period, monitoring should be carried out in order to detect changes once the test site is operational.

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**Stress influence of offshore wind farms on the reproduction of the viviparous eelpout (Zoarces viviparus)**

Disagreements around offshore wind farms considering the stress it may cause on both species and ecosystem made this a hot topic in need of more research. There are concerns about the potential impacts on biodiversity, like habitat loss, killing of sea birds, noise disturbance and increased risk for settling of invasive species. Here we investigate offshore wind farm impact on reproduction in fish. We use pregnant eelpout (*Zoarces viviparus*) as model species and we compare fish fecundity in a wind park with a control area. Future offshore energy projects can gain from these results since they will give important input to environmental impact assessments and monitoring.

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**Predicting the ecosystem effects of harvesting beach-cast seaweed for biofuel: A field-based approach combined with food-web modelling**

Global declines in fossil fuels, together with climate change and energy security issues have led to an urgent need to find viable biofuel alternatives to petroleum products. Several sources of seaweed have been proposed as biofuel feedstocks on the West Coast of Scotland. One such major feedstock is beach‐cast kelp. Before this seaweed can be removed for biofuel it is necessary to understand its ecological role and predict the impacts of removal. This study combines field‐based studies with ecological food‐web modeling, using software Ecopath with Ecosim, to predict the ecosystem effects of removing seaweed for biofuel. Results from the field studies indicate that use of beach‐cast seaweed for biofuel would be detrimental to the functioning of beach ecosystems.

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**Interactions between seabirds and oceanographic variables off the Isle of May to inform the potential deployment of a tidal energy device**

This project examines the relationship between small scale oceanographic variables and seabird distribution and at sea behaviour in a tidal stream area. This will lead to quantitative definitions of seabird foraging habitat which will allow the predictions of the environmental effects of tidal turbines. Land based seabird surveys were undertaken in the breeding season alongside biophysical data collection. Results indicate seasonal variation in usage between species and low proportions of foraging. Ongoing analysis is targeting the finer temporal scales to test if species use different physical aspects of the daily tidal cycle for foraging. An approach to predicting probability of collision risk has also been developed.

Rouse. Sally; Porter, J and Wilding T

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**Understanding benthic productivity on artificial structures: maximising the benefits of marine renewable energy devices**

Marine renewable energy devices (MRED) constitute artificial reefs and have the capacity to host biological assemblages that deliver ecological services. Understanding the performance of artificial reefs, in terms of productivity, has been identified as one of the pressing research needs in relation to the ecological impacts of offshore renewables. Cuttings of the bioindicator bryozoan *Flustra foliacea* will be collected and redeployed to the Loch Linnhe Reef, a 6200 tonne multi-modular, purpose-built underwater experimental matrix located off the west coast of Scotland. Variations in the growth of these colonies will be linked to variations in the food supply, as a function of flow interactions and sedimentation on, or within, a single reef unit (e.g. height on the reef), and between different reef units. Understanding the processes that govern the productivity associated with artificial structures will enable us to both predict the ecological consequences of deploying MRED and inform us how to modify proposed, or existing structures, in order to maximise their benefit to coastal ecosystems. Such an approach will mitigate against the potential loss of access (e.g. to fishermen) that may occur around offshore renewable devices.

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**Scenarios for evaluating tidal current energy potential in the UK**

Tidal current energy can provide a predictable and periodic power output that can make a significant contribution in meeting the UK governments’ renewable energy targets. However, unlike the mechanical availability of the conventional generation, tidal current energy is dependant on the resource availability and therefore presents a variable output. This paper presents different scenarios that can be developed for tidal current energy in the UK waters. The scenario incorporates constraints specific to first generation tidal technology considered for deployment over the next decade. Time-series data is used for sites identified as high energy and economical to assess the overall spatial and temporal variability of the resource. Temporal variability of the different sites are investigated to better understand tidal phasing of the majority of sites in the UK.

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**Marine renewable energy technologies and the [marine] historic environment**

The development and deployment of marine renewable technologies has driven rapid changes to national legislation and policy concerning their interaction with and impact on the historic environment. These changes often lag behind the rapidly evolving industry. There are both problems and opportunities presented by regulations and statutory requirements to assess the impact of developments on the historic environment at sea as well as on land. The investigation of heritage, archaeological and cultural considerations is presented, as experienced by a commercial heritage consultancy working with developers in the marine renewables sector in the north of Scotland.

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**Evaluating the Baltic Sea action plan with the help of a newly developed assessment tool (mesma): experiences and lessons learned**

This paper provides the first results from the pilot application of a new generic and flexible methodological framework tool (MESMA FW) for monitoring and evaluation of spatially managed marine areas. The MESMA FW addresses the demand for a practical tool for integrating monitoring, evaluation and implementation of Spatially Managed Areas (SMA) in coastal and offshore waters. It has integrated the lessons learned from existing frameworks (Integrated Environmental Assessment and Marine Spatial Planning) and aims to provide guidance for assessing and achieving good environmental status in line with the EU Marine Strategy Framework Directive (MSFD). This paper shows how the MESMA FW has been applied on the international and cross-sectoral Baltic Sea Management Plan.

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**Ecosystem recovery: how long does it take?**

A key question for any habitat manager dealing with a degraded landscape is how quickly it will recover. A recent metadata study looking at rates of recovery in over 240 long-term ecological datasets spanning the past 150 years concluded that 30% of the studies showed full recovery. The recovery time depends strongly on ecosystem type and can take over 100 years, if it occurs at all. We argue that in terms of planning, information on recovered versus non-recovered ecosystems is in many ways more insightful than the actual number of recovered ecosystems. Knowledge on why specific types of ecosystems are likely or unlikely to recover from a specific disturbance provides essential information for current and future environmental perturbation management.

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**ETI Tidal Resource Modelling Project**

This project will model the UK’s tidal energy resources to help improve understanding of the possible interactions between the various tidal energy extraction systems expected to be deployed between now and 2050.

It will develop models of the whole UK Continental Shelf that will be used to investigate how energy extraction at one site may affect the energy available elsewhere. A wide range of possible future tidal current and tidal range sites, with differing technology possibilities will be represented in the models.

The project will identify how the interactions between different sites around the UK combine to form overall flow effects, and what constraints these interactions will place on the design, development and location of future systems.

At the end of the project the models will be made available to the wider marine industry to help inform future plans and strategies through a service provided by HR Wallingford.