Seabird Surveys at Ireland's Atlantic Marine Energy Test Site (AMETS).

Jackie Hunt[1], Jessica Beaubier[2], Derek McLoughlin[3]
[1]*Upper Deerpark, Belcarra, Castlebar, Co. Mayo, Ireland. Tel 00353 (0)94 9032965.*
Email: jackiehunt@iol.ie
[2]*D10 City Square, Dublin. Email: beaubier@shaw.ca*
[3]*Loughloon, Westport, Co. Mayo. Email: derekmcloughlin@eircom.net*

A wave energy test site is proposed for inshore waters off the west coast of County Mayo, Ireland. The test site has been selected for its high wave energy levels, due to full Atlantic exposure conditions. Some seabird data for the test site is available from past surveys of Irish waters. Detailed data is not available and baseline bird surveys as part of the Environmental Impact Assessment began in 2009. Surveys at sea followed standard European Seabird at Sea survey methods. Eight surveys were completed between October 2009 and October 2010, excluding the winter months. A total of 8,092 birds of 33 species were recorded. In March 2011 monitoring surveys began at the wave energy test site. The monitoring survey design has been adapted to detect effects of wave-energy related activities on bird densities within the immediate area surrounding each test berth. It is an experimental approach that uses test (berth) and control sites with pre- and post-activity monitoring. Because there are only two test berths, the 'treatment' sample size of our sampling design is limited to two in order to avoid pseudoreplication. This, coupled with natural variance in seabird numbers, means that power to detect *small* differences in seabird densities will be rather limited. Large scale differences should however be detectable. The key challenge has been how to develop an effective sampling strategy, within practical and budgetary limitations and for a novel development. Baseline survey work was financed by Tonn Energy Ltd.

INTRODUCTION

The Atlantic Marine Energy Test Site (AMETS)

Ireland is ideally placed, geographically to utilise ocean energy and in particular wave energy as a source of local renewable energy (Kavanagh *et al.*, in press). As part of Irelands Ocean Energy Strategy, an offshore Atlantic Marine Energy Test Site (AMETS) has been proposed for the Annagh Head area of County Mayo, Ireland (Figure 1).

Figure 1. Location of the Atlantic Marine Energy Test Site off the west coast of Ireland. Berth locations and EIA transects shown in inset.

The AMETS will provide the first full scale wave energy test site in Ireland. It will be a grid connected national test facility, at which full scale pre-commercial wave energy convertors could be deployed during their final stages of commercial development One aim of the test site will be to assess the environmental impacts associated with wave energy developments (Kavanagh *et al.*, in press).

The AMETS encompasses two berths, within which Wave Energy Devices (WEDs) will be deployed, and the submarine cable route (Figure 2). There is an offshore berth located at 100m depth, 15km from shore, and a near-shore berth located at 50m depth and four km from shore. Each berth will have an array of up to 10 WEDs. Underwater cabling will run from the berths to the shore on the Mullet Peninsula. Consent allowing, construction activities are planned for between June and September 2013 and the test site will be operational for 20 years thereafter (Kavanagh *et al.*, in press).

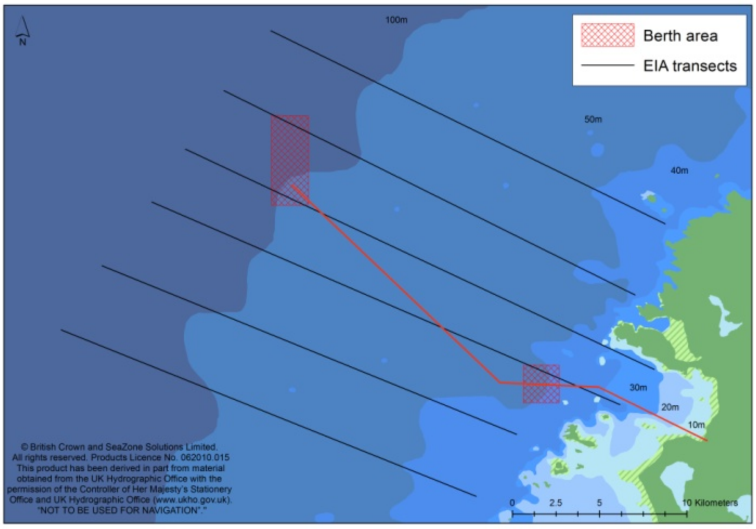

Figure 2. The study site, showing inshore and offshore berth locations, the submarine cable route (red line) and transect lines for EIA surveys. The terrestrial habitats of the Mullet peninsula are shown in green. Depth contours are indicated.

The AMETS was selected following a site selection and evaluation study which was completed in 2008 (Fielding *et al.*, 2008). A number of site selection criteria were used, including the presence/absence of protected marine and terrestrial areas. The AMETS and submarine electricity cable routes are not within any protected area under national legislation. However, the cable landfall will cross a designated Special Area of Conservation (SAC) and four terrestrial designated Special Protected Areas (SPA)s lie within 5km of the test site.

After selection of the test site, an Environmental Impact Assessment (EIA) was required as part of the development consent process. The EIA for the test site (discussed herein) included a biological assessment of sub tidal reefs, benthic communities, marine mammals, birds and terrestrial habitats and provided a baseline ecological characterisation of the AMETS along with estimates of likely impacts. The EIA was funded by Tonn energy, developers of Wave Bob wave energy devices.

While the EIA served as a basis of estimating potential impacts, further pre-development data is now being gathered as part of a pre-development monitoring programme. Monitoring of the test site began in March 2011 and is funded by Sustainable Energy Authority of Ireland (SEAI).

EIA for wave energy developments

Guidance on seabird survey methods specific to wave energy developments have yet to be developed. The standard methods for surveying seabirds at sea are those developed by the Joint Nature Conservation Committee (JNCC) for European Seabird at Sea Surveys (ESAS) (Tasker *et al.*, 1984; Webb and Durinck, 1992). These methods were used for the WaveHub EIA, a consented wave energy development off the south coast of England (Halcrow, 2006). The ESAS methods have also been adapted for use in EIA for offshore wind farms (Camphuysen, 2004). While not developed for EIA purposes the ESAS method provides the best available standard method for surveying seabirds at sea in the EIA context.

Monitoring at wave energy sites

A standard monitoring approach is yet to be developed for wave energy developments. However, in a review of the potential impacts of wave powered marine renewable energy installations (MREI), Grecian *et al.*, (2010) recommend use of Before After/ Control Impact (BACI) assessment (Underwood, 1992) as a minimum standard in future research studies of MREI impacts. In a review of the Lysekil wave power park in Sweden, Langhammer *et al.* (2010) discuss the use of BACI in EIA and follow up studies.

Ecological impacts of wave energy developments

As yet, there is limited data on the impacts of wave energy developments on birds. However, various reports, reviews, workshops and papers (e.g Langhamer *et al*., 2010; MASTS workshop, 2010, Grecian *et al*., 2010, Wilson *et al.*, 2007) have outlined the potential impacts, positive and negative from wave energy devices. Some of those, which may affect birds are listed box 1.

Box 1: Some potential impacts between wave energy developments and birds.

- Changes in local food web interactions
- Creation of artificial reefs
- Creation of resting sites
- Disturbance during construction and maintenance
- Use of anti foulants and impacts on water quality
- Influence of magnetic fields on the behaviour of marine mammals (changes in fish behaviour may have secondary impacts on birds)
- Changes in benthic community patterns due to changes to local sediment patterns.
- Displacement of birds from feeding areas
- Displacement of breeding birds
- Collision with underwater cables
- Disturbance and /or disorientation due to night lighting
- Connectivity impacts, where birds from Special Protection Areas, are using the wave energy test site.

AIMS

The test site at Annagh Head is the first of its kind in Ireland and will support full scale WED's in one of Europe's best wave climates. The aim of this paper is to describe the learning process underway at this test site in terms of monitoring for a novel development. The EIA survey methods, design and brief results will be described. Changes to the EIA survey design for monitoring purposes will then be presented. Implementation of the monitoring programme within practical and budgetary project constraints will be outlined. Finally, some wider issues relating to ocean energy development in Ireland will be considered.

METHODS

Study Site

The study site encompasses the two test berth locations and the submarine cable route and covers an area of approximately $180km^2$ (Figure 2). The study site comprises the shallow coastal waters of the Mullet peninsula and deeper waters west of the peninsula for a distance of c. 15km. Water depths range from between <30m to >100m deep. Existing and historical bird data is available for coastal and terrestrial habitats of the Mullet peninsula (e.g. Crowe, 2005, Suddaby, 2011). However, data for the rest of the study site is limited. Two surveys of Ireland's seabirds at sea covered waters west of the Mullet peninsula (Pollock *et al.,* 1997, Mackey *et al.,* 2004). However these surveys covered waters around large areas of Ireland, limiting the amount of data available for this area particularly.

Survey Methods

Seabirds were recorded using the ESAS standard survey method. This method uses three elements the band transect, the snapshot, and the scan to give an assessment of the numbers and distribution of seabirds. The band transect is where birds are counted in a 300m perpendicular distance from the boat's route. Birds on the water in this 300 m strip are allocated to distance bands from the ships track (A = <50 m, B = 51-100 m, C = 101-200 m, D = 201–300 m, E >300 m). The snapshot is used for flying birds encountered at 1 min intervals (in these surveys) within the 300 m bow-to-beam quadrat, with a constant boat speed of 10 knots. The scan records all species encountered in a 90^{O} arc (from bow to beam). Age class, direction of flight and feeding activity are recorded where possible.

Following ESAS methods, two surveyors were used during surveys and on most surveys these were the same two people, for consistency in observer effort. One surveyor was the primary observer, while the other scribed. The same vessel was used for all offshore surveys and gives an observer eye-height of 5 m (within the recommended range of Camphuysen *et al*., 2004)

Numbers and distribution of the most common seabirds encountered were mapped using ArcGIS v.9.0. Density maps were produced for species were sufficient data was gathered for analysis. Density was calculated by dividing the number of birds in the transect area by the transect area, i.e. the number of birds/km^2. Where insufficient data was gathered to produce density maps, these data were presented as relative abundance maps. Relative abundance was calculated by dividing the number of birds observed each month, both in and out of the transect (i.e. all bird sightings), by the distance travelled by the survey vessel, (i.e. number of birds/km). Birds considered to be associating with the survey vessel were not included in the analyses.

The detectability of each species associated with the surface of the ocean (engaging in behaviour such as feeding, preening, etc.) varies considerably depending on size and behaviour of bird, distance from the survey vessel and sea state. For species necessitating density maps, correction factors are required to compensate for this varying degree of detectability. These multiplication factors are calculated by comparing the number of species observed at differing distances from the survey vessel. Due to the relatively small amount of data generated in this study, correction factors listed in Stone *et al.,* 1995 are used (whose correction factors were derived from a much larger data set). No correction factors were used for flying birds.

EIA Survey

The test site was surveyed by boat using parallel line transects lying perpendicular to the shore (crossing bathymetric features) and at a distance of approx 2km apart (Figure 2; following Campyhuysen *et al.*, 2002). The survey area was 180 km^2. This survey area was selected to cover the WED berth areas, the submarine cable route and as much area around these features as could be covered in a single day. The aim of the EIA survey was to gather base line data on numbers, distribution and density of birds within the study site.

RESULTS

Transect surveys were conducted on a total of eight occasions. The first survey occurred in October 2009. Surveys were planned to cover the winter season, however heavy seas hindered any visit between November 2009 and February 2010. Surveys were completed monthly from March to October 2010, with the exception of September when no survey was complete due to inclement weather. During the first three surveys five line transects were covered, taking an average survey time of five hours 20 mins. To increase coverage of the site an additional, sixth line transect was covered in the remaining surveys, increasing survey time to approximately six hours 20 mins.

The species groups encountered in greatest numbers during surveys at sea were petrels (Manx Shearwater, Great Shearwater, Storm Petrel and Fulmar), Auks (Razorbill, Puffin, Guillemot), Gulls (Kittiwake and Great Black-backed Gull) and Terns (Arctic Tern). Gannet was the most commonly encountered species.

Some bird species such as Auks, Terns, Gulls, Fulmar and Storm Petrel breed locally and their occurrence in the study area may be linked to nearby breeding colonies. There are no local breeding sites for Gannet and Manx Shearwater, however the study site lies within the foraging range of Irish and Scottish breeding colonies for these species and non breeding birds may also have been present. Large rafts of Manx Shearwater were of note, and may be linked to the late arrival of non-breeding birds in Irish waters (Pollock *et al*., 1997). The occurrence of Great and Sooty Shearwater in the Autumn was clearly linked to their southward migration.

Some possible distribution patterns within the study site were apparent e.g. Storm Petrels were mainly recorded further out to sea, while Arctic tern and Manx Shearwater were more closely associated with the coast. However, further studies are required before conclusions can be drawn.

The total mean densities of birds observed throughout the monthly surveys varied considerably. Highest monthly densities occurred in October 2009 and 2010 although particularly large numbers of single species distort this picture. Great Shearwater accounted for over 50% of the October 2009 total, while Gannets accounted for over 80% of the October 2010 total (Figure 3). Relatively high mean bird densities from April through to July are apparent with lowest mean densities being recorded in August.

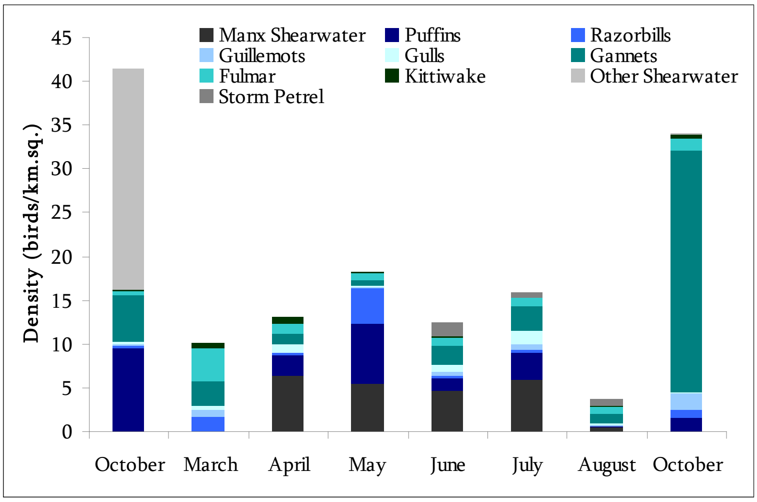

Figure 3. Relative species contributions to observed mean avian density (birds/km^2) by month.

The cumulative number of species in each 300 x 300 metre segment (Figure 4) appears to be relatively evenly distributed throughout the study area. It should be noted that the most southerly transect route was only surveyed on a total of five occasions.

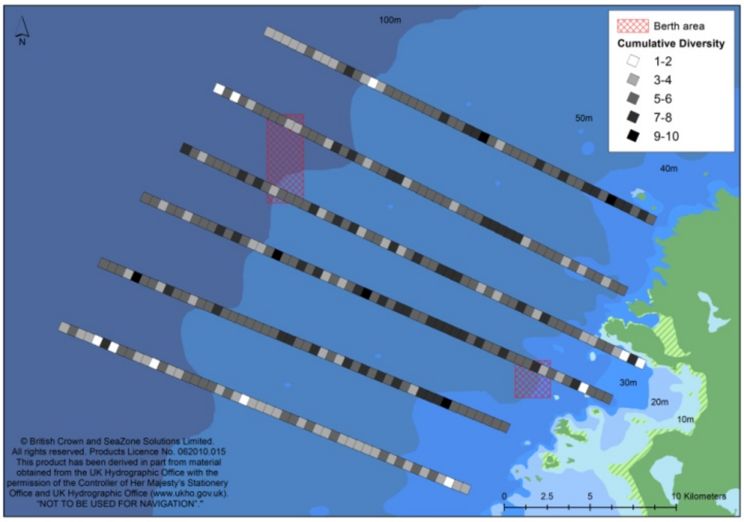

Figure 4. Cumulative number of species observed in each 300m x 300m segment over the eight surveys with the exception the most southerly transect, which was only surveyed on five occasions.

Monitoring Surveys

The EIA provided an initial snapshot characterization of seabird use in the AMETs area and long-term monitoring of the EIA transects provides data on the distribution of seabird species in the broader AMETs region. However, the EIA survey approach is not able to experimentally link changes in seabird populations to AMETS-related activities. The goal of the long term monitoring program is to specifically detect impacts of the WED installation and associated activities on the use of the area by seabird populations. The initial EIA survey design was thus modified to include a before-after-control-impact (BACI) design, while maintaining comparability with EIA survey data. This allows the detection of change (displacement/attraction) in the immediate vicinity of the WED (BACI design) in addition to monitoring regional population dynamics (original EIA transects).

The main modifications consisted of the addition of specific 'test' survey zones and 'control' survey zones and reductions in the extent of initial EIA transects. Test survey zones (2 total) comprise of the WED berth impact area and a 500m buffer zone of potential impact. Each of these is paired with a control zone of the same size. Control zones were placed non-randomly in order to better match bathymetric attributes between control and impact sites. Because the test areas are small, (test transects are 2.1 km; area of inshore berth is 1.2 km^2; outer berth is 3.6km^2) we spaced transects 1km apart, a distance that is within JNCC recommendations (Camphuysen *et al*., 2004) and followed the same transects each survey. To avoid pseudoreplication, the experiment uses a nested split plot design, with transect treated as a random factor nested in plot, and the split-plot aspect represented by the before-and-after-impact timing. The experimental set-up is depicted in Figure 5. Statistical analysis of WED effects will likely employ a generalized linear model with poisson error (modified as necessary) and a log-link function, though particulars may vary with the nature of the resulting data.

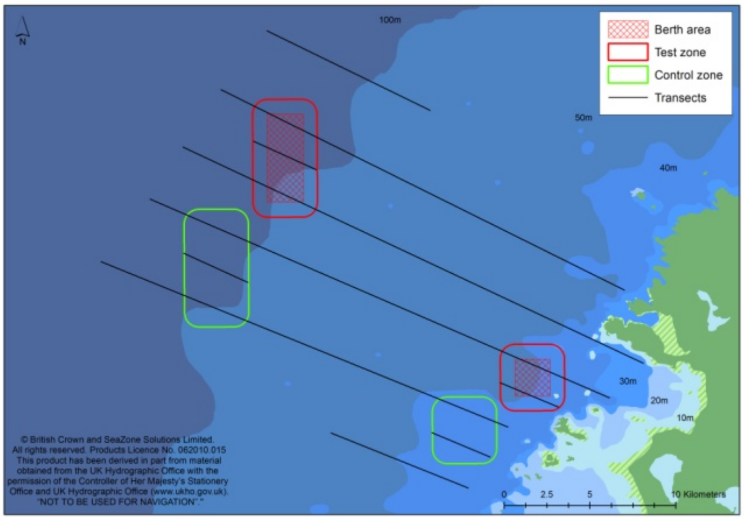

Figure 5. Experimental design for seabird monitoring at AMETS.

RESULTS

Monitoring surveys began in March 2011 and will continue until March 2013. To date surveys have been completed in March, April, June and July of this year. No survey took place in May due to adverse weather conditions. Surveys in April were hampered by sea fog during the second half of the day. Results from the first year of monitoring will not be analysed until April of 2012. Installation of wave energy devices is planned to take place in 2013 which, including the EIA, will give 3 years of pre-development data.

DISCUSSION

EIA base line surveys completed at the test site provided a general spatial and temporal picture of seabird numbers and distribution, over one year, excluding the winter months. Given the paucity of data for the test site, the need for further base line surveys was recognised. However, the need to gather meaningful data for impact assessment purposes was also recognised. To meet both of these demands the EIA survey design was adapted for monitoring purposes. Changes to the survey design were limited by practical and budgetary constraints. Nonetheless the monitoring surveys aim to gather data which can be used to assess changes in seabird numbers and distribution at both local and regional scales.

Local scale impacts

The limited sample size in our experiment, coupled with natural variance in seabird numbers, means that power to detect small differences in seabird densities is rather limited. Large scale differences at the test and control sites should however be detectable.

Regional scale impacts

While effects of wave energy activity on birds is most likely to be concentrated in the berth areas, more regional effects due to displacement or disturbance are also possible (Grecian *et al*., 2010). Regional effects would not be captured by the localized sampling at berth areas and for this reason the 2010 transect approach and sampling frequencies (monthly) were maintained, though with modifications. The extent of initial baseline transects was reduced by 17 km in order to allow surveys to be completed within a single day. Retaining the 2010 baseline transect design also maintains data compatibility with existing recommended standards (i.e. JNCC seabirds at sea surveys).

To gain more from survey data bird activity is now included in the data recorded, under the categories of passing, actively feeding, searching and loafing (adapted from JNCC point watch methodology).

Practical aspects of the monitoring programme.

In striving to achieve a monitoring programme that would provide meaningful data, a number of practical issues have presented challenges. The aim has been to overcome these obstacles while at the same time ensuring integrity in survey methods and design. The following challenges are on-going.

<u>Several changes in the location of the outer berth</u>

The location of the outer berth has been changed four times and each time it is changed the survey design must be changed so the test transect goes through the berth area. This will have implications for the amount of data gained for the outer test and control areas.

<u>Problems with accessing the site in winter</u>

The AMETS has been selected for its wave energy climate. Winter swell conditions in this area mean that all boats are taken out of the water between December and March. While monitoring surveys are planned for the winter months of 2011/2012, conditions may well not be suitable. Consideration has been given to aerial surveys, but disregarded at present due to cost and differences in survey approach.

<u>Ensuring required survey coverage under the constraints of one survey day</u>

The transect surveys must be complete in one day including short autumn and winter days. Fuel and time costs increased with the addition of test and control transects. This meant that two of the original transects had to be shortened. Survey time remains at close to 7 hours, with 2 hours transit.

Ensuring the transect survey approach can continue once the wave energy installations are in place.

This question is critical and it seems surveys will be able to continue once the development is in place, though some manoeuvring is likely. This question was raised as the WaveHub development (Halcrow, 2006) off the South Coast of England used point counts rather than transect surveys and one reason for this is that they would not be able to survey through the berth areas post development.

Other Issues

How to identify the reasons for any change in bird use of the study site.

Results from the AMETS EIA surveys completed in 2010 have characterised the seabird interest within the off shore survey area. Further transect surveys, with changes as outlined, are underway and will provide further data on the survey area. Over time data from these surveys will be able to detect change due to the wave energy development locally, as well as overall regional trends, however, they will not provide data on the specific biological reasons for change (e.g. adult mortality, behavioural change). While EIA and monitoring surveys are constrained in their scope, the AMETS provides an opportunity for research questions relating to WED impacts to be addressed.

The lack of context for seabird data in Irish waters.

The AMETS selection process included a preliminary consideration of potential environmental impacts and the Annagh Head site was selected in part because there was no overlap with existing marine protected areas (Special Areas of Conservation (SAC), Special Protection Areas for birds (SPA)). However, a lack of designation does not imply a lack of ecological value in this instance as Ireland has to date designated very few marine SPA's or SAC's. Data on use of Ireland's offshore sea area to inform the selection of, for example, important seabird foraging or moulting areas is limited. The data which is available (Pollock *et al.*, 1997, Mackey *et al.*, 2004, Hall *et al.*, in prep) has yet to be integrated and analysed for the purpose of marine SPA designation (Hall, *et al*. in prep). The conservation status of the open sea area in the AMETS area is therefore not known.

CONCLUSION

The development of a full scale wave energy test site is the first of its kind in Irish waters and wave energy remains a novel development. At present tested methods for monitoring seabird impacts due to wave energy developments are not available and data on seabird impacts due to such developments is limited. The survey approach at AMETS combines established seabird survey methods together with an established impact assessment approach (BACI). The experimental design has been challenged by practical and budgetary constraints. Nonetheless, monitoring surveys at AMETS will provide a means of linking observed local changes in seabird numbers and distribution back to wave energy installations. They will also provide baseline data for estimating the importance of the study site to marine birds. Furthermore on-going bird surveys at AMETS will contribute to the information available on the impacts of wave energy developments and to the improvement of monitoring approaches for future wave energy developments.

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